Leach's Storm Petrels *Hydrobates leucorhous* breeding on Gloup Holm: the third discovered breeding site in Shetland

Will Miles[1], Peter Hunter[1], Matt Wilson[1], Alice Bacon[1], Glen Tyler[2], Kevin Kelly[3], Jenny Sturgeon[1], Pete Ellis[3], Logan Johnson[1], Rory Tallack[4], Brydon Thomason[5] and David Okill[6].

** Correspondence author. Email: willtsmiles@hotmail.com*

[1] *SOTEAG, Ground Floor, Stuart Building, Alexandra Wharf, Lerwick, Shetland, ZE1 OLL;*

[2] *NatureScot, Ground Floor, Stuart Building, Alexandra Wharf, Lerwick, Shetland, ZE1 OLL;*

[3] *RSPB Shetland, Sumburgh Head Lighthouse, Sumburgh, Virkie, Shetland ZE3 9JN;*

[4] *Shetland Amenity Trust, Garthspool, Lerwick, Shetland, ZE1 0NY;*

[5] *Shetland Nature, Rohan, Baltasound, Unst, ZE2 9DS;*

[6] *Heilinabretta, Trondra, Shetland, ZE1 0XL.*

Abstract

In the UK, Leach's Storm Petrel *Hydrobates leucorhous* breeding colonies are few and geographically very remote. Single Leach's Storm Petrels were heard calling from burrows on Gloup Holm, north Shetland, in July 2019, July 2020 and August 2020, in response to call-playback. The occupied burrow network found in August 2020 was examined by endoscope and a Leach's Storm Petrel eggshell was seen, constituting the first proven breeding record at this site. A sample call was recorded from each bird heard, sonograms produced, and comparison with criteria for determining sex from calls indicated the bird heard in 2019 was female and those in 2020 were one or possibly two males. Currently, Leach's Storm Petrel breeds in very low numbers in Shetland on just two small islands. Restoration projects to eradicate introduced predators and preserve natural breeding habitat on select other islands could result in increased breeding numbers.

Introduction

Leach's Storm Petrel *Hydrobates leucorhous* is a highly pelagic burrow-nesting storm petrel, active on land primarily at night (Cramp & Simmons 1977). Individuals can live for 30 years, normally start breeding at four to six years, and both sexes share incubation of a single white egg (Huntingdon *et al.* 1996; Brooke 2004). The species is very numerous and widespread across the northern hemisphere (estimated global population > 6 million pairs) but is Red-listed and classified as 'Vulnerable' by IUCN, due to recent declines of ≥ 30% (BirdLife International 2021). In Europe, breeding has been proven on only a few dozen islands, all in the northeast Atlantic, and the UK breeding sites are very few and extremely remote (Brooke 2004; Mitchell *et al.* 2004). The most recent complete UK census (Seabird 2000) recorded 15 active colonies and an estimated total population of 48,047 occupied burrows ('apparently occupied sites', AOS), with

99.9% on remote islands off the Western Isles — primarily St Kilda (94.5%), the Flannan Isles (3.0%) and North Rona (2.3%) — and 0.1% on two islands in Shetland: Foula and Gruney (Mitchell *et al.* 2004; Pennington *et al.* 2004).

Foula was the first Leach's Storm Petrel colony discovered in Shetland (Pennington *et al.* 2004). Breeding had been suspected since the early 1900s but was confirmed in 1974 (Mainwood 1975). Fifteen AOS were reported during Seabird 2000, but the colony is now thought to be extinct due to predation by Feral Cats *Felis catus* and possibly Great Skuas *Stercorarius skua* (Mitchell *et al.* 2004; Miles *et al.* 2012). On Gruney, Leach's Storm Petrels were first found in August 1980 (at least 10 occupied burrows) and breeding was proven in July 1981 (Fowler 1982; Fowler & Butler 1982). To date, full-scale total population surveys using call-playback methods have been logistically unfeasible on Gruney, due to the time required for full surveys, and also access restrictions imposed by severe sea and weather conditions frequent in Shetland even in summer; occupied burrows have been found using call-playback on just one or a few *ad hoc* site visits per year (see Ratcliffe *et al.* 1998 and Murray *et al.* 2016 for full survey methods). Numbers found have fluctuated but generally decreased since 1980, with five in 2020 being the most recent count (Figure 1). However, such *ad hoc* methods are likely to underestimate numbers because birds ashore do not always respond to call-playback, due to a variety of possible reasons such as age, sex, time of day, time of year, weather conditions and the acoustic properties of call-back tracks (Ellis *et al.* 1998).

For many years there was speculation that Leach's Storm Petrels might breed on other remote islands in Shetland (Pennington *et al.* 2004). In 2010 and 2011, the Holm of Skaw, Muckle Flugga, Tipta Skerry, Cliff Skerry, the North and South Holms of Woodwick (all off north Unst), Gloup Holm (off north Yell) and Fair Isle were prospectively surveyed for new breeding colonies (Miles *et al.* 2010, 2012). Three

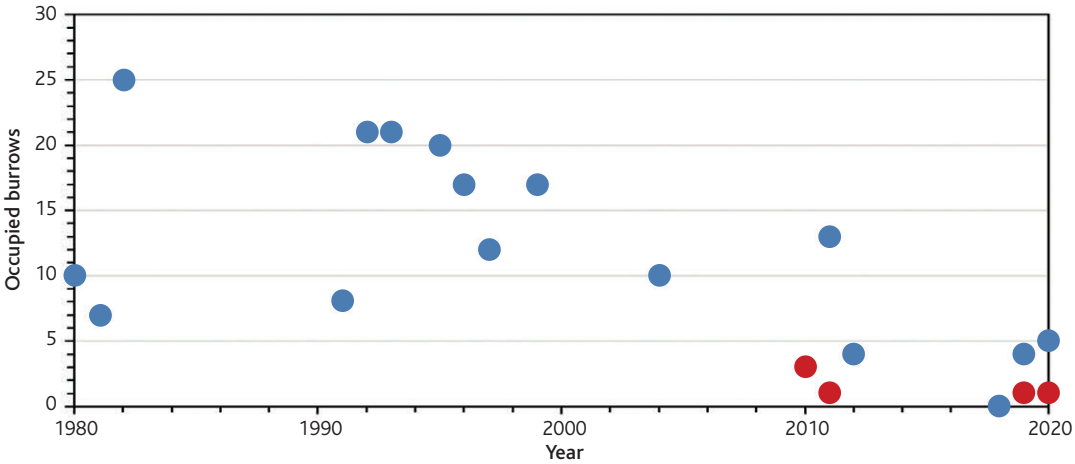

Figure 1. Total number of occupied burrows where Leach's Storm Petrels *Hydrobates leucorhous* responded to call-playback on Gloup Holm (red) and Gruney (blue), 1980–2020. Occupied burrows were first found on Gloup Holm in 2010 and on Gruney in 1980. All data are from just one or a few *ad hoc* site visits per year (Pennington *et al.* 2004; Miles *et al.* 2012).

occupied burrows were found on Gloup Holm in 2010, one containing two adults with a nest and the other two each a single adult, but no eggs or chicks were found (Figure 1; Miles *et al*. 2010).

Burrow occupancy by non-breeding petrels is a normal behaviour that occurs frequently, especially among immature birds that may 'play house' and practice nest building for several years before actually breeding (Brooke 2004). Studies of Leach's Storm Petrels at St Kilda, North Rona and Gruney, for example, have shown that up to 30% of all burrows where a response to playback is heard are occupied by apparently non-breeding individuals with no eggs or chicks (Money *et al*. 2008; Bicknell *et al*. unpubl. data 2010; Miles *et al*. 2012). Therefore, to confirm breeding at any Leach's Storm Petrel colony requires an egg or chick (or remains thereof) to be sighted or a chick to be heard. Confirmation of whether or not breeding occurs on Gloup Holm, by careful examination of occupied burrows by endoscope, has been one of the key aims of survey visits there since 2010.

Gloup Holm (60°45'N 1°07'W) is a small island of approximately 10 hectares, located 0.5 km off the northwest coast of Yell and approximately 15 km northeast of Gruney. It was resurveyed using call-playback in June and August 2011 and one occupied burrow was found (Figure 1). It was examined by endoscope but was too deep to check conclusively, and no egg or chick was seen (Miles *et al*. 2012). This short paper presents the results of subsequent Leach's Storm Petrel surveys of Gloup Holm, in 2019 and 2020, the first proven breeding record, and sonograms of recorded chatter calls.

Methods

Gloup Holm was visited on 12 July 2019, 22 July 2020 and 14 August 2020 and surveyed for Leach's Storm Petrels under British Trust for Ornithology Schedule 1 disturbance license for the purposes of ringing and nest recording. A custom digital loop-track of male and female Leach's Storm Petrel purring and chatter calls was played over all accessible areas of potential breeding habitat using mobile phones, carried slowly above the ground at c. 30 cm height, to elicit response calls from birds underground occupying burrows (Gilbert *et al*. 1998). Duration on the island was approximately one hour in July 2019 and July 2020 and two hours in August 2020. In July and August 2020, burrows were examined using a small, lightweight endoscope (Powerfix Profi Inspection Camera).

One sample chatter call from each bird heard responding to call-playback was recorded on a mobile phone and a sonogram produced using Raven Lite 2.0.1 acoustic software (Cornell Lab 2020). This was purely for speculative interest, with two aims: 1) to simply document and quantify the acoustic characteristics of a sample call from each bird; 2) to compare sonograms with criteria for determining sex from chatter calls (Taoka *et al*. 1989), in case this could give an indication of whether males or females had been heard. Chatter calls have a complex structure typically comprising nine to 11 syllables in total, beginning with three to five relatively short syllables, followed by one of distinctly longer duration ('syllable-C'), then four to six of shorter duration (Taoka *et al*. 1988). Working on the Japanese

island of Daikoku, Taoka *et al.* (1989) found that chatter calls are sexually dimorphic, with the frequency of the fundamental band of syllable-C ('HFC') > 800 Hz in males and < 750 Hz in females. The timing and acoustic frequency of the syllables in each call are otherwise highly variable (Cramp & Simmons 1977; Taoka *et al.* 1989; Huntingdon *et al.* 1996; Robb *et al.* 2008). Geographical disparity in vocal characteristics has not been studied in detail, although chatter calls recorded on Diakoku Island and at north Atlantic colonies have been compared, and no geographical differences were detected (Robb *et al.* 2008).

Results

Single adult Leach's Storm Petrels were heard responding to call-playback from within burrows during all three visits to Gloup Holm in 2019 and 2020. All adults were found in the northwest of the island, and those in 2020 were both found in exactly the same network of burrows, but their underground locations were not clearly separate, meaning only one occupied burrow could be confirmed (Figure 1). During the first two visits, on 12 July 2019 and 22 July 2020, no conclusive evidence of breeding was seen or heard. However, endoscopy of the occupied burrow found during the third visit, on 14 August 2020, revealed the remains of a Leach's Storm Petrel eggshell (Figure 2). Approximately 50% of the shell was still intact, suggesting that the egg may have recently hatched (eggshells tend to disintegrate very quickly after hatching, presumably due to adult and chick activity within the burrow; Money *et al.* 2008, W. Miles pers. obs. 2007–11). All occupied burrows were found in the same fragile habitat type: deep, damp, loose spongy soil of at least 30 cm depth, overlain by an ungrazed, thick and tussocky vegetation sward predominantly composed of Red Fescue *Festuca rubra,* Tufted Vetch *Vicia cracca*, Sea Plantain *Plantago maritima* and Thrift *Armeria maritima*.

Figure 2. Leach's Storm Petrel *Hydrobates leucorhous* eggshell remains found by endoscopy of a burrow occupied by an adult Leach's Storm Petrel on Gloup Holm, Shetland, on 14 August 2020.

Three sample chatter calls were recorded, one from each bird found during the three different site visits. Comparison of sonograms showed that none of the chatter calls matched each other, each had different acoustic characteristics (Figure 3). For example, the time spacing and duration of syllables, total number of syllables, and total call duration, all differed in each call (Figure 3). Comparison of the fundamental band frequency of syllable-C (HFC) in each chatter call with criteria for determining sex (HFC > 800 Hz in males, < 750 Hz in females; Taoka *et al.* 1989), indicated that the bird heard on 12 July 2019 was female (HFC = 645 Hz), the bird on 22 July 2020 was male (HFC = 975 Hz) and the bird on 14 August 2020 was male (HFC = 865 Hz; Figure 3).

Discussion

The discovery of a Leach's Storm Petrel eggshell in a burrow occupied by an adult on Gloup Holm on 14 August 2020 constitutes the first proven breeding record of Leach's Storm Petrels at this site. The state of the eggshell indicated recent hatching, which would be slightly later than the normal hatching period in the UK (mid- to late-July), but not unprecedented in Shetland, where eggs and tiny chicks have been observed previously in August on Gruney (Cramp & Simmons 1977; Ellis *et al.* 1998; Money *et al.* 2008; Miles *et al.* 2012). No chick was seen in the burrow on Gloup Holm in August 2020, but after the eggshell was found, examination of the burrow by endoscope ceased immediately to reduce potential disturbance.

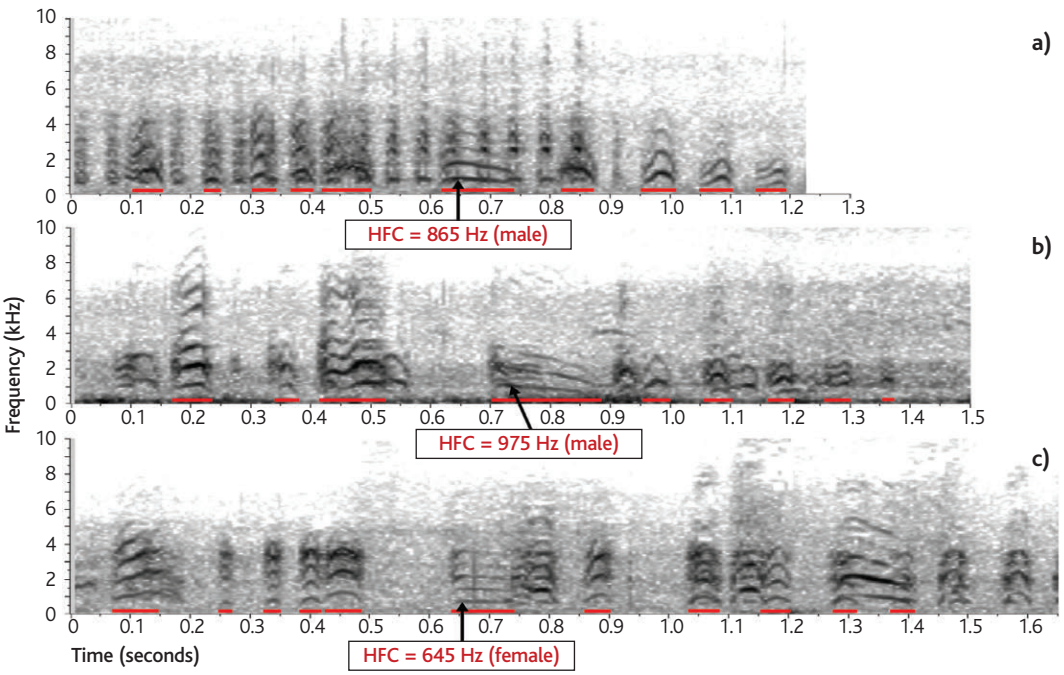

Figure 3. Sonograms of sample chatter calls recorded from single Leach's Storm Petrels *Hydrobates leucorhous* heard responding to call-playback on Gloup Holm on a) 14 August 2020, b) 22 July 2020 and c) 12 July 2019. Each sonogram shows one complete chatter call. Red lines mark the individual syllables of each chatter call (unmarked sounds are background noise from the call-playback track). HFC is the frequency of the fundamental band of syllable-C (red text).

The criteria of Taoka *et al*. (1989) for determining sex from chatter calls indicated that the bird heard on Gloup Holm in 2019 was female and those in 2020 were male (either one male that gave a call with different characteristics in July and August, or two different males, each with a different call). The extent to which chatter calls vary in and between individuals is currently unknown. The occupied burrow network on Gloup Holm in 2020, although small, comprised several different tunnels and chambers (dug by Leach's Storm Petrels or in the past by Puffins), so conceivably it could have held more than one pair. Verification of the sex and number of birds found on Gloup Holm by DNA analyses would have been useful but was outside the scope of this study. A large-scale, detailed analysis of the chatter call characteristics of male and female Leach's Storm Petrels breeding at different Atlantic and Pacific colonies would be valuable, and perhaps allow further insight into our call recordings from Gloup Holm.

Leach's Storm Petrel is currently the rarest breeding seabird in Shetland, with just six occupied burrows found in 2020: one on Gloup Holm and five on Gruney (Figure 1). However, given that survey methods in 2020 were *ad hoc*, and breeding adults sometimes remain silent in their burrows, ignoring call-playback, there may have been additional occupied burrows on Gruney and Gloup Holm that remained undetected (Gilbert *et al*. 1998; Ratcliffe *et al*. 1998; Murray *et al*. 2008; Newson *et al*. 2008; Murray *et al*. 2010; Murray *et al*. 2016). Resurveys of Foula have found no signs of breeding Leach's Storm Petrels for over a decade, and it appears the colony is no longer active (Miles *et al*. 2012; S. Gear pers. comm.). It is conceivable that breeding might occur in small, isolated, Feral Cat-free patches of potential breeding habitat on the island's steepest sea cliffs (some of the highest in the UK), but this remains unknown, and specialised climbing techniques would be required to investigate these areas. It is also possible that additional, currently unknown breeding pairs of Leach's Storm Petrels exist at other remote locations in Shetland.

Currently, all known active Leach's Storm Petrel colonies in the UK are located on remote islands that do not have rats or cats, and most colonies are situated in extremely fragile natural habitats, for example steep, loose boulder scree, or the ungrazed tussocky grassland with deep, soft, soil that is favoured on Gloup Holm, and also on Dùn at St Kilda, the largest UK colony (Mitchell *et al*. 2004; Miles *et al*. 2010, 2012; Miles 2018). Many islands and sea stacks in Shetland, and elsewhere in the UK, now have rats or cats or are annually grazed by livestock, and sites suitable for Leach's Storm Petrel breeding colonies are rare. In Shetland there are very few, other than Gruney and Gloup Holm, but future prospective call-playback surveys of these small, hard to reach locations might result in the discovery of more breeding pairs.

Knowledge of the breeding and foraging distributions of rare or declining species is very useful for conservation purposes (Boyd *et al*. 2006; Sutherland 2000). In the last 20 years, many species of seabird have declined in Shetland, often in association with reductions in prey availability caused by commercial fishing and

global climate change (Durant *et al*. 2003; Frederiksen *et al*. 2006; Miles 2013, 2015). Large-scale protection of offshore foraging areas is now an important seabird conservation challenge (Lascelles *et al*. 2012; Thaxter *et al*. 2012; Cleasby *et al*. 2020). However, for species such as storm petrels that are highly vulnerable to predation on land, island restoration projects that eradicate introduced predators and preserve areas of natural habitat suitable for breeding are also extremely important (Mulder *et al*. 2011). Such projects have been successfully carried out in the UK and overseas by both private and public organisations and would be very valuable in Shetland, where there are currently many islands with rats, cats and other introduced mammals that predate breeding seabirds.

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