Survey of Wood Mice (*Apodemus sylvaticus*) on the Isle of Rum

Report submitted to Scottish Natural Heritage by:

Dr Sheila Pankhurst, Department of Life Sciences, Anglia Ruskin University

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For further information about this report, please contact:

Dr Sheila Pankhurst
Department of Life Sciences
Faculty of Science and Technology
Anglia Ruskin University
East Road
CAMBRIDGE CB1 1PT

Email: sheila.pankhurst@anglia.ac.uk
Tel. 0845 196 2153 (direct line)

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Summary

Project title:

Survey of Wood Mice (*Apodemus sylvaticus*) on the Isle of Rum

Keywords:

Rum, Inner Hebrides, wood mice, *Apodemus sylvaticus*, rat predation

Background:

There is currently little knowledge of the wood mouse population on the Isle of Rum (Inner Hebrides). Informal monitoring suggests that the mice on the island are larger than their mainland conspecifics, and also that wood mice on Rum are found living at higher altitudes than on the mainland.

In 2009, SNH staff on Rum invited the Department of Life Sciences at Anglia Ruskin University to carry out a short survey of the wood mice on Rum, using live trapping to determine distribution and abundance. An important objective of this survey was to provide information about the likely consequences for the Rum wood mouse population of proposed rat control measures on the island.

Main findings:

1. Wood mice were found at all sites (n= 8) surveyed on Rum, from just above sea level to above 450m in the manx shearwater nesting colonies.

2. Wood mice were most abundant in areas of mature mixed woodland, but were also found in other habitats such as coniferous woodland and *Molinia*-dominated wet grasslands, and in areas where there has been no permanent human habitation for several decades.

3. Trap damage sustained during this survey indicates possible brown rat (*Rattus norvegicus*) predation of wood mice on Rum. The implications of this finding, in relation to proposed future rat control on Rum, are discussed.

4. Morphological data obtained during this study show that the wood mice on Rum are particularly large (a number of adult mice captured, of both sexes, had body weights of >30g). There was a significant difference in size between mice found around human habitation at low altitudes, and the (larger) mice living at high altitudes on Rum in the shearwater colonies.

5. Recommendations for further research into the wood mice on Rum are outlined.

1. Introduction

The island of Rum, part of the Inner Hebrides off the west coast of Scotland, was established as a National Nature Reserve (NNR) in 1957. The island has a rich and diverse flora, and is home to globally important seabird populations, but has an impoverished vertebrate fauna. Only four species of non-domesticated terrestrial mammal are found on Rum; these are the red deer (*Cervus elaphus*); the pygmy shrew (*Sorex minutus*); the brown rat (*Rattus norvegicus*), and the wood mouse or long-tailed field mouse (*Apodemus sylvaticus*)[1](Clutton-Brock & Ball, 1987). In addition, there are ponies, Highland cattle and feral goats on the island. Magnusson (1997) provides an account of the human and natural history of the island.

There is relatively little known about the present distribution and ecology of wood mice on Rum. It has been suggested that the mice on the island are larger than their mainland conspecifics (see Delany, 1964, 1970, and Delany and Healy, 1964), and also that wood mice on Rum are commonly found living at higher altitudes than on the mainland.

It is very likely that all of the terrestrial mammals presently found on Rum are the result of introductions. The present red deer population is known to be the result of deliberate re-introduction in the 19th century (Magnusson, 1997), whereas it is thought that the populations of small mammals on the island are the result of accidental introductions (Corbet, 1961; Yalden, 1982). Berry *et al.* (1967) suggest that wood mice came to Rum from the neighbouring island of Eigg, some 7 km to the south-east, and prior to this, probably from Scandinavia to the Hebridean islands after the last ice age, carried by Viking ships (Berry, 1985).

For a comprehensive review of information about the biology of the wood mouse, see Flowerdew & Tattersall (2008).

In addition to its status as a NNR, Rum is also designated as a Special Protection Area (SPA) for its seabird populations, and particularly its globally important manx shearwater (*Puffinus puffinus*) breeding colony. Predation of shearwater eggs and chicks by brown rats is of increasing concern, and has led to proposals for the controlled eradication of rats in an experimental area in the near future (at the time of writing, this work was scheduled to start in late 2010).

In 2009, SNH staff on Rum invited the Department of Life Sciences at Anglia Ruskin University to carry out a short survey of the wood mice on Rum, using live trapping to obtain data on distribution and abundance. A key objective of this survey was to increase current knowledge of the wood mouse population on the island, in order to facilitate mitigation of any adverse consequences for the Rum wood mice of rat control measures on the island. A secondary objective of the survey was to obtain preliminary data on the morphological characteristics of the Rum wood mice.

[1] Scientific names of species are given on first mention in the main text.

2. Objectives

1. To carry out a survey, using live trapping along trap lines (transects) and trap grids, to obtain data on the distribution and abundance of wood mice on Rum.
2. To compare the abundance of wood mice at low altitude, around the main area of human habitation on Rum (Kinloch village), with the abundance of this species at higher altitudes in the manx shearwater nesting colonies.
3. To obtain preliminary data on the morphological characteristics of the wood mice on Rum, and in particular to investigate whether the Rum mice are significantly larger than their conspecifics on the Scottish mainland.

Methods

3.1 Site selection

After discussion with SNH staff on the island, eight sites on Rum were selected for this survey, across a range of different habitats (see Table 1 and Figure 1). These sites included areas at low and high altitude, and also close to and away from current human habitation on Rum.

3.2 Survey methodology

Unless otherwise specified, trap setting and animal handling methodology for this survey followed standard small mammal live trapping procedures set out in the guide produced by the UK's The Mammal Society (Gurnell & Flowerdew, 2006).

The traps used in this study were standard Longworth traps. To avoid capture of pygmy shrews, all traps used in this survey had shrew holes of 12mm diameter in the side or back of the nest box portion of the trap (see photographs in Appendix B).

3.2.1 Trapping patterns and procedures

Two trap patterns were used for this survey. Firstly, 250m transects or trap lines were used to determine presence or absence of wood mice at different locations on Rum. Secondly, in areas where informal monitoring had indicated that wood mice were present, trap grids ($60m^2$) were set up to obtain data on population densities.

Site name (and reference)	**Transect (T) or grid (G) trapping**	**Grid reference***	**Altitude (m above sea level)**	**Topography and vegetation** (for a detailed account of the flora of Rum, see Pearman *et al.,* 2008).
Kinloch Glen plantation (G1)	Grid	NM394998	30-35	Tree plantation, predominantly pine *Pinus* and some birch *Betula*, merging into goat willow *Salix caprea* towards eastern edge of grid. Ground vegetation >40% purple moor grass *Molinia caerulea.* Ploughed ridge and furrow system (for tree planting); poorly drained, particularly in furrows.
Hallival (G2)	Grid	NM398969	410 - 455	Boulder and scree slope, interspersed with areas of *Molinia* grassland and some finer grasses. Sparse areas of heather (*Calluna* spp.) and sphagnum mosses, and also some ground flora more typical of calcareous areas (e.g. thyme)
Kinloch Castle woodlands (G3)	Grid	NM402995	3-5	Mature mixed woodland, including some atypical species planted in the 19th century; shrub layer of bramble, ground flora ferns and mosses.
Dibidil (T1)	Transect	NM395928	2-110	Transect from top of shore line (boulder beach) up through open grassland/heath. Predominantly wet *Molinia* grassland, with some bramble and finer grasses (fescues) around ruins (low walls) of old shielings.
Scresort (T2) shoreline/woodlands	Transect	NM413992	1- 75	Transect from top of shore line (boulders) up through mature mixed woodland onto *Molinia* grassland/open heath and wet heath, with *Calluna vulgaris* locally abundant.
Harris plantation (T3)	Transect	NM338962	70-80	Established woodland, predominantly alder *Alnus,* with some pine *Pinus,* birch *Betula* and mountain ash *Fraxinus.*
Harris heath/grass moorland (T4)	Transect	NM338957	20-85	Transect from valley floor up through heath/wet heath and *Molinia* grassland.
Kilmory woodland (T5)	Transect	NG362032	15-30	Mixed woodland, predominantly oak *Quercus,* birch *Betula* and alder *Alnus.* Some pine trees *Pinus.* Good ground flora cover and developing shrub layer.

*For trapping grids, the grid reference was recorded at trap point A1 on the grid; for transects, the grid reference refers to trap point 1.
**Altitude is given for the lowest point of each grid/transect i.e. at trap point A1 for grids, and trap point 1 for transects.

Table 1: Trapping site locations: grid references and site topography/vegetation

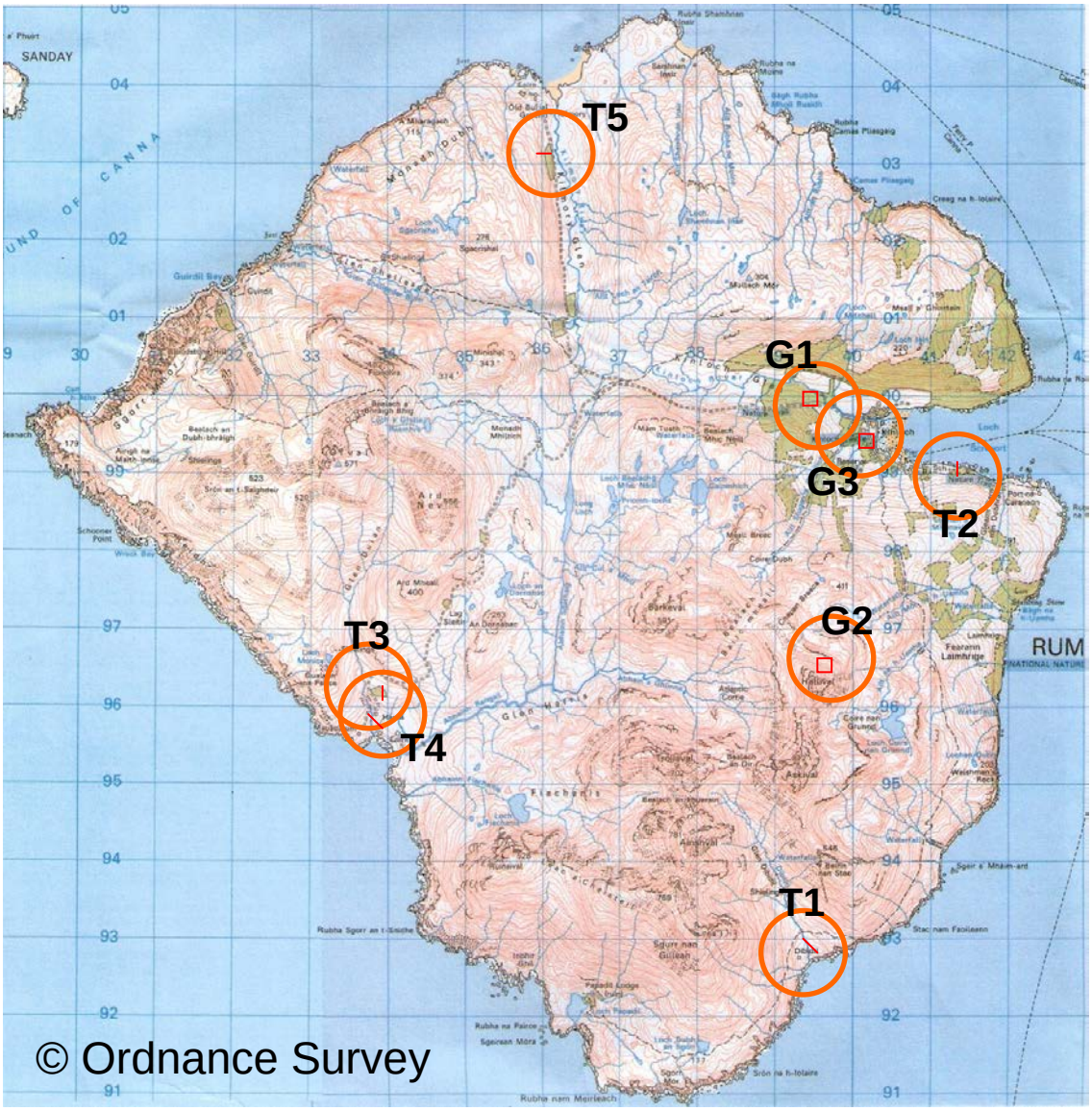

Figure 1: **Map of Rum (© Ordnance Survey) showing locations of trapping sites (G = grid, G1 - G3, and T = transect, T1 – T5).**

NOTE: The small boxes representing trapping grids, and lines representing transects, are indicative of location but are not drawn fully to scale. OS grid references for each site are provided in Table 1.

Table 2 provides details of the spacing and numbering of traps for both transects and grids (see also Table 3 for information about trapping intensity).

Trapping pattern	Number of trap points	Number of traps at each trap point	Distance between trap points	Total area/ length	Total number of traps
GRID (G)	36	2	10m	60m^2	72
TRANSECT (T)	25	2	10m	250m	50

Table 2: Spacing and numbering of traps in transects and grids

Figure 2 (below) provides a diagrammatic representation of the layout and numbering of trap points in trapping grids used in this survey.

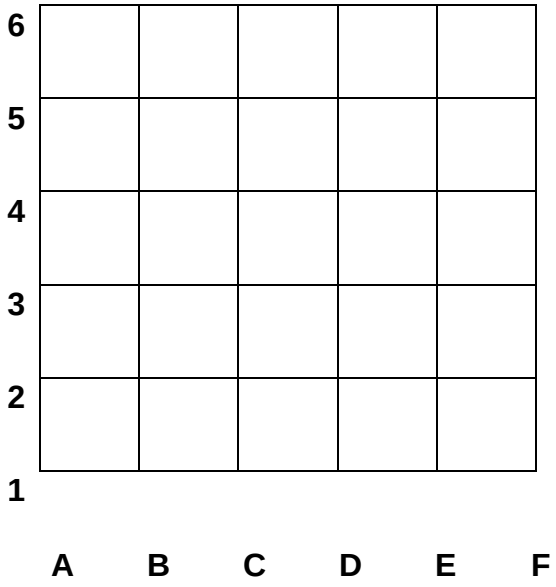

Figure 2: Diagram showing the layout and identification of trap points for trapping grids. Each line intersection on the grid indicates a trap point e.g. A1, B4, F5 etc. Traps were set at a total of 36 trap points (6 x 6 layout), with two traps at each trap point (72 traps per grid). Trap points were spaced at 10m apart, making the total area of the grid 60 x 60m.

Two Longworth traps were placed at each trap point, with the tunnel opening of each trap facing in a different direction. Traps were positioned, where possible, adjacent to logs or under shrubby vegetation, as recommended by Gurnell & Flowerdew (2006), to maximise capture success.

3.2 Field period and trapping intensity

This survey was carried out over a period of two weeks in mid-October 2009. In total, more than 60 'man days' of field work were carried out during this period, with a team of five experienced mammal ecologists supported by student volunteers from the Department of Life Sciences at Anglia Ruskin University.

A commonly used measure of trapping intensity is trap-nights; this is calculated as the number of traps used (per each transect or grid), multiplied by the number of nights for which they were set (Gurnell & Flowerdew, 2006).

Table 3 (below) summarises trap-nights for each of the eight sites surveyed on Rum (grid references for these sites are given in Table 1; see also Figure 1):

Site (and reference)	**Transect (T) or grid (G)**	**Number of traps set**	**Number of nights traps set**	**Total trap nights per site**
Kinloch Glen plantation (G1)	Grid	72	3	216
Hallival (G2)	Grid	72	3	216
Kinloch Castle woodlands (G3)	Grid	72	3	216
Dibidil (T1)	Transect	50	1	50
Scresort (T2) shoreline/woodlands	Transect	50	1	50
Harris plantation (T3)	Transect	50	1	50
Harris heath/grass open moorland (T4)	Transect	50	1	50
Kilmory woodland block (T5)	Transect	50	1	50
			Overall total of trap-nights =	**898**

Table 3: Summary of trap-nights per site, as a measure of trapping intensity.

Figure 3 shows the work plan for this survey. Grid trapping was carried out simultaneously in Kinloch Glen and at altitude on Hallival, in order to provide comparative data on abundance whilst controlling, as far as possible, for differences in day length, intensity of moonlight, climatic variables etc.

Date (Oct '09)	GRIDS			TRANSECTS				
	G1	G2	G3	T1	T2	T3	T4	T5
	Kinloch Glen plantation	Hallival	Kinloch Castle woodlands	Dibidil	Scresort	Harris woodland	Harris heath /grassland	Kilmory woodland
Fri 9th	Pre-survey planning, site selection							
Sat 10th	(set up)	(set up)						
Sun 11th								
Mon 12th								
Tues 13th				(set up)				
Weds 14th			(set up)					
Thurs 15th					(set up)			
Fri 16th								
Sat 17th								
Sun 18th						(set up)		
Mon 19th							(set up)	
Tues 20th								(set up)
Weds 21st								

Figure 3: Work plan and timetable for survey

3.2.2 Trap setting and provisioning

Traps were set in the hour before dusk, and left open overnight. The traps were then checked the following morning, as soon after dawn as possible. Throughout the survey, traps were baited with a small (15mm diameter) ball of equal parts oats and peanut butter. There was no pre-baiting period (this is of greater importance for surveying vole rather than mice populations; Gurnell & Flowerdew, 2006). Bedding was provided in all traps.

For the trap grids, where trapping took place over three consecutive nights, any wet bedding found during trap checks was removed, and the trap cleaned and dried before being replaced in position. Partially eaten bait balls were removed and replaced with fresh bait.

3.2.3 Animal handling and marking

For all trap captures of wood mice, the following data were recorded (see Appendix A for a sample data recording sheet):

- Weight, g, measured using a Pesola spring balance 0-50g, calibrated at 0.2g intervals
- Age (adult, juvenile) (juvenile mice can be recognised by their smaller body size and, often, a grey colouration to the pelage)
- Sex
- Head length, mm, measured in a straight line with callipers from tip of nose to base of back of skull (i.e. occipito-nasal length; see photographs in Appendix B)
- Left hind foot length, mm, including digits, measured in a straight line with callipers from base of calcaneus (heel bone) to the tip of the longest toe, but excluding the claw

Notes were made of other features, such as any injuries or the presence of ectoparasites. Captured mice were also examined for any evidence of breeding condition (e.g. well developed testes in males, or pronounced nipples in females), although mid-October is towards the end of the breeding season for this species in the wild in the UK (Flowerdew & Tattersall, 2008).

To obtain an estimate of the proportion of animals captured which were then subsequently re-captured on consecutive nights of trapping (grids only), all mice captured on the first and second night of trapping in grids were marked by fur-clipping before release (see Gurnell & Flowerdew, 2006; p. 19).
This is a non-invasive method of marking with no reported adverse welfare implications.

3.2.4 Scoring of damaged traps and escapes

On examination after a night of trapping, a small number of traps at some survey sites were found to have sustained damage by gnawing. These were scored as either mouse- damaged traps, or rat-damaged traps, or damaged (unknown).

In most cases, traps damaged by mouse gnawing still contained a live mouse. In a small number of cases, gnawing around the shrew hole or tunnel entrance flap had enlarged the hole to a size which would allow a mouse to escape. In these cases, the number of mice recorded as having been captured at that site includes any traps found empty but where there were clear signs that a mouse had occupied the trap (the trap door had been triggered, and any one of more of the following were found; the bait had been eaten, and/or mouse faeces were found inside the trap, and/or a nest had been made).

A number of traps, however, had sustained damage which appeared to be the result of rats attempting to gnaw into baited traps (see photographs in Appendix B). In these cases, marks from the incisors of the gnawing animal were too large to have been made by mice, and also appeared to be the result of gnawing from the outside, rather than the inside, of the trap. These traps were scored as rat-damaged.

Where there was any ambiguity about the likely cause of damage to a trap, this was scored as ‘damaged (unknown)’. For some trapping sites, particularly Harris, disturbance (but not necessarily damage) to traps was noted, presumably by deer, cattle or goats displacing traps.

For the grids, where trapping took place over three consecutive nights, damaged traps were removed from trap points and replaced with new traps for subsequent trapping nights.

Traps which had been triggered (i.e. the trap door was found closed after a trapping night) but which did not contain a mouse, nor any evidence of mouse occupancy, were not included in the data on number of mice caught. These traps were carefully tested before re-use.

3.3 Welfare considerations

The weather on Rum is often inclement, and October 2009 was no exception. To minimise any adverse effects of wet or cold weather on live captured mice, the following precautions were taken:

- Care was taken to position all traps in such a way that any water which found its way into the trap would run downhill and drain out through the tunnel entrance, rather than accumulate in the bedding chamber.

- Two types of bedding were provided in the nest chamber of each trap, with hay above a layer of non-absorbent cotton wool (to provide additional insulation).

A small bottle of ether, together with cotton wool, were carried with other field survey equipment, in case of any need for humane euthanasia of mice (e.g. in the case of an animal injuring itself attempting to escape from a trap).

3.4 Health and safety

All normal health and safety precautions were taken during this survey (following Gurnell & Flowerdew 2006; see pp. 11-12), with a full risk assessment completed prior to the start of work in the field. Due to the rugged terrain on Rum, and remoteness of much of the island, members of the survey team worked in groups of no fewer than two whilst out in the field. Each group carried a satellite phone and full first aid kit, in addition to adequate warm clothing and wet weather gear. An updated work plan was filed with the SNH office on the island before each stage of the study.

3.5 Data collection and analysis

Data on mice captured during the study were recorded initially onto check sheets out in the field. These data were then transferred onto an Excel spreadsheet, for analysis using both Excel and the statistical software package SPSS (version 16.00). All data were tested for normality prior to analysis, via a visual assessment of histograms for skewness. Non-parametric statistical tests were used for analysis where data were not normally distributed, and/or where sample sizes were too small to employ parametric tests.

Two-tailed tests were used throughout to provide levels of significance, with rejection of the null hypothesis at $p > 0.05$.

Results

4.1 Distribution and abundance of wood mice on Rum

Wood mice were found at all eight sites surveyed on Rum, at altitudes ranging from 2m above sea level (just above the top of the shore line) to 445m on Hallival.

Table 4, and Figures 4 and 5, provide summaries of the number of mice captured at each site.

Site and trapping plan (G = grid, T= transect)	**Total number of mice captured at site** (includes empty traps with clear signs of occupancy/escape; scores for these empty traps are indicated in parentheses)	**Number of trap nights**	**Number of captures per trap night (= trapping intensity)**
Kinloch Glen plantation (G1)	14	216	0.07
Hallival (G2)	8 (1)	216	0.04
Kinloch Castle woodlands (G3)	23 (4)	216	0.11
Dibidil (T1)	7 (1)	50	0.14
Scresort (T2) shoreline/woodlands	12 (1)	50	0.24
Harris plantation (T3)	3 (1)	50	0.06
Harris heath/grass open moorland (T4)	3	50	0.06
Kilmory woodland block (T5)	6 (1)	50	0.12
TOTAL	**76 (9)**	**898**	**0.085**

NOTE: *Sites with trapping grids were sampled over three consecutive nights; trap lines or transects were sampled for one night only.*

Table 4: Total number of mice captured at each survey site on Rum.

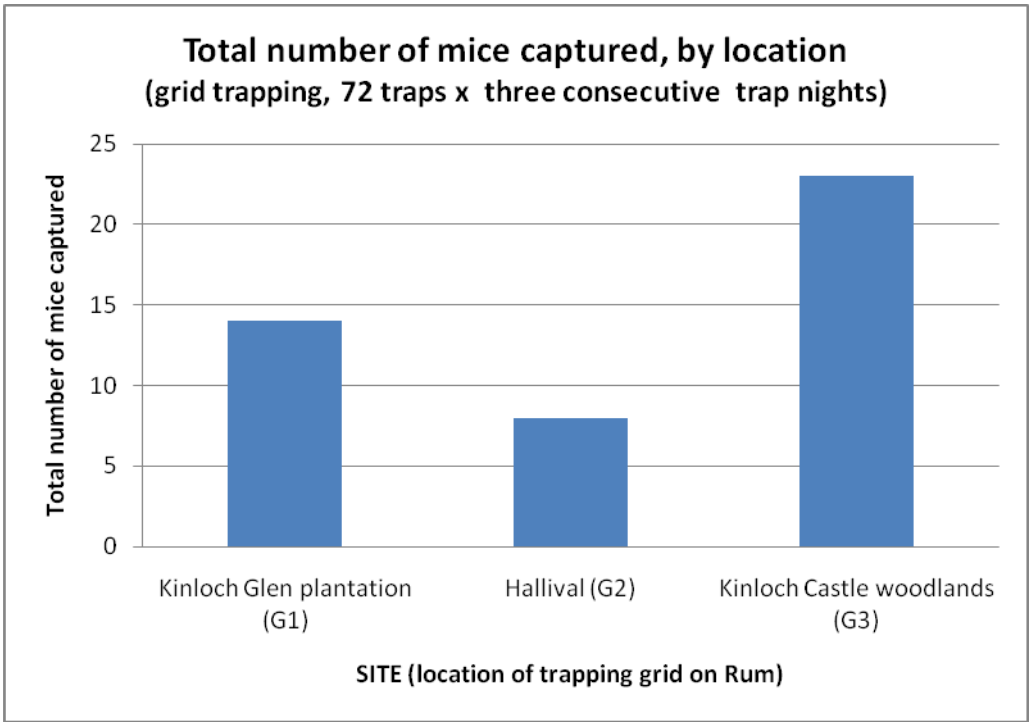

Figure 4: Total number of mice captured, by site, for trap grids

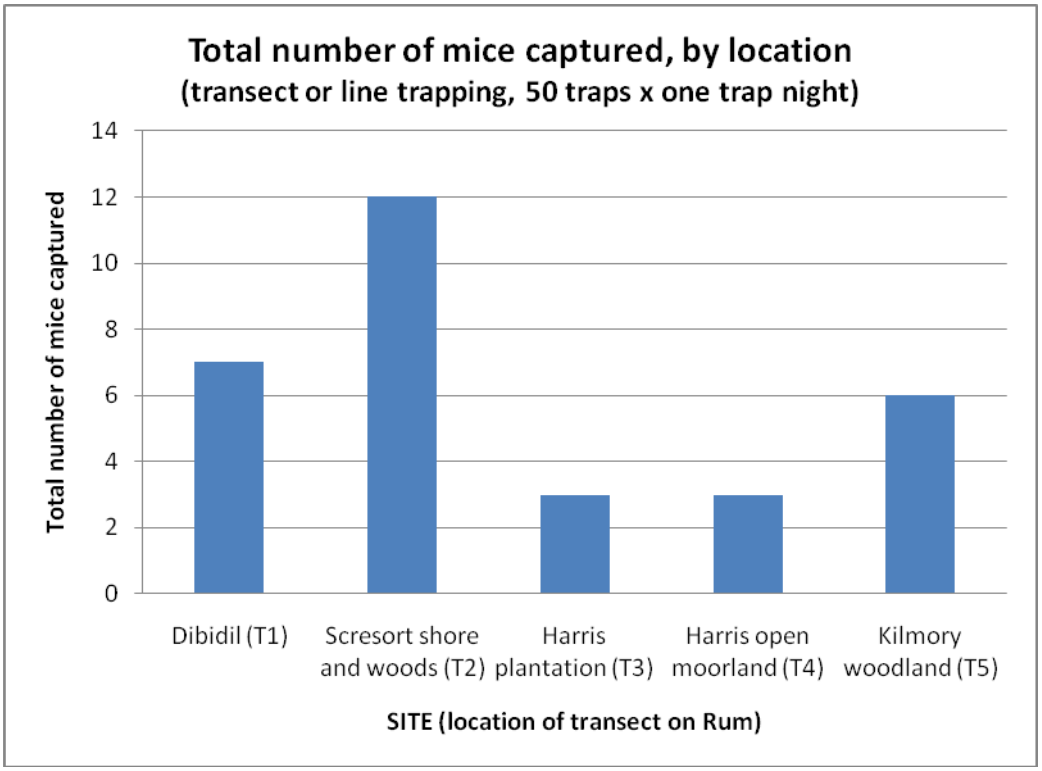

Figure 5: Total number of mice captured, by site, for trap lines (transects)

Table 4 also shows the number of captures per trap night, as does Figure 6.

This provides a rough and ready measure of mice abundance at each site, and is calculated by dividing the number of animals captured by the number of trap nights (Gurnell & Flowerdew, 2006, p. 25). The lower the number of captures per trap night, the lower the trapping success at that site. Figure 6 shows that trapping success was highest along the Scresort transect, indicating a greater abundance of mice in this area.

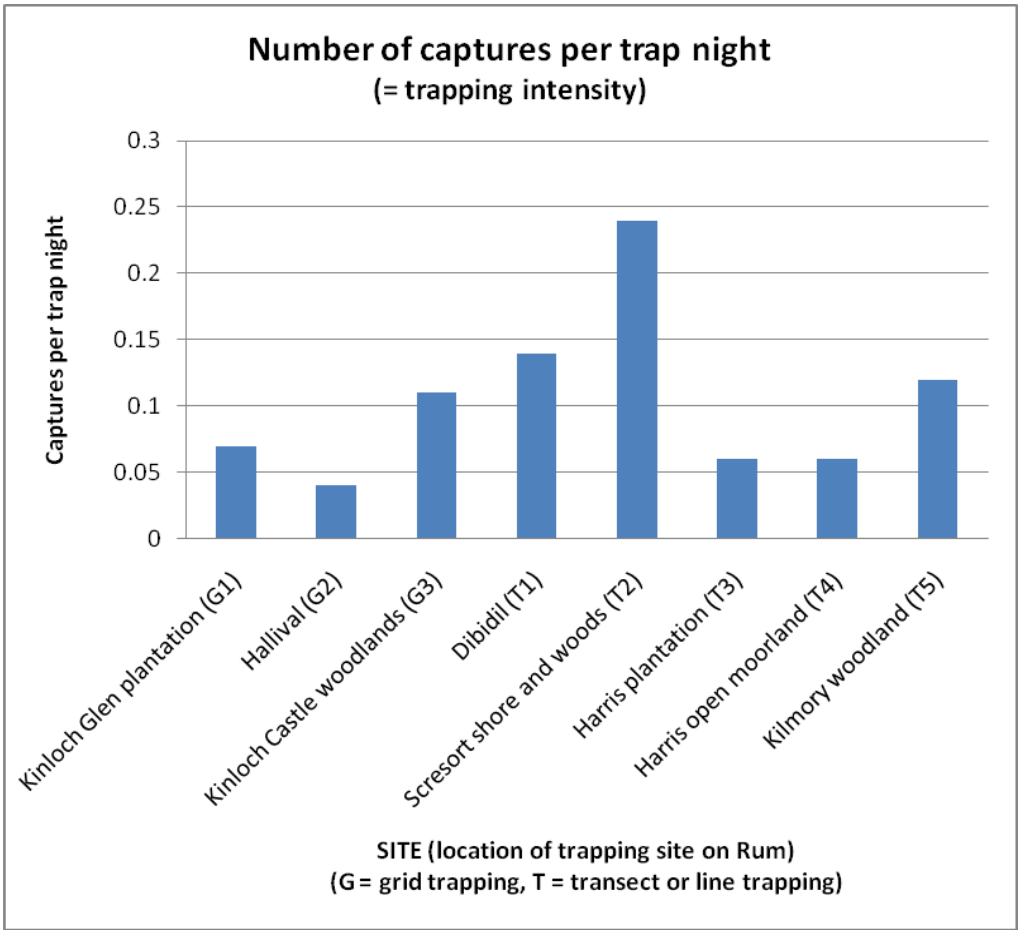

Figure 6: Number of captures of mice per trap night, by trapping site.

4.1.1 Habitat preferences

Whilst mice were found at all sites surveyed on Rum, there was some evidence of habitat preferences along transects where these passed through different vegetation types.

All mice (n=12) captured on the Scresort transect (T2) were found only in the mature mixed woodland habitat; no mice were captured in traps set at the top of the rocky shore or above the woodland in the open heath and *Molinia* grassland (Fisher's exact test, p = 0.0026).

There is no woodland at Dibidil. The transect at this site ran from the top of the rocky shore up the valley slope through wet *Molinia* grassland, passing through areas with finer grasses and some shrubby plants such as bramble, growing among the ruins of the walls of the abandoned shielings. Of the mice captured along this transect (n = 8), there was a significantly higher capture rate (n = 4) for traps set in the areas of finer grasses, herbs and low shrubs around the low ruins of the shielings (Fisher's exact test, mice, p = 0.014). Nevertheless, mice were also captured at Dibidil just above the shore (n=1) and in areas of *Molinia* grassland (n = 3).

At Harris, however, equal numbers of mice were captured in the established woodland block (n=3) and along a transect away from the woodland, running through heath and open *Molinia* grassland (n=3).

4.1.2 Change in trapping success over time

For the grids used in this survey, there was a significant increase in the number of mice caught with the number of consecutive nights that traps were set (Fisher's exact test, p = 0.0068; Table 5, Figure 7).

Table 5 also provides information on the re-capture of marked animals (grids only) on subsequent trapping nights.

Site (grid trapping only)	**No. of mice caught 1st night**	**No. of mice caught 2nd night**	**No. of mice caught 3rd night**
	Numbers in parentheses indicate re-captures (i.e. mice which had been captured, marked and released after a previous night's trapping). These re-captures are included in the overall totals given for each location/night.		
Kinloch Glen plantation (G1)	3	4	7 (1)
Hallival (G2)	2	2	4 (1)
Kinloch Castle woodlands (G3)	7	8 (1)	8 (5)

Table 5: Trapping success by consecutive night, for grid traps.

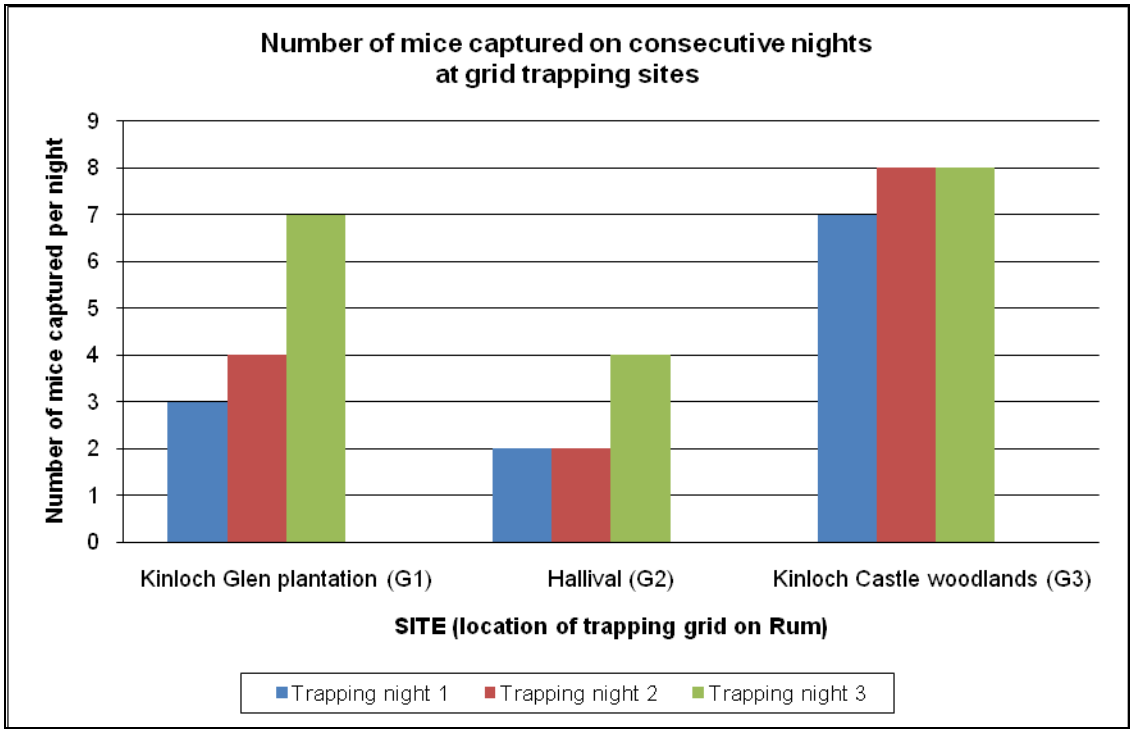

Figure 7: Trapping success on consecutive nights of trapping (grid trapping only), at three sites on Rum. The totals shown include re-captured marked animals (see Table 5).

4.1.3 Sex, age classes and reproductive condition of captured mice

For sex and age classes, data were pooled for all sites, as numbers caught at each site were too low for meaningful analysis. An apparent sex bias in the mice captured (25♀:42♂) was not significant ($\chi^2 = 3.05$, $p = 0.88$). None of the mice captured were scored as being in breeding condition, and the number of mice caught which were recorded as juveniles was low (n = 7).

4.2 Morphological data

Mean weights for all mice captured during this survey were 24.50g (±5.95) for female mice, and 24.95g (±4.21) for male mice. These data include weights for mice recorded as juveniles (all mice recorded as juveniles in this survey had a body weight of <20g).

For adult mice only, the mean weight of adult female mice was 24.75 (±5.96), and the mean weight of adult male mice was 25.79g (±3.79) (Figure 8).

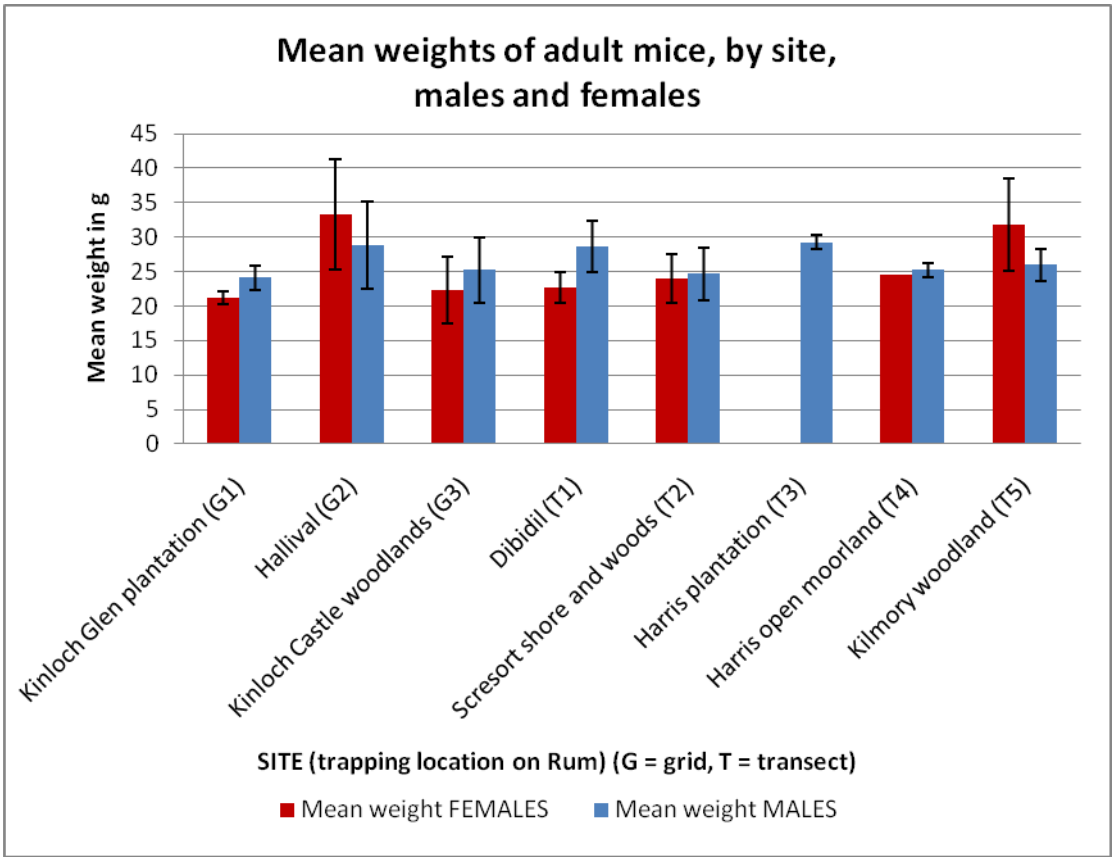

Figure 8: Mean weights of adult mice, by sex and by site (bars show mean weights and vertical lines indicate standard deviation).

The heaviest mouse captured during this survey was an adult female mouse (not obviously pregnant) trapped on Hallival (site reference G2). This individual weighed 41.00g. The heaviest male mouse weighed 33.00g; two mice of this weight were captured, one on Hallival and one at Dibidil.

There was no significant difference overall, however, between the weights of male and female mice, either for all age classes combined (adults and juveniles) (Mann-Whitney U test, U = 398.5, p = 0.26, NS), or for adult mice only (Mann-Whitney U test, U = 289.0, p = 0.071, NS). Looking at the eight survey sites, and taking data for all mice captured (adults and juveniles), there was a significant difference between trapping sites in body weight (Kruskall Wallis, χ^2 =18.05, df = 7, p = 0.012). This difference between sites in body weight of the mice remained significant when juveniles were removed from the dataset (Kruskall Wallis, χ^2 =14.63, df = 7, p = 0.041).

A comparison of data for mice captured at lower altitudes around Kinloch village (data from grids G1 and G3), and mice captured at higher altitudes on Hallival (data from grid G2) showed a significant difference in body weights between the 'village' and the Hallival mice (Mann-Whitney U test, U = 31, p = 0.007), although it should be noted that the sample size for the Hallival grid was small (n = 8).

This weight comparison remained significant when adult mice only were considered (i.e. juvenile mice were removed from the dataset) (Mann-Whitney U test, U = 31, p = 0.02).

Mean values, by site and by sex, for other morphological measures are summarised in Table 6 (data in this table are for adult mice only). There was a significant difference between survey sites in foot length of adult mice (Kruskall Wallis, χ^2 =14.57, df = 7, p = 0.042) and in head length of adult mice (Kruskall Wallis, χ^2 = 23.64, df = 7, p = 0.001), although it should be noted that sample sizes for some survey sites were very small (e.g. n = 3 for the Harris transects).

A comparison of the data for adult male mice and adult female mice showed a significant difference in hind foot length (Mann-Whitney U test, U = 268.00, p = 0.031), with male mice having longer hind feet than females. There was no significant difference between the sexes (adult mice only) for head length (Mann-Whitney U test, U = 380.50, p = 0.73).

Site and trapping plan (G = grid, T = transect)	**Mean head length, mm (= occipito-nasal length)** (± standard deviation)		**Mean length of left hind foot, mm** (± standard deviation)	
	Adult females	**Adult males**	**Adult females**	**Adult Males**
Kinloch Glen plantation (G1)	31.20±4.88 (n = 4)	31.99±3.54 (n = 9)	23.13±2.25 (n = 4)	24.21±1.71 (n = 9)
Hallival (G2)	26.00±1.36 (n = 3)	25.00±2.65 (n = 3)	23.00±0.90 (n = 3)	25.00±1.73 (n = 3)
Kinloch Castle woodlands (G3)	26.71±1.38 (n = 7)	26.30±2.00 (n = 10)	22.43±0.89 (n = 7)	22.85±1.83 (n = 10)
Dibidil (T1)	29.00±4.58 (n = 3)	28.83±6.21 (n = 3)	23.33±1.15 (n = 3)	24.97±0.95 (n = 3)
Scresort (T2) shoreline/woodlands	28.00±2.00 (n = 3)	29.33±2.08 (n = 4)	21.67±0.58 (n = 3)	23.00±2.65 (n = 4)
Harris plantation (T3)	(none captured)	28.75±1.77 (n = 2)	(none captured)	24.50±0.71 (n = 2)
Harris heath/grass open moorland (T4)	21.00 (n = 1)	26.00±1.41 (n = 2)	24.50 (n = 1)	25.00±1.41 (n = 2)
Kilmory woodland block (T5)	27.25±1.06 (n = 2)	25.83±1.76 (n = 3)	25.75±0.35 (n = 2)	24.33±1.26 (n = 3)
TOTAL (mean value across all sites)	**27.67 ±3.37 (n = 23)**	**28.21 ±3.74 (n = 36)**	**23.02 ±1.49 (n = 23)**	**23.92 ±1.77 (n = 36)**

NOTE: Numbers in parentheses indicate the sample size at each site (excluding juveniles, and also excluding escapes during handling).

Table 6: Mean values ± standard deviation (SD) for measurements of left hind foot and head length (occipito-nasal), in mm, by sex and by trapping site on Rum.

4.3 Trap damage

Table 7 summarises trap damage caused by gnawing, either by mice or by rats. Where the damage to the trap was ambiguous, and could not be clearly ascribed to either rat or mouse gnawing, this was recorded as 'unknown'. The assessment of gnawing damage by mice or by rats was subjective; there were no direct observations of rat activity around the traps during this survey. The size of the incisor marks on some of the damaged traps was, however, strongly indicative of rat gnawing (see photographs in Appendix B).

At some survey sites, particularly at Harris, traps were displaced from their original position but not damaged. This displacement is likely to have been caused by goats, deer or cattle in the area (and is not included in the scores given here for damaged traps).

All traps damaged by gnawing (without exception across all sites and all trapping nights) contained a captured mouse. For two of the rat-damaged traps on grid G1 (Kinloch Glen plantation), the mouse inside the trap was found dead (although with no visible signs of external injury). No dead mice were found inside undamaged traps, at any of the survey sites.

Site and trapping plan (G = grid, T = transect)	**No. of damaged traps** (number in parentheses indicates total number of traps set at site)	**Probable cause of damage (rat, mouse, or unknown)**
Kinloch Glen plantation (G1)	7 (72 traps set, grid)	4= rat damage 2= mouse damage 1 = unknown
Hallival (G2)	3 (72 traps set, grid)	1 = ? probable rat damage (minor) 2 = mouse damage
Kinloch Castle woodlands (G3)	9 (72 traps set, grid)	1 = ? probable rat damage 7 = mouse damage 1 = unknown
Dibidil (T1)	6 (50 traps set, transect)	4 = rat damage 2 = mouse damage
Scresort (T2) shoreline/woodlands	2 (50 traps set, transect)	1 = rat damage 1 = unknown
Harris plantation (T3)	2 (50 traps set, transect)	2 = mouse damage
Harris heath/grass open moorland (T4)	2 (50 traps set, transect)	2 = mouse damage
Kilmory woodland block (T5)	2 (50 traps set, transect)	2 = mouse damage
TOTALS (across all sites)	**33 (total no. of traps set = 466)**	**11 = rat damage or probable rat damage 19 = mouse damage 3 = unknown**

Table 7: Summary of damaged traps, by site.

No rat damage was sustained to traps that did not contain a mouse.

The likelihood that rat damage to traps occurred independently of their occupancy by mice is extremely low (for the Kinloch Glen plantation, Fisher's exact test, $p = 0.0000023$).

5. Discussion

5.1 Distribution and abundance of wood mice on Rum

Wood mice appear to be widely distributed on Rum, across a range of habitats. This survey showed that wood mice on the island are not confined to areas of woodland, nor to areas in close proximity to human habitation, nor to lower altitudes on the island.

Flowerdew and Tattersall (2008) have described the wood mouse as 'highly adaptable and opportunistic', and this species has been recorded elsewhere in a wide range of habitats, including field margins, reed beds, sand dunes and urban gardens (Flowerdew & Tattersall, *op. cit*., Leach, 1990). Wood mice have even been recorded living in areas of blanket bog (Lance, 1973), so it is perhaps not surprising that a number of mice on Rum were trapped in areas of wet *Molinia* grassland, and in other areas where the habitat may seem sub-optimal for small mammals.

Whilst the greatest densities of wood mice on Rum were found in the mature mixed woodland at low altitude, mice were also found close to the top of the rocky shore at Dibidil, and in the sparsely vegetated scree slopes above 400m on Hallival. It was not possible during this survey to sample areas at higher altitude on Rum outside the shearwater breeding colony (the possible relationship between mice, rats and shearwaters is discussed later in this report).

The abundance of wood mice found at some of the survey sites on Rum is comparable to, if not greater than, abundance of this species in various habitats on mainland Britain. Studies of small mammal populations use a number of different methods of calculating abundance, however, so direct comparisons are not always straightforward. Because of the relatively short duration of this survey, a rough-and-ready measure of abundance was used (number of captures per trap-night).

Moore *et al*. (2003), for example, sampled small mammals on arable farms and in new farm woodlands in Yorkshire, UK, and obtained a capture per trap-night rate of 0.04 for wood mice. This compares with the abundance measure found on Hallival during this survey (0.04), which represents the lowest rate of captures per trap night for this survey. In the woodland area of the Scresort transect, the capture per trap night rate was 0.24, representing a relatively high catch rate of almost one mouse per four trap nights.

It should be noted, however, that on Rum the wood mice do not have other competitors of similar body size, such as voles, nor are predators such as foxes and stoats found on the island.

5.2 Morphology of the Rum wood mice

The wood mice on Rum are markedly larger than their mainland counterparts, with juvenile mice on Rum often weighing more than their adult conspecifics on the mainland. Flowerdew & Tattersall (2008) report a body weight range for adult male wood mice in Perthshire as between 13-27g (mean 19.1g), and for adult female wood mice of 13-24g (mean 17.8g). The body weights of the adult mice captured on Rum were often over 30g, and in one case exceeded 40g (see Delany & Healy, 1964, for comparative morphological data for wood mice from a number of different sites across Scotland, including Rum).

Data for hindfoot length also exceeded the maximum measurements for the Perthshire wood mice dataset reported in Flowerdew and Tattersall (*op. cit*.)

Although the number of mice captured on Hallival was small (n = 8), these mice were significantly heavier than mice captured at lower altitudes on the island, around Kinloch. This finding should be treated with some caution, however, because of the small sample size, and also because of the inclusion in the Hallival sample of a single mouse weighing >40g (all weights for each captured mouse were checked by a second recorder, but it is not impossible that this mouse represents a weighing error). Further investigation of local morphological differences in the wood mice on Rum is recommended.

5.3 Trap damage and possible rat predation

An unexpected finding from this survey was the apparent targeting by rats of traps occupied by mice. Rats are known to catch and kill mice, although most of the descriptions of rat muricide are from the psychological and pharmaceutical literature, rather than from studies of wild rats and mice (see, for example, Karli, 1956, who provides a detailed account of the rat mice-killing response).

Elizabeth Bell, who has examined rat stomach contents on Rum, has not found any evidence of rat consumption of mice (pers. comm.).

Nevertheless, the rat gnawing damage sustained to a number of traps containing mice is of concern, particularly in relation to the known predation of manx shearwater eggs and chicks by rats on Rum. It is possible that, in the shearwater nesting colonies on Rum, the resident wood mouse population may be providing a food source which could help to sustain overwintering rats.

If there is rat predation of wood mice on Rum, then a likely consequence of rat control measures on the island will be an increase in the mouse population. A number of recent studies (for example, Angel *et al.*, 2009; Wanless *et al*., 2007, and Cuthbert & Hilton, 2004) have recorded mouse predation of island populations of sea birds. On St Kilda, where a large-bodied sub-species of the wood mouse, *A. sylvaticus hirtensis*, is recognised, probable predation of storm-petrel eggs by mice has recently been reported (Bicknell *et al*., 2009).

On Rum, there is no current evidence of mouse predation of shearwater eggs or chicks. The possibility of this occurring cannot, however, be ruled out, and further research on the interactions between rats, mice and shearwaters on Rum is clearly needed.

Recommendations for future research:

The survey reported here was a short pilot study of the wood mice population on Rum, and, as such, was limited both in extent and in duration.

Recommendations for future research into the wood mice on Rum are as follows:

- Further sampling of mice on Hallival, to validate the finding from this survey that mice living in the shearwater colony on Rum are significantly larger in size than mice living at lower altitudes on the island

- Sampling of wood mice on Rum in spring, and over a longer period of time, to obtain further data on population density of wood mice in different areas of the island

- Site survey for presence/absence of wood mice in other areas of the island, and in particular in areas at higher altitudes on Rum outside the shearwater colony

- Analysis of stomach contents of mice in the shearwater colony during the shearwater breeding season, to determine if there is any evidence of predation of shearwater eggs or chicks by mice

- Analysis of stomach contents of rats on Rum in the shearwater colony, in the winter months, to determine the extent, if any, of rat predation of mice (by over wintering rats)

- Close monitoring of wood mouse distribution and abundance during any experimental trial of rat control measures on the island

ENDS

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APPENDIX A: Data recording sheet for trapping

Rum Wood Mouse survey	Small Mammal Trapping Field Record.									
Study Area:			Date:		Time:					
Present weather:			Recent weather:		Observations:					
GPS way point (Trap A1 or 1):							Measurements			Comments
Trap No.	Species	Recapture	Mark	Sex	Age (Juv,, A)	Breeding (PRG/LACT/F.LACT/TA/TL)	Weight/g	Hind left foot, mm	Head (o-n), mm	