

Color Morph Bias and Conservation Concerns for a Tropical *Pterodroma*

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Along the outer continental shelf of North Carolina (ca 35° 40' N, 74° 50' W), the majority of the Herald (South Trinidad) Petrels (*Pterodroma arminjoniana*) reported are dark-plumaged individuals. At the only Atlantic breeding sites (South Trinidad Island, 20° 30'S, 29° 19'W, and Martin Vas Rocks, 20° 30'S, 28° 51'W), ca 500 miles [800 km] off southeastern Brazil, however, the majority of chicks and breeding adults were historically reported to be light-morph birds (Murphy 1936). This discrepancy is the subject of this article; it is testimony to the value of reporting by recreational bird watchers. In this particular case sightings reported from off the southeastern United States provide indirect evidence for the continued decline of a seabird breeding on a remote, seldom visited, oceanic island.

Color ratios in the North Atlantic vs. breeding grounds

Herald Petrels have a rather protracted season of occurrence off North Carolina and presumably elsewhere in the western North Atlantic, where reported occurrences range from 21 May through 26 September. These dates correspond roughly to the period of maximum occurrence of many of the more common tropical seabirds in the region (Lee 1995). Plumage morphs in the North Atlantic are highly biased toward dark-plumaged individuals (>80%); dark and intermediate morphs account for >90% of the records; while light morphs make up approximately 9% of reported occurrences (NCSM records). Of the 60+ records and reports of Herald Petrel from the western North Atlantic, the majority (>90%) are from the Gulf Stream off the Outer Banks of North Carolina. Individual records of Herald Petrels are available for Virginia (July 1996, September 1996), Puerto Rico (Gochfeld *et al.* 1988), and the mid-North Atlantic (21° 51'N, 43° 35'W, Lowe 1911). There is a hurricane-driven specimen record from New York (Allen 1934), and there are a small number of sightings from coastal sites and piedmont reservoirs in Virginia that are associated with hurricanes (Brinkley *et al.* 1997). All but one of these are also dark-plumaged birds. Unfortunately not enough pre-1985 records of these *Pterodroma* away from breeding areas are available to show if dark morphs were always dominant in the North Atlantic.

Actual percentages are probably even more biased toward dark individuals than available records and reports suggest. There were a number of summer and fall reports of Sooty Shearwaters (*Puffinus griseus*) from waters off the

southeastern United States made prior to the documentation of Herald Petrel in the region. The Sooty Shearwater is a very rare summer resident and fall migrant in the sub-tropical western North Atlantic, and some of these Sooty Shearwater reports are likely to represent dark morphs of the Herald Petrel (Lee 1979). There is a problematic photograph of a Kermadec Petrel (*P. neglecta*) from Pennsylvania (Heintzelman 1961) that many believe to be of a dark phase Herald Petrel, and two turn-of-the-century records from the UK of Kermadec and Collard (*P. leucoptera*) Petrels are suspected to be Herald Petrel (Cramp and Simmons 1977). Additionally, there are a number of sightings of dark *Pterodroma* from the western North Atlantic that, because of distance and other factors, were not identified to species but which were most likely this petrel (e.g., Lee 1984, Aud. Field Notes 50:267).

The ratios of plumage morphs of Herald Petrels nesting on South Trinidad Island, on the other hand, have been reported as highly biased toward light morphs. Early authors did not provide estimates of the ratios of the plumage morphs, but from reading early accounts it is clear that the dark 'arminjoniana' were by far the least common whereas white-breasted petrels were abundant (Sharpe 1904, Wilson 1904, Nicoll 1906, and Murphy 1936). Storrs Olson (US National Museum), however, visited the island between December 1975 and January 1976 and found the reverse to be true. He recorded only "40 out of 100 birds to be light phase" (Olson, field notes).

Using the most conservative figures (all birds unquestionably identified to species) for the ratios of dark-to-light and intermediate morphs visiting the western North Atlantic (49:12), and the highest reported ratio of dark-to-light morphs on the Atlantic breeding site by Olson (60:40), the dispersal of dark color morphs into the North Atlantic is much more frequent than expected, and the disproportionate number of dark-plumaged birds occurring in the North Atlantic is highly significant ($x^2 = 7.17$, $df = 1$, $P = 0.007$).

Factors possibly affecting North Atlantic color morph ratios

Color morph variance may have selective value. Spear and Ainley (1993) have demonstrated an absence of kleptoparasitism by jaegers and skuas (subfamily Stercorariinae) on Kermadec and dark morph Herald Petrels in the eastern tropical Pacific. Batesian mimicry, where one species gains advantage in resembling another, allows these petrels to avoid being parasitized because jaegers and skuas do not parasitize conspecifics. Other *Pterodroma* of similar sizes are parasitized. Lee (1979) noted the striking similarity between dark morph Herald Petrels and dark morph jaegers in the western North Atlantic. The flash marks in the primaries of Atlantic Herald Petrels are quite conspicuous (Lee 1979, Harrison 1983), whereas they are absent on Herald Petrel (*P. [a.] heraldica*) of the Pacific (Spear and Ainley 1993). Additionally, Herald Petrels often exhibit flight styles that are straight and direct (wings held parallel to the ocean's surface), thus more reminiscent of a jaeger than of a *Pterodroma* (Lee 1979, 1984).

Spear and Ainley (1993) suggest that mimic petrels are Batesian 'defensive' and resemble a dangerous/noxious species (skuas). Skuas and large jaegers (and thereby their mimics) enjoy some degree of predator avoidance.

In skuas and large jaegers, long distance visual signals are effective, and these birds do not parasitize conspecifics (Furness 1987) and seldom parasitize smaller jaegers (Spear and Ainley 1993). However, Spear (pers. comm.) is aware of no compelling evidence suggesting that dark morph birds are more successful kleptoparasites than light morph birds, and there does not appear to be a distributional difference between light and dark morph Herald Petrels in the Pacific. Furthermore, even the evidence for selection of plumage for kleptoparasitism in Parasitic Jaegers (*Stercorarius parasiticus*) is conflicting (Furness and Furness 1980). Thus, it seems unlikely that a differential marine distribution of color morphs would be driven by mimicry.

Another explanation for the discrepancy in color morph ratios of Herald Petrels seen off the southeastern United States is that the population on South Trinidad Island and Martin Vas Rocks is in severe decline and that the color morphs, because of differential survival at these breeding sites, are actually declining at different rates. The differences in rate of decline may relate to differences in nest site selection of the two plumage types. Williams (1984) noted that the colony at South Trinidad Island probably has been significantly reduced since Murphy (1936) recorded 'vast numbers' there in 1914. Comparison of turn-of-the-century descriptions of the petrel colony size on South Trinidad Island to those of Olson (1981) indicate extreme declines for the Atlantic population. The early reports of Sharpe, Wilson and Nicoll are from November and January, the same general season of Olson's visit. Thus, it seems likely that the more accessible nesting colonies of the lighter morphs had been depleted by feral animals and the military garrison stationed on the island (Olson 1981, Williams 1984), thus accounting for the discrepancy in color morph abundance in the 50-75 year period between reports. While there is no hard data on population size, Williams (1984) states that this petrel is now confined to inaccessible cliff nesting sites, probably as a result of predation by feral cats. Olson (1981) reported that the petrels were fairly abundant on several of the high peaks of Trinidad, implying that they were absent from the lower sites where they were reported to occur abundantly earlier in the century. Nearby Martin Vas, the only other Atlantic nesting site, is used as a naval target by the Brazilian military, and populations are believed to be reduced there as well (Williams 1984).

The petrels originally nested on the soil beneath the trees, so it can be assumed that their populations were numerically larger prior to deforestation. Even the earliest accounts from South Trinidad were made after the destruction of the *Colubrina* forest that covered most of the island. The forest died within a short period as a result of ring barking actions of feral goats (Murphy 1936) or fire (Olson 1981).

In view of the non-selective value of color morphs in kleptoparasites in the Pacific, it seems likely that the high occurrence of dark morphs off North Carolina reflects actual ratios of the breeding population. Assuming that the abundance of dark morphs does not result from a selective marine distribution of color morphs and that the available predator-free nesting sites on the cliff faces of South Trinidad Island are finite, and in view of the significant additional shift in the color morph ratio of birds between the mid-1970's and mid-1990's, conservation concerns for this population appear to be serious.

Furthermore, under current taxonomy, the race of Herald Petrel nesting on South Trinidad Island breeds only at one other locality – Round Island, off Mauritius, in the Indian Ocean. Here it has also undergone severe declines (Tempel 1974, Vinson 1976), and the population continues to be harvested for human food (Gardner *et al.* 1985).

The conservation aspects of this story are more complex than the taxonomy indicates. Current taxonomy is based on Murphy and Pennoyer's (1952) revision of the larger *Pterodroma*. They reported on a newly-discovered population of Herald Petrels in the Indian Ocean and reclassified the Pacific *P. heraldica* as a race of *arminjoniana* on the basis of supposed intermediate characteristics in the Indian Ocean population. Imber (1985) reexamined the taxonomy of *Pterodroma* and considers *heraldica* and *arminjoniana* as separate species. Brook and Rowe (1996) do not refer to Pacific birds as races of *arminjoniana*, while other authors (*e.g.*, Warham 1990) and the American Ornithologists' Union have not followed this arrangement. Olson and Lee (*in ms*), based on a number of characteristics, consider the two taxa to represent distinct species. Brook and Rowe (1996) found dark morph *Pterodroma* of this species complex mating only with other dark morph individuals and nesting away from light morph birds in the Pitcairns (western South Pacific). Combining behavioral information with sequencing data of the mt cytochrome-b gene, they concluded two species were involved. They named the dark morph birds *P. atrata* and the light ones remained *P. heraldica*. The situation may be similar in the Atlantic. Nicoll (1906) noted that the nests of the then-rarer dark morph birds were found only at higher altitudes on South Trinidad Island. It has also been suggested that the ratios of different morphs vary with season. Wilson (1904) not only found nesting dark birds to be higher on the island and 'well away from their white breasted cousin,' but during his September 1901 visit, he found the white-breasted birds in all stages of nesting and found the darker birds with no young and eggs in only early stages of incubation (also see discussion in Murphy 1936). Additionally, Sharp (1904) mentions noticeable differences in bill sizes between the different color morphs. Thus, conservation concerns should be directed at the species level, and anecdotal information from early in this century and conjecture based on studies of *P. heraldica* in the Pacific suggests that more than one taxon of *Pterodroma* may be endemic to South Trinidad Island.

Despite the lack of recent inventory of population size, or even current reports of color morph ratios at Atlantic breeding sites, available information strongly implies that the high ratios of dark birds visiting the North Atlantic are not biased but actually reflect recent changes in population composition and size at tropical Atlantic breeding sites. Whatever future taxonomic decisions occur regarding the petrels breeding on South Trinidad Island, it remains clear that 1) the population on South Trinidad Island has declined since the early part of this century, 2) the lower numbers of nesting light morph individuals, which were formerly the best represented, are now the ones less often encountered, and 3) the highly skewed morph ratios of birds seen off of North Carolina support the hypothesis of continued declines in the numbers of white morph individuals for the last several decades.

The vulnerability of petrels and their extinction rates in the Atlantic and Caribbean are well known. At least three species have been exterminated from Saint Helena since man first discovered that island (Olson 1975). The Jamaican Petrel (*P. caribbea*) is assumed to be extinct (van Halewyn and Norton 1984), and the four remaining *Pterodroma* of the North Atlantic are all species of major conservation concern, with Black-caped Petrel (*P. hasitata*) on the top of the Partners in Flight 'Watchlist' (Carter *et. al.* 1996). Declines of other seabirds nesting on South Trinidad Island have been described by Olson (1981) and Williams (1984). Of two endemic subspecies of frigatebirds, the Great Frigatebird (*Frigata minor nicolli*) no longer breeds on the island, and the Lesser Frigatebird (*F. ariel trinitatis*) is reduced to 25 to 50 pairs. Red-footed Boobies (*Sula sula*) were reduced to two small colonies totalling less than 100 pairs, and the population of White Terns (*Gygis alba*) was lower than suggested in earlier accounts. All available information indicates that the South Trinidad petrel(s) are in serious decline. Populations are in need of updated assessments, taxonomic issues need to be addressed, and conservation action is warranted.

Acknowledgments

I thank Storrs Olson for access to his field notes. Chris Haney and Larry Spear reviewed an earlier version of this manuscript, Ricky Davis provided information on color morph of birds seen off North Carolina in 1996 and 1997, and David Johnston shared information on the Virginia reports.

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