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The Australian Museum Lord Howe Island Expedition 2017—Birds and Mammals

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Abstract. The Australian Museum Research Institute Terrestrial Vertebrates team was on Lord Howe Island from 12–24 March 2017. Our aims were to improve the Museum's specimen and tissue collection of birds and mammals from the Island, to collect base-line samples of the two introduced rodent species before their planned eradication, and to exhume the skeletal remains of three beaked whales which were buried on the Island in 2011. Samples were collected from 96 individuals of 10 species of birds on Lord Howe Island. Blood samples were collected from 30 individuals that were subsequently released, including representatives of three of the four extant endemic taxa. Feather samples were collected from a further 17 living individuals, while 47 specimens that had been found dead on the island by residents were transported back to the Museum for curation as skins, skeletons and tissues. Twenty-seven Lord Howe Woodhen, *Hypotaenidia sylvestris* specimens were included in this collection. These samples will be used in future research projects on the conservation ecology of the Woodhen, and microevolution of island avifauna. Fifteen genetic samples (4 specimens and 11 wing biopsy samples) were obtained from the Island's only extant native mammal, the Large Forest Bat, *Vespadelus darlingtoni*. Preliminary analysis indicated that the Lord Howe Island population was most similar to the northeast New South Wales population, but variation across the species' range in calls, morphology and genetics warrants further investigation. Specimens and tissue samples were also collected from populations of the Island's introduced House Mouse, *Mus musculus* (n = 38) and Black Rat, *Rattus rattus* (n = 12). These samples will provide a valuable record of the pre-eradication rodent population of Lord Howe Island. Three Dense-beaked Whale, *Mesoplodon densirostris* skeletons, two females and a sub-adult male, were successfully recovered. Overall, these new specimens and tissue samples will significantly enhance the Australian Museum's collection, provide documentation of the contemporary bird and mammal fauna of Lord Howe Island, as well as support current and future research projects.

Keywords. Vespertilionidae; Ziphiidae; Muridae; Passeriformes; Rallidae

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Lying 600 km off the east coast of central New South Wales, Lord Howe Island (1,455 ha) is the eroded remnant of a much larger island formed by volcanic activity on the Lord Howe Rise some 7 million years ago (Hutton, 1986, 2008). With a long history of isolation, and a terrestrial biota derived by dispersal from surrounding landmasses, Lord Howe Island has long fascinated scientists as a natural laboratory of evolution. Its abundant biodiversity, high levels of endemism and relatively intact island ecosystems saw Lord Howe Island added to the World Heritage list in 1982 (Recher & Clark, 1974; Hutton, 2008). The high biological significance of Lord Howe Island has made it a research focus for Australian Museum staff and expeditions for much of the Museum's 190-year history.

Lord Howe Island is famous for its unique, abundant and conspicuous bird life, the history of which has been well documented (Hutton, 1991; McAllen *et al*., 2004; Frith, 2013). Fourteen species of seabirds and 27 species of land birds have been recorded breeding on the island of which 12 land bird species have arrived since the island was discovered in 1788. Habitat modification, especially clearing of forest to produce pasture, has created novel habitats that have probably enabled many of these recent arrivals to have become established where the land was previously unsuitable for colonization (Hutton, 1991). Of the original 15 land bird species, 13 are considered to be endemic species or subspecies, but nine have been driven to extinction, first by harvesting for food, and later by the introduction of exotic predators, particularly rats (Frith, 2013).

One endemic species that has been the subject of extensive research and conservation activities by the Lord Howe Island Board, the Office of Environment and Heritage (formally New South Wales National Parks and Wildlife Service), CSIRO and Australian Museum is the Lord Howe Woodhen, *Hypotaenidia sylvestris* (Recher & Clarke, 1974). As a result of hunting, over-collection and predation by feral mammals, this species declined to fewer than 30 individuals in the 1970s (Frith, 2013) before recovering to an estimated 286 individuals in 2016 (LHI Board, 2016).

Comparative DNA analyses of the endemic Lord Howe Silvereye, *Zosterops lateralis tephropleurus* in relation to other island and mainland Silvereyes has been influential in understanding microevolutionary changes in island faunas (Clegg *et al.*, 2002). However, the relationships between the Lord Howe Golden Whistler, *Pachycephala pectoralis contempta*, another endemic subspecies, and the mainland and Norfolk Island subspecies have not been determined, although high levels of differentiation have been identified in the *P. pectoralis/melanura* species complex in Polynesia (Andersen *et al.*, 2014). Collection and long-term storage of DNA samples of Lord Howe endemic taxa is important research infrastructure that the Australian Museum can provide to facilitate future studies.

The Australian Museum ornithology collection holds over 500 specimens of 45 bird species occurring on or around Lord Howe Island, including specimens of 10 of the 13 endemic species/subspecies of land bird. The majority of the Museum's Lord Howe Island collection are study skins of birds that were obtained between 1887 and 1983, prior to the establishment of the Museum's tissue collection. Accordingly, the collection holds only five tissue samples containing the high-quality DNA that can readily be used for determining the evolutionary relationships and genetic diversity of the Island's fauna. Of these, there are only two tissue samples of the land bird species that represent two of the four extant endemic taxa. A recent and notable acquisition was a specimen of Long-tailed Cuckoo, *Urodynamis taitensis* in 2013, which represents the third specimen and the sixth record of this species from the island (Boles *et al*., 2015).

In contrast to the diverse avifauna, the terrestrial mammal fauna of Lord Howe Island is depauperate, reflecting the superior over-water dispersal ability of birds compared to most mammals. Only two native species of land mammals, both microbats, have been recorded as resident on Lord Howe Island. The endemic Lord Howe Island Long-eared Bat, *Nyctophilus howensis*, now extinct, is only known from a single, relatively recent, skull collected in 1972 from a cave at the north end of Lord Howe Island (McKean, 1975; Richards, 2008). Although tentatively placed in *Nyctophilus* by McKean (1975), its generic status remains unresolved and there is no compelling evidence that it had long ears, or that it belongs within *Nyctophilus* (Parnaby, 2009). The second species, the Large Forest Bat, *Vespadelus darlingtoni* remains extant on the Island and also occurs in southeast mainland Australia and Tasmania (Van Dyck & Strahan, 2008). However, the relationship between the mainland and Lord Howe Island populations remains uncertain and only a few studies have examined the biology of the Lord Howe Island population (e.g., Law *et al*., 2002; Hoye, 2016).

In the early literature there is some confusion about the identity of bats recorded from Lord Howe Island as they could not be traced to specimens, compounded by the nomenclatural and taxonomic confusion typical of the late 19th century. The identity of *Scotophilus morio*, given for the bat obtained by Etheridge (1889) misled Troughton (1920) to suggest that *Chalinolobus morio* also probably occurred on Lord Howe Island in addition to what Troughton called *Eptesicus pumilus* (now *Vespadelus darlingtoni*). The genus *Scotophilus* as applied by 19th century Australian zoologists included a wide range of currently recognized genera including *Chalinolobus*, *Scotorepens*, *Miniopterus* and *Vespadelus*. However, these early records are all attributable to *V. darlingtoni*.

While vagrant bird species are regularly reported from Lord Howe Island (McAllan *et al*., 2004), there are very few records of vagrant bats, most likely reflecting the greater difficulty in both their detection and identification. Flying-foxes have occasionally been reported from the Island (Etheridge, 1889), and the Australian Museum has a Grey-headed Flying-fox, *Pteropus poliocephalus* specimen (M.46698) found on Boat Harbour Beach in 2014. There are also reports of a live Yellow-bellied Sheathtail Bat, *Saccolaimus flaviventris* found on Lord Howe Island in May 2009 and a live adult female Gould's Wattle Bat, *Chalinolobus gouldii* captured on Lord Howe Island during November 2010 (Hoye & Bower, 2017).

Over 25 marine mammal species could potentially be found in the waters around the Lord Howe Island group (Van Dyck & Strahan, 2008), although there are relatively few confirmed records. The Australian Museum holds specimens of three marine mammal species from Lord Howe Island: Dense-beaked Whale, *Mesoplodon densirostris*, Long-finned Pilot Whale, *Globicephala melas* and Australian Fur Seal, *Arctocephalus pusillus doriferus* (Table 1). In addition, the Natural History Museum, London has a skull of a female Leopard Seal, *Hydrurga leptonyx* (NHMUK.4287460) from Lord Howe Island. There are also sight records from the Lord Howe Island group of at least four other marine mammal species including Humpback Whale, *Megaptera novaeangliae*, Sperm Whale, *Physeter macrocephalus*, Common Dolphin, *Delphinus delphis* and Bottle-nosed Dolphin, *Tursiops truncatus* (unpubl. data; Hutton, 2017). Nevertheless, the marine mammal fauna of the Lord Howe Island group requires additional investigation.

In the 19th century five additional terrestrial mammal

Table 1. Summary of Australian Museum mammal specimens and samples from Lord Howe Island prior to current survey.

Scientific name	Common name	Number of individuals	Number of frozen tissues
Vespadelus darlingtoni	Large Forest Bat	13	0
Pteropus poliocephalus	Grey-headed Flying-fox	1	1
Mus musculus	House Mouse	3	1
Rattus rattus	Black Rat	30	14
Mesoplodon densirostris	Dense-beaked Whale	2	3
Mesoplodon sp.	Unidentified Beaked Whale	1	0
Globicephala melas	Long-finned Pilot Whale	1	0
Arctocephalus pusillus doriferus	Australian Fur Seal	1	0

species were introduced to Lord Howe Island and established wild populations; these were the Pig, *Sus scrofa*, Goat, *Capra hircus*, European Rabbit, *Oryctolagus cuniculus*, House Cat, *Felis catus* and House Mouse, *Mus musculus* (Priddel & Hutton, 2010; Frith, 2013). The Rabbits had died out by the late 1890s and the Pigs, Goats and Cats were successfully eradicated during the 1970s–1990s due to concern about their negative environmental impacts (Priddel & Hutton, 2010; Frith, 2013). A further mammal species, the Black Rat, *Rattus rattus* was accidently introduced to the Island in 1918 and rapidly spread with major impacts on biodiversity including declines and extinctions of multiple endemic bird, reptile, plant, land snail, beetle and other invertebrate taxa (Hutton, 1991; Ponder, 1997; LHIB, 2009; Priddel & Hutton, 2010; Wilkinson & Priddel, 2011). The continuing negative impact of *R. rattus* on many native plant and animal species on Lord Howe Island (LHIB, 2009; Auld *et al*., 2010) saw the species listed as a Key Threatening Process under both NSW and Australian biodiversity conservation legislation *(TSC Act 1995*; *EPBC Act 1999)*, and after many years of planning, a Rodent Eradication Program is to commence on Lord Howe Island in 2018 (LHIB, 2009; Priddel & Hutton, 2010; Wilkinson & Priddel, 2011).

The Australian Museum's Lord Howe Island mammal collection dates from the late 1860s with specimens added at irregular intervals over a period spanning around 150 years. Prior to the current survey, the collection contained 52 mammal specimens from Lord Howe Island comprising four terrestrial and three marine mammal species (Table 1). Frozen tissue samples for genetic studies were available for only four of these species (Table 1) and there were no tissue samples of Lord Howe Island *V. darlingtoni* in the collection.

The earliest literature report we have found on the indigenous land mammals on Lord Howe Island is a statement by Hill (1869: 46) that "There are no indigenous animals except a small bat". Hill (1870) provided a summary of a four-day visit to the Island in early June, 1869 which included Australian Museum collector George Masters in the team. Masters collected birds and insects on the trip but appears not to have obtained bat specimens. A one-page appendix in Hill (1870), written by then Australian Museum Curator G. Krefft, lists bird and invertebrate species but makes no reference to bats. Prior to 1875, the documentation of early mammal specimens entering the Australian Museum was ad hoc and did not include a register of incoming specimens (Parnaby *et al*., 2017).

The earliest record in the Australian Museum's mammal collection from Lord Howe Island is a full skeleton of *M. densirostris* (PA.372) figured in Gray (1870). This was only the third specimen of this species ever recorded and the first almost complete skeleton in existence at the time (Raven, 1942). Another *Mesoplodon* specimen (S.405) was acquired by T.G.C. Nichols in 1892, after it was washed up on Blinky Beach, Lord Howe Island on 18 November 1892. Nichols sent the full skeleton to the Museum in March 1893. It was reportedly in poor condition and the skull damaged. The whole skeleton was evidently retained and registered into the collection on 9 May 1893.

Almost a century later in October 1989, an adult male *M. densirostris,* with numerous shark bites, was found floating in the Lord Howe Island lagoon. The body was buried in the sand hills behind the lagoon and in November 1992 the skeleton was exhumed and sent to the Australian Museum where it was registered into the collection (M.28155).

More recently in 2011, the Australian Museum acquired tissue samples from three specimens of *M. densirostris* from Lord Howe Island. In August 2011, after several days of heavy seas, three *M. densirostris* were found stranded on the fringing reef towards the northern end of the Lord Howe Island lagoon. They subsequently died and their bodies were towed to shore and then transported towards the southern end of the Island where they were buried together in a c. 2 m deep trench dug in a paddock near Johnsons Beach. At the time of burial, the specimens were thought to be three females and were 4.30, 4.45 and 4.60 m total length (Kerr, 2011). The largest female was pregnant with a well-developed foetus. Tissue samples were taken from the three adults and lodged in the Australian Museum's frozen tissue collection (M.43481, M.43482, M.43483). The species identity was later confirmed by DNA sequencing of the tissues carried out by the Australian Centre for Wildlife Genomics, Australian Museum.

Only one other cetacean specimen from Lord Howe Island is present in the Australian Museum collection. It is the skeleton of a *G. melas* (S.1125) registered in August 1909 from the "Old Collection" for which the collection date is not known. This fully articulated skeleton was on display in the Museum's skeleton gallery for many years, until August 2011.

The occasional presence of seals on Lord Howe Island, presumed to be vagrant *Arctocephalus* species (Fur Seals), was reported by Museum staff member A. Morton in 1882 (Etheridge, 1889). However, the Australian Museum mammal collection contains only a single seal specimen from Lord Howe Island, an *A. pusillus doriferus* (M.24356), a juvenile female which stranded in October, 1990.

The earliest documented Lord Howe Island land mammal specimens received at the Australian Museum were entered in the M register as "2 mammals—bat and mouse, Lord Howe Island, Etheridge + Party". This entry was inserted between line entries for M.81 and M.82, registered in July 1887 and September 1887 respectively. It appears that neither specimen was assigned an M number at the time (but now allocated M.49042 and M.49041 respectively), and neither specimen has been found in the collection nor have we located any other documentation regarding those specimens. It is likely that these two specimens were the "*Mus domesticus*, var." and "*Scotophilus morio*, Gray" on the

list of vertebrate species from Lord Howe Island compiled by Ramsay (1888).

It appears that the Australian Museum's holdings of Lord Howe Island's only remaining resident bat species *V. darlingtoni* (Table 2) represent nearly all of the specimens in world collections. An additional specimen obtained in 1979 and lodged in the Australian National Wildlife Collection (CM04825), appears to be the only other specimen of *V. darlingtoni* from Lord Howe Island in Australian museum collections. As noted above, the first specimen was reportedly collected during the Etheridge expedition in August-September 1887 (Etheridge, 1889), but Troughton (1920) was unable to locate it and this specimen (now assigned the registration M.49042) has not been sighted since. Three specimens (M.8819–21) were later collected by E. H. Saunders during October–December 1887 and registered in July 1966. Although McKean (1975) states that these could be the missing specimens collected by Morton and Unwin in 1882, his suggestion probably arose from ambiguous statements by Etheridge (1889). The trip report by Alex Morton, assistant Australian Museum taxidermist (Morton, 1882), states that he did not collect any bats during his brief visit of April 1882. Morton remarked that "small bats and a flying fox are sometimes seen", but Morton did not specify whether he made the observations or whether he was reporting comments from locals (Morton, 1882). Etheridge (1889: 6) states that the only bat obtained was "A single specimen of *Scotophilus morio*, Gray, similar to those obtained by Morton was shot by Mr. Unwin" (Unwin volunteered as a collector with the party). If, as we suspect, Morton visited Lord Howe Island once, then it is possible that Etheridge mistakenly referred to Morton, but meant to refer to the bat specimens purchased from Saunders, who collected three specimens in the months after Etheridge's team had left the Island. McKean *et al*. (1978) later used two of these 1887 specimens (M.8819–20) as paratypes of *Eptesicus sagittula*, which is now regarded as a synonym of *V. darlingtoni* following the taxonomic revision of Kitchener *et al*. (1987). The only other early *V. darlingtoni* specimens in the Museum's collection include M.2652, collected by P. R. Pedley and registered in July 1916; two collected by A. R. McCulloch in March 1922 (M.4902–03), and two that have no collection date but were registered in 1929 and attributed to E. Waite and A. R. McCulloch (M.4740–41). We have not determined how many visits Waite and McCulloch jointly made to Lord Howe Island but if only once, then the latter two bat specimens would have been collected during their 1902–1903 visit. The total specimens in the collection by 1929 was therefore eight. The specimens M.4740–41 were likely added to the Australian Museum collection after 1920, given that Troughton (1920) reported six specimens in the collection.

There is a c. 50 years gap in Australian Museum specimen records of *V. darlingtoni* between 1922 and 1976 (Table 2). McKean (1975) reported that *V. darlingtoni* was not sighted on the Island from 1956–1975, despite efforts by several researchers to locate them, and concluded that it was probably extinct there. From 1976–1986 five more *V. darlingtoni* specimens were entered into the Museum's collection (Table 2). It is possible that the species was present on Lord Howe Island in very low numbers during 1956–1975 and so was not detected. Alternatively, and less likely, the species became locally extinct on Lord Howe Island and then subsequently recolonised the Island. A detailed morphological and genetic study of the *V. darlingtoni* specimens in the Australian Museum collection should be able to distinguish between these hypotheses.

Although the introduced House Mouse, *Mus musculus* was reported as arriving on Lord Howe Island around 1860, possibly from Norfolk Island (Etheridge, 1889), there are no surviving specimens from this period in the Museum's collection and only three specimens prior to the current survey. Two specimens were collected in 1971 (M.26068–69) and one in 2004 (M.37353). Only one tissue sample was present in the collection prior to this study (Table 1).

The second invasive rodent species present on Lord Howe Island, *R. rattus,* is better represented in the Museum's mammal collection. The species arrived on Lord Howe in 1918 following the wreck of the "Makambo" between the Admiralty Islands and Neds Beach (Hutton, 1991; Wilkinson & Priddel, 2011). In February–March, 1921, only three years after their arrival on the Island, Ellis Troughton, then Curator of Mammals at the Australian Museum, visited Lord Howe Island and collected five *R. rattus* specimens (M.2943–47). He visited the Island again in 1924 and obtained two *R.*

Table 2. Summary of *Vespadelus darlingtoni* specimens from Lord Howe Island held by the Australian Museum prior to the current survey.

Registration number	Sex	Specimen type	Date registered	Date collected	Collector
M.49042	?	Unknown[a]	?Jul–Sep 1887	1887	R. Etheridge Jr. & party
M.8819	M	Body in spirit; dry skull & skeleton	05 Jul 1966	Oct–Dec 1887	E. Saunders
M.8820	M	Body in spirit; dry skull	05 Jul 1966	Oct–Dec 1887	E. Saunders
M.8821	F	Body in spirit	05 Jul 1966	Oct–Dec 1887	E. Saunders
M.2652	F	Body in spirit; dry skull	21 Jul 1916	?	P. R. Pedley
M.4740	M	Body in spirit	16 Sep 1929	1902–1903[b]	E. Waite & A. R. McCulloch
M.4741	F	Body in spirit; dry skull	16 Sep 1929	1902–1903[b]	E. Waite & A. R. McCulloch
M.4902	F	Dry skull & skin	12 Mar 1930	06 Mar 1922	A. R. McCulloch *et al.*
M.4903	M	Dry skull & skin	12 Mar 1930	07 Mar 1922	A. R. McCulloch *et al.*
M.10327	M	Dry skull & skin	May 1976	01 May 1976	
M.10469	F	Body in spirit; dry skull	02 Sep 1977	Dec 1976	J. Messersmith
M.11761	F	Body in spirit; dry skull	18 Feb 1981	24 Oct 1981	P. Colman
M.21829	M	Body & skull in spirit	17 May 1990	01 Feb 1986	G. Hoye
M.21830	M	Body & skull in spirit	17 May 1990	04 Feb 1986	G. Hoye

[a] Specimen not found and no registration number assigned in 1889.
[b] Registered in 1929 but likely collected in 1902–1903.

Figure 1. Harp trap positioned in microbat flyway in Stevens Reserve, Lord Howe Island.

rattus skulls (both S.1880) from owl pellets. Additional *R. rattus* specimens from Lord Howe Island were obtained in 1971–1972 (M.9409, M.11832, M.26034–40) and further specimens and a series of tissue samples obtained in 2004 (M.37361–63, M.37365–72, M.37408–10).

The aim of the Australian Museum Terrestrial Vertebrates team's 2017 expedition to Lord Howe Island was to improve the Museum's specimen and tissue collection from the Island, focusing on poorly sampled native species including the microbat *V. darlingtoni* and the endemic land bird taxa: *P. p. contempta, Z. l. tephropleurus,* Lord Howe Pied Currawong, *Strepera graculina crissalis* and *H. sylvestris.* We also planned to collect specimens of the two introduced rodents (*R. rattus*, *M. musculus*) and DNA samples of all land bird species captured incidentally, as a record of their genetic and/or morphological characteristics prior to the planned rodent eradication program, and to exhume the skeletal remains of the three *M. densirostris* specimens which were buried on the Island in 2011 for addition to the Australian Museum collection.

Methods

From 12–24 March 2017 up to six Australian Museum Research Institute (AMRI) staff (AD, ME, SI, RJ, RM, LT) were on Lord Howe Island.

Birds

Bird capture and tissue sampling. Between one and four 12 m mist-nets were used to capture land birds during seven days of fieldwork. Only one net could be used in locations where Currawongs were present because the net needed to be kept under constant surveillance to prevent predation of birds from the net. Capture was facilitated by playback of recorded calls of mainland Silvereyes, *Zosterops lateralis* and Golden Whistlers, *Pachycephala pectoralis* which attracted birds to the net. Emerald Doves, *Chalcophaps indica* were successfully "herded" towards the net and then caused to fly into catching range.

Unlike mammals, birds have nucleated red blood cells, so blood is an excellent source of avian DNA. Large amounts of DNA can therefore be obtained from small blood samples, allowing DNA samples to be collected from birds that can be released alive. Accordingly, blood samples were collected by pricking the brachial vein and collecting the blood droplet in a capillary tube, prior to aspiration on filter paper. Samples were air-dried and frozen. Between 10 and 130 µl of blood were collected from each bird captured, up to a maximum of the 10 samples per species which was allowed under the Scientific Permit. Shed feathers were collected from excess individuals that were captured, which also provide small DNA samples. All birds were photographed and measured, recording the mass and wing, tail, tarsus, bill and head-bill lengths.

We did not end up targeting the endemic Currawong and Woodhen because these species will be captured in 2018 prior to the Rodent Eradication Program, and it was proposed by OEH staff that blood samples could be collected at that time, removing the need for additional handling. Additional tissue samples and whole specimens of both land birds and seabirds were obtained from salvaged individuals that had been found by local residents and stored in a freezer by the Lord Howe Island Board. These specimens were brought back to the Museum while still frozen.

Microbats

Trapping and detection. Two standard double frame Austbat harp traps (FaunaTech, Vic) (Fig. 1) were set for a total of 11 nights (22 trap nights) at seven sites around the Research Station, Nursery and in Stevens Reserve. Traps were moved to a new location each 2–3 nights and were positioned in perceived flyways. Traps were set at dusk and checked between 21:00–22:00 and again at 06:00–06:30 the following morning. Bats caught in the evening were either processed immediately and released or held overnight and released the following evening after dusk. For individuals retained as specimens, liver tissue was removed and preserved in 90% ethanol, and the specimen subsequently preserved in 75% ethanol. For individuals that were released, wing punch samples c. 2 mm diameter were taken and stored in 90% ethanol. For all bats captured, sex and standard body measurements were recorded.

Two *Anabat Express* detectors (Titley Scientific, Brendale, Qld) were set up at six locations around the northern end of the Island (Table 3). Recorders were in operation for 11 nights in total and operated continuously except when being transferred to new locations. The *Anabat Express* bat detection system was considered appropriate to address the two main objectives of the bat call survey: *(a)* to inventory bat species; *(b)* to assess overall levels of bat activity.

Bat calls were analysed using *AnalookW* software (Chris Corben, USA) which produced a frequency versus time display of bat call sequences (Fig. 2). All of the c. 16,000 sound files (which included all sounds such as wind and insects, additional to any bat calls) were manually inspected for bat call sequences or fragments of call sequences. Three file scan filters were constructed using *AnalookW* to identify files that contained bat calls: *(a)* an "all bats filter" designed to identify calls of any bat species; *(b)* a filter to identify any bat call above 40 Khz using broad parameters; and *(c)* a filter with more restrictive parameters to identify bat calls above 40 Khz. The latter two filters were used to provide two estimates of the number of call sequences, because decreasing the

Table 3. Location of *Anabat Express* detectors deployed on Lord Howe Island in March 2017. Map datum WGS84, precision ±10 m.

Dates at site March 2017	Site number	Nights active at site	Detector number	Location	Latitude	Longitude	Altitude (m)
12–13	1a	2	1	Research Station	-31.52603	159.06702	10
14–15	2a	2	1	Stevens Reserve	-31.52363	159.06610	14
16–18	3a	3	1	Stevens Reserve	-31.52356	159.06606	15
19–22	4a	4	1	Research Station	-31.52556	159.06639	12
12–13	1b	2	2	Neds Beach	-31.51939	159.06586	9
14–15	2b	2	2	Neds Beach	-31.51914	159.06427	17
16–19	3b	4	2	Valley of Shadows	-31.52786	159.07473	29

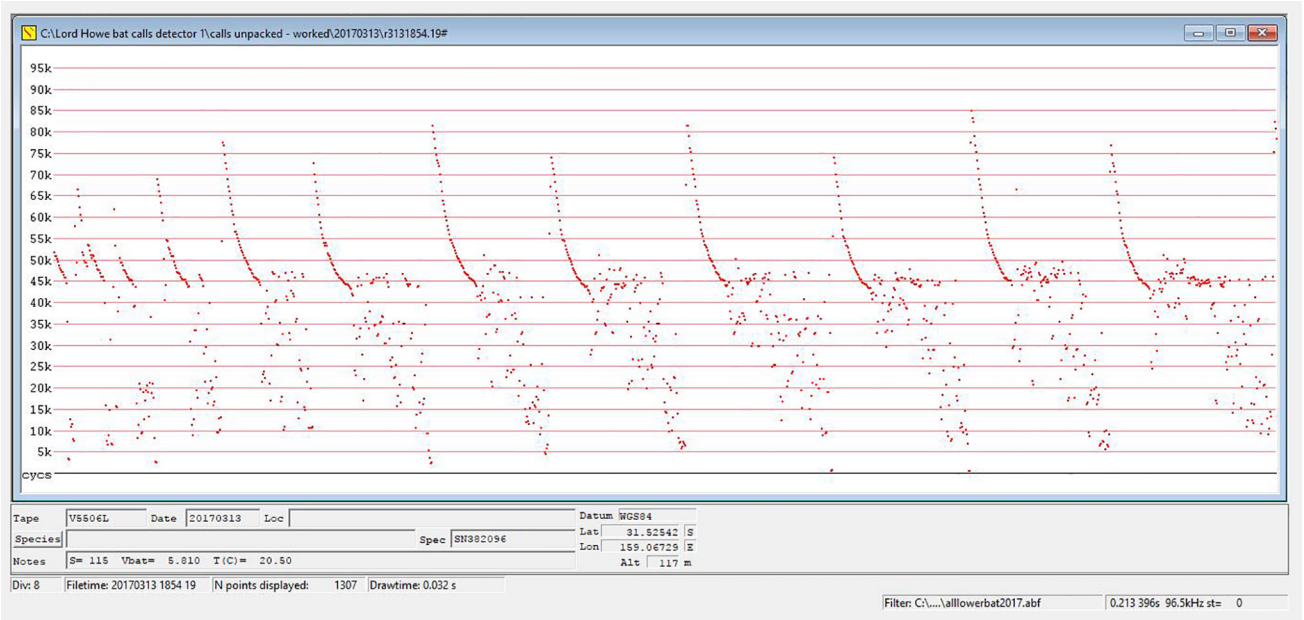

Figure 2. Sample of echolocation call sequence of a Large Forest Bat, *Vespadelus darlingtoni* from Lord Howe Island.

rigor of call parameters increases the incidence of incorrect identification of background noise as fragments of bat call sequences.

Genetic analysis. To genetically confirm the identity of the Lord Howe Island *Vespadelus*, and to compare genetic divergence between Island and mainland populations, mitochondrial DNA sequence was compared between two Island specimens and eight individuals from throughout eastern New South Wales (Table 4). Total genomic DNA was extracted from 10 mg tissue using the *Bioline Isolate II Genomic DNA Kit*, following manufactures instructions. Fragments of two mitochondrial DNA genes, cytochrome b (cytb) and cytochrome oxidase 1 (CO1), were PCR amplified using the following primers: cytb - L14841 (F), AAAAA GCTTCCATCCAACATCTCAGCATGATGAAA, H15149 (R) AAACTGCAGCCCCTCAGAATGATAT TTGTCCTCA (Kocher *et al*., 1989); CO1-BAK1490 (F) CTCAACCAAC CACAAAGACATCGG, BAK2198 (R) TAGACTTCTGGGTGGCCGAAGAATCA modified from Folmer *et al*. (1994). PCRs were conducted in 25 µl reactions using 10–20 ng of genomic DNA, 1 × reaction buffer (*Bioline MytaqRed Reagent Buffer*; Bioline, Australia), 2 pmol primers and *Bioline MyTaqRed* DNA polymerase (0.5 unit). Thermocycling was performed on an *Eppendorf Mastercycler Pro S* (Eppendorf, Hamburg, Germany) under the following conditions: initial denaturation 94°C (3 min), 38 cycles of denaturation at 94°C (20 s), annealing at 54°C (40 s) and extension at 72°C (40 s) with a final extension step of 72°C for 5 min. PCR products were visualized on a 2% E-gel (Life Technologies Corp. #G5018-02), then purified using *ExoSAP-IT* reagent (ThermoFisher Scientific #78201.1.ML) and sequenced at the Australian Genome Research Facility (AGRF). Sequences were edited using *Sequencher v5.4* (Gene Codes Corporation, Ann Arbor, USA) and aligned using *ClustalW in Mega 7.0.21* (Kumar *et al*., 2016).

The evolutionary history of the haplotypes was inferred using Maximum Likelihood analysis based on the HKY model in *Mega 7.0.21* (Kumar *et al*., 2016). Initial trees for the heuristic search were obtained automatically by applying *Neighbor-Join* and *BioNJ* algorithms to a matrix of pairwise distances estimated using the *Maximum Composite Likelihood* (MCL) approach, and then selecting the topology with superior log likelihood value.

Table 4. Collecting localities of *Vespadelus* used in genetic comparisons. Specimens in Australian Museum.

Registration number	EBU (tissue)	Taxon	Location
M.23963	26263	*Vespadelus darlingtoni*	Berry Rd, Billilimbra State Forest, NSW
M.23965	26266	*Vespadelus darlingtoni*	Crabapple Rd, Billilimbra State Forest, NSW
M.35347	12109	*Vespadelus darlingtoni*	Tambool, Mitchell Park Rd, Cattai, NSW
M.36555	36428	*Vespadelus darlingtoni*	East Boyd State Forest, NSW
M.39876	46109	*Vespadelus darlingtoni*	Mobong Rd, Cascade, NSW
M.39884	46105	*Vespadelus darlingtoni*	Mobong Rd, Cascade, NSW
M.47831	71053	*Vespadelus darlingtoni*	Jenolan Caves, NSW
M.47890	48188	*Vespadelus darlingtoni*	Kearl Rd, Glenside, NSW
M.48731	83445	*Vespadelus darlingtoni*	Lord Howe Island, NSW
M.48733	83449	*Vespadelus darlingtoni*	Lord Howe Island, NSW
M.21408	25830	*Vespadelus finlaysoni*	Pilbara, WA

Figure 3. Excavator opening the beaked whale burial pit on Lord Howe Island.

Rodents

Rodents were not actively trapped by the AMRI team but dead specimens were received from the LHI Board and Rodent Eradication Program staff. Liver samples, preserved in 90% ethanol, were taken from all individuals and standard body measurements were recorded. Specimens of *M. musculus* were then preserved in 75% ethanol, while those of *R. rattus* were first fixed in formalin.

Beaked Whales

In February 2017 the whale burial pit was reopened and the top c. 1.5 m of soil removed by an excavator (Fig. 3). From 13th March the remaining soil was removed by hand (shovel and trowel) so that the whale skeletons could be carefully uncovered (Fig. 4, 5) and labelled prior to removal and cleaning (Fig. 6).

To confirm the sex of the three *M. densirostris* specimens, total genomic DNA was extracted from tissue samples collected at the time of stranding using the *Animal Tissue* protocol of the *Bioline Isolate II Genomic DNA Kit*, following manufactures instructions. Gender determination was conducted as described by Jayasankar *et al*. (2008). With this method, in female cetaceans only one PCR product is expected (amplification of the *ZFX/ZFY* gene), in males two PCR products are expected (amplification of *ZFX/ZFY* and the male sex determining gene *SRY*). A multiplex PCR was carried out using the primers ZFX/ZFY-F (5' ATAATCACATGGAGAGCCACAAGCT 3') and ZFX/ZFY-R (5' GCACTTCTTTGGTATCTGAGAAAGT) and SRY-F (5' CCCATGAACGCATTCATTGTGTGG 3') and SRY-R (5' ATTTTAGCCTTCCGACGAGGT CGATA 3'). PCRs were conducted in 25 µl reactions using 100–500 ng of genomic DNA, 1 × reaction buffer (*Bioline MytaqRed Reagent Buffer*; Bioline, Australia), 2 pmol primers and *Bioline MyTaqRed* DNA polymerase (0.5 unit). Thermocycling was performed on an Eppendorf *Mastercycler EpS* (Eppendorf, Hamburg, Germany) under the following conditions: initial denaturation 94°C (3 min), 35 cycles of denaturation at 94°C (45 s), annealing at 58°C (45 s) and extension at 72°C (1 min) with a final extension step of 72°C for 7 min. PCR products were visualized on a 2% *E-Gel Precast Agarose Gel* (Thermofisher Scientific) and gender was determined where one band represented a female and two bands represented a male (Fig. 7).

Figure 4. Australian Museum staff (Anja Divljan, Rebecca Johnson and Mark Eldridge) working in the beaked whale burial pit on Lord Howe Island. On the left is the sub-adult male (M.43483), on the right is the sub-adult female (M.43481). The adult female (M.43482) was uncovered last, and lies between the others.

Figure 5. Adult female Dense-beaked Whale, *Mesoplodon densirostris* (M.43482) skeleton ready to be removed from the burial pit on Lord Howe Island.

Figure 6. Australian Museum staff (Sandy Ingleby and Mark Eldridge) cleaning Dense-beaked Whale, *Mesoplodon densirostris* skeletons at the Lord Howe Island Research Station.

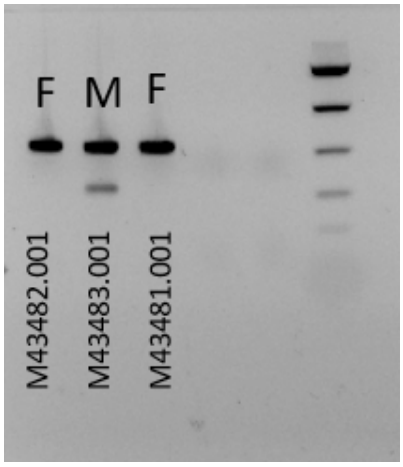

Figure 7. Visualization, under UV light, of sex-test PCR products in three sampled Dense-beaked Whale, *Mesoplodon densirostris* specimens.

Results and discussion

Birds

A total of 45 birds were captured, sampled and measured (Table 5 and 6) representing seven land bird species including three of the endemics (O.76650–94). The total included 20 Silvereyes, *Zosterops lateralis tephropleurus* (Fig. 8), 16 Golden Whistlers, *Pachycephala pectoralis contempta* (Fig. 9), four Common Blackbirds, *Turdus merula*, three Emerald Doves, *Chalcophaps indica*, two Buff-banded Rails, *Hypotaenidia philippensis,* one Sacred Kingfisher, *Todiramphus sanctus* and one Pied Currawong, *Strepera graculina crissalis* (Fig. 10).

Forty-seven birds were obtained from the Lord Howe Island Board's freezer in March 2017, including 10 seabirds and 37 land birds (Table 7). Species represented include Masked Owl, *Tyto novaehollandiae*, Sooty Tern, *Onychoprion fuscata*, Providence Petrel, *Pterodroma*

solandri, *H. philippensis* and Bar-tailed Godwit, *Limosa lapponica*. The 27 specimens of *H. sylvestris* will provide valuable tissue samples for a population genetics study that is now underway. In collaboration with the Lord Howe Island Board and the Office of Environment of Heritage, the Museum has commenced a project investigating the presumed loss of genetic variability in this species following the severe population bottleneck that occurred in the early 20th century (Frith, 2013). We are using next-generation DNA techniques to measure genetic variability in the contemporary samples obtained during the present expedition and to compare that variability with samples extracted from Museum skins collected in the early 1900s. We will supplement these collections with historic samples held by other museums, and with contemporary blood samples that will be collected by the LHI Board during their annual Woodhen mark/recapture survey. In addition to the temporal comparison, we will identify any genetic structuring between the component of the population living on the summit of Mt Gower, with the component living in the Settlement. Anecdotal observations suggest that there is minimal dispersal between the two regions, and if significant genetic differentiation is present, translocation may be a desirable conservation action.

Figure 8. Lord Howe Silvereye, *Zosterops lateralis tephropleurus* captured in Stevens Reserve. Australian Museum staff member Leah Tsang is in the background.

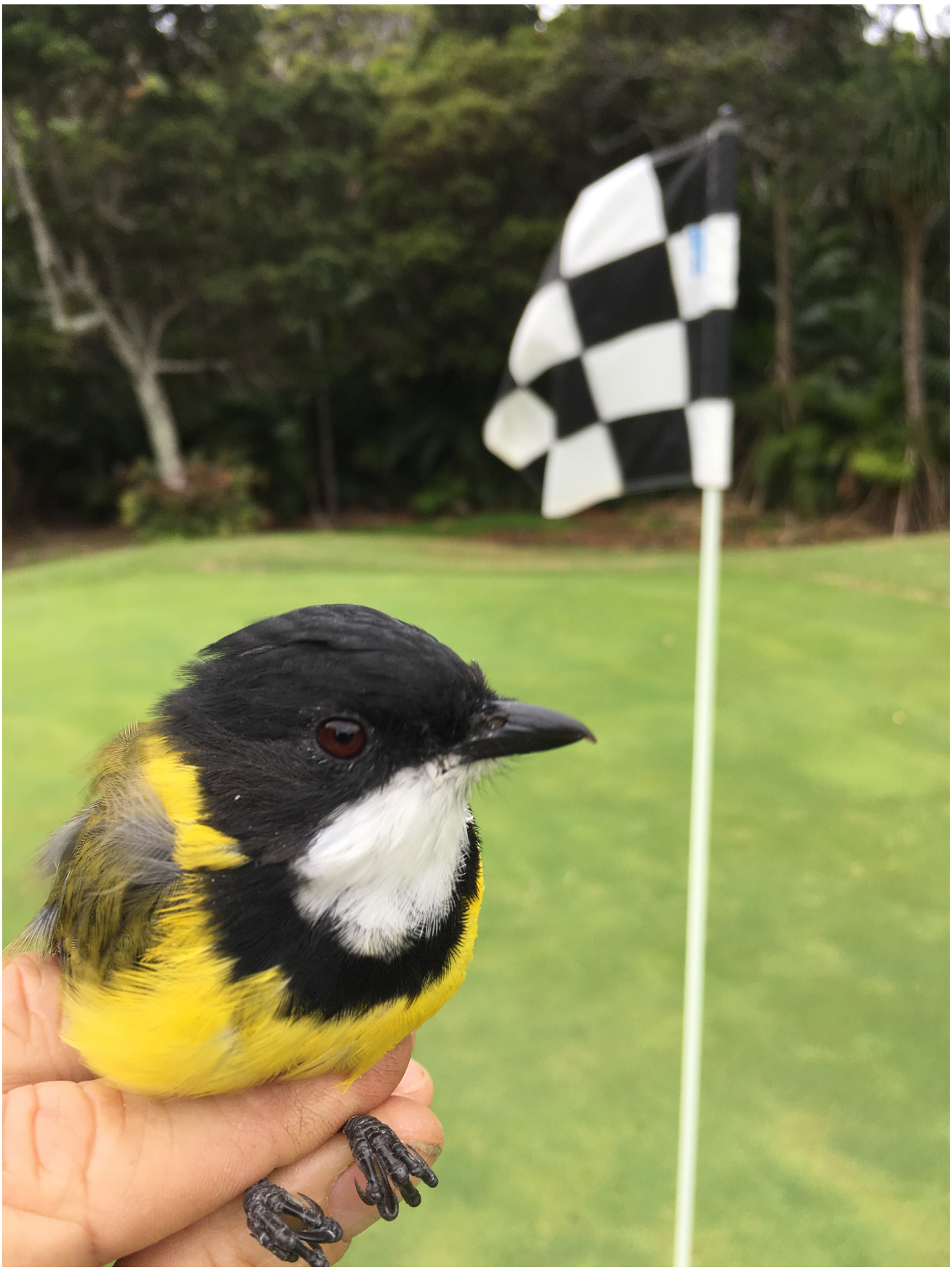

Figure 9. Lord Howe Golden Whistler, *Pachycephala pectoralis contempta* captured on Lord Howe Island Golf Course.

Table 5. Details of bird specimens that were blood sampled and released on Lord Howe Island in March 2017. Map datum WGS84, precision ±10 m; specimens in Australian Museum, Sydney with collection registration numbers (Reg. no.) and EBU tissue numbers (EBU).

Reg. no.	EBU	Common name	Scientific name	Date captured	Tissue type	Latitude	Longitude
O.76662	95187	Emerald Dove	*Chalcophaps indica*	13/3/2017	Blood spot	-31.52389	159.06713
O.76693	95218	Emerald Dove	*Chalcophaps indica*	18/3/2017	Blood spot	-31.51392	159.05116
O.76694	95219	Emerald Dove	*Chalcophaps indica*	18/3/2017	Blood spot	-31.52204	159.05845
O.76661	95186	Buff-banded Rail	*Gallirallus philippensis*	13/3/2017	Blood spot	-31.52390	159.06713
O.76692	95217	Buff-banded Rail	*Gallirallus philippensis*	17/3/2017	Blood spot	-31.52577	159.06742
O.76855		Sacred Kingfisher	*Todiramphus sanctus*	21/3/2017	Feather	-31.52551	159.06678
O.76650	95175	Golden Whistler	*Pachycephala pectoralis contempta*	12/3/2017	Blood spot	-31.52341	159.06675
O.76660	95185	Golden Whistler	*Pachycephala pectoralis contempta*	12/3/2017	Blood spot	-31.52389	159.06713
O.76663	95188	Golden Whistler	*Pachycephala pectoralis contempta*	13/3/2017	Blood spot	-31.52389	159.06713
O.76664	95189	Golden Whistler	*Pachycephala pectoralis contempta*	13/3/2017	Blood spot	-31.52389	159.06713
O.76665	95190	Golden Whistler	*Pachycephala pectoralis contempta*	13/3/2017	Blood spot	-31.52389	159.06713
O.76668	95193	Golden Whistler	*Pachycephala pectoralis contempta*	14/3/2017	Blood spot	-31.52310	159.06614
O.76672	95197	Golden Whistler	*Pachycephala pectoralis contempta*	15/3/2017	Blood spot	-31.52310	159.06614
O.76680	95205	Golden Whistler	*Pachycephala pectoralis contempta*	16/3/2017	Blood spot	-31.52577	159.06742
O.76682	95207	Golden Whistler	*Pachycephala pectoralis contempta*	16/3/2017	Blood spot	-31.52577	159.06742
O.76685	95210	Golden Whistler	*Pachycephala pectoralis contempta*	17/3/2017	Blood spot	-31.54712	159.07820
O.76671	95196	Golden Whistler	*Pachycephala pectoralis contempta*	15/3/2017	Feather, body[a]	-31.52310	159.06614
O.76686	95211	Golden Whistler	*Pachycephala pectoralis contempta*	17/3/2017	Feather	-31.54712	159.07820
O.76688	95213	Golden Whistler	*Pachycephala pectoralis contempta*	17/3/2017	Feather	-31.54712	159.07820
O.76689	95214	Golden Whistler	*Pachycephala pectoralis contempta*	17/3/2017	Feather	-31.54712	159.07820
O.76690	95215	Golden Whistler	*Pachycephala pectoralis contempta*	17/3/2017	Feather	-31.54712	159.07820
O.76651	95176	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52341	159.06675
O.76652	95177	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52341	159.06675
O.76653	95178	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52341	159.06675
O.76654	95179	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52341	159.06675
O.76655	95180	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52341	159.06675
O.76656	95181	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52341	159.06675
O.76657	95182	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52341	159.06675
O.76658	95183	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52389	159.06713
O.76659	95184	Silvereye	*Zosterops lateralis tephropleurus*	12/3/2017	Blood spot	-31.52389	159.06713
O.76670	95195	Silvereye	*Zosterops lateralis tephropleurus*	15/3/2017	Blood spot	-31.52310	159.06614
O.76673	95198	Silvereye	*Zosterops lateralis tephropleurus*	15/3/2017	Feather	-31.52310	159.06614
O.76674	95199	Silvereye	*Zosterops lateralis tephropleurus*	15/3/2017	Feather	-31.52310	159.06614
O.76675	95200	Silvereye	*Zosterops lateralis tephropleurus*	15/3/2017	Feather	-31.52310	159.06614
O.76676	95201	Silvereye	*Zosterops lateralis tephropleurus*	15/3/2017	Feather	-31.52310	159.06614
O.76677	95202	Silvereye	*Zosterops lateralis tephropleurus*	15/3/2017	Feather	-31.52310	159.06614
O.76678	95203	Silvereye	*Zosterops lateralis tephropleurus*	15/3/2017	Feather	-31.52310	159.06614
O.76681	95206	Silvereye	*Zosterops lateralis tephropleurus*	16/3/2017	Feather	-31.52577	159.06742
O.76683	95208	Silvereye	*Zosterops lateralis tephropleurus*	16/3/2017	Feather	-31.52577	159.06742
O.76684	95209	Silvereye	*Zosterops lateralis tephropleurus*	16/3/2017	Feather	-31.52577	159.06742
O.76691	95216	Silvereye	*Zosterops lateralis tephropleurus*	17/3/2017	Feather	-31.54712	159.07820
O.76666	95191	Pied Currawong	*Strepera graculina crissalis*	13/3/2017	Blood spot	-31.52389	159.06713
O.76667	95192	Common Blackbird	*Turdus merula*	13/3/2017	Blood spot	-31.52389	159.06713
O.76669	95194	Common Blackbird	*Turdus merula*	15/3/2017	Blood spot	-31.52310	159.06614
O.76679	95204	Common Blackbird	*Turdus merula*	15/3/2017	Blood spot	-31.52310	159.06614
O.76687	95212	Common Blackbird	*Turdus merula*	17/3/2017	Blood spot	-31.54712	159.07820

[a] Depredated by Lord Howe Pied Currawong in mistnet; body yet to be prepared.

Figure 10. Lord Howe Pied Currawong, *Strepera graculina crissalis* captured in Stevens Reserve, being held by Australian Museum staff member Richard Major.

Table 6. Summary of morphometrics of bird specimens that were DNA sampled and released on Lord Howe Island in March 2017. Emerald Dove *(Chalcophaps indica)*, Buff-banded Rail *(Gallirallus philippensis),* Golden Whistler *(Pachycephala pectoralis contempta),* Silvereye *(Zosterops lateralis tephropleurus),* and Common Blackbird *(Turdus merula).*

Common name	n	Mass (g) mean ± (sd)	Wing (mm) mean ± (sd)	Tail (mm) mean ± (sd)	Head (mm) mean ± (sd)	Bill (mm) mean ± (sd)	Tarsus (mm) mean ± (sd)
Emerald Dove	2	167.50 ± (34.65)	149.75 ± (4.24)	95.00 ± (4.24)	45.35 ± (0.57)	13.63 ± (0.30)	29.14 ± (1.32)
Buff-banded Rail	2	225.75 ± (34.29)	132 ± (—)	—	64.01 ± (4.89)	24.49 ± (3.31)	41.54 ± (0.49)
Golden Whistler	14	28.12 ± (0.97)	90.32 ± (1.99)	74.46 ± (1.99)	41.18 ± (0.46)	11.71 ± (0.26)	23.55 ± (0.43)
Silvereye	20	12.21 ± (0.65)	61.28 ± (1.82)	46.42 ± (1.82)	31.28 ± (0.68)	12.12 ± (0.49)	19.15 ± (0.66)
Common Blackbird	5	95.40 ± (4.29)	122.20 ± (3.01)	104.10 ± (3.01)	52.39 ± (1.97)	19.02 ± (0.92)	33.40 ± (1.19)

Table 7. List of species retrieved from the Lord Howe Island Board freezer, with numbers of each species.

Common name	Scientific name	Number
Feral Pigeon	*Columba livia*	1
Flesh-footed Shearwater	*Ardenna carneipes*	5
Providence Petrel	*Pterodroma solandri*	1
White-faced Heron	*Egretta novaehollandiae*	1
Purple Swamphen	*Porphyrio porphyrio*	1
Buff-banded Rail	*Hypotaenidia philippensis*	1
Lord Howe Woodhen	*Hypotaenidia sylvestris*	27
Bar-tailed Godwit	*Limosa lapponica*	1
Sooty Tern	*Onychoprion fuscata*	4
Masked Owl	*Tyto novaehollandiae*	3
Song Thrush	*Turdus philomelos*	1
Lord Howe Pied Currawong	*Strepera graculina crissalis*	1

Microbats

Microbat captures and morphology. *Vespadelus darlingtoni* appeared to be common around the Settlement on Lord Howe Island and multiple individuals (up to 5 simultaneously) were regularly observed at dusk and especially dawn. A total of 15 *V. darlingtoni* were captured over 11 nights trapping. Four were retained as whole specimens (M.48731–734), while 11 had wing punches taken before being released (Table 8). Five individuals were captured more than once during the trapping period bringing the total number of captures to 20. Two males and a female, captured near the Research Station and in Stevens Reserve, had been banded 3–6 years earlier by researcher Glenn Hoye (pers. comm.). One of these males had been banded in Stevens Reserve on 5 February 2015 and the other at the Research Station on 9 November 2015. The female was originally banded at the Research Station on 30 December 2011 (Table 8).

Our limited sampling suggests that male and female Lord Howe Island *V. darlingtoni* differ in body size (Table 8). Comparisons of the morphology of the Lord Howe Island population with published morphological data for mainland Australian *V. darlingtoni* populations is difficult as sexes are not separated, nor are sampling localities indicated in most data sets (e.g., Kitchener *et al.*, 1987; Law *et al.*, 2002; Churchill 2008). However, based on our own analyses, Lord Howe Island *V. darlingtoni* appear to have a smaller body size than NSW mainland populations, although our sample of males from the Island is limited. Morphological comparisons are restricted to males, for which species identification is confirmed by penile morphology. Mean forearm length for nine males from Lord Howe Island (33.25 mm, sd = 0.52, range 32.60–34.00) is smaller compared to 25 male voucher specimens from NSW north of Sydney (mean = 35.63, sd = 0.84, range 34.40–37.00) and 17 male specimens from NSW localities south of Sydney (mean = 34.54, sd = 0.62, range 33.50–35.50. See Table 8 and Appendix 1 for list of specimens examined.

Microbat call survey. *Vespadelus darlingtoni* was the only species detected and there was no clear evidence for the presence of additional species. Several incomplete call sequences around 25 Khz were most likely partial recordings of social calls of *V. darlingtoni*. Total bat call files recorded per site per night varied from one instance of zero, to 566 call files. Mean number of bat call files per night averaged across all nights and sites was 179.5 using the broader filter scan 2 and 159.0 using a the more restrictive file filter scan 3 (Table 9). This is remarkably close to levels of activity of 180 recorded on the Island during 2016 (Hoye, 2016) for sites at forest edges, which is where the majority of sites were located in this study. The average characteristic call frequencies varied from 44–46 Khz. This is closer to frequencies of 43–48 Khz reported for southeastern Queensland populations of *V. darlingtoni*, is at the upper limit of 41–44 Khz reported from northeastern NSW, but higher than the 38–43 kHz reported from southern NSW (Law *et al*., 2002). Law *et al*. (2002) reported a characteristic frequency of 44 Khz for Lord Howe Island populations of *V. darlingtoni* and placed them with those of northeastern NSW. Our results indicate that the Lord Howe Island bats overlap in characteristic call frequency with both northern New South Wales and southern Queensland. More widespread sampling throughout the species range appears to be required to clarify geographic variation in call characteristics.

Microbat genetic analysis. A 307 bp fragment of cytb was amplified from all individuals. The ML tree with the highest log likelihood (-630.5907) is illustrated (Fig. 11), with the percentage of trees in which the associated taxa clustered together shown next to the branches. Mainland NSW *V. darlingtoni* formed two monophyletic lineages distributed north and south of the Sydney Basin (Fig. 11). The two examined Lord Howe Island *V. darlingtoni* specimens had identical cytb haplotypes which were more similar to northern NSW specimens (average 1.2% divergence) than southern NSW specimens (average 2.3% divergence). The northern and southern mainland NSW samples differed by an average of 2.2%, while overall *V. darlingtoni* differed from the distantly related (Adams *et al*., 1987) *V. finlaysoni* by an average of 10.9% sequence divergence. 658 bp was also amplified for COI from six individuals, and while the pattern of divergence amongst samples was similar to that found for cytb, the levels of divergence where somewhat lower (data not shown). The presence of two mtDNA lineages of *V. darlingtoni* from NSW is significant since the only other molecular study of *Vespadelu*s, the electrophoretic study of Adams *et al*. (1987), did not include NSW samples from south of Sydney.

Table 8. Details of *Vespadelus darlingtoni* captured on Lord Howe Island in March 2017. Map datum WGS84, precision ±10 m.

Registration number	EBU (tissue)	Sex	Age	Mass (g)	Forearm (mm)	Date captured	Latitude	Longitude	Alt. (m)	Banded
M.48731	83445	F	Sub-adult	5.0	34.12	13/03/2017	-31.52389	159.06606	14	
M.48732	83446	F	Sub-adult	5.0	34.60	14/03/2017	-31.52589	159.06758	13	
NA (released)	83448	F	Adult	5.0	34.03	14/03/2017	-31.52589	159.06758	13	
NA (released)	83451	F	Adult	6.5	33.60	14/03/2017	-31.52389	159.06606	14	30/12/2011
NA (released)	83453	F	Adult	5.5	34.43	16/03/2017	-31.52614	159.06736	10	
NA (released)	83455	F	Sub-adult	4.0	34.20	20/03/2017	-31.52614	159.06736	10	
NA (released)	83459	F	Adult	5.5	33.80	22/03/2017	-31.52589	159.06758	13	
NA (released)	83460	F	Adult	4.0	34.20	22/03/2017	-31.52589	159.06758	13	
Mean (n = 8)				**5.1**	**34.04**					
NA (released)	83447	M	Adult	6.0	—	13/03/2017	-31.52389	159.06606	14	09/11/2015
M.48733	83449	M	Adult	5.0	33.80	14/03/2017	-31.52364	159.06611	14	
M.48734	83450	M	Adult	4.6	33.60	15/03/2017	-31.52364	159.06611	14	
NA (released)	83452	M	Adult	6.0	34.00	15/03/2017	-31.52614	159.06736	10	
NA (released)	83454	M	Adult	5.5	33.10	16/03/2017	-31.52614	159.06736	10	05/02/2015
Mean (n = 5)				**5.4**	**33.63**					

Table 9. Number of sound files containing bat call sequences identified using file scan filters in *AnalookW* with broader parameters (Filter scan 2) or more restrictive parameters (Filter scan 3) for bat call recognition.

Site number	Date in March 2017	Detector number	Total number of sound files/night	Filter scan 2		Filter scan 3	
				Number call files/night	Mean call files/hr	Number call files/night	Mean call files/hr
1a	12	1	680	58	4.83	50	4.17
1a	13	1	2330	328	27.33	293	24.42
2a	14	1	567	67	5.58	57	4.75
2a	15	1	792	139	11.58	88	7.33
3a	16	1	319	198	16.5	191	15.92
3a	17	1	1618	105	8.75	97	8.08
3a	18	1	259	194	16.17	190	15.83
4a	19	1	433	222	18.5	220	18.33
4a	20	1	216	210	17.5	203	16.92
4a	21	1	235	226	18.83	220	18.33
4a	22	1	324	284	23.67	274	22.83
1b	12	2	532	50	4.17	50	4.17
1b	13	2	599	79	6.58	22	1.83
2b	14	2	1472	566	47.17	479	39.92
2b	15	2	1536	438	36.5	356	29.67
3b	16	2	350	90	7.5	87	7.25
3b	17	2	2762	16	1.33	15	1.25
3b	18	2	878	140	11.67	129	10.75
3b	19	2	12	1	0.08	0	0
			15914	**179.53**	**14.96**	**159.00**	**13.25**

Our preliminary genetic study has shown that the Lord Howe Island population clusters within mainland NSW populations of *V. darlingtoni* as currently circumscribed. In addition, the Lord Howe Island population appears more similar both genetically (Fig. 11) and in call frequency to northern NSW populations than those from southern NSW (Law *et al*., 2002). However, based on our limited data, Lord Howe Island individuals appear smaller than the NSW mainland population. These interesting but complex patterns of variation in genetics, calls and morphology across the range of *V. darlingtoni* require a more detailed and comprehensive study of individuals from throughout the species distribution.

It would also be of interest to further investigate the historical population dynamics of *V. darlingtoni* on Lord Howe Island by comparing the morphology and population genetics of specimens collected before and after the period of 1956-1975, during which they were not detected on the Island. Additional trapping and acoustic surveys for microbats on Lord Howe Island would also be useful to improve the chances of detecting vagrant microbat species, and so increase our understanding of the frequency and nature of microbat dispersal from Australia, and elsewhere, to the islands of the Southwest Pacific.

Rodents

A total of 38 *M. musculus* specimens (M.48747-84) collected from the Lord Howe Island nursery, and 10 *R. rattus* specimens (M.48736-46) from around the Lord Howe Island golf course were donated by staff from the Lord Howe Island Board. A further two *R. rattus* specimens (M.48735, M.48785) were collected opportunistically by AMRI staff.

These samples will provide a scientifically valuable record of the genetic and morphological characteristics of the pre-eradication rodent population of Lord Howe Island. They will also enable the origin of any rodents discovered on the Island post-eradication to be genetically identified as either new immigrants or members of the original population that had survived the eradication attempt (e.g., Abdelkrim *et al*., 2007). In addition, introduced populations of *R. rattus* and *M. musculus* are of increasing scientific and historic interest. Both species have been widely introduced around the world, including to many islands, with serious impacts on biodiversity, agriculture and human health (Howald *et al.*, 2007; Varnham, 2010; Aplin *et al*., 2011). They are also both highly genetically divergent across their natural ranges, and introduced populations often have complex histories, diverse genetic/geographic origins and are the subject of ongoing studies (Searle *et al*., 2009; Aplin *et al*., 2011; Bonhomme *et al*., 2011). Establishing via genetic studies the origins of Lord Howe Island's introduced *M. musculus* and *R. rattus* populations would be of both historical and biological interest.

Beaked Whales

All three *M. densirostris* skeletons were successfully recovered from the burial pit, cleaned at the Research Station, and returned to the Australian Museum for addition to the mammal collection. Examination of skull morphology indicated that the largest individual and one of the smaller were females, but the other smaller individual was an immature male with the enlarged single pair of teeth characteristic of males (i.e. tusks) present in the lower jaw but not yet fully erupted (Fig. 12). The successful PCR amplification of the sex-testing genes (Fig. 7) identified M.43481 and M.43482 as females (one band) and M.43483 as a male (2 bands). This allowed the tissues collected at the time of stranding to be matched to the individual skeletons

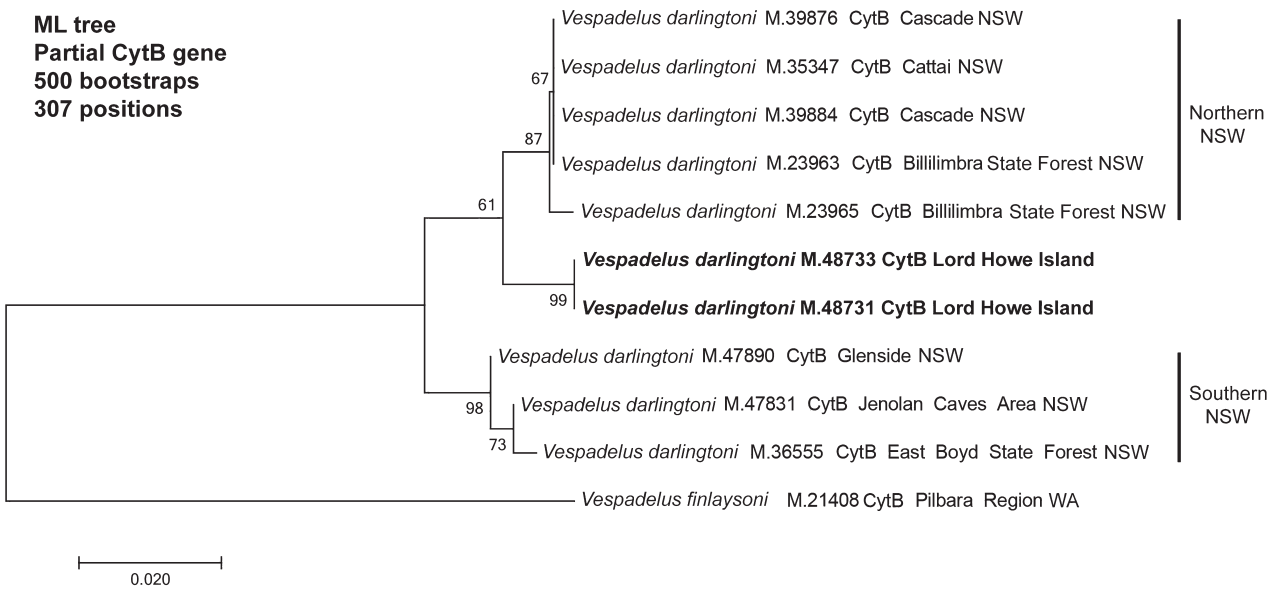

Figure 11. Maximum Likelihood tree showing relationships amongst the 11 sampled *Vespadelu*s cytb haplotypes.

exhumed and confirmed the sexes of the specimens based on skull morphology. Thus M.43482 was an adult female (4.60 m), M.43481 was a sub-adult female (4.45 m) and M.43483 a sub-adult male (4.30 m). Although most skeletal elements from the three whales were still in good condition, the majority of the distal digit bones had decomposed and many of the ribs and dorsal vertebral spinous processes had been broken. Similarly, the anterior tip of the rostrum and dentaries of each skull had some damage. Nevertheless, the three skeletons of this poorly known species are a valuable addition to the Australian Museum's marine mammal collection and will be useful for cetacean researchers worldwide.

The Australian Museum now holds five specimens of *M. densirostris* from Lord Howe Island and seven from scattered locations along the NSW mainland coast. The species has previously been reported to be more common around oceanic islands (MacLeod, 2014) and local fishermen indicated that small pods (up to 4 individuals) of this species were regularly sighted in the waters around the Island.

Figure 12. Damaged anterior right dentary of male Dense-beaked Whale, *Mesoplodon densirostris* (M.43483) showing enlarged but not fully erupted tusk. Bone surrounding the tusk has been eroded.

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Appendix 1. Australian Museum adult male Large Forest Bat, *Vespadelus darlingtoni* voucher specimens from Lord Howe Island, northeast (NE) and southeast (SE) New South Wales measured for morphological comparisons. Abbreviations: *NP,* National Park; *NR*, Nature Reserve; *SF,* State Forest.

Reg. no.	Location	Region
M.4740	Lord Howe Island	
M.8819	Lord Howe Island	
M.8820	Lord Howe Island	
M.21829	Lord Howe Island	
M.21830	Lord Howe Island	
M.26517	Curramore State Forest	NE
M.26524	Warra State Forest	NE
M.26571	Mount Boss State Forest	NE
M.26702	Washpool Forest Way	NE
M.26703	Washpool National Park, Gibraltar Range	NE
M.27272	Billilimbra State Forest, SW of Tabulam	NE
M.27273	Malara State Forest, SE of Tenterfield	NE
M.27275	Chichester State Forest	NE
M.27278	Enfield State Forest	NE
M.27278	Enfield State Forest	NE
M.27279	New England National Park	NE
M.27280	Northeastern NSW	NE
M.27281	Boorook State Forest	NE
M.27283	Bald Rock National Park	NE
M.27285	Bald Rock National Park	NE
M.27286	Wallaby Creek Rd, Upper Tooloom	NE
M.27287	Wallaby Creek Rd, Upper Tooloom	NE
M.27290	London Bridge State Forest	NE
M.27292	Oakwood State Forest	NE
M.27292	Oakwood State Forest	NE
M.27295	Brother State Forest	NE
M.27539	Boonoo State Forest	NE
M.27571	New England National Park	NE
M.27571	New England National Park	NE
M.28508	Hyland Nature Reserve	NE
M.7339	Red Hills State Forest, NE of Tumut	SE
M.12743	Mumbulla State Forest, N of Tathra	SE
M.12750	Mumbulla State Forest, N of Tathra	SE
M.13450	Jervis Bay Nature Reserve	SE
M.13451	Jervis Bay Nature Reserve	SE
M.13454	Jervis Bay Nature Reserve	SE
M.13455	Jervis Bay Nature Reserve	SE
M.14176	SW of Garrawarra Farm, Royal NP	SE
M.17765	Coolangubra Forest Way, W of Eden	SE
M.22167	Glenbog State Forest, NW of Eden	SE
M.22168	Tantawanglo Creek, Tantawanglo SF	SE
M.22171	Tantawanglo Creek, Tantawanglo SF	SE
M.33299	Tantawanglo Creek, Tantawanglo SF	SE
M.36555	East Boyd State Forest, near Eden	SE
M.36559	East Boyd State Forest, near Eden	SE
M.36560	East Boyd State Forest, near Eden	SE
M.47831	Jenolan Caves area	SE