LUNDY FIELD SOCIETY

Journal of the Lundy Field Society

Volume 9, 2025

ISSN 1758-3276

Red Admiral butterflies
on Ivy flowers in Millcombe,
October 2024.
© Mandy Dee.

Journal of the Lundy Field Society
Volume 9 2025

Editor:
John Hedger

LUNDY
FIELD
SOCIETY

Journal of the Lundy Field Society
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Editor:
John Hedger

Production Editor:
Robin Padian

First published 2025

www.lundy.org.uk

Printed by:
Hobbs the Printers Ltd

ISSN 1758-3276

Cover:
A Small white butterfly, photographed on Lundy by Mandy Dee.

IN THIS VOLUME…

Papers

The definitive history of recording Butterflies on Lundy 5

The Lundy Cabbage Beetle, how is it doing? 30

Some odd behaviour by Lundy Fulmars 48

Do Manx Shearwater burrows amplify their calls? 61

Bats over Lundy 68

Is the mystery of the Grey Waxcap on Lundy solved? 83

Sparrows' nests, some unexpected co-habitants 105

International art-detectives discover 'lost' Lundy paintings 113

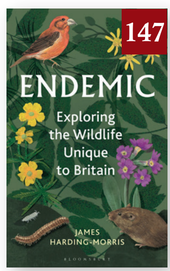
Short Communications

Who lived on Lundy in 1921 and 1939? 135

Book Review

Endemic – includes a chapter on Lundy! 147

Full titles, authors and page numbers of these contributions are on the back cover



EDITORIAL

The JLFS which was begun in 2008 by Jenny George, has continued to thrive, and has usually appeared every two years since, firstly under her editorship and latterly that of Keith Hiscock. So we now arrive at Volume 9, a new editor and a healthy number of papers (eight plus two short articles and a book review).

One function of the Journal is to provide authoritative accounts of the status of organisms on Lundy. *Alan Rowland* provides us with just such a baseline in his account of Butterflies on Lundy, which includes the history of all the species found to date. In the following paper *Laura Larkin* of Buglife discusses the status of just one species of insect, the Lundy Cabbage Flea Beetle, endemic to Lundy, and makes important recommendations for maintaining healthy population of the beetles.

Reports on bird behaviour regularly find their way into the Journal and this volume contains two. The first is by *Are Værøyvik, Sunyeong Lee, Euan Bielby and Shayan Shoaee*, from the University of Exeter on some unexpected flying behaviour of Fulmars which they observed around Gannets Rock in April/May 2024. The second is an intriguing study by *Yuheng Sun, Sue Anne Zollinger & Julia Schroeder* as to whether the burrows of the Manx Shearwaters on Lundy can act as amplifiers of calls made to attract mates returning from migration in the Spring.

Results of research work on Lundy funded by grants from the LFS are required to be published in the Journal and this volume contains two. *Geoff Billington* gives an account of his 'bat recorder' survey of Bats carried out in 2014-18. It is the first detailed study made of them on the island and includes some surprising information on where they are roosting and how many species are using Lundy as a staging post during migration. The second report, by *Ruben Mole, John Hedger, Alan Rowland, Andrew Detheridge and Gareth Griffith* attempts to answer the question as to why a fungus, the Grey Waxcap, appears to be restricted to the North End of Lundy. I have added a note to help navigating the many technical terms around the DNA technology used in the paper. A much simpler text accompanies my own paper written with *Jamie Dunning* on the surprising numbers of fungi, especially 'heat loving' species, we found in Sparrows' nests from Lundy.

André Coutanche has continued his scholarly investigation of the Icelandic artist Kristján Magnússon, whose paintings of Lundy he first brought to our attention in his account of the artist in the 2016 (Volume 5) Journal. His account includes some newly discovered paintings, based on intriguing art-detective work by André.

In the 'Notes and Short Articles' the accounts by *Malcolm Lee* of the 1921 and 1936 census data also use detective work to interpret the records and to track down where the Lundy inhabitants listed lived and worked; it is illustrated by some fascinating photographs.
The volume ends with a review by *Bee Cox* of a newly published book '*Endemic: Exploring the Wildlife Unique to Britain'* by James Harding-Morris. It includes a chapter on the Lundy Cabbage, but Bee thinks it is a good read for other reasons too.

Finally very many thanks to Jenny George and André Coutanche for sage advice during the editing process

John Hedger
Editor
September 2025.

LUNDY BUTTERFLIES

by

Alan Rowland

Mole Cottage, Woodford, Morwenstow, Cornwall, EX23 9JR.

Email: Alan Rowland morwenstow@btinternet.com

ABSTRACT

All extant butterfly records have been extracted from the Lundy Field Society Annual Reports and logbooks from 1946 to 2023. To these have been added listings from published accounts to produce a definitive list for future reference and comparison. There are no rare or endemic species, but occasional unusual visitors are reported.

Keywords: *Lundy, butterfly, Lepidoptera, transect*

INTRODUCTION

Species of butterfly on Lundy

Currently, there are 59 species of butterflies in five families recorded in the United Kingdom. In contrast, Lundy has had up to 34 species in three families. At present there are 22 species that can regularly be found on the island.

The earliest record of Lundy butterflies was the mention of a Painted Lady *Cynthia cardui* by Wollaston (1845) and "a moth". This list was expanded by John Robert Chanter's (1877) list of 21 species including the Large Tortoiseshell *Nymphalis polychloros*, now extinct in UK, and some more localised fritillaries; Chase later listed four butterflies (1894) which was expanded by Longstaff (1907) to 18 species. In Loyd's (1925) book, he repeated Chanter's list which was forwarded to him by the owner of the island at that time, H.G. Heaven. The final listing was in Palmer (1946) which in his account of butterflies of the Ilfracombe area in North Devon also identified those seen on Lundy. His list contains a different range of 20 species.

The first record of named butterflies in the Lundy Field Society (LFS) Annual Report was in 1967 when C Garret-Jones stayed on Lundy from 6th to 9th July 1968. He reported only five species (AR Vol 19).

When Nick Dymond was employed as warden in 1972, he began systematically to list his sightings throughout the year and in the 1972 Annual Report (Dymond Vol 23 AR). His list is very similar to the current one. He notes the first records of Holly Blue *Celastrina argiolus* and also the absence of Comma *Polygonia c-album*, Clouded Yellow *Colias croceus*, and Orange Tip *Anthocharis cardamines* and, the now extinct on Lundy, Pearl-bordered *Boloria euphrosyne* and Small Pearl-bordered Fritillary, *B. selene* and Heath Fritillary, *Melitaea athalia.* Some of these species and Speckled Wood remain as unusual sightings that would be welcome entries in our logbook. Others remain extinct:-.

- **Large Tortoiseshell** Extinct in UK c1950 Chanter 1877, Chase 1894, Longstaff 1901, Loyd 1925, Palmer 1946

- **Small Pearl-bordered Fritillary** Extinct on Lundy: Chanter 1877, Longstaff 1907, Loyd 1925, Palmer 1946
- **Pearl-bordered Fritillary** Extinct on Lundy Chanter 1877, Longstaff 1907, Loyd 1925, Palmer 1946
- **Heath Fritillary** Extinct on Lundy: Chanter 1877, Chase 1894, Loyd 1925, Palmer 1946

METHODS

Butterfly Records from past LFS reports

Butterfly records extracted from the Lundy Field Society Annual Reports and logbooks from 1946 to 2023 are presented in the figures in the text as bar charts in which yearly occurrence on Lundy in each year has been simplified into categories of relative abundance. The scale on the Y axis was derived from the recorded numbers, which fluctuated between 0 and to more than 500 and is explained in Table 1.

Table 1: Scales used in the bar charts of yearly records of Butterflies on Lundy (figures 2-20).

Yearly records	Y axis scale
Listed as "present"	present
One sighting on one date (rare)	singles
2- 9 sightings (occasional)	few
10-99 sightings (common)	common
100 or more sightings (abundant)	abundant

Recording effort began in 1968. There are year gaps where species were not recorded. There has only been a consistent effort to record butterflies in more recent years and in some of the earlier years, for example 1969 to 1971 and 1974 to 1978, 1982, 1985 and 1991 there are no records of butterflies either in the *LFS Annual Report* or in any existing logbooks. Such absence was presumably due to lack of recorders rather than of butterflies.

The Lundy Butterfly Transect

In 2019, together with the then warden, Dean Jones, I established a butterfly transect on the island covering typical habitats: the only wooded area, rough gorse and grassland, former Rhododendron planting on the sheltered eastern side and on the plateau. This will result in more consistent recording and will yield much better data in future. This uses the standard methods recommended and accepted by UK Butterfly and Moths Society (see figure 1 and table 1). All records are automatically recorded on iRecord.

Some effort has been made to walk the transect regularly, but COVID had an impact, as has the recent re-establishment of the island as a bird observatory. Island and observatory staff have a huge workload and to regularly walk the transect relies heavily on volunteers from the staff and visitors.

The transect commences at Millcombe Pond and its nine sections wind up through Millcombe valley and the only wooded area on the island to follow the Upper East Side

Path along the crest of the eastern sidelands. Each section is marked by easily identified landmarks and terminates on a final section from the east side to the middle of the island. After around 1500 metres and a walk of one hour the transect ends at Quarter Wall gate.

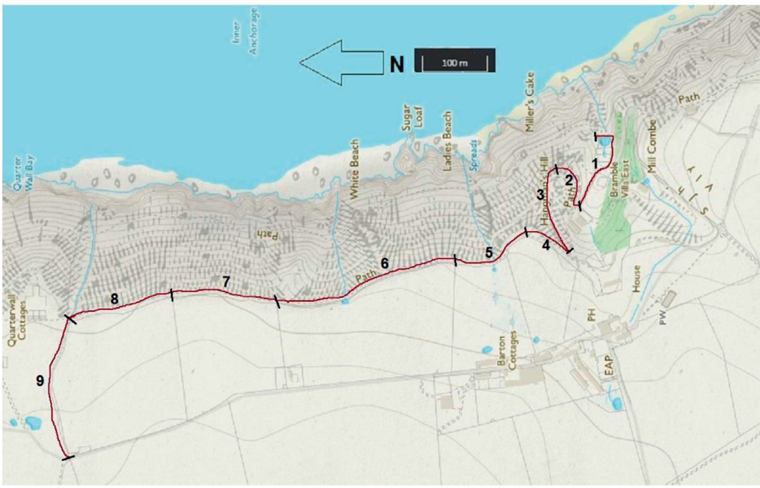
Figure 1: Route of the Butterfly transect on Lundy (reproduced with permission from the UKBMS).

UKBMS

F1(S): BUTTERFLY TRANSECT DETAILS FORM (SMALL SITE)
DETAILS OF RECORDER, HABITAT, MANAGEMENT & ROUTE MAP
Please fill in this form as fully as possible, with reference to Guidance Notes G3 & G4

CEH · Butterfly Conservation

SITE NAME	LUNDY Upper East Side			COUNTY	DEVON				
OS GRID REF. (6 FIG.)	SS136440	OS MAP NO. (1:50 000)	180	YEAR TRANSECT ESTABLISHED	2019				
TRANSECT LENGTH (M)	1440	TRANSECT WIDTH (m) (tick one)	5		6		10	✓	OTHER
OVERALL HABITAT DESCRIPTION	Coastal Cliffs/undercliffs, bracken hillsides			HAB. CODE(S)	B3, E5.3				
LAND USE (if the transect is on a disused industrial site indicate type)	RAILWAY		QUARRY		PIT/MINE		OTHER (add to notes)		
SITE'S CONSERVATION STATUS	SSSI			TYPE OF RECORDER	M				
RECORDER DETAILS	Dean Woodfin Jones (Wildlife Warden)								
OWNER DETAILS	National Trust/Landmark Trust								



SECTION DETAILS:

Section Number	Grid Ref.	Length (m)	HABITAT: Description/notes & main species	HABITAT: Code(s)	MANAGEMENT: Description/notes	MANAGEMENT: Code
1	SS13994405	155	Trees. Unimproved grassland, allotment, walls with ferns- Ivy-leaved Toadflax, Wall Pennywort, Fushia, Common Valerian		Paths are kept trimmed, Goats graze, trees are managed.	M3
2	SS13974409	100	Few trees, predominantly Gorse and bare rock			M3
3	SS13924412	152	Gorse, mixed woodland, Bluebell dominates in season			M3
4	SS13884412	83	Gorse, rough grassland mixed woodland			M3
5	SS13854422	138	Gorse, rough grassland, Bracken, Bluebells, coastal		Formerly Rhododendron dominated, but now Bracken, Bluebells and Gorse. Paths are mowed, regrowth of Rhodi is sprayed, formerly burnt	M4
6	SS13814443	293	As Section 5, to the east, improved grassland			M4
7	SS13824465	167	As Section 6			M4
8	SS13804480	122	As Section 7			M4
9	SS13694492	230	Rough moorland some gorse damp areas with Juncus		Grazed by Cattle and Ponies	M1

By submitting these records you confirm that they contain data that you have collected, give permission for the records to be used for research, education and public information, and to be made generally available for re-use for any other legal purpose under the terms of the Open Government Licence (http://www.nationalarchives.gov.uk/doc/open-government-licence/), and agree that your name will be associated with the record.

Section	Detailed description
1	The transect commences at SS1404405, on the north side of Millcombe Pond. Walk south to the road and then right up the hill, through Millcombe gates until you almost reach the house
2	At the first grassy path SS13934408 on your right, turn east passing the bench and sundial. The path continues upwards until you reach the Ugly
3	From the Ugly SS13984411, turn west inland, passing the steps to the Lower East Side Path and continuing under the trees towards the steps that climb Millcombe Valley to the Village.
4	Ascend the few steps at SS13844409, to the bench dedicated to David Trapnell and turn along the path which leads north along the field boundary.
5	At the wooden field gate SS13894416 continue north along the Upper East Side path which follows the field boundary
6	At the Boundary of Barton's Field and Tillage Fields SS13834455, continue north along the Upper East Side path which follows the field boundary
7	At the boundary of Tillage Field and Brick Fields SS13854428, continue north along the Upper East Side path which follows the field boundary
8	At the post and wire fence that divides Brick Field SS13824472, continue north along the Upper East Side path which follows the field boundary
9	At the wooden gate in the fence at end of Quarter Wall SS13794488, turn west and follow the field boundary to Quarterwall gate on the main track where your transect ends.SS13574489
	The End Roughly 1 ½ Km length and one hour in time

Table 2: Descriptions of the sections of the Lundy Butterfly transect.

RESULTS

A spreadsheet of all records extracted from the LFS Annual Reports from 1947 to 2023 is available on the LFS website. This raw data can be downloaded from this location:- **https://www.lundy.org.uk/images/downloads/Journal_9_Butterflies_analysis.xlsx**

In the species accounts below, the earliest and latest dates of sightings on Lundy for each year have been extracted together with the highest number seen on one day. The bar charts show year by year abundance of the species. A photograph of each species taken on Lundy is included where this exists. Where no photograph is available from Lundy, a mainland photograph has been used. The origin of each photograph is also indicated. Nomenclature follows Eeles (2019).

HESPERIDAE: Skippers

Large Skipper *Ochlodes sylvanus*

The Large Skipper is common throughout England and Wales but is rare on Lundy. Only one example has been recorded by Roger Key on 9th June 1995 at the Quarries. Although this is an undisputed record, due to the expertise of the recorder, it is the only recorded sighting. No sightings are listed in Chanter, Loyd or Palmer. This small brown

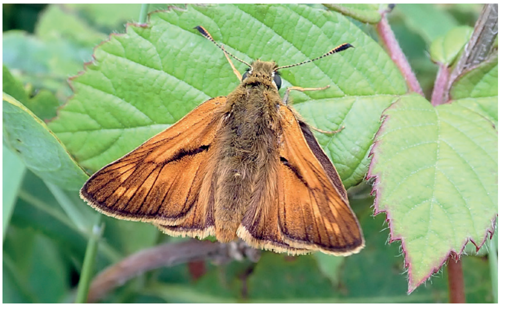


Plate 1 Large Skipper photographed in North Cornwall ©Alan Rowland.

butterfly is unmistakeable with crossed wings and yellow chequer-board patterned wings. It is common on unimproved grassland and adults can be seen on the mainland from late May to early August.

The adult's food plants are Brambles *Rubus* spp.. and Thistles *Cirsium* sp. whilst the larvae prefer grasses, in particular Cocksfoot *Dactylis glomerata* and should therefore be at home on Lundy. It is classified as a Lundy rarity.

Silver-spotted Skipper: *Hesperia comma*

The Silver-spotted Skipper was recorded once on Lundy on 2nd September 1981 by an unknown observer who recorded two. It is a very localised and rare species found on chalk downland in southern England. The flight period of adults is August. This record is highly doubtful, cannot be confirmed and no sightings are listed in Chanter, Loyd or Palmer.

PIERIDAE: Whites

Orange Tip: *Anthocharis cardamines*

Males of Orange Tips are unmistakeable as the only white butterfly with orange tips to its wings. Females lack this marking so are not so easily identifiable unless the green mottled underwing can be seen.It is one of the earliest spring butterflies to be seen flying from early April to the end of June. It is very much a hedgerow species, a habitat that Lundy lacks. There are seven records of this species from Lundy, two in 1997, singletons in 2007, 2014, 2017 and 2019 and six 2018 and five in 2023. It was reported from late April to early August with one rogue sighting in October which is probably a misidentification. It was first reported by Chanter in 1877, and again in 1907 by Longstaff, and in 1946 by Palmer. It must remain a Lundy rarity.

Plate 2 Orange Tip, photographed in North Cornwall. © Alan Rowland.

Adults and larvae depend on Cabbage family *Brassicaceae* for food with larvae preferring Cuckoo Flower *Cardamine pratensis* which is rare on Lundy or Garlic Mustard *Alliaria petiolata* which has not been reported so far.

Large White: *Pieris brassicae*

This species is easily confused with Small and Green-veined White and female Brimstones. Size is not a determining factor. The best identifier is the black tip to the wings which are more extensive that those of the Small White and tend to wrap along both edges of the wing. The underwing is not as yellow as that of the Small White.It is bivoltine and can be seen flying from mid-April to late June and again from late July to the end of September.

Adults feed on a wide range of plants but the larvae depend on the Cabbage family *Brassicaceae* and Mignonette family *Resedaceae* which are abundant on Lundy and

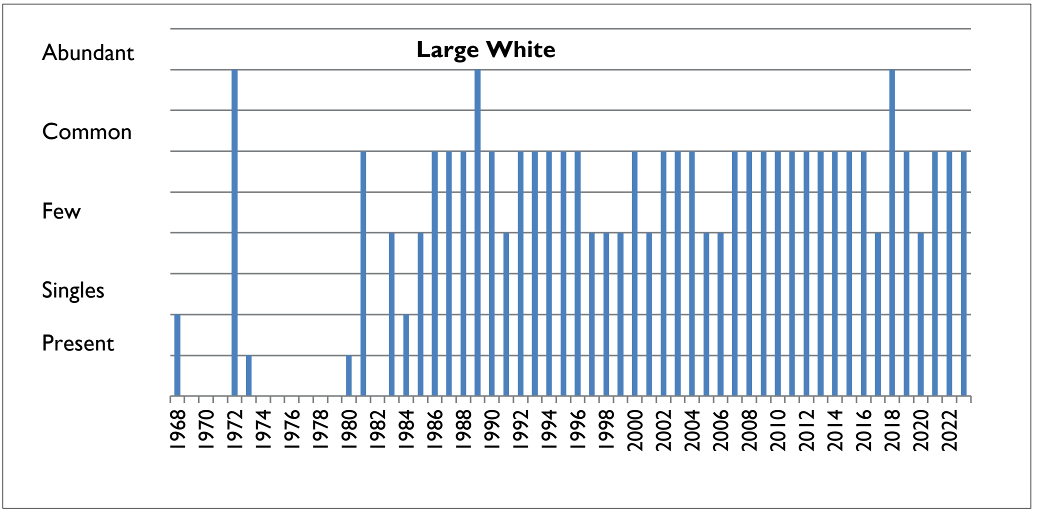


Figure 2: Large White abundance/year.

include Lundy Cabbage, *Coincya wrightii* and Wild Mignonette, *Reseda lutea* which does not occur on Lundy. It is one of the commonest butterflies reported from Lundy and has been seen from 1877, when it was called the Cabbage White, to the present day. It can be extremely abundant and numbers often rise to three figures when there is an eruption from the continent.

Plate3: Large White, photographed on Lundy © Alan Rowland.

Small White: *Pieris rapae*

This species is easily confused with Large and Green-veined Whites and female Brimstones. Size is not a determining factor. The best identifier is that Small Whites are more lightly marked on the corner of the upper wing and the underwing is distinctly yellow. It is very abundant and can be recorded in all months from March to November with peaks during the two breeding seasons of May/June and late July to early September. Like the Large White, numbers can increase dramatically when there is an influx from the continent. It was first reported on Lundy by Loyd (1877) and has been recorded from as early as April and

Plate 4: Small White, photographed in North Cornwall © Alan Rowland.

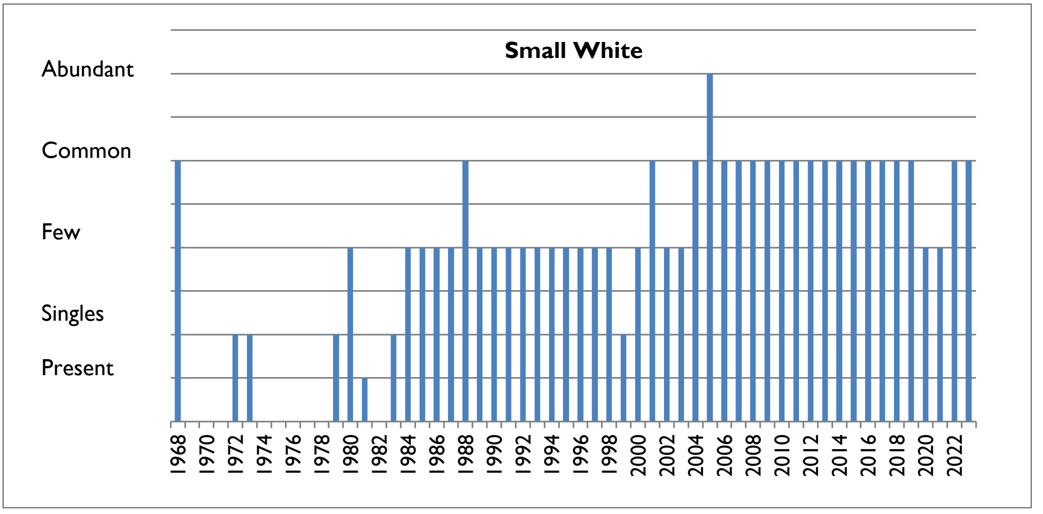


Figure 3: Small White abundance/year.

as late as November. It is one of the most abundant butterflies with around 500 being reported in the peak year of 1995.

The adults are as catholic in their food plants as the Large White and the larvae similarly depend on Cabbage family *Brassicaceae* , Mignonette family *Resedaceae* and Nasturtium family *Tropaeolaceae* On Lundy food plants include Lundy Cabbage, *Coincya wrightii* , Nasturtiums, *Nasturtium officinale agg* . and various Water Cresses.

Green-veined White: *Pieris napi*

If the underwing can be seen there is no mistaking this otherwise easily confused species. With more experience, the green underwing can also be discerned through the upper wing.It was first recorded by Loyd in 1877 and since modern recording began on Lundy has been present in almost all years as one of the most common butterflies. Unlike the Large and Small Whites, this species does often settle and allow easier recognition. It flies from mid-April to mid-November and has been reported from Lundy from April to October. It is bivoltine and ubiquitous throughout the UK in almost any habitat

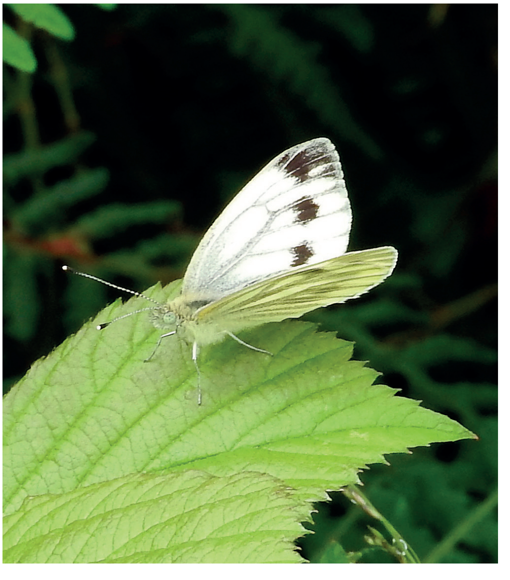


Plate 5: Green-veined White, photographed in North Cornwall © Alan Rowland.

The adults feed on a wide variety of plants, but the larvae depend on Cabbage family *Brassicaceae* plants in particular, Charlock, Cuckooflower, Garlic Mustard and Water-cresses all of which, with the exception of Garlic Mustard, grow on the island.

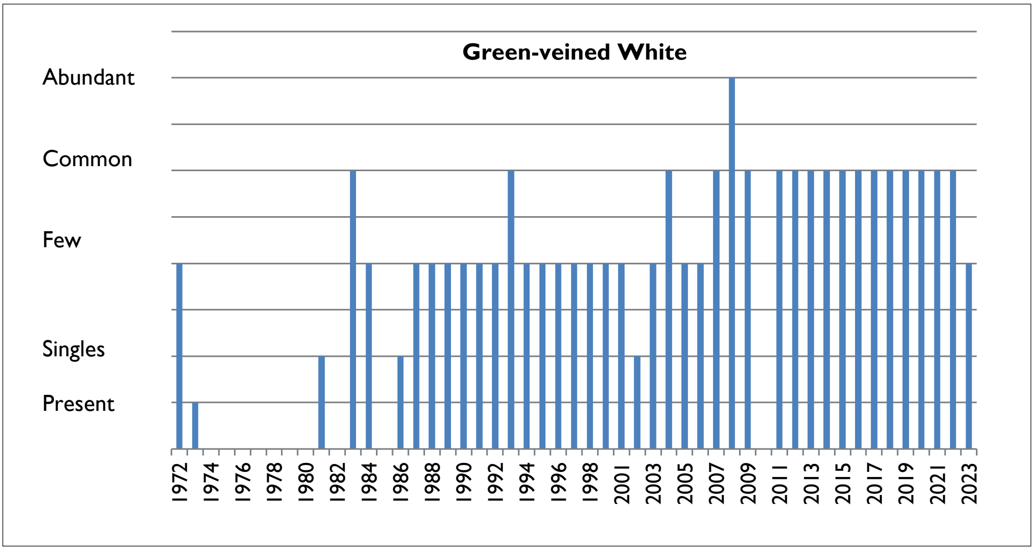


Figure 4: Green-veined White, abundance/year.

Clouded Yellow: *Colias croceus*

There is no mistaking a Clouded Yellow butterfly with its very chrome yellow wings. This is a highly migratory species which reaches the UK each year, but around once in a decade there is an irruption, when the species is abundant. It is during these bountiful years when

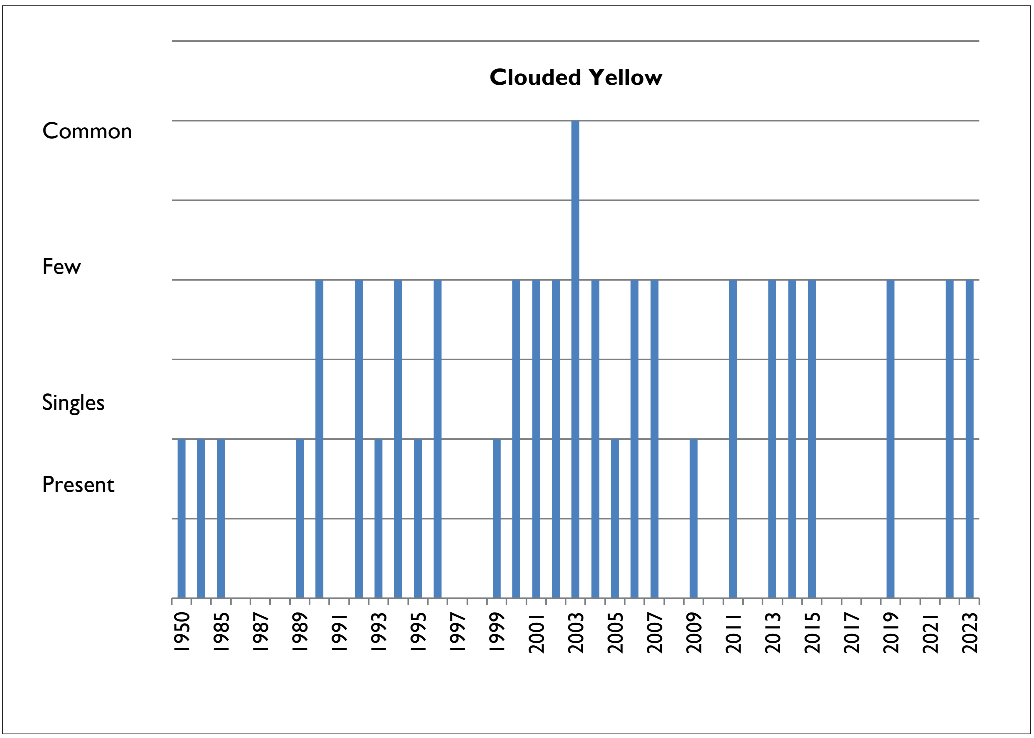


Figure 5: Clouded Yellow abundance/year..

they are recorded on Lundy. When they do breed in the UK, they are bivoltine and can be seen flying in May, in August and October/November. Reports from Lundy cover all the months from May to October. The first record was in Longstaff (1907).

Plate 6: Clouded Yellow photographed on Lundy © Neil & Shaun Barnes.

Adults feed on a wide variety of plants, but larvae need the Pea Family *Fabaceae*, especially Clovers *Trifolium spp*., Lucerne *Medicago sativa* and Bird's-foot Trefoil, *Lotus corniculatus*, all of which, with the exception of Lucerne, are common on Lundy. It is one of Lundy's most uncommon species appearing intermittently and rewards those who are fortunate to be on the island when they make a visit.

Brimstone: *Gonepteryx thamni*

Plate 7: Brimstone, photographed in North Cornwall © Alan Rowland.

This is the species from which the word "butterfly" is thought to originate. The large male has butter yellow wings with a distinctive brown mark on the underwing. The female is coloured pale yellow or even greenish and could easily be confused with the Whites although the leaf-shaped wings are distinctive. Despite being common in the southern half of Britain, it has rarely been seen on Lundy. It is univoltine, but long-lived and can be seen in the UK in all months of the year. Not so on Lundy, when it has only been recorded in August 1999, June 2000, April 2007 and from April to July in 2022. Apart from 2007 when three were seen, records were of single butterflies, although on four different dates in 2022. The earliest record was in Loyd (1877) and again in Longstaff (1907) and Palmer (1946).

The adult is well catered for on Lundy with a preference for a wide range of purple or blue flowers. However, the larvae are fully dependent on Buckthorn *Rhamnus* sp. or Alder Buckthorn *Frangula alnus*, both in the Buckthorn family *Rhamnaceae,* neither of which grow on Lundy.

NYMPHALIDAE: Nymphalids, Fritillaries and Browns

Wall: *Lasiommata megera*

This is one of the species on the GB Red List and noted as Near Threatened and as such is at risk.It has bright golden wings and is usually quite active only settling to display its black and gold wing panels when investigating bare earth for essential minerals. It prefers open

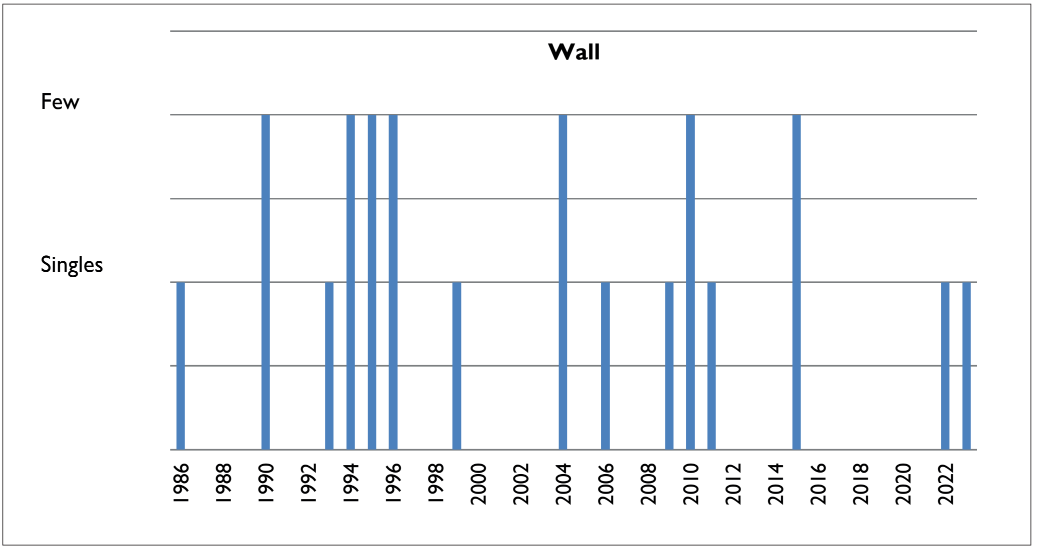


Figure 6: Wall, abundance/year.

Plate 8: Wall, photographed in North Cornwall © Alan Rowland.

cliff top grasslands and walls (hence the name) and should therefore be at home on Lundy. It is bivoltine with adults on the wing from May to June and again between August and early November. It has been recorded on Lundy from April to October albeit only in ones and twos at the most, making it one of Lundy's rarer butterflies.Figure 6 shows that it was first recorded in 1986, there being no earlier records in the historic literature. What caused this colonisation is unclear, but Newland & Hill (2010) confirm it is expanding its range northwards and demonstrably westwards.

Whilst adults feed on a wide variety of plants, the larvae depend on specific grasses mostly, Cock's-foot *Dactylis glomerata*, Tor-grass *Brachypodium pinnatum*, Wavy Hairgrass *Deschampsia flexuosa* and Yorkshire-fog *Holcus lanatus*, which, with the exception of Tor grass, occur widely on Lundy.

Speckled Wood: *Pararge aegeria*

This is one of the commonest butterflies on the mainland and the flash of yellow from the upper wings is unmistakeable. However, like the Wall, it did not colonise Lundy until comparatively recently. No historic records exist before 1979.On the mainland is it ubiquitous where there are trees and is seen from late March to Early October. It can have three breeding cycles.The sparseness of tree cover may be why it colonised the island so recently and why there are so few sightings. Except for 2003, when a total of 10 individuals were counted, all

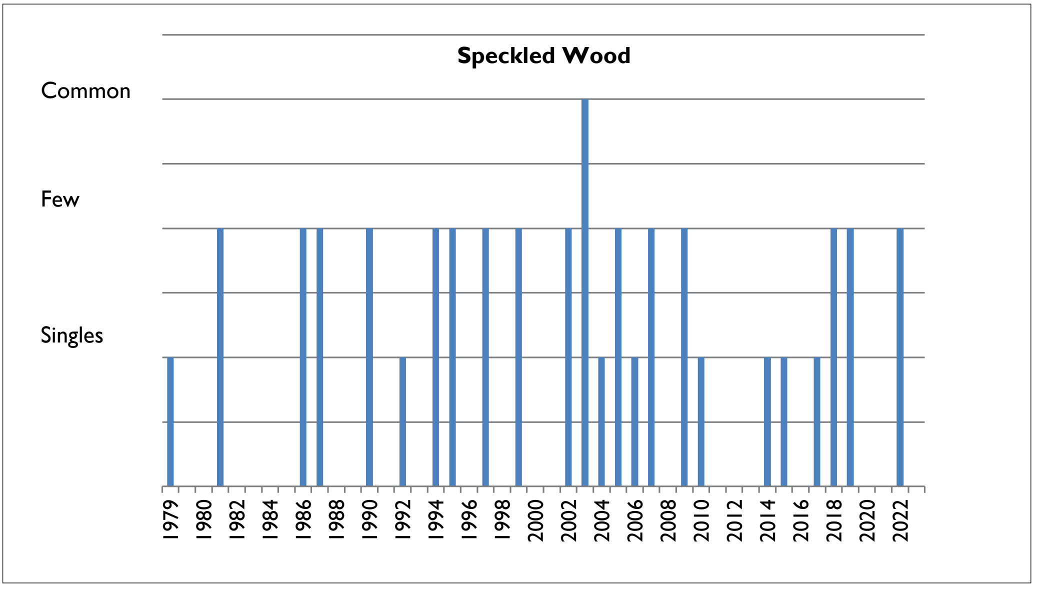


Figure 7: Speckled Wood, abundance/year.

other sightings were of one or two individuals. On Lundy it has been recorded in all months between March and October.It is therefore one of Lundy's rarer butterflies.

Adults feed high in the trees on Aphid Honeydew on Ash, Birches and Oaks but when these are not available, on Ragwort *Senecio jacobaea* itself common on Lundy, though under threat of removal. The larvae are grass specialists feeding on Cock's-foot *Dactylis glomerata*, False-brome *Brachypodium sylvaticum* and Yorkshire Fog *Holcus lanatus.*

Plate 9: Speckled Wood, photographed on Lundy © Mandy Yates.

Small Heath: *Coenomypha pamphilus*

This is one of the Butterfly species on the GB Red List and noted as Near Threatened and as such is at risk although doing quite well on Lundy and has featured in the list of Lundy butterflies since being first recorded by Chanter (1877).It is the smallest of the "brown" butterflies and rarely settles with open wings. They are a variable washed out brown in colour but with a distinct black spot with a white centre on the upper

Plate 10: Small Heath, photographed on Lundy © Alan Rowland.

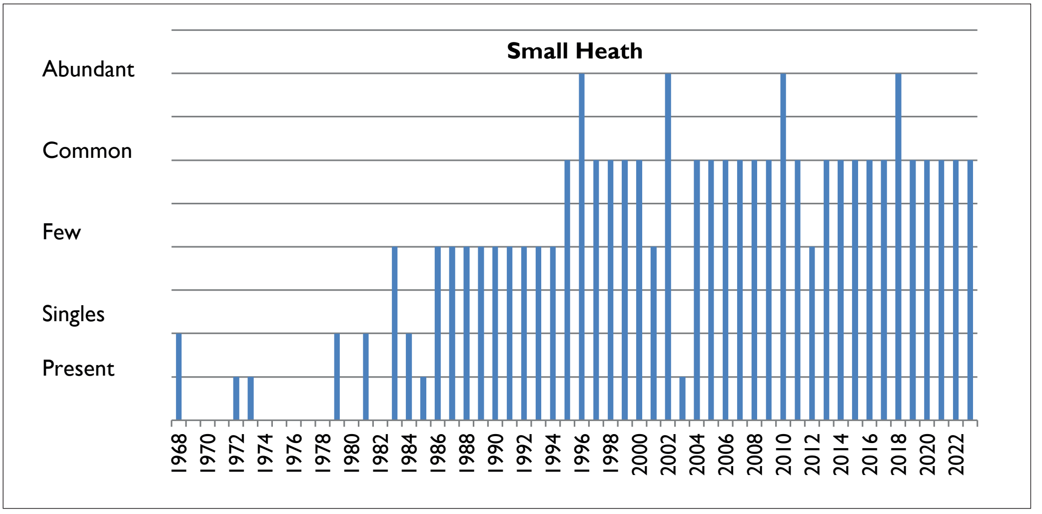


Figure 8: Small Heath, abundance/year.

under wing. The species is bivoltine and can be seen on the wing from mid-May to mid-July and again in August and September. On Lundy it has been recorded from April to October when it is occasionally extremely numerous. Peak sightings typically give counts in three figures.

Adults feed on a wide variety of plants but the larvae depend on species of grass, in particular Sheep's fescue *Festuca ovina* of which there is an ample supply on Lundy.

Ringlet: *Aphantopus hyperantus*

Although a "brown" butterfly, the wings in some lights are almost black. It is easily distinguished by the series of yellow-ringed black dots with white centres on the underside of both pairs of wings.It is a recent addition to the Lundy butterfly list. It was not recorded in Chanter, Loyd or Palmer and first appeared in the LFS Annual Report of 1968 since when it has been recorded in most years up to the present day.The Ringlet is univoltine being on the wing only from mid-June to mid-September. On Lundy it has been recorded in June, July and August and in peak years it has been counted in double figures, up to about 50 individuals. It is thus one of the commoner butterflies on Lundy.

Plate 11: Ringlet, photographed on Lundy © Alan Rowland.

Adult butterflies feed on Brambles *Rubus spp*. and composites, whereas the larvae depend on a variety of coarse grasses, for example Cock's-foot *Dactylis glomerata* and Common Couch *Elymus repens*, of which there is no shortage on Lundy.

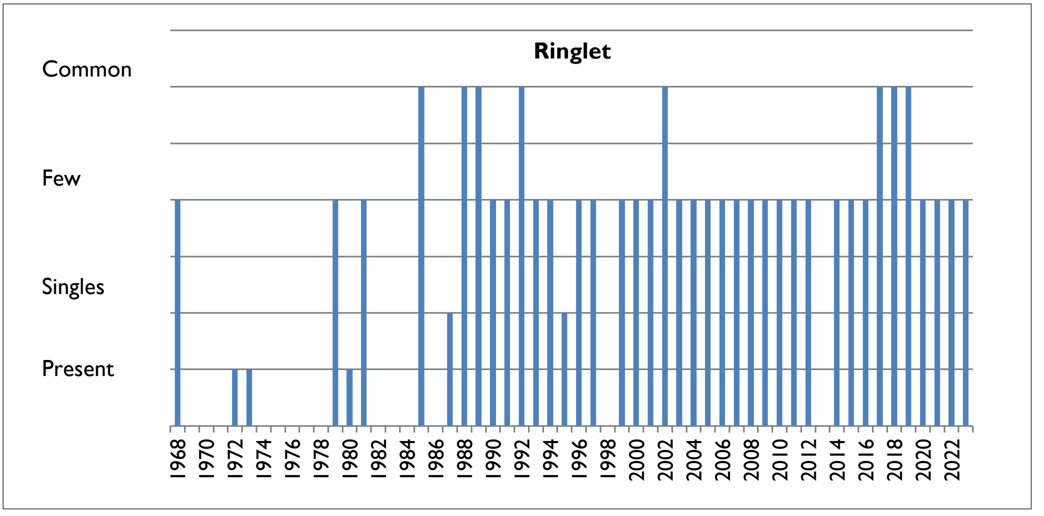


Figure 9: Ringlet, abundance/year.

Meadow Brown: *Maniola jurtina* (formerly Large Meadow Brown *Epinephele janira*).

This is our most common "brown" butterfly with very little to distinguish it. It does have a single eye-spot, black with a central white dot but otherwise quite plain. When at rest even this eye spot can be covered. This species, then known as the Large Meadow Brown, featured in the first Lundy butterfly listing in Chanter (1877) and has been recorded most years ever since. It is the most common butterfly on Lundy.It is a univoltine species, present for most of the summer and into autumn. On Lundy it has been reported on the wing from April with the last seen in early October. Numbers can rise to over a thousand individuals although they are usually in the hundreds.

The adults feed mainly on various species of Thistle whereas the larvae are less selective and can exist on a wide variety of grasses, but with a preference for Cock's-foot and False Brome.

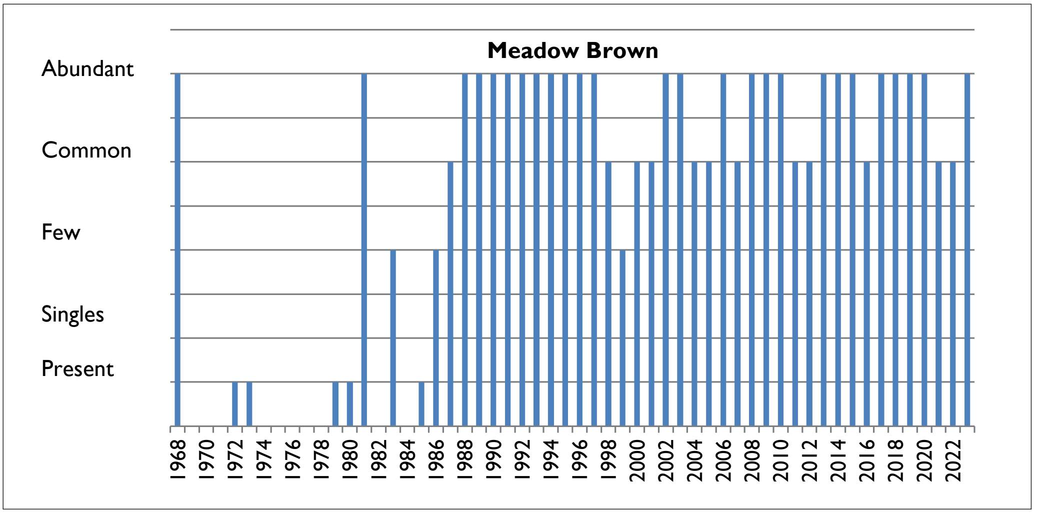


Figure 10: Meadow Brown, abundance/year.

Plate 12: Meadow Brown, photographed on Lundy © Alan Rowland.

Gatekeeper: *Pyronia tithonus*

This brown butterfly can most easily be confused with the duller Meadow Brown. However, where close inspection is possible, it is distinguishable by having two small white spots inside the dark circle on the underside of the hindwings. These underwings are much more bright orange compared to a Meadow Brown.It is univoltine and adults are only on the wing in July and August. On Lundy it has been reported in the months between June and October although the possibility of confusion with Meadow Brown brings

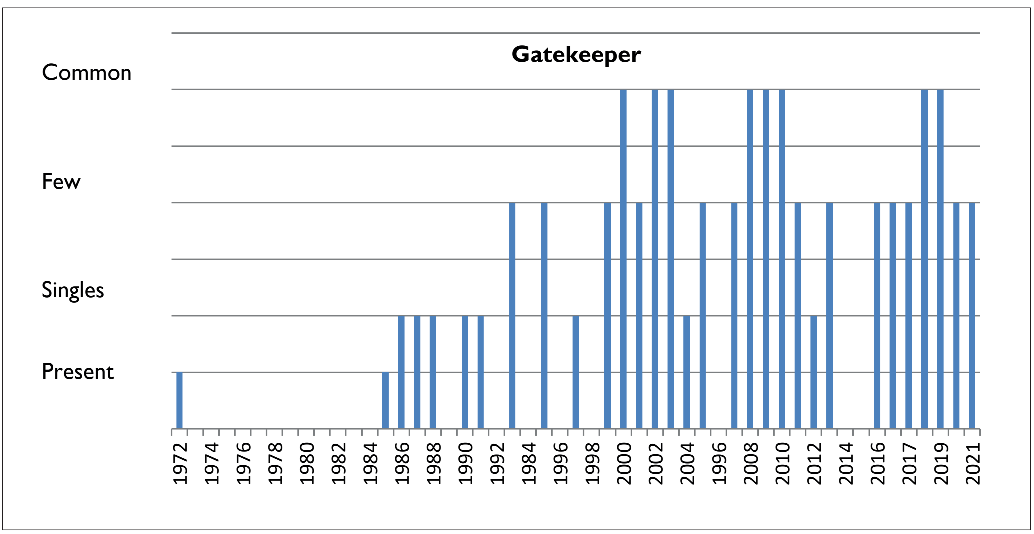


Figure 11: Gatekeeper, abundance/year.

the sightings in the outlying months into question. In season, it is one of the most common butterflies to be seen on Lundy. It was first recorded by Chanter (1877) under its previous name of Small Meadow Brown *Epinephele tithonus.*

Habitat preference is for hedgerows and scrubby woodland; its alternative name is Hedge Brown. The adult butterfly feeds on Brambles *Rubus* spp., Common Fleabane *Pulicaria dysenterica* and Ragworts *Jacobaea* sp. whereas the larvae rely on Bents *Agrostis* spp, Fescues *Festuca* spp. and Meadow grasses *Poa* spp.-all of which grow in abundance on Lundy.

Plate 13: Gatekeeper, photographed on Lundy © Alan Rowland.

Grayling: *Hipparchia semele*

Grayling is listed under UKBAP as a priority species and as Vulnerable on the GB Red List. It is a cryptic species of butterfly which settles almost invariably with its wings closed. On Lundy its grey, white and brown patterning when seen on granite can make it almost invisible. It flies fast and in a fluttering manner and, when in flight, broad yellow bands can be discerned by the keen-eyed. It is univoltine, with adults on the wing in the months of July and August and occasionally September. It was first listed in Chase (1894) under its earlier name of *Satyrus semele*, who stated is as "common" on Lundy, but was not subsequently listed by either Loyd or Chanter. It has been reported as early as May through to September on the island. There have been as many as 58 recorded in some years, in others just single sightings. Numbers are highly volatile, depending on the

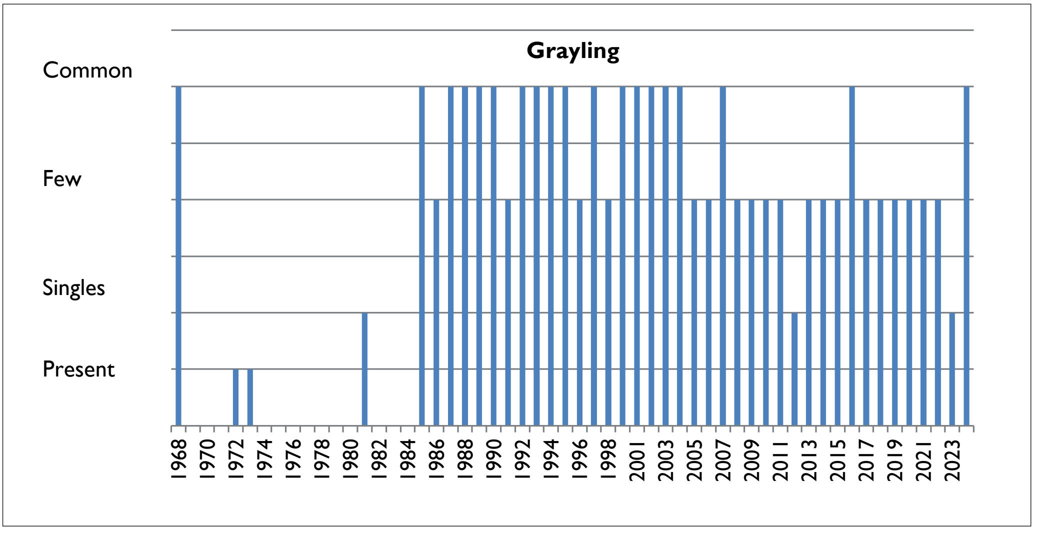


Figure 12: Grayling, abundance/year.

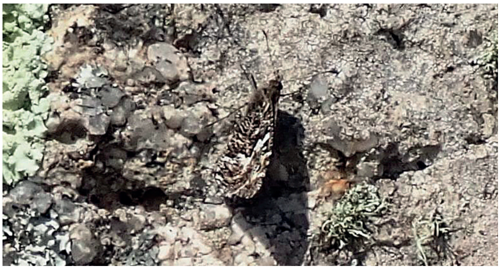


Plate 14: Grayling, photographed on Lundy © Alan Rowland.

identification skills of the observer, but are generally declining.

Adult butterflies have catholic tastes feeding on flowers of many heathland plants, whereas the larvae prefer Bristle Bent *Agrostis curtisii*, Early Hair-grass *Aira praecox*, Fescues *Festuca* spp., Marram Grass *Ammophila arenaria* and Tufted Hair-grass *Deschampsia caespitosa* almost all of which grow on Lundy.

Dark Green Fritillary: *Argynnis aglaja*

Fritillaries are distinctive although separation of species is more of a challenge, with all having golden upper wings with chocolate brown markings. This species is similar in size and shape to the much commoner (on the mainland) Silver-washed Fritillary but is found in a different habitat. Silver-washed are a woodland species whereas Dark Green prefers the more open areas of flower-rich meadows, sand dunes and both chalk-rich and limestone grassland. It was not listed on Lundy in the historic literature. The first report was in 1980 since when only three more sightings have been made (1994, 2002 and 2003), all between May and July. On the mainland it can be found on the wing generally in July and August. Having not been reported for 20 years, and with neither a full description nor photograph, these records cannot be verified and must remain doubtful and unconfirmed.

Adults prefer plants with purple and mauve flowers, but the larvae depend on various species of Violet *Viola* spp.

White Admiral: *Limenitis camilla*

A White Admiral was recorded on 11th October 2008 by an unknown recorder with location on the island not given. This species is known to inhabit the tree canopy and occurs in Southern and South-eastern England. It is highly localised and rare with a flight period of July to early August and mid-September. No sightings are listed in the historical literature and the 2008 record is therefore highly doubtful and cannot be confirmed.

Plate 15: Red Admiral, photographed on Lundy © Alan Rowland.

Red Admiral: *Vanessa atalanta*

One of, if not, the most easily recognised butterfly in the UK. It is the only black, white and red British butterfly and the fact that most people can and do recognise it is evidenced by the number of years in which it has been recorded on Lundy since 1877. More than one individual is always seen, the lowest count being three. It is a migratory species and most of the British records are of migrants with only a few adults successfully

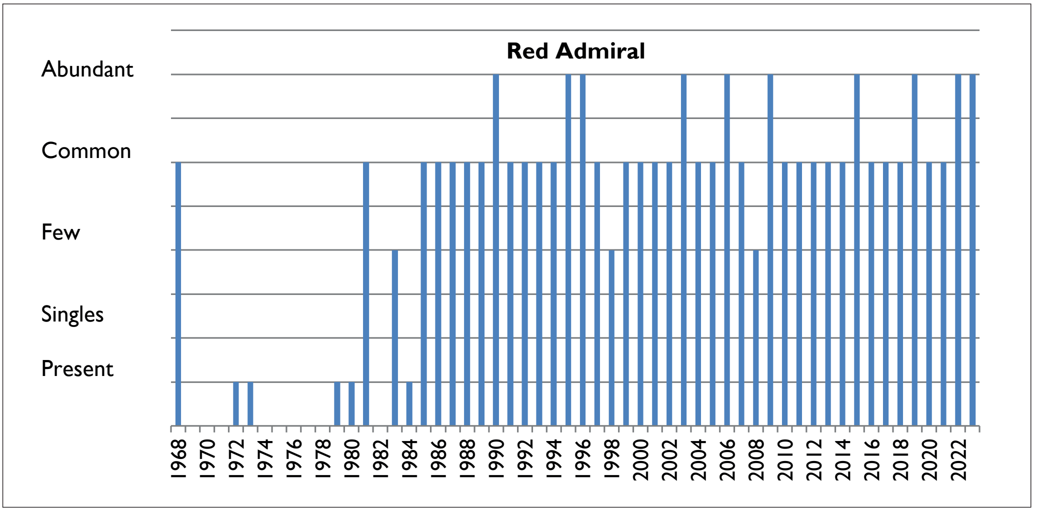


Figure 13: Red Admiral, abundance/year.

hibernating each year. It can reliably be seen between February and November on the mainland and on Lundy has been reported from February through to December, with the lack of January sightings perhaps due to shut-down and sparsity of visitors.

The larval food plant is Common Nettle *Urtica dioica* (and occasionally Small Nettle *U. urens* and Pellitory of the Wall *Parietaria judaica*) but the adults are very catholic in their diet and can be found almost everywhere.

Painted Lady: *Vanessa cardui*

This is a migratory species which in some years is absent in the UK whilst in others there is a huge influx when it is super-abundant. It is unmistakeable, one of our largest butterflies with distinctive orange, black and white upper wings surfaces. Its breeding is staggered during its migration from Africa but once here may continue to breed when adults can be seen on the wing from April to November and indeed has been reported on Lundy in all of those months. In peak years numbers recorded can exceed 1000 individuals. The first Lundy record is in Wollaston (1845) when it was listed under its previous name of *Sylvia cardui*.

Adults prefer wide open areas and generally shun woodlands and will feed on almost anything, but the larvae depend on Thistles *Cirsium* spp.

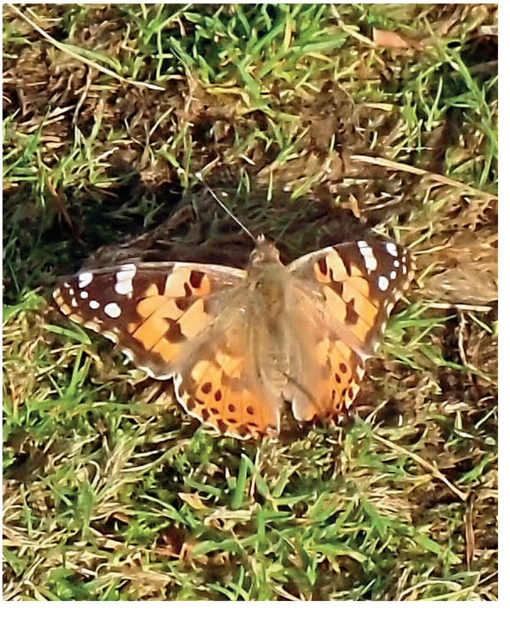


Plate 16: Painted Lady, photographed on Lundy © Alan Rowland**.**

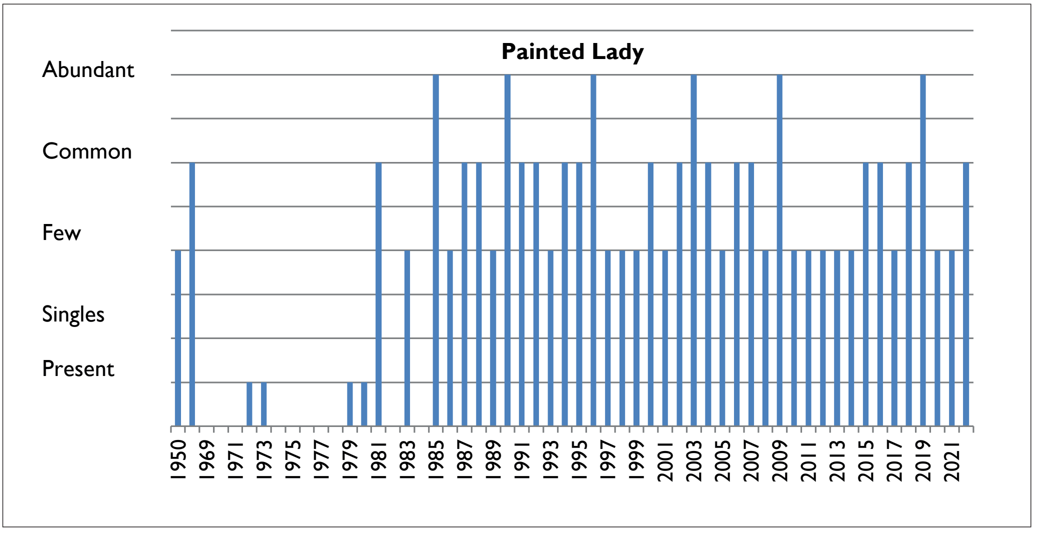


Figure 14: Painted Lady abundance/year.

Peacock: *Aglais io*

When at rest with wings open this butterfly is unmistakeable with its pair of multi-coloured "eyes" on a rich burgundy background. It can be found almost anywhere and at any time. It does hibernate, but during any unseasonably warm weather will wake it so that it can be seen on the wing in all months of the year, true also for Lundy apart from January when visitors/

Plate 17: Peacock, photographed in North Cornwall © Alan Rowland.

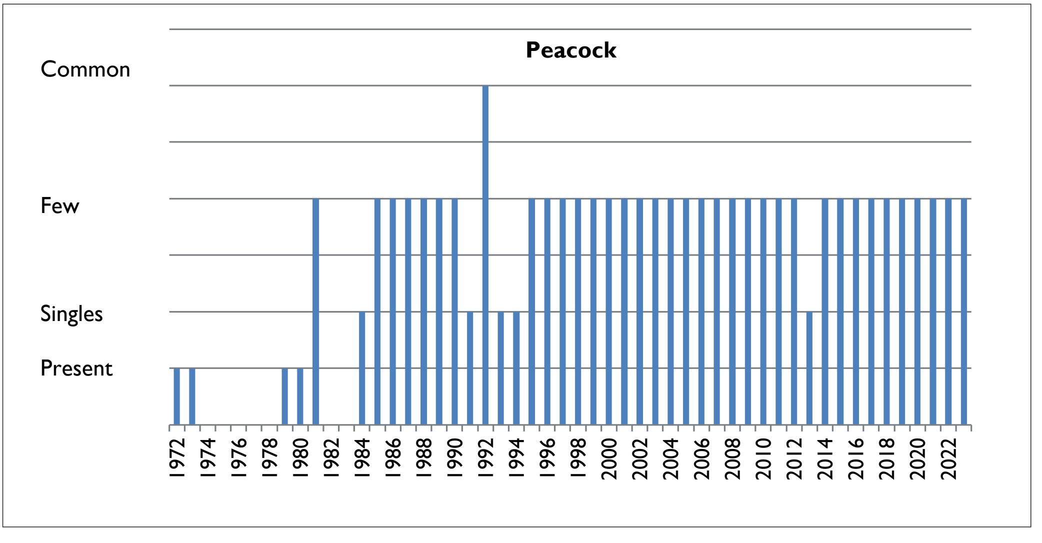


Figure 15: Peacock abundance/year.

recorders are few. It is generally in ones and twos with a high of 10 in 1992. It has been recorded in almost every year since Chanter (1877) noted it on Lundy under its earlier name of *Vanessa Io*.

Adults can be found on Buddleias, Hemp agrimony *Eupatorium cannabinum*, Teasels *Dispacus spp.* and a wide variety of other plants where they congregate in numbers. Larvae prefer Common Nettle *Urtica dioica* and Small Nettle *U. urens* and Hop *Humulus lupulus*. With the exception of Hop all are these plants are common on Lundy.

Small Tortoiseshell: *Aglais urticae*

Plate 18: Small Tortoiseshell, photographed on Lundy© Mandy Dee.

This is an easily identifiable butterfly with striking patterns of alternate yellow and black barring and bright blue lower wing edging. It is easily confused with the Large Tortoiseshell, but this species went extinct in the 1960s and apart from a few individuals prospecting in the South East of the country has not yet made its way to the far west. It hibernates over winter with adults emerging in spring. It can be seen on the wing in all months of the year if awakened by warm weather during hibernation. Like the Peacock and Red Admiral, it has been recorded on Lundy from February to November. The earliest sighting was by Chanter in 1877, as *Vanessa urticae.* Numbers on Lundy fluctuate between 10s of individuals to 70 in 2003, 100 in 1987 and a high of 500 in 1991.

Adults feed on a wide variety of plants whereas larvae depend specifically on Common and Small Nettle.

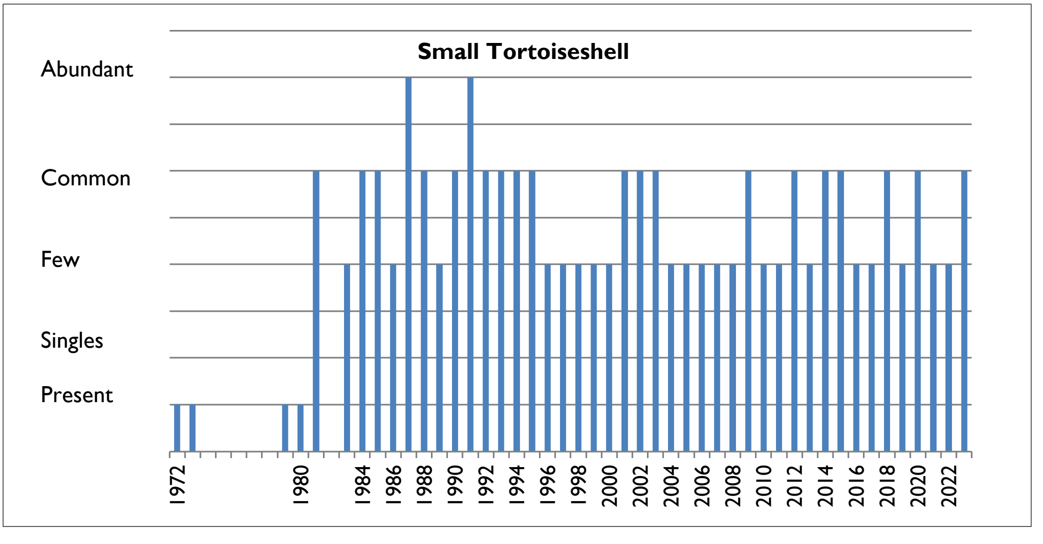


Figure 16: Small Tortoiseshell, abundance/year.

Plate 19: Comma, photographed on Lundy © Alan Rowland.

Comma: *Polygonia c-album*

This is the only British butterfly with a ragged edge to its wing in its natural state. With folded wings it can look like a dead leaf with only the white "comma" mark to give it away. The upper wings have a rich golden-brown hue.On the mainland this is a common species which is expanding its range. Not so on Lundy. Sightings are few and far between. Most are of single butterflies, with two exceptions in 2021 and 2023 when two were found each year. Under its earlier name of *Vanessa c. album* it was recorded by Chanter (1877). Palmer (1926) noted it as "uncommon" on Lundy. It is bivoltine with adults emerging from hibernation to breed in early spring when it can be the first butterfly to be recorded. Breeding takes place again by these individuals in July and later breeding in September can result in the adults hibernating. Thus, individuals can be recorded in every month of the year, but on Lundy they have only been recorded in April, July, August, September and October.

It is generally a woodland species which feeds on a wide variety of plants. The larvae prefer Currants, *Ribes* sp. Elms *Ulmus* sp., Hops, Common Nettle and Willow *Salix* sp, the latter two being the only food plants to be found on Lundy.

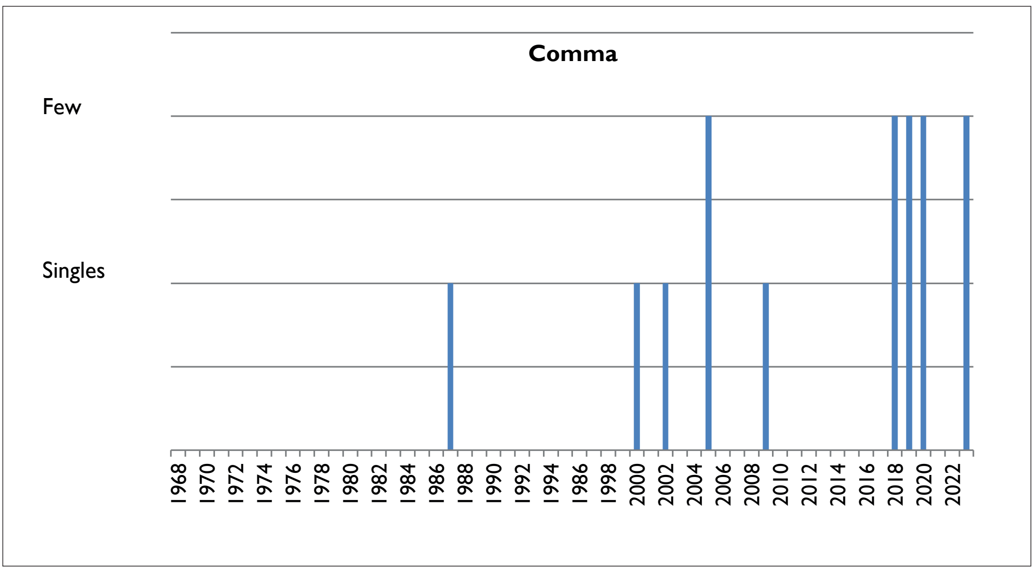


Figure 17: Comma, abundance/year.

Monarch: *Danaus plexipus* (also known as the Milkweed Butterfly)

Plate 20: Monarch, photographed in North America © J.J.Cotten**.**

This is an unmistakeable butterfly. It is the largest that might be seen in the UK and with wings conspicuously coloured orange above and almost white below enclosed by dark line markings. It is not native to the British Isles but is a rare migrant to the rest of UK and Lundy. That it is unmistakeable is evidenced by the description given by someone unfamiliar with butterflies in his entry in the School Bungalow Logbook on Tuesday August 14th 1951 (Harrison), quoted below: -

Fine Northerly wind + rather cool. Saw big butterfly on way to Hotel for Breakfast Showed 4 inches across was blowing up the valley from Bill Fisher's Bungalow looked white on top but when nearer was blown by Southerly wind over wall + then saw a beautiful yellow underneath. Had some dark markings but was unable to detail the markings. Duly reported to Warden David Lee. (Harrison 1951).

This record never made it into the LFS annual report, and the logbooks have not survived. However, Monarchs are known to reach the UK when there are strong westerly winds during their annual migration from Canada to Mexico although there are populations in the Iberian Peninsula and Canary Islands.It was first reported in 1876 in South Wales and the latest irruption into the UK was 2023 when numbers were recorded in the south of England but not on Lundy. Its food plant Milkweed, *Asclepias* spp., is not native to the British Isles so there is no possibility of breeding.

This recently discovered record by Harrison is the first known record of a Lundy sighting, but it has since been reported on 25th September and 2nd October 1982, 9th October 1996 and 11th August 1986 when single specimens were seen.

LYCAENIDAE: Hairstreaks, Coppers and Blues

Brown Argus: *Aricia agestis*

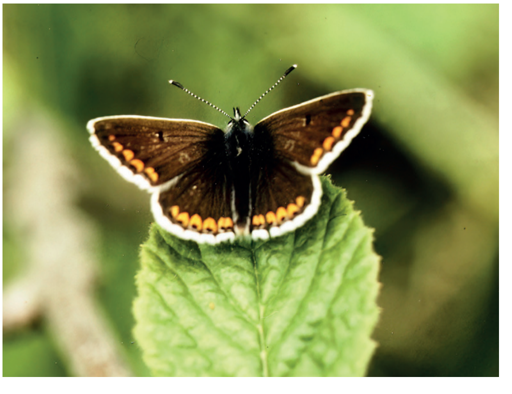


Plate 21: Brown Argus, photographed on Lundy (27.07.1989) © Anthony J.Parsons.

The earliest sighting is in Chanter in 1877. More recently, one was seen on 27th July 1989 by Tony Parsons. There is no dispute about this sighting as Tony provided a photograph. Although widespread in south-eastern England occasional sightings are made further west, as is indeed the case here. The Brown Argus could easily be confused with the brown form of a female Common Blue, but the photograph taken by Tony Parsons shows the distinctive orange markings on the upper wings.A bivoltine species, the adults have two flight periods late April to late June and late July to mid-September.

The adults' primary food plant, Common Rock-rose *Helianthemum nummularium* does not occur on the island but they will feed on a variety of plants including buttercups, Thyme and Clovers. Its larvae's food plants; Common Stork's-bill *Erodium cicutarium* and Dove's-foot Cranesbill *Geranium molle* do. Breeding and further sightings on the island have not been recorded.

Plate 22: Common Blue, photographed on Lundy © Alan Rowland.

Common Blue: *Polyommatus icarus*

The upper wings show a brilliant blue with a distinctive white edge whilst the under wings bear orange marks.The earliest sighting on Lundy was in 1925 in Loyd's list. Early records were of single sightings but since the 1980s there have been sightings of up to five and in the bumper year of 1987, 22 were recorded. This species featured in Chanter's, Loyd's and Palmer's lists. Usually a bivoltine but occasionally trivoltine species, the flight periods are May/June and again July to September and occasionally into October. Lundy sightings have been as early as April, although these could have been misidentified Holly Blue, and up until September.

Adults use a wide variety of food plants, but the larvae depend on Common Bird's-foot Trefoil *Lotus corniculatus* usually in association with one of two ant species – Southern Wood Ant *Formica rufa* and a Red ant *Myrmica sabuleti*. The plants are extremely common on Lundy although neither of the ant species nor larvae have yet been recorded.

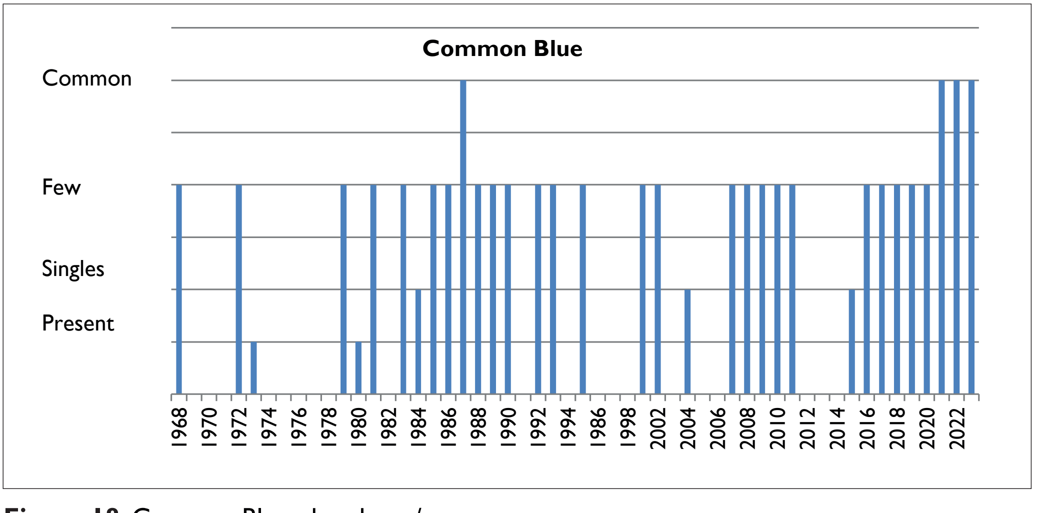


Figure 18: Common Blue, abundance/year.

Green Hairstreak: *Caliphyrs rubi*

Plate 23: Green Hairstreak, photographed on Lundy © Anthony J.Parsons.

A surprisingly small butterfly, but as the only green species that can be seen in the UK it is unmistakeable. It is not listed in Chanter, Loyd or Palmer so may be a more recent colonist. It has been seen on Lundy on four occasions only: in 1983, 1988, 2002 and in 2007 when on each occasion two specimens were recorded. The 1988 sighting was by Tony Parsons who photographed it and it is not in doubt. Three of the sightings were in June with the 2007 sighting being at the end of May. Its flight period is mid-May to late June.

The adult butterfly's food plants are Hawkweeds *Hieracium* spp, and Hawthorn *Crataegus monogyna* whilst the larvae depend upon Common Bird's Foot Trefoil, Gorse *Ulex* spp.. and Broom *Cytisus scoparius* all of which are common on Lundy. This is the widest range of food plants of all the UK butterflies.

Holly Blue: *Celastrina argiolus*

The first recorded sightings of the Holly Blue were made by Dymond in 1972. No sightings were listed in Chanter, Loyd or Palmer It is not very common on Lundy with mainly single sightings each year with occasionally as many as eight individuals. However, in 1992 and 2007 20 and ten individual sightings respectively were recorded. The time and location of sightings is a good clue to identification. The distinctive under wing of pale blue separates it from all other small blue butterflies. It has two flight periods of

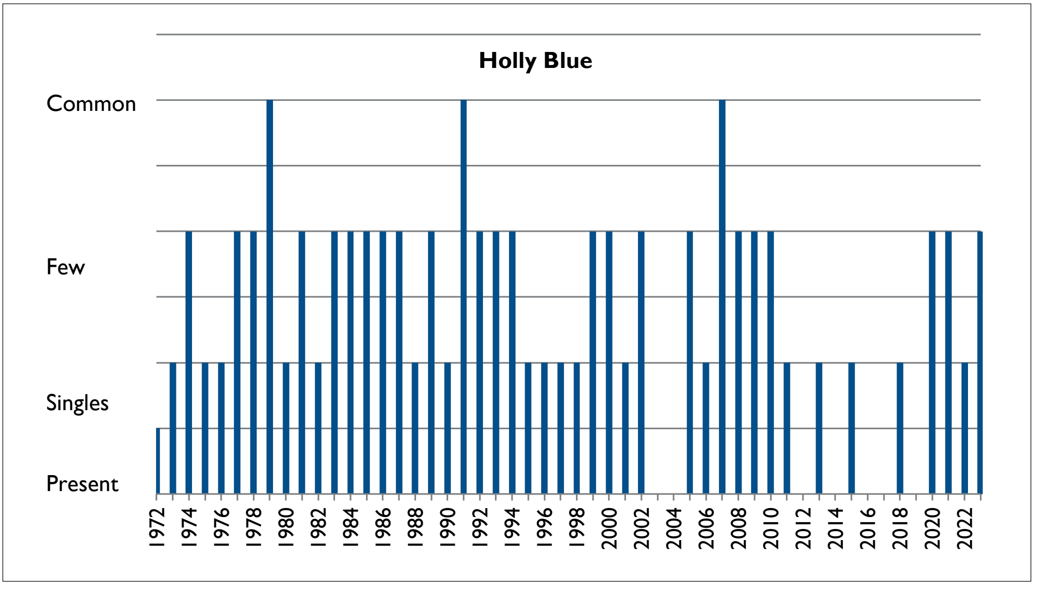


Figure 19: Holly Blue abundance/year.

Plate 24: Holly Blue, photographed in North Cornwall © Alan Rowland.

Plate 25: Small Copper, photographed on Lundy © Alan Rowland.

late March to late May and mid-July to the end of November. On Lundy it has been recorded from as early as March to July and again from July to October.

It is a common resident throughout England and Wales and the larvae feed on Holly *Ilex aquifolium* buds and flowers early in the year and Ivy buds and flowers at the end of the year. The adult butterfly prefers Hawkweeds and Hawthorn and can often be seen on the latter. These feeding habits will help with identification.

Small Copper: *Lycaena phlaeas*

This is a distinctive small (26-40mm) butterfly with glowing bright copper wings. It was first recorded in 1877 by Chanter and has been common ever since. It can be seen in all seasons of the year except for winter, being multivoltine with up to four generations in a good year. On Lundy it has been recorded from April to October.

Larvae feed on Common Sorrel *Rumex acetosa* or Sheep's Sorrel *R. acetosella* whilst the adults have more catholic tastes and can be found feeding on yellow composites (*Asteraceae* spp.).

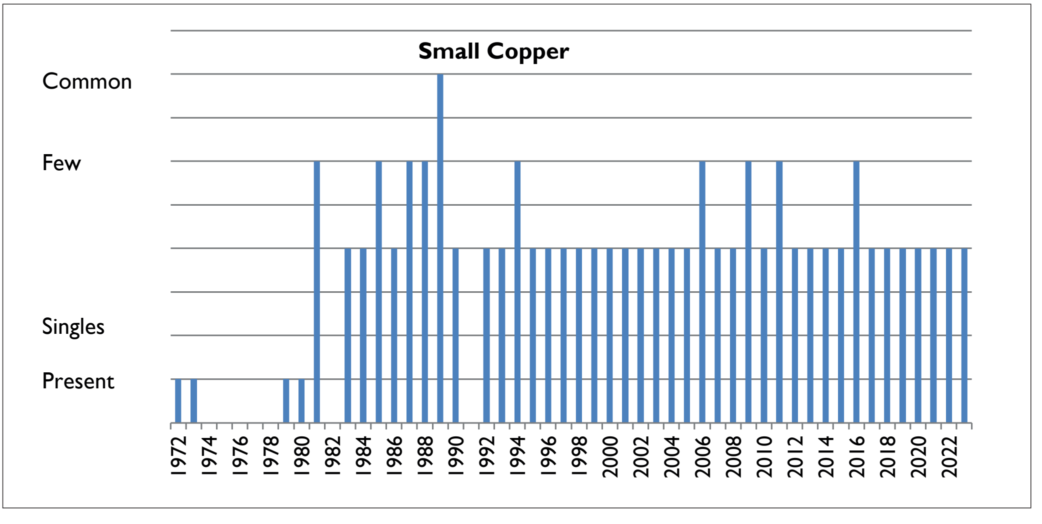


Figure 20: Small Copper abundance/year.

CONCLUSIONS

There have been losses of species which mirror the general decline in Butterfly species on the British mainland. There are no specialised local habitat species on Lundy. Nevertheless, the number of species remains constant, in the low twenties. With more regular transect surveys the numbers can be monitored and contribute to the UKBMS database. I recommend those interested in butterflies to volunteer to walk the transect during their visit and submit their records directly to the Warden.

ACKNOWLEDGEMENTS

This paper would not have been possible without the consistent and generous logging of butterflies seen on Lundy by the many lepidopterists and other visitors that visit the island. My thanks go to everyone who has entered their sightings in the LFS logbook and to those hard-working individuals who collate and report those results in the LFS Annual Reports.

Thank you everyone and do please continue to seek out and record butterflies. It is my hope that this account will ensure that if you see a rare or never recorded on Lundy butterfly in the future you will enter a description, or better yet, a photograph.

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LUNDY CABBAGE FLEA BEETLE (*PSYLLIODES LURIDIPENNIS*) - A REVIEW

by

Laura Larkin

Buglife, Allia Future Business Centre, London Road, Peterborough, PE2 8AN

Email: laura.larkin@buglife.org.uk

ABSTRACT

The Lundy Cabbage Flea Beetle (*Psylliodes luridipennis*) is endemic to Lundy and is a global conservation priority. In 2024, Buglife undertook a research trip to Lundy to survey for the Lundy Cabbage Flea Beetle in order to understand more about its current status and distribution on the island. Lundy Cabbage Flea Beetles were found at six locations in the south east of the island, and Lundy Cabbage Weevil (*Ceutorhynchus contractus var. pallipes)* were found at five.

To help secure the future of the Lundy Cabbage Flea Beetle it is recommended that structured annual monitoring be put in place. The beetle should be added to the Lundy SSSI citation as an interest feature, and the boundary should be extended to include all areas where Lundy Cabbage is regularly present. Habitat management trials and interventions should be undertaken with an aim to increase the abundance and distribution of Lundy Cabbage in the south of the island.

Keywords: *Lundy Cabbage Flea Beetle, survey, vegetation management.*

INTRODUCTION

Lundy Island is home to the Lundy Cabbage (*Coincya wrightii*) (Plate 1) which is endemic to the island and is found nowhere else in the world. It is listed as Vulnerable on the GB Red List (Stroh *et al* 2014) and is also protected under Schedule 8 of the Wildlife and Countryside Act which means it is protected from picking, uprooting, destruction or sale (Wildlife and Countryside Act 1981). Lundy Cabbage is also unique in the UK as it is the only endemic plant known to also support endemic invertebrates (Compton *et al* 2007).

The Lundy Cabbage Flea Beetle (*Psylliodes luridipennis*) (Plate 2a) is approximately 3.5mm in length, and is often a faint metallic bronze colour, although this can vary (UK Beetle Recording). It is also endemic to Lundy and is found nowhere else in the world. It is Nationally Rare and has been listed as Critically Endangered on the IUCN Red List and is a global conservation priority (Macadam 2022, Macadam 2023). Parts of Lundy have been designated by Buglife as an Important Invertebrate Area (IIA)for the Lundy Cabbage Flea Beetle.

Lundy Cabbage Flea Beetles live on Lundy Cabbage. The adults oviposit into the soil at the base of the plants and seem to demonstrate a preference for sandier substrates (Craven 2002). The beetle larvae mine the stems, roots and leaves of the plant and then return to the soil to pupate (Craven 2002). Despite searches of other species of brassica on Lundy, larvae have not been found present on any other plant species they would be able to viably complete their development on (Craven 2007). The adults feed on the leaves of the cabbage, although have also been observed feeding on Sea Rocket (*Cakile maritima)* (Compton *et al* 2002, Compton *et al* 2001). The adult beetles are capable of flight (Key 1994 (1)). There is a possibility that substrate attributes might influence their choice of site (Craven 2002), and with cabbage plants growing both in land and on bare, rocky cliffs, this could potentially limit their ability to disperse throughout the island.

Lundy Cabbage Flea Beetles are entirely reliant on the Lundy Cabbage throughout their different life stages and have no mechanism for dormancy. This presents a risk to the viability of the population as there is a requirement for sufficiently abundant Lundy Cabbage plants each year to support the beetle.

Plate 1: Lundy Cabbage in flower © Andrew Whitehouse.

Lundy Cabbage flowers between May and October and only grows within a 2.5km stretch along the southeastern side of the island from Marisco Castle Bay to Knights Templar Rock (Compton *et al* 2004). It can be found between 2m and 120m above sea level and grows in a range of habitats from the vertical sea cliff to 300 metres in land growing amongst bracken and bramble (Compton *et al* 2002, Compton *et al* 2007, Compton and Key 2000).

The location of the largest populations of Lundy Cabbage varies from year to year, but the area of slate cliffs above Landing Beach, Millcombe, the Sugar Loaf, the cliffs below the various combes on the eastern Sidelands and sections of the granite cliffs at Quarry Bay are the most important areas for the plant. (Compton and Key 2000). The number of plants recorded each year can fluctuate enormously. In 1978 there were only 324 flowering plants recorded (Compton and Key 2000), but 6800 in 2017 (R. Key, personal communication). Numbers of flowering Lundy Cabbage plants have been monitored annually since 1993. This work was undertaken by Roger and Rosy Key and Steve Compton between 1993 and 2018, (Compton *et al* 2018) with more recent surveys from 2019 onwards being carried out by Alan and Sandra Rowland from the Lundy Field Society (Rowlan and Rowland 2022, 2023).

When the Lundy Cabbage surveys were established, the aim was to help inform the conservation of both the plant and the insects, but it appeared that the beetles could be found wherever the plant was, and so efforts started to focus on the conservation of the plant, which would then in turn benefit the insects (Compton *et al* 2002). It has not been possible to search all cabbage locations for beetles however, as they often grow in inaccessible places (Compton *et al* 2001, Key *et al* 2002), and the cabbage surveys are usually undertaken in June ahead of times when peak beetle numbers have been recorded. In 1993, no beetles were found in late May, but by July they were abundant (Key 1994), with good numbers also being found on into early October in some years (Key 1994 (1)).

There have been previous attempts to undertake limited semi-quantitative surveys for the beetle, using pan traps and an extract of Lundy Cabbage leaves mixed with ethanol, but both methods were lethal and have not knowingly been repeated (Compton 1998, Compton 1999).

Roger Key's report in 2002 noted that it had taken 20 hours of searching to find similar numbers of beetles that in the past could be found in 5 minutes with a sweep net (Key *et al* 2002). This corresponded with a poor year for Lundy Cabbage with only 900 flowering plants estimated, compared to a mean number of 5100 (Roger Key pers. comm). In 2004, more than 50 adult beetles were seen in Quarry Bay (Key *et al* 2004) as Lundy Cabbage numbers had recovered to approximately 2400 flowering plants (R. Key personal communication).

In 2014 it was recommended that a summer survey for Lundy Cabbage Flea beetle was undertaken because numbers had been low for four years (Key *et al* 2014). There is no evidence that this has ever happened. Beetles were abundant again in 2016 for the first time in 6 years (Key *et al* 2016), but only one beetle was seen in both 2017 and 2018, and since then it has not knowingly been recorded (Rowland and Rowland 2022, Rowland and Rowland 2023). It is clear that more survey effort is required for this species at the correct time of year,ideally using a quantitative method, so numbers can be compared to effort across the years.

There is thought to be a link between the numbers of beetles and the number of plants, but as only very limited semi-quantitative surveys have been undertaken, it is very difficult to draw anything other than anecdotal comparisons (Compton *et al* 2004). The recovery of beetle numbers appears to lag behind the recovery of the Lundy Cabbage population (Key *et al* 2005, Key *et al* 2006) and it is quite possible that the fluctuations in numbers of Lundy Cabbage might pose an issue for the beetle (Compton *et al* 2004).

Plate 2a: Lundy Cabbage Flea Beetle © John Walters.
Plate 2b:Lundy Cabbage Weevil © John Walters.

Along with the Lundy Cabbage Flea Beetle, there is another beetle which can be found on Lundy Cabbage,the Lundy Cabbage Weevil (*Ceutorhynchus contractus var. pallipes)* (Compton *et al* 2000) (Plate 2b). This is taken to be the pale legged form of the Cabbage Leaf Weevil (*Ceutorhynchus contractus*). From work undertaken in the early 2000s by Jenny Craven, it was established that there were potentially two different taxa that are recognised as the Cabbage Leaf Weevil - the shape of the aedeagus is different in each. One is found throughout Britain and Europe but has not been found on Lundy, the other has been recorded on Lundy and also in Northern Spain (Craven 2007). This other beetle has both pale and dark forms, both of which are found on Lundy, and it was recommended that the specimens be considered for elevation to the status of a distinct species (Craven 2007). Even if this beetle were to be declared a distinct species it would not be classified as endemic as it can also be found in Spain; however the pale form has not yet been found anywhere other than Lundy (Craven 2007).

Lundy Cabbage (Plate 3) is a short-lived perennial. It tends to grow in open, sunny locations and usually flowers in its second year. It is a pioneer plant and grows very well in the bare ground conditions created after disturbance - both from animal activity and rock falls and landslips (Compton *et al* 2002, Key 1994). It is able to rapidly recolonise areas (Compton *et al* 2000), and numbers of the plant should be able to recover quickly once any factors limiting its growth are addressed (Key *et al* 2002).

There is evidence that Lundy Cabbage is prevented from growing and establishing if a thick grass sward develops. (Compton *et al* 2002). Experiments have previously been undertaken to see how the islands plant communities alter when grazing is excluded and these found that after the initial colonisation, the Lundy Cabbage plants quickly disappeared as the seedlings were rapidly outcompeted as the grass sward closed (Compton *et al* 2004, Key *et al* 2004). There have however also been instances where areas of grass have been dramatically reduced following periods of very hot weather which scorched the plants, and Lundy Cabbage seedlings were able to take advantage and successfully germinate (Key 1996) so it is likely it can grow in more open swards.

Plate 3: Lundy Cabbage foliage © Laura Larkin.

Despite not growing well through grass, Lundy Cabbage can grow successfully amongst plants such as bramble (*Rubus fruticosus* agg.) and bracken (*Pteridium aquilinum*) and can also survive in the shade of plants such as Gorse (*Ulex europaeus*) and Blackthorn (*Prunus spinosa*) (Compton *et al* 2000). It is also able to successfully seed into the deep litter under bracken, as well as under gorse and bramble (Compton *et al* 2000, Key 1994, Key 1994 (1)) with new plants successfully germinating and surviving under one metre height of bramble cover (Key and Compton 1995) and in areas heavily dominated by taller bracken (Key *et al* 2005).

Another limiting factor in the distribution of Lundy Cabbage comes from the various mammals that graze the island. Lundy is home to sheep, deer, cattle, goats and rabbits, all of which could have a potentially detrimental impact on the survival of Lundy Cabbage plants, although none are likely to threaten the plant with total extinction (Compton *et al* 2000), largely because it is able to survive on the steep and inaccessible cliffs (Compton *et al* 2002), and amongst plants such as bramble and gorse which deter any grazers from consuming it. That said, the intensity and type of grazing will undoubtedly affect the abundance of Lundy Cabbage.

Goats have previously been sighted about 15m up one of the rocky outcrops feeding on Lundy Cabbage (Key 1995) and are likely the reason why the plant is absent from such a large part of the eastern side of the island (Compton *et al* 2002). They have also historically taken up residence in Millcombe, where the majority of the Lundy Cabbage population can be found. Here they repeatedly grazed plants, preventing them from flowering and setting seed (Key *et al* 2015) with mature plants also being lost (Key *et al* 2016). The impact of grazing is not always as bad though, and in wet years when growth is lush and other forage is available, the impact from the goats is not so pronounced (Key *et al* 2014), and it is likely they help to reduce the growth of scrub on some of the steeper parts of the island.

Historically, rabbit activity has been at its highest along the Sidelands (Smith and Compton 2008) where most of the Lundy Cabbage plants can also be found. Rabbits could potentially benefit the Lundy Cabbage by grazing other plants and generating bare ground (Compton and Key 2003), but they also have the capacity to be incredibly detrimental to the plant and in high rabbit years they have grazed most of the cabbage plants in Millcombe, even those beyond the stock fencing (Compton and Key 2003). The exclosure experiments previously undertaken on the Sidelands restricted access to grazers, including rabbits, and Lundy Cabbage plants were able to grow and flower where they had not been seen for decades (Compton *et al* 2002).

The biggest botanical threat to Lundy Cabbage has historically been from *Rhododendron ponitcum.* Rhododendron arrived on the island in the early 19th century and by the 1970s it was the dominant plant in parts of the eastern side of the island, potentially preventing the Lundy Cabbage from colonising new areas (Compton *et al* 2004). If left untreated it could have continued to spread, threatening not only the Lundy Cabbage but also the endemic invertebrates (Compton *et al* 2004). This threat was realised and in the 1980s and 1990s the first larger scale attempts at clearance were started. In 2004 a plan was developed for the rhododendron to be fully eradicated from Lundy in the long-term (Compton *et al* 2004). This has been very successful and in 2024 only a very small number of immature plants remain which are regularly monitored and cleared by the island team.

Where the rhododendron has been cleared, large areas of bare soil are left and there have been several instances of Lundy Cabbage successfully germinating into these areas. In 1994, Lundy Cabbage was an early coloniser of the bare ground created by clearance at Helen's Copse, but the plants did not survive, possibly because of grazing pressure (Key 1994). Also, in 2000 a small number of plants were seen flowering amongst the brash left behind after rhododendron clearance – these were also likely protected from the grazing and so able to survive (Compton *et al* 2000). In both 2008 and 2009, large numbers of Lundy Cabbage plants were again seen growing amongst the brash left behind after clearance (Key *et al* 2008, Key *et al* 2009) but these were lost in 2010, again likely as a result of grazing (Key *et al* 2010). Work has been undertaken to plant these post rhododendron areas with gorse and blackthorn in the hope that the Lundy Cabbage plants might be able to survive here alongside occasional grazing (Compton *et al* 2004).

There are many pressures that impact the distribution and abundance of the Lundy Cabbage plants, but there is also potential to identify opportunities for further work, which may help to increase the abundance and distribution of the plant. It is clear that more work is needed to ensure that the beetles are not detrimentally impacted by the fluctuating numbers of Lundy Cabbage plants, and whether they are indeed present throughout the cabbage population as has previously been thought.

In 2024, Buglife undertook a research trip to Lundy to survey for the Lundy Cabbage Flea Beetle and the Lundy Cabbage Weevil, in order to understand more about the current distribution of both on the island, whether they seemed to be present wherever the plants were found, and whether there were any additional measures that could be undertaken to ensure the beetles and the cabbage were as widespread as possible and ensure they thrive into the future.

METHODS

The field visit to Lundy took place between the 2nd and 4th July 2024 and was undertaken by Laura Larkin and Andrew Whitehouse. The surveys were carried out in dry weather and the daytime temperature was approximately 15 degrees. Joe Parker, Head Warden on Lundy very kindly provided us with maps of the known Lundy Cabbage locations which we used to delimit our survey areas. This corresponded with the Lundy Important Invertebrate Area which can be seen at **https://www.buglife.org.uk/our-work/important-invertebrate-areas/** and in Figure1 below.

As many of the areas known to contain Lundy Cabbage plants were visited as was possible, and any accessible plants were surveyed for the beetles. Much of the survey area falls within the Lundy Island SSSI and so permission was sought for the surveys from Natural England prior to their commencement. To locate Lundy Cabbage plants, binoculars were used from safe locations to scan for plants in the distance (Plate 4)

The surveys were undertaken using a sweep net, which where necessary was attached to a 3m extendable pole. The sweep net was used to gently knock any insects present on the Lundy Cabbage from the plants and into the net, and where plants were not easily accessible from ground level, the 3m handle was added to extend the reach of the net (Plate 4). Many of the plants were inaccessible for survey, either because they were growing amongst bramble which cannot be surveyed using the net, or they were out of reach on cliffs or high up on rocky outcrops. If possible, the plants growing with bramble were visually searched. This lack of access severely restricted the places we were able to survey. In total, 11 locations were searched across three days.

RESULTS

Six Lundy Cabbage Flea Beetles were recorded at six locations, along with over 50 Lundy Cabbage Weevils at five locations.

Plate 4: Lundy Cabbage Flea Beetle surveys © Laura Larkin.

Figure 1: The 11 survey locations on Lundy Island with IIA shown in grey: red points, visible cabbage plants, but unreachable; blue points, no beetles found; purple points, weevil records alone; yellow points, Lundy Cabbage Flea Beetle found.

Figure 2: Lundy Cabbage Flea Beetle records from near Sugar Loaf, Millcombe and Landing Bay. Purple points are weevil records alone, yellow points are Lundy Cabbage Flea Beetle records. The Lundy IIA is shown in grey.

Locations of the beetle records can be seen below. Figure 1 shows the 11 survey locations on Lundy, and Figure 2 shows in more detail locations with Lundy Cabbage Flea Beetle records, with further information in Table 1. The most northerly beetle record was from just north of Sugar Loaf at SS 13938 44428 along the coast path, with other records from Millcombe, the Landing Bay road and on the cliffs just below Marisco Castle. Figure 2 shows this in more detail.

Despite covering large areas of the island, opportunities to search Lundy Cabbage Plants were more limited than expected. This was due to plants growing on cliffs and slopes that were not easily or safely accessible. It is also likely that plants were present within blocks of bramble, bracken or scrub but not visible from footpaths.

The surveys were undertaken to determine presence or absence and not the abundance of beetles, and so if we found a beetle at a particular location, we did not search for further beetles and instead moved on to a new point. This also minimised damage to Lundy Cabbage plants from sweep netting. The numbers of beetles found should not be viewed as representative of the abundance of beetles at each location.

Table 1: Further details of the 11 survey locations on Lundy Island and records of any beetles found.

Grid reference	Name	Date	Lundy Cabbage Flea Beetles found	Lundy Cabbage Weevils found	Notes
SS 14045 44058	Millcombe near bench	2nd July	1	10	
SS 13938 44428	Near Sugar loaf	2nd July	1	-	Most northerly beetle recorded during this survey
SS 14175 43832	Near Marisco Castle	3rd July	1	some	
SS 14121 43996	Landing Bay Track	3rd July	-	10+	
SS 14135 43962	Landing Bay Track	3rd July	1		
SS 13884 44100	Above Millcombe House	3rd July	1	some	
SS 14159 43934	Landing Bay Track	3rd July	1		
SS 14072 44072	Millcombe near coast	2nd July		2	
SS 13925 44636	Near White Beach	2nd July	-		Surveyed plants but no beetles found
SS 13839 45854	Halfway Wall	3rd July	-		Unable to reach plants to survey
SS 13789 45874	Halfway Wall	4th July	-		Unable to reach plants to survey

DISCUSSION

Lundy Cabbage Flea Beetle Surveys

Lundy Cabbage Flea Beetles were found at six locations on the south of Lundy, around Sugar Loaf, Millcombe and the Landing Bay track which are as expected from the historical records. Whether these records actually demonstrate the full range of the beetle is unknown because it is not possible to survey in any other locations without use of full climbing gear (Plate 5), but it is assumed the beetle is found wherever the cabbage grows (Compton *et al* 2002). The same is true for the Lundy Cabbage Weevil which was found at five locations.

These surveys were for beetle distribution, rather than abundance and so more work needs to be done to establish the locations within the south of the island which have the highest abundance of Lundy Cabbage Flea Beetles. A better understanding of this could help to provide more specific advice in how best to support these endemic species in the future.

In order to effectively assess the abundance of the beetles, the surveying will need to be more structured and quantitative. We also recommend that surveys are undertaken to study the phenology of the beetle - recording beetle numbers throughout the seasons, because although there are records for beetles in both June and October, it is not known when their peak month of activity is, or indeed whether they are active beyond these months.

Establishing a regular monitoring regime for the beetle would be a very good place to start.

Future surveys should focus on any accessible plants in the Landing Bay and Millcombe areas, as these contain the majority of flowering plants on the island (Roger Key personal communication). Table 2 below show the average number of flowering plants in each area where Lundy Cabbage Flea Beetles were found in the 2024 survey. All of these numbers are high apart from the record above Millcombe House at SS 13884 44100. There had been no flowering plants recorded here for at least 8 years between 1993 and 2018, and the area had an average of just 2 (Roger Key personal communication). This small patch of plants is set apart from the nearby larger and more stable areas of cabbage by approximately 130m which would suggest that either the beetles are able to survive on very small numbers of plants, and/or they are able to travel distances of at least 100m to seek out the plants.

Plate 5: An east side cliff with possible Lundy Cabbage sites © Laura Larkin.

Table 2 – Average number of flowering plants in areas with Lundy cabbage Flea Beetle records (Roger Key personal communication).

Area	Average number of flowering Lundy Cabbage plants between 1993 and 2018
Track above Millcombe House	2
Millcombe near bench	356
Landing Bay	228
Marisco Castle	277
Sugar Loaf	183

It would be interesting to undertake a mark-recapture study of beetles across a number of months to see how far they are able to travel. There has been extensive research into the Cabbage Stem Flea Beetle (*Psylloides chrysocephala*) because it is considered a pest species of commercial brassica crops. This closely related species is able to disperse over 10km (Hausmann *et al* 2024). Not much is known about the Lundy Cabbage Flea Beetle's ability to disperse, and what any barriers to this might be. There is a possibility that they may be able to easily travel to cabbage plants throughout the island, but without being able to access the plants for survey, a mark-recapture study is currently not a viable option. Even if the beetles are found throughout the island, it is possible that they are not regularly breeding on some of the steeper cliffs. Lundy Cabbage Flea Beetles demonstrate a preference for ovipositing in sandy soil (Craven 2002), and potentially the underlying substrate on the cliff faces may not be suitable, although the beetles may well use plants to feed. It would be useful to gather further information on this aspect of their life cycle if the opportunity to undertake surveys of the cliffs ever presents itself.

Lundy Cabbage and island vegetation

Lundy Cabbage plants need to be present year-round in the long term to ensure the future viability of the Lundy Cabbage Flea Beetle (Craven 2007). The cabbage populations between the Landing Bay and Sugar Loaf seem to be stable (Roger Key personal communication), but more work could still be undertaken to further increase the number of plants and patch areas, and also to better link them. This would not only help to secure the beetle populations but would also help to improve the number of endemic cabbage plants, with the possibility of increasing their visibility to island visitors too. An endemic insect feeding on an endemic plant is really something very special and should be something that all visitors to Lundy in the appropriate season, are given the opportunity to experience.

Lundy Cabbage can be easily grazed off by the island's mammals including goats, sheep and rabbits. Ideally, grazing should be prevented in populations of Lundy Cabbage from between April and October when it is growing and setting seed, which will allow the plant to reproduce and hopefully spread, which should in turn be beneficial to the beetle. This could be achieved by erecting additional stock proof barriers, which is unlikely to be an aesthetically pleasing solution. For some grazers, no-fence collars could potentially prove a valuable tool. A reduction in the overall number of grazing animals on the island could also help to reduce any detrimental impacts to the cabbage populations. If there are fewer grazers consuming vegetation elsewhere on the island, they may travel to the cabbage areas to seek out alternative food sources.

It may also be worth investigating the impacts of winter grazing on some small existing areas of Lundy Cabbage. Previous exclosure trials only looked into whether allowing grazers access or preventing it entirely had impact on cabbage plants (Compton *et al* 2002), but winter grazing has not knowingly previously been trialled. To enable this, decent stock fencing would be required around the trial area, and consideration would also need to be given as to which grazing animals to use. Whether this is possible would also depend on current numbers of rabbits on the island. If grazers are permitted access to cabbage plants over winter, any disturbance caused could potentially allow for bare ground to be created which would assist with the germination of new plants. It is possible that heavy cattle may provide a greater level of disturbance than goats and sheep. This method would not work however if the site was grass dominated, as a lack of grazing through the summer would lead to the grasses crowding out any cabbage plants.

Lundy Cabbage does not grow well in dense grass (Compton *et al* 2002) and if there are plants that suppress the growth of grasses already present on Lundy such as Yellow Rattle (*Rhinanthus minor*), Red Bartsia (*Odontites vernus*), or Eyebright (*Euphrasia sp*.), then one option could be to use these to see whether they are able to suppress any grass growth enough to allow the Lundy Cabbage plants to successfully establish. All three of these plants are hemi-parasitic and extract their nutrients from the roots of grasses, reducing how tall and quickly they are able to grow. Ideally, any seed would be sourced from the island itself rather than brought in.

Lundy Cabbage is predominantly a pioneer plant that can easily and quickly colonise landslips and new areas of bare ground (Compton *et al* 2000). It would be good to test whether it is possible to clear small areas of existing scrub and other vegetation and seed it with Lundy Cabbage with a view to link any of the existing areas of cabbage and reduce the fragmentation. Multiple small plots could potentially be cleared of vegetation and roots with differing conditions imposed on these to see which provides the best outcome for seed germination over the course of the next few seasons. These areas will need to be free of grazers to allow time for the seeds to establish and grow, or the trial will not be possible. If these areas could be sited where they are visible to island visitors, they could also help to increase the visibility of both the cabbage and the beetle.

It would also be beneficial to trial seeding Lundy Cabbage into the open areas created by previous rhododendron clearance. Previously, cabbage seedlings have grown after rhododendron clearance where piles of brash have been left (Compton *et al* 2004), and so creating some kind of 'cabbage refugia' may be an option if it is not possible to exclude grazers from this area.

It is not advised that any new tree plantings be added to any areas currently containing Lundy Cabbage plants, and that if there is ever a desire to increase the size of the wooded areas on the island, that this takes place elsewhere and not anywhere near Marisco Castle, Landing Bay, Millcombe or Sugar Loaf or anywhere within the Lundy Important Invertebrate Area. More information on the areas involved can be found at **https://www.buglife.org.uk/our-work/important-invertebrate-areas/**

Site of Special Scientific Interest

Much of the area where Lundy Cabbage grows has been designated as a Site of Special Scientific Interest (SSSI) and so permission for any works undertaken within this designated site will require the permission of Natural England. Lundy Cabbage itself is also protected under Schedule 8 of the Wildlife and Countryside Act, and so permission would also be required for any activities involving picking, uprooting or destruction of the plant.

A small area of Lundy Cabbage falls outside of the boundary of the current SSSI as can be seen on Figure 3 below. The SSSI is outlined in red and the Lundy Important Invertebrate Area, which denotes the key flea beetle habitat is in yellow. A lot of the vitally important beetle habitat around Millcombe is not within this protected area, but the SSSI citation also does not mention the beetle, and so it is likely this is why. We recommend that the Lundy Cabbage Flea Beetle is added to the SSSI citation as an interest feature, and that the boundary is extended to include all areas where Lundy Cabbage is regularly present. Neglecting the presence of this globally Critically Endangered endemic beetle within the SSSI citation and ongoing monitoring and management is a considerable oversight.

CONCLUSIONS

This study has reviewed previous work undertaken on both the Lundy Cabbage Flea Beetle and the Lundy Cabbage and has sought to determine the current distribution of the beetle on the island and whether anything further could be done to better enable the Lundy Cabbage Flea Beetle to continue to thrive into the future. Below are some recommendations of specific actions that would ideally be undertaken to ensure this Lundy endemic is supported going forwards.

Figure 3 – Lundy SSSI is marked in orange stripes, and Buglife's Lundy Important Invertebrate Area for the Lundy Cabbage Flea Beetle shown in grey. The SSSI does not offer statutory protection to key beetle hotspot around Millcombe.

Survey, monitoring and further research

We are currently unable to determine the health of the Lundy Cabbage Flea beetle population, and therefore do not know if it is sustainable, and resilient enough to cope with annual fluctuations in food plant availability or weather conditions. Further work is needed to gather more information about the abundance and distribution of the Lundy Cabbage Flea Beetle. We are aware that the beetle has hotspots in the south of the island amongst the Lundy Cabbage hotspots, but we are currently unable to draw population comparisons between these. There is also a reasonable chance that the beetle occurs on the island wherever the cabbage is found, but the inaccessibility of the plants severely reduces the chances of confirming this without significant expenditure.

A replicable and quantitative survey methodology would ideally be designed to help ascertain beetle abundance and distribution, particularly in the south of the island, throughout the seasons. Having some structured monitoring in place would allow beetle numbers to be monitored over time so comparisons can be made with the annual cabbage counts. In an ideal world, this would be undertaken by people who are regularly present on the island.

If there is ever an opportunity to gain access to survey Lundy Cabbage plants in the more inaccessible parts the island, undertaking a mark-recapture study of the beetle would allow more to be learnt about the beetle's ability to disperse throughout the island and allow additional suggestions for how to help both the beetle and the cabbage thrive into the future. It would also be beneficial to undertake a Favourable Conservation Status assessment and produce a Species Recovery Plan for the Lundy Cabbage Flea Beetle.

We recommend that the Lundy Cabbage Flea Beetle is added to the Lundy SSSI citation as an interest feature, and that the boundary is extended to include all areas where Lundy Cabbage is regularly present. Neglecting the presence of this globally Critically Endangered endemic beetle within the SSSI citation and ongoing monitoring and management is a considerable oversight.

Habitat interventions

The abundance of flowering Lundy Cabbage plants can fluctuate wildly from year to year but appear to be generally stable over the longer term (Roger Key personal communication), however it is known that their current range is restricted by grazing animals (Compton *et al* 2000) and as a result many of the plants can only be found on vertical cliff faces where they are inaccessible to both grazing animals, surveyors and island visitors alike.

We recommend that management trials and interventions are considered to increase the abundance and distribution of Lundy Cabbage, particularly in the south of the island. Focus should be given to increasing the size of existing patches of the cabbage, and creating "stepping stones" of cabbage patches to improve habitat connectivity for the flea beetle.

Specific interventions include:

- further restricting access to or reducing numbers of grazing animals within the Important Invertebrate Area, at least between April and October each year.
- trialling whether winter only access to stock is beneficial to the cabbage plants by creating additional bare ground for germination.
- trialling the seeding of new areas with differing conditions/existing vegetation to determine which is most likely to be successful.
- trialling supressing the growth of any patches of dominant grasses with hemi-parasitic plant seeds sourced elsewhere on the island to see whether the cabbage and grass can grow together if the sward is not too thick.
- Creating accessible cabbage patches alongside footpaths and access routes providing an "opportunity to see" for visitors, as well as essential habitat for cabbage and flea beetles. Intensive "gardening" of such areas could be used to create super abundant stands of Lundy Cabbage which could be used to harvest seed from.

Education

Working to improve the structured monitoring of Lundy Cabbage Flea Beetle would provide an opportunity to raise awareness of both the beetle and the cabbage to island staff and visitors, and having these two endemic species growing and thriving in an easily accessible part of the island would also provide an additional opportunity for island visitors view them. Undertaking this vital conversation work in highly visible parts of the island, will enable everyone who steps foot on Lundy to not only experience being on this incredible island, but also to feel invested in and part of the future of two of Lundy's most special species.

ACKNOWLEDGEMENTS

With thanks to Andrew Whitehouse for support with undertaking the fieldwork; Roger Key for his incredible knowledge and sharing his research; Joe Parker and the Lundy Island Trust for support with project costs; Alan Rowland for his advice and survey information; Tom Thompson for support with GIS and mapping and Steven Payne for his advice and support. Also, thanks to the Buglife Senior Leadership Team for supporting my sabbatical and enabling this work to go ahead.

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STUDIES ON PATROLLING FLIGHTS AND 'CANCELLED LANDINGS' BY THE NORTHERN FULMAR (*FULMARUS GLACIALIS*) ON LUNDY

by
ARE VÆRØYVIK*, SUNYEONG LEE, EUAN BIELBY AND SHAYAN SHOAEE,
Biological Sciences, University of Exeter, Perry Rd, Exeter EX4 4QG
**corresponding author, email: Værøyvik, Are are.vik@online.no*

ABSTRACT
Northern Fulmars arrive on land around January to prepare for the breeding season. Energy conservation is important during this time, but they perform seemingly purposeless "patrolling flights". We observed patrolling flights of the fulmars along Gannet's Rock, Lundy Island, for six days during the pre-laying period, and noticed a novel behaviour, "cancelled landings", performed during the flights. We explored the possibility that these flights, and the cancelled landings, play a role in mate-seeking. We propose that the flights represent an energetically costly 'honest signal' leading to courtship, and that performing cancelled landings represent approaching a potential mate. Results showed that longer flight durations predicted landing in a different location compared to the take-off location. However, this effect was mediated by the effect of performing cancelled landings. Furthermore, longer flights were not predictive of landing next to a conspecific, or of performing courtship behaviours. Cancelled landings were predictive of landing next to a conspecific, but not of performing courtship behaviours. This almost unstudied behaviour of patrolling flights may help give insight into the breeding status of fulmar populations, although longer studies are needed to confirm the basis of the behaviour.

Key words: *Northern Fulmar, patrolling flights, breeding, courtship, mate-seeking*

INTRODUCTION
Most seabirds spend their lives predominantly at sea, but must come to land to breed (Ballance, 2007). Such birds spend their winters alone and conjoin at their breeding sites to find mates and produce offspring (Hunter, 1999). The Northern Fulmar (*Fulmarus glacialis) belongs to this category, nesting and breeding on cliff shelves and ledges in the Northern Atlantic, Northern Pacific, and High Arctic (Hatch & Nettleship, 1998). As a monogamous species,* Northern Fulmars generally retain their mate- and nest-site across breeding seasons (Carrick & Dunnet, 1954, Ollason & Dunnet, 1978, Warham, 1964). However, extra-pair copulations can occur, although rarely (Hunter *et al*., 1992), and can be initiated by both males and females (Hatch, 1987).

During the breeding season, Northern Fulmars occasionally depart from the cliffside to embark on foraging journeys that can span hundreds of kilometres (Dunnet & Ollason, 1982, Edwards *et al.*, 2013). They have specialised adaptations for minimising the energy costs of such flights, such as lower basal metabolic rates compared to other seabirds (Bryant & Furness, 1995). They also predominantly employ gliding flight when on foraging journeys (Alerstam *et al.*, 1993), giving them lower at-sea metabolic rates than seabirds that rely on other flying techniques such as flapping flight or pursuit diving (Birt-Friesen *et al.*, 1989), especially during windy conditions (Furness & Bryant, 1996). Such energy conserving measures are especially relevant prior to egg-laying, when Northern Fulmars require substantial endogenous reserves to support on-land activities such as nest maintenance, and pair-bonding and courtship behaviours (Mallory & Forbes, 2008).

Interestingly, Halle (1979) describes a breeding-season behaviour of the Northern Fulmar that seemingly spends energy for no obvious purpose. Termed by him as "patrolling flights" they occur within a restricted space along the cliffside, and consist of riding the wind back and forth, side-to-side, using the turbulence of the updraft. They require great dexterity and rely on frequent adjustments of the wings and tail to respond appropriately to the winds.

Surprisingly, there seems to be no other research, or even mention of this behaviour in the literature. Halle (1979) suggests patrolling flights to be a pure pastime. Birds may at

Plate 1: Fulmar in flight near a Lundy cliff © Richard Campey.

Plate 2: Fulmar pair at a nest site on Lundy © Richard Campey.

times perform behaviours "for fun" (Emery & Clayton, 2015) but given the importance of conserving energy reserves during the pre-laying period, it seems likely that these repetitive behaviours have an adaptive significance beyond mere leisure.

We studied fulmars nesting on Gannet's Rock on Lundy Island in 2024 between April 27th and May 3rd, before their egg-laying period (Fisher, 1966) to investigate their patrolling flights. During preliminary observations, we made similar observations as those described by Halle (1979), where individuals would regularly perform seemingly purposeless flights outside and around the nest-sites on the cliff shelves before landing and taking off again shortly after. Unlike Halle's (1979) descriptions, we mainly observed figure-of-eight-like flight patterns in front of the cliff shelves, often sailing over the various nest-sites at the intersection of the figure-of- eight shape. Additionally, we noticed that they frequently appeared to attempt landing at a certain spot occupied by one or more conspecifics, slowing down and extending their legs, but then cancelling at the last second and continuing their figure-of-eight-like flights. In some cases, where multiple cancelled landings were performed at the same site during a single flight, the behaviour seemed almost ritualistic.

Given the limited pre-existing information about this behaviour, many equally justifiable hypotheses could be explored. For instance, it could be posited that it serves some form of social function, or that it is a way for immature birds to practice their flying. It may be that the patrolling flights are linked to their breeding activities. Since the pre-laying period is characterised by mating and breeding behaviours (Mallory & Forbes, 2008), it seems plausible that these flights serve some purpose in mate-finding. We suggest that the flights themselves could represent an energetically costly honest signal (Zahavi, 1975). Fulmar chick survival is highly dependent on male parental investment (Hatch, 1987), so patrolling flights may serve as a signal of their adeptness at performing flights as an indicator of future foraging success, similarly to how some female passerines use male song rate to assess their ability to feed their chicks (e.g., Hofstad *et al.*, 2002, Welling *et al.*, 1997). Based on the consistent observations of cancelled landings at occupied nest-sites, we propose that this behaviour may represent approaching a potential mate. Relying on the assumption that Northern Fulmars are mate- and nest-site faithful (Carrick & Dunnet, 1954, Ollason & Dunnet, 1978, Warham, 1964), and that extra-pair copulations are rare (Hunter *et al.*, 1992), we considered the act of landing in a different location than the take-off location to represent being unpaired and seeking to find a mate. We also recorded the act of landing next to a conspecific and performing any of the three courtship behaviours (bill-fencing, bill-opening, and head-swinging) as further indicators of mate-seeking.

METHODS

We investigated the potential significance of two aspects of patrolling flights by fulmars: (1) flight duration, (2) the performance of cancelled landings.

Subjects

The study was on the fulmar population nesting on Gannet's Rock on Lundy Island. Daily counts suggested there were approximately 30 individuals during the time of the study. Individuals were not identified or sexed. The observations were made a few weeks before the population was expected to lay eggs.

Procedure

Individual fulmars were observed over six days through focal follows performed by four observers. Initially, the four observers split up into two groups, in which one observer performed the focal follows, using no equipment during flight, and 8x magnification binoculars when the individual was landed, while communicating their observations to the other observer, who recorded the data. Data were recorded using the "Timestamped Field Data" app from Neukadye on an iPad. This allowed for touch-based recording of flight durations and the different variables. However, from day 4-6, three observers performed both jobs of observing and logging data, as this was made possible through the acquisition of another device with the "Timestamped Field Data" app. Here, the three observers used binoculars to perform the focal follows, while the fourth observer assisted with observing behaviours performed while landed.

A focal follow was initiated by the take-off of an individual, after which one of the observers exclaimed that they were following this individual. A focal follow was concluded: (1) after the individual had performed three flights, to promote capturing a wider range of the population, (2) when it had remained landed for five minutes, to promote the acquisition of data from more flights, (3) or when it went out of sight, or was suspected to be mixed up with another individual (in this case the recordings from the current flight were discarded). To promote reliability, we defined the behavioural variables prior to the observations, and practiced recording these variables in concordance with our definitions on day 1. We attempted to avoid pseudo replication by clearly communicating which experimenter observed which individual, and by tracing the observed individual with a pointed finger while in flight. However, given the limited number of individuals each one was likely recorded more than once. All variables recorded are defined and described in Table 1.

Table 1: Descriptions of the variables used in the present study.

Variable	Description
Flight duration Continuous, independent variable	Duration of individual flights, starting from take-off until landing. Measured in seconds.
Landing location Binary, dependent variable	Whether the focal individual landed in the same location as it took off from, or a different location, as judged by the observer's vision and memory. Recorded as "different location" (0) or "same location" (1).
Landing context Binary, dependent variable	Whether the focal individual landed next to a conspecific, or alone. The individual was considered to have landed next to a conspecific if it was perceived by the observer to be less than two "fulmar lengths" (a fulmar's length as seen from the side) away from the nearest conspecific, and alone if two or more fulmar lengths away from the nearest conspecific. Recorded as not alone (0) or alone (1).
Cancelled landing Binary, independent variable	When an individual initiated landing by breaking and extending its legs, sometimes lightly touching the surface with its feet, but cancelled the landing last second and continued flying. Only occurred at occupied nest-sites. Recorded as did not (0) or did (1) perform one or more cancelled landings during a flight.
Courtship behaviours Binary, dependent variable	Whether an individual performed a courtship behaviour following a patrolling flight. Recorded as did not (0) or did (1) perform either of the three following courtship behaviours: Bill-fencing: individual rubbed bills with another individual up and down both sides alternately (described in Luders, 1977). Bill-opening: individual performed forwards neck-extension with its bill wide open (described in Nelson and Baird, 2001). Head-swinging: individual performed side-to-side, or up-and-down head movements with its bill closed. (described in Luders, 1977).

Statistical Analysis

Data was analysed using the programming language "R" in RStudio. Logistic regression analyses assessed relationships between predictor variables flight duration and performing cancelled landings and outcome variables landing location, landing context, and courtship behaviours. The predictors were divided into separate models due to collinearity. The model assessing the relationship between performing cancelled landings and landing location violated assumptions of logistic regression. This relationship was instead assessed using a Fisher's exact test, and the direction of the relationship was inferred graphically. A *post-hoc logistic regression mediation analysis using Baron and Kenny's (1986) four-step method was conducted* to assess whether the effect of flight duration on landing location was mediated by the performance of cancelled landings. Figure 1 was produced with the "ggplot2" package in RStudio; Figures 2 and 3 were produced in Excel; Figure 4 was produced in Word.

RESULTS

Longer flight durations predicted landing location but not landing context or performing courtship behaviours. The output from the logistic regression models is presented in Table 2. The relationship between flight duration and landing location is illustrated in Figure 1.

Figure 1: Illustration showing the difference in flight duration (measured in seconds) between flights concluded by landing in the same and different location compared to the take-off location.

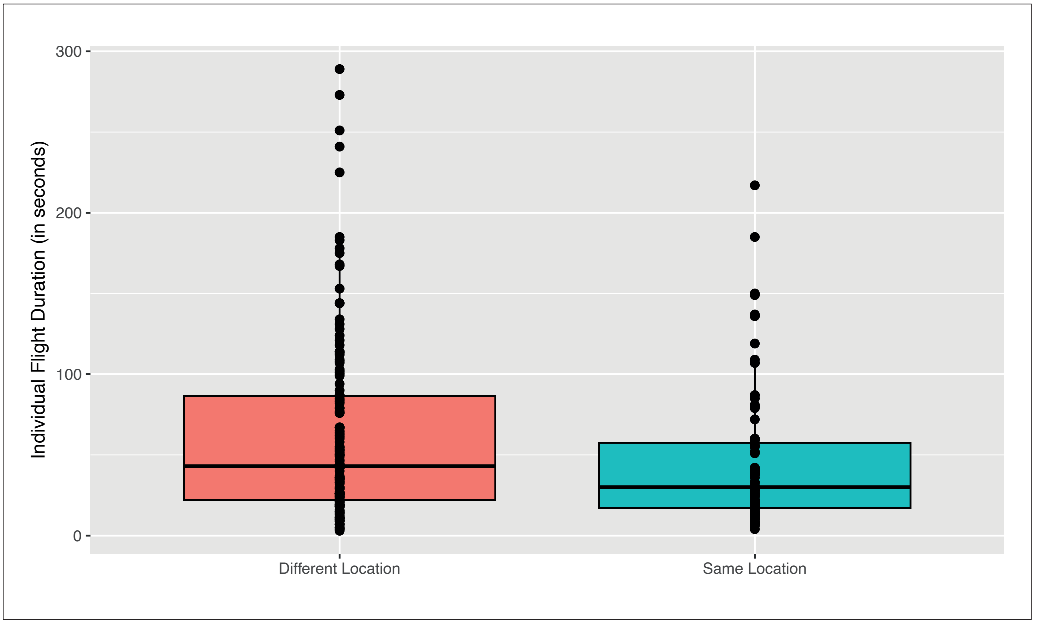


Table 2: Effects of flight duration on the different outcome variables. The model for the effect of flight duration on landing location fits significantly better than the null model (X21= 5.68, p = 0.017).

Flight Duration	b ± s.e.	Wald Z	df	p	OR	95% CI
Land Location	-0.007 ± 0.003	-2.242	1	0.025	0.99	0.987-0.999
Land Context	0.004 ± 0.003	1.100	1	0.271		
Courtship	0.001 ± 0.003	0.314	1	0.754		

Did performing cancelled landings predict landing location, landing context, or performing courtship behaviours?

As derived from the logistic regression models, performing cancelled landings predicted landing context (relationship illustrated in Figure 2), but not performing courtship behaviours. The output from the logistic regression models is shown in Table 3. As derived from the Fisher's exact test, performing cancelled landings was significantly associated with landing location (p = 0.002, relationship illustrated in Figure 3). Descriptive statistics of all variables are presented in Table 4.

Table 3: Effects of performance of cancelled landings on the different outcome variables. The model for the effect of performance of cancelled landings on landing context fits significantly better than the null model (X21= 4.64, p = 0.031).

Cancelled Landing	b ± s.e.	Wald Z	df	p	OR	95% CI
Land Context	0.628 ± 0.293	2.143	1	0.032	1.87	1.058-3.343
Courtship	0.250 ± 0.292	0.856	1	0.392		

Figure 2: Illustration showing that flights with cancelled landings were more often concluded by landing alone, and flights without cancelled landings were more often concluded with landing next to a conspecific.

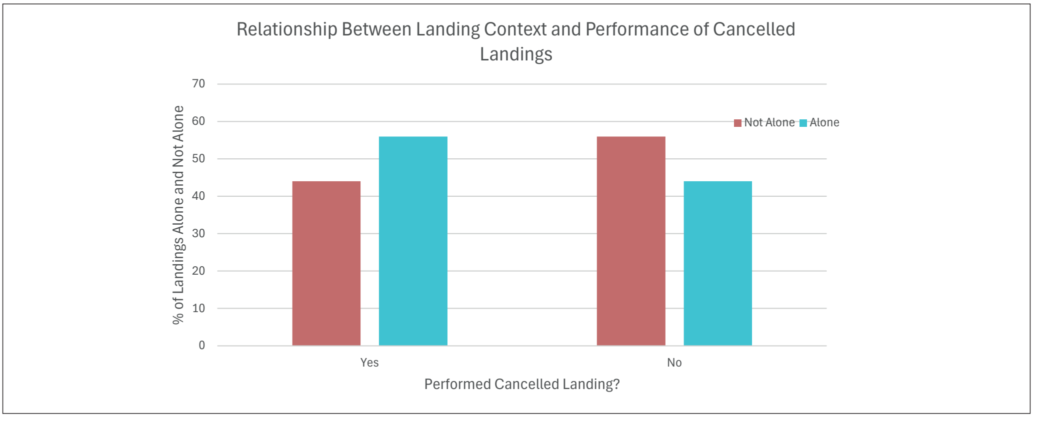


Figure 3: Illustration showing that the difference between landing in the same and different location compared to the take-off location was much larger in flights that featured cancelled landings. Flights were concluded with landing in a different location more frequently after having performed a cancelled landing.

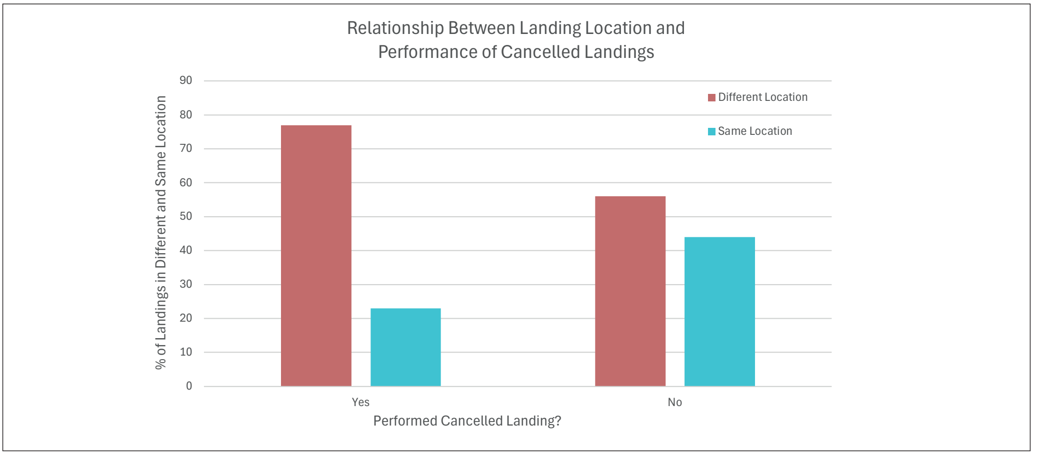


Table 4: Descriptive statistics of all variables.

Variable	n	Min	Max	Mean	SD
Flight Duration	229	3	289	56.03	53.33
Land Location	229	0	1	0.38	0.49
Land Context	229	0	1	0.48	0.50
Cancelled landing	206	0	1	0.36	0.48
Courtship	206	0	1	0.53	0.50

Was the effect of flight duration on landing location mediated by the performance of cancelled landings?

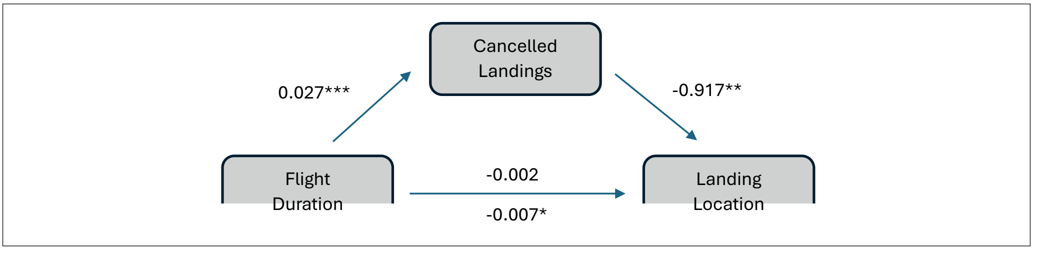
Step 1: Flight duration was significantly correlated with landing location (b ± s.e. = -0.007 ± 0.003, Wald Z = -2.242, df = 1, p = 0.025).

Step 2: Flight duration was significantly correlated with the performance of cancelled landings (b ± s.e. = 0.027 ± 0.004, Wald Z = 6.103, df = 1, p = <0.001). The model was inevitably affected by multicollinearity as the two predictors were significantly correlated, and there was evidence of non-linearity in the logit (b ± s.e. = -0.025 ± 0.009, Wald Z = -2.702, df = 2, p = 0.007).

Step 3: The performance of cancelled landings was significantly correlated with landing location (b ± s.e. = -0.917 ± 0.374, Wald Z = -2.449, df = 2, p = 0.014).

Step 4: The performance of cancelled landings mediated the relationship between flight duration and landing location (b ± s.e. = -0.002 ± 0.004, Wald Z = -0.433, df = 2, p = 0.665). The Sobel test (Sobel, 1982) for the indirect effect of cancelled landings was significant (z = 2.25, p = 0.025).

Figure 4: Directed Acyclic Graph (DAG) showing that the performance of cancelled landings mediated the relationship between individual flight duration and landing location.



DISCUSSION

We found that longer flight durations were predictive of landing in a different location compared to the take-off location, but not of landing next to a conspecific, or of performing courtship behaviours. Performing cancelled landings was predictive of landing in a different location compared to the take-off location, and of landing alone, but not of performing courtship behaviours. These results only partly confirm our initial hypotheses. In the following paragraphs, we provide possible interpretations of these findings.

Our hypothesis that longer flights predicted landing in a different location compared to the take- off location was confirmed. However, since longer flights did not predict landing next to a conspecific, or performing courtship behaviours, it seems unlikely that they are related to mate-seeking. Therefore, our suggestion that patrolling flights represent an energetically costly honest signal of future foraging success is likely to be incorrect. However, it remains interesting as to why longer flights predicted landing in a different location. It is possible that instead of mate-seeking, patrolling flights serve the purpose of scouting the cliffside for potential nest-sites, and that landing in a different location represents finding a suitable nest-site. Finding ideal nest-sites is likely to be important for fulmars as it promotes successful egg-hatching (Mallory & Forbes, 2011). Thus, individuals that land in a different location may simply have had more time to scout the cliffside for a suitable nest-site. However, this interpretation is problematic because it leaves the purpose of shorter flights unexplained.

Why should an individual stop their patrolling flight if they have not found what they are looking for? It is possible that shorter flights are simply thwarted by other factors, such as energy levels, or from being too energetically costly due to lack of wind or updraft. Indeed, wind facilitates less costly flight in the Northern Fulmar (Furness & Bryant, 1996).

Alternatively, these flights may serve a different purpose altogether. Logically, longer flights would allow more time to perform cancelled landings. Therefore, we suspected that the significant effect of flight duration on landing location may have been mediated by the effect of performing cancelled landings. To assess this possibility, we conducted a logistic regression mediation analysis using Baron and Kenny's (1986) four-step method, which showed that this was the case. This means that performing cancelled landings was the better predictor of landing in a different location than the take-off location, and that the significant effect of flight duration likely was explained by the effect of performing cancelled landings.

Since fulmars mate for life, and extra-pair copulations are rare, mate-seeking behaviours should also be rare. Although we did not identify individuals, cancelled landings appeared to be a widespread behaviour performed by most members of the colony. If cancelled landings indeed are a common behaviour, this may point to an explanation other than mate-seeking. However, given our finding that performing cancelled landings predicted landing in a different location compared to the take-off location, and landing alone, we will explore the possibility that it does play a role in mate-seeking. Since cancelled landings only occurred over occupied nest-sites, we postulated that individuals performing cancelledlandings were "asking" the nest-host for approval to join. Our finding that performing cancelled landings more often led to landing alone, and that not performing cancelled landings more often led to landing next to a conspecific (see Fig 2), provides support for this explanation. It is possible that cancelled landings signify rejection by the host, while landings without cancellation signify approval. However, although significant, the difference between these groups was small. As with landing duration, performing cancelled landings did not predict performing courtship behaviours. It is possible that our selection of courtship behaviours is unsuitable for use as indicators of courtship or mate-seeking. Bill-fencing is suggested to be predominantly performed when females approach lone males (Hatch, 1987), so it is possible that it serves a specific purpose rather than being a general courtship behaviour. Behaviours often considered indicative of courtship in fulmars are also reported to be involved in hostile interactions, such as site-defence (Luders, 1977, Nelson & Baird, 2001).

Landing in a different location than the take-off location may not be indicative of being unpaired, as we have assumed in the present study. Our recommendation for future studies of Northern Fulmar patrolling flights is to identify each individual of the focal population, and determine their paired status (see Hatch, 1987). Identity- and paired status-data can be compared to establish which individuals are more likely to perform cancelled landings, land in a different location than the take-off location, or perform patrolling flights at all. Identifying individuals may be particularly useful since fulmars have a delayed sexual maturity compared to some other seabirds, with an average age of 9.2 years at first breeding (Ollason & Dunnet, 1978), meaning that there can be many non-breeders present on the cliff (Hatch & Nettleship, 1998). Future studies may also record pre-flight context, such as whether an individual was alone or in a pair before taking off, to better understand whether the flights may be related to mate-seeking or something else. Studies with greater time-budgets could also investigate whether patrolling flights persist after chick hatching. If fulmars continue their patrolling flights after hatching, then this behaviour may be unrelated to mate-seeking. Such studies could also assess associations between aspects of patrolling flights and subsequent success or failure in mate-finding and reproduction. This could be especially useful for uncovering whether cancelled landings indeed represent rejection by the nest-host, and whether landings without cancellations represent approval.

CONCLUSIONS

We have produced exploratory data on the almost unstudied behaviour of the Northern Fulmar patrolling flights. We found a relationship between longer flight durations and landing location which was mediated by performing cancelled landings, and a relationship between performing cancelled landings and landing context. But there was no relationship between flight duration and courtship behaviours, nor between performing cancelled landings and courtship behaviours.

The potential links between performing cancelled landings and mate-seeking require further investigation. Future studies could be longer, enabling identification of the individuals of the focal population and their paired status, to investigate whether some are more likely to participate in the different aspects of patrolling flights, and assess whether there are associations between such aspects of patrolling flights and subsequent success or failure in mate-finding and breeding.

It must also be recognized that there are other potentially valid hypotheses that could also explain the observed behaviour. These could include (a) that the birds undertaking the 'cancelled landings' are immature birds of pre-breeding age that are 'practicing' breeding behaviour, rather than actively looking for mates; or (b) that the 'cancelled landings' play a social function that has nothing to do with mate selection. In addition, the longevity of fulmars and the stability of their pairings means it was not possible to say what proportion of the birds at the Gannet Rock site already had a mate and would not be seeking a breeding partner.

If these flights are indeed linked to breeding behaviours, identifying their role could provide information about individuals' breeding status. For instance, identifying which individuals are actively seeking mates or successfully forming pairs. Such information can be useful in quantifying changes in proportion of successful breeders as an indicator of colony health (Mallory & Forbes, 2013).

We have included an ethogram featuring noteworthy behaviours from our observations (see Appendix), as this is not available in the existing literature. This includes the three behaviours we used in our study to indicate courtship, as well as other behaviours we noticed, and behaviours described in books and research papers. This ethogram could be applied in future Northern Fulmar research.

ACKNOWLEDGEMENTS

We thank our supervisors Dr. Lisa Leaver, Dr. Andrew Higginson, and Ingerid Helgestad for their professional guidance and feedback throughout the project. We also thank the reviewers for their constructive criticisms, which we have tried to address. We also thank the University of Exeter for providing us with the necessary equipment to conduct our study.

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Appendix: Ethogram featuring noteworthy behaviours of the Northern Fulmar noted during the study on Lundy

Behaviour		**Description**
State	Resting	Individual sits with its wings folded and its breast resting on its feet. In paired birds, resting positions can vary and include face-to-face, half-face, side-by-side, or head-to-tail orientations.
State	Flying	Aerial locomotion
Event	Cancelled landing	Individual initiates landing by braking and extending legs, but cancels last second, sometimes lightly tapping the surface with their feet, and continues flying.
Event	Bill-fencing	Two individuals rub their bills together along both sides alternately.
Event	Nest-clearing	Individual removes materials from its nest by digging with their feet.
Event	Bill-opening	Individual performs forwards neck- extension with widely open bill.
Event	Head-swing	Individual moves its head from side to side. This movement is generally accompanied by raising its head and/or opening its bill.
Event	Head-tossing	Individual repeatedly throws its head back, usually accompanied by calling.
Event	Oil-ejection	Individual ejects stomach oil from its mouth, usually preceded by high-pitched sounds.
Event	Bowing	Individual moves its head up and down.
Event	Mating	The male mounts the female, often stroking her bill or nibbling the nape of her neck.
Event	Preening	Individual grooms its feathers using the bill.
Event	Allopreening	Individual nibbles head, cheeks, neck, throat or flanks of its partner.

VOCALISATION BEHAVIOURS OF MANX SHEARWATERS ON LUNDY

By

Yuheng Sun[1,2,3], Sue Anne Zollinger[4], Julia Schroeder[3,5]

[1] Groningen Institute for Evolutionary Life Sciences, University of Groningen, Linnaeusborg, Groningen, 9711NB, the Netherlands,[2] School of Natural Sciences, Macquarie University, Sydney, 2109, Australia [3] Department of Life Sciences, Imperial College London Silwood Park, Ascot SL5 7PY, United Kingdom[4] Department of Natural Sciences, Manchester Metropolitan University, Manchester, M1 5GD, United Kingdom

[5] Corresponding author, e-mail: julia.schroeder@imperial.ac.uk

ABSTRACT

Manx Shearwater is the most numerous breeding bird species on Lundy, and vocalisations play an important role in their communication. Here, we present an overview of knowledge on Manx Shearwater vocalisations, and of research that has been carried out on this topic on Lundy. Then observations of a previously unknown vocalisation behaviour are described, which led us to hypothesize that the nest burrows of Manx Shearwater's could amplify the calls emitted inside the burrow. Our study is the first to test this novel hypothesis. Our research on the Lundy Manx Shearwater population is a significant contribution to the study of their natural history and communication behaviour.

Keywords: *Manx Shearwater, vocalisation, communication, individuality*

INTRODUCTION

Background

A survey in 2023 conducted by The Royal Society for the Protection of Birds (RSPB) found that more than 25,000 Manx Shearwaters (*Puffinus puffinus*) bred on Lundy in that year (Davis and Jones, 2024). This was a new record for the island and the population continues to expand rapidly, a result of the successful conservation project in 2004 which removed rats from the island (Davis and Jones, 2024). Manx Shearwaters are pelagic and migratory seabirds of the family Procellariidae. These long-lived birds undertake trans-equatorial, trans-Atlantic migration every year between their oceanic breeding grounds in the North Atlantic (including Lundy) and their non-breeding areas, which extend to the seas far off the eastern South American coast (Guilford *et al*, 2009). Manx Shearwaters are long-lived, socially monogamous and reunite with the same mate year after year at their breeding colony (Brooke, 1977, Brooke, 1978). While some shearwater species do copulate extra-pair (Bried *et al*. 2010), no such study has been done in Manx Shearwater. To breed, Manx Shearwaters typically return to the same nesting burrow year after year, however, they may move burrows after a poor previous breeding outcome (Brooke, 1990). The birds form large breeding colonies on the slopes of islands in the North Atlantic.

Generally, Manx Shearwaters breed in burrows in the ground, in cave-like rocky outcrops, or even in man-made structures. On Lundy, most birds breed in old rabbit burrows, with a few pairs every year breeding in artificial burrow boxes that are accessible for research purposes (Plate 1 and more information below). The occupied burrows can be grouped into loose colonies. Generally, burrow quality is known to be associated with variation in breeding success (Thompson, 1987, Storey and Lien, 1985). In breeding locations where no pre-existing burrows are available, birds excavate new ones – construction of such can take a whole breeding season. Given the high availability of rabbit burrows, such is unlikely on Lundy. However even here, Manx Shearwater renovate their burrows every year, clean them from debris and re-excavate where needed (Lockley, 1942).

Then, Manx Shearwaters typically spend up to six weeks on the breeding grounds before egg laying, during which females spend a lot of time out on sea to gather nutrients and form the egg. On land they are active almost exclusively at night. They assemble at sea in the late afternoon in large rafts and only fly into their breeding colonies after dark (Brooke, 1990). The female typically lays one egg per breeding season (Harris, 1966), on Lundy starting in May. The chicks hatch in June and July (Brooke 2004), and both parents provide parental care to the nestling over a period of approximately 62 days (Brooke, 1990).

How Manx Shearwaters initially manage to find their mate after such long-distance migration, and how they recognise each other among thousands of conspecifics present at the colony, has drawn the interest of researchers. The answer to both questions may lie in the shearwaters' vocalizations. Given that their eyes are not specifically adapted to night vision (Martin and Brooke, 1991), it is unlikely that they rely purely on vision to recognise and locate their mate and nest burrows in the dark. However, upon arriving at the colony, both sexes emit a series of prolonged rasping calls, in the air or from the ground. This behaviour implies that vocalisation may be important for recognising and locating their mate (Brooke, 1990).

Nest Burrow Inspection Behaviour

In 2021, we noted a previously undescribed behaviour in Manx Shearwater. We used motion-activated infra-red trail cameras to passively record Manx Shearwaters on the breeding site on Lundy. The cameras were set pointing towards the entrance of natural burrows, so that every time when a bird entered or left the burrow the camera would record its movements and sound. We found a Manx Shearwater of unknown sex approaching a burrow, then stuck its head into the entrance, called into the burrow, and then left without entering (Sun *et al*, 2022). This behaviour had not been previously described and led to the novel hypothesis that Manx Shearwaters may use vocalisations in the context of burrow assessment during prospecting for nesting sites.

Manx Shearwater vocalisations differ between islands, colonies and individuals

To be used as cues for mate recognition, vocalisations must vary between individuals and contain information about individual identity. This individually distinct information coded in vocalisations, or "individual vocal signature", has been found in many bird and mammal species (Beecher, 1989; Seyfarth and Cheney, 2014; Thiebault *et al*. 2016). Earlier studies suggested that dialects existing among Manx Shearwaters on different islands (James, 1985).

The recordings of Manx Shearwaters on Lundy were included to test this hypothesis, revealing the existence of call variations among colonies (Du, 2023). This was confirmed in a follow-up study using data from the Lundy colonies and from three further colonies on Bardsey, which also found evidence for dialects among islands (Zhang, 2024).

It is long known that Manx Shearwaters females respond to their mate's call exclusively, while males were equally likely to respond to any female calls (Brooke, 1978). These behaviours suggest that at least male calls can contain elements that identify them to the females – individual signatures. We suggest that these signatures can account for the individual recognition in Manx Shearwaters. We conducted a quantitative analysis to confirm the existence of individual vocal signatures on the Lundy birds. Using acoustic analytic methods, we found that calls of Manx Shearwaters indeed contained individual signatures and identified temporal features (such as durations and intervals) and low-frequency components are most important for encoding individual signatures (Sun *et al*. 2023).

Here, we present a follow-on study testing whether Manx Shearwater burrow shapes change the sound of vocalisations. To be used for localisation, the vocalisations are required to propagate efficiently. Manx Shearwaters make calls from inside the burrow, and these calls will be louder for recipients present directly in the direction that the burrow tunnel points at than for recipients in other directions (Storey 1984). If this were true, burrow shape might be an adaptive trait that birds flying past can use to locate individuals in burrows. However, to what extent the burrows do amplify the calls produced from inside remains to be tested. Therefore, we designed and performed experiments to test the amplification effect of Manx Shearwater breeding burrows.

METHODS

Study site

The study site is a grassy slope on the west coast of Lundy, between Old Light and Battery Point, where the breeding density is highest among accessible colonies (Booker and Price, 2014). Apart from natural Manx Shearwater burrows, 10 artificial nest boxes were set on the study site by the RSPB in 2016 to study the breeding biology of Manx Shearwaters. These artificial burrows are wooden boxes of the same size, half-buried in the earth, connected to the ground with a plastic tube to be the entrance. Plate 1 shows a chick in such a box.

Measuring the amplification effect of the burrows

The burrows' quality for amplifying the bird calls was tested using playback experiments. In brief, a playback of two Manx Shearwater calls was played inside the burrows and re-recorded from outside the burrows at a 1 m distance. Using the same set-up, the same playback was played outside the burrows and re-recorded at 1 m from playback location, in the close vicinity of the burrow. By comparing the continuous sound level (Leq) of the two recordings, we quantified the burrows' ability to amplify sound played inside to the outside. We ran this experiment for 31 natural burrows and the 10 artificial nest boxes within the study area. Experiments were performed during the daytime in calm weather (wind speed < 8 mph, no rain) in the pre-breeding season (16 – 21 April 2021), when most of the burrows were not occupied by birds, to prevent disturbance. The recordings were then calibrated and used for acoustic analysis.

Plate 1: Manx Shearwater chick in a nest box on Lundy West Side11.07.2020 © Dean Jones.

Acoustic analysis

The amplification effect of the burrows was analysed in Raven Pro 1.6 (Cornell Laboratory of Ornithology). Because the playbacks played inside the burrows were further from the microphone than those played at the opening of the burrows, we expected the former to be quieter than the latter due to attenuation of sound pressure with distance, if there was no burrow amplification effect. This loss of Leq caused by distance was corrected using the spherical spreading loss equation: $Leq_2 = Leq_1 + 20*\log_{10}(d_1/d_2)$, where Leq_2 is the Leq corrected to the amplitude at 1 m, Leq1 is the measured Leq at distance d_1, and d_1/d_2 is the ratio of the distances from the sound source to microphone.

Statistical analysis

Statistical analysis was performed in R 4.0.3 (R Core Team, 2020). We compared the corrected Leq of calls played at the entrance of the burrows with the Leq of calls played inside of the burrows using a Gaussian linear mixed effects model (LMM), with corrected Leq as the response variable, position and call as fixed factors, and burrow as a random factor.

RESULTS

We found that for natural burrows, the Leq of calls played from inside a burrow was higher than the ones played outside the entrance of the burrow, even after correcting for distance ($n = 31$. LMM: $r = 0.800$, $p = 0.03$). However, this amplification does not compensate for the energy loss caused by distance (1.58 dB loss of Leq). In other words, for a recipient standing at 1 m from the entrance of the burrow, a bird calling from inside the burrow still sounds quieter than a bird calling at the entrance of the burrow. The amplification effect was significantly higher in the artificial burrows, not only compensating for the energy loss due to distance but even increasing the amplitude of calls from inside by 4.52 dB, such that calls from inside were even louder than calls at the entrance, despite the further distance the sound had to travel ($n = 10$. LMM: $r= 4.518$, $p < 0.001$, Figure 1).

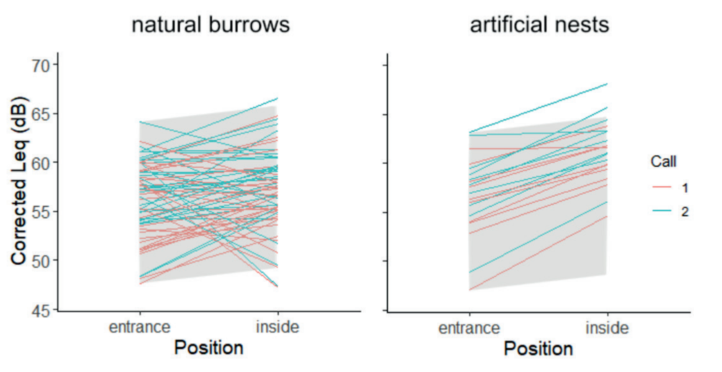

Figure 1. Continuous sound level received in 1m distance from either emission of vocalization inside a Manx Shearwater burrow on Lundy, or from outside the entrance (in dB). Lines depict differences in Leq (equivalent continuous sound level) in dB, corrected for distance. Red lines indicate the first call in the playback file and blue the second call. The two playback calls differed in amplitude and spectral properties and so were treated separately in the analysis. The shading indicates how much amplification an inside call needs to compensate the attenuation caused by distance. Both natural burrows and artificial nests amplify the calls ($p = 0.03$ and < 0.001 respectively), but in natural burrows, the amplification does not compensate the attenuation caused by distance ($r = 0.800 < 1.58$).

DISCUSSION

We found the natural nest burrows amplified calls produced inside the burrows, but this amplification effect was too weak to compensate for the loss caused by distance, if the receiver remained in the same place. In contrast, artificial nest boxes did amplify the calls, potentially due to the resonance of the construction. We found a large variation in the amplification quality of natural burrows. This variation could be attributed to the variation in the architecture of the natural burrows, including size (e.g. diameter of the tunnel, length of the non-curved section), shape (e.g. straightness, how uniform the diameter is) and the surface or material of the tunnel (e.g. smooth hard-packed dirt, stone on one or more sides, loose or lumpy dirt) (Li, 2020). There are many rocks and stones on Manx Shearwater colonies on Lundy, which could force the Manx Shearwater burrows to turn a corner. We expect a long straight cylindrical burrow entrance will have a clear amplifying effect (Keefe, 1984), while one that turns just behind the calling bird will have very little, and smooth hard surfaces will reflect more than rough or soft surfaces (Berry *et al*, 2016). Our findings highlight that burrow structure and the application of artificial nest boxes have effects on the animal's signal propagation.

Our findings suggested that the quality of a burrow could be partly affected by how well it amplifies calls. It is possible that the birds pre-breeding activities (re-excavation) could manipulate the amplification. However, a pilot study did not find a link between whether a burrow was occupied and it's acoustic qualities (Ren, 2022). Burrow choice was not associated with burrow quality with respect to likelihood of flooding either, presumably because the birds had no way to assess the quality of the burrow other than breeding in it (Thompson, 1987). Factors that drive Manx Shearwater's burrow choices other than the previous breeding outcome remain unknown, and whether burrow shape is important for Manx Shearwater breeding biology remains uncertain.

Apart from the vocalisations of the mate, other cues could also play a part in Manx Shearwaters' locating their nest burrows. Although Manx Shearwaters' eyes are not strongly adapted to night vision, visual cues could still play a role, for example, after they land on the colony (Brooke, 1990). Proprioception, the sense of self-movement, force, and body position, could also play a part in reaching the burrow (Brooke, 1990). While it is unclear whether smell is used as a cue for locating burrows by Manx Shearwaters, it might be used by other petrels (Brooke, 1990).

Our studies on vocalisation behaviours of Manx Shearwaters on Lundy have contributed to the knowledge of the natural history of the species as well as animal communication behaviour in general. Further research on vocalisations in Manx Shearwaters is ongoing. An incoming PhD project will study of the development of vocal behaviour and individual vocal signatures in juveniles, and the degree to which offspring vocalisations resemble those of their parents. Furthermore, the recordings taken of Manx Shearwaters on Lundy for this and previous studies are also used to develop methods to separate overlapping vocalisations using deep learning, which continues to contributes to the methodology of bioacoustics analysis (e.g. Liu, 2023), with the aim of using machine learning to semi-automate the currently labour-intensive breeding census of this species. There is clearly still much to learn about the vocalisations of these magnificent seabirds.

ACKNOWLEDGEMENTS

We sincerely thank the Lundy Field Society for supporting YS to present the study on individual vocal signatures at an international conference (EMPSEB 28, Scotland). We also thank Tony Taylor, Dean Jones, Rosie Ellis, Ben Arkless for their help with the fieldwork. We thank Lundy company and its staff for making Lundy a lovely place to live! We also thank the reviewers of our paper for their useful criticism.

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BAT RESEARCH ON LUNDY ISLAND 2014-18

by
GEOFF BILLINGTON
Greena Ecological Consultancy .
email: geoffbillington@btconnect.com

ABSTRACT
The study, carried out between 2014-18, aimed to survey bat presence and activity at different locations and sites across Lundy i.e. water bodies, woodland, buildings, selective caves and tunnels. Methods used included: short and long duration static bat detector recording; building, cave and tunnel inspections; bat emergence surveys; bat trapping and radio tracking. Eleven bat species were recorded, some of which will only be transitory and day roosting for short periods. Common Pipistrelle was the most common resident on the island but the fluctuations in numbers suggested that there is regular interchange to/from the mainland.

Key words: *Lundy, bat species, static monitoring, bat migration, bat roosts, radio tracking.*

INTRODUCTION

Long term studies of bat movements in Europe have shown that most species migrate up-to 2000km and this is also the case for one of smaller species, *Pipistrellus nathusii.* All other species can move annually distances up to several times their daily range. Hutterer *et al*. 2005 reviewed over 70 years of bat ringing records of over 1 million bats. The results showed that most bat species migrate. Of those occurring in the UK, most were recorded traveling seasonally at least 300km, with some over 1500km (Noctule & Leislers), and up to over 1900km (Nathusius Pipistrelle*).*The species considered to be mainly sedentary (Long-eared, Bechstein's, Lesser & Greater Horseshoe) were still found to occasionally move seasonally, with Greater & Lesser Horseshoe ranging up to 320km & 153km respectively, and others over 70km.

Lundy is a small island composed mainly of granite with steep ground or cliffs rising over 100m to a flat plateau with highest ground of 143m, partially intersected by one short, wooded valley/coombe in the southeast. The island is around 5km long and 1.3km wide. It is located 18km north of Hartland Point and 27km west of Baggy Point in North Devon, well within the migratory range of bats. The aim of the study was to increase the knowledge of Bat's use of Lundy and to try to determine if migration was occurring through the island.

METHODS

Objectives

The main objectives were:-

- To determine which bat species occur on Lundy.
- To find where resident bats roost and decide the roost status.
- To investigate whether there is seasonal variation in bat activity levels and whether migration occurs.

These were to be achieved as follows:-

- Long term static monitoring by bat detectors to determine species present and changes throughout the year.
- Island-wide static monitoring by bat detectors to determine species present and snapshots of activity in May and September.
- Attempted trapping and radio tracking to determine roosts and activity on and/or passage through the island in September.
- Investigation of most buildings by bat activity surveys and some by inspection to determine bats occupying them.
- Investigation of accessible caves and a tunnel (Benson's Cave) to determine bat use.

Long term static monitoring 2014-2015

Two Batcorder bat detector units were used, powered by solar panels through a voltage controller. Control units daily transmitted details of previous night's recordings, card space and voltage of systems by mobile text. Figure 1 shows the locations of the two static detectors fixed to trees. Bat detector one was located on a tree at the head of Millcombe valley below the east side of the village and recorded from April 2014 to August 2015. Bat detector two (Plate 1) was located on a tree in Quarter Wall Copse on steep ground southwest of Quarry Bay, and recorded from May 2014 to August 2015.

Figure 1: Locations of Bat Detectors on Lundy.

Island-wide short duration static recording

On the 1st September 2015 a single night recording sessions was carried out at: Quarry beach, Landing Beach, Rat Island, Pondsbury and inside St Helen's Church.

From 26th May-2nd June 2018 multiple night recordings were made at the following locations: Battery, Benjamin's Chair, Jetty, Jenny's Cove, Millcombe, Mouse Hole & Trap, Path to North Light and Quarry Pool.

Plate 1: Bat detector two in Quarter Wall Copse.

Building inspections

In 2015 there was a check by Laura Holmes and Tereza Rush who conducted several potential roost inspections. Sites included the following: -

- Square cottage
- Fire Station
- Old House South
- Old House North
- The Battery
- The Church
- Quarter Wall cottage
- Felix Gade Bothy
- Millcombe House outbuilding

Plate 2: Queen Mabb's Grotto.

Plate 3: Benson's Cave.

Caves

Watson (2012) provides an up-to-date list of the caves on Lundy. Five caves and a tunnel that could be reached easily and by straightforward scrambling were investigated. These were: Benson's cave (tunnel), subterranean passage under Rat Island, cave at Mousehole & Trap, Landing Key cave, Sentinels cave and Queen Mabb's Grotto.

It would be a project in itself to investigate all the island's caves for bats. A number of factors severely restrict surveying the caves:-

- Most are very difficult to access, with vertical cliffs and tidal conditions.
- The majority are used by resident Grey Seals throughout the year so preventing access to most caves at sea level.
- Important colonies of sea birds nest on the island particularly on the west and south coasts preventing access during the nesting season.
- Sea conditions are frequently unsuitable for access close to the cliffs by boat.

Bat emergence surveys

These were carried out mainly by Tereza Rush at: -

- Square Cottage
- Fire Station
- Old House South
- Old House North
- Farm barn
- Quarter Wall cottage
- The Church

Trapping and radio tracking

Trapping and radio tracking were undertaken under Natural England licence 2015-8374-SCI-SCI. On the 1st to 5th September 2015 three surveyors stayed on Lundy; a fourth surveyor was due to take part with a hired boat and skipper that would work throughout the night with radio tracking from the sea, but strong north east winds meant the idea had to be abandoned.

Trapping was carried out at Quarry Pond and in Millcombe Valley on three nights, bats were caught in single height mist nets. After capture, bats were held in catch bags before biometric data were obtained. Animals were identified, measured, sexed, and the reproductive condition of females was assessed. Bats if in good health, of a good size and not heavily pregnant, were radio tagged They were fitted with lightweight radio-tags of maximum weight 0.31g. By adding the weight of the glue the maximum weight that each bat could carry was set at no more than 5% of its body weight. The transmitters had an expected battery life of at least 7 days.

The transmitters were attached to the back of the bats between the scapulae, the fur was trimmed, and the tag was glued close to the skin using surgical ostomy cement (Salts adhesive), then the bats were put into a bag to settle / calm down and for the glue to dry prior to release. No injuries or excessive stress to any bats resulted from the catching and tagging, and all bats were recorded feeding afterwards. Tagged bats were released and radio-tracked for up to four consecutive nights. The ferry 'round island tour' was used to locate the Pipistrelle in the eastern cliff.

Two fieldworkers, experienced in radio-tracking, used *Australis* 26K or *Sika* radio receivers with

Yaggi rigid aerials to track bats. Both receivers are able to automatically scan through the different frequencies, which made it possible to search for more than one tagged bat at any time.Bespoke recording sheets were used to record data and a combination of radio sets and mobile phones were used for two-way communication. Accurate bearings of bat locations were taken from handheld sighting Silva Expedition 54 compasses. Global Positioning System devices were used to increase the speed and accuracy of the surveyors supplying exact location of surveyors continuously. Bearings of up to 1° accuracies were obtained. The data used in this report were gathered by using joint bearings (fixes, positive contact).

For all tagged bats the following data were recorded: -

- Observer location.
- Bat ID number.
- Triangulation bearings.
- Apparent location, route and behaviour.
- Roost location and details when located.

Whenever bats were commuting or at their first foraging sites, they were usually observed from fixed, often elevated points chosen where good radio reception was available, such as at high or other suitable vantage points. Where possible surveyors made close approaches to bats, to ascertain the exact foraging area and behaviour or to commence pursuit if the bat was moving away. Tracking ended when all bats had returned to the roost, moved too distant or were static.

At the start of each survey night, environmental conditions were noted. These included wind strength and direction, rainfall, cloud cover and air temperature. Any significant changes in weather throughout the survey period were also noted. Daytime work included verifying roost occupation, recording and plotting out results and investigation of any night roosting sites discovered during the tracking sessions.

The locations of the tagged bats were recorded in regular intervals throughout the night by simultaneous triangulating the signal direction. Two or three field workers co-ordinated their simultaneous bearings remaining in contact with one another using hand-held licensed channel FM- radios. Time, location of observers, bearings on the bats, accuracy data and general observations were recorded in the field onto bespoke data sheets. The positions of the bats in the field were calculated from the bearings using software package Locate III (2011).

Limitations

Underground sites

It was not realistic to access many of the caves and mines due to the presence of seals and seasonal nesting seabirds. In addition, the high rifts in some of the longer caves would be difficult to view/access. We believe a number of migrating bats may stop over in caves, but it is difficult to prove.

Radio tracking

The accuracy of a radio location varies with habitat type and may result in biased estimates of observed habitat use, Lundy's physical structure creates two extremes: signals being completely shielded (so zero reception) or good vantage from cliff tops to pick up signals to a distance.

Weather conditions (see Table 1) were suitable for bat emergence and foraging throughout the duration of our study (1st to 5th September 2015).

Building surveys

Even though repeat surveys were conducted of some buildings the nature of temporary transitional Day-roosts means that it is likely that bats were absent on some surveys.

RESULTS

Long-term static monitoring 2014-2015

Batcorder 1 (Millcombe):-

- The majority of recorded calls were Common Pipistrelles *(Pipistrellus pipistrellus)* followed by unidentified Pipistrelle species *(Pipistrellus spp.),* Soprano Pipistrelles *(Pipistrellus pygmaeus)* and unidentified bat species.
- Greater Horseshoe bats *(Rhinolophus ferrumequinum)* were recorded in low numbers mainly towards the beginning of the season.
- More unusual species included Nathusius Pipistrelle *(Pipistrellus nathusii),* Barbastelle *(Barbastella barbastellus)* and Savi's Pipistrelle *(Pipistrellus savii)*, species not considered resident in the UK.

- Other species included Noctule *(Nyctalus noctula)*, Long-eared bat *(Plecotus spp.)* and Myotis species *(Myotis spp.)* in low numbers. Myotis bats were mostly not identified to species with the exception of individual Natterer's bats *(Myotis nattereri).*
- Peak activity occurred between mid-August and mid-September.

Batcorder 2 (Quarter Wall Copse):-

- The vast majority of recorded calls were Common Pipistrelles *(Pipistrellus pipistrellus)* up to 98%.
- Greater Horseshoe bats *(Rhinolophus ferrumequinum)* were recorded throughout May, in relatively high numbers.
- More unusual species included Alcathoe bat *(Myotis alcathoe)* – a species only recently discovered and Kuhl's Pipistrelle *(Pipistrellus kuhlii)*, a species not considered resident in the UK and Nathusius Pipistrelle *(Pipistrellus nathusii).*
- Other species included Soprano Pipistrelle *(Pipistrellus pygmaeus)*, Noctule *(Nyctalus noctula)* and Long-eared bat *(Plecotus spp.)* as well as a Pipistrelle of unidentified species *(Pipistrellus sp.).*
- Peak activity occurred between the second week of August and the end of August.

Unfortunately, no weather data was available for most of this recording period as Warden Rebecca MacDonald reported the weather station was defective.

Island-wide short duration static recording

Table 1: Static bat detector recordings 1-2 September 2015.

Site Landing beach Quarry beach	Common Pipistrelle 13 3 + social calls	Savi's Pipistrelle	Natterer's
Rat Island	1127	1	2
Pondsbury			
Inside Church			

The social calls recorded on Quarry Beach suggest male roost(s) in cliffs close to the Pipistrelle cliff roost. High Common Pipistrelle foraging activity occurred on south (sheltered) side of Rat Island likely to be due to brisk NE winds.

Table 2: Static bat detector recordings 26th May to 2nd June 2018

Site	Date	Common Pipistrelle	Nathusius Pipistrelle	Savis Pipistrelle	Myotis
Battery	26/05/2018				
	27/05/2018				
	28/05/2018				
	29/05/2018				
	30/05/2018				
Benjamins Chair	26/05/2018	3			
	27/05/2018	5			
	28/05/2018	52	23		1
	29/05/2018	4			
	30/05/2018				
	31/05/2018				
	01/06/2018				
Dive Hut on the Jetty	26/05/2018				
	27/05/2018				
	28/05/2018	2			
	29/05/2018				
	30/05/2018				
	31/05/2018				
	01/06/2018				
	27/05/2018				
	28/05/2018	4			
	29/05/2018	2			
	30/05/2018	3			
	31/05/2018				
	01/06/2018				
	27/05/2018	13	1		
	28/05/2018	1			
	29/05/2018	1			
	30/05/2018				
	31/05/2018				
	01/06/2018	4			
Millcombe	26/05/2018	1			
	27/05/2018	4			
	28/05/2018	4	1		
	29/05/2018	3			
	30/05/2018	34			
	31/05/2018				
	01/06/2018	4			
Mouse Hole & Trap	26/05/2018				
	27/05/2018				
	28/05/2018				
	29/05/2018				
	30/05/2018				

Site	Date	Common Pipistrelle	Nathusius Pipistrelle	Savis Pipistrelle	Myotis
Path to North Light	26/05/2018				
	27/05/2018				
	28/05/2018	4			
	29/05/2018	2			
	30/05/2018	3			
	31/05/2018				
	01/06/2018				
Quarry Pool	26/05/2018	3			
	27/05/2018	373	48		
	28/05/2018	345	10		
	29/05/2018	92	5		
	30/05/2018	115			
	31/05/2018				
	01/06/2018	519	53	1	1
	02/06/2018	1638	148		

These recordings showed significant numbers of Nathusius Pipistrelle (a migratory species) either temporarily resident before moving on or continuously passing through at the end of May/early June, not present in September 2015.

Surveys for roosts in buildings and underground sites and bat emergence surveys. Old House South was possibly a small nursery before 2010 of Common Pipistrelle bats but since then a day roost of small numbers of individuals.

Signs of Greater Horseshoe bats were found in Queen Mabbs Grotto and The Battery. It is most likely they roost in other caves when moving seasonally.

Table 3: Roost Surveys.

Site	Findings	Type of roost
Bensons Cave	Odd droppings	Night
Queen Mabb's Grotto	10+ GHS & 6+ LE or Myt	Night, possibly day
Sentinel Cave	2 droppings	Night
Landing Quay Cave	Droppings	Night
Square Cottage	1x 45P emerging	Day
Fire Station	1x 45P emerging	Day
Old House South	c24x 45P bats resident 2010 & before	Possibly nursery or day
	5x 45P bats resident 2013	Day
	3x Pp droppings in attic 2015	Day
Old House North	1x Pp dropping in attic 2015	
The Battery	1x BLE bat and GHS & Pp droppings	Day & night
The Church	2 droppings	Day
¼ Wall Cottage		Day
Felix Gade Bothy	Droppings	Night
Millcombe outbuilding	Droppings	Night

45P – Common Pipistrelle, BLE – Brown Long-eared, GHS – Greater Horseshoe, Pp – Pipistrelle species

Tracking

During the September 2015 fieldwork on the island only four species were recorded foraging on the island, over three nights in different locations. Two bats were caught and radio tagged, a female Common Pipistrelle and a female Brown Long-eared Bat. The Common Pipistrelle was recorded late into the first night heading several kilometres (>5km) out to sea towards Baggy Point (27km away) subsequently it was found to have returned, roosting in a Manx Shearwater burrow in a cliff on the east side of the island (Plate 6) for four nights, emerging to feed at Quarry Pond and the east coast each night. The Brown Long-eared headed south later in the night and probably left the island towards Hartland Point (18km away).

Plate 4: Pipistrelle Bat © Geoff Billington.

Plate 5: Long-eared Bat © James Shipman.

Plate 6: Location of the Manx Shearwater burrow roost on the east side cliffs.

Plate 7: The Battery, the location of a bat roost on the west side of Lundy © Alan Rowland.

Table 4: Weather during trapping and tracking

Date	Temp C	Rainfall mm	Wind km/hr	Cloud %
01-09-15	15-16	0	19-34	29-87
02-09-15	14-16	0.2	22-36	49-79
03-09-15	14	0	19-39	40-85
04-09-15	14-15	0.4	25-41	37-88
05-09-15	15-17	0	24-40	46-78

Table 5: Captured bats

Bat species	sex	age	breeding condition	date of capture	location	Grid ref.	Forearm/ weight
Common Pipistrelle	F	adult	Post- lactating	01-09-15	Quarry Pond	SS137864 50	31.1/5.5
Brown Long- eared	M	adult	nulliparous	02-09-15	Millcombe Valley	SS140244 02	39.0/7.4

CONCLUSIONS

Nine species of bat were recorded and are listed below, together with their status on the island.

Table 6: Bat species and island use.

Bat species	Use of island	Migratory
Common Pipistrelle	Resident day roosting, possibly nursery before 2010, moves between island and mainland	Not indicated
Soprano Pipistrelle	Odd bats day roosting on the island, passing through island in September	Yes
Savi's Pipistrelle	Possible individual bats day roosting, passing through island in September	Yes
Nathusius Pipistrelle	Odd bats resident day roosting on the island, passing through island in July & September	Yes
Barbastelle	Odd records, probably visiting from mainland	Not indicated
Noctule	Odd records, probably visiting from mainland	Not indicated but they do migrate so probably not via the island
Great Horseshoe	Only recorded in May & early June passing through the island resident day roosting for limited periods	Yes
Brown Long-eared	Resident day roosting, moves between island and mainland	Not indicated
Natterer's	Resident day roosting	Not indicated

Four bat species were found to migrate via the island, Greater Horseshoe in early summer and three Pipistrelle species in late summer/early autumn. All migrating bats apparently passed through the island only one way, using alternative routes at the other end of the season.

Four caves and nine buildings were confirmed as bat roosting sites.

ACKNOWLEDGEMENTS

The National Trust and The Landmark Trust are thanked for giving consent for access to their land and for assistance from the island staff in transporting and setting up equipment and advice. The Lundy Field Society are thanked for providing information, including freshwater, sheltered habitats and caves on the island and for a grant which funded accommodation during the September 2015 fieldwork.

The Volunteers who have assisted me with fieldwork and/or data processing: Tereza Rush, Stephen Davison, Linda Kergon, Laura Holmes and Jaqueline Billington.

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EDITOR'S NOTE

Further studies by eDNA metabarcoding of the ecology of the Grey Waxcap (Cuphophyllus lacmus) and other fungi on Lundy by Ruben Mole, John N. Hedger, Alan Rowland, Andrew P. Detheridge and Gareth W. Griffith…follows this note.

In view of the 'information dense' nature of their account I felt it might be useful to explain some of the technical terms used, listed in the table below, most of which will be unfamiliar to many Lundy Field Society members. The project, which arose from previous field work done by LFS members, was supported by LFS grants to the lead author, Ruben Mole and to Professor Gareth Griffith.

Plate 1: Fruit bodies of the Grey Waxcap (*Cuphophyllus lacmus*) in Heather at the North End © David George.

Term	Meaning
ASV	Actual Sequence Variant: DNA sequence that represents a true biological sequence after correcting for errors
basidiolichen	Lichen made up of a basidiomycete fungus (e.g gill fungi)and an alga
biotrophic fungus	A fungus only able to grow in association with a living plant
CHEGD	Acronym of the names of fungi whose presence in grasslands indicates a high conservation value (Clavariaceae ,Hygropohraceae, Entolomataceae, Geoglossaceae & Dermoloma).
clade	A natural grouping of organisms that is composed of a common ancestor and all of its descendants.
eDNA	Environmental DNA (DNA extracted from the natural environment- e.g. water, soil, air)
Metabarcoding	Large-scale sequencing of DNA barcode regions obtained from eDNA samples (for fungi/plants ITS2 locus is generally used)
Endophytic fungus	A fungus living inside a leaves,stems etc of a plant with little or no effect on the host
epitypification	Designation of a 'type' for a species where the original material , e.g a dried specimen used to name name a specie, no longer exists or was a painting
GenBank/NCBI	Public database of DNA and protein sequences run by the National Center for Biotechnology Information, Bethesda USA (**https://www.ncbi.nlm.nih.gov/**)
Isotopic data	Relative abundance in the sample of (non-radioactive) isotopes (e.g 1% of nitrogen in air is the heavier 15N isotope [with 99% being the more 14N). Similarly for 13C and 12C carbon
ITS2 region	Barcode region for metabarcoding of Fungi. Part of the ribosomal RNA (rRNA) locus. These genes encode components of the ribosome
mycorrhiza	Mutual (symbiotic) association of plant roots with fungi
NVC Classification	System developed by John Rodwell for classificiation of plant communities across UK
ordination	Method of visualising complex (multivariate) data in simpler 2-dimensional (XY) plot. Where only the two most important components of variance across the samples are presented.
OTU	Operational taxonomic unit. Cluster of closely related sequences (typically 97% or more identical). Could represent the range of sequence of a given gene which occur in a single species
PCoA	Principle Coordinates Ordination -an ordination method
PCR	Polymerase Chain Reaction:a laboratory technique for rapidly copying specific segments of DNA, creating millions of copies from a tiny sample for analysis
phylogenetic reconstruction	Creating of a phylogenetic tree to reflect the evolution of a group of related organisms based on DNA sequences
Primer	Short synthetic DNA sequence used in PCR reactions
RA	Relative Abudance (here as % of all the fungal sequences in a sample)
Read/reads	A single sequence from the metabarcoding process
saprotrophic fungus	A decomposer fungus which derives its nutrition from dead organic matter
Sequence/sequencing	Determining the order (sequence) of nucleotides in a DNA molecule i.e. the DNA 'code'.
SIMPER analysis	SIMPER (SIMilarity PERcentages) analysis is a statistical method used in ecology to identify which species contribute the most to the differences between groups of samples
Taxon/taxa	usually species e.g of fungi
Type specimen	original specimens used to first describe a species, usually based on the dried example kept in a herbarium (fungarium) but can be a painting (18th & 19th century taxonomy).
UNITE data base	an international data base for the molecular identification of fungi and other organisms
UNITE species hypothesis (SH)	Species Hypothesis code obtained from UNITE. Many but not all of these SH codes are linked to Latin binomial names for known organisms

FURTHER STUDIES BY eDNA METABARCODING OF THE ECOLOGY OF THE GREY WAXCAP (*CUPHOPHYLLUS LACMUS*) AND OTHER FUNGI ON LUNDY

by

Ruben Mole[1], John N. Hedger[2], Alan Rowland[3], Andrew P. Detheridge[4] and Gareth W. Griffith[4*]

[1]Department of Life Sciences, Faculty of Natural Sciences, Imperial College London, London SW7 2AZ
[2] 9 Durnamuck, Dundonnell, Little Loch Broom, by Garve, Wester Ross, SCOTLAND, IV23 2QZ
[3] Mole Cottage, Woodford, Morwenstow, Cornwall, EX23 9JR,
[4] Department of Life Sciences, Pont Cledwyn, Aberystwyth University, Penglais, Aberystwyth WALES SY23 2DD
* Corresponding author: *gwg@aber.ac.uk*

ABSTRACT

The metabarcoding of fungal environmental DNA (eDNA) was used to study the fungal community of ten 0.09 ha quadrats on Lundy dominated by Heather (*Calluna vulgaris*). At each site samples of soil, Heather roots and lichen (*Cladonia* species) were removed, and following storage and transport off the island were assayed by eDNA extraction and metabarcoding at Aberystwyth University. 1331 unique fungal OTUs (operational taxonomic units, approximating to species numbers) were detected in soil, lichen and roots. The northerly distribution of the Grey Waxcap (*Cuphophyllus lacmus*) on Lundy, previously established by fruit body surveys, was confirmed via eDNA. The significant presence of *C. lacmus* in Heather roots suggests it may be mycorrhizal (mutualistic), consistent with isotopic data and the general lack of saprotrophic ability amongst Hygrophoraceae. However, another agaric fungus, *Mycena galopus* was regularly the most abundant basidiomycete species detected in Heather roots, likely as a latent decomposer of senescent roots. A number of the other species of fungi found during the study represent new records for Lundy and data suggest an undescribed species of Waxcap may be present at the North End.

INTRODUCTION

As of 2023 a total of 833 different species or forms of true fungi, excluding the Slime Moulds and the Chromista, have been recorded on Lundy (Lundy.org.uk 2024) . The records are all based on morphology via identification of fruiting bodies of the macrofungi from field collections, as well as by microscopy of microfungi on living and dead plants and insects. Griffith *et al* (2020) were the first to study the mycoflora of Lundy by analysis of fungal eDNA of profiles in soil samples. eDNA is DNA released from an organism into the environment (Niemiller *et al.*, 2017) and is a useful tool to assess biodiversity (Bellemain *et al.*, 2010) by comparing sequences to data held online

Griffith *et al* (2020) analysed fungal eDNA in soil samples across six selected sites on Lundy in 2016. The aim was to compare the results of fruiting body and eDNA surveys of grassland fungi, especially the CHEGD species : **C**lavariaceae (Club Fungi), **H**ygrophoraceae (Waxcaps), **E**ntolomataceae (Pink Gills) , **G**eoglossaceae (Earth Tongues), **D**ermoloma/Porpoloma). Particular emphasis was placed on one species of Waxcap *Cuphophyllus lacmus* (Grey Waxcap). Yearly surveys in November by members of the Lundy Field Society since 2006 had shown that fruit bodies of this fungus seemed to be restricted to the heath of short Heather(*Calluna vulgaris*)and lichens (*Cladonia* spp.) on the north end of the island, none being found south of a line from Gannett's Coombe to St James stream on the west side, even on Heather dominated areas. Of the six sites studied, the samples from the two at the north end (one near John O'Groats and the other near Squires View), where fruit bodies of *C.lacmus* were regularly recorded, had significant presence of eDNA of this species (73% and 17 % respectively of the total fungal DNA) In contrast samples from the two grassland sites (Airfield and Castle Hill) had little or no *C.lacmus* eDNA .Of the two southerly Heather-dominated sample sites only one, below Rocket Pole, had significant presence of *C.lacmus* DNA but it was only 5% of the total fungal DNA in soil extracts. No fruit bodies of *C.lacmus* have ever been found here nor in the other sample site, above Quarry Pond.

The Grey Waxcap thus seems to be largely restricted to the species-poor Heather/lichen community at the north end of Lundy. The challenge is to determine the reason for this association. It is unlikely that the fungus acts as a decomposer saprotroph of Heather leaf and root litter in the soil, as *Cuphophyllus* and other Waxcap genera have yet to be grown in axenic culture (Halbwachs *et al.*, 2013a) and are not decomposer fungi in the usual sense, as they lack the depolymerase enzymes necessary to utilise lignocellulose from plant litter. A more likely hypothesis suggested by studies in grassland by Halbwachs *et al.* (2018), is that Waxcaps are biotrophic partners in mycorrhizal relationships with the roots of the higher plants. In the case of *C. lacmus* on Lundy, Heather is the most likely partner, being the only higher plant in the North End heathlands where its fruit bodies are found and where the soil samples also contained Grey Waxcap eDNA. Since the family Hygrophoraceae contains several genera of basidiolichens, notably *Lichenomphalia* e.g the Heath Navel (*L.ericetorum*) on Lundy, it is possible that *C. lacmus* may form an association with Chlorophyte algae (Oberwinkler, 2012).

We are also unaware of any similar observations of *C. lacmus* fruiting in such profusion amongst Heather from any other part of the British Isles and beyond. Lundy North End is very unusual from a vegetation perspective (Figure 1). From NVC classification it would be classified most closely to '*Calluna vulgaris-Cladonia arbuscula* heath' (NVC class H13a; (Rodwell, 1991)), a habitat mainly restricted to the Cairngorm region of Scotland. Unusually, the dominant lichen at the North End is *C. portentosa*, rather than *C. arbuscula* and *C. rangifera*, which more typically dominate H13a habitats. The unexpected presence of such a community at such low altitude and latitude, is likely to be due to the thin soils

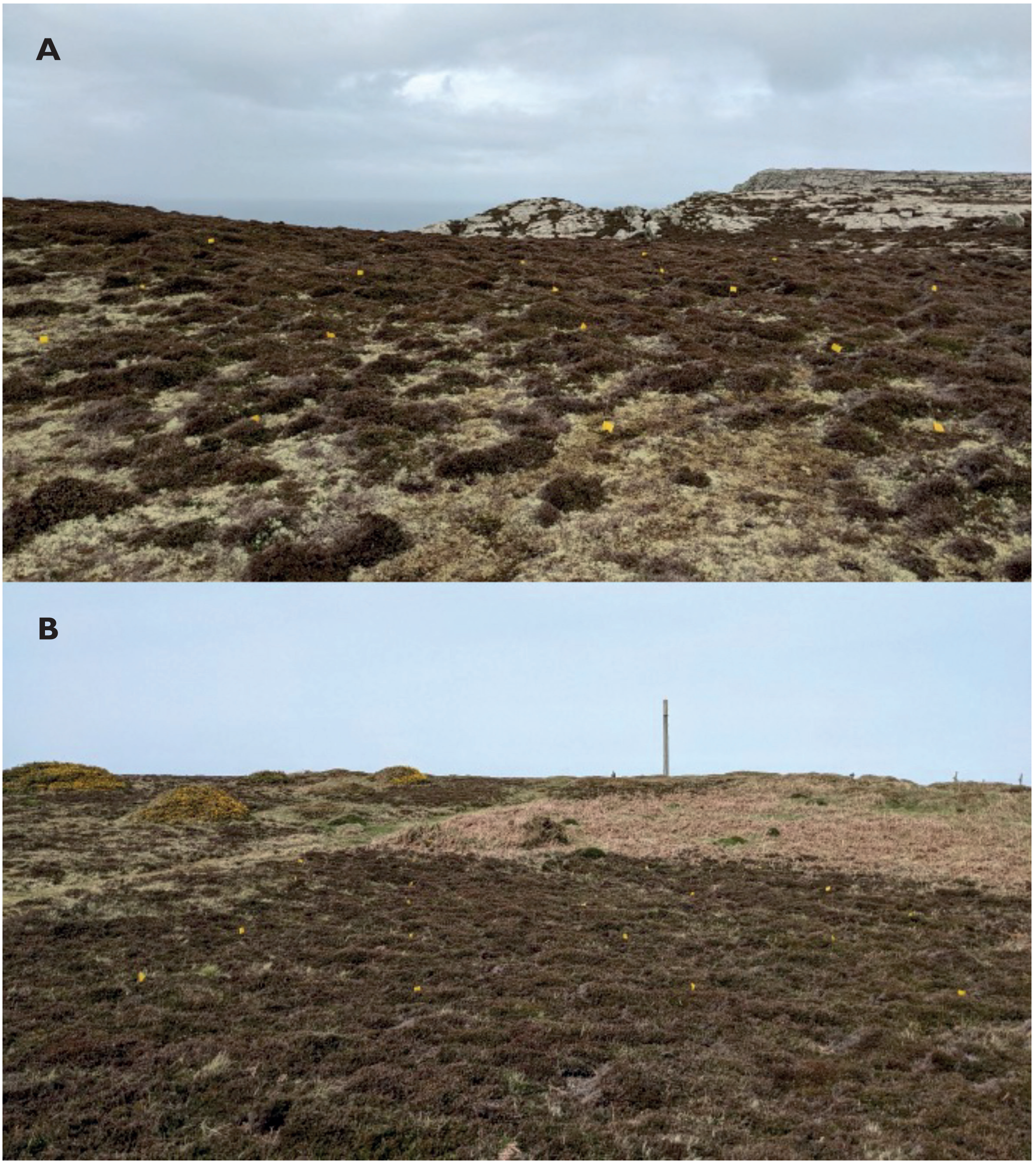


Figure 1. Heather vegetation on Lundy. A: Long Roost North (site NA1), viewed from the south, with high cover of *Cladonia* spp. (foreground) and heather; B: Rocket Pole West (site SC9), viewed from the south, with higher heather cover and little lichen. Yellow flags show the locations of the sampling positions.

on granitic rock, combined with the high wind exposure and salt spray, as well as the low levels of nitrogen deposition, to which the site is subject (Tripp *et al.*, 2012). However, it may be that the severe fire at the North End in the 1930s (Langham 1992), which destroyed much of the vegetation cover, may also be a causal factor.

AIMS

In order to test the hypothesis that the Grey Waxcap has a mycorrhizal association with either Heather or Lichen, more detailed island-wide sampling was needed. Consequently, sampling was carried out in April 2024 to compare its presence via eDNA extraction in soil, Heather roots and lichens at 10 sites north to south on Lundy

METHODS

a) *Sample Collection*

Sample collection at each site was based on the fungal eDNA sampling protocol set out by Natural England (Detheridge and Griffith, 2021). At each of the 10 sites (Figure 2), a 10 m x 10 m grid was laid out. Within each grid, 25 soil samples were taken with a T-bar gauge auger which had an 18 mm inner diameter and pooled into a sample bag; only the top 5cm of soil was taken. Four *Cladonia* thalli (each ca. 3x3 cm) were picked from a point 2 m from the edge of the grid and pooled as a single sample. It should be noted that no lichen samples were obtained from the two southern sites below Rocket Pole (SC9/SP10) due to their absence (Figure 2).

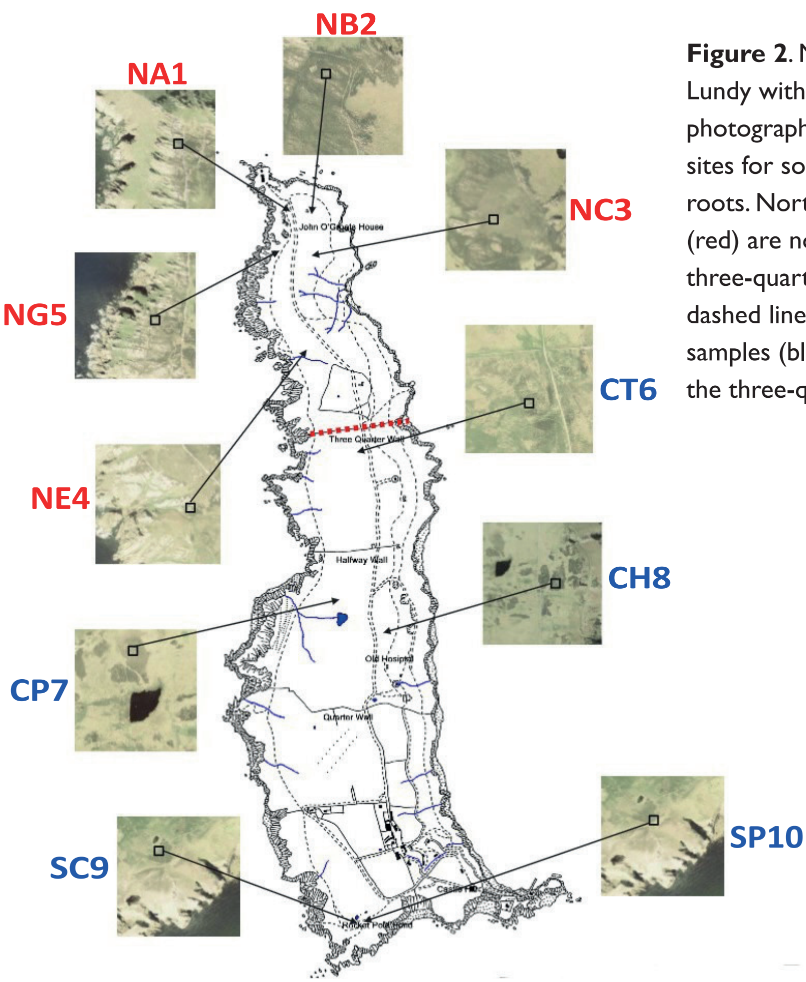


Figure 2. Map of Lundy with inserts of photographs of sampling sites for soil, lichen and roots. North samples (red) are north of the three-quarter wall (red dashed line). Southern samples (blue) are below the three-quarter wall.

Table 1. Sample and sample site details

Site code	Site name	La/Long	Soil cores FW (g)	Heather root FW (g)	Lichen thallus FW (g)
NA1	Long Roost North	51.199845, -4.674841	195	1.3	0.5
NB2	John O'Groat's House	51.199699, -4.673115	200	1.1	0.5
NC3	Gannets' Coombe	51.197597, -4.673056	188	0.7	0.3
NE4	St Peter's Stream	51.191669, -4.672654	193	0.9	0.7
NG5	Long Roost South	51.196979, -4.676416	200	1.3	0.5
CT6	Middle Park (Quarter Wall)	51.190889, -4.668675	203	0.8	0.5
CP7	Pondsbury	51.179143, -4.670674	210	0.5	0.7
CH8	Old Hospital	51.176913, -4.666633	213	1.2	1.1
SC9	Rocket Pole Pond West	51.161304, -4.668930	190	0.7	NA
SP10	Rocket Pole Pond East	51.161253, -4.668541	195	0.7	NA

Four Heather root samples were also taken 2 metres from the edge of the grid by cutting out a 10 cm x 10 cm x 5 cm (L x W x depth) soil block, which was then stored in a sample bag. On return to the Bird Observatory Laboratory in the Village, each root sample was soaked in water for at least 2 hours, after which the roots free of soil were removed with forceps, and washed again under water until 2 g of clean roots had been obtained; these were then stored in labelled sealed plastic bags. All sampling was undertaken on 5th April 2024 and samples were refrigerated within 6 hours of collecting. All equipment was scrupulously cleaned with soapy water between use on each site.

Since the site is protected under Section 28(E)(1)(a) of the Wildlife and Countryside Act 1981, sampling consent was obtained from Natural England (Charlotte Selway, Date: 4th March 2024)

b) *DNA Extraction*

Samples were sent to Aberystwyth University by overnight courier and stored at -80°C until the DNA extraction protocol had begun. For all stages, samples from different sample locations and sample types (soil, Heather roots and lichen) were kept separate, and thorough cleaning of equipment and lab space was conducted between handling of different sample locations and when switching between sample types. For the first step of this protocol, all samples were freeze-dried. The soil was freeze-dried for 1 week, and Heather root and lichen material for 24 hours. The soil samples were then sieved twice, first through a 2 mm sieve and then a 0.5 mm sieve. A 50 mg sub-sample of the fraction which had passed the 0.5mm sieve was stored in 2 ml test tubes. Lichen samples were crushed in bags using a pestle and mortar, and subsamples weighing between 10 mg and 19.5 mg were stored in 2 ml test tubes. Heather root samples were crushed in individual pestles and mortars, and 142 mg and 365 mg sub-samples were placed in 2 ml tubes. All samples were stored at -20°C until DNA extraction.

The DNA extraction of soil was conducted using the DNeasy PowerSoil Pro Kit, as described by the manufacturer's instructions, alongside two blanks, with the exception that

50 mg of freeze-dried soil was used for each location due to the hypothesised organic nature of the soil. The DNA extraction of roots was conducted using CTAB PVP lysis buffer (2% cetyltrimethylammonium bromide, 2% polyvinylpyrrolidone, 100 mM Tris-HCl, 1.4 M NaCl, 20 mM EDTA) alongside two blanks. The DNA extraction of the lichen alongside two blanks was conducted using CTAB DNA extraction as above, but without the PVP (2% cetyltrimethylammonium bromide, 100 mM Tris-HCl, 1.4 M NaCl, 20 mM EDTA).

A polymerase chain reaction PCR was then conducted on the DNA extracted from the samples using primers fITS7 and ITS4 (to isolate the ITS 2 region), which were supplemented at the 5' end with adaptors for 2nd round PCR. The 2nd round PCR products were quantified using the Qubit v2 Fluorometer with the broad range dsDNA kit and pooled in equal concentrations. The pooled library was cleaned using Ampure XP beads (Beckman Coulter) and quality checked using a Bioanalyser 2100 with high sensitivity chips (Agilent) and sequenced on the Illumina MiSeq platform (2x300 bp paired end reads).

c) *Bioinformatics*

The Illumina 2x300reads were paired using PEAR (Zhang *et al.*, 2014). Primer sequences were trimmed and the sequences quality checked with short sequences (<150bp) discarded using a Python script. Sequences were then clustered to actual sequence variants (ASV) using the UNoise3 algorithm (Edgar, 2016), singleton sequences and clusters of 5 or fewer sequences were rejected as likely sequence errors. Taxonomy of ASVs was assigned using the naïve Bayesian classifier (Wang *et al.*, 2007) against a data base created from UNITE v10 (downloaded February 2024) (Abarenkov *et al.*, 2024), with species hypotheses clustered at 98.5%.

The UNITE Species Hypothesis (SH) allows for identifying and communicating fungal species using DNA ITS sequences. Both described and undescribed fungal species are assigned a unique SH based on different levels of sequence identity (99.5% – 97%), here we use the numbers assigned to clusters at 98.5% identity. The SH is then assigned to a species name when those sequences are unambiguously named but can be left as a number if the species name is uncertain. This approach helps address the challenge of identifying fungal species, especially when actual species identification is absent but giving higher level taxonomic information.

RESULTS AND DISCUSSION

eDNA sequences recovered

From the soil and root samples taken from the five North and five South quadrats (see Figure 2 and Table 1 for a description of their locations), a total of 3,864,753 sequence reads were obtained. Following removal of singletons (sequences found only once) and low-quality sequences (76,868), as well as non-fungal sequences (254,048), there was a mean of 176,692 sequences per sample (range108,618-263,435). Similar sequences (>98.5% identical) were grouped into unique 'Species Hypothesis' (SH) clusters using the UNITE database, where they were linked to taxon names. Most SHs are linked to named species but for others, identification was only possible to higher taxonomic levels, since a high proportion of fungi are not yet sequenced and some also do not yet have reference barcodes. Within the whole dataset of soil and root samples, 1333 unique fungal ASV's were detected.

eDNA metabarcoding and distribution of 50 species of fungi in soil and root samples
eDNA metabarcoding analysis of the soil and root samples from the ten Heather quadrats is shown in Table 2. Relative abundance (as % of all fungal DNA sequences) of the 50 most common fungal taxa detected is given for soil (left hand side as two columns, *Soil north and soil south* and Heather roots (right hand side as two columns, *Root north and root south*). Also shown in the second to last column are the average abundance of these species in the Heather root samples. The ratio of abundance of the taxa in soil vs. root samples is shown in the last column. The Grey Waxcap,*Cuphophyllus lacmus* and Milking Bonnet, *Mycena galopus* are indicated in blue and red font respectively. Lower rows of the table indicate the cumulative abundance of the major families/orders found in the soil and roots.

Even with meticulous washing of roots, it not possible to be certain that all the adherent soil and mycelia have been removed (and some root fragments will be present in bulk soil). Equally it is likely that some of the roots sampled were in early stages of senescence. However, given the high disparity in relative abundance of different fungal species in roots vs soil (Table 2), it is likely that most have some endophytic capability and several may be mycorrhizal.

Communities of fungi detected in the soil samples
Analysis of the fungal communities present in the ten samples at class level (Figure 3) reveals the dominance of classes Eurotiomycetes and Leotiomycetes. Orders Chaetothyriales (12 of the 50 most abundant taxa; notably family Herpotrichiellaceae) and Helotiales (12 of the 50 most abundant taxa; notably family Helotiaceae) were dominant across all samples (mean RA 35% and 21%), thus dominating the fungal community (Table 2).

It is known that many species within these taxa are associated with the roots of plants but they are taxonomically poorly known, so most are only identifiable to family level. However, the most abundant species in the soil was identified to species level: *Pezoloma ericae,*

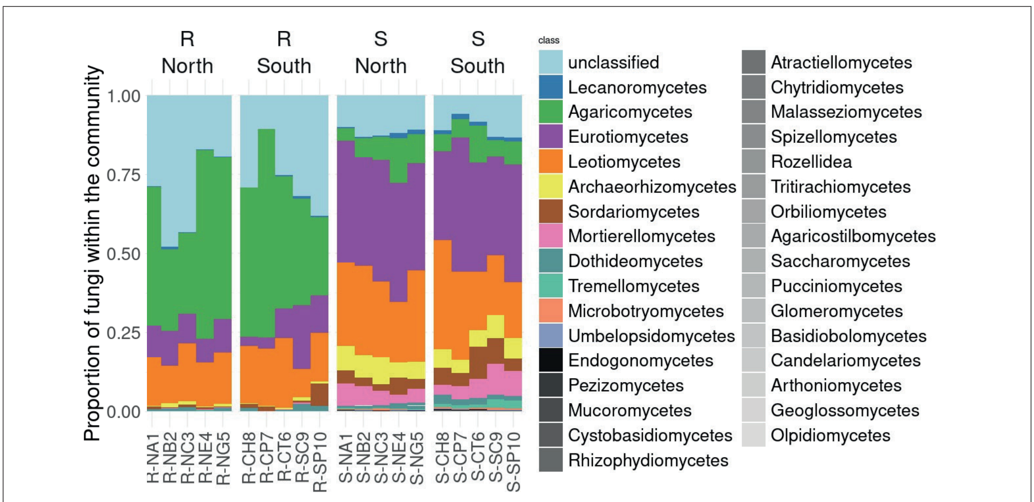


Figure 3. Stacked barchart, showing the more abundant classes of fungi detected by eDNA extraction in samples of soil and Heather roots from the North End sample sites.

Table 2. A list of the 50 most abundant species of fungi detected in soil and root eDNA at the 10 sampling sites.

				Soil NORTH					Soil SOUTH						Root NORTH					Root SOUTH						Soil:Root
	Phylum	Class	Species	NA1	NB2	NC3	NE4	NG5	CT6	CP7	CH8	SC9	SP10	Soil AVE	R-NA1	R-NB2	R-NC3	R-NE4	R-NG5	R-CT6	R-CP7	R-CH8	R-SC9	R-SP10	Root AVE	Ratio
1	Ascomycota	Leotiomycetes	Pezoloma_ericae:SH0897049.10FU	13.64%	18.63%	14.18%	6.041%	18.09%	5.436%	10.63%	13.14%	1.905%	0.742%	**10.24%**	1.685%	4.846%	6.480%	1.103%	2.980%	0.490%	3.783%	1.957%	0.254%	0.067%	**2.36%**	4.3
2	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:SH0828226.10FU	6.164%	3.881%	3.985%	7.500%	8.226%	9.446%	10.37%	8.292%	7.359%	6.182%	**7.14%**	5.94%	3.53%	2.86%	2.13%	3.69%	5.79%	1.83%	1.26%	10.87%	3.24%	**4.12%**	1.7
3	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:SH0828602.10FU	10.32%	9.054%	9.015%	6.980%	6.467%	5.976%	9.434%	3.914%	2.931%	3.615%	**6.77%**	0.412%	1.040%	0.958%	0.359%	0.678%	0.303%	0.194%	0.084%	0.344%	0.331%	**0.47%**	14.4
4	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:SH0827748.10FU	2.952%	3.723%	5.977%	4.925%	6.522%	3.419%	6.769%	7.615%	4.084%	4.791%	**5.08%**	0.475%	1.752%	1.188%	0.514%	1.079%	0.779%	0.468%	0.487%	2.901%	0.293%	**0.99%**	5.1
5	Ascomycota	Eurotiomycetes	Sclerococcum_sp:SH0855981.10FU	4.354%	7.878%	7.177%	4.862%	2.997%	4.052%	1.023%	5.290%	5.562%	5.701%	**4.89%**	8.19%	21.36%	15.64%	2.63%	4.42%	5.47%	0.39%	4.78%	8.56%	5.41%	**7.69%**	0.6
6	Ascomycota	Archaeorhizomycetes	Archaeorhizomyces_sp:SH0764667.10FU	5.602%	4.858%	4.557%	3.459%	3.847%	3.696%	3.975%	5.662%	4.555%	4.942%	**4.52%**	0.368%	1.034%	0.522%	0.245%	0.661%	0.272%	0.129%	0.136%	0.443%	0.629%	**0.44%**	10.2
7	Mortierellomycota	Mortierellomycetes	Podila_humilis:SH0879619.10FU	4.037%	1.963%	2.135%	1.789%	1.554%	3.846%	2.153%	2.046%	6.056%	5.557%	**3.11%**	0.029%	0.024%	0.035%	0.054%	0.044%	0.061%	0.006%	0.017%	0.188%	0.065%	**0.05%**	59.6
8	Ascomycota	Eurotiomycetes	Cladophialophora_sp:SH0827868.10FU	2.066%	2.038%	2.518%	2.594%	3.272%	3.952%	3.136%	1.993%	2.368%	2.789%	**2.67%**	0.696%	0.242%	0.425%	1.024%	1.358%	1.215%	0.419%	0.099%	1.808%	1.107%	**0.84%**	3.2
9	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:OTU 18	2.221%	3.311%	2.027%	3.376%	1.331%	2.102%	3.872%	1.779%	2.607%	3.779%	**2.64%**	0.276%	1.056%	0.746%	0.292%	0.746%	0.522%	0.103%	0.342%	1.786%	1.019%	**0.69%**	3.8
10	Ascomycota	Eurotiomycetes	Eurotiomycetes_sp:OTU 48	3.952%	1.283%	2.536%	1.458%	0.348%	2.348%	3.595%	1.784%	1.384%	3.588%	**2.23%**	0.109%	0.079%	0.046%	0.055%	0.004%	0.115%	0.036%	0.010%	0.113%	0.393%	**0.10%**	23.2
11	Ascomycota	Eurotiomycetes	Herpotrichiellaceae_sp:SH0828653.10FU	3.019%	5.266%	4.464%	3.934%	2.875%	2.350%			0.067%	0.100%	**2.21%**	0.631%	1.415%	1.042%	0.552%	0.797%	0.226%			0.016%	0.041%	**0.47%**	4.7
12	Ascomycota		Ascomycota_sp:SH0945193.10FU	2.019%	3.064%	1.564%	2.947%	1.604%	0.780%	1.784%	2.915%	1.719%	1.383%	**1.98%**	0.072%	0.093%	0.062%	0.112%	0.146%	0.047%	0.018%	0.026%	0.022%	0.077%	**0.07%**	29.4
13	Basidiomycota	Agaricomycetes	Cuphophyllus_lacmus:SH0952050.10FU	0.590%	2.981%	2.913%	9.170%	3.259%	0.010%			0.002%	0.804%	**1.97%**			2.976%	2.492%	1.509%					0.006%	**0.70%**	2.8
14	Ascomycota	Leotiomycetes	Helotiales_sp:SH0741605.10FU	0.757%	0.961%	0.765%	1.827%	0.768%	2.470%	0.204%	3.208%	3.567%	3.148%	**1.77%**	0.052%	0.214%	0.052%	0.054%	0.091%	0.159%		0.858%	1.209%	0.229%	**0.29%**	6.1
15	Ascomycota	Eurotiomycetes	Capronia_sp:SH0828621.10FU	2.073%	0.444%	1.966%	2.013%	1.088%	1.810%	3.131%	0.796%	1.311%	1.373%	**1.60%**	0.016%	0.031%	1.030%	0.728%	0.178%	0.012%	0.267%	0.200%	0.489%	0.647%	**0.36%**	4.4
16	Ascomycota	Leotiomycetes	Leotiomycetes_sp:SH0741574.10FU	1.849%	1.637%	1.342%	0.727%	0.711%	1.542%	1.039%	2.051%	2.206%	2.149%	**1.53%**	0.052%	0.148%	0.136%	0.015%	0.048%	0.234%	0.023%	0.138%	0.267%	0.182%	**0.12%**	12.3
17	Ascomycota	Leotiomycetes	Helotiales:_UNKsp:OTU 52	2.157%	0.364%	0.197%	1.289%	2.138%	0.002%	5.212%	2.999%			**1.44%**	0.128%	0.003%	0.043%	0.054%	0.143%		0.622%	0.045%			**0.10%**	13.8
18	Ascomycota	Leotiomycetes	Helotiales_sp:SH0741401.10FU	1.454%	2.101%	1.222%	1.031%	0.558%	2.037%	1.415%	1.722%	0.030%	1.715%	**1.33%**	0.096%	0.786%	0.321%	0.008%	0.435%	0.044%	0.026%	0.077%	0.005%	0.200%	**0.20%**	6.7
19	Ascomycota	Leotiomycetes	Hyaloscypha_sp:SH0897600.10FU	2.324%	0.570%	1.996%	1.407%	1.240%	0.826%	2.086%	0.773%	0.828%	1.179%	**1.32%**	3.527%	0.321%	4.970%	2.337%	5.504%	1.594%	0.469%	2.947%	0.432%	0.638%	**2.27%**	0.6
20	Ascomycota	Eurotiomycetes	Sclerococcum_sp:SH0931721.10FU	0.714%	0.956%	1.939%	0.513%	3.299%	0.326%	0.007%	0.005%	1.777%	2.539%	**1.21%**		1.695%	2.821%	0.004%	0.871%	0.002%		0.002%	0.020%	0.252%	**0.57%**	2.1
21	Ascomycota	Archaeorhizomycetes	Archaeorhizomyces_sp:SH0783911.10FU	1.918%	2.183%	3.579%	0.661%	1.041%	1.232%	0.078%	0.178%		0.038%	**1.09%**	0.005%	0.162%	0.333%	0.015%	0.099%	0.031%					**0.06%**	16.9
22	Ascomycota	Eurotiomycetes	Capronia_sp:SH0827807.10FU	2.933%	0.606%	0.924%	0.179%	1.077%	0.745%	0.135%	0.148%	1.512%	2.503%	**1.08%**	0.190%	0.264%	0.629%	0.189%	0.307%	0.001%			0.029%	2.204%	**0.38%**	2.8
23	Ascomycota	Eurotiomycetes	Herpotrichiellaceae_UNKsp:OTU 89	1.432%	2.800%	3.278%	0.620%	0.272%	1.035%	0.069%		0.313%	0.720%	**1.05%**	0.011%	0.092%	0.049%	0.010%	0.019%	0.015%	0.004%		0.033%	0.030%	**0.03%**	40.0
24	Ascomycota	Sordariomycetes	Hypocreales_sp:SH0940997.10FU	0.256%	0.058%	0.153%	1.265%	0.723%	3.873%	0.078%	0.175%	3.424%	0.314%	**1.03%**			0.076%		0.021%	0.032%		0.001%	0.033%	0.197%	**0.04%**	28.7
25	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:SH0828164.10FU	0.339%	0.625%	0.303%	1.536%	0.310%	0.274%	0.749%	0.865%	1.249%	2.657%	**0.89%**	0.319%	1.469%	0.292%	0.436%	1.224%	0.250%	0.077%	0.357%	0.014%	0.003%	**0.44%**	2.0
26	Mortierellomycota	Mortierellomycetes	Mortierella_turficola:SH0867680.10FU	1.007%	1.378%	1.281%	0.357%	0.776%	1.103%	0.477%	0.242%	0.645%	0.463%	**0.77%**	0.019%	0.011%	0.008%	0.003%	0.022%	0.010%	0.009%		0.027%	0.005%	**0.01%**	68.5
27	Ascomycota	unclassified_Ascomyc	Ascomycota_sp:SH0857096.10FU	0.790%	0.223%	0.417%	0.932%	0.568%	0.981%	0.650%	0.534%	1.075%	0.667%	**0.68%**	0.237%	0.072%	0.002%	0.303%	0.023%	0.030%		0.027%	**0.075%**	0.003%	**0.08%**	8.9
28	Ascomycota	Lecanoromycetes	Micropeltidaceae_sp:SH0735777.10FU	0.231%	0.124%	0.236%	0.994%	0.533%	0.945%	1.251%	0.980%	0.544%	0.757%	**0.66%**						0.002%		0.024%	0.005%		**0.00%**	206.1
29	Ascomycota		Ascomycota_sp; OTU 42	0.781%	0.171%	0.365%	1.096%	0.611%	0.293%	0.551%	0.502%	0.501%	1.203%	**0.61%**	1.402%	1.139%	0.569%	0.606%	0.818%	0.539%	0.247%	0.192%	0.424%	0.276%	**0.62%**	1.0
30	Ascomycota	Leotiomycetes	Leotiomycetes_sp:SH0741719.10FU	0.020%	0.716%	0.825%	0.047%		0.286%		0.112%	2.454%	1.153%	**0.56%**			0.219%	0.038%	0.021%				0.048%	0.182%	**0.05%**	11.0
31	Ascomycota	Leotiomycetes	Meliniomyces_sp:SH0897224.10FU	0.323%		0.080%	1.421%	0.170%	0.313%	0.484%	1.922%	0.030%	0.399%	**0.51%**	1.868%		0.004%	0.033%		0.028%	4.506%	4.182%	0.002%	0.027%	**1.06%**	0.5
32	Ascomycota	Leotiomycetes	Ascocorticium_sp:SH0887512.10FU	0.243%	0.208%	0.472%	0.404%	0.343%	1.281%	1.292%	0.728%		0.103%	**0.51%**	0.142%	0.594%	0.187%	0.071%	0.205%	0.320%	0.572%	0.114%			**0.22%**	2.3
33	Ascomycota	Leotiomycetes	Hyaloscyphaceae_UNKsp:OTU 33	0.759%			0.298%	0.036%	0.510%	1.663%	1.410%	0.305%	0.084%	**0.51%**	1.185%			0.025%		1.240%	4.700%	3.131%	0.131%	0.034%	**1.04%**	0.5
34	Ascomycota	Sordariomycetes	Tolypocladium_album:SH0848502.10FU	0.633%	0.899%	0.218%	0.464%	0.248%	1.031%	0.093%	0.952%	0.272%	0.147%	**0.50%**	0.039%	0.009%	0.027%	0.011%	0.030%	0.002%	0.002%	0.024%		0.006%	**0.02%**	33.0
35	Basidiomycota	Agaricomycetes	Serendipitaceae_sp:SH0734281.10FU	0.165%	0.045%	0.031%	0.547%	0.693%	0.404%	0.544%	0.903%	0.534%	1.083%	**0.49%**	1.046%	0.027%	0.016%		0.034%	0.034%	0.015%	0.153%	0.464%	0.010%	**0.18%**	2.8
36	Ascomycota	Leotiomycetes	Hyaloscypha_gryndleri:SH0897609.10FU	0.537%	0.007%	0.168%	0.634%	0.119%	0.776%	0.467%		1.373%	0.830%	**0.49%**	1.620%	0.505%	0.191%	0.389%	0.328%	1.448%			3.406%	1.191%	**0.91%**	0.5
37	Basidiomycota	Agaricomycetes	Mycena_galopus:SH0748945.10FU/OTU835	0.827%	0.366%	0.139%	0.279%	0.536%	0.256%	1.290%	0.505%	0.307%	0.190%	**0.47%**	38.96%	20.35%	18.88%	49.16%	46.99%	22.84%	33.81%	40.92%	23.71%	20.22%	**31.58%**	0.015
38	Ascomycota	Leotiomycetes	Oidiodendron_majus:SH0945817.10FU	0.392%	0.268%	0.394%	0.672%	0.586%	0.271%	0.210%	0.410%	0.828%	0.595%	**0.46%**	1.225%	1.439%	0.847%	0.705%	1.476%	0.227%	0.202%	0.214%	1.085%	0.429%	**0.78%**	0.6
39	Ascomycota	Archaeorhizomycetes	Archaeorhizomyces_sp:SH0783903.10FU	0.163%	0.087%		0.291%	0.460%	0.079%			2.337%	0.768%	**0.42%**			0.295%	0.064%	0.011%				0.503%	0.018%	**0.09%**	4.7
40	Mortierellomycota	Mortierellomycetes	Mortierella_rishikesha:SH0960692.10FU	0.276%	0.012%	0.067%	0.037%	0.684%	0.176%	0.234%	0.117%	1.466%	0.929%	**0.40%**	0.038%		0.006%	0.002%	0.016%				0.067%	0.018%	**0.01%**	27.4
41	Mortierellomycota	Mortierellomycetes	Entomortierella_parvispora:SH0867675.10FU	0.554%	0.187%	0.148%	0.312%	0.629%	0.560%	0.979%	0.260%	0.093%	0.218%	**0.39%**	0.013%	0.009%		0.009%	0.003%	0.002%	0.004%	0.003%	0.006%	0.003%	**0.01%**	76.8
42	Basidiomycota	Agaricomycetes	Hyaloriaceae_sp:SH0749083.10FU	0.170%	0.096%	0.273%	0.741%	0.444%	0.708%	0.395%	0.296%	0.305%	0.260%	**0.37%**	1.131%	2.099%	3.252%	2.076%	0.982%	1.753%	0.013%	0.104%	1.287%	0.111%	**1.28%**	0.3
43	Basidiomycota	Agaricomycetes	Agaricomycetes_sp:SH0848226.10FU	0.124%	0.003%	0.102%	0.503%	0.504%	1.440%	0.099%	0.003%	0.337%	0.297%	**0.34%**	0.064%	0.034%		0.027%	0.013%	0.268%			0.337%	0.094%	**0.08%**	4.1
44	Ascomycota	Sordariomycetes	Neopestalotiopsis_foedans:SH0911533.10FU	0.202%	0.103%	0.150%	0.240%	0.385%	0.605%	0.419%	0.598%	0.260%	0.216%	**0.32%**	0.006%		0.007%	0.007%	0.026%	0.004%	0.006%				**0.01%**	57.2
45	Basidiomycota	Agaricomycetes	Hymenochaetales_sp:OTU 138	0.361%	0.884%	0.861%	0.193%	0.461%	0.076%	0.219%	0.113%			**0.32%**		0.047%	0.031%	0.008%	0.066%	0.002%	0.030%				**0.02%**	17.2
46	Ascomycota	Eurotiomycetes	Capronia_sp:SH0828033.10FU	0.006%			0.561%	0.018%		0.072%		1.705%	0.788%	**0.31%**				0.017%			0.007%		0.011%	0.060%	**0.01%**	33.0
47	Ascomycota	Sordariomycetes	Tolypocladium_inflatum:SH0940809.10FU	0.164%	0.006%	0.176%	0.257%	0.083%	0.003%	0.405%	0.560%	0.804%	0.684%	**0.31%**	0.005%		0.005%	0.013%	0.007%		0.005%	0.009%	0.025%	0.023%	**0.01%**	34.4
48	Ascomycota	Leotiomycetes	Helotiales_sp:SH0741541.10FU	0.347%	0.504%	0.554%	0.253%	0.393%	0.004%	0.085%	0.776%	0.011%	0.011%	**0.29%**	0.004%	0.003%	0.245%		0.106%			0.114%		0.050%	**0.05%**	5.6
49	Ascomycota	Leotiomycetes	Hyaloscyphaceae_sp:SH0908101.10FU	0.212%	0.188%	0.225%	0.259%	0.405%	0.298%	0.123%	0.176%	0.272%	0.401%	**0.26%**		0.006%	0.004%		0.003%	0.001%					**0.00%**	192.9
50	Basidiomycota	Agaricomycetes	Clavaria_sphagnicola:SH0737317.10FU	0.419%	0.473%	1.529%	0.017%	0.034%	0.003%			0.017%	0.040%	**0.25%**		0.016%	0.046%		0.004%						**0.01%**	38.6
			Ascomycota/Basidiomycota Ratio	17.83	12.89	10.48	5.55	8.78	5.82	11.73	12.67	8.99	7.92	**10.27**	0.94	2.06	2.08	0.50	0.75	0.93	0.42	0.74	1.27	1.75	**1.14**	9.0
	Basidiomycota		**Clavariaceae**	0.42%	0.47%	1.53%	0.02%	0.03%	0.01%			0.76%	0.78%	**0.40%**		0.02%	0.05%		0.00%					0.06%	**0.0001**	31.5
	Basidiomycota		**Entolomataceae**	0.03%	0.00%	0.01%	0.02%	0.02%	0.00%		0.01%	0.32%	0.29%	**0.07%**											n/a	n/a
	Basidiomycota		**Hygrophoraceae**	0.59%	3.08%	2.99%	9.17%	3.33%	0.01%			0.00%	0.80%	**2.00%**		0.02%	3.02%	2.49%	1.51%				0.003%	0.01%	**0.01**	2.8
	Basidiomycota		**Mycenaceae**	0.87%	0.41%	0.18%	0.54%	0.68%	0.79%	1.93%	0.88%	0.61%	0.51%	**0.74%**	40.65%	20.47%	18.88%	49.26%	48.05%	22.84%	65.83%	46.77%	24.07%	20.28%	**0.36**	0.021
	Ascomycota		Chaetothyriales	38.17%	34.21%	38.29%	37.59%	33.37%	34.37%	41.98%	27.65%	30.58%	36.72%	**35.29%**	9.53%	11.04%	9.44%	7.43%	10.43%	9.33%	3.49%	2.86%	19.99%	11.77%	**0.10**	3.7
	Ascomycota		**Archaeorhizomycetes**	7.71%	7.14%	8.42%	4.78%	5.42%	5.24%	4.05%	5.89%	7.21%	6.54%	**6.24%**	0.37%	1.20%	1.17%	0.34%	0.77%	0.32%	0.13%	0.14%	1.16%	0.73%	**0.01**	9.9
	Ascomycota		**Helotiales**	24.41%	25.69%	21.67%	17.70%	27.70%	16.25%	26.05%	31.61%	12.26%	13.31%	**21.67%**	14.59%	11.13%	17.33%	12.96%	14.93%	6.30%	17.46%	17.61%	8.22%	14.79%	**0.14**	1.6
	Ascomycota		**Lecanoromycetes (lichenised fungi)**	0.37%	0.36%	0.45%	1.74%	1.40%	1.29%	1.61%	1.27%	0.87%	1.34%	**1.07%**	0.15%	0.83%	0.13%	0.05%	0.20%	0.43%	0.05%	0.08%	0.70%	0.39%	**0.00**	3.5

a known mycorrhizal symbiont of Heather (>10% mean relative abundance across all the samples). Also abundant were three species of the genus *Archaeorhizomyces*, a recently discovered group of abundant soil dwelling fungi (Rosling *et al*., 2011), which are associated with ericoid hosts (Baba and Hirose, 2024). Several species of *Mortierella*, a genus found in higher abundance in Arctic/alpine soils were also abundant (Telagathoti *et al*., 2021).

Ordination of the whole fungal community present in the soils showed that the fungal communities in soils from the North End were significantly different (PERMANOVA pseudo-P=0.0159) from those further south (Figure 4). SIMPER analysis revealed that the five taxa contributing most to this difference and explaining 26% of the total variance were: *Pezoloma ericae*, *Cuphophyllus lacmus* and three unidentified Chaetothyriales species.

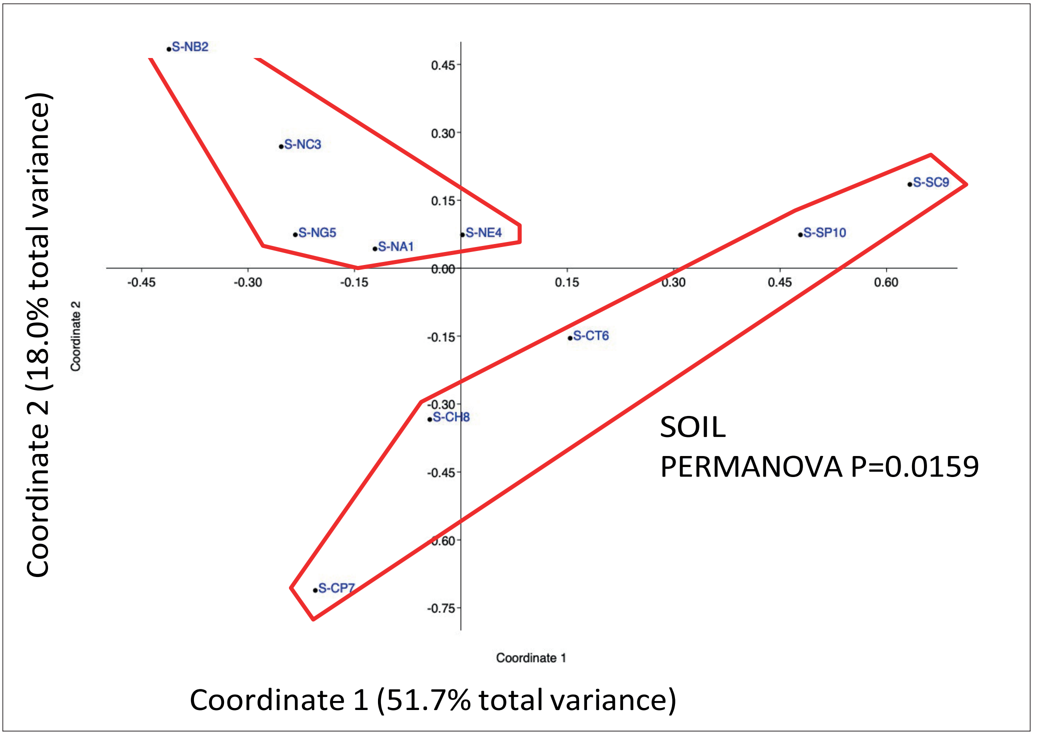


Figure 4. Ordination of soil fungal communities using Principal Coordinates Ordination analysis (PCoA). The communities from quadrats at the north end and south end of Lundy were significantly different (PERMANOVA pseudo-P = 0.0159).

CHEGD species of fungi found in the soil samples

In the **C**lavariaceae (Club and Coral Fungi), the most abundant was *Clavaria sphagnicola*, not yet recorded from fruit bodies on Lundy, which was present in 8/10 soil samples, including all the North End samples. As well as the Grey Waxcap, three other Waxcaps (**H**ygrophoraceae) were detected. Two were identifiable to species level (Goblet Waxcap, *Hygrocybe cantharellus* and Glutinous Waxcap, *Hygrocybe glutinipes*), with a fourth, detected in 3/5 of the North End soil samples, not matching any known species but closest to the Cedarwood Waxcap *Cuphophyllus russocoriaceus*. The ITS2 sequence was only 93% identical to *C. russocoriaceus*, so may represents a new species. The basidiolichen Lichenomphalia *umbellifera* (not strictly a Waxcap but closely related and belonging to family Hygrophoraceae) was also detected in the soil from two quadrats.

Five **E**ntolomas(Pink Gills,family Entolomataceae) were identifiable to species level *Entoloma elodes, E. jubatum* (Sepia Pinkgill) ; *E. conferendum* (Star Pinkgill); *E. turbidum* (Yellowfoot Pinkgill) *and E. ventricosum*. *E.elodes* and *E.ventricosum* have not yet been recorded for Lundy. The other species are widespread on Lundy though the Yellow Foot PInkgill is recorded most frequently from the North End with Heather. No **G**eoglossaceae nor ***D****ermoloma* spp. were detected in soil samples. Many of the Clavariaceae and Entolomataceae sequences detected (37.2% and 8.1% respectively) could not be identified to species level, due to lack of reference DNA barcode or potentially the species being unknown to science, as are >95% of all fungi (Hawksworth and Lücking, 2017).

Grey Waxcap (*Cuphophyllus lacmus).*

By far the most abundant CHEGD species in the eDNA from the soil samples was *C.lacmus* (1.97% mean relative abundance [RA] of all fungal sequences) (summarised in Figure 5). It was detected in all the North quadrats (mean RA 3.78%; maximum RA was 9.2% in quadrat NE4) but also present in three of the South quadrats though at lower RA (0.16%). These data are consistent with annual autumn monitoring of Lundy-wide fruiting of this species by Lundy Field Society members since 2006 (summarised in Griffith *et al*.2020), the north end being the only place it has been found. The *C. lacmus* sequences detected from soil samples in the present study confirmed the northern distribution of the fungus on Lundy, though the detection of *C. lacmus* eDNA in soil at site SP10 (below Rocket Pole and above the Devil's Limekiln), a finding also made by Griffith *et al.* (2020), means that the species is present in more southerly quadrats but only as a minor component of the soil mycota. Data from GBIF (https://www.gbif.org/species/2538616) do not indicate that *C. lacmus* is particularly associated with heathland vegetation but for most of the >2000 global records, no habitat description is provided. However, several UK mycologists report that they encounter this species commonly in heathland habitats (Emma Williams and David Mitchel, personal communications, 2025).

Our earlier eDNA analysis (Griffith *et al.*, 2020) included two heathland quadrats (Lu2/Lu3) from the north end of the island. The metabarcoding approach used was slightly different (LSU S1 barcode locus which provides inferior taxonomic resolution compared to ITS2) but, as in the present study, *C. lacmus* was the dominant Waxcap in both quadrats. Whilst it is risky to make direct comparison of the RA (relative abundance) of *C. lacmus*, it is noteworthy that the RA of *C. lacmus* from the heathland quadrats was higher (74% and 17%) than found in the present study. This may relate to the dates of sampling, February 2016 in the 2020 report, vs April in the present study, where decomposition of roots which had died over the winter period could have resulted in a decline in *C. lacmus* RA in the April samples.

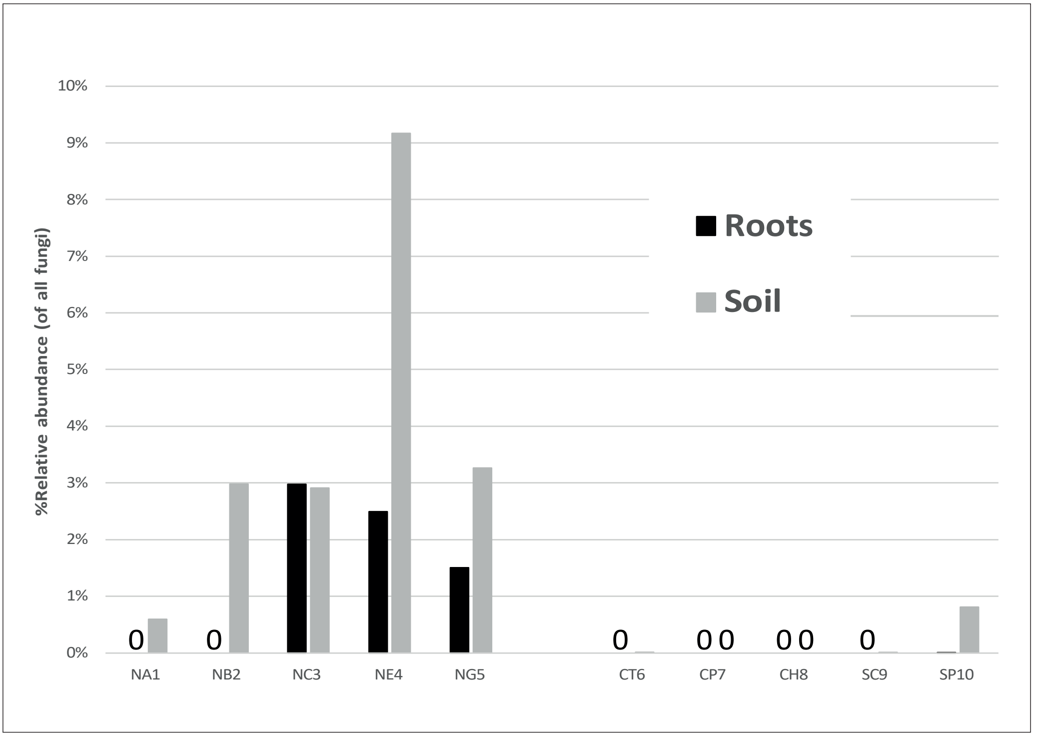
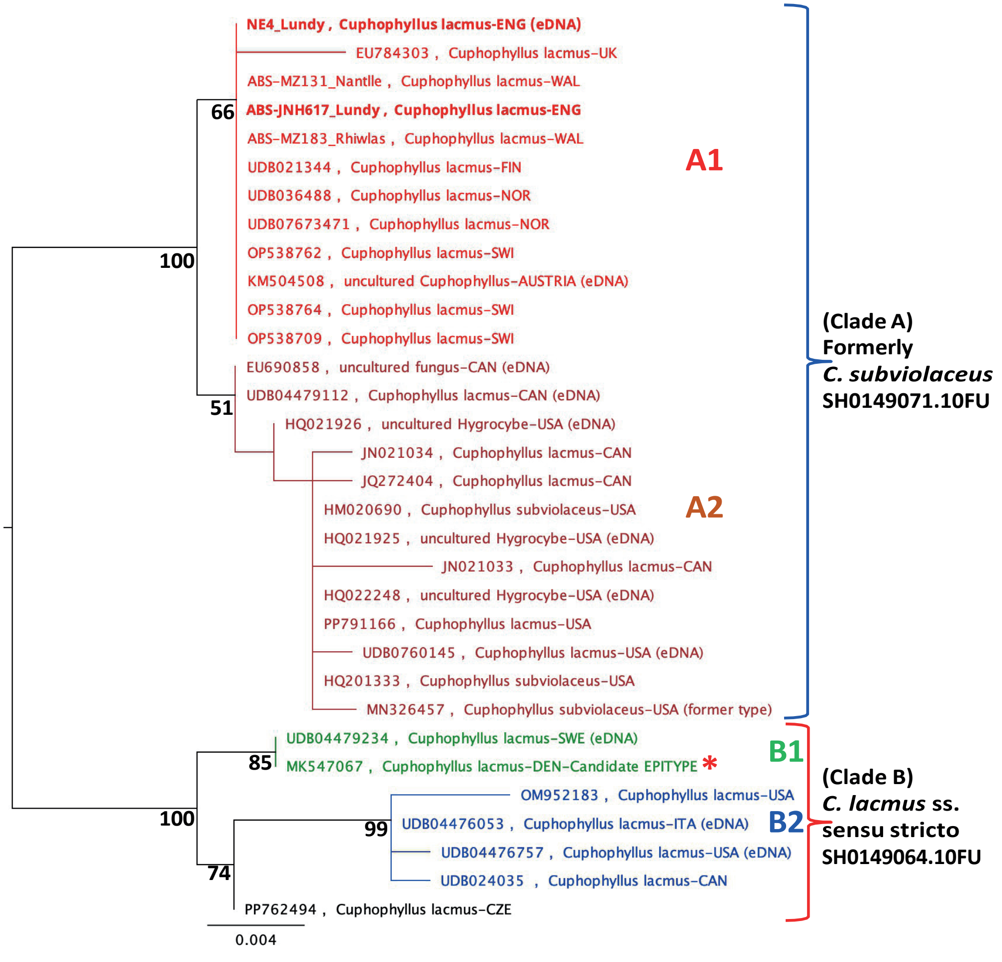


Figure 5. Percentage relative abundance of *Cuphophyllus lacmus* sequences in soil and roots from the ten quadrats.

The DNA sequence obtained from eDNA metabarcoding was identical to that obtained from a fruitbody collected at the North End in 2004. Comparison of these ITS sequences with others from the GenBank and UNITE sequence repositories and DNA barcodes from the Aberystwyth (ABS) fungarium revealed that *C. lacmus* exhibits some intraspecific variation, with two distinct clades present (Figure 6), corresponding to UNITE species hypotheses SHSH0149071.10FU and SH0149064.10FU (both at 97% clustering).

The Lundy samples and all other UK sequences sit close to a species formerly known as *C. subviolaceus* (Peck) Bon (Voitk *et al*., 2020), mostly recognised from north America. However, this species was synonymised with *C. lacmus* by Bon (1985). The data presented here support Bon's decision, since, whilst distinct, the ITS sequences of the two clades are >96% identical and members of both clades are present both in northern Europe and north America. It is interesting to note that *C. lacmus* was first named (as *Agaricus lacmus*) by Schumacher in 1803 ("*in ericetis circa*" [amongst Heather] in Birkerød, Denmark). To our knowledge, Schumacher's observation is the only other record of *C. lacmus* being found in Heather.

It is suggested that formal epitypification of *C. lacmus* is undertaken, potentially using voucher C-F-17644 (GenBank MK547067), collected in Denmark by David Boertmann (Voitk *et al*., 2020).



		ABS-JNH61...	HM020690	MK547067	UDB024035
A1: lacA EUR	ABS-JNH617_Lundy		99.055%	96.423%	97.003%
A2: lacA US	HM020690	99.055%		95.814%	96.541%
B2: lacB EUR	MK547067	96.423%	95.814%		97.196%
B1: lacB US	UDB024035	97.003%	96.541%	97.196%	

Figure 6. Phylogenetic reconstruction of the *Cuphophyllus lacmus* clade.

Communities of fungi in the Heather roots

Fungal communities within the Heather roots clearly differed from those of the bulk soil (Figure 7). Whilst Leotiomycetes (mostly Helotiales) were still present at high abundance, root communities were dominated by Agaricomycetes (Gill Fungi). Of the top 40 fungal taxa present in roots at highest mean relative abundance, only 16 were also in the 40 most abundant in soil detected in roots (Appendix 1). SIMPER analysis showed that the ten species contributing most strongly to the differences between the root and soil samples and were more abundant in roots; two were *Mycena* spp. and three were very poorly defined taxa identifiable only to phylum level or higher (Fungi_sp:SH1010170.10FU; Ascomycota_sp:SH0855981.10FU; Fungi_sp:SH0748653.10FU). Of the 40 taxa most abundant in roots, 13 were at least 25-fold more abundant in roots than soil (Appendix 1) suggesting that they may have a role either as mycorrhizas or early-stage root decomposers.

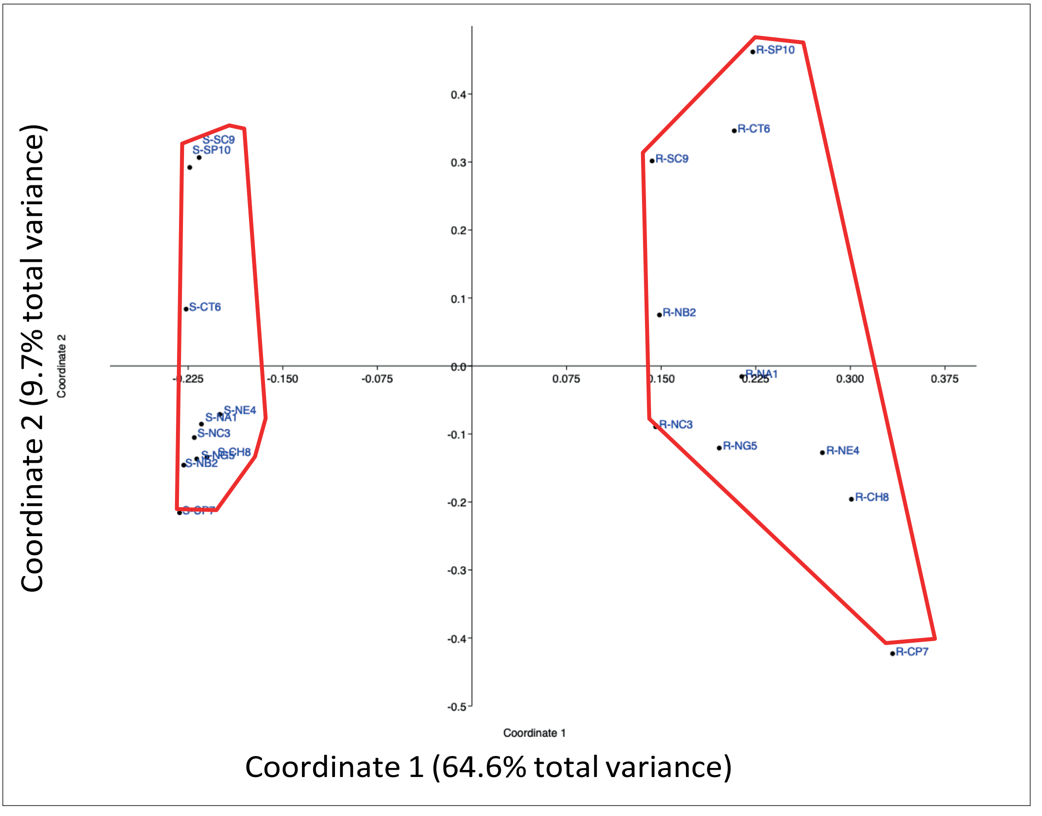


Figure 7. Ordination of soil and root fungal communities using Principal Coordinates Ordination analysis (PCoA). The communities from soil and roots were significantly different (PERMANOVA pseudo-P <0.0001).

Grey Waxcap (*Cuphophyllus lacmus*) in roots of Heather

The Grey Waxcap, *C. lacmus,* was detected in 3/5 of the northern root samples and also in roots from one of the two southern quadrats where this species had been detected in soil in the 2020 survey (Griffith *et al* 2020). In all but one of these samples, the relative abundance of *C. lacmus* was lower than in the associated soil (see figure 5). The nutrition of soil-dwelling Hygrophoraceae is not well-understood. Evidence from $\delta^{15}N$ and $\delta^{13}C$ isotopic analysis suggest that they may be mycorrhizal, since their isotopic profiles are very different from saprotrophic species, resembling those of ectomycorrhizal fungi (Seitzman *et al.*, 2011; Halbwachs *et al.*, 2018). Several other lines of evidence are also strongly suggestive of a biotrophic nutritional mode (Griffith *et al.*, 2012; Halbwachs *et al.*, 2013a; Halbwachs *et al.*, 2013b). The novel discovery of the presence of *C. lacmus* DNA in Heather roots (the only potential higher plant host present in the north Lundy heathland) is consistent with this possibility. Further microscopic analysis is needed to characterise the nature of the putative mycorrhizal interface (Halbwachs *et al.*, 2013a).

Mycena species in roots of Heather

The gill fungus *Mycena galopus* (Milking Bonnet) was present in all root samples and was particularly dominant, comprising ca. 32% of the fungal sequences detected within roots. A second species, *Mycena galericulata* (Common Bonnet) was also present in most (7/10) root samples with a mean relative abundance of 4.1% (Figure 8), and in one root sample (CP7) these two species together comprised >65% of all the fungal DNA detected.

The dominance of the Heather root mycobiome in all quadrats by *Mycena galopus* was unexpected. Whilst *Mycena* spp. are generally considered to be litter saprotrophs (Emmett *et al.*, 2008), several studies have detected *M. galopus* (and other *Mycena* spp.) within the roots of Ericaceae, including *C. vulgaris* as well as in roots of Birch, *Betula spp.* , Pine, *Pinus spp.* and several other Arctic-alpine host plants. These studies have also demonstrated a growth-promoting effect in some cases (*Vaccinium corymbosum* inoculated with *M. galopus* in plant-pot experiments), the formation of distinctive peg-like structure within roots and also some transfer of radiolabelled (^{32}P) phosphate from the fungus to *Betula* seedlings (Grelet *et al.*, 2017; Thoen *et al.*, 2020).

More detailed investigation of the possible role of *Mycena* spp in the roots of heathland plants has shown that they can invade the internal tissues of healthy roots. However, they do not display the distinctive 15N/13C isotopic profiles observed in ectomycorrhizal fungi (and Hygrophoraceae), and the prevailing view at present is that they are latent-invading root saprotrophs (Harder *et al.*, 2023).

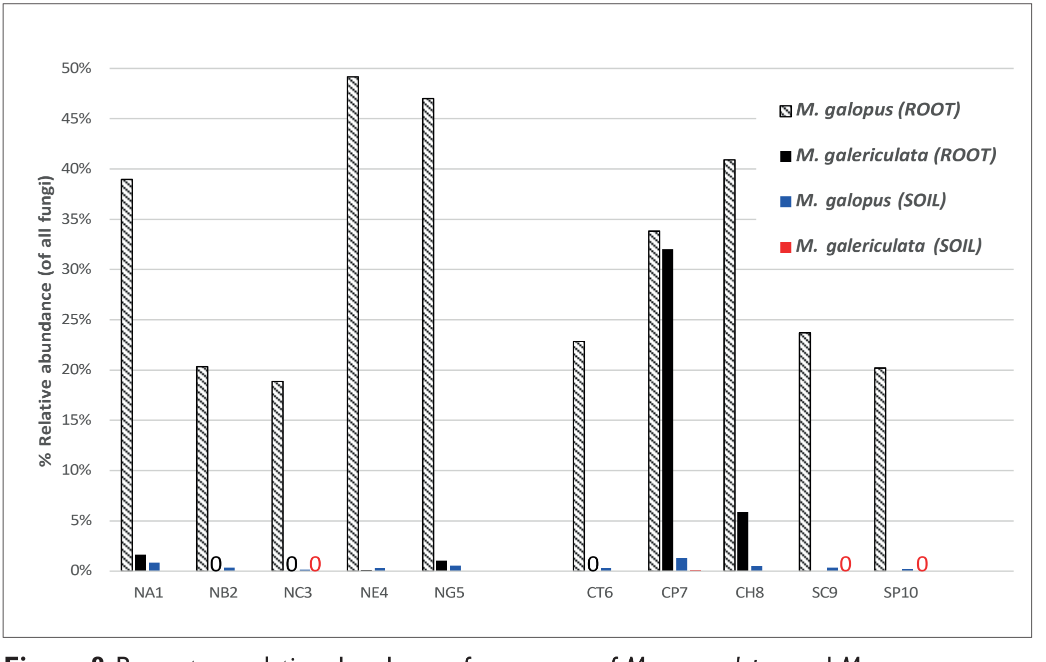


Figure 8. Percentage relative abundance of sequences of *Mycena galopus* and *Mycena galericulata* detected in Heather roots (black) and soil (blue/red) from the ten quadrats.

Other fungi present in Heather roots.
The second most abundant taxon in roots was an unidentified *Sclerococcum* species (SH0855981.10FU; family Dactylosporaceae, Ascomycota), which was also abundant in soil. Members of this genus are often lichenicolous and abundant in tundra soils (Alstrup *et al*., 2009; Huusko *et al*., 2024). However, this particular species was found only at very low abundance in lichen thalli in the quadrats (see below), suggesting that the ecological niche of this particular species is very different from other members of this genus.

Another unusual, potentially mycorrhizal, species found in the root samples (>50-fold more abundant than in soil), was an unidentified ascomycete *Colpoma* species (SH0748653.10FU; ascomycete family Rhytismataceae), also abundant in ericoid roots in Bohemia (Vohník *et al*., 2023).

Comparison of fungal communities in Heather roots: north vs south Lundy.
Ordination of the root-inhabiting fungal communities from the North and South quadrats revealed them to be significantly different (PERMANOVA pseudo-P<0.0487; Figure 9). The species primarily responsible for this difference were identified via SIMPER analysis as *Mycena galopus*, Ascomycota sp:SH0855981.10FU and Fungi_sp:SH1010170.10FU (all more abundant in northern quadrats), whereas *Mycena galericulata*, Fungi sp:SH0858794.10FU, Fungi sp:SH0897234.10FU and Trechisporales sp:SH1010152.10FU were more abundant in southern quadrats.

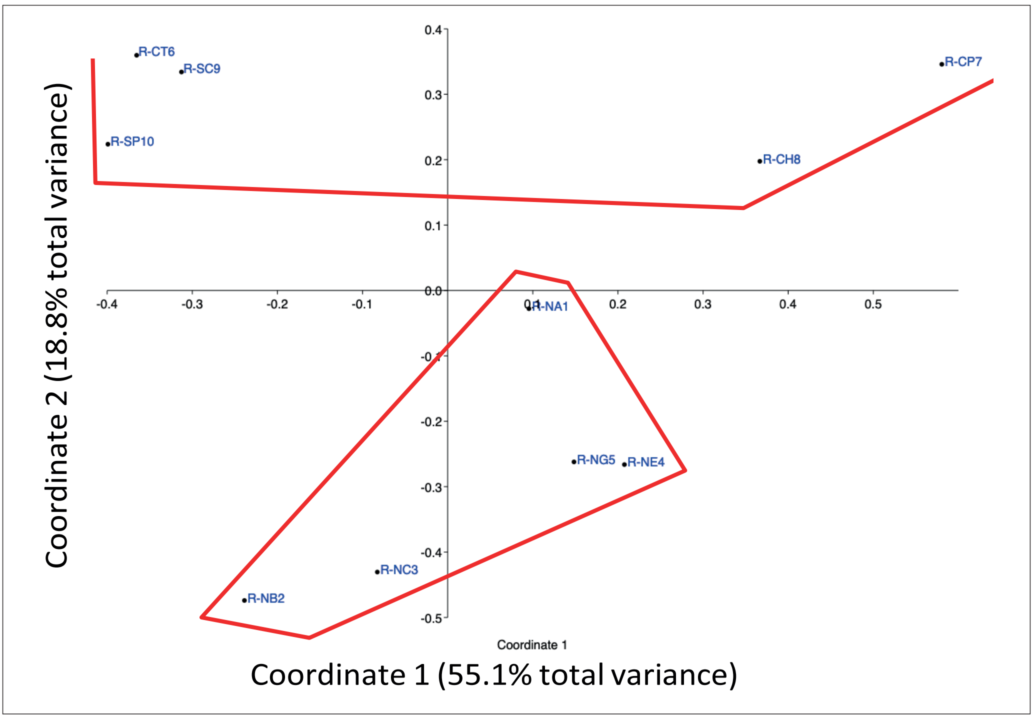


Figure 9. Ordination of soil and root fungal communities using Principal Coordinates Ordination analysis (PCoA). The root fungal communities from North and South quadrats were significantly different (PERMANOVA pseudo-P<0.0487).

Results of eDNA extraction from the lichen samples

eDNA analysis of eight lichen samples from each of the North quadrats and three of the South quadrats, found no trace of *C. lacmus*. No other CHEGD fungi were detected in any of the lichen thallus samples. As expected, the dominant fungus in the lichen thalli was *Cladonia portentosa* (SH0933093.10FU), with small amounts of other *Cladonia* species, including *C. ciliata* (SH0932955.10FU) and *C. furcata* (SH0993788.10FU) (data are summarised in Appendix 2).

Within the lichen thalli examined, 353 ASV's were detected, of which 246 and 101 were also detected in soil or roots respectively, with 98 ASV's being unique to lichen thalli. These included lichenicolous fungi, for example *Zyzygomyces bachmannii* (SH0880452.10FU; Filobasidiaceae), a well-defined lichenicolous fungus, specific to *Cladonia* spp. (Diederich *et al*., 2022). Two of the other abundant taxa, *Xenopolyscytalum* sp. (SH1012222.10FU; Pezizellaceae) and *Neopestalotiopsis (*SH0911533.10FU; Sporocadaceae), have also been reported from within lichen thalli (Park *et al*., 2015; Masumoto and Degawa, 2019) (see Appendix 2).

The eDNA metabarcoding method used here also detects members of kingdom Viridiplantae (higher plants/green algae), so it is also possible to identify the Chlorophyta photobionts associated with the lichenised fungi. The most abundant of the Viridiplantae was *Asterochloris woessiae* (SH0769029.10FU; Trebouxiaceae), comprising 71% of the non-fungal sequences. Members of genus *Asterochloris* are the dominant photobionts of *Cladonia* spp. (Pino-Bodas and Stenroos, 2021). Smaller amounts of other Trebouxiaceae (*Trebouxia suecica*:SH0769319.10FU) were also detected but only at very low abundance.

Coccomyxa viridis (SH0832661.10FU; Coccomyxaceae) and several unidentified species of the same genus were abundant in all the lichen thalli, comprising ca. 18% of the non-fungal sequences (and >50% in one case). Although *Coccomyxa* spp. are photobionts associated with *Licheomphalia* and several other basidiolichens (Oberwinkler, 2012), they are generally regarded as "non-photobiont" algae. However, it has recently been discovered that they are abundant in the internal tissues of the thalli of many lichen species globally (Tagirdzhanova *et al*., 2023), and it is possible that their significance in the lichen symbiosis (relative to Terebouxiaceae algae) has hitherto been underestimated.

The same range of *Coccomyxa* spp. were also detected in the soil eDNA samples, though the most abundant (*Coccomyxa* sp:SH0818359.10FU) was not the dominant species in the thalli. The significance of these algae was only recently discovered and their ecological significance and potential photosynthetic contribution to the lichen thallus economy is at present unclear.

CONCLUSIONS

- This study deployed eDNA analysis to further investigate the apparent restriction of fruit bodies of the Grey Waxcap, *Cuphophyllus lacmus*, to the heathland areas of north Lundy. This distribution was largely confirmed by the soil data and presence of the fungus in the roots of the Heather adds weight to the hypothesis that this species and perhaps other Waxcap fungi are mycorrhizal.
- The fact that the relative abundance of *C. lacmus* in soil samples from the present study (taken in April) was much lower than observed in our earlier 2016 sampling (February)

(Griffith *et al.*, 2020) raises the possibility that there may be a strong seasonal component. There is high turnover of Heather and other root tissues in heathland ecosystems (Aerts *et al.*, 1989; Aerts *et al.*, 1992), root mortality is known to exhibit seasonal variation (Huo *et al.*, 2022; Garthen *et al.*, 2025). Thus the putatively mycorrhizal *C. lacmus* would be expected to proliferate during periods of root growth in the summer, both inside the roots (mycorrhizal interface) and in the soil (uptake network).

- Despite the fact that *Cladonia portentosa* thalli were also much more abundant in the north end quadrats, we found no evidence of any association between *C. lacmus* and the *Cladonia* lichens.
- One surprising outcome of the study was the consistent presence of DNA *of Mycena* species in the roots of Heather across all the study sites, raising the possibilities of an undiscovered relationship between the plant and these *Mycena* species. It is hypothesised that latent colonisation of healthy roots by Mycena may accelerate decomposition of dead roots and more rapid recycling of their nutrients. Microscopic analysis of roots could elucidate the role of both *Mycena* spp. and also *C. lacmus* in Heather roots, though since both bear clamp connections, some means of staining the hyphae of one species but not the other (e.g. Fluorescent *in situ* hybridisation using sequence specific probes) would need to be devised.
- Any latently invading *Mycena* spp. would show the opposite pattern to infection by *C.lacmus*, proliferating as roots senesce/die in Winter and early Spring, thus mediating rapid decomposition of dead roots and rapid recycling of nutrients contained within them.
- Whilst the majority of fungi detected via eDNA were microfungi, and thus not easily detectable by field surveys of fungi, several species not previously known from Lundy were revealed to be present. For example, the lichenicolous *Zyzygomyces bachmannii*, which causes distinctive deformation of *Cladonia* podetia (**https://www.dorsetnature.co.uk/pages-lichen/lch-433.html**) was widely present and should be easily discoverable if sought.
- Similarly, it would be good to pay particular attention to any small white Waxcaps found in heathland areas, these may be fruitbodies of a hitherto unknown (or not yet DNA barcoded) species close to the Cedarwood Waxcap *Cuphophyllus russocoriaceus.*

ACKNOWLEDGEMENTS

RM thanks the Lundy Field Society for a generous research grant which made it possible for him to travel to Lundy and carry out the field work. We also thank the LFS for an additional grant to support consumables for the DNA sequencing work carried out by RM in Aberystwyth in the laboratory of Professor Gareth Griffith. We also thank the Lundy Warden Joe Parker and Natural England for permission to carry out the sampling on the SSSI on Lundy and the Lundy Bird Observatory for the use of their headquarters to carry out the sample preparation.

Appendix 1 Relative abundance (as % of all fungal sequences detected) of the 40 most abundant fungal taxa detected in Heather roots.

				Soil NORTH					Soil SOUTH						Root NORTH					Root SOUTH						Root:Soil
SoilRank	phylum	class	species	NA1	NB2	NC3	NE4	NG5	CT6	S-CP7	CH8	SC9	SP10	Soil AVE	NA1	NB2	NC3	NE4	NG5	CT6	S-CP7	CH8	SC9	SP10	ROOTtot	R/Sratio
37	Basidiomycota	Agaricomycetes	Mycena_galopus:SH0748945.10FU	0.827%	0.366%	0.139%	0.279%	0.536%	0.256%	1.290%	0.505%	0.307%	0.190%	0.470%	38.96%	20.35%	18.88%	49.16%	46.99%	22.84%	33.81%	40.92%	23.71%	20.22%	31.584%	67.3
5	Ascomycota	Eurotiomycetes	Sclerococcum_UNKsp:SH0855981.10FU	4.354%	7.878%	7.177%	4.862%	2.997%	4.052%	1.023%	5.290%	5.562%	5.701%	4.890%	8.19%	21.36%	15.64%	2.63%	4.42%	5.47%	0.39%	4.78%	8.56%	5.41%	7.685%	1.6
136	Ascomycota	Dothideomycetes	Dothideomycetes_UNKsp:SH1010170.10FU	0.042%	0.077%	0.101%	0.072%	0.111%	0.016%		0.017%	0.075%	0.066%	0.058%	10.92%	10.41%	5.72%	5.47%	4.95%	3.23%	0.01%	1.03%	2.56%	4.96%	4.926%	85.1
108	Ascomycota	Leotiomycetes	Colpoma_UNKsp:SH0748653.10FU	0.054%	0.013%	0.044%	0.105%	0.163%	0.050%	0.060%	0.056%	0.115%	0.156%	0.082%	1.97%	5.99%	3.32%	2.00%	0.99%	10.01%	0.74%	2.62%	9.96%	4.33%	4.193%	51.4
2	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:SH0828226.10FU	6.164%	3.881%	3.985%	7.500%	8.226%	9.446%	10.371%	8.292%	7.359%	6.182%	7.141%	5.94%	3.53%	2.86%	2.13%	3.69%	5.79%	1.83%	1.26%	10.87%	3.24%	4.114%	0.6
215	Basidiomycota	Agaricomycetes	Mycena_galericulata:SH0948057.10FU	0.002%	0.022%		0.010%	0.067%	0.011%	0.103%	0.079%			0.029%	1.62%			0.10%	1.05%		31.99%	5.84%		0.05%	4.065%	138.5
145	unclass_Fungi		Fungi_sp:SH0897234.10FU	0.003%	0.007%	0.003%	0.047%		0.064%	0.108%	0.239%	0.035%	0.054%	0.056%	0.04%		9.19%				4.11%	11.62%	4.28%	2.82%	3.206%	57.2
119	Ascomycota	Leotiomycetes	MollisiaceaeiUNK_sp:SH0858794.10FU	0.007%	0.003%	0.131%	0.060%	0.012%	0.109%	0.059%	0.046%	0.108%	0.157%	0.069%	0.08%	0.26%	0.02%			5.49%	0.17%	0.21%	5.13%	18.95%	3.031%	43.7
322	Ascomycota	Dothideomycetes	Ascomycota_sp:SH0942786.10FU	0.016%	0.025%	0.016%	0.012%	0.020%	0.014%	0.021%	0.013%			0.014%	4.38%	2.51%	3.57%	3.96%	2.91%	0.09%	3.46%	4.97%	0.05%	0.27%	2.617%	192.8
95	Basidiomycota	Agaricomycetes	Trechisporales_sp:SH1010152.10FU	0.042%		0.010%	0.152%	0.006%	0.373%	0.168%		0.160%	0.079%	0.099%	0.903%	1.691%		0.187%	0.052%	15.44%	0.002%		3.417%	3.765%	2.546%	25.7
1	Ascomycota	Leotiomycetes	Pezoloma_ericae:SH0897049.10FU	13.637%	18.634%	14.176%	6.041%	18.089%	5.436%	10.632%	13.138%	1.905%	0.742%	10.243%	1.685%	4.846%	6.480%	1.103%	2.980%	0.490%	3.783%	1.957%	0.254%	0.067%	2.365%	0.2
19	Ascomycota	Leotiomycetes	Hyaloscypha_UNKsp:SH0897600.10FU	2.324%	0.570%	1.996%	1.407%	1.240%	0.826%	2.086%	0.773%	0.828%	1.179%	1.323%	3.527%	0.321%	4.970%	2.337%	5.504%	1.594%	0.469%	2.947%	0.432%	0.638%	2.274%	1.7
494	Ascomycota	Leotiomycetes	Pezicula_rhizophila:SH0948646.10FU	0.004%	0.002%	0.002%	0.004%	0.003%	0.005%	0.006%		0.010%	0.018%	0.005%	2.072%	0.215%	3.044%	0.799%	1.851%	0.078%	0.216%	0.161%	0.735%	7.660%	1.683%	317.3
633	Ascomycota	Leotiomycetes	Coccomyces_australis:SH0980036.10FU						0.029%					0.003%						15.59%			0.002%		1.559%	529.7
111	Ascomycota	Leotiomycetes	Hyphodiscus_UNKsp:SH0907918.10FU	0.008%	0.232%	0.113%	0.058%	0.297%	0.017%	0.021%	0.004%			0.075%	1.322%	4.048%	2.042%	1.825%	4.121%	0.168%	0.016%	0.138%			1.368%	18.3
42	Basidiomycota	Agaricomycetes	Hyaloriaceae_sp:SH0749083.10FU	0.170%	0.096%	0.273%	0.741%	0.444%	0.708%	0.395%	0.296%	0.305%	0.260%	0.369%	1.131%	2.099%	3.252%	2.076%	0.982%	1.753%	0.013%	0.104%	1.287%	0.111%	1.281%	3.5
31	Ascomycota	Leotiomycetes	Meliniomyces_sp:SH0897224.10FU	0.323%		0.080%	1.421%	0.170%	0.313%	0.484%	1.922%	0.030%	0.399%	0.514%	1.868%		0.004%	0.033%		0.028%	4.506%	4.182%	0.002%	0.027%	1.065%	2.1
33	Ascomycota	Leotiomycetes	Leotiomycetes_sp:OTU 33	0.759%			0.298%	0.036%	0.510%	1.663%	1.410%	0.305%	0.084%	0.507%	1.185%			0.025%		1.240%	4.700%	3.131%	0.131%	0.034%	1.045%	2.1
4	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:SH0827748.10FU	2.952%	3.723%	5.977%	4.925%	6.522%	3.419%	6.769%	7.615%	4.084%	4.791%	5.078%	0.475%	1.752%	1.188%	0.514%	1.079%	0.779%	0.468%	0.487%	2.901%	0.293%	0.994%	0.2
36	Ascomycota	Leotiomycetes	Hyaloscypha_gryndleri:SH0897609.10FU	0.537%	0.007%	0.168%	0.634%	0.119%	0.776%	0.467%		1.373%	0.830%	0.491%	1.620%	0.505%	0.191%	0.389%	0.328%	1.448%			3.406%	1.191%	0.908%	1.9
8	Ascomycota	Eurotiomycetes	Cladophialophora_sp:SH0827868.10FU	2.066%	2.038%	2.518%	2.594%	3.272%	3.952%	3.136%	1.993%	2.368%	2.789%	2.673%	0.696%	0.242%	0.425%	1.024%	1.358%	1.215%	0.419%	0.099%	1.808%	1.107%	0.839%	0.3
38	Ascomycota	Leotiomycetes	Oidiodendron_majus:SH0945817.10FU	0.392%	0.268%	0.394%	0.672%	0.586%	0.271%	0.210%	0.410%	0.828%	0.595%	0.463%	1.225%	1.439%	0.847%	0.705%	1.476%	0.227%	0.202%	0.214%	1.085%	0.429%	0.785%	1.7
956	Ascomycota	Sordariomycetes	Diaporthe_sp:SH0754169.10FU						0.001%	0.008%				0.001%							0.399%	0.951%	0.044%	6.404%	0.780%	828.9
77	Ascomycota	Leotiomycetes	Glutinomyces_UNKsp;OTU 53		0.044%		0.162%	0.756%			0.006%	0.159%	0.187%	0.131%		0.015%		6.310%	0.518%	0.010%		0.205%			0.706%	5.4
13	Basidiomycota	Agaricomycetes	Cuphophyllus_lacmus:SH0952050.10FU	0.590%	2.981%	2.913%	9.170%	3.259%	0.010%			0.002%	0.804%	1.973%			2.976%	2.492%	1.509%					0.006%	0.698%	0.4
9	Ascomycota	Eurotiomycetes	Chaetothyriales_UNKsp:OTU 18	2.221%	3.311%	2.027%	3.376%	1.331%	2.102%	3.872%	1.779%	2.607%	3.779%	2.641%	0.276%	1.056%	0.746%	0.292%	0.746%	0.522%	0.103%	0.342%	1.786%	1.019%	0.689%	0.3
29	Ascomycota		Ascomycota_UNKsp; OTU 42	0.781%	0.171%	0.365%	1.096%	0.611%	0.293%	0.551%	0.502%	0.501%	1.203%	0.607%	1.402%	1.139%	0.569%	0.606%	0.818%	0.539%	0.247%	0.192%	0.424%	0.276%	0.621%	1.0
70	Basidiomycota	Agaricomycetes	Hydnodontaceae_UNKsp;OTU 72	0.014%	0.259%	0.099%	0.200%	0.102%	0.108%	0.225%	0.500%	0.004%	0.006%	0.152%	0.003%	1.090%	0.132%	4.554%	0.003%	0.016%			0.011%		0.581%	3.8
20	Ascomycota	Eurotiomycetes	Sclerococcum_UNKsp:SH0931721.10FU	0.714%	0.956%	1.939%	0.513%	3.299%	0.326%	0.007%	0.005%	1.777%	2.539%	1.208%		1.695%	2.821%	0.004%	0.871%	0.002%		0.002%	0.020%	0.252%	0.567%	0.5
11	Ascomycota	Eurotiomycetes	Herpotrichiellaceae_sp:SH0828653.10FU	3.019%	5.266%	4.464%	3.934%	2.875%	2.350%			0.067%	0.100%	2.208%	0.631%	1.415%	1.042%	0.552%	0.797%	0.226%			0.016%	0.041%	0.472%	0.2
3	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:SH0828602.10FU	10.322%	9.054%	9.015%	6.980%	6.467%	5.976%	9.434%	3.914%	2.931%	3.615%	6.771%	0.412%	1.040%	0.958%	0.359%	0.678%	0.303%	0.194%	0.084%	0.344%	0.331%	0.470%	0.1
25	Ascomycota	Eurotiomycetes	Chaetothyriales_sp:SH0828164.10FU	0.339%	0.625%	0.303%	1.536%	0.310%	0.274%	0.749%	0.865%	1.249%	2.657%	0.891%	0.319%	1.469%	0.292%	0.436%	1.224%	0.250%	0.077%	0.357%	0.014%	0.003%	0.444%	0.5
6	Ascomycota	Archaeorhizomyce	Archaeorhizomyces_sp:SH0764667.10FU	5.602%	4.858%	4.557%	3.459%	3.847%	3.696%	3.975%	5.662%	4.555%	4.942%	4.515%	0.368%	1.034%	0.522%	0.245%	0.661%	0.272%	0.129%	0.136%	0.443%	0.629%	0.444%	0.1
872	Ascomycota	Leotiomycetes	Helotiales_sp;OTU 67		0.003%		0.003%			0.004%	0.002%			0.001%	0.475%	0.565%	0.355%	0.794%	1.002%		0.549%	0.202%	0.283%	0.198%	0.442%	349.0
22	Ascomycota	Eurotiomycetes	Capronia_sp:SH0827807.10FU	2.933%	0.606%	0.924%	0.179%	1.077%	0.745%	0.135%	0.148%	1.512%	2.503%	1.076%	0.190%	0.264%	0.629%	0.189%	0.307%	0.001%			0.029%	2.204%	0.381%	0.4
174	Basidiomycota	Agaricomycetes	Agaricales_sp:SH0814676.10FU	0.006%			0.016%	0.056%				0.193%	0.144%	0.042%			0.036%						3.469%	0.231%	0.374%	9.0
251	unclass_Fungi		Fungi_sp:SH0846109.10FU	0.066%	0.004%	0.009%	0.005%	0.061%	0.003%	0.027%	0.045%			0.022%	0.068%		0.022%	0.116%	0.037%		1.364%	2.118%			0.373%	17.0
15	Ascomycota	Eurotiomycetes	Capronia_sp:SH0828621.10FU	2.073%	0.444%	1.966%	2.013%	1.088%	1.810%	3.131%	0.796%	1.311%	1.373%	1.601%	0.016%	0.031%	1.030%	0.728%	0.178%	0.012%	0.267%	0.200%	0.489%	0.647%	0.360%	0.2
522	Ascomycota	Dothideomycetes	Dothideomycetes_sp:SH0822430.10FU	0.002%			0.002%	0.008%	0.002%			0.020%	0.014%	0.005%	0.318%	0.081%	0.193%	0.104%	0.311%				1.645%	0.830%	0.348%	73.0
126	Ascomycota	Leotiomycetes	Lachnum_pygmaeum:SH0948769.10FU	0.036%	0.021%	0.024%	0.078%	0.043%	0.065%	0.031%	0.130%	0.073%	0.137%	0.064%	0.265%	0.256%	0.241%	0.247%	0.203%	0.325%		0.689%	0.297%	0.770%	0.329%	5.2

Appendix 2 Relative abundance of eDNA of species of fungi in lichen thalli

phylum	class	order	family	genus	species	Trait	Count	CumulTOT	Mean	Max	Min	L-NA1	L-NB2	L-NC3	L-NE4	L-NG5	L-CT6	L-CP7	L-CH8
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_portentosa:SH0933093.10FU	lichenized	8	601.75%	75.22%	86.03%	65.76%	85.08%	76.08%	65.76%	69.61%	69.01%	86.03%	68.37%	81.81%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_ciliata:SH0932955.10FU	lichenized	8	58.85%	7.36%	15.19%	0.02%	0.02%	3.28%	11.97%	8.93%	7.14%	3.63%	15.19%	8.69%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_furcata:OTU 79	lichenized	7	24.98%	3.12%	9.43%	0.00%	3.090%	0.010%	0.010%	8.520%	9.430%	0.550%	3.370%	0.000%
X	X	X	X	X	OTU 64 (Unidentified)		8	19.70%	2.46%	5.70%	0.61%	2.390%	5.510%	1.400%	0.610%	5.700%	1.540%	1.700%	0.850%
Basidiomycota	Tremellomycetes	Filobasidiales	Filobasidiaceae	Zyzygomyces	Zyzygomyces_bachmannii:SH0880452.10FU	Lichenicolous	7	15.06%	1.88%	5.19%	0.00%	3.710%	1.590%	5.190%	0.050%	0.860%	0.000%	3.260%	0.400%
Basidiomycota	Agaricomycetes	Cantharellales	Hydnaceae	Sistotrema	OTU 136 (Unidentified)	litter_saprotroph	5	10.46%	1.31%	8.51%	0.00%	0.010%	0.420%	8.510%	1.510%	0.000%	0.000%	0.000%	0.010%
Ascomycota	X	X	X	X	OTU 93 (Unidentified)		8	8.780%	1.098%	3.000%	0.140%	0.880%	3.000%	0.660%	1.270%	1.230%	0.140%	0.840%	0.760%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	OTU 527 (Unidentified)	lichenized	7	7.730%	0.966%	1.730%	0.000%	0.000%	0.390%	1.480%	1.020%	0.880%	0.550%	1.730%	1.680%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	OTU 177 (Unidentified)	lichenized	7	5.660%	0.708%	1.320%	0.000%	0.000%	0.240%	1.140%	0.760%	0.640%	0.300%	1.260%	1.320%
Ascomycota	Sordariomycetes	Amphisphaeriales	Sporocadaceae	Neopestalotiopsis	Neopestalotiopsis_foedans:SH0911533.10FU	foliar_endophyte	8	2.740%	0.343%	0.870%	0.090%	0.090%	0.460%	0.110%	0.630%	0.870%	0.100%	0.100%	0.380%
Ascomycota	Leotiomycetes	Helotiales	Pezizellaceae	Xenopolyscytalum	Xenopolyscytalum_sp:SH1012222.10FU	foliar_endophyte	7	2.650%	0.331%	1.130%	0.000%	0.540%	0.210%	0.140%	0.150%	0.460%	0.000%	0.020%	1.130%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_arbuscula:OTU 170	lichenized	1	2.550%	0.319%	2.550%	0.000%	0.000%	0.000%	0.000%	2.550%	0.000%	0.000%	0.000%	0.000%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_rangiformis:SH0933060.10FU	lichenized	2	2.290%	0.286%	2.110%	0.000%	0.000%	2.110%	0.000%	0.000%	0.180%	0.000%	0.000%	0.000%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_fenestralis:SH0932988.10FU	lichenized	4	2.180%	0.273%	1.090%	0.000%	0.010%	0.000%	0.000%	0.290%	1.090%	0.000%	0.790%	0.000%
Basidiomycota	Tremellomycetes	Tremellales	Bulleribasidiaceae	Vishniacozyma	OTU 193 (Unidentified)	soil_saprotroph	3	1.810%	0.226%	1.780%	0.000%	0.010%	0.020%	1.780%	0.000%	0.000%	0.000%	0.000%	0.000%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_uncialis:SH0933004.10FU	lichenized	2	1.370%	0.171%	1.250%	0.000%	0.000%	0.000%	0.000%	0.120%	0.000%	0.000%	1.250%	0.000%
Ascomycota	Dothideomycetes	Pleosporales	Sporormiaceae	unclassified_Sporormiaceae	Sporormiaceae_sp:SH0967217.10FU		7	1.280%	0.160%	0.970%	0.000%	0.010%	0.120%	0.010%	0.020%	0.120%	0.970%	0.030%	0.000%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_ochrochlora:SH0932963.10FU	lichenized	1	1.070%	0.134%	1.070%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	1.070%	0.000%	0.000%
Ascomycota	Leotiomycetes	Phacidiales	Phacidiaceae	Phacidium	Phacidium_lacerum:SH0931217.10FU	foliar_endophyte	7	0.870%	0.109%	0.240%	0.000%	0.000%	0.240%	0.010%	0.150%	0.060%	0.120%	0.050%	0.240%
Ascomycota	Eurotiomycetes	Chaetothyriales	X	X	OTU 378 (Unidentified)		6	0.850%	0.106%	0.620%	0.000%	0.060%	0.620%	0.030%	0.030%	0.000%	0.080%	0.000%	0.030%
Ascomycota	Dothideomycetes	Pleosporales	Sporormiaceae	Sporormiella	Sporormiella_intermedia:SH0790049.10FU	litter_saprotroph	6	0.710%	0.089%	0.550%	0.000%	0.010%	0.000%	0.000%	0.040%	0.060%	0.550%	0.020%	0.030%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_merochlorophaea:SH0933165.10FU	lichenized	1	0.690%	0.086%	0.690%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.690%	0.000%	0.000%
Ascomycota	Dothideomycetes	Venturiales	Venturiaceae	Venturia	Venturia_sp:SH0987965.10FU	plant_pathogen	3	0.650%	0.081%	0.550%	0.000%	0.000%	0.030%	0.000%	0.000%	0.000%	0.070%	0.000%	0.550%
Basidiomycota	Agaricomycetes	Cantharellales	Hydnaceae	Sistotrema	OTU 422 (Unidentified)	litter_saprotroph	2	0.620%	0.078%	0.600%	0.000%	0.000%	0.000%	0.020%	0.600%	0.000%	0.000%	0.000%	0.000%
Ascomycota	Dothideomycetes	Pleosporales	unclassified_Pleosporales	unclassified_Pleosporales	Pleosporales_sp:SH0757640.10FU		1	0.560%	0.070%	0.560%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.560%	0.000%	0.000%
Ascomycota	Leotiomycetes	X	X	X	OTU 468 (Unidentified)		6	0.490%	0.061%	0.310%	0.000%	0.310%	0.030%	0.010%	0.040%	0.080%	0.020%	0.000%	0.000%
Basidiomycota	Agaricomycetes	Agaricales	Mycenaceae	Mycena	Mycena_UNKsp:SH0952157.10FU	litter_saprotroph	5	0.470%	0.059%	0.230%	0.000%	0.010%	0.000%	0.000%	0.030%	0.170%	0.230%	0.000%	0.030%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	Cladonia_merochlorophaea:SH0933073.10FU	lichenized	6	0.440%	0.055%	0.140%	0.000%	0.010%	0.080%	0.010%	0.130%	0.000%	0.140%	0.070%	0.000%
Ascomycota	Dothideomycetes	Pleosporales	Sporormiaceae	Sporormiella	Sporormiella_irregularis:SH0967100.10FU	litter_saprotroph	5	0.430%	0.054%	0.120%	0.000%	0.000%	0.120%	0.000%	0.020%	0.100%	0.110%	0.000%	0.080%
Ascomycota	Dothideomycetes	Pleosporales	Phaeosphaeriaceae	Neostagonospora	Neostagonospora_caricis:SH1021722.10FU	litter_saprotroph	2	0.430%	0.054%	0.410%	0.000%	0.410%	0.000%	0.000%	0.020%	0.000%	0.000%	0.000%	0.000%
Ascomycota	Leotiomycetes	Thelebolales	Thelebolaceae	Thelebolus	Thelebolus_globosus:SH0897423.10FU	dung_saprotroph	3	0.390%	0.049%	0.290%	0.000%	0.290%	0.000%	0.000%	0.000%	0.060%	0.040%	0.000%	0.000%
Ascomycota	Leotiomycetes	Helotiales	X	X	OTU 513 (Unidentified)		6	0.370%	0.046%	0.150%	0.000%	0.150%	0.060%	0.060%	0.080%	0.010%	0.010%	0.000%	0.000%
Ascomycota	Dothideomycetes	Myriangiales	Elsinoaceae	unclassified_Elsinoaceae	Elsinoaceae_sp:SH1015477.10FU		2	0.360%	0.045%	0.350%	0.000%	0.000%	0.350%	0.000%	0.000%	0.010%	0.000%	0.000%	0.000%
Ascomycota	Eurotiomycetes	Chaetothyriales	Herpotrichiellaceae	Cladophialophora	Cladophialophora_minutissima:SH0959369.10	soil_saprotroph	5	0.370%	0.046%	0.150%	0.000%	0.110%	0.010%	0.000%	0.010%	0.000%	0.150%	0.090%	0.000%
Ascomycota	unclassified_Ascomy	unclassified_Ascor	unclassified_Ascomycota	unclassified_Ascomycota	Ascomycota_sp:SH0926002.10FU		8	0.380%	0.048%	0.150%	0.010%	0.020%	0.150%	0.060%	0.010%	0.020%	0.040%	0.060%	0.020%
Ascomycota	X	X	X	X	OTU 523 (Unidentified)		4	0.350%	0.044%	0.280%	0.000%	0.000%	0.280%	0.040%	0.010%	0.000%	0.020%	0.000%	0.000%
Ascomycota	Leotiomycetes	Helotiales	Arachnopezizaceae	Arachnopeziza	Arachnopeziza_sp:SH1023313.10FU	wood_saprotroph	5	0.340%	0.043%	0.110%	0.000%	0.010%	0.000%	0.000%	0.100%	0.100%	0.000%	0.020%	0.110%
Ascomycota	Leotiomycetes	Helotiales	Helotiaceae	Neocrinula	Neocrinula_xanthorrhoeae:SH0748395.10FU	litter_saprotroph	8	0.330%	0.041%	0.090%	0.010%	0.010%	0.070%	0.040%	0.010%	0.020%	0.080%	0.010%	0.090%
X	X	X	X	X	OTU 491 (Unidentified)		1	0.320%	0.040%	0.320%	0.000%	0.000%	0.000%	0.000%	0.320%	0.000%	0.000%	0.000%	0.000%
Ascomycota	Dothideomycetes	Cladosporiales	Cladosporiaceae	Cladosporium	Cladosporium_herbarum:SH0962330.10FU	foliar_endophyte	7	0.310%	0.039%	0.190%	0.000%	0.010%	0.000%	0.010%	0.050%	0.010%	0.010%	0.190%	0.030%
Ascomycota	Sordariomycetes	Sordariales	Podosporaceae	Podospora	Podospora_excentrica:SH0941777.10FU	dung_saprotroph	6	0.320%	0.040%	0.190%	0.000%	0.000%	0.000%	0.040%	0.030%	0.020%	0.190%	0.030%	0.010%
Ascomycota	Sordariomycetes	Xylariales	Microdochiaceae	Microdochium	Microdochium_phragmitis:SH0913814.10FU	foliar_endophyte	2	0.300%	0.038%	0.250%	0.000%	0.000%	0.000%	0.000%	0.250%	0.000%	0.050%	0.000%	0.000%
Ascomycota	Leotiomycetes	X	X	X	OTU 299 (Unidentified)		6	0.300%	0.038%	0.240%	0.000%	0.240%	0.000%	0.010%	0.010%	0.010%	0.010%	0.000%	0.020%
Ascomycota	Leotiomycetes	Helotiales	Myxotrichaceae	Oidiodendron	Oidiodendron_cereale:SH0946007.10FU	soil_saprotroph;ro	2	0.300%	0.038%	0.290%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.290%	0.000%	0.010%
Ascomycota	Lecanoromycetes	Lecanorales	Pilocarpaceae	Micarea	OTU 510 (Unidentified)	lichen_parasite	7	0.280%	0.035%	0.170%	0.000%	0.010%	0.170%	0.010%	0.050%	0.010%	0.020%	0.010%	0.000%
Ascomycota	Eurotiomycetes	Chaetothyriales	Herpotrichiellaceae	Cladophialophora	OTU 604 (Unidentified)	soil_saprotroph	8	0.290%	0.036%	0.090%	0.020%	0.090%	0.020%	0.020%	0.020%	0.040%	0.030%	0.020%	0.050%
Ascomycota	Dothideomycetes	Mycosphaerellale:	Teratosphaeriaceae	Constantinomyces	Constantinomyces_oldenburgensis:SH0938147.10FU		6	0.270%	0.034%	0.150%	0.000%	0.000%	0.150%	0.020%	0.010%	0.000%	0.040%	0.020%	0.030%
Ascomycota	Dothideomycetes	Hysteriales	Hysteriaceae	Hysterobrevium	Hysterobrevium_rosae:SH0886013.10FU	wood_saprotroph	6	0.270%	0.034%	0.100%	0.000%	0.010%	0.000%	0.100%	0.040%	0.020%	0.050%	0.050%	0.000%
Ascomycota	Sordariomycetes	Hypocreales	X	X	OTU 695 (Unidentified)		4	0.250%	0.031%	0.190%	0.000%	0.030%	0.000%	0.000%	0.020%	0.000%	0.000%	0.010%	0.190%
Ascomycota	Eurotiomycetes	Chaetothyriales	Herpotrichiellaceae	Cladophialophora	Cladophialophora_sp:SH0976513.10FU	soil_saprotroph;ro	5	0.250%	0.031%	0.180%	0.000%	0.020%	0.180%	0.010%	0.000%	0.030%	0.010%	0.000%	0.000%
Ascomycota	Lecanoromycetes	Lecanorales	Cladoniaceae	Cladonia	OTU 2300 (Unidentified)	lichenized	4	0.260%	0.033%	0.100%	0.000%	0.000%	0.000%	0.000%	0.100%	0.070%	0.010%	0.080%	0.000%
unclassified_Fu	unclassified_Fungi	unclassified_Fung	unclassified_Fungi	unclassified_Fungi	Fungi_sp:SH1015224.10FU		6	0.250%	0.031%	0.060%	0.000%	0.000%	0.050%	0.060%	0.060%	0.030%	0.010%	0.040%	0.000%
Ascomycota	Dothideomycetes	Venturiales	Sympoventuriaceae	unclassified_Sympoventuriaceae	Sympoventuriaceae_sp:SH0743259.10FU		6	0.240%	0.030%	0.090%	0.000%	0.010%	0.020%	0.020%	0.050%	0.000%	0.050%	0.000%	0.090%
Ascomycota	Sordariomycetes	Amphisphaeriales	Sporocadaceae	Pestalotiopsis	Pestalotiopsis_rhododendri:SH0911739.10FU	plant_pathogen	4	0.250%	0.031%	0.140%	0.000%	0.000%	0.140%	0.000%	0.030%	0.050%	0.000%	0.000%	0.030%
Ascomycota	Dothideomycetes	Pleosporales	Sporormiaceae	Preussia	Preussia_dubia:SH0967183.10FU	dung_saprotroph	3	0.230%	0.029%	0.110%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.030%	0.090%	0.110%
Ascomycota	Dothideomycetes	X	X	X	OTU 281 (Unidentified)		8	0.230%	0.029%	0.080%	0.010%	0.020%	0.080%	0.010%	0.030%	0.010%	0.020%	0.030%	0.030%
Basidiomycota	Agaricomycetes	Agaricales	Mycenaceae	Mycena	Mycena_galopus:SH0748945.10FU	litter_saprotroph	1	0.220%	0.028%	0.220%	0.000%	0.220%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Ascomycota	Leotiomycetes	Helotiales	Discinellaceae	Pezoloma	Pezoloma_ericae:SH0897049.10FU	root_endophyte	5	0.200%	0.025%	0.120%	0.000%	0.120%	0.030%	0.000%	0.000%	0.010%	0.030%	0.000%	0.010%
Ascomycota	Leotiomycetes	Helotiales	unclassified_Helotiales	unclassified_Helotiales	Helotiales_sp:SH0908128.10FU		2	0.190%	0.024%	0.130%	0.000%	0.130%	0.000%	0.000%	0.000%	0.060%	0.000%	0.000%	0.000%
Ascomycota	Dothideomycetes	Pleosporales	Sporormiaceae	unclassified_Sporormiaceae	Sporormiaceae_sp:SH0789780.10FU		3	0.200%	0.025%	0.180%	0.000%	0.000%	0.000%	0.010%	0.000%	0.010%	0.180%	0.000%	0.000%
Ascomycota	Sordariomycetes	Amphisphaeriales	X	X	OTU 808 (Unidentified)		3	0.190%	0.024%	0.110%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.010%	0.110%	0.070%
Ascomycota	Eurotiomycetes	Chaetothyriales	Herpotrichiellaceae	Cladophialophora	OTU 331 (Unidentified)	soil_saprotroph	6	0.190%	0.024%	0.090%	0.000%	0.020%	0.020%	0.020%	0.030%	0.000%	0.010%	0.000%	0.090%
Ascomycota	Leotiomycetes	Helotiales	Lachnaceae	Lachnum	Lachnum_pygmaeum:SH0948769.10FU	litter_saprotroph	7	0.170%	0.021%	0.060%	0.000%	0.010%	0.020%	0.060%	0.020%	0.000%	0.020%	0.020%	0.020%
Ascomycota	Lecanoromycetes	Lecanorales	Scoliciosporaceae	Scoliciosporum	Scoliciosporum_sarothamni:SH0925044.10FU	lichenized	6	0.170%	0.021%	0.070%	0.000%	0.010%	0.020%	0.000%	0.020%	0.070%	0.020%	0.030%	0.000%
Basidiomycota	Tremellomycetes	Tremellales	unclassified_Tremellales	unclassified_Tremellales	OTU 691 (Unidentified)		6	0.170%	0.021%	0.080%	0.000%	0.020%	0.010%	0.080%	0.020%	0.010%	0.030%	0.000%	0.000%
Basidiomycota	Cystobasidiomycete	Cystobasidiomyce	Microsporomycetaceae	unclassified_Microsporomycetaceae	Microsporomycetaceae_sp:SH0964623.10FU		5	0.170%	0.021%	0.120%	0.000%	0.120%	0.000%	0.000%	0.010%	0.010%	0.010%	0.020%	0.000%
Ascomycota	Dothideomycetes	Capnodiales	unclassified_Capnodiales	unclassified_Capnodiales	Capnodiales_sp:SH0950800.10FU		5	0.170%	0.021%	0.080%	0.000%	0.000%	0.080%	0.020%	0.020%	0.030%	0.000%	0.020%	0.000%
Ascomycota	Eurotiomycetes	Chaetothyriales	Herpotrichiellaceae	Capronia	Capronia_sp:SH0828111.10FU	soil_saprotroph	4	0.160%	0.020%	0.090%	0.000%	0.000%	0.090%	0.040%	0.020%	0.010%	0.000%	0.000%	0.000%
Ascomycota	Lecanoromycetes	X	X	X	OTU 973 (Unidentified)		3	0.150%	0.019%	0.120%	0.000%	0.000%	0.120%	0.020%	0.000%	0.000%	0.010%	0.000%	0.000%

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DO THERMOPHILOUS FUNGI OCCUR IN THE NESTS OF LUNDY HOUSE SPARROWS?

by
JOHN HEDGER[1] AND JAMIE DUNNING[2]
[1]9 Durnamuck, Dundonnell,Wester Ross, IV23 2QZ [2] 38 Gratitude Road, Greenbank, Bristol, Bs5 6EH
[1] Corresponding authors: johnnhedger2@gmail.com [2] jamiedunning8@gmail.com

ABSTRACT
The micro-fungi in the nest cups of the House Sparrow (*Passer domesticus*) collected from farm buildings on Lundy in 2020 were investigated in 2025 by two methods: 1, incubation of samples in damp chambers; 2, preparation of a dilution series on a selective agar medium to count colony forming units (CFUs). Incubation was at 20°C (for mesophilic fungi) and 40 °C (for thermophilous fungi). Taxa were identified and counted by microscopy. Six species of thermophile and nine species of mesophile were found, totalling 15, of which 13 were new records for Lundy. Populations of thermophilous fungi were lower than reported in most previous studies of bird's nests, possible due to the long storage of the nests (3 years).

INTRODUCTION

The population of House Sparrow, *Passer domesticus,* living and breeding on Lundy is the subject of long-term study and represents one of the longest running wild genetic pedigree systems on earth (for methods, see Dunning, Burke & Schroeder 2023). In recent years two days of field work on the fungi of Lundy have been successfully added to the programme of the postgraduate field course to give students experience of a completely different set of organisms, beyond sparrows. The week ends with a seminar session entitled 'Sparrows and Fungi', a unique idea but really just a serendipitous juxtaposition of presentations on the separate findings of their field work.

However, there is a real connection between House Sparrows and fungi, and indeed with many other birds; their cup nests provide an ideal place for some fungi to grow, especially because the temperature of the nest material is raised during the incubation of eggs and young chicks, often to 30- 40 °C.The heat, retained well by the nest construction, allows populations of heat loving micro fungi ('moulds') to develop in the nest material, which is also damp, the only similar environments being places like compost heaps and self- heating hay where temperature is raised by microbial activity, and where there are high populations of these fungi. Some have optimum growth temperatures of around 45°C (described as thermophilic, heat loving, by Cooney & Emerson 1964) although the term thermophilous, used by Apinis & Pugh in 1967, encompasses a wider range of fungi with optima around 35 °C and was employed in our study. In contrast mesophilic fungi found in soil and litter grow optimally around 20-25 °C. In their pioneering study Apinis & Pugh (1967) found a rich diversity of fungal thermophiles in nests of Passerine birds, with populations far higher than in the surrounding environment and several thermophilous species were first found and described from nests. Subsequent studies have confirmed the high populations of thermophilous fungi in nests of many species of bird e.g. Satanarayana *et al* 1977; Chaturvedi & Sarethy 2022. For the most part the association remains benign, but scarcely studied, with the fungi benefitting from the warmth but also able to use nest material, especially plant materials, as a food source, but also including keratin from the feather linings.

No studies have been carried out on fungi in bird's nests on Lundy. An opportunity came during Covid lockdown when the then Warden Rosie Ellis and Jamie Dunning collected nests of House Sparrow, following the breeding period, and sent them by post to John Hedger who had the intention of studying the fungal population during lockdown. Procrastination led to the study being delayed until 2025, when the stored nests were eventually investigated and the results are presented in this short paper.

METHODS

Collection of House Sparrow nests on Lundy

Nesting boxes on Lundy are clustered into 'neighborhoods', with a median distance of 7.8 m (SE = 0.52) between boxes within each neighborhood. Each cluster is associated with farm infrastructure, and the majority are inside farm buildings (Dunning, Burke, and Schroeder 2023), with associated fitness cost/benefits to the breeding pair - that is, some nest sites are of higher quality than others through factors proximity to resources and their environment (Schroeder *et al*. 2012). A minority of House Sparrows on Lundy use either nesting boxes on the outside of farm buildings or, to a lesser extent, 'wild' nest sites, often in drystone walling on the periphery of existing neighborhoods. Plate 1 shows a typical nest.

Three nest cups were collected during annual nest box cleaning in December 2022, outside of the sparrow breeding period, from two neighbourhoods, both inside farm buildings and so all nest cups were drier and warmer than outdoor nest sites. House Sparrows typically have two to three broods of four or five eggs per breeding season (Westneat *et al* 2014), and so nests were generally incubated by either parent birds or thermoregulating chicks between April and July. Nest cups were stored in dry bags kept in the buildings within which they were collected, until sent off for mycological sampling.

Plate 1 Sparrow's nests with eggs © Jamie Dunning.

Ethical Note

Although all handling of birds on Lundy is subject to licenses from the British Trust for Ornithology and the UK Government Home Office, no specific laws prevent the cleaning of nest boxes, or the collection of passerine nests, outside of the breeding season

Mycological Studies

Samples were taken in January 2025 from the three nests, labelled 1-3, which had been stored dry in polythene bags since 2020. A sample of about 100g dry weight was removed with a knife from the inside of each nest cup. It consisted of woven grass (including *Festuca ovina* seed heads), moss, feathers, invertebrate frass and bird droppings. They were stored in a labelled sterile petri dishes. Two approaches were used to examine the fungal populations in the samples: -

1) *Estimation of relative abundance of fungal species by direct observation of nest material held in damp chambers.* 10 randomly selected small pieces (5mm maximum length) of nest material were incubated in damp chambers (petri dishes lined with damp filter paper). Ten dishes were set up for each nest sample. Five were sealed in plastic bags and placed in an incubator with temperature controlled at 40-43 °C (average 40 °C). Five were sealed in bags and kept at room temperature (range17-22 °C, average 20 °C). After one week and two weeks incubation the nest material samples were checked under a dissecting microscope and sporulating fungi identified, removing samples for mounting on slides under a compound microscope for final checking of identity. Each species was given a score of one (in one damp chamber) to five (in all five).

2) *Dilution plating on a selective agar medium to give quantitative estimates of the fungal populations.*10g samples from nests 1,2 & 3 were weighed out and separately added to 1 litre of tap water in a 5 litre plastic can. The top was replaced and the contents shaken vigorously for five minutes. This suspension was a dilution of 1:100. 1ml was then added to 9ml of water, giving a dilution of 1:1000. 1.0ml samples of the dilutions were withdrawn with a wide mouthed pipette and added to one of eight petri dishes. About 20ml of liquid (at around 50°C temperature) Rose-Bengal agar medium (Oxoid Ltd.), containing 0.1g/l Chloramphenicol to suppress bacterial growth, was poured into each dish and the contents swirled to disperse the suspension. After the agar had set, the petri dishes were sealed in plastic bags and incubated at 40-43 °C (average 40 °C), for development of thermophilous fungi, and at room temperature 17-22 °C (average 20 °C) for development of mesophilic fungi (four plates/each dilution). Fungal colonies were counted after one week of incubation and identified using dissecting and compound microscopes. Average numbers of colonies per plate vs dilution factor (1 x 102 and 1 x 103) were used to calculate populations as colony forming units (CFUs) derived from propagules like spores and hyphae, per g dry weight of the nest material.

RESULTS

The results are shown in Table 1, incubation at 20 °C (average) and Table 2-incubation at 40 °C (average). The data for the damp chambers shows presence/absence of a species in each of five dishes, so 5/5 = 100% record. The data for the dilution plating represents numbers of colony forming units (CFUs) per g. of material, calculated from the colony counts and dilution factor.

Plate 2 Fungal colonies growing on Rose Bengal/ Chloramphenicol selective medium. Incubated at 20°C. Dilution 1:1000 from Nest 2. The yellow/ white colonies are *Scopulariopsis brevicaulis*.

At 40 °C *Aspergillus fumigatus* had the highest colony count on plates from all three nests and it was also found on all the incubated material, as were two other fungi, *Myceliophthora thermophila* and *Absidia ramosa* (illustrated in Plate 2) . Three species, *Rhizomucor pusillus*, *Coprinopsis cinerea* and *Scytalidium thermophilum* were recorded on the incubated material but only one of these species, *Rhizomucor pusillus,* also grew on the plates. The plate-count totals gave a figure of 1-2,000 CFUs/ g/dry weight nest material for thermophilous fungi.

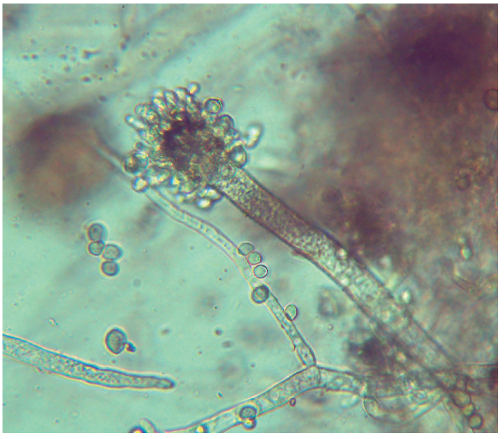
Table 1a Frequency of fungi in five Damp Chambers (40°C incubation).

	Nest 1	Nest 2	Nest 3	Total Score/15
Apergillus fumigatus	4	5	3	12
Absidia ramosa	4	2	0	6
Myceliophthora thermophila	4	1	5	10
Rhizomucor pusillus	4	0	1	5
Coprinopsis cinerea	1	0	0	1
Scytalidium thermophilum	1	1	0	2

Table 1b Numbers of fungi (CFUs) /g dw nest material (40°C incubation of agar plates).

	Nest 1	Nest 2	Nest 3
Aspergillus fumigatus	2000	1000	1500
Scopulariopsis brevicaulis	0	0	62
Absidia ramosa	0	250	250
Myceliophthora thermophila	0	0	62
Rhizomucor pusillus	0	250	0
Unknown	150	0	0
Aspergillus flavus	100	100	200

At 20 °C eight species were recorded by plating out and damp chambers, though the lists differed: *Aspergillus candidus, A.flavus* and *Scopulariopsis brevicaulis* were recorded by both methods; the two *Chaetomium* species, *C.elatum* and *C.globosum* were only found on the incubated nest material; *Absidia ramosa, Cladosporium herbarum, Penicillium brevicompactum*, *Stachybotrys dichroa*



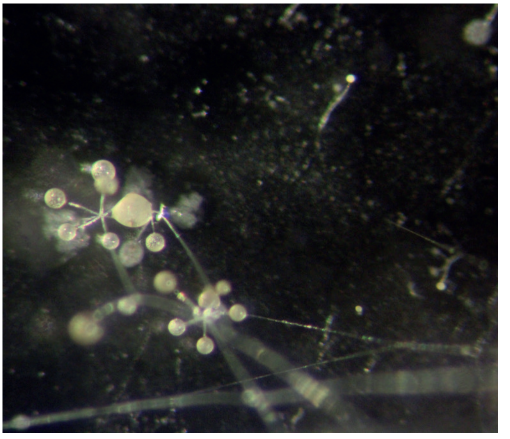


Plate 3 Photomicrographs of thermophilous microfungi
3a *Aspergillus fumigatus* conidial head (x 400). **3b** *Absidia ramosa* sporangia (x 20).

were only found by plating out. *A.flavus* and *A.candidus* were recorded from incubated material of all three nests but only by plating out from nest three; no colonies grew on plates from nests one and two. *Scopulariopsis brevicaulis* was easily the most abundant fungus on all the incubated nest material but colonies only occurred on plates from the nest two dilutions.Green/yellow colonies of *Trichoderma* completely dominated plates from dilutions of nest one material, but only a few grew on plates from nests two and three. The conidia were covered in small spines, placing the fungus in the *Trichoderma viride* species complex.

The total population of mesophilic fungi calculated from the plate-counts was 10-20,000 propagules/g/dry weight nest material.

Table 2a Frequency of fungi in five Damp Chambers (20°C incubation).

	Nest 1	Nest 2	Nest 3	Total Score/15
Apergillus fumigatus	4	5	3	12
Absidia ramosa	4	2	0	6
Myceliophthora thermophila	4	1	5	10
Rhizomucor pusillus	4	0	1	5
Coprinopsis cinerea	1	0	0	1
Scytalidium thermophilum	1	1	0	2

Table 2b Numbers of fungi (CFUs) /g dw nest material, (20°C incubation of agar plates).

	Nest 1	Nest 2	Nest 3
Aspergillus fumigatus	2000	1000	1500
Scopulariopsis brevicaulis	0	0	62
Absidia ramosa	0	250	250
Myceliophthora thermophila	0	0	62
Rhizomucor pusillus	0	250	0
Unknown	150	0	0
Aspergillus flavus	100	100	200

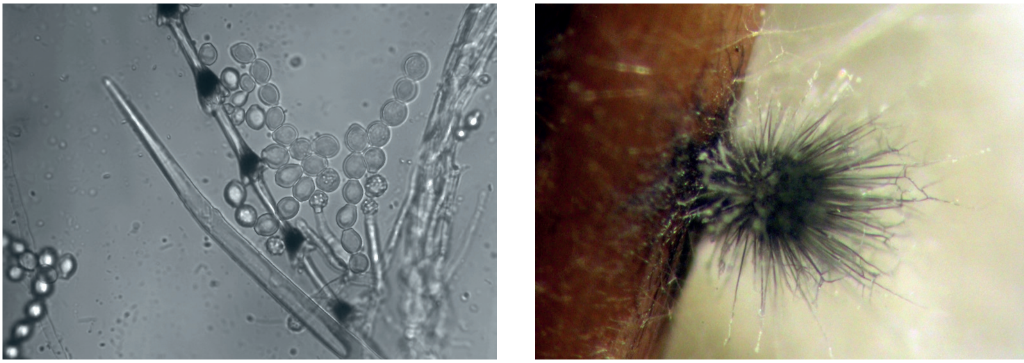


Plate 4 Mesophilic microfungi
4a Conidiophores and conidia of *Scopulariopsis brevicaulis* on nesting material x 400.
4b Perithecia of *Chaetomium elatum* on nesting material (x20).

DISCUSSION

The project set out to study the micro fungi within the nest cups of Lundy House Sparrows, with a prediction that thermophilous species would take advantage of nest cup warmth whilst breeding is taking place. Apinis & Pugh (1969) were the first mycologists to investigate the nests of passerine birds and found 27 species of thermophilous fungi in a survey in Nottinghamshire. Our own results were somewhat disappointing in comparison, detecting only six species of thermophilous fungi, with populations of only c.2,000 propagules per g of nest material as against up to 20,000 for mesophilic fungi. *Aspergillus fumigatus* was the most frequently found in all three nests. It is thermophilous, with an optimum growth temperature of 37 °C and is sometimes of concern because of its known pathogenicity to birds (Beernaert *et al* 2010).

Myceliophthora thermophila is thermophilic, as against thermophilous, with an optimum growth temperature of 45 °C and was also recorded for all three nests. It was also frequently found in passerine nests by Apinis & Pugh as its anamorph (asexual state), *Sporotrichum thermophile*. *Rhizomucor pusillus* and *Scytalidium thermophilum* (=*Mycothermus thermophilus*) are also thermophilic, with growth optima at 45 °C and were found as large populations in bird's nests by Apinis & Pugh (*S.thermophilum* as *Torula thermophila*). They did not feature much in the plating data in our study but were recorded in the damp chambers, so were probably at very low populations.

The other two *Aspergillus* species we found, *A.candidus* and *A.flavus* only appeared at 20 °C incubation but are near thermophilous, having growth optima around 30 °C . Both have been recorded from bird's nests e.g. Korniłłowicz-Kowalska & Kitowski (2013) but are best known as food spoilage organisms in warm conditions, for example *A.flavus* on Peanuts where it releases potent toxins, Alfatoxins (Samson & van Reenen-Hoekstra 1988). *Absidia ramosa* (=*Lichtheimia ramosa*), is a 'pin mould', which is also near thermophilous and was recorded after incubation at both 40 and 20 oC on both nest material and by plating out. It is common in composts and other self-heating habitats.

Scopulariopsis brevicaulis (=*Microascus brevicaulis*), has been recorded from soils all over the world (Woudenberg *et al* 2017) and has a wide temperature/ growth range, with a few colonies appearing on the 40 °C plates (Figure 1). It often colonises keratin, e.g. hair, feathers,is considered keratinophilic and can also be a dermatophyte on humans, infecting skin or nails. Its frequency on the 20 oC incubated nest material suggests a high population, confirmed by the dilution plating for nest 2 (20,000 propagules/ g) though it was inexplicably absent from nest 1 and 3 counts. It may well have been growing on the feathers lining the nest cups; perhaps nest 2 had feathers and the others not. Hubalek (1976) found keratinophilic fungi, including *S.brevicaulis,* to be active colonisers of feathers lining the cups of Tree Sparrow nests so its occurrence in the nests of Lundy House Sparrows is logical.

The record of *Coprinopsis cinerea* on material from nest 1 incubated at 40 °C in a damp chamber is interesting. This gill fungus normally grows in places rich in nitrogen such as manure heaps, where it forms white 'Inkcap' fruiting bodies .It was recorded from birds' nests by Apinis & Pugh in their 1967 study, as *Coprinus delicatulus.* We identified it by the presence of clamp connections (characteristic of basidiomycete fungi) on a white mycelium covering the nest material in one of the damp chambers. Further inspection found brown egg-shaped sclerotia characteristic of this species, which is thermophilous (Hedger 1974). One hypothesis is that its presence was linked to the Sparrow droppings in the nest cups.

The two *Chaetomium* species, *C.elatum* and *C.globosum* are well known as decomposers of plant remains and are widely recorded on hay and straw in storage (Ellis & Ellis 1988) so may have grown on the nest material such as grass stems before, and more probably, after the nests were taken down and stored in December 2022 *Stachybotrys dichroa* recorded on agar plates from nest three is most likely to have been a coloniser of the nest material before it was incorporated into the nest, persisting as spores which germinated on the plates. *Botrytis cinerea* colonies, found on plates from nest probably arose from its black sclerotia on the dead plant remains collected by the birds for nest material and is commonly seen on stems of dead plants in and around Millcombe, though only recorded officially in 2024!

A caveat must be added: all three nests had been stored for four years prior to the investigation of their mycoflora. They were 'dry', but at room temperature the storage may have altered the species composition compared to when they were' just used nests', with 'nest fungi' being replaced by mesophilic 'storage fungi' like the *Aspergillus* species, which can grow at low water contents. Nest one is a good example of a mycoflora affected by storage. *Trichoderma viride* made up most of the colonies on the dilution plates. This fungus is often recorded as a secondary invader of plant litter and wood, replacing other fungi by chemical and parasitic antagonism, but needs a higher water content (Watkinson *et al* 2016). So perhaps this nest was much damper than the other two, allowing *T.viride* to dominate.

CONCLUSIONS

This simple study has confirmed that thermophilous micro fungi can be found in the used nests of House Sparrows on Lundy. Numbers both in populations and species diversity were disappointingly low, although undoubtedly higher than in Lundy soils, but the nests had been in store for some years. Should the opportunity arise, fresher nests would give more accurate results. The study increased the number records of fungi on Lundy, since thirteen of the mesophilic and thermophilous species found are not on the current database (**https://www.lundy.org.uk/**).

It has also added another facet to the ongoing Lundy Sparrow Project, making the annual November seminar title 'Sparrows and Fungi' real rather than theatrical.

ACKNOWLEDGEMENTS

We thank past Lundy Warden Rosie Ellis for permission to collect the Sparrow nests and dispatching them to NW Scotland. Lily Page is thanked for her help with preparing agar media and plating out the samples. Hypha Discovery Ltd., Abingdon, Oxford and Professor Gareth Griffith, Aberystwyth University are thanked for gifts of laboratory supplies which made the bench work possible to isolate the fungi.

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'THIS EXCELLENT MAN …': KRISTJÁN MAGNÚSSON, MARTIN COLES HARMAN AND PAINTINGS OF LUNDY

by

ANDRÉ COUTANCHE

14 Queens Road, Bishopsworth, Bristol, BS13 8LB

e-mail: acoutanche@gmx.co.uk

ABSTRACT

Kristján Helgi Magnússon (1903-1937) was an Icelandic artist who studied in the U.S.A. and worked in Iceland, the U.S. and the U.K. In spring 1931 he lived and painted on Lundy. My paper in 2016 described what was then known of these events. Subsequent significant discoveries and collaborative work with Icelandic researchers now provide much more detail and a broader context for the artist's work on Lundy. The relationship between Kristján Magnússon and Martin Coles Harman is explored. More of the Lundy paintings have been located and are described here.

Keywords: *Kristján Magnússon, Lundy, Iceland, art history*

INTRODUCTION

My paper in the 2016 *Journal of the Lundy Field Society* described what could be discovered then about the paintings of Lundy done by Kristján Magnússon in 1931 at the behest of the then owner of Lundy, Martin Coles Harman (MCH). Two subsequent developments have transformed our knowledge of what happened in 1931 and made possible and necessary this updated account. One was the discovery of a file of papers relating to Kristján Magnússon (KHM) in the archives of Martin Coles Harman. The other was the publication of the 2016 paper on the website of the Lundy Field Society (LFS) which resulted in two contacts. One contact led to the location of a 'lost' painting and the other led to an extremely fruitful collaboration with an Icelandic researcher who had been commissioned to write a major book on the artist's life and work. Work has also continued to try to trace more of the Lundy paintings and the number of them now documented has gone from two in 2016 to nine now.

THE ARCHIVE FILE

When MCH died in 1954, his son, Albion Harman, continued to operate his own business interests from the same office at 65 Broad Street Avenue, London, E.C.2. When Albion died in 1968, the documents and files from that office were moved to the 'box room' of Diana Keast (MCH's younger daughter) and her husband's flat in Marlborough. When Diana moved to a residential home, all the material was put into storage. In 2020, it became necessary to vacate the storage facility and a group of LFS members volunteered to help sort the material and ensure its conservation in an appropriate place – the British Library for the philatelic material and the North Devon

Record Office for other historically important Lundy-related material. One of the files in the archive related to MCH's dealings with Kristján Magnússon. It contained carbon copies of Harman's letters to KHM and originals of KHM's letters to Harman. There were also letters to and from galleries which exhibited the artist's work and internal memoranda and lists of paintings. All this has enabled answers to questions raised in the 2016 paper which could only be speculated about then. It has also illuminated the relationship between Harman and the artist. They clearly became friends, while maintaining a business relationship in which both parties appreciated the value of money.

All the material in the file has been scanned at 400dpi and is available for future researchers on the LFS website at https://www.lundy.org.uk/journal-9-resources. Each document has been given a number; where a document has more than one page, the scans of the individual pages are suffixed with 'a', 'b' etc. References to these documents are shown in this paper in square brackets, e.g. [075a]. The original documents have been deposited at North Devon Record Office.

THE ICELANDIC CONNECTION

Rakel Olsen is the daughter-in-law of the sister of Kristján Magnússon's wife, Klara. She collects KHM's work and believes that he is seriously neglected and under-appreciated in Iceland. She commissioned Einar Falur Ingólfsson, a writer, photographer and artist, to research Kristján Magnússon's life and works. Rakel Olsen had found my 2016 paper on the LFS website and Einar Ingólfsson e-mailed me to ask whether any more of the Lundy paintings had been discovered since then.

We have been co-operating since May 2023. I have supplied him with all the information from the Harman archive file, which includes almost all of the known surviving letters from Kristján Magnússon, and he has discovered a newspaper reference to an unknown painting of Lundy being shown in 1932 in Reykjavík and found a 'new' Lundy painting owned by a member of the artist's family in Canada. His broader researches into KHM's life and career also provide valuable background information and context for the Lundy visit.

A major book about the life and work of Kristján Magnússon by Einar Ingólfsson (editions in both Icelandic and English) was published in May 2025, coinciding with an exhibition about the artist's work ('Kristján H. Magnússon Revisited') held at the Icelandic National Gallery in Reykjavík.

ICELANDIC PERSONAL NAMES AGAIN

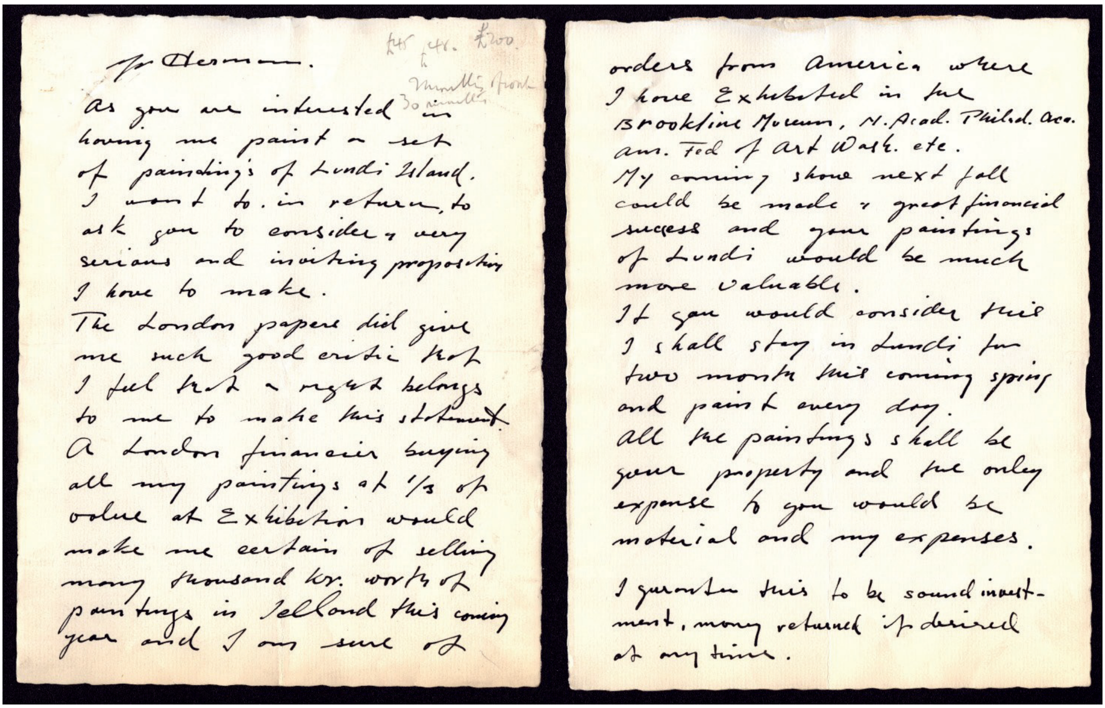
I noted in my 2016 paper that to call Kristján Magnússon 'Magnússon' or 'Mr Magnússon' made no sense in an Icelandic context (though he was used to being addressed in that way in the U.S. or U.K.). Icelanders are properly addressed simply by their given names.

As a matter of courtesy, therefore, I shall refer in this paper to the artist as 'Kristján' or by his initials, KHM, and I shall refer to my fellow researcher Einar Ingólfsson as 'Einar'.

MARTIN COLES HARMAN AND KRISTJÁN MAGNÚSSON

As described in the 2016 paper, MCH and Kristján met when Harman visited an exhibition of paintings of Iceland put on by KHM at the Alpine Club Gallery in London in September 1930. We have no documents to explain why and how KHM came to London and arranged this exhibition, but Einar Ingólfsson's research into the artist has shown that he was enterprising and ready to take initiatives to get his work seen – and sold. For example, when an exhibition was held in Stockholm in autumn 1932 of works by Icelandic artists, the Icelandic art 'establishment' which selected the paintings excluded anything by Kristján. Undaunted, he travelled to Stockholm and found and rented premises to show his paintings independently of the official exhibition.

The contemporary newspaper articles following the Alpine Club exhibition in 1930 report that MCH invited KHM to dinner and the theatre, and the idea of painting on Lundy had obviously been raised in conversations between them because the first letter in the archive [001] is from the artist to Harman with a proposition to that effect.



Mr Harman.

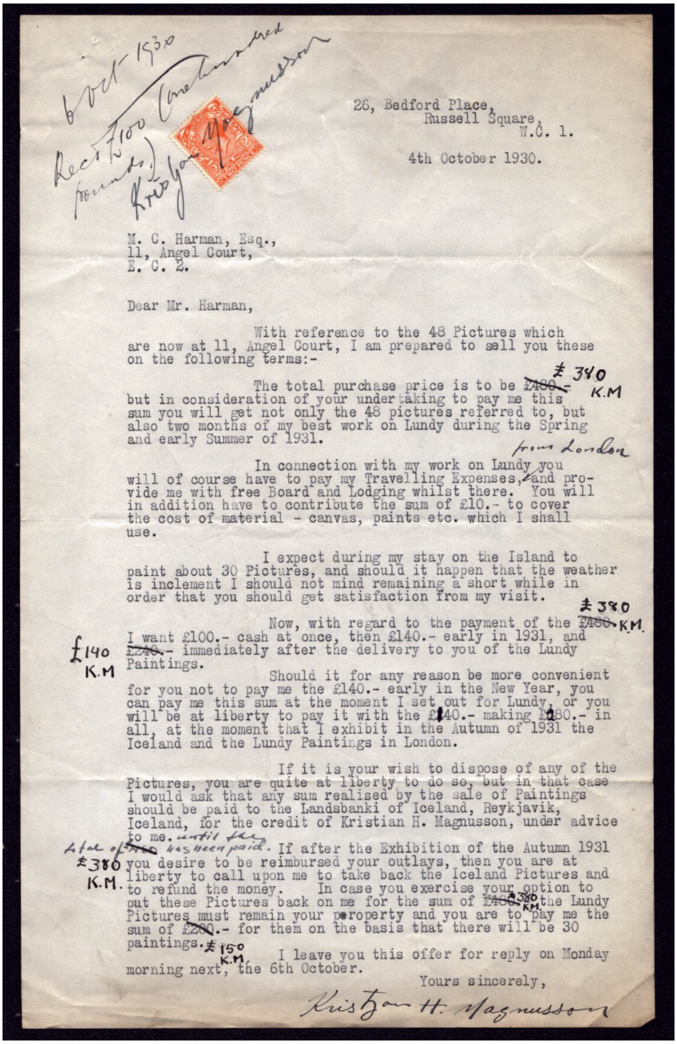
As you are interested in having me paint a set of paintings of Lundi Island. I want to. in return, to ask you to consider a very serious and inviting proposition I have to make.
The London papers did give me such good critic that I feel that a right belongs to me to make this statement.
A London financier buying all my paintings at 1/3 of value at Exhibition would make me certain of selling many thousand kr. worth of paintings in Iceland this coming year and I am sure of orders from America where I have Exhibited in the Brookline Museum, N. Acad. Philad. Aca. Am. Fed of Art Wash. etc.
My coming show next fall could be made a great financial success and your paintings of Lundi would be much more valuable.
If you would consider this I shall stay in Lundi for two months this coming spring and paint every day.
All the paintings shall be your property and the only expense to you would be material and my expenses.

I garantee this to be sound investment, money returned if desired at any time.

Plate 1: Letter from Kristján Magnússon to MCH proposing a deal [001]

The letter is undated and handwritten, and Kristján's English, while not quite perfect, is as excellent as would be expected from someone who had worked and studied in the U.S. It may be that a final page has been lost, because the letter isn't signed, though it might have been an informal note in response to a request from Harman for a proposal.

The next document in the archive [002] is formal. It is dated, typewritten and signed by Kristján Magnússon and is the contract between the artist and his patron. It also shows that the friendship between the two men was independent of their relationship as businessmen; MCH has 'beaten down' KHM's initial prices by £100.



26, Bedford Place,
Russell Square,
W.C. 1.

4th October 1930.

M. C. Harman, Esq.,
11, Angel Court,
E. C. 2.

Dear Mr. Harman,

With reference to the 48 Pictures which are now at 11, Angel Court, I am prepared to sell you these on the following terms:-

The total purchase price is to be ~~£480.-~~ £340 K.M but in consideration of your undertaking to pay me this sum you will get not only the 48 pictures referred to, but also two months of my best work on Lundy during the Spring and early Summer of 1931.

In connection with my work on Lundy you will of course have to pay my Travelling Expenses, from London and provide me with free Board and Lodging whilst there. You will in addition have to contribute the sum of £10.- to cover the cost of material - canvas, paints etc. which I shall use.

I expect during my stay on the Island to paint about 30 Pictures, and should it happen that the weather is inclement I should not mind remaining a short while in order that you should get satisfaction from my visit.

Now, with regard to the payment of the ~~£480.~~ £380 K.M. I want £100.- cash at once, then £140.- early in 1931, and ~~£240.-~~ £140 K.M immediately after the delivery to you of the Lundy Paintings.

Should it for any reason be more convenient for you not to pay me the £140.- early in the New Year, you can pay me this sum at the moment I set out for Lundy, or you will be at liberty to pay it with the £140.- making £280.- in all, at the moment that I exhibit in the Autumn of 1931 the Iceland and the Lundy Paintings in London.

If it is your wish to dispose of any of the Pictures, you are quite at liberty to do so, but in that case I would ask that any sum realised by the sale of Paintings should be paid to the Landsbanki of Iceland, Reykjavik, Iceland, for the credit of Kristian H. Magnusson, under advice to me. until the total of ~~£480~~ £380 K.M. has been paid. If after the Exhibition of the Autumn 1931 you desire to be reimbursed your outlays, then you are at liberty to call upon me to take back the Iceland Pictures and to refund the money. In case you exercise your option to put these Pictures back on me for the sum of ~~£480.~~ £380 K.M. the Lundy Pictures must remain your p•roperty and you are to pay me the sum of ~~£200.-~~ £150 K.M. for them on the basis that there will be 30 paintings.

I leave you this offer for reply on Monday morning next, the 6th October.

Yours sincerely,

Kristjan H. Magnusson

Plate 2: The contract between Harman and Kristján Magnússon [002]

In 2016 I speculated that the deal between them meant that the Lundy paintings automatically became Harman's property. This is now confirmed, and the contract also covers the paintings of Iceland from the Alpine Club exhibition, many of which were ultimately returned to KHM. Kristján is guaranteeing to deliver 30 paintings from Lundy; he actually delivered 32, illustrating the good self-employed businessman's maxim: don't undercharge – overdeliver. Note that he is committing to 30 paintings in two months (and offering to stay longer to meet the commitment if the weather is too bad to paint every day). This is consistent with what is known of his work in Iceland and North America; he was very prolific. However, Einar Ingólfsson's research has discovered that, while meeting his commitment in full, Kristján didn't deliver *all* his Lundy paintings to MCH. In a review in a short-lived Reykjavík newspaper, the reporter writes about an exhibition of 30 paintings Kristján Magnússon mounted in a Reykjavík restaurant in June 1932, the year after his Lundy adventure. The reviewer writes: 'Best þykir mér lítil mynd frá Lundy – eyju i Írlandshafi' – 'The best one is a small painting from Lundy – an island in the Irish Sea' (Einar's translation). And another Lundy painting now belongs to a member of the extended family in Canada. These two – and we have no way of knowing if there were more – were perhaps brought from Lundy on rolled-up canvases and were retained by the artist either as personal mementos or as additional sales material.

Another exchange of letters in 1931/1932 illustrates the mix of business and genuine friendship which characterised the relationship between MCH and Kristján Magnússon. On 5 December 1931, Harman wrote to the artist [043] while he was back in Iceland. The primary subject is a planned exhibition of KHM's paintings of Iceland in Hull, but MCH adds a personal request: he refers to a painting of Mount Hekla which Kristján had exhibited at the Fine Art Society and asks to acquire it as a 'swap' against some of the paintings of Iceland which MCH had already bought. Kristján replies on 20 December 1931 [046] saying that he probably has a buyer in Iceland for the painting of Mount Hekla and makes a counter-offer: if Harman pays him before the end of January the £140 which is still outstanding under their agreement, he will paint 'a fine painting' of Hekla which will cost Harman nothing. (Kristján had to press Harman several times to pay what he owed; the recession was starting to bite and MCH, like other businessmen, was short of cash). Harman replied on 4 January 1932 [047], thanking Kristján fulsomely for his generous offer and concluding:

> 'I am going to ask you one emphatic question, and that is this: Are you thoroughly satisfied that you have been decently treated by me? I think you will say 'yes' but I should like to have it on record.
>
> 'Had times not been so very difficult I should have liked to have done more than I have done. You on your part have been simply splendid and have done everything that you said that you would do.'

The £140 was not paid in January, and settlement was not reached until November 1932 [054]. However, MCH didn't forget about a painting of Hekla; on 12 June 1933 [058] he wrote to Kristján to raise the subject again. On 1 August 1933 [059], KHM replied, saying that he would paint the picture for Harman 'sometime during next winter' – but asking for help in finding a loan of £500 to build a studio in Reykjavík. As one businessman to another, Kristján calls it an 'Icelandic real estate investment'. There is no evidence that the painting of Hekla was ever done or a loan arranged.

In another file in the archive, relating to philatelic matters, there is a letter from MCH to Antoine Medawar, a stamp dealer who marketed Lundy stamps in the 1950s. Harman is referring to the forthcoming launch of a stamp issue in 1953. He writes:

> 'My family have a number of paintings of Lundy by Kristjan Magnusson, the Icelandic artist who died in 1934. [*sic* - he died in 1937]
>
> 'This excellent man had a studio in Reykjavik and another in Boston, Mass.
>
> 'I wonder whether it would assist Mr. Gade if he had some of these pictures of Lundy with him?
>
> 'I am trying to find out whether Magnusson's pictures have any considerable value in Boston.'

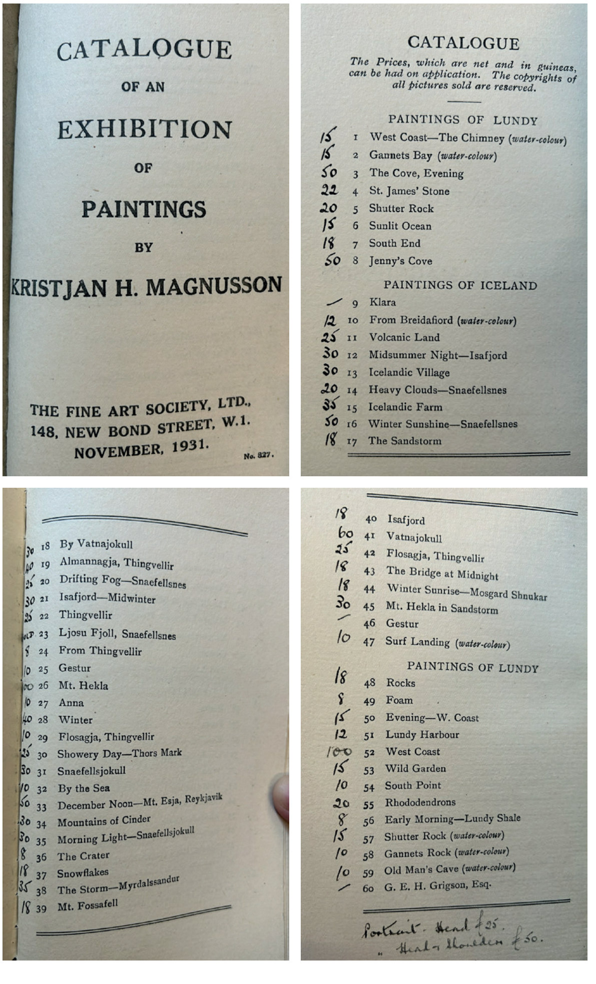
(Felix Gade was MCH's agent on Lundy and was clearly involved in the stamp launch). Sixteen years after Kristján's death, Martin Coles Harman is simultaneously remembering him with admiration and trying to make money out of him.

KRISTJÁN MAGNÚSSON'S EXHIBITIONS IN THE U.K.

In the 2016 paper, two exhibitions were known: the September 1930 Alpine Club exhibition of paintings of Iceland, where Kristján and MCH met, and the Fine Art Society exhibition in November 1931 which showed many of the Lundy paintings and some more of Iceland. As a result of letters in MCH's archive, contacting the art galleries and further newspaper archive research, five exhibitions can now be identified:

September 1930: Alpine Club, London (paintings of Iceland)
December 1930: Alpine Club, London (Iceland)
November 1931: Fine Art Society, London (Lundy and Iceland)
January-March 1932: Ferens Art Gallery, Hull (Iceland)
October 1936: Cooling Galleries, London (Iceland).

The Cooling Galleries no longer exist, but the other three galleries have been very helpful in searching their archives for exhibition catalogues. The Alpine Club could not find a catalogue for the original exhibition in September 1930 but had one for a subsequent exhibition the following December, where six of Kristján's paintings of Iceland were shown as part of a mixed exhibition by various artists. Fortunately, the catalogue for the Fine Art Society exhibition exists. Twenty of the 32 paintings of Lundy which Kristján delivered to Harman were shown, along with 39 paintings of Iceland.



CATALOGUE
OF AN
EXHIBITION
OF
PAINTINGS
BY
KRISTJAN H. MAGNUSSON

THE FINE ART SOCIETY, LTD.,
148, NEW BOND STREET, W.1.
NOVEMBER, 1931.
No. 827.

CATALOGUE

The Prices, which are net and in guineas, can be had on application. The copyrights of all pictures sold are reserved.

PAINTINGS OF LUNDY

15 1 West Coast—The Chimney (*water-colour*)
15 2 Gannets Bay (*water-colour*)
50 3 The Cove, Evening
22 4 St. James' Stone
20 5 Shutter Rock
15 6 Sunlit Ocean
18 7 South End
50 8 Jenny's Cove

PAINTINGS OF ICELAND

— 9 Klara
12 10 From Breidafiord (*water-colour*)
25 11 Volcanic Land
30 12 Midsummer Night—Isafjord
30 13 Icelandic Village
20 14 Heavy Clouds—Snaefellsnes
35 15 Icelandic Farm
50 16 Winter Sunshine—Snaefellsnes
18 17 The Sandstorm

30 18 By Vatnajokull
40 19 Almannagja, Thingvellir
25 20 Drifting Fog—Snaefellsnes
30 21 Isafjord—Midwinter
25 22 Thingvellir
[illegible] 23 Ljosu Fjoll, Snaefellsnes
8 24 From Thingvellir
10 25 Gestur
[illegible] 26 Mt. Hekla
10 27 Anna
40 28 Winter
10 29 Flosagja, Thingvellir
25 30 Showery Day—Thors Mark
30 31 Snaefellsjokull
10 32 By the Sea
50 33 December Noon—Mt. Esja, Reykjavik
30 34 Mountains of Cinder
30 35 Morning Light—Snaefellsjokull
8 36 The Crater
18 37 Snowflakes
35 38 The Storm—Myrdalssandur
18 39 Mt. Fossafell

18 40 Isafjord
60 41 Vatnajokull
25 42 Flosagja, Thingvellir
18 43 The Bridge at Midnight
18 44 Winter Sunrise—Mosgard Shnukar
30 45 Mt. Hekla in Sandstorm
— 46 Gestur
10 47 Surf Landing (*water-colour*)

PAINTINGS OF LUNDY

18 48 Rocks
8 49 Foam
15 50 Evening—W. Coast
12 51 Lundy Harbour
100 52 West Coast
15 53 Wild Garden
10 54 South Point
20 55 Rhododendrons
8 56 Early Morning—Lundy Shale
15 57 Shutter Rock (*water-colour*)
10 58 Gannets Rock (*water-colour*)
10 59 Old Man's Cave (*water-colour*)
— 60 G. E. H. Grigson, Esq.

Portrait - Head £25.
" Head & Shoulders £50.

Plate 3: The catalogue for the exhibition at the Fine Art Society Gallery in November 1931

The Gallery cannot explain the entry for painting no. 60, a portrait of the poet, author and critic, Geoffrey Grigson, nor the handwritten annotation for portrait painting. The figures added in ink to the left of each painting are the asking prices in guineas. The Gallery have confirmed that there was scope for negotiation in these prices, but if they have records for actual pieces sold and prices achieved, such information would still be regarded as commercially confidential and not released. One painting stands out as having a significantly higher price than the others, no. 52, 'West Coast', at 100 guineas. Other documents in the archive refer to a 'larger' or 'very big' painting with this title being sold for £70. This may reflect a negotiated reduction in the price or it may be simply the result of the Gallery's commission: 100 guineas less one-third is £70.

THE PAINTINGS: WHAT WE KNOW NOW

In 2016 I had essentially one primary source of information for the Lundy paintings: a notebook maintained by Martin Coles Harman with a page for each painting showing the serial number given to it by MCH, its title, and its whereabouts. There was also a typewritten sheet cross-referencing the exhibition catalogue number with Harman's numbering system. The documents in the archive file add considerably to this information. There are several lists of paintings, both of Lundy and of Iceland, produced by Harman's staff. Unfortunately, these are not dated and there are inconsistencies between different lists. There is also at least one downright error, where painting L63 is listed as being 8"×10" (20cm×25cm). Painting L63 is now known and documented and is 50.8cm×19.8cm. Nevertheless, it is possible to cross-check various documents in the file and arrive at a highly likely summary which describes all 32 paintings – see Table 1.

One source of information relates to the framing of the paintings. Kristján had brought the paintings of Iceland to London already framed – he carved and made his own frames and his wife, Klara, helped with this. However, there wasn't time for them to make frames for the Lundy paintings before the exhibition so Harman was obliged to pay the Gallery to provide suitable frames [025]. [036] is the invoice from the Gallery to MCH, listing all the Lundy paintings by their catalogue number, and [037] is a Statement from the Gallery which is heavily and usefully annotated with Harman's own reference number for each painting, its name and a note against the two paintings sold at the exhibition and what they fetched. MCH had to pay a total of £38 3s 6d for framing (mounting and framing for the watercolours).

This list tells us definitively which paintings were watercolours and which were oils, and it also gives a clue to the size of a painting. Two different types of frame are known for the oil paintings, one relatively simple in a vaguely art deco style (L54 and L68), and one more ornate in a traditional art gallery style (L76 and L79). We cannot be certain whether more styles were used, but the cost of frames seems to separate into just two categories, with the higher price band correlating with the known 'ornate' frames and the lower price with the 'simple' ones. If this is correct, then one can expect for each price band a larger painting to have cost more to frame than a smaller one.

The two paintings which were known in 2016 – then and still now hanging in Millcombe House on Lundy – were not then possible to identify by title, catalogue number or MCH's number. This has now changed, and they and the others which have subsequently been discovered can be positively identified – see Table 1.

Plate 4: The label on the back of L54

Some identifications are immediate and unambiguous because Martin Coles Harman stuck a label to the back of each painting with his number, preceded by an 'L' (for 'Lundy'; the paintings of Iceland were preceded with an 'I'). One of the Millcombe paintings has such a label, so we now know that the painting of 'The Sentinels' with part of Rat Island in the background is called simply – and unhelpfully – 'Rocks'. The other painting in Millcombe also has a label, but it is torn and only the letter 'L' remains.

If a painting has lost its label, then its subject can sometimes identify it. The other Millcombe painting is an oil of Shutter Rock, and the lists in the archive show two paintings of the Shutter; the oil is L76 and the watercolour is L75. The watercolour of Shutter Rock has also now been discovered, so both paintings can be allocated their correct numbers.

Other paintings can be identified depending on whether or not they have a frame, and were therefore in the Fine Art Gallery exhibition, and their size. As mentioned above, a (fallible) note of the sizes of some paintings exists in the archive and cost of framing in a particular style of frame indicates size. On that basis, the painting of Rat and Mouse Islands has been identified as L79, called simply 'South End' in the exhibition catalogue.

L80 ('Lundy Harbour') is an oddity because, despite having been in the exhibition, it now has no frame. However, it does still have its label, so there is no doubt. Of the five watercolours, two are now known but they both have had their frames replaced, so we cannot say what type of frame was used for watercolours by the Gallery in 1931.

As well as MCH's notebook listing the paintings of Lundy which was the sole source in 2016, the archive contains documents which have individual references to specific paintings. Table 1 is a greatly expanded version of the Table in the 2016 paper and summarises all the currently known information about the Lundy paintings.

CURRENTLY RECORDED PAINTINGS

Nine paintings of Lundy by Kristján Magnússon are now documented, one of them not listed in Harman's notebook or archive since, as mentioned above, it was not delivered to MCH and remained in the artist's family. As suggested in 2016, some of the newly documented paintings are owned by members of the Harman family, but not all.

In this context, it should be noted that Martin Coles Harman could be very generous about his enthusiasms, sometimes whether the recipients of that generosity wanted it or not. In 1947, MCH arranged for a reprint of 'Some Account of the Island of Lundy' by George Steinman Steinman, an early (1836) account of Lundy which by then had become difficult to access. (See also 'Some Account of George Steinman Steinman' by Alan Rowland in *Journal of the Lundy Field Society*, 2, 2010). In his enthusiasm, MCH had 1000 copies printed. In the years that followed, MCH sent copies of the his reprint *gratis* to anyone who contacted him about Lundy. Similarly for the paintings, the notebook and archive documents show them being given to people who were friends, acquaintances or business contacts. Where they are now will be very difficult to trace. Even when Harman gave paintings to members of his extended family – his unmarried sister, Beryl Harman, or the sister of his daughter-in-law – any memory of where they are now has been lost.

One painting which 'escaped' from the family has been found in circumstances which offer some hope for future discoveries. MCH's second son, Albion Pennington Harman, trained as a mining engineer and was living with his wife in digs near Barnsley. After war was declared in September 1939, Albion and Kay Harman left their digs – and left behind the painting. When the owner of the digs died, the painting came into the possession of his daughter-in-law and it followed her through decades of house moves, getting a little battered in the process. In November 2019 I received an e-mail from that daughter-in-law's grandson whom she had asked to investigate the painting. Because my 2016 paper was available on the LFS website, he was able to see that his grandmother's painting – which was signed 'Magnusson, Lundy '31' – had the same type of frame as one of the paintings in Millcombe. It also had the label 'L.68' on the back. Cutting a long and entertaining story short, its owner agreed to sell the painting to me and my wife and we have had it cleaned and restored. One may hope that the internet may make possible future discoveries of 'lost' paintings.

Harman's notebooks show one Lundy painting ('Gannets Bay') and one painting of Iceland ('Hrutafell') as 'Given Mr Badley'. John Haden Badley was the founder and headmaster of Bedales School where three of MCH's four children were educated. Diana Keast remembered the Iceland painting hanging in Mr Badley's office when she was a pupil. We have no way of knowing whether Mr Badley regarded the paintings as a personal gift or a gift to the school, but the very helpful archivist at the school has confirmed that there are no paintings by Kristján there any more.

Einar Ingólfsson has written other books about Icelandic artists (or foreign artists who worked in Iceland) and one of his techniques is to visit the places painted and take modern photographs of the views in the paintings. In June 2024, he, Rakel Olsen and I, with our partners, visited Lundy, staying in Millcombe House where Kristján and Klara had stayed 93 years earlier. I had tried to take modern photos of the views in the known paintings on an earlier visit but it wasn't straightforward. Many of the subjects painted are in the south-east corner of the island and the construction in 1999 of the jetty and its access road have changed the topography significantly. One painting (still to be discovered) is of Old Man's Cave; the new road runs half-way up across its entrance.

Nevertheless, it is clear that Kristján generally painted accurately what was in front of him. The contours and the different colours and textures of the Sentinels in L54, or Mouse Island in L63 or Shutter Rock in L75 and L76, for example, are reproduced in the paintings. However – and Einar has confirmed that this happened in some of KHM's paintings of Iceland – Kristján took advantage of artistic licence when he regarded it as necessary to improve a composition. It is impossible to reproduce exactly the oil painting of Shutter Rock (L76) in a modern photo as Kristján has moved Black Rock closer to the Shutter so that it appears in the same frame.

Photographs of all the known paintings are on the following pages, with a modern photo of the view where possible and some commentary about what is known of the painting's history.

Plate 5: L54 'Rocks'
Oil; 59×41cm.
In Millcombe dining room.
One of five paintings sent by MCH to Lundy in 1932 [055].
Bottom of stretcher has 'The Property of Mrs Ruth Pennington Harman Jones 1948' written in pencil

Plate 6: The view in L54 taken in March 2024

Plate 7: L63 'South End'
Oil; 50.8×19.8cm.
Owned by Rose Skeet

Plate 8: The view in L63 taken in March 2024

Plate 9: L68 'Wild Garden'
Oil; 58.5×48.5cm.
Owned by André & Marie Jo Coutanche.
One of five paintings sent by MCH to Lundy in 1932 [055]. Location identified by Diana Keast as below Upper East Side path east of Barton Cottages

Plate 10: The view in L68 taken in June 2024

Plate 11: L73 'West Coast - The Chimney'
Watercolour; 47.1×32.7cm.
Owned by Inez Lunan.
One of five paintings sent by MCH to Lundy in 1932 [055]

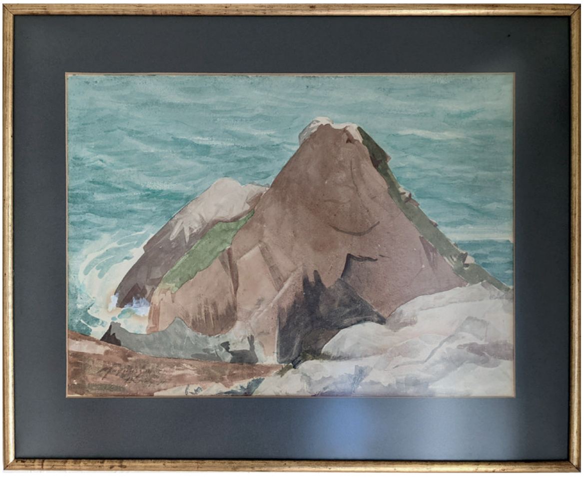


Plate 12: L75 'Shutter Rock'
Watercolour; 49.4×35.1cm.
Owned by Reg Lo-Vel.
One of five paintings sent by MCH to Lundy in 1932 [055].
When the other paintings had returned to the mainland, this one seems to have stayed on Lundy, because it used to hang in Marisco Cottage, the home of Felix and Rene Gade (now part of the Tavern).
Diana Keast had this story about it:
'I only remember the watercolour of "The Shutter Rock" which was in my bedroom in Millcombe when I stayed there in Landmark time. The twin room was next to the bathroom, a back room. Mary Gade was housekeeping at the time. The picture hung above my bed and the cord broke and the picture fell like a guillotine one morning, behind the bed-head, thank goodness. It was taken up to the Office above the Tavern for repair - as glass broken it may have been sent away.'

Plate 13: The view in L75 taken in June 2024

Plate 14: L79 'South End'
Oil; 61×51cm.
Owned by André & Marie Jo Coutanche.
'Lundy' in pencil on bottom of back of frame.
It is impossible to match this view exactly today. It is easy to position Mouse Island between Rat Island and Lundy but the elevation doesn't work. It may be that Kristján was standing on the bridge which was part of the old path from the Beach Road up to the South Light

Plate 15: L76 'Shutter Rock'. Oil; 61.5×51cm.
In Millcombe lounge. One of five paintings
sent by MCH to Lundy in 1932 [055]

Plate 16: The view in L76 taken in June 2024. Note that Black Rock, shown in the painting, is actually well off to the right

Plate 17: L80 'Lundy Harbour'. Oil; 51×25cm. Owned by Inez Lunan.
It is possible to frame this view today, but the jetty running out in front of Rat Island from the Cove makes the comparison of little interest.
This painting used to be owned by Diana Keast. It looks slightly unfinished and John Dyke offered to paint over it. Diana refused the offer

The next painting is not included in Table 1 because Kristján did not deliver it to Martin Coles Harman. It therefore has no 'L' number. It was traced through Rakel Olsen's connections with the wider family of Kristján and Klara and is in Canada.

Plate 18: The Canadian painting. Oil; 57.8×40cm. Owned by Ella Berry.
A striking and attractive painting despite being dirty and in poor shape. It is signed bottom left 'Magnusson Lundy '31'

Plate 19: The view in the Canadian painting taken in June 2024.
It isn't exact because Kristján seems to have 'compressed' more than one view point. This is from the northern end of the Earthquake, which is clear in the painting, but from this viewpoint there is less sea visible than in the painting

This final painting by Kristján is not *of* Lundy but it spent a lot of time *on* Lundy. It is one of the 'Iceland' paintings bought by MCH at the Alpine Club exhibition in September 1930. It is signed 'Magnusson '30'. It may be the one titled 'Young Fisherman', though the features look rather feminine. There is no label on the back so we cannot identify it unambiguously.

It is not known how this painting arrived on Lundy, but it used to hang in Marisco Cottage, the home of Felix and Rene Gade, in the 1960s (as did L75, the watercolour of Shutter Rock). Rene Gade liked it because the eyes reminded her of Diana Keast's.

Plate 20: 'Young Fisherman'[?]. Oil; 41×51cm. Privately owned.

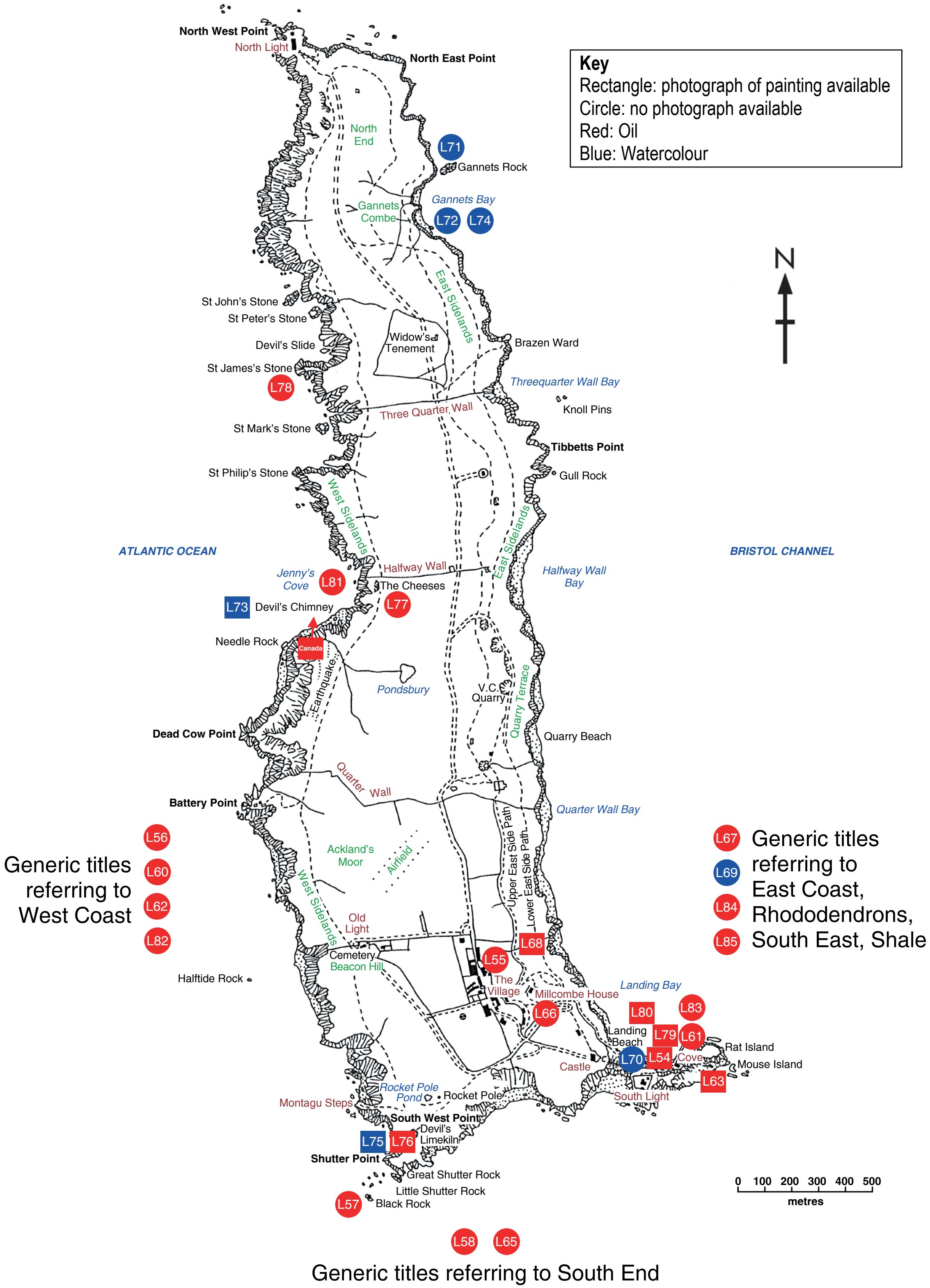
PRELIMINARY THOUGHTS ABOUT THE NOW KNOWN PAINTINGS

There is nothing in the letters to explain Kristján's choice of subjects – he seems to have had a free hand. He might have felt obliged to paint Millcombe House, his patron's residence, though it might have been an attractive subject anyway; that painting is still to be discovered so we cannot say. Generally speaking, throughout all his work in Iceland and North America, Kristján was drawn to landscapes rather than the built environment, especially the bold and hard landscapes of Iceland which find a softer reflection in Lundy's west coast. However, one might have thought that the Old Light or the (then ruinous) Castle might have attracted him. There is a painting titled 'Lundy Village' but we have no information about it and do not know what it looks like.

As we have seen with 'Young Fisherman', Kristján painted some superb portraits. However, there were no portraits from his and Klara's visit to Lundy, which is a loss. Perhaps he felt that MCH would want his island on his walls rather than his staff.

The map (overleaf) shows where Kristján went on Lundy to paint where that can be identified. Some of the titles are unidentifiable – 'Foam', 'Evening Lights' (though this last is also described in the archive as 'rock on W. coast'). Some titles are generic, but can be broadly placed. As might be expected, there is a cluster of paintings in the south-eastern corner of the island, but Kristján ranged as far north as Gannets Combe. At least one painting – L73, the Devil's Chimney – was painted from the sea. Not surprisingly, this and the Gannets Combe paintings are watercolours, but Kristján (with help from Klara?) carried heavy easels and canvases to Jenny's Cove and St James Stone. Apart from these practical considerations, we do not know why the artist might have chosen one medium or the other.

MAP OF THE ISLAND OF LUNDY
with locations painted by Kristján Magnússon where identifiable (L59 & L64 unidentifiable)



CONCLUSIONS

The story of Kristján and Klara's Lundy adventure is now known in much more detail than it was in 2016. The broader context of the artist's career is now accessible through the research of Einar Ingólfsson which has been made possible by the enthusiasm and support of Rakel Olsen. More of Kristján's paintings of Lundy remain to be discovered and documented, and some may exist outside the U.K. The archive files which underpin this paper are now freely available at the LFS website, where it is hoped they will attract the attention of future researchers. The 'forgotten Lundy artist' of my 2016 paper is now less so and more of his Lundy paintings will hopefully be found in the future.

ACKNOWLEDGEMENTS

The late Diana Keast made an essential contribution to this research by keeping safe her father's archives for decades and allowing members of the Lundy Field Society to inspect them and to ensure that they will be properly preserved in future. She also provided me with information about some of the paintings and suggestions for where some of them might be.

Rakel Olsen made possible the research into Kristján Magnússon's life and works and Einar Ingólfsson has been tireless in carrying it out. Einar also took some of the photographs in this paper. Their co-operation and friendship have made this research project so much richer than it otherwise would have been.

I am very grateful to the owners of paintings who have supplied information and allowed photographs to be taken and published. The archivist at Bedales School was very helpful and interested in the research. The Alpine Club, the Fine Art Society and the Ferens Art Gallery have also been keen to help and have provided important primary sources.

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Ingólfsson, Einar Falur, 2025, *Kristján H. Magnússon: The Forgotten Artist*, Veröld, Reykjavík, ISBN 978 9935 30 408 7. In English.

This paper is dedicated to the memory of Diana Pennington Keast, who inspired the original research, maintained an encouraging interest in its progress while she lived, and who would have been delighted at how it has developed.

Table 1: Lundy Paintings by Kristján Magnússon delivered to Martin Coles Harman (part 1 of 2)

MCH No.*	Catalogue No. and Title	Apparent Price§	Medium	Size#	Title of Painting in notebook	Notes in notebook
L54	48 Rocks	18	Oil	59x 41cm	Rock formations (Rocks)	Exhibition Nov. 1931 Returned 11 Angel Court, 3.12.1931 ~~With Miss B. Harrison~~ ~~To Miss B Harrison~~ Lundy
L55	[Not in Exhibition]		Oil		Lundy Village	~~STH?~~ Angel Court
L56	[Not in Exhibition]		Oil		West Coast	[No notes]
L57	[Not in Exhibition]		Oil	9"x12"	Black Rock	S.T.H. March 1934 X Given to Mrs Mandly by M.C.H. Nov. 1937
L58	[Not in Exhibition]		Oil	8"x10"	South End	S.T.H. March 1934 Returned + sent to Lundy (Blake) Sept. 1935
L59	49 Foam	8	Oil	10"x10"	Foam	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 S.T.H. March /34 X
L60	50 Evening–W. Coast	15	Oil		Evening, West Coast	~~(Burraland)~~ Returned to 11 Angel Court Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 S.T.H. March /34
L61	3 The Cove, Evening	50	Oil		The Cove, Evening	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931
L62	6 Sunlit Ocean	15	Oil		West Coast, Evening	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 Given to W.F. Tipper 4.12.51
L63	[Not in Exhibition]		Oil	50.8x 19.8cm	South End	Exhibition Nov. 1931 [sic] Returned 11 Angel Court 3.12.1931 S.T.H. March /34
L64	[Not in Exhibition]		Oil	9"x12"	Evening Lights	Given to Mr Bratby
L65	54 South Point	10	Oil		~~Evening~~ Lundy Heath South End South Point+	Angel Court
L66	[Not in Exhibition]		Oil		The Villa (Mill Combe)	~~Burraland~~ ~~Taken to Deans Place (S.T.H.)~~ Returned 11 Angel Court S.T.H. March /34
L67	55 Rhododendrons	20	Oil		Rhododendrons	Exhibition Nov. 1931 Fine Art Society Returned 11 Angel Court 3.12.1931 Given to Miss B. Harman
L68	53 Wild Garden	15	Oil	58.5x 48.5cm	East Coast + Flowers	~~Burraland~~ Returned to 11 Angel Court Exhibition Nov 1931 Returned 11 Angel Court 3.12.1931 ~~With Miss B. Harman~~ ~~To Mrs Florence Harman~~ Lundy
L69	[Not in Exhibition]		Water-colour	9"x12"	Bit of East Coast	~~S.T.H. March 1934~~ X Given Miss K Joyce August 1937

*Numbers in notebook not preceded by 'L'; labels on paintings have 'L'; Numbers in red are on the actual paintings
§from hand annotations in Catalogue (guineas) #Measured canvas size for L54, L68, L76 and L79. Visible size in mount for L75. L73 estimated from photo and e-mail from owner. Others from [072a]. In centimetres for measured sizes; in inches for reported sizes in archive.

Other information	Cost of frame from [037]	Type of frame	Current Owner/ Location
Sent to Lundy November 1932 [055] Bottom of stretcher has 'The Property of Mrs Ruth Pennington Harman Jones 1948' written in pencil	£1 7s 6d	Simple	Millcombe (dining room)
Given to Mr Birmingham [065]			
Very small (9"x12") on cardboard**			
Small (8"x10") S. Light in upper edge**			
Small (10"x10")** Between 2 large rocks+	17s 6d		
	£1 7s 6d		
Miss ?Binns [065]	£3 15s 0d		
	£1 7s 6d		
Small (8"x10") [sic] SE rocks in sunshine. Similar to a canvas of same rocks and a bit of Rat Island on left**		None	Rose Skeet
Rock on W. Coast with glow on sea 9"x12" canvas on cardboard**			
'?L63'+	19s 0d		
Unframed†			
Given by MCH to Dee, sister of Kay Harman (née Bloxham). Other paintings also with Dee†	£3 0s 0d		
Sent to Lundy November 1932 [055] Titled 'Wild Garden - East Coast'+	£1 7s 6d	Simple	André & Marie Jo Coutanche
Watercolour 9"x12"**			

+from typewritten sheet **from [072a] m & f for watercolours = mounted and framed
†Diana Keast *pers. comm.*

Table 1: Lundy Paintings by Kristján Magnússon delivered to Martin Coles Harman (part 2 of 2)

MCH No.*	Catalogue No. and Title	Apparent Price§	Medium	Size#	Title of Painting in notebook	Notes in notebook
L70	59 Old Man's Cave	10	Water-colour		Old Man's Cave	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 S.T.H. March /34
L71	58 Gannets Rock	10	Water-colour		Gannet's Rock	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 S.T.H. March 1934
L72	2 Gannets Bay	15	Water-colour		Surf, West Coast	Given Mr Badley
L73	1 West Coast–The Chimney	15	Water-colour	47.1x 32.7cm	West Coast, The Chimney	Returned 11 Angel Court [E.C. ?] ~~With Miss B. Harman~~ ~~To Mrs Lewin~~ Lundy
L74	[Not in Exhibition]		Water-colour		Gannet's Bay	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 S.T.H. March 1934
L75	57 Shutter Rock	15	Water-colour	49.4x 35.1cm	Shutter Rock	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 ~~With Miss B. Harman~~ ~~To Mr Lewis Harman~~ Lundy
L76	5 Shutter Rock	20	Oil	61.5x 51cm	Shutter Rock	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 ~~With Miss B. Harman~~ ~~To Mr Lewis Harman~~ Lundy
L77	[Not in Exhibition]		Oil		The Cheeses	S.T.H. March /34 Given to Ruth from 11 Angel Court 24/4/37 X
L78	4 St. James' Stone	22	Oil		St James' Stone	Exhibition Nov. 1931 Sold. at Exhibition Fine Art Society Nov. 31 £
L79	7 South End	18	Oil	61x 51cm	Early Morning ~~South Coast~~ South End South East Rat I.⁺	~~Burraland~~ Returned to 11 Angel Ct Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 S.T.H. March /34
L80	51 Lundy Harbour	12	Oil	51x 25cm	Lundy Harbour (with Lerina)⁺	~~Burraland~~ Returned to 11 Angel Ct Exhibition Nov. 1931 Returned to 11 Angel Court 3.12.1931 S.T.H. March 1934
L81	8 Jenny's Cove	50	Oil		Jenny's Cove	Exhibition Nov. 1931 Returned to 11 Angel Court 3.12.1931 With Miss B. Harman ~~To Mrs Cole~~ [?]
L82	52 West Coast	100	Oil		West Coast	Exhibition Nov. 1931 Sold at Exhibition Fine Art Society Nov. 31 £
L83	[Not in Exhibition]		Oil		The Cove	[No notes]
L84	[Not in Exhibition]		Oil		Early Morning South East	Given Miss B. Harman
L85	56 Early Morning–Lundy Shale	8	Oil	12"x14"	~~Rock Formation~~ Early Morning, Lundy Shale Rock formations	Exhibition Nov. 1931 Returned 11 Angel Court 3.12.1931 Given to Miss Mason

*Numbers in notebook not preceded by 'L'; labels on paintings have 'L'; Numbers in red are on the actual paintings
§from hand annotations in Catalogue (guineas) #Measured canvas size for L54, L68, L76 and L79. Visible size in mount for L75. L73 estimated from photo and e-mail from owner. Others from [072a]. In centimetres for measured sizes; in inches for reported sizes in archive.

Other information	Cost of frame from [037]	Type of frame	Current Owner/ Location
glass+	£1 1s 0d m & f		
glass+	£1 1s 0d m & f		
'?L74'+ glass+ Titled 'Gannets Bay'+	£1 7s 6d m & f		
Sent to Lundy November 1932 [055] No visible number†	£1 7s 6d m & f	Modern	Inez Lunan
Sent to Lundy November 1932 [055] Was in back bedroom in Millcombe in Landmark time (Mary Gade was housekeeper). Fell during the night and glass broke. Sent away?†	£1 7s 6d m & f	Modern	Reg Lo-Vel
Sent to Lundy November 1932 [055]	£3 0s 0d	Ornate	Millcombe (Lounge)
Sold at exhibition for £20 [036]	£3 0s 0d		
'Lundy' in pencil on bottom of back of frame Given to Diana Keast c.2000 by Joy Harman†	£3 0s 0d	Ornate	André & Marie Jo Coutanche
Was owned by Diana Keast. John Dyke offered to paint over it†	£1 0s 0d	None	Inez Lunan
'Larger' [Western Morning News 19311109] at Miss B Harman [065]	£3 15s 0d		
Sold at exhibition for £70 [036] Very big picture sold for £70 [031] 'Larger' [Western Morning News 19311109]	£3 5s 0d		
Board Room [065]			
Miss B Harman [065]			
Should be ca. 12"x14" painted on brown cardboard (near landing place)** Miss Mason [065]	17s 6d		

+from typewritten sheet **from [072a] m & f for watercolours = mounted and framed
†Diana Keast *pers. comm.*

APPENDIX 1: Updates and corrections to the 2016 paper

Following feedback and further research, some details in the first paper in the 2016 *Journal of the Lundy Field Society* can be updated, as follows:

p. 110, para. 1. Klara's letter to MCH [061] says that Kristján died from a stomach operation.
p. 110, Plate 1. Kristján is in the highlands of Iceland, in the area called Kjölur; he is painting Lake Hvítárvatn and the Langjökull Glacier rather than Mount Hekla.
p. 117, para. 1. Myrtle Ternstrom, one of the editors of Felix Gade's *My Life on Lundy* confirmed to me that she and her fellow editor, Tony Walker, included in the published book everything which Felix Gade had written. Kristján and Klara's visit either slipped Mr Gade's mind or he regarded it as peripheral to his narrative.
p. 117, para. 3. We now know that Kristján and Klara were on Lundy for two months, arriving on or just before 12 April 1931. We also now know that Kristján painted more than the 32 pictures he delivered to Martin Coles Harman.
p. 117, para. 5. The review in the *Hull Daily Mail* refers not to the Alpine Club exhibition in 1931 but to a later exhibition of paintings of Iceland at the Ferens Gallery in Hull in January 1932.
p. 118, para. 6. We now have the catalogue for the 1931 exhibition at the Fine Art Society Gallery. There were 20 paintings from Lundy and 39 paintings from Iceland.
p. 118, para. 7. We now know exactly which of the Lundy paintings were watercolours and which were oils – see Table 1.
p. 119, para 1. The contractual arrangement between Kristján and MCH is now clear and is discussed in this paper.
p. 119, para. 1. Major Noel Clarke was in a 'syndicate' with MCH to acquire the Iceland paintings and may have received one of the Lundy paintings as part of a settlement of their arrangement [031].
p. 120, para. 2. The employee who was given a painting by MCH was W.F. Tipper, not Tinker. Diana Keast described him to me as 'an elderly office boy', but he seems from the correspondence to have been a trusted aide to MCH.
p. 121, penultimate para. We now know that five paintings were sent to Lundy – see Table 1.
p. 123, para. 6. The two paintings in Millcombe House are now positively identified – see Table 1.
p. 128, no. 73 in Table. We now know that this was indeed Catalogue no. 1.
p. 128, nos 75 & 76 in Table. We now know that no. 75 is the water colour of Shutter Rock and no. 76 is the oil.
p. 128, no. 85 in Table. We know now that Miss Mason worked for the Secretarial agency which MCH used [022].

THE 1921 CENSUS DATA FOR LUNDY

By Malcolm Lee
Gullrock, Port Gaverne, Port Isaac, Cornwall, PL29 3SQ
e-mail: gullrockportgaverne@btinternet.com

ABSTRACT
The 1921 census showed there were 37 people living on Lundy on census night, with a further 11 people on a steam trawler in the bay. Apart from showing the recorded data on those people, the article gives the results of further research into who those people were and why they were on the island, plus an interesting report on the status of Lundy which was raised as the census results were published.

Keywords: *1921 Census, Charles Herbert May, Annie Sage, Malcolm Mungavin, Augustus Langham Christie, Martin Coles Harman, legal status of Lundy*

Alan Rowland wrote an article when the 1911 census data was released in 2010 (LFS Newsletter 41 pp35-48). The 1921 census data was released in 2022 following digitisation by FindMyPast.co.uk, and members may be interested to see who was on the island on census night. The use of subscriptions to the genealogical website and the British Newspapers digitised archive, together with Felix Gade's comprehensive and well indexed 1978 memoir of his half century on Lundy, enabled the fleshing out of the lives of many of the people named in the dry pages of the census.

Census Night in 1921 should have been Sunday 24th April, but was delayed to Sunday 19th June due to widespread industrial unrest following the decision on 15th April 1921 (known as Black Friday) by the Rail and the Transport unions not to support the Miners in their strike action.

The official 1921 census population of Lundy was recorded as 48 people, as listed in the table below. However, only 37 were on the island, with the census authorities including 11 fishermen from the Motor Trawler 'Conway Castle' out of South Dock, Swansea. The master gave her exact position as 'Lundy' at midnight on census night. It seems most likely this was a specific reference to the vessel sheltering in the landing bay, as the sea area we now know as 'Lundy' was not adopted until 1949, and the first radio shipping forecast in 1924 used the much larger sea area term 'Severn', which incorporated the current sea areas Lundy, Fastnet, and the southern part of Shannon.

The enumerator's summary book, listing non-residential properties, empty residential properties, as well as the occupied property in which each household was to be found, is not available for this census. Each of the household returns has the same postal address of simply 'Lundy Island, North Devon' without specifying the property. Some are obvious from who was on the returns, eg. Coastguard Cottages and the two lighthouses. Annie Sage was in charge of the Manor Farm Hotel, so she would be on the return she received for that property. There was a second form delivered to Annie Sage, suggesting she was also in charge of another property. It is likely this was a self-contained part of Manor

Farm. Fred Allday had moved from Quarter Wall Cottages (which were abandoned in 1921) to Cliff Cottage (Hanmers) by census night. From the number of rooms recorded on the forms for each property, plus the properties known to be in use in the 1911 census, an educated guess has been made as to where each of the remaining households stayed. Should the enumerator's summary book become available, the properties allocated for some of the households may change.

The Heavens had left Lundy in 1916, and in 1917 the island was purchased by Augustus Langham Christie. He lived in Tapeley Park, about two miles northeast of Bideford. Christie never visited the island, so at the time of the 1921 census The Villa (Millcombe House) was empty. In 1920, the island was leased to Charles Herbert May. Not only was there a new owner and a new tenant since the previous census, but everyone on Lundy in the 1911 census had left by 1921, apart from the postmaster Frederick Allday and his wife Hannah. They came to Lundy in 1896 with their daughter Mildred. Following Mildred's marriage in 1916 to William Thomas, a Trinity House man, she had left the island. The Lundy Post Office closed in 1926, after which Frederick and Hannah departed. Frederick died in 1935 at the age of 77 and was buried at St John the Baptist Church in Eltham, south east London. At that time, he and Hannah were living with Mildred and William in Eltham. Hannah died in 1947 when she was still with her daughter and son-in-law.

One question not asked on previous censuses was to state the name of your employer, and there were eight persons who recorded they worked for Mr C. H. May: Annie Sage, Ronald Tuck, Samuel Stookes, Frederick Dawse, William Trenury, John Parminter, Charles Parminter, and William Lang. Alice Hill was on the return with Annie Sage, where she described herself as a servant working on Lundy but did not actually record that she worked for Mr May. Annie Sage was running the hotel as housekeeper, with Frederick Dawse as waiter and Alice Hill as general servant. William Lang was Mr May's gardener. With a non-resident tenant, Mr May employed Ronald Tuck as his farm manager, with Samuel Stookes, John Parminter and Charles Parminter (presumably John's older brother) as the farm labourers. Felix Gade tells us that Samuel Stookes was brought up in a Dr Barnardo's home and was a good lad who loved all the animals, even naming the milking cows and singing to them while they were being milked. Samuel met and married Nellie Alford on the island and set up their home on Lundy before leaving at the end of 1932.

It is clear that Mr May was carrying out some improvements. Staying in Manor Farm was Archibald Sprague, a blind maker, working for S S Abbott (Furnishers) in Barnstaple. This would be Seymour Stanley Abbott who acquired J S Rice's blind making business in 1911 and traded from 40 High Street in Barnstaple. Also in Manor Farm were Henry Morrish, a mason, with Percy Lock, as his labourer, who he recorded as his son. With a different surname, perhaps he was his son-in-law. However, Henry only had a daughter, Ethel, who married Archibald Sprague's son, Frances. We may never know why Henry put son. Technically, as the return was for Annie Sage to complete, it was their relationship to her that should have entered, which was visitors. Henry and Percy were working for J Morrish (Builders). John Morrish was Henry's brother, who was a mason in Bishops Tawton, just south of Barnstaple.

As the census was delayed until mid-June, there would have been visitors staying on the island. The only two people who declared themselves visitors were Nellie Windiate (19) and, presumably her mother, Mary Windiate (50) from Crookham, Hants, who were staying in the Manor Farm Hotel. Nellie gave her employer as the Salvation Army.

Another possible visitor was Mary Alice Smith (57), a widow born in Yorkshire. Her husband had been an engineer, and in 1913 they were living at Stoley Barton, about three and a quarter miles NNE of Barnstaple, quite close to Mr May's home in Shirwell. In the Hartland News and Chronicle of 14th December 1920 is a report of Lundy's Harvest Festival in which there is a reference to a 'Mrs Smith, of the Villa', who may be the same lady and perhaps a friend of Mr May. The census return refers to her accommodation as having just two rooms which a subsequent person had amended to five rooms, so that would rule out her staying in the villa on census night.

There was a family of four, probably staying in The Bungalow (now replaced by Bramble Villa), and that was Malcolm Mungavin (30), born in Roorkee, India, and his wife Edith (29) born in Guiseley, Yorkshire, with their two children, Michael (8), born in Paris, and David (3) born in Littleham, near Exmouth. Research shows the family had been on Lundy for a while, as the Hartland and West Country Chronicle of 26th October 1920 reports on an island concert on 2nd September 1920 which mentions a Mr & Mrs 'Montgowin' and their son, with a recitation given by Master 'Macgowin', undoubtedly simple mistranscriptions from a handwritten note of the concert. In the census he describes himself as an agricultural student working on Lundy. He left blank the section on employment status, but perhaps he might have been helping Mr May. There is no evidence he pursued agriculture as a career. In 1909 he was a medical student at Cambridge but never qualified. In World War One he was a sergeant in the Royal Field Artillery and later a second lieutenant in the Royal Garrison Artillery. In 1939, the family was living in Buntingford, Hertfordshire where he described himself as an Insurance Broker. His eldest son, Michael, was then a medical student, qualifying as a doctor in 1940. His younger son, David, had become a journalist.

In 2024, Malcolm Mungavin's granddaughter, Denise Collins, contacted the warden asking if there was any information on her grandfather, who she thought was the warden at that time. Whilst there was no warden then, this contact enabled some family information to be obtained. The Mungavins were very much part of the Victorian Raj in India, where there had been generations of doctors in the family. Malcolm was regarded as the black sheep of the family for failing to carry on this tradition by dropping out of medical school. During his wartime service with the Royal Artillery, he was mentioned in dispatches for capturing a number of German soldiers single handedly by implying to them that he was followed by several other members of his unit, and they should surrender.

Malcolm Mungavin c1930

Denise was not sure why the family were on Lundy in 1921, but her grandfather was a rebel who kicked against the traces of anything that he felt restricted him. Perhaps he saw a few years on Lundy as an escape from all he had been through in wartime. Denise's father, Michael, and her Uncle David spoke in glowing and happy terms of their time on Lundy, which they regarded as the happiest days of their childhood. As young children, they recall building makeshift rafts with their father to sail in the landing bay, and later acknowledged they were very lucky not to drown. Michael and David were educated privately in Mill Hill School and later went up to Cambridge. After qualifying as a doctor, Michael had a career in medicine, mainly with the pharmaceutical industry, and spent five years in India researching and conducting clinical trials for a drug which went on to be the cure for leprosy. In the latter half of the 1930s, Malcolm became the manager of the UK office of the Canadian company, Crown Life Insurance. Her grandmother later split up with Malcolm and moved to America with David. In his final years, he lived with Michael and his family in Macclesfield, where Denise and her siblings thought him rather stern. He died in 1967.

C. Herbert May's grave at Instow churchyard

Charles Herbert May: He was born at Tiverton in August 1882 to Walter John May and his wife Alma. They lived at the 400 acre Holmead Farm, four and half miles north west of Tiverton. By 1901, when he was 18, the family had moved to Dunwear Farm on the south east edge of Bridgwater. In 1911 he was still at Dunwear Farm, where he gave his profession as Farmer and Livestock Agent. He became lessee of Lundy in March 1920. A few months later, he married his wife Clara in summer 1920. In 1921 they were living in The Cottage, Shirwell, about three and a half miles north east of Barnstaple, with Clara's parents. His father died in May 1921 at Longstone House, Pilton, a suburb of Barnstaple, leaving him an estate valued at £1,396.1s.11d (about £57,700 today). In 1925, when Martin Coles Harman acquired Lundy, he gave up the lease. Subsequently, Felix Gade reported that Mr May gave him a lot of help and advice on farming Lundy, and at one time Felix Gade was renting a house on the mainland from him. On 27th April 1936 he died suddenly of a cerebral embolism at his home in Ashleigh House, Barnstaple. His estate was valued at £39,314.7s.1d (about £2.3 million today). His obituary in the Western Times of 1st May 1936 refers to Instow church 'crowded with mourners' and described him as 'one of the largest cattle dealers and farmers in the Barnstaple district'. He was also vice-president of the Livestock Trades Association of Great Britain and had the grazing rights to Hyde Park for some time. He is buried at the Church of St John the Baptist, Instow, just above the War Memorial.

Annie (Nancy) Sage: She was born on 6th January 1873 at Kersbrook Farm, a 116 acre farm in East Budleigh, Devon. Although her birth name was Annie Sage, she was always known as Nancy Sage, a diminutive form of her name. Her mother died when she was eight and her father died in 1890, so in the 1891 census she was helping her stepmother on the farm. The

1901 census showed her first links to the May family, as she was then working as the general indoor servant at Dunwear Farm for Walter John May. That would have been when she first met his teenage son C Herbert May. She was still living at Dunwear Farm in 1911 where she was the housekeeper. No doubt when Mr May became lessee of Lundy in March 1920, his long association with Miss Sage, and knowledge of her capabilities, thought her perfect to manage the Manor Farm Hotel. She probably arrived to get the hotel ready for the 1920 season shortly after Mr May leased Lundy. She was certainly on the island in late summer that year, as she was responsible for the refreshments at the concert held at the hotel on 2nd September 1920, with Mr May being present. She was clearly very good to the other islanders, as the Hartland and West Country Chronicle of 31st January 1922 reports she laid on a sumptuous feast on Boxing Day for the whole island, and only those on duty in the lighthouses or coastguard stations were unable to attend (no doubt they got something taken up to them from the hotel). In the speech of thanks, a Mr Montgomery mentioned the wonderful qualities she displayed on all and every occasion, and her strenuous work during the season when, with a house full of visitors and an acute water shortage, she carried out her work smilingly and with a stout heart.

Nancy Sage (left) with her friend **Phyllis Blackburn** c1926

Nancy Sage was a resolute woman, not easily perturbed, even when she had to cater for a 150 guest lobster luncheon at the opening of the new golf course in July 1927. Felix Gade mentions Mr Harman was anxious to extend the hotel business and welcomed the new golf course as a potential source of customers. It was likely a blow to him when Miss Sage left the island in October 1927 at the end of the season. Felix Gade was busy running the farm, so in the 1928 season Mr Harman decided not to open the hotel to paying guests, just keeping it as accommodation for his own friends. Nancy was a devout woman and was a churchwarden during her time on the island. The Hartland and West Country Chronicle of 12th November 1927 reported on the harvest festival on 12th October, shortly before she left. The Reverend Muller described her as the 'Soul of Lundy'. Mr Harman's staff and employees got together and bought her a gold wristlet watch as a leaving present. In 1939, when Miss Sage was 66, she was living at Ford House, Drewsteignton. The other occupants were three children's nurses and seven children, so she was no doubt helping run the house. She died on 28th February 1942, at her home in Greenway Lane, Budleigh Salterton. The informant of the death was her nephew, who was present when she died. He gave her occupation as a domestic housekeeper and the cause of death was coronary thrombosis and arteriosclerosis.

Augustus Langham Christie: He was the owner of Lundy at the time of the 1921 census, having bought it from Walter Charles Hudson Heaven in September 1917. No trace of him could be found in the 1921 census, so perhaps he was abroad on census night. It was Christie who paid to build the stone landing stage in 1920. Apparently, he

Augustus Langham Christie's sarcophagus at Westleigh Churchyard

purchased the island because he could not bear to see from his house any land he did not own. Despite this, he sold Lundy in October 1925 for £16,000 (about £822,000 today). The previous year Christie had been declared insane after attacking his wife and in 1925 wrote a new will cutting out his wife and son. When he died in 1930, he left an estate valued at £312,857 17s 11d (about £17.3 million today). Not surprisingly, his wife challenged the 1925 will and produced an earlier 1901 will leaving everything to her. The sensational court case gripped North Devon in 1931, and the North Devon Journal of 26th March 1931 reported on its conclusion. It was finally decided that Christie did not have the mental capacity to make a valid will in 1925, so the earlier one stood. He is buried at St Peter's Church, Westleigh in the northeast corner of the churchyard with his wife and son.

Martin Coles Harman: In the 1921 census, the soon to become owner of Lundy, Martin Coles Harman (35), was living in his 13 room house at Dean's Place, Chaldon in Surrey, with his wife Amy Ruth (36) and his sons John (6) and Albion (4) and daughter Ruth (2) plus a child's nurse and a general servant. His younger brothers Andrew (22) and Lewis (21) were visiting on census night. His occupation was given as a merchant banker with Lazard Brothers & Co. Ltd.

The Legal Status of Lundy: It took several years of manual inspection of all the individual UK census returns to give local population numbers, and it was not until July 1925 when the handwritten 1921 census summary for the Bideford Region was compiled. Lundy is included within the Hartland sub-district, being described as 'Ex. Par.' for extra parochial. There is a large asterisk alongside referring to this footnote - 'Lundy Island is for convenience included, in census returns, with Bideford RD'. The particular reference to 'in census returns' suggests that whoever made that note wished it to be clear no wider assertions on its status were being made.

As the national figures were being compiled, no doubt many questions were raised by the Registrar General, but one specific query was made regarding Lundy. In the Western Morning News of 4th February 1925, Lundy made the local headlines when the Bideford Guardians discussed its legal status following a letter from Devon County Council who had received an enquiry from the Registrar General concerning whether any poor rates were being levied on the island. The Registrar General stated that Section 1 of the Extra Parochial Places Act 1857 made clear that every Extra Parochial place included in the 1851 census should be made a separate parish for civil purposes. Lundy was certainly included in the 1851 census, with 34 people recorded. This enquiry had everyone scratching their heads, with the Clerk to the County Council saying Lundy was 'more or less a law unto itself'. As far as he was aware (from hearsay only, he wished to make clear) no poor rates or income tax were paid. The Clerk also said Parliament specifically made Lundy part of Devon for the Representation of the People Act, following his particular enquiry. The Lord Lieutenant of Devon thought his jurisdiction extended to Lundy but was not sure. Reverend Muller, the Vicar of Appledore, who conducted services in the church on Lundy, reported that at the last inquest on the island, in Reverend Hudson Grosset Heaven's time, the coroner was made to sit at his side to emphasise that the island was absolutely private property which acknowledged no outside jurisdiction. It had been made very clear to Reverend Muller that he was only allowed on the island 'as a matter of courtesy'. The chairman of Bideford Guardians referred to similar situations for islands off the Irish coast where tax-collectors had been driven off by women pouring boiling water on them. No doubt with that alarming image foremost in their minds, the guardians sensibly decided to just report what was known and leave it up to someone else to do something about it. Nothing appears to have happened subsequently, and the Registrar General may well have looked at the large amount of work needed to sort out this legal headache involving a handful of islanders and concluded that as local officials were unwilling to rock the boat, he was also happy to go with the status quo and dropped the matter.

Acknowledgements: I am grateful to André Coutanche for the image of Nancy Sage. Findmypast.co.uk is acknowledged as the source of the 1921 data, and all other genealogical data. Britishnewspaperarchive.co.uk is acknowledged as the source for the old newspaper articles. Current valuations included here have come from the Bank of England's online Inflation Calculator.

Lundy occupants as shown on the fourteen separate 1921 Census returns

Manor Farm Hotel					
	Age				
Name (relationship)	*Y*	*M*	*Where Born*	*Occupation*	*Working For*
Annie **Sage** (Head)	50	6	East Budleigh, Devon	Housekeeper	Mr C H May
Ronald Athole **Tuck** (Servant)	30	1	Southsea, Hampshire	Farmer	Mr C H May
Nellie **Windiate** (Visitor)	19	8	Bristol, Gloucestershire	Assistant	Salvation Army
Mary **Windiate** (Visitor)	50	4	Crookham, Hampshire	Household Duties	Private
Alice **Hill** (Servant)	50	5	Dunwear, Bridgwater, Somerset	Household Duties	(Servant Mr C H May?)
Mildred **Hill** (Visitor)	12	7	Dunwear, Bridgwater, Somerset		
Samuel **Stookes** (Servant)	18	1	Not Given	Farm Labourer	Mr C H May
Frederick **Dawse** (Servant)	17	8	Portsmouth, Hampshire	Waiter	Mr C H May
Manor Farm Hotel (part)					
Henry **Morrish** (Head)	48	8	Bishops Tawton, Devon	Mason	J Morrish, Builder
Percy **Lock** (Son)	23	6	Devon	Mason Labourer	J Morrish, Builder
Archibald **Sprague** (Head)	46	3	Bishops Tawton, Devon	Blind Maker	S S Abbott (Furnishers)
William **Trenury** (Servant)	29	1	Barnstaple, Devon	Fisherman	Mr C H May
John **Parminter** (Servant)	20	6	Witheridge, Devon	Farm Labourer	Mr C H May
Cliff Cottage (Hanmers)					
Frederick W **Allday** (Head)	63	4	Lewisham, Kent	Sub-Postmaster, Retired RN	General Post Office
Hannah Elizabeth **Allday** (Wife)	64		London	Home Duties	

Sea View (Barton)					
	Age				
Name (relationship)	*Y*	*M*	*Where Born*	*Occupation*	*Working For*
Rose **Parminter** (Wife)	23	11	Torquay, Devon	Home Duties	
Sea View (Barton)					
William Henry **Lang** (Head)	44	5	Torquay, Devon	Gardener	Mr C H May
Sarah Georgina Margaret **Lang** (Wife)	43	2	Bath, Somerset	Household Duties	
Sea View (Barton)					
Mary Alice **Smith** (Head)	57	6	Bradford, Yorkshire	None	
The Bungalow (Brambles)					
Malcolm **Mungavin** (Head)	30	2	Roorkee, India	Agricultural Student	
Edith **Mungavin** (Wife)	29	2	Guiseley, Yorkshire	Home Duties	
Michael **Mungavin** (Son)	8	1	Paris, France		
David **Mungavin** (Son)	3	6	Littleham, Devon		
Coastguard Cottages					
Edward **Splain** (Head)	46	6	Dover, Kent	HM Coastguard Chief Officer	Admiralty
Mary **Splain** (Wife)	37		Ireland	Home Duties	
Henry **Brain** (Head)	40	1	Shipston-on-Stour, Worcestershire	Coastguard	Admiralty
Emma **Brain** (Wife)	40	3	Portsmouth, Hampshire	Home Duties	
Elias **Davies** (Head)	45	10	Birkenhead, Cheshire	Coastguard	Admiralty
Henry **Harvey** (Head)	46		Bath, Somerset	HM Coastguard Petty Officer	Admiralty
Rebecca **Harvey** (Wife)	43		Bath, Somerset	Home Duties	
South Light					
Charles **Thomas** (Head)	50	9	Llanstadwell, Pembrokeshire, Wales	Lighthouse Keeper	Trinity House
Robert James **Hall**	47	1	Padstow, Cornwall	Lighthouse Keeper	Trinity House
Henry **Quinton**	37	4	Withernsea, Yorkshire	Lighthouse Keeper	Trinity House
North Light					
Sydney Charles **Warder** (Head)	33	3	Haisborough, Norfolk	Lighthouse Keeper	Trinity House
William James **Hast**	31	4	Bow, London	Lighthouse Keeper	Trinity House
Edmund Victor **Reach**	24	3	Cowes, Hampshire	Lighthouse Keeper	Trinity House
Motor Trawler Conway Castle					
Walter **Mayhew** (Crew)	32	6	Lowestoft, Suffolk	Captain	Cons. Steam Fishing Co
Johan **de Vries** (Crew)	28	11	South Shields, Durham	Mate	Cons. Steam Fishing Co
Chester **Brown** (Crew)	40	5	Mutford, Suffolk	Deckhand	Cons. Steam Fishing Co
John **Holmes** (Crew)	40	6	Antwerp, Belgium	Cook	Cons. Steam Fishing Co
Sidney **Lewis** (Crew)	36		Swansea, Glamorganshire, Wales	Chief Engineer	Cons. Steam Fishing Co
George Williams (Crew)	32		Haverfordwest, Pembrokeshire, Wales	Second Engineer	Cons. Steam Fishing Co
David Cawley (Crew)	31	6	Ballaghadereen, Roscommon, Ireland	Fireman	Cons. Steam Fishing Co
Aneurin Owen (Crew)	28	7	Llanelly, Carmarthenshire, Wales	Fireman	Cons. Steam Fishing Co
Carl Johan Pettersen (Crew)	54	5	Tonsberg, Norway	Fireman	Cons. Steam Fishing Co
William H Ware (Crew)	39	4	Tenby, Pembrokeshire, Wales	Bosun	Cons. Steam Fishing Co
Albert Mayhew (Crew)	28	7	Lowestoft, Suffolk	Deckhand	Cons. Steam Fishing Co

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THE 1939 NATIONAL REGISTER DATA FOR LUNDY

By Malcolm Lee
Gullrock, Port Gaverne, Port Isaac, Cornwall, PL29 3SQ
e-mail: gullrockportgaverne@btinternet.com

ABSTRACT:
The 1939 National Register was set up at the outbreak of World War Two to record the civilian population. This article sets out the data recorded for those 21 civilians on Lundy at the start of the war, together with the results of further research on some of those people.

Keywords: *1939 National Register, Felix William Gade, Henry Herbert Kortright, Jack Crews.*

As war was approaching, the government realised there was a need for more accurate information on the civilian population. The last census of 1931 was now eight years out of date, and the next one was not due until 1941. The National Registration Act 1939 was passed by Parliament as an emergency wartime measure on 5th September 1939 and gave rise to the 1939 National Register. This can be regarded as a mini census of the civilian population for autumn 1939, but, unlike a census, it was to be constantly maintained throughout the war and well after. The basic information it contained was similar to that on a normal census but, as a living register, it contained the full date of birth. Under the act, each parish was to compile a register of every civilian within it. The primary purpose of this register was for the system of wartime Identity Cards, which began to be issued from 29th September 1939 and did not end until 1952. When the National Health Service was founded in 1948 the register was taken over for that purpose and, until the NHS system was computerised in 1991, was manually updated to record a woman's change of name on marriage, and the date of death of a person on the register. These additional features make the register an invaluable source for genealogists, not least as this will be the most recent UK population data to be released for a long time. All the documents for the 1931 census were destroyed in a fire in December 1942, and there was no census taken in 1941. The next census of 1951 will not be available to view for almost 30 years, being scheduled for release in 2052.

Before the 1939 register could be released, thought had to be given about protecting the privacy of those who may still be alive. A census is not normally released until 100 years after it was taken, for just this reason. A decision was made that information on persons who would be less than 100, and are not known to have died, were to remain closed until 100 years have elapsed from their year of birth. As the release would involve providing images of the original register pages for viewing online, the line for any such person is blacked out and noted 'This record is officially closed'.

The 1939 register for Lundy has a front cover printed with the title 'National Registration Transcript Book'. The Rural District is filled in as 'Bideford', Registration District, and sub-district no. as '286 (1)', and Enumeration District Letter Code as 'WHEJ'. There are two manuscript notes on the front cover 'Total Number of Persons 21' in black ink, and '1 pages' (sic) in blue ink. The cover has been signed by F. W. Gade as Enumerator and dated 13th October 1939. With subsequent additions, Lundy's register resulted in two pages with each page containing 44 lines, one for each individual. On page one, the first 21 lines have only two that are blacked out. The next 14 lines are blacked out, then one open entry for John (Jack) Crews, which was not written in Felix Gade's distinctive hand, confirming others were maintaining the register. The final eight lines on the first page are blacked out. On the second page, only the entry on the first line is open, being for two year old Mary A Livie-Noble, and this is written in yet a third hand. The remaining 43 lines on page 2 are blacked out.

It was surprising to see 67 of the 88 lines blacked out. In the West Country, such large blacked out sections are often for groups of young evacuees billeted locally, but none were ever placed on Lundy, not least due to the lack of resources to feed and school young children. The 1939 Register was not to include service personnel in military, naval and air force establishments, as they would already be included in official records, and I think the most likely explanation for the fourteen blacked out lines immediately below those first 21 is that Felix Gade erroneously included Coastguard staff (*Admiralty*) on the register. For the 1931 national census, Felix Gade was the senior person on the island, and he would obviously have been required to include the Coastguard staff. No doubt he treated the 1939 Register in the same manner. Felix Gade mentions a detachment of an officer and six naval ratings arriving in January 1940 to man a watching station, so possibly the other blacked out entries may represent the comings and goings of them and other forces during the war. Any military personnel in 1939 would be over 100 today, so it is not clear why this erroneous inclusion has been treated in this manner. No doubt this was not an uncommon error throughout the whole process of compiling the national register, and presumably some official decision was taken to effectively remove all similar errors.

The full list of persons recorded on Lundy in the register at the beginning of the war is shown in the table. From there, we see Felix Gade was the Estate Manager and Farmer, living in Manor Farm Hotel. A note alongside his entry states 'Capt. General Reserve of Officers 191a'. The estate staff were living in the two Signal Cottages, with Albert Morris as horseman, William Little as cowman, Leslie Tucker as the estate carpenter, and John (Jack) Crews as gardener. Nothing could be found about the other workers, but the index to Felix Gade's 'My Life on Lundy' has Jack Crews listed 27 times, so he was clearly a reliable and good worker. Jack Crews was originally a fisherman from Padstow and came to Lundy in 1929. In 1932 he married Dorothy who was then a waitress in the hotel, and they had a daughter Joan. They had to leave the island in 1939 when Joan reached school age. Dorothy is listed on the register, but her occupation is shown as 'Domestic Duties Unpaid', which was the phrase used for all married women not in paid employment. Presumably she had been waitressing during the 1939 season, although once war broke out few visitors came, so her services as a waitress would no longer be required. Their daughter Joan is not on the register, so must already have left the island, perhaps to stay with grandparents or friends to start her schooling in September. Jack is listed twice in the register, which likely means he left temporarily too, perhaps to arrange matters before they both departed later that year. Felix Gade stated that Jack could turn his

Jack Crews 1933

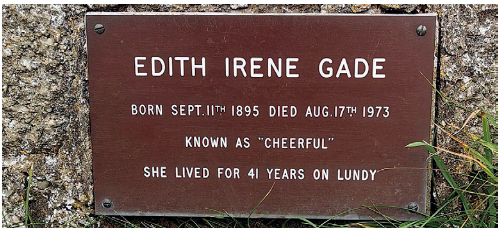
hand to many things, particularly when he returned to Lundy in 1947 after picking up slating and plastering skills. He was also a capable butcher. Jack died in 1979.

In the hotel, Mrs Gade was the manageress (and also the cook), with Frank Curtis as Porter. Directly below Mrs Gade in the register is a blacked out entry, and that can only be for her daughter Mary Gade, who was 6 when war broke out. There were two other people in the hotel. George Turner BA is listed as a tutor and was presumably there for Mary Gade's tuition. The other is Henry Herbert Kortright, who had been a resident magistrate in Sarawak. He retired to the UK and spent seven months on Lundy, where he was a popular and likeable man. He was 54 when he left the island at the end of December 1939 to enlist. He was drafted into a Pioneer Battalion but resigned his commission in 1940. He returned to Lundy in 1943 and stayed with Felix Gade in Millcombe House. He died in spring 1961.

In Garden Bungalow (Brambles) was Mary Hall Livie-Noble. The blacked out entry below her must be for her two year old daughter Mary Ann, who is the only open entry on page two of the register. Her husband, Frederick, was a consultant psychologist and in the 1939 register he was living at Barnes in London. Possibly Mary and their daughter had been sent away to the west country to avoid the anticipated bombing. Also staying in Garden Bungalow was Evelyn Courier. Little could be found out about her. In 1911 she was an embroidery student in West Bromwich, and in 1927 she was living in Birmingham. In the 1939 register her husband was in Sutton Coldfield. She may have been a friend of Mrs Livie-Noble and also escaping the likely bombing, or perhaps she was a nurse for young Mary Ann.

In the South Light the principal keeper was Harry Sibert, with assistants Cecil Tresize and Thomas Cuthbertson, and in the North Light was Reginald Cooper as principal keeper, with Charles Waghorn and Harold Woodruff assisting.

Felix William Gade: He was born on 10th July 1890 in Fulham to Felix Theodore and Winifred Annie Gade. In 1901 they were living in Caterham, where his father was described as an Importer and Merchant. In the 1911 census he was living in Hampton Court with his mother and sister Isabelle, where he gave his occupation as 'motor expert' working for a Motor Car Manufacturer. On 3rd February 1912 Isabelle married Sargent Terry Harman, the older brother of Felix's boyhood friend, Martin Coles Harman. During World War One he joined the 8th Royal Fusiliers, rising to the rank of Captain, where he won the Military Cross. On census night 1921, Felix was staying in a Cheltenham Hotel. His occupation is now an automobile salesman working for a motor car manufacturer in Manchester. This was undoubtedly Ford, who opened their Trafford Park factory just before World War One. In 1926 he became the resident agent of Lundy. It was on 11th November 1926 when Felix first landed on Lundy, after a five day wait at Instow for the gales to subside before Fred Dark could make the crossing in the *Lerina*. In 1928 he married Edith Irene Clark, known as Rene or 'Cheerful'. Felix was a very tall man and known as 'Giant'. In December 1944 he had a severe bout of sciatica, and it became clear that a break from the hard manual work on Lundy was needed if it was to improve. On 1st July 1945 he and Rene left Lundy to manage the Hartland Quay Hotel for Major Stucley, who wanted to reopen the hotel now the war in Europe was over. They returned to Lundy on 2nd May 1949, where Felix steered Lundy through the rest of the Harman years into the Landmark



The Memorials on Lundy to Felix and Rene Gade

Trust era in 1969. On 30th September 1971, Felix had his last day as Land Agent. Rene's health was failing, and she died on Lundy on 17th August 1973.5 Felix lived on Lundy for another 5 years, passing away on 28th October 1978, in his 89th year.

Acknowledgements: The image of Jack Crews is a crop from Dr A T J Dollar's 1933 photo of a group of islanders in Felix Gade's 'My Life on Lundy' (opposite page 64). Findmypast.co.uk is acknowledged as the source for the 1939 register data and all other genealogical data.

Lundy occupants as shown on the 1939 Register

Signal Station Cottages 1				
Forename	*M/F*	*Date of Birth*	*Marital Status*	*Occupation*
Albert E **Morris**	M	09 November 1909	M	Horseman (Farm)
Phyllis G **Morris**	F	23 November 1916	M	Domestic Duties Unpaid
Signal Station Cottages 2				
John **Crews**	M	24 April 1900	M	Gardener
Dorothy **Crews**	F	27 November 1910	M	Domestic Duties Unpaid
Leslie **Tucker**	M	11th January 1891	S	Estate Carpenter
William **Little**	M	11 November 1904	S	Cowman on Farm
Garden Bungalow (Brambles)				
Mary H **Livie-Noble**	F	09 February 1907	M	Domestic Duties Unpaid
Mary A **Livie-Noble**	F	18 April 1937	S	Under School Age
Evelyn W **Courier**	F	2nd January 1896	M	Domestic Duties Unpaid
Manor Farm Hotel				
Felix W **Gade**	M	10th July 1890	M	Estate Manager and Farmer
Edith I **Gade**	F	11 September 1901	M	Hotel Manageress
Mary E A **Gade***	F	27 May 1933	S	School Age
George **Turner** BA	M	03 November 1900	S	Tutor
Henry H **Kortright**	M	7th April 1885	M	Sarawak Civil Service Retired
Frank **Curtis**	M	17th July 1894	M	Hotel Porter
Lundy South Lighthouse				
Harry A **Sibert**	M	3rd May 1880	W	Principal Lighthouse Keeper
Cecil T **Trezise**	M	18th June 1898	M	Assistant Lighthouse Keeper
Thomas T **Cuthbertson**	M	15 July 1902	M	Assistant Lighthouse Keeper
Lundy North Lighthouse				
Reginald G **Cooper**	M	8th September 1890	M	Principal Lighthouse Keeper
Charles F **Waghorn**	M	10th September 1892	M	Assistant Lighthouse Keeper
Harold D **Woodruff**	M	28th February 1896	M	Assistant Lighthouse Keeper

* Entry 'officially closed' on the actual register. Information completed from other sources

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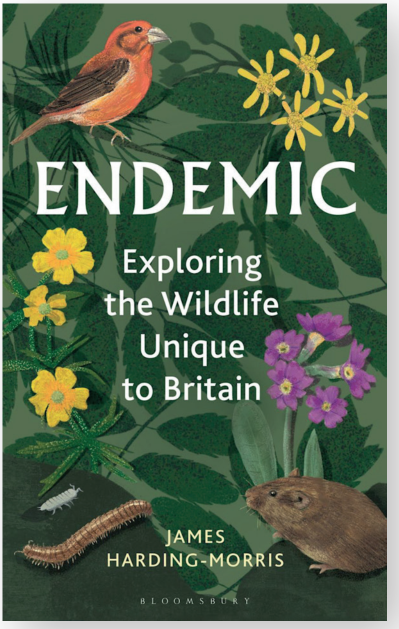
Endemic:
Exploring the Wildlife Unique to Britain

BY JAMES HARDING-MORRIS

Bloomsbury. 2025. 336 pages.

ISBN 978-1-3994-0567-6 hardback
ISBN 978-1-3994-0566-9 ePub
ISBN 978-1-3994-0571-3 ePDF



James Harding-Morris, who describes himself as a passionate nature enthusiast, realised a few years ago that there is no definitive list of British endemics, so he decided to create one. Discovering that there are around 700 British endemics he chose 20 to research further and has put his findings into this highly entertaining and informative book.

I bought *Endemic* initially for its chapter on the Lundy cabbage but once asked to write a review, read it in its entirety – and I'm glad I did! It is an extremely well written and easy to read book.

The book presents Harding-Morris's travels across Britain as he searches for his chosen endemic animals, plants, and fungi, sharing both his field experiences and insights from local experts whose knowledge he draws on in his quest, rather than serving as a formal reference guide.

Unlike many natural history books, *Endemic* doesn't contain any photographs and relies solely on the power of language to fuel one's imagination. The descriptions are detailed and imaginative, with occasional quips to make one smile: 'If you're cool like me, they're shaped a bit like the Pokémon Starmie.' I found that the absence of images did force a slower reading pace, re-reading some of the descriptions to ensure I understood them, and in some cases taking time to look at online images.

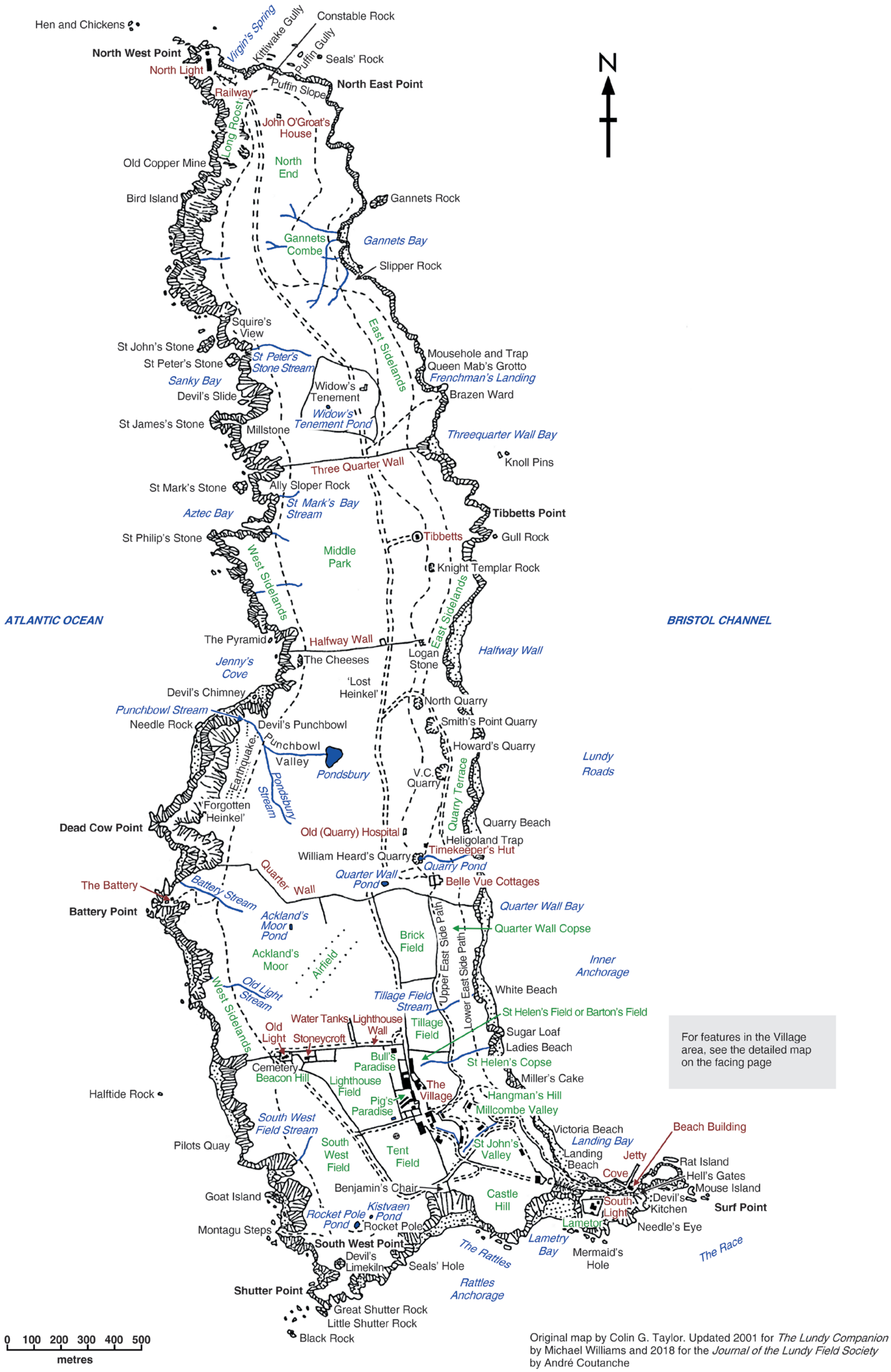
This is not a book to take out on a walk to help you identify species, but it certainly piqued my curiosity, and I found myself wondering how many of his 20 I could manage to find if I went out looking. Maybe I could seek out the No Parking Whitebeam, only found in six square kilometres of North Devon, or should I pop up to Orkney to try and find the Orkney vole which is around 10 times bigger than the Pygmy shews on Lundy? Maybe I could detour to Arran on the way home to view the Catacol Whitebeam, allegedly one of the rarest trees on the planet…

Of course, my favourite chapter was *Devon's Galapagos: Lundy Cabbage and its Beetles*, containing many familiar names and places, and I learnt that Lundy has the only endemic that hosts other endemics!

Overall, *Endemic* is a compelling and inspiring read and offers a deeply rewarding journey around some of Britain's rarest species.

Bee Cox, July 2025

MAP OF THE ISLAND OF LUNDY



Original map by Colin G. Taylor. Updated 2001 for *The Lundy Companion* by Michael Williams and 2018 for the *Journal of the Lundy Field Society* by André Coutanche

Journal of the Lundy Field Society Volume 9, 2025

EDITORIAL 4

PAPERS 5

Alan Rowland
Lundy Butterflies 5

Laura Larkin
Lundy Cabbage Flea Beetle (*Psylliodes luridipennis*) - a review 30

Are Værøyvik, Sunyeong lee, Euan Bielby and Shayan Shoaee
Studies on patrolling flights and 'cancelled landings' by the Northern Fulmar (*Fulmarus glacialis*) on Lundy 48

Yuheng Sun, Sue Anne Zollinger and Julia Schroeder
Vocalisation behaviours of Manx Shearwaters on Lundy 61

Geoff Billington
Bat research on Lundy Island 2014-18 68

Editor's note
Further studies by eDNA metabarcoding of the ecology of the Grey Waxcap (*Cuphophyllus lacmus*) and other fungi on Lundy 81

Ruben Mole, John Hedger, Alan Rowland, Andrew P. Detheridge and Gareth W. Griffith
Further studies by eDNA metabarcoding of the ecology of the Grey Waxcap (*Cuphophyllus lacmus*) and other fungi on Lundy 83

John Hedger and Jamie Dunning
Do thermophilous fungi occur in the nests of Lundy House Sparrows? 105

André Coutanche
This excellent man…': Kristjan Magnusson,Martin Coles Harman and paintings of Lundy 113

SHORT COMMUNICATIONS
Malcolm Lee
The 1921 census data for Lundy 135

Malcolm Lee
The 1939 National Register data for Lundy 143

BOOK REVIEW
Bee Cox
Endemic: Exploring the Wildlife Unique to Britain by James Harding-Morris 147

MAP OF LUNDY 149