THE ECOLOGY OF THE HOUSE MOUSE, *MUS MUSCULUS* LINNAEUS, ON MARION ISLAND

by

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ABSTRACT

House mice inhabit a variety of habitats on Marion Island, with the density of mice varying according to vegetation type and invertebrate biomass, and highest mouse densities occurring in biotically influenced areas.

The density of mice fluctuated seasonally, peaking towards the end of summer. The reproductive season lasted 8,7 months, and was apparently regulated by the relative availability of food which mainly affected the reproductive activity of the females. The age structure of the population varied during the year, with no sex related mortality factors being observed.

The mice, in the approximately 100-150 years that they have inhabited the island, appear to have adapted physiologically to this harsh climate, by having enlarged kidneys and adrenals, an increased amount of brown adipose tissue, and being in general larger in size.

Mice ate predominantly invertebrate material throughout the year, with plant material occurring mainly during the summer months. The larvae of the flightless moth *Pringleophaga marioni* was the most important prey species.

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Ingrid Vis typed this manuscript, and I thank her for her patience and perseverance.

LIST OF CONTENTS

/ Chapter 7 ....

LIST OF CONTENTS (continued)

/ Summary . . . .

LIST OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

CHAPTER 1

INTRODUCTION

It has not been possible to determine the date that mice were first introduced onto Marion Island. The Prince Edward Islands were used for sealing operations from the late 1700's, with the last sealing expedition occurring in 1930 (Marsh 1948). Sealers are known to have lived on the islands in 1802, and it is possible that mice may have been introduced during this period, since Moseley visited the island in 1873, aboard the H.M.S. Challenger, as a member of the first biological expedition, and reported that, "I saw a hole with ears of grass dragged into it, and like a mouse's" (Moseley 1892). Thus mice were established on the island at this time and must have been introduced at some earlier date, although it is possible that there may have been several introductions of mice onto the island, for there was a shipwreck there, that of the S.S. Solglimt in as late as 1908 (Marsh 1948). Little else is known of possible introductions of mice onto the island, thus it would appear that mice have inhabited Marion Island for the last 100 - 150 years.

House mice are known for their adaptability (Bronson 1979), and are able to colonise and breed in a wide variety of habitats, ranging from cold stores, at a temperature of -10^{o}C (Laurie 1946), to semi-arid areas (Newsome & Corbett 1975). It is therefore not surprising that although sub-Antarctic islands would seemingly present an unfavourable habitat for small mammals, due to their extreme climate, mice have not only survived but thrived on at least eight islands: Amsterdam, St. Paul, Crozet, Kerguelen, Macquarie, South Aucklands, South Georgia and Marion (Holdgate & Wace 1961; Prévost & Mougin 1970; Anderson & Condy 1974; Bonner & Leader-Williams 1977; Pye & Bonner 1980) (Fig. 1).

House mice have been extensively studied on islands in the northern hemisphere (Berry 1963, 1968, 1970, 1977; Berry & Jakobsen 1974, 1975a, 1975b). Yet little research has been carried out on the islands in the southern hemisphere, apart from that of Bonner & Leader-Williams (1977), at South Georgia; Berry & Peters (1975), at Macquarie; and several workers on islands around New Zealand (Dingwall, Atkinson & Hay 1976). Anderson & Condy (1974) briefly recorded the distribution, habitat preference and feeding of mice on Marion Island, while Berry, Peters &

van Aarde (1978) looked at the age structure, organ weights and female reproduction, with the major part of the study being devoted to gene loci and frequencies. They determined that the mice from Marion Island possessed the Es-2^{C} allele, previously described for mice from the Faroe Islands, in the northern hemisphere, and also found in mice from Scandanavia. Early sealers were known to have come from the Scandanavian countries, thus it is possible that the mice on Marion Island may be of Scandanavian origin. Robinson (1978), however, found that female mice on Marion possessed a Robertsonian translocation, which has previously only been found in populations from southern Europe. Thus whether the founder population came from Scandanavia and this translocation arose on the island, or from a southern European population, or from a multiple introduction from both these areas, is a moot point.

Neither the fauna nor the flora of these southerly islands are adapted to coping with the small mammalian herbivores or carnivores which have been introduced (Dingwall *et al.* 1976). Apart, however, from the studies on Macquarie and some of the small islands around New Zealand, not much is known of their effect on sub-Antarctic islands. The present study was, therefore, undertaken in an attempt to determine the effect of the mice on the indigenous avian and invertebrate fauna and flora on Marion Island.

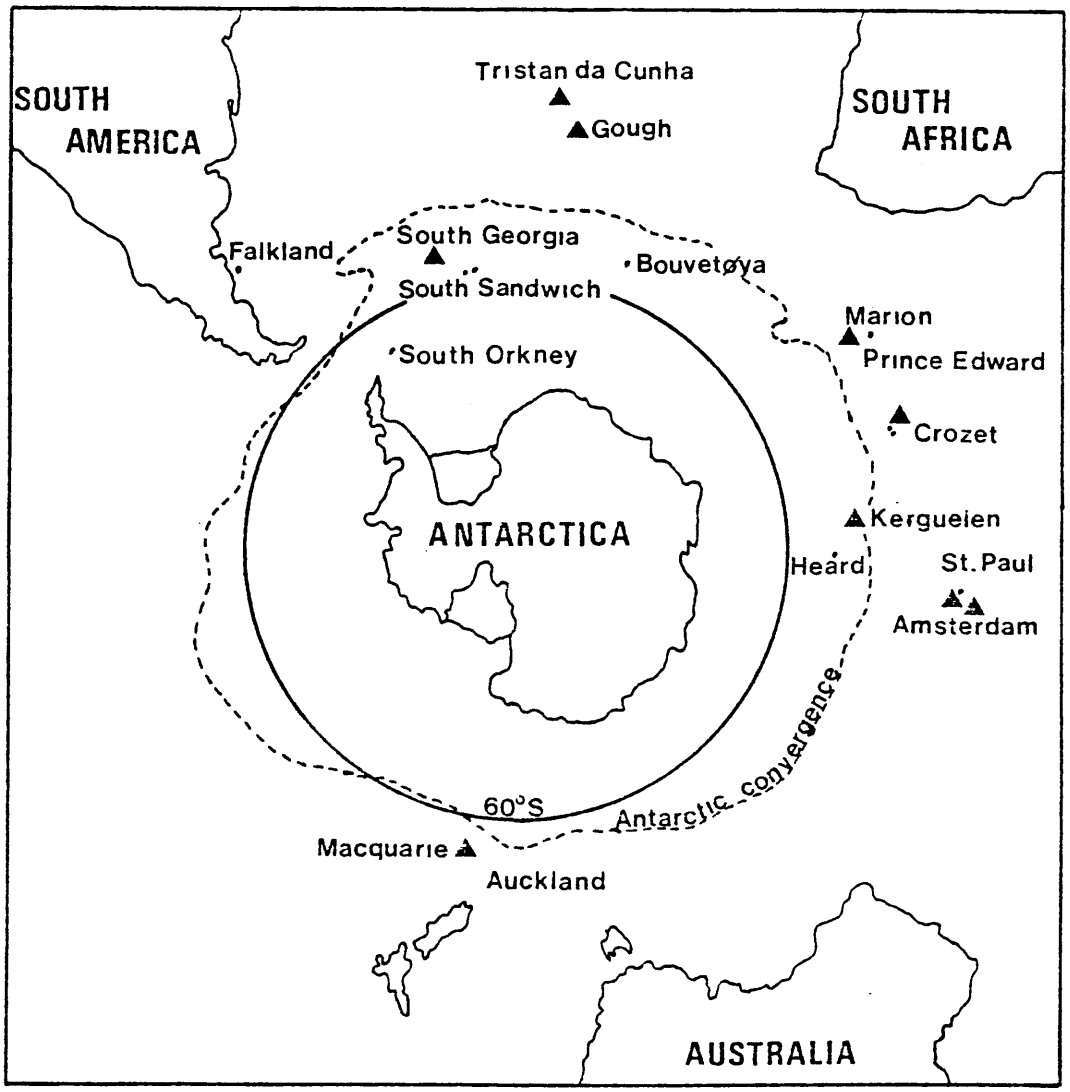

Figure 1: Sub-Antarctic islands on which established populations (▲) of house mice are found.

CHAPTER 2

THE STUDY AREA

TOPOGRAPHY

Marion Island (46°54'S, 37°45'E) and Prince Edward Island (46°38'S, 37°57'E), are closely related, coalescing shield volcanoes (Verwoerd 1971) which lie in the southern Indian Ocean (Fig. 1). For a complete description of the topography and geology, *vide* Langenegger & Verwoerd (1971) and Verwoerd (1971). Marion Island is oval in shape and dome-like in cross-section. It is 290 km^2, with a circumference of 72 km, the highest point being 1230 m above sea level (Verwoerd 1971) (Fig. 2). It can be divided into five physiographic regions: coastline; coastal plain; an island slope; a central highland and escarpment (Verwoerd 1971).

The coastal plain is situated on the western / south western portion of the island, and is separated from the central highland by a 200 - 300 m high escarpment. This plain varies from 0,8 - 2,0 km wide, and lies approximately 50 m above sea level. It is volcanic in origin, rather than being a raised marine terrace (Verwoerd 1971).

The greatest portion of the island is formed by the island slope, which varies in incline, being steeper in the west than in the east. The high areas of the island slope consist primarily of plateaus and ridges with glacially smoothed grey lava areas, covered in places by younger black lava flows, and with scoriae cones scattered around. The lower areas of the island slope consist of depressions, with flows of black lava inundating these depressions, giving it a hummocky appearance (Verwoerd 1971). Volcanic cones, of various types, are scattered all over the island, and vary in height up to 200 m (Verwoerd 1971).

Marion Island is drained by a great number of streams, although only the Soft Plume and van den Booghart are perennial. In the upland areas, lakes are seldom fed by rivers, but receive their water from the high precipitation. While in the low land areas, water is ponded by the marshy swamp areas and small tarns. The greatest percentage of water reaches the sea through the underground drainage system (Verwoerd 1971).

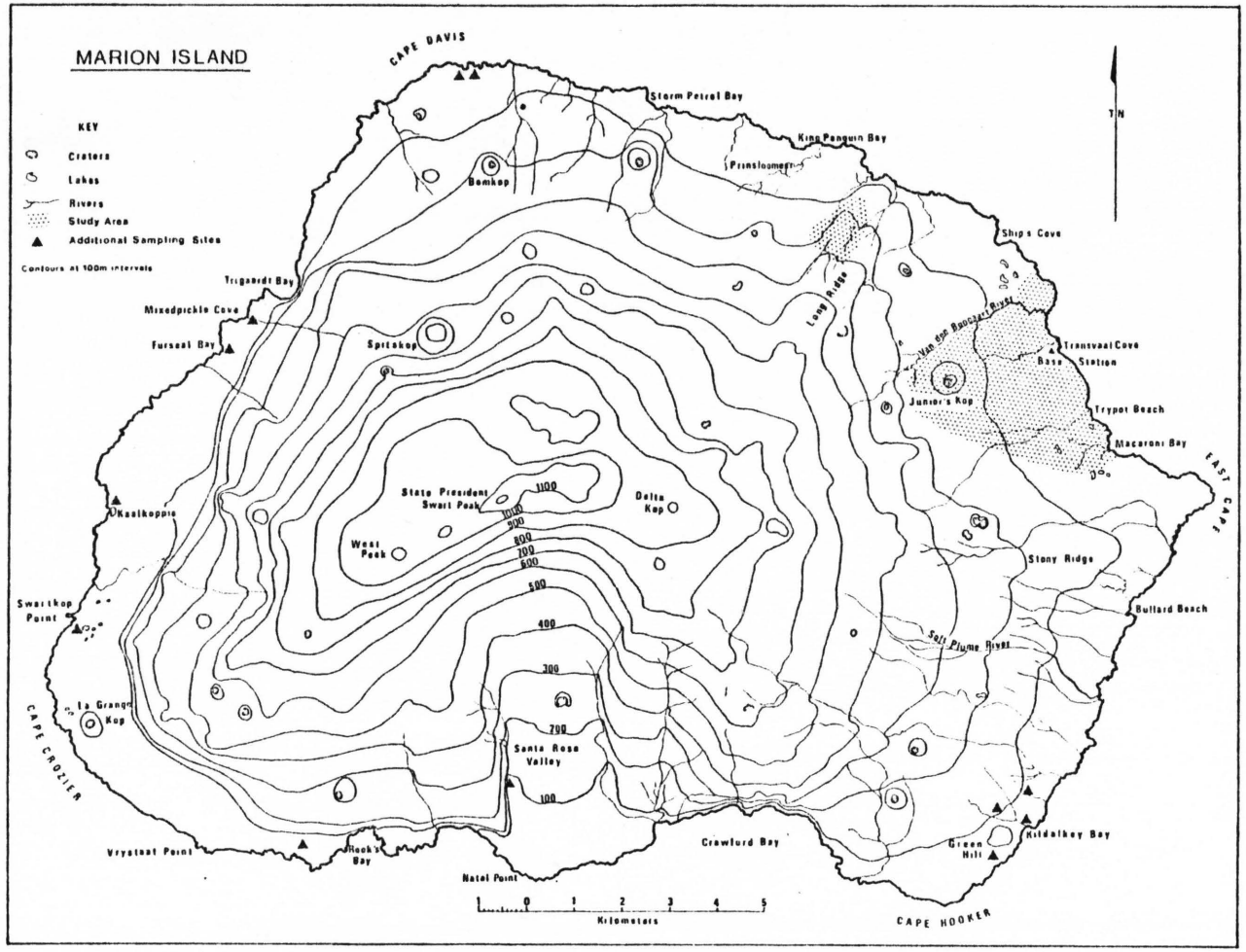

Figure 2: Topographic map of Marion Island, showing the main trapping area and additional trapping sites of mice on the island during 1979-1980.

Marion Island experienced two distinct volcanic stages: the older glaciated grey lava stage, 276 000 ± 30 000 to 100 000 years old, and the younger black lava stage, 15 000 ± 8 000 years old (McDougall 1971). Although described as being volcanically inactive, an outflow of lava occurred at Kaalkoppie, on the west coast, during 1980 (Verwoerd, Russell & Berruti 1981).

The older grey succession consists of three component rock faces: Grey basaltic lavas, stratified tuff and massive pyroclastic deposits. Glaciation occurred after the deposition of these older grey lavas, and evidence in the form of glacial striations can be found all over the island (McDougall 1971). The greater part of the island was inundated by black basaltic lava during the second volcanic stage. These flows occurred at different times, and this is reflected in the degree of vegetation that covers the flows at the present stage.

VEGETATION

The vegetation of Marion Island has been fully described by Huntley (1967, 1971). A characteristic of the vegetation is the paucity in the number of species. Grasses and bryophytes dominate the low lying swamp areas with grasses and a herb community found on the well drained slopes, while vascular plant growth is not found above the 500 m contour level. The vegetation may be classified into five complexes (Huntley 1971):

Salt spray complex, with *Tillea moschata* and *Cotula plumosa* herb-fields dominating.

Biotic complex, with *Poa cooki* tussock grassland.

Swamp complex, with *Agrostis magellanica* mire and various bryophytes.

Slope complex, with *Blechnum penna-marina*, *Acaena adcendens* and *Azorella selago*.

Wind desert, with *Azorella selago* feldmark.

The vegetation would appear to be more affected by wind velocities than by the low temperatures (Huntley 1971). Thus, the greatest diversity of micro-habitats are found in the hummocky black lava areas that give shelter from the wind, with these micro-habitats containing the greatest variety of plant species displaying the most luxuriant growth.

CLIMATE

The most noticeable climatological factors of Marion Island are:

(a) Strong winds, predominantly from the west. Highest wind velocities occurring diurnally with most frequent gales during the winter months.

(b) High relative humidity, with little daily or annual variation from 80%.

(c) High precipitation, in the form of rain, snow and graupel, with a mean annual precipitation of 2576 mm. There is little annual variation, with the exception of a slight autumnal peak.

(d) A high degree of cloudiness, with only 20 - 33% of the possible amount of sunshine reaching the island surface. Sunshine duration is 15 h in summer and 9 h in winter.

(e) Low temperatures, with a mean annual temperature of 5°C, an annual variation of approximately 5°C and a diurnal variation of approximately 5°C (Schulze 1971).

Snow covers the island for several consecutive days during the winter months, but may occur occasionally during summer. The high mountain peaks are continually covered in ice and snow.

The grass minimum temperature, measured 2,5 cm above the ground, is given in Table 1. This is the temperature that is most likely to have an effect on a small mammal. Climatological data for Marion Island are given in Table 1 from Schulze (1971).

Table 1: Climatological data for Marion Island, from Schulze (1971)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean monthly air temperatures (1949 - 19609 (°C)	6,7	7,3	7,2	6,0	4,8	4,0	3,6	3,2	3,3	4,3	51,	5,8	5,1
Mean "grass-minimum" temperatures (1959 - 1963) (°C)	2,8	3,5	3,1	1,9	0,9	0,3	-0,5	-0,3	-0,7	0,7	1,0	2,2	1,2
Precipitation (mm) (1951 - 1965)	222	207	225	238	249	232	231	185	201	165	196	225	225
Relative humidity (%) (1949 - 1960)	84	85	85	85	84	84	84	83	83	83	83	83	84
Mean daily sunshine (h) (1948 - 1965)	4,9	4,8	3,7	2,6	2,2	1,8	2,0	2,4	3,0	4,4	5,0	5,1	3,5
Mean monthly wind speed (km/h)	25,0	23,4	25,3	25,3	25,0	27,4	28,5	29,0	27,0	26,4	25,9	26,9	26,4

CHAPTER 3

TRAPPING AREA

The five physiographic areas described by Verwoerd (1971) may be grouped into three area types: the coastal area below 100 m above sea level, the inland area between 100 m and 450 m above sea level and the central mountainous area above 450 m above sea level (van Aarde 1977).

Trapping was largely confined to the eastern side of the island, in an area referred to as the study area (Fig. 2), but traps were set on a few nights at various points around the island (Fig. 2). All trapping was conducted below 150 m above sea level, except for one area at Longridge at 250 m above sea level. Six habitat types can be described for the study area:

Hummocky beach areas
Hummocky vegetated black lava areas
Swamp areas
Vegetated grey lava slopes
Grey lava flats
Scoriae cones.

Hummocky beach areas: these surround the landing areas of the penguins, family Sphenicidae, and the seals (*Mirounga leonina* and *Arctocephalus* species). They are characterised by numerous wallow areas created by the seals, and the eroded paths caused by the penguins. Numerous burrows created by the burrowing petrels of the family Procellariidae are scattered throughout the area. The influence of the seals and birds can be seen in their nitrification of the soil by manuring, and their trampling of the vegetation (Huntley 1971). *Cotula plumosa*, which is a characteristic plant of biotically influenced areas, is the dominant plant species. Stands of *Poa cooki*, *Agrostis stolinifera* and *Poa annua* as well as various bryophytes are scattered throughout the area. These beach areas are also heavily utilised by gulls (*Larus dominicanus*) and sheathbills (*Chionis minor*), foraging for terrestrial invertebrates (Burger 1978).

Hummocky vegetated black lava areas: these comprise the largest portion of the study area. The amount of vegetation found in these areas varies with the amount and depth of the soil layer. Two extremes of vegetation can be recognised, with a range in the degree of vegetation of other areas

lying between these two extremes. In areas that are well drained, rocky with little soil cover, the vegetation consists of primarily *Blechnum penna-marina* and *Azorella selago*. Other areas are less well drained, less rocky and have a thicker soil layer on the slopes. Here small mires and tarns are found in the depressions of the wetter areas with *Agrostis magellinica* and *Uncinia dickeii* being the dominant vascular species with various bryophytes also present (Huntley 1971). The slopes are dominated by *Blechnum penna-marina* and *Acaena adcendens* with small stands of *Poa cooki*, caused by the manuring action of the burrowing Procellariidae (Huntley 1971). *Azorella selago* is dominant on the crests of the hummocks, with areas of bare rock also occurring.

Swamp areas: are found in areas where the water table is at or near the surface. There are four types of swamp areas found (bog, spring, mire and flush) with *Agrostis magellinica* mire being the largest and most predominant (Huntley 1971). These mires occur on both grey and black lavas, with those occurring on black lava being smaller due to its greater porosity. *Agrostis magellanica* is the dominant vascular species, with *Uncinia dickeii* and *Juncus scheroides* also occurring, while numerous bryophytes dominate the ground surface (Huntley 1971). These swamp areas are subject to minimal vertebrate activity except for some areas near the coast where gulls and sheathbills forage for invertebrates.

Vegetated grey lava slopes: these occur both inland and at the coast, and vary in incline, with some of those near the coast being approximately 70^{o}. The soil depth is one meter or more in some places, and the slopes are primarily covered in *Poa cooki* tussock grassland, due to the manuring action of the burrowing Procellariidae that utilise these slopes in great numbers (Smith 1976, 1977). *Poa annua* encroachment onto these slopes has occurred in those areas in which the number of burrows of the Procellariidae is lower (M. Schramm, *Pers. comm.*). Large stands of *Acaena adcendens* herbfield are found on many of the east facing slopes, while *Blechnum penna-marina* is found on those slopes in which few bird burrows occur (Huntley 1971).

Grey lava flats: are found on the top of the grey ridges, they have gentle inclines and are characterised by the flat glaciated grey lava rocks found here. Vegetation is sparse and is mainly confined to *Azorella selago* cushions with some epiphytic *Agrostis magellanica* and

mosses also occurring (Huntley 1971). Small streams bisect many of these areas, and this has resulted in valleys being formed. These valleys afford some protection from the wind and have become vegetated with mainly *Blechnum penna-marina*, *Acaena adcendens* and *Poa cooki*.

Scoriae cones: these volcanic cones rise up, in some cases to 200 m, above the coastal plain and inland areas, and they are made up of uneven oxidised vascular volcanic fragments. *Blechnum penna-marina*, *Acaena adcendens* and *Poa cooki* form the greatest part of the vegetative cover on the lower slopes. *Azorella selago* dominates the middle areas, while cryptograms are found on the peaks of the cones.

Live trapping of mice was conducted in four of these habitat types: hummocky beach areas, hummocky vegetated black lava areas, swamp areas and grey lava flats. Two swamp areas were trapped, one was a plain very wet swamp and the other was drier swamp and had rocks scattered throughout the area. Snap trapping of mice was conducted in all of the habitats described.

CHAPTER 4

MATERIALS AND METHODS

The present study may be divided into five sections, with the two major sections being a live trapping and a snap trapping programme, and the three minor sections being an investigation into the invertebrate fauna associated with various vegetation types, a determination of the distribution of the mice around the island and an analysis of the vegetation found on each of the live trapping grids.

LIVE TRAPPING PROGRAMME

Mice were captured using Sherman 75 x 90 x 230 mm live traps baited with a mixture of rolled oats and peanut butter, while shorn-off sheep's wool was used to provide nesting material during the winter months, from June 1979 to September 1979. Trapping was conducted on a grid, with 10 x 10 stations, with an interstation distance of 10 m, as well as on eight assessment lines, with four stations lying inside the area of the grid and nine extending beyond the perimeter of the grid (Fig. 3). Lines A, C, E and G, the vertical lines, had an interstation distance of 10 m, while the lines B, D, F and H, the corner lines, had an interstation distance of 14,5 m. Assessment lines of various forms have been used by various researchers (Stenseth, Hagen, Ostbye & Skar 1974; Swift & Steinhorst 1976; O'Farrel, Kaufman & Lundahl 1976) to determine the area of effect of the grid live trapping, or in some cases snap trapping grid, or of a set of parallel trapping lines (O'Farrel *et al.* 1976). The area of effect may be considered to be that area around the grid, or parallel lines, from which animals are attracted to traps on the grid. It is necessary to determine this area in order to calculate the density of animals in an area, so that an overestimate of the number of animals utilising a grid area is not made. The assessment lines, in the present study, were laid out in such a manner that corner lines had a 14,5 m spacing and vertical lines had a 10 m spacing, thus increasing the grid as a square for each trap station away from the grid perimeter. This method was used rather than the methods of Swift & Steinhorst (1976) and O'Farrel *et al.* (1976), in which the area of assessment increased as an octagonal. Although the present method does bring in a measure of error, as the distance moved by mice on the vertical and corner lines is

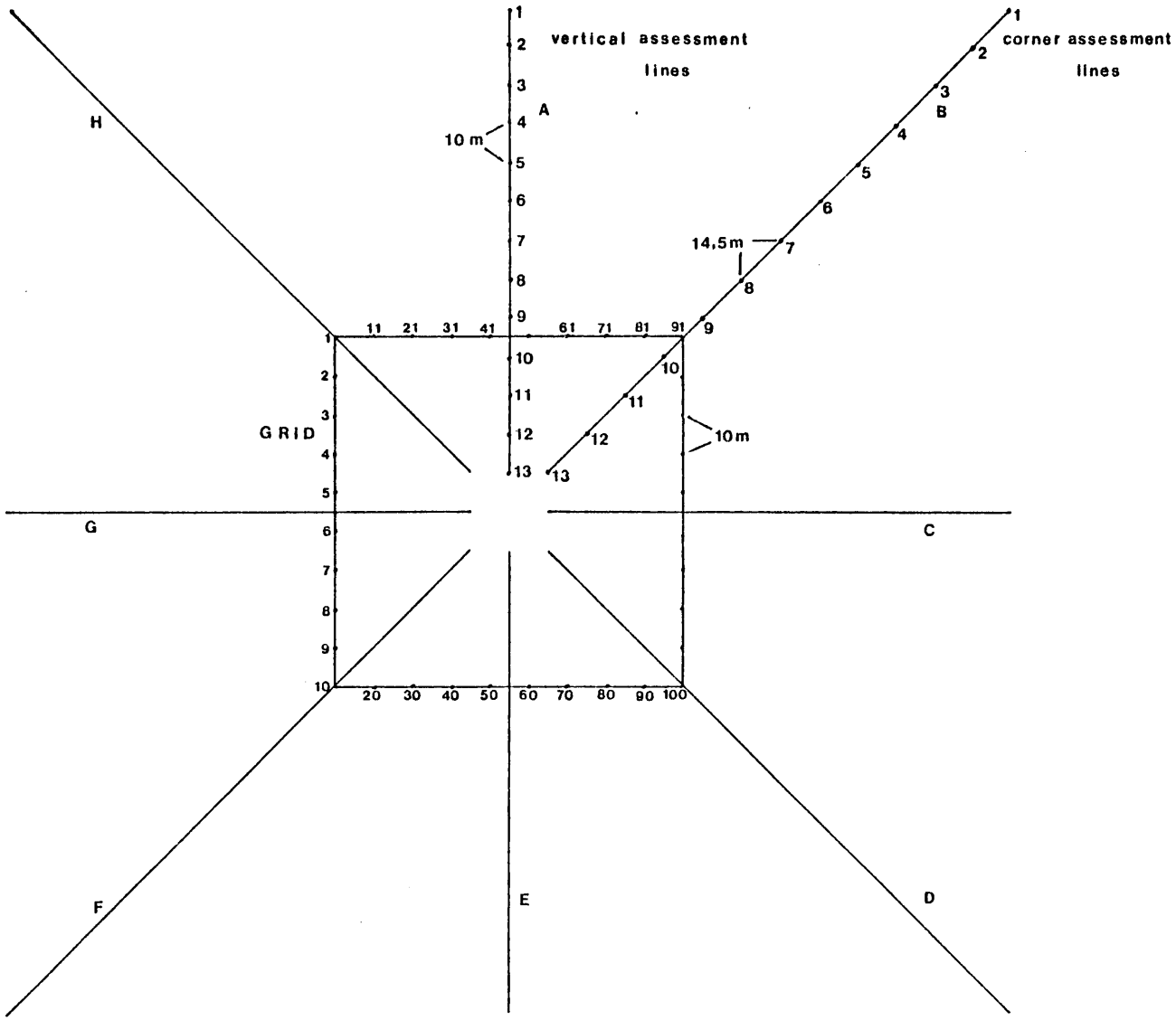

Figure 3: Schematic diagram of the grid and assessment lines used in the live trapping programme of house mice on Marion Island during 1979-1980.

different for the same trap station site away from the grid, this amounts to, however, only five percent of the total area of assessment and facilitates the actual calculation.

Live trapping was conducted on grids set out in the following five habitat types:

GRID 1. Hummocky beach area
GRID 2. Hummocky vegetated black lava area
GRID 3. Swamp areas a. Dry swamp with rock intrusions
b. Wet swamp
GRID 4. Grey lava flats

Grids 1, 2, 3a and 3b were trapped on a two monthly cycle, from May 1979 to April 1980, with six trapping sessions being completed, while Grid 4 was trapped on a three monthly cycle, from June 1979 to April 1980, with four trapping sessions being completed. Table 2 shows the date that the live trapping sessions, and the snap trapping periods were conducted during the study. No assessment lines were laid out on Grid 4, as there was a very low density of mice in this area and the rate of capture would have been too low to make any reliable estimate of the area of effect. Grids 1, 2, 3a were trapped for six nights continuously during each trapping session, with the first four nights trapping taking place on the grid and the last two nights trapping taking place on the assessment lines. Grid 4, however, was only trapped for four nights continuously during each trapping session. Traps were set in the evening and were checked as soon as possible the following morning, when the number of traps containing mice, those still open and those closed but empty were recorded. The following were recorded for each mouse trapped on any of the nights that it was caught: weight, sex, reproductive status, individually numbered by toe clipping (if not already marked), number noted, capture station noted, released at the station of capture. Toe clipping has been criticised as affecting the animal's behaviour for a period immediately prior to the operation, but it does provide a permanent individual mark that cannot get lost, as is the case with ear tags, and is in addition convenient when dealing with a large number of individuals (Blair 1941). Mice trapped on the assessment lines were: checked if marked or unmarked, site of capture noted and released at the site of capture. Some mice were removed from Grids 1 and 2 on the fourth

Table 2: The dates and duration of the grid live trapping sessions, and the snap trapping periods of house mice on Marion Island during 1979 - 1980. (Live trapping sessions 1 - 6 for Grids 1, 2, 3a and 3b, and Sessions 1a - 4a for Grid 4)

Session / Period	Live trapping Session	Snap trapping Period
1	10/05 - 24/06/1979	21/07/1980 - 20/05/1980 +21/05/1979-20/06/1979
1a	11/07-14/07/1979	
2	27/06 - 28/08/1979	21/06 - 20/08/1979
2a	1/10- 4/10/1979	
3	31/08 - 26/10/1979	21/08 - 20/10/1979
3a	6/01-9/01/1979	
4	4/11 - 15/12/1979	21/10 - 20/12/1979
4a	27/04-30/04/1979	
5	31/01 - 10/02/1979	21/12 - 20/02/1979
6	2/03 - 9/04/1979	21/02 - 20/04/1979

night of the 6th trapping session, as these were animals of a known age, and in removing them on the last night of trapping on the grid, this would not affect the estimate of density, although it may have had a small effect on the estimate of area of effect.

The number of mice on the grid was determined from use of the capture mark recapture data, from the first four nights of the grid trapping session, and an estimate was made using a modified Petersen Index of:

$$N = \frac{M(n+1)}{m+1} - 1 \qquad \text{STANDARD ERROR} = \sqrt{\frac{m^2(n+1)(n-m)}{(m+1)^2(m+2)}}$$

Where: N = number of mice on the grid

M = total number of mice marked during the first capture session

n = total number of mice recaptured during the second session

m = total number of marked mice recaptured during the second session (Caughley 1977).

The first three trap nights on the grid were combined to represent the first capture session, while the fourth night represented the recapture session. This method was adopted as the time interval between the first and last captures was short, four days, thus reducing the effect of immigration, emigration, mortality and natality to a minimum, while by extending the first capture session, this ensured that a large portion of the population was marked to facilitate other aspects of the study.

The area of effect of the grid was determined from captures of marked and unmarked mice along the successive assessment line capture sites, by summing the data from the two nights of capture along these assessment lines. The point of the furthest capture of mice from the grid perimeter, unless this was represented by a single extreme movement of a single mouse away from the grid, was used to determine Wd, the distance from the grid of the furthest captures. This was taken as half an interstation distance, based on the vertical lines, beyond the trap station of furthest capture. Although this is calculated using the vertical lines capture points, the captures on the corner lines were also utilised, even though there is a difference in the interstation distance, between the corner and vertical assessment lines. The area of effect (Ae) is determined from the formula

$$Ae = (90 + 2Wd)^2$$

where 90 is the length of the grid in meters. The ratio of marked (Mr)

to unmarked mice caught on the assessment lines determines the ratio of marked to unmarked mice within the area of effect, thus

$$R = \frac{Mr}{Un}$$

where Mr is the number of marked mice and Un is the number of unmarked mice caught on the assessment lines.

The density of mice within the area of effect (Da) is then calculated from $Da = \frac{R\ Ng}{Ae}$

where Ng is the number of mice on the grid (O'Farrel *et al.* 1976).

The utilisation by mice of the total grid area was determined by determining the cumulative number of captures per four trap stations, which then represented a capture block, per trapping session. The captures per block were then graphically displayed in a row by column format with the Z-axis illustrating the sum of captures per block, using a "Statistical analysis system program: procedure block chart version 79.3A" *

SNAP TRAPPING PROGRAMME

Mice were captured primarily, using Baby Victor snap traps, baited with raisins, although Museum Special snap traps, baited with a mixture of rolled oats and peanut butter, were used occasionally. Baby Victors, baited with raisins, were more successful at catching mice than were the Museum Special traps, as it was found that the oats/peanut butter mixture was prone to be washed off the treadle by the continuous rain. Traps were laid out in grids that varied in number from 5 x 5 to 10 x 10 trap stations, with an interstation distance that varied from 5 to 10 m, depending on whether the area being trapped had a suspected high or low density of mice. A total of 7304 nights were employed, which yielded a total of 612 mice, which represents a 8,4 percent trap success.

*Address: SAS Institute Inc., Box 8000, Cary., NC 27511

Trapping was conducted on a two monthly cycle, with trapping periods starting on the 21st of a month and ending on the 20th of a month two months later. This system was used as these dates correspond most closely to those of the equinox and solstice dates. A total of six trapping periods were completed, and the mice captured were used to provide material for an investigation into changes in various body parameters as well as various reproductive characteristics of the population. Snap trapping was conducted in habitats similar to those described for the live trapping grids, while in addition several other areas in the study area were also trapped, namely:

vegetated grey lava slopes
scoriae cones
boulder beaches at the landing beaches.

A variety of sites around the island were in addition also trapped (Fig. 2).

Traps were set in the evening and checked as soon as possible the following morning, any traps that had not been sprung were left set during the day. When mice were caught during any of the field trips outside the study area, they were: weighed, measured, their reproductive status noted and the stomach and skull stored in 10% alcohol for analysis on return to the laboratory. Mice caught in the study area were removed to the laboratory where the following parameters were measured:

Total length, nose to tail	:- to 1 mm
Tail length	:- to 1 mm
Body weight	:- to 0,5 g
Testis weight, left and right	:- to 1 mg
Adrenal weight, both adrenals	:- to 1 mg
Kidney weight left only	:- to 1 mg
Interscapular brown fat weight	:- to 1 mg
Inguinal fat bodies weight	:- to 1 mg
Foetus weight	:- to 1 mg
Foetus crown rump length	:- to 0,1 mm

In addition indices were determined for the following parameters by dividing the organ weight by the total body weight (which in the case of

females is minus the weight of the gravid uterus); right testis, kidney, brown fat, inguinal fat. Relative frequency histograms were constructed for the total length, body weight, kidney index, brown fat index and the inguinal fat index and the difference between the means for the frequency classes between the sexes, and in the one case between the left and right testes, tested for each sampling period, using the following t-test:

$$t = \frac{\bar{X} - \bar{Y}}{\sqrt{\frac{(n_x - 1)\, Sx^2 + (n_y - 1)\, Sy^2}{n_x + n_y - 2} \cdot \left(\frac{1}{n_x} \; \frac{1}{n_y}\right)}}$$

$$\bar{X} = \frac{1}{n_x} f_x X \qquad S_x 2 = \frac{1}{n_y - 1} f_x 2 - n_x \bar{X}^2$$

$\bar{X}$ = mean for the sample
f_x = frequency class
x = midpoint of the frequency class
n_x = the sample size
S_x = the variance (G. Steyn *Pers. comm.*).

A one way analysis of variance was used to test the effect of trapping period on the right testes index, while a two way analysis of variance was used to test the effect of sex and trapping period on the following parameters: total length and body weight and the following indices: kidney, brown fat and inguinal fat.

The following reproductive characteristics were measured:

The sex ratio for each sampling period, using a X^2 test to test for significance of difference in the sex ratio.

The number of pregnant females per reproductively active females for each sampling period. Reproductively active females are all those of 14 g or larger (Delong 1967).

The number of foetuses per female, using a X^2 test to test for a significant difference between the two uterine horns.

The number of uterine scars per female, with the mean number of scars determined if more than one set of scars were found, and a X^2 test used to determine any significance of difference in number between the uterine horns.

The age of any foetuses found was determined following Theiler (1972). Using the age so determined a linear regression of mean weight of foetuses against age of those foetuses was plotted. In addition a linear regression of foetus weight against crown-rump length was also plotted.

The age of the pregnant females in each trapping session, the season of births and frequency of births per trapping session, and in addition an age specific fecundity schedule were all determined (Caughley 1977).

AGEING OF SKULLS

Skulls from 383 snaptrapped mice in which the upper right molar toothrow was intact, were boiled in sodium per borate and cleaned by hand. The teeth in the upper right molar tooth row were examined under a 25X stereo-microscope. Skulls from 43 mice, collected on the live trapping grids, for which a minimum age was known, were used to determine absolute minimum ages for the skulls. Ageing of the mouse population was based on the degree of wear (attrition) of M^1, M^2 and M^3 (Lidicker 1966).

Seven age classes based on the known aged skulls are described. These are developed from the age classes described by Lidicker (1966), but have been modified to apply to the mouse population on Marion Island. See Fig. 4 for description of tooth morphology.

1	0 - 1 month old:	M1 not fully emerged, M2 not fully emerged, M3 not erupted.
2	>1 - ≤2 months old:	Body weight less than 12 g. M1 - slight wear C1, C2, C3, no lake development of L1. Valley 1, 2 still very deep. M2 - slight lake development of L2, L3. M3 - no wear
3	>2 - ≤4 months old:	M1 - slight lake development of L1, but not on lingual side between lobes 1 and 2. Slight lake development of L3.

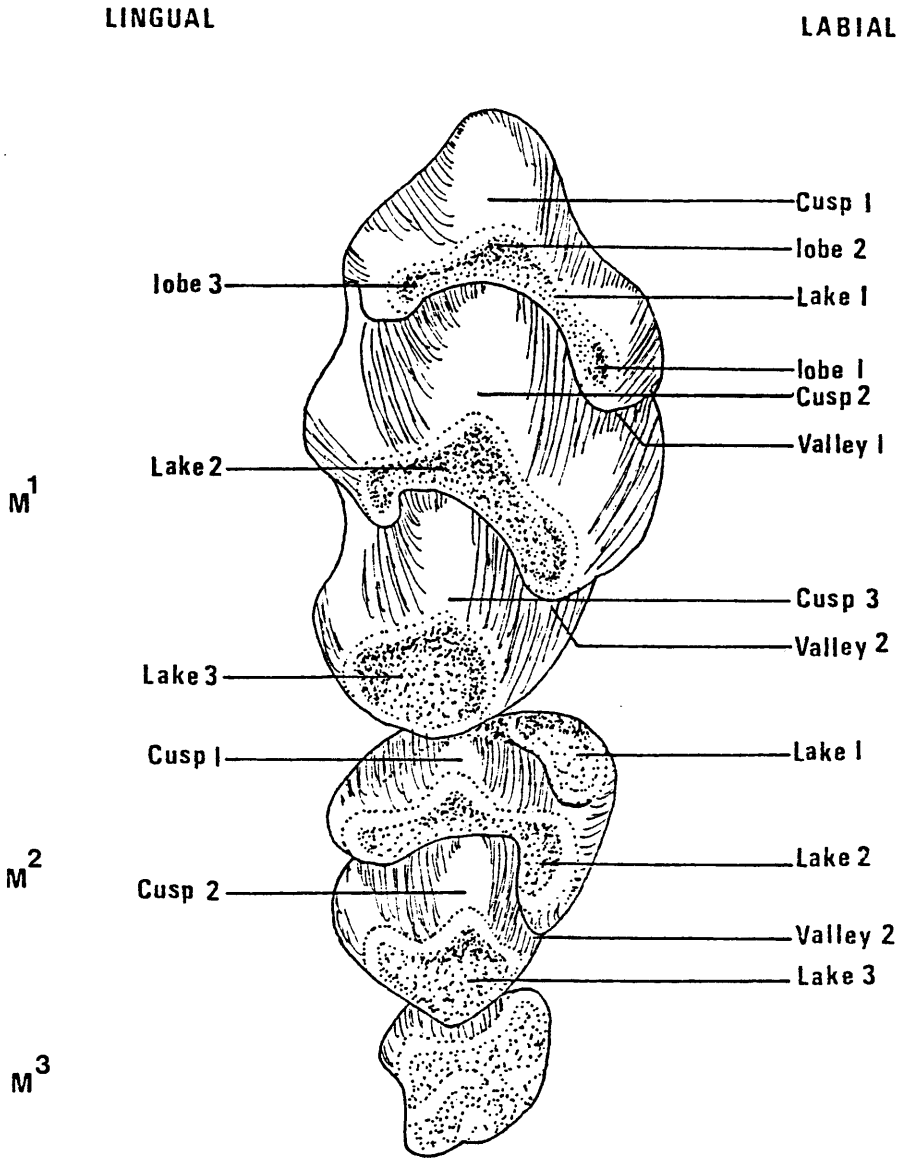

Figure 4: Upper right molar tooth row of a house mouse from Marion Island, showing the main features used in determining the degree of attrition of the M^1, M^2 and M^3 teeth.

3 (continued)		M2 - little wear of C1. Valley between C2, C3 still prominent.
		M3 - slight wear with initial lake development.
4	>4 - ≤9 months old:	M1 - angle of C1 wear tends to the horizontal, while that of C3 is still vertical. Lobes of L1 joined. Valley between C1, C2 shallow.
		M2 - L1 larger than in class 3. Valley 1 and 2 shallow. L3 is larger especailly in the older members of the class.
		M3 - noticeable wear of M3, with resultant lake development.
5	>9 - ≤11 months old:	M1 - L1, L2 starting to join lingually. L2, L3 approaching lingually. Only slight valleys remain between the cusps.
		M2 - L1, L2 are in some cases joined lingually. Only slight valleys remain.
		M3 - slight cusps, but no valleys.
6	>11 - ≤13 months old:	M1 - All lakes very broad. L1, L2 joined lingually with L2, L3 starting to join lingually.
		M2 - L1, L2, L3 all joined lingually. In older 6 L1, L2 tend to form one lake.
		M3 - only slight cusps remain, but essentially one large lake.
7	>13 months old:	M1 - some interlake cusps remain, beginning of labial connections of the lakes.
		M2 - minimal enamel left, tends to one lake.
		M3 - no enamel left, only a large lake remains.

To facilitate statistical analysis of the six age classes used, excluding age class 1 as these did not normally enter the trappable population, these were divided into three age groups, with age classes 2 and 3 forming age group 1, age class 4 representing age group 2, and age classes 5 and 6 forming age group 3. The three age groups formed were then statistically analysed, using a

log-linear model of contingency tables (G. Steyn *pers. comm.*), for the following sets of parameters:

Sex ratio x Age class
Sex ratio x Trapping session
Age class x Trapping session
Age class x Age class x Trapping session.

STOMACH CONTENT ANALYSIS

The stomach contents of 405 snap trapped mice were examined, during the duration of the study. The stomachs, after removal from the mice, were weighed wet, and the wet weight of the contents was determined to 1 mg. The stomach contents after removal from the stomach were spread out in a petri dish and examined under a stereo microscope, with a maximum magnification of 25X. These contents were then sorted into the following food types:

Pringleophaga marioni larvae
P. marioni adult
weevil adults
weevil larvae
spiders
earthworms
plant material, both white and green together
other - all foods only occasionally found in the contents and including any unidentifiable material.

The percentage contribution of each food type, of the total stomach content was estimated on the basis of percent volume, on a scale of 1-10, and the mean percentage contribution of each food type per trapping period per individual was determined. The mean percentage occurrence per individual of each food type, based on the number of times each food type was found in the stomachs during each trapping period, was also determined.

Diet variety, which was the total number of different foods found in all the stomachs during a trapping period, and the diet diversity (D) (Ebersole & Wilson 1980)

$$D = \frac{1}{\sum p_i^2}$$

where p_i is the mean percentage contribution of each of the eight food types per trapping period, were also determined.

REFUGE AVAILABILITY

Refuge availability was determined by counting the number of grid blocks in which mouse burrows (or refuges) were seen. A grid block is defined as the area in the grid which has a trap station at each corner, thus a 10 x 10 grid has 9 x 9 grid blocks. The percentage refuge availability was then determined from the 81 grid blocks, and represented as the percentage of the grid that was available for refuges for mice.

INVERTEBRATE INVESTIGATION

Soil cores of 7 cm in diameter and up to 10 cm in depth, and which included all the vegetation above the soil, were taken at 25 set sampling sites, these being located at 25 of the trap stations on each of the grids during each of the live trapping sessions. When a site was situated on rock a core was not taken. The vegetation in each core was noted, and the soil and vegetation in that core sorted through in order to remove all the macro-invertebrates present, macro-invertebrates being all these invertebrates visible to the naked eye. The macro-invertebrates from the cores were lumped according to the vegetation types sampled, and the invertebrate species in each vegetation type. These invertebrates were then oven-dried at 60°C for approximately 96 h, and the dry mass, to 1 mg, was determined for each invertebrate species in each vegetation type.

The dry mass and numbers per m^2 of the four main invertebrate species that mice preyed on (see Food, feeding and stomach content analysis in Chapter 10) were determined for each vegetation type on each grid. Then using the data of the percentage contribution of each vegetation on each grid (see Vegetation analysis: results and discussion in Chapter 6) it was possible to determine the sum total dry biomass per grid of these four main prey species summed together.

The change in dry biomass and numbers per m^2 of each of the four main invertebrate species per trapping session was determined summing the numbers and biomass per m^2 on grids 1, 2, 3a and 3b, thus giving an indication of the change in biomass and numbers of these invertebrate prey species during the year on Marion Island, when all the vegetation types are considered together. In addition the change in mean biomass (mg) per individual per trapping session of these four prey species was also determined.

VEGETATION ANALYSIS

A vegetation analysis of each of the live trapping Grids 1, 2, 3a and 3b was carried out in September 1980, using a bridge point method (Brown 1954), the bridge having a total of 10 points each 2,54 cm apart. The bridge was placed at each of the 100 trap stations, and each of the vegetation types touched was scored, thus yielding a total of 1000 scored points per grid. The percentage contribution of each vegetation type (ground small rocks and rock were also scored as a vegetation type) was determined for each of the grids, as a percentage of the total number of scored points.

MOUSE DISTRIBUTION

Mouse distribution was determined in two ways, by using a direct method of trapping in areas around the island, but concentrating on the east coast (Fig. 2), and an indirect method of searching for evidence of mice or their activities. This was conducted during two circuminsular trips, and other trips away from the study areas. Evidence of mice or their activities may be classes as such:

accumulation of seeds under stones or rocks
runways through the vegetation
mouse burrows
mouse faeces.

Using this evidence it was possible to plot the distribution of the mice around the island, and in addition making it also possible to estimate three degrees of density, based on the degree of evidence of the activities as well as from the density of mice on the live trapping grids in the various habitat types. Fig. 5 shows the distribution of mice around the island based on these three density estimates.

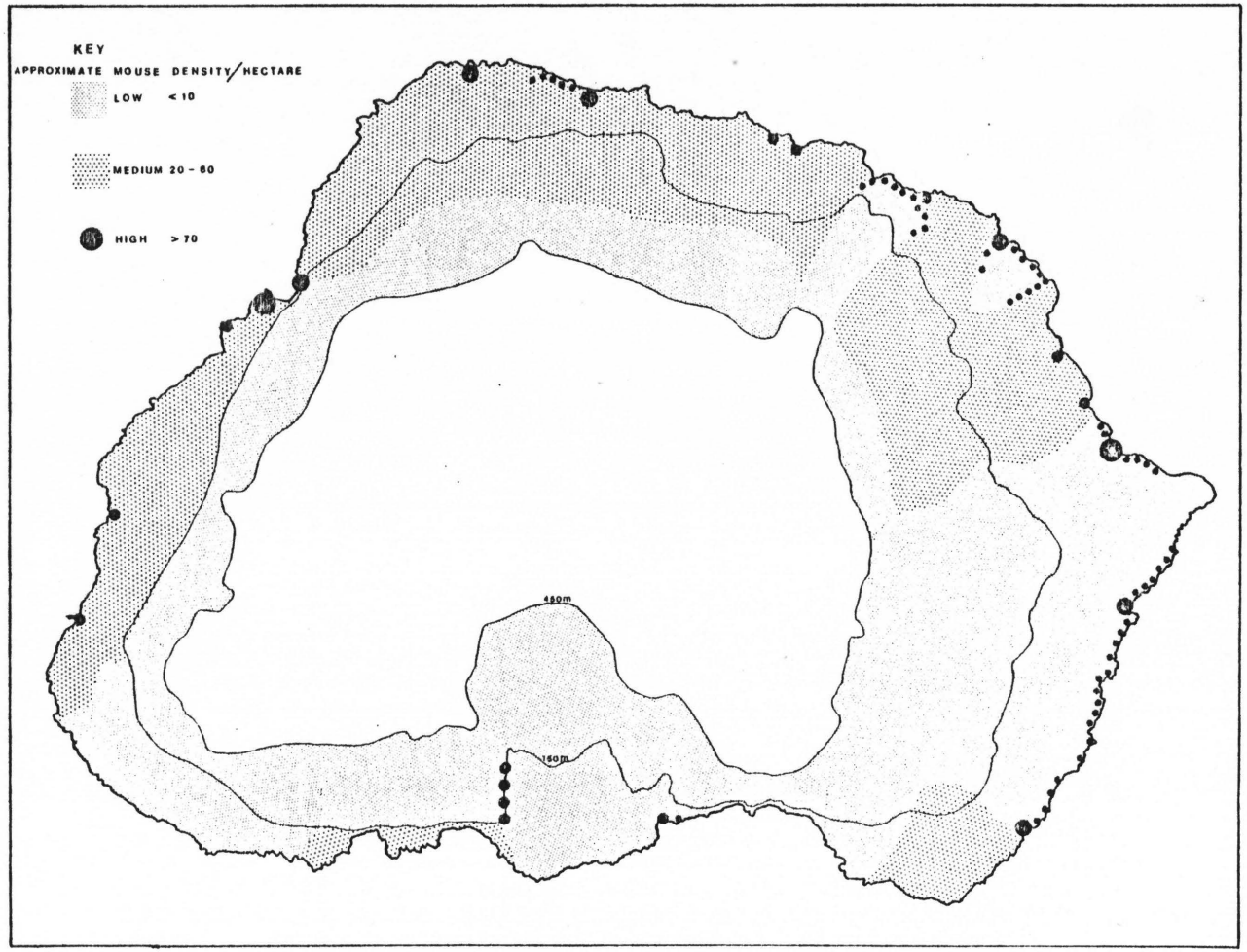

Figure 5: The distribution and relative density of house mice on Marion Island during 1979-1980.

CHAPTER 5

INVERTEBRATE INVESTIGATION: RESULTS AND DISCUSSION

It is apparent from Fig. 6 that Grids 1, 2, 3a and 3b supported varying amounts of biomass of the four main prey species (*Pringleophaga marioni* larvae, weevil larvae and pupae, weevil adults and spiders) of the mice (*vide* Food, feeding and stomach content analysis, in Chapter 10), during the various trapping sessions. Apart from Grid 4, which supported such a low biomass, that these main prey species were only caught occasionally, Grid 4 supported the lowest biomass during any trapping session. This is probably due to the high percentage of rocks and ground and *Blechnum penna-marina*, which tends to only support low densities of invertebrates (Burger 1978), both then contributing to cause the low total biomass of invertebrates on this grid.

Grid 1 supported the highest biomass of the four main prey species, during all the trapping sessions, except Sessions 4 and 5 when Grid 3a supported the highest biomass. This high biomass of invertebrates on Grid 1 is to be expected due to the vegetation types found on this grid, especially *Cotula plumosa* and *Calitriche antarctica* which Burger (1978) found to support the highest density of invertebrates of any vegetation type sampled.

Although the species composition of Grids 3a and 3b varied greatly (*vide* Vegetation analysis: results and discussion, in Chapter 6), these two grids tended to support a similar biomass of the main prey invertebrates, during all the trapping sessions except Session 1 and again more noticeably in Session 5. It would appear that on these two grids the biomass of the main prey invertebrates tended to decrease in winter, Period 2, and then increase in summer to a peak in Session 5, with a subsequent post-summer decline. While on Grid 1 there was a decrease in the biomass of these four prey species to a mid-summer low, in Session 4, with a subsequent increase towards winter. Little is known of the life cycle of these invertebrates, so any explanation of the changes occurring in the numbers and biomass in the different habitats represented by these grids would be speculative. The change in biomass and numbers / m^2 of these four main prey species, as calculated from the sum of the grids, is shown in Figs 7 & 8. In plotting the change in biomass and numbers / m^2 from the four grids summed, this would tend to negate the different trends that might occur between the grids. This does, however, give an indication of the total change in numbers and biomass

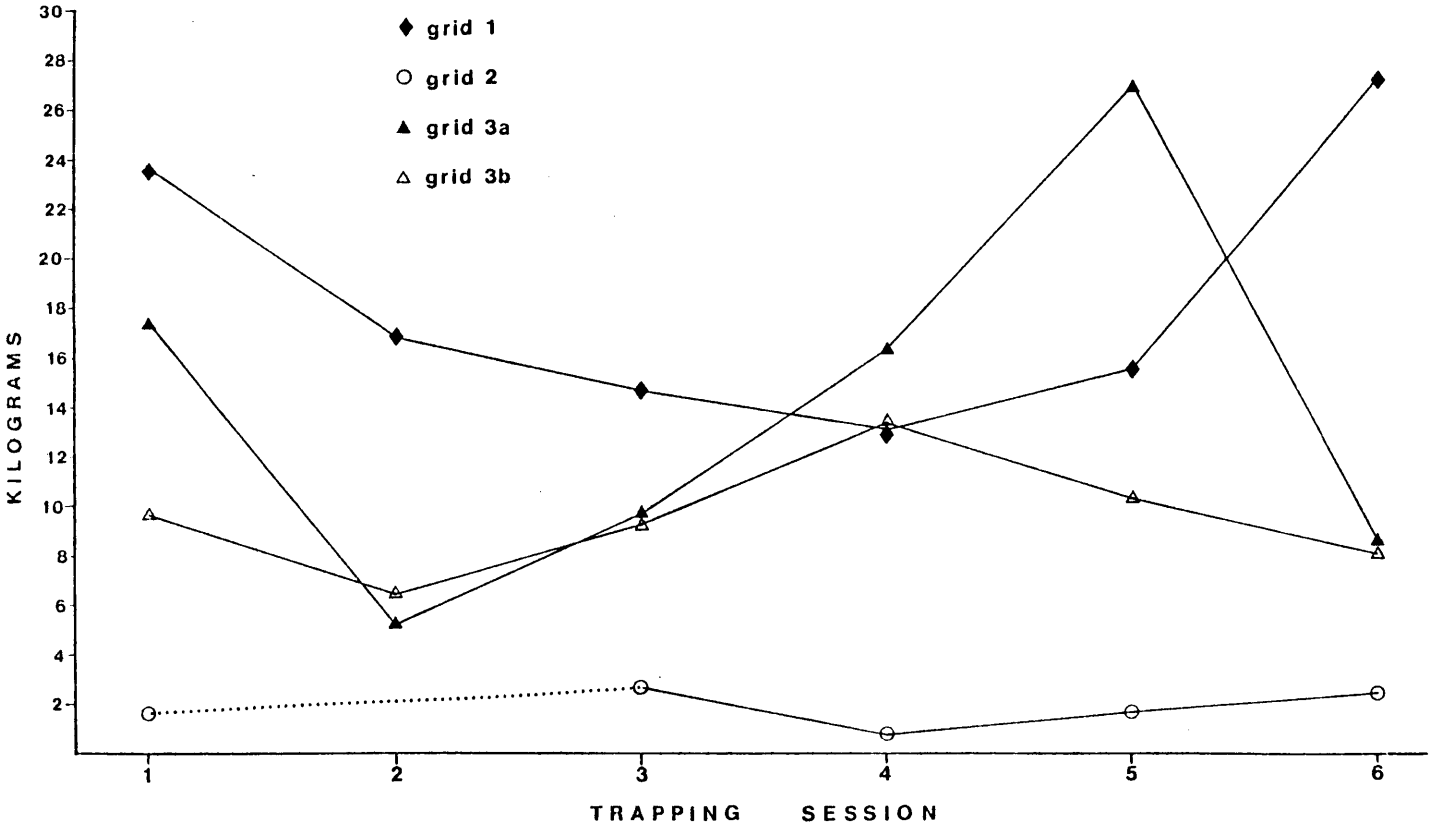

Figure 6: The sum total kilograms dry mass per grid area of the four main invertebrate prey species (*Pringleophaga marioni* larvae, weevil adults, weevil larvae and spiders) for each trapping session on Grids 1, 2, 3a and 3b on Marion Island during 1979-1980. Data for trapping session 2 on Grid 2 are missing.

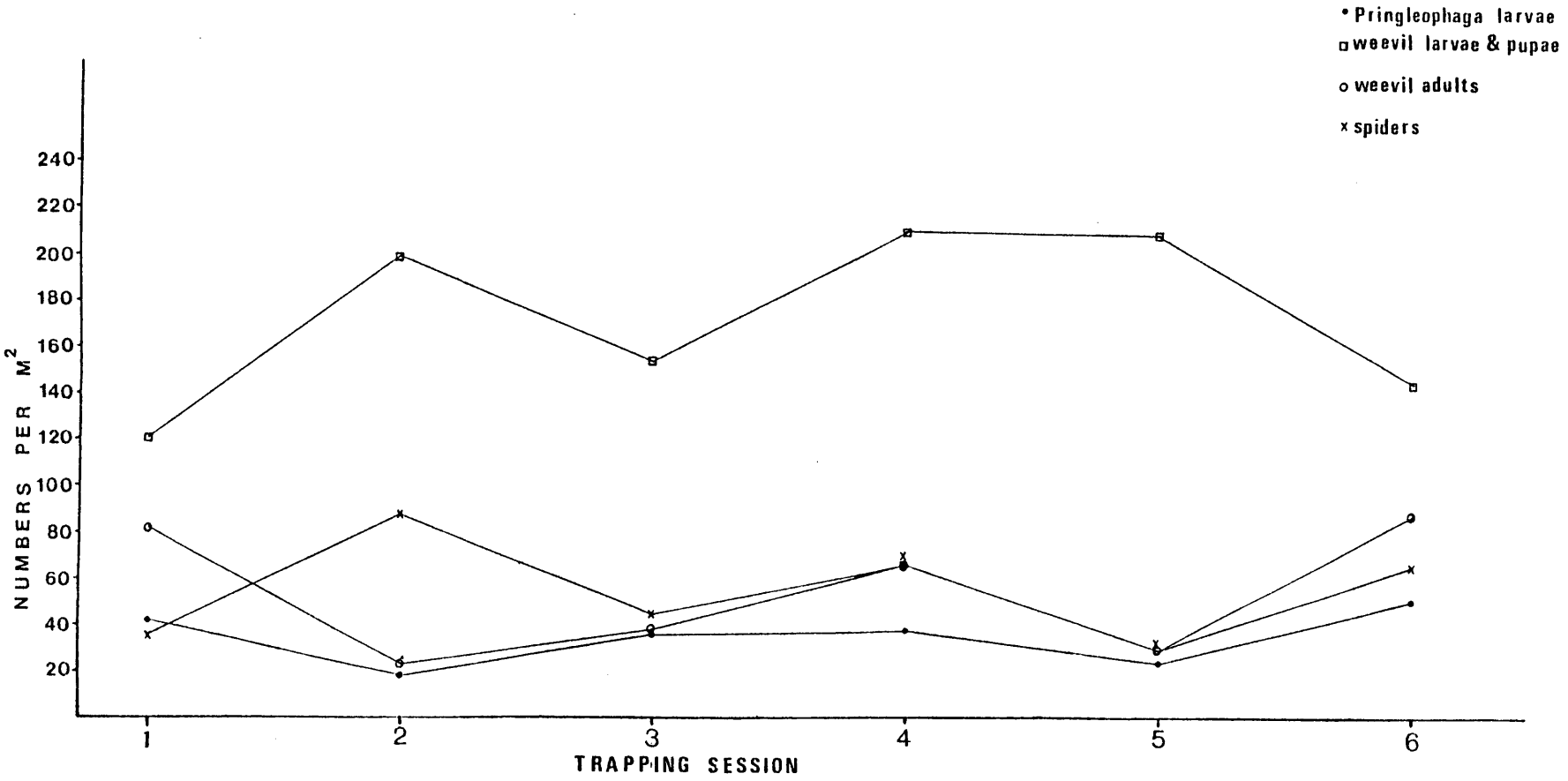

Figure 7: The mean numbers per m^2, for the sum of Grids 1, 2, 3a and 3b, of the four main invertebrate prey species of mice for each trapping session on Marion Island during 1979-1980.

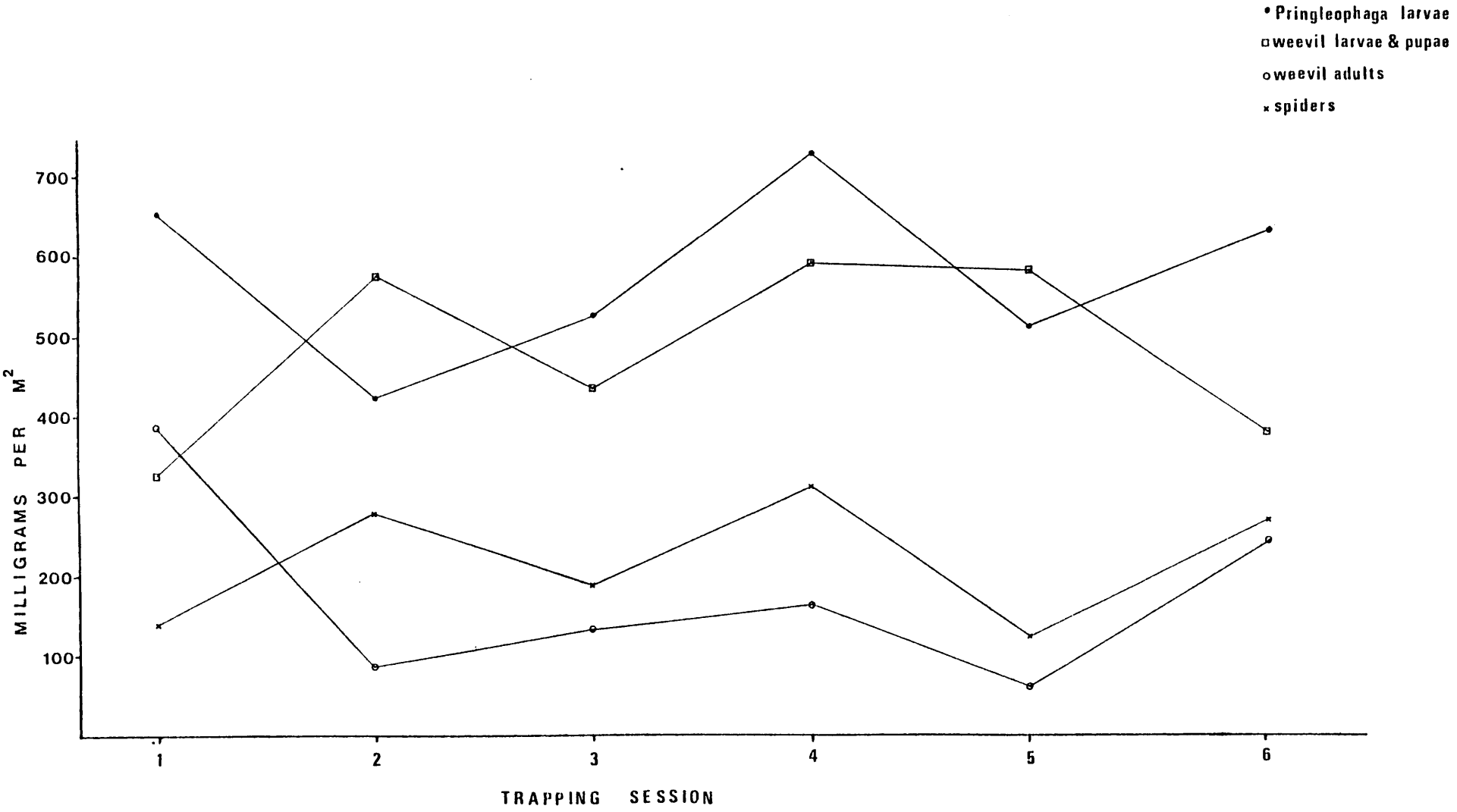

Figure 8: The mean biomass per m^2, for the sum of Grids 1, 2, 3a and 3b, of the four main invertebrate prey species of mice for each trapping session on Marion Island during 1979-1980.

occurring for these species in the study area on Marion Island during the year.

The mean biomass per individual per trapping session is shown in Fig. 9. From this it is apparent that with the exception of the *Pringleophaga marioni* larvae, there does not appear to be a great variation in the individual biomasses of the other three prey species. *P. marioni* larvae increased greatly in size during the summer months. It was during this period that *P. marioni* pupae tended to be found in the stomach contents of the mice, so it is possible that the larvae were increasing in size in order to pupate.

Although earthworms formed the greatest percentage of the biomass, 87% of the total biomass of cores sampled by Burger (1978), these were not included in these data, as earthworms did not normally enter into the diet of the mice (*vide* Food, feeding and stomach content analysis, in Chapter 10).

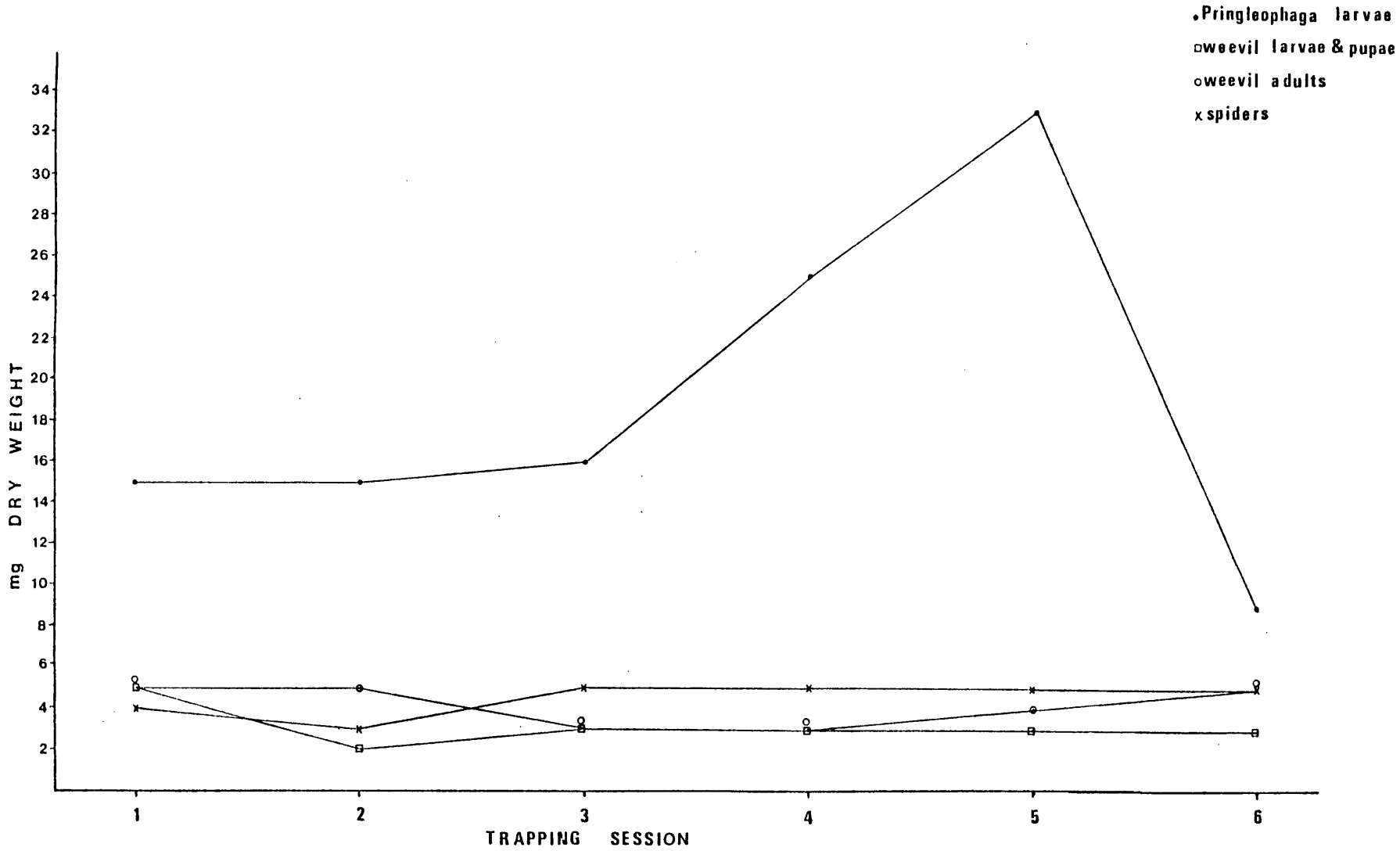

Figure 9: The mean g dry weight per individual for the four main invertebrate prey species of mice, for each trapping session on Marion Island, during 1979-1980.

CHAPTER 6

VEGETATION ANALYSIS: RESULTS AND DISCUSSION

The percentage contribution of each vegetation type on the Grids 1, 2, 3a and 3b is shown in Table 3. On Grid 1 *Cotula plumosa* and *Callitriche antarctica* together represented 38% of the vegetation, as these two species are indicative of biologically influenced areas (Huntley 1971), and this has been found to be due to the manuring action of the penguins and the Procellariid bird species in this area (Smith 1977). It should also be noted that little *Azorella selago*, *Blechnum penna-marina* and *Acaena adscendens* was found on Grid 1, as these tend to be negatively influenced by manuring (Huntley 1971). *Agrostis stolinifera*, which is an exotic grass species, covers 21% of the grid, and this grass would appear to exclude the indigenous grasses in these disturbed areas (*Pers. obs.*).

The species composition of Grids 2 and 3a appeared to be very similar, but the relative percentage contribution of each species was very different, with the species dominant on Grid 2 being more characteristic of a well-drained slope complex, as is found in these porous black lava areas (Huntley 1971), with *B. penna-marina* fernbrake dominating, and with 23% of the grid being covered with rock or ground, with in addition *Azorella selago* being an important plant species on this grid. Approximately 50% of Grid 3a is covered with grass species, with a great amount of mosses and leafy liverworts also being found. It is apparent that Grid 3a is more well drained than Grid 3b, as there was a greater percentage of those plant species more characteristic of well drained conditions, namely *B. penna-marina* and *A. selago*, with in addition approximately 4% of the grid being covered in rock and ground. Grid 3b was the swampiest grid sampled, and was the most characteristic of a mire, with 68% of the grid being covered in grass species, while in addition the lowest percentage of plant species that are dependent on a well drained substrate were found on Grid 3b.

It is thus apparent that the vegetation varied greatly between these four grids. Although the vegetation was not sampled on Grid 4 this consisted mainly of *A. selago* with a few mosses and a small amount of epiphytic *Agrostis magellanica*, as is typical of the *A. selago* feldmark, on which this grid was situated. The density of invertebrates associated with the various vegetation types would vary with the varying amounts of the vegetation types in each of the grids (Burger 1978).

Table 3: The percentage of each vegetation type on Grids 1, 2, 3a and 3b in September 1980, on Marion Island

	Vegetation type														
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Grid 1	14%		2%		9%	<1%	3%		2%	25%	2%	18%	13%	3%	21%
Grid 2	6%	<1%	33%	19%	9%	3%	7%	8%	8%			4%	<1%	< 2%	
Grid 3a	33%	16%	13%	10%	>1%	>1%	1%	>1%	2%			15%	1%	8%	
Grid 3b	54%	14%	7%	1%							2%	9%		12%	

a. *Agrostis magellanica*
b. *Unicinia dickeii*
c. *Blechnum penna-marina*
d. *Azorella selago*
e. *Poa cookii*
f. *Acaena adscendens*
g. Rock
h. Small rock
i. Ground
j. *Cotula plumosa*
k. *Ranunculus biternatus*
l. Mosses and liverworts
m. *Callitriche antarctica*
n. Others
o. *Agrostis stolinifera*

CHAPTER 7

LIVE TRAPPING RESULTS

MOUSE NUMBERS

The estimate (± S.E.) of mouse numbers for each of the grid trapping sessions is shown in Fig. 10. From this it can be seen that all the grids contained large numbers of mice in Session 1, just before winter, with the numbers then decreasing during winter, Sessions 2 and 3, and early summer, Session 4, with the numbers of mice then finally increasing to a peak during mid- and late summer, Sessions 5 and 6.

Grid 1 contained the largest number of mice during any of the trapping sessions, with the lowest number of mice being trapped during Session 3, and the numbers then increasing to a peak during Session 5. The greatest rate of increase in numbers of mice trapped occurred from Session 4 to Session 5, with r = 1,03, while the greatest decrease in numbers occurring between Sessions 5 and 6, with r = 0,67. A storm, during which waves swept across approximately 18% of the grid occurred between Sessions 5 and 6, and may have been a contributing factor to this rapid decrease in numbers.

Grid 2 showed a steady decrease in numbers of mice on the grid, r = -0,3/ Session, from Session 1, to the mid-summer low in numbers of mice in Session 5. There was a subsequent increase in mouse numbers, to a late summer maximum during Session 6, with r = 0,93.

The number of mice on Grid 3a decreased from a pre-winter peak during Session 1, to a summer trough during Session 4, with r = -0,57 / Session, with a subsequent increase to a late summer peak in Session 6, with r = 0,78 / Session.

Grid 3b showed a decrease in mouse numbers from Session 1 to Session 4, with r =-0,43 / Session, with the numbers of mice on the grid then increasing to Session 5, r = 0,56, with only a slight subsequent increase to Session 6.

The numbers of mice on Grid 4 were the lowest for any of the grids sampled, with the peak number of mice occurring during mid-winter in Session 1, and decreasing to a spring trough during Session 2, with r = -0,18. The numbers of mice on the grid then increased to a maximum during Session 4, in late summer, with r = 0,55 / Session.

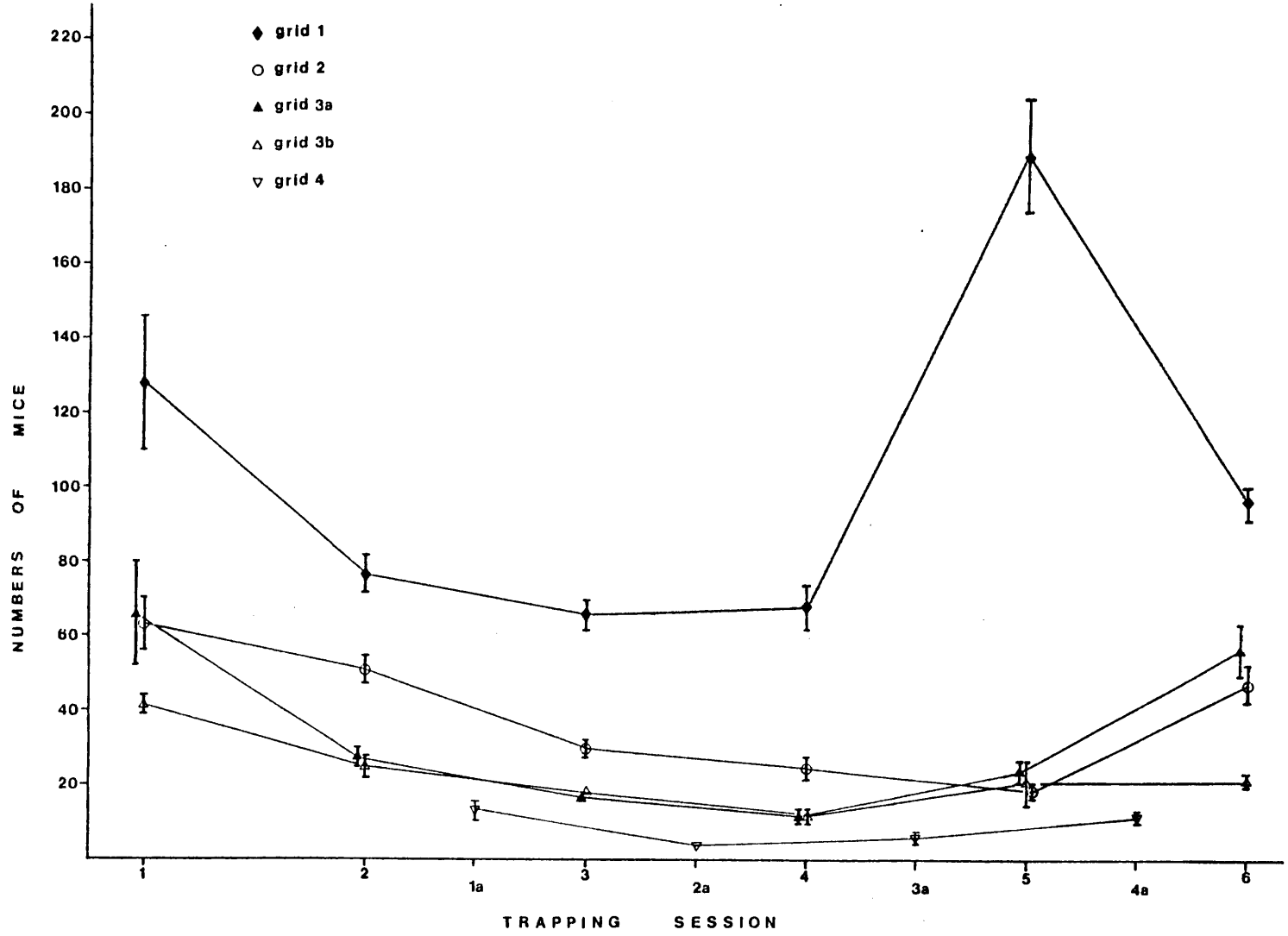

Figure 10: Estimate (± S.E.) of numbers of mice during each trapping session on five grids on Marion Island during 1979-1980. Grid 4 was trapped on a different trapping regime to that of Grids 1, 2, 3a and 3b. Best fit of line between points, fitted by eye.

MOUSE DENSITY

The density of mice per hectare for the habitat types represented by Grids 1, 2 and 3a, was determined using a correction factor determined from the assessment lines. The log density (± S.E.) for each of the grid trapping sessions is shown in Fig. 11. Although assessment lines were laid out on Grid 3b, data from these lines was not used as one of the assumptions, that of even distribution of mice on the grid (O'Farrell *et al.* 1973), is not met. This can be seen in Fig. 12, which shows the distribution of captures of mice on each of the grids for all the trapping sessions.

Table 4 shows the number of mice per hectare, as determined from the numbers of mice on each of the grids, as well as the corrected density of mice per hectare for Grids 1, 2 and 3a, as determined using the assessment line data. From this it can be seen that the mouse density, on these three grids, is lower and probably more accurate when using the assessment line correction factor, which eradicates the edge effect of the grid encountered during trapping (Stenseth, Hagen, Østbye & Skar 1974; Swift & Steinhorst 1976; O'Farrell *et al.* 1976).

Figure 11 shows a similar trend to that in Fig. 10, but with these three grids supporting the lowest density of mice during Session 4. Grid 1 still peaked during Session 5, but with the increase from Session 4 being r = 1,37, and the subsequent decrease to Session 6 being r = -0,53. There was, however, in addition a large decrease in mouse density from Session 1 to Session 2. Grids 2 and 3a showed a similar trend, with a decrease in mouse density from Session 1 to Session 4, with r = -0,52 and r = -0,65 respectively, and a subsequent increase to Session 6, with r = 0,68 and r = 0,69 respectively.

SEX RATIO

The sex ratio of unity was tested using X^2, for all mice caught on each of the grids for each of the trapping sessions. The sex ratio did not deviate significantly ($p<0,05$) from unity.

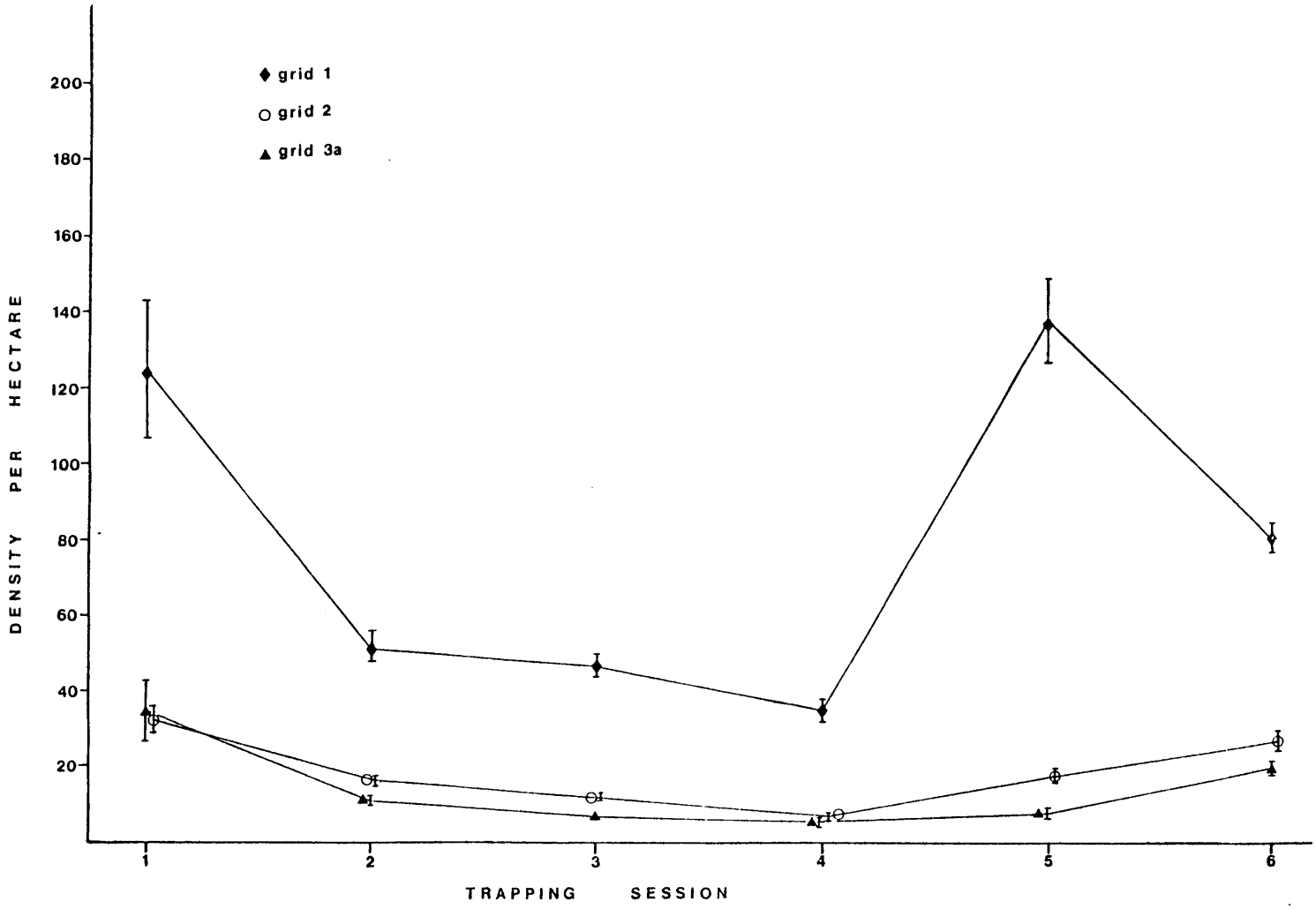

Figure 11: Density (± S.E.) of mice per hectare, corrected using assessment line data, during each trapping session on Grids 1, 2, and 3a on Marion Island during 1979-1980. Best fit of line between points, fitted by eye.

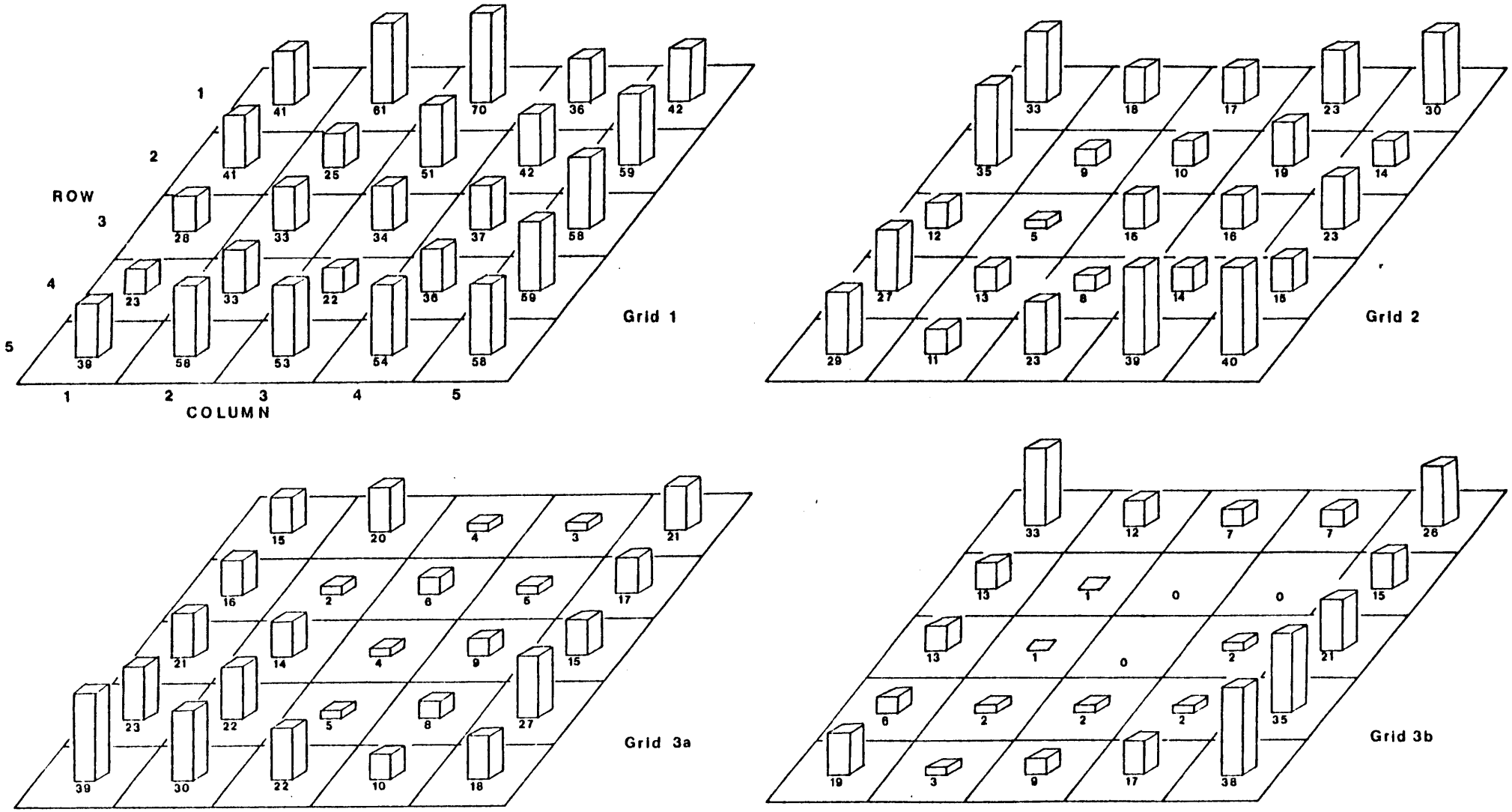

Figure 12: Blocked distribution of captures of mice, for the sum of all the trapping sessions, on Grids 1, 2, 3a and 3b on Marion Island during 1979-1980.

Table 4: The (a) numbers (± S.E.) of mice per grid, (b) density (± S.E.) of mice per hectare and (c) the corrected density (± S.E.) of mice per hectare, from assessment live data on Grids 1, 2 and 3a, of house mice for each trapping session on Marion Island during 1979 - 1980.

		Trapping Session					
		may/June	July/Aug	Sept/Oct	Nov/Dec	Jan/Feb	March/April
1	a	128,3 ± 18,6	77,5 ± 5,4	66,6 ± 4,0	68,3 ± 6,3	190,0 ± 15,6	97,0 ± 4,6
	b	158,4 ± 22,9	96,1 ± 6,7	82,2 ± 4,9	84,3 ± 7,8	234,6 ± 19,2	119,8 ± 5,7
	c	125,7 ± 18,3	52,2 ± 3,6	47,6 ± 2,8	34,9 ± 3,2	138,4 ± 11,3	80,8 ± 3,9
2	a	63,0 ± 7,1	51,1 ± 3,7	29,8 ± 2,2	25,5 ± 3,1	19,1 ± 1,9	48,0 ± 4,8
	b	77,8 ± 8,8	63,1 ± 4,6	36,8 ± 2,7	31,4 ± 3,8	26,6 ± 2,3	59,3 ± 5,9
	c	32,9 ± 3,6	16,3 ± 1,2	12,0 ± 0,9	6,9 ± 0,9	9,7 ± 0,9	20,9 ± 2,1
3a	a	66,0 ± 14,7	28,5 ± 1,5	17,0 ± 0	12,0 ± 2,3	24,0 ± 3,0	57,0 ± 6,8
	b	81,5 ± 18,2	35,2 ± 1,9	20,9 ± 0	14,8 ± 2,8	29,6 ± 3,6	70,4 ± 8,4
	c	35,0 ± 8,0	11,0 ± 0,5	6,8 ± 0	5,3 ± 1,0	8,3 ± 1,0	20,1 ± 2,3
3b	a	41,6 ± 2,6	24,9 ± 3,2	18,0 ± 0	12,0 ± 2,0	21,0 ± 6,0	21,8 ± 1,8
	b	51,4 ± 3,2	30,7 ± 4,0	22,2 ± 0	14,8 ± 2,5	25,9 ± 7,4	26,9 ± 2,3
4		1a	2a	3a	4a		
	a	13,3 ± 2,5	4,0 ± 0	6,4 ± 1,6	12,1 ± 1,1		
	b	16,5 ± 3,1	4,9 ± 0	7,9 ± 2,0	14,9 ± 1,4		

SIZE CLASSES

Relative percentage frequency histograms, with 3 g weight class intervals, were constructed for Grids 1, 2, 3a and 3b, and are shown in Figures 13, 14, 15 and 16. There was a significant difference ($p<0,05$) between the means of the frequency classes of males and females for some of the grid trapping sessions. Males were found to be heavier in their mean weight in all cases. Weights of all mice caught and measured were used, but as pregnant females can only be detected in the last three to four days of pregnancy (Delong 1967; Theiler 1972) this would bias the distribution to the heavier weight classes, during the periods when the females were reproductively active.

The weight distribution of mice increased, on all the grids, between Sessions 1 and 3, with no recruitment into the population occurring. A new cohort of trappable mice, however, entered the population on Grid 1, during Session 4, while new cohorts entered the populations on Grids 2, 3a and 3b during Session 5, and mice of a low weight continued to be caught in Session 6.

REPRODUCTIVE STATE

The reproductive state of males over 12,5 g, with either scrotal or non-scrotal testes, for each grid trapping session, is shown in Fig. 17. There are at least some males with scrotal testes during all the trapping sessions on each of the grids, with all males, on all the grids, having scrotal testes during Session 4, in mid-summer, and fewest males having scrotal testes during pre- and mid-winter, in Sessions 1 and 2. A greater percentage of males were scrotal during Session 3 on Grid 1 than on any of the other grids.

The reproductive state of females over 12,5 g, either non-parous, parous or pregnant/lactating, for each grid trapping session, is shown in Fig. 18, but as pregnancy could only be detected in the last three to four days, this last category would have been underestimated. If the parous and pregnant/lactating categories are lumped to represent reproductively active females this would then give an idea of the season of reproductive activity. Apart from a few females being parous during Sessions 1 and 2 on Grid 1, the main period of reproductive activity

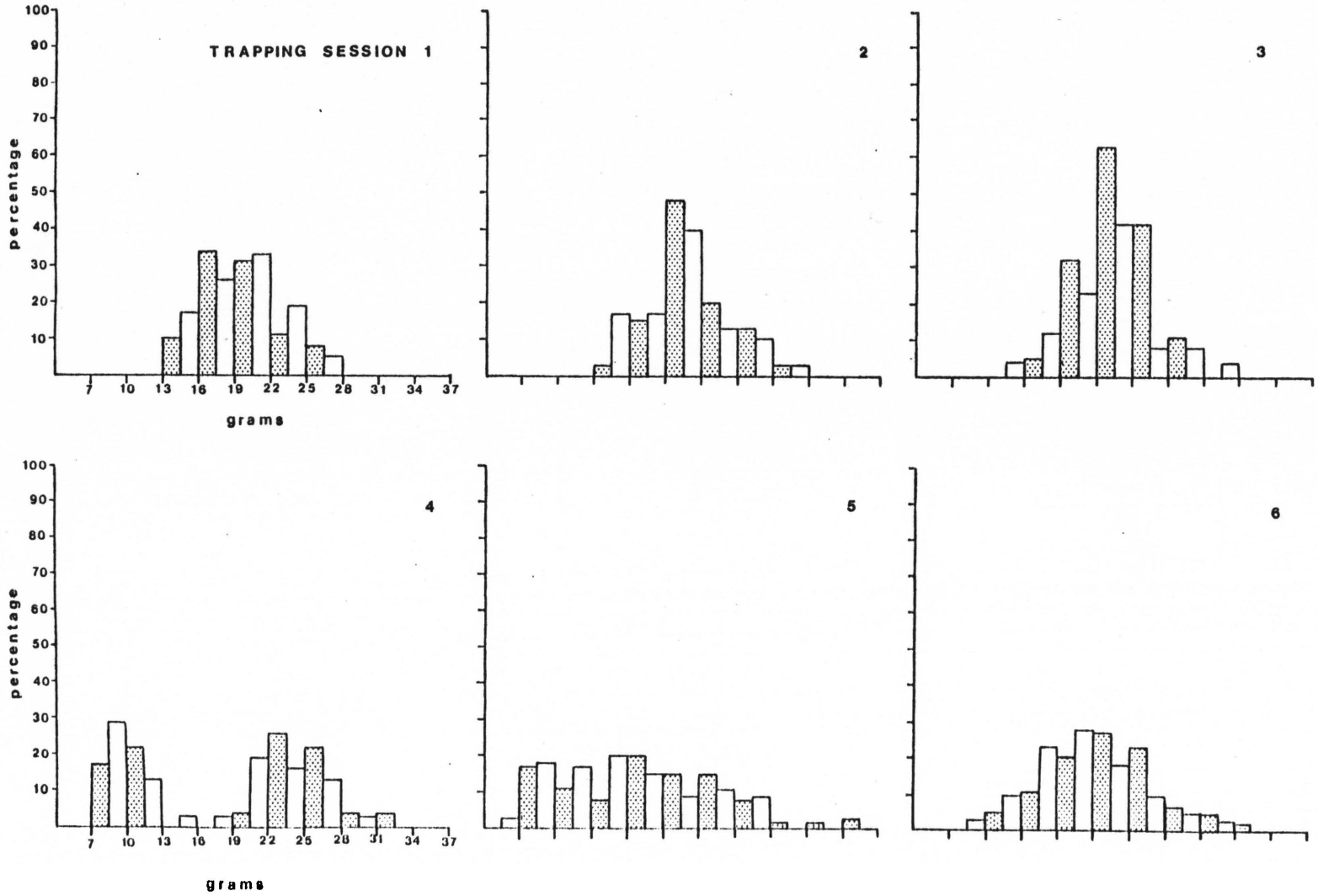

Figure 13: Relative percentage frequency histogram, with 3 g weight class intervals, for each trapping session, of male (stippled) and female (open) house mice on Grid 1 on Marion Island during 1979-1980.

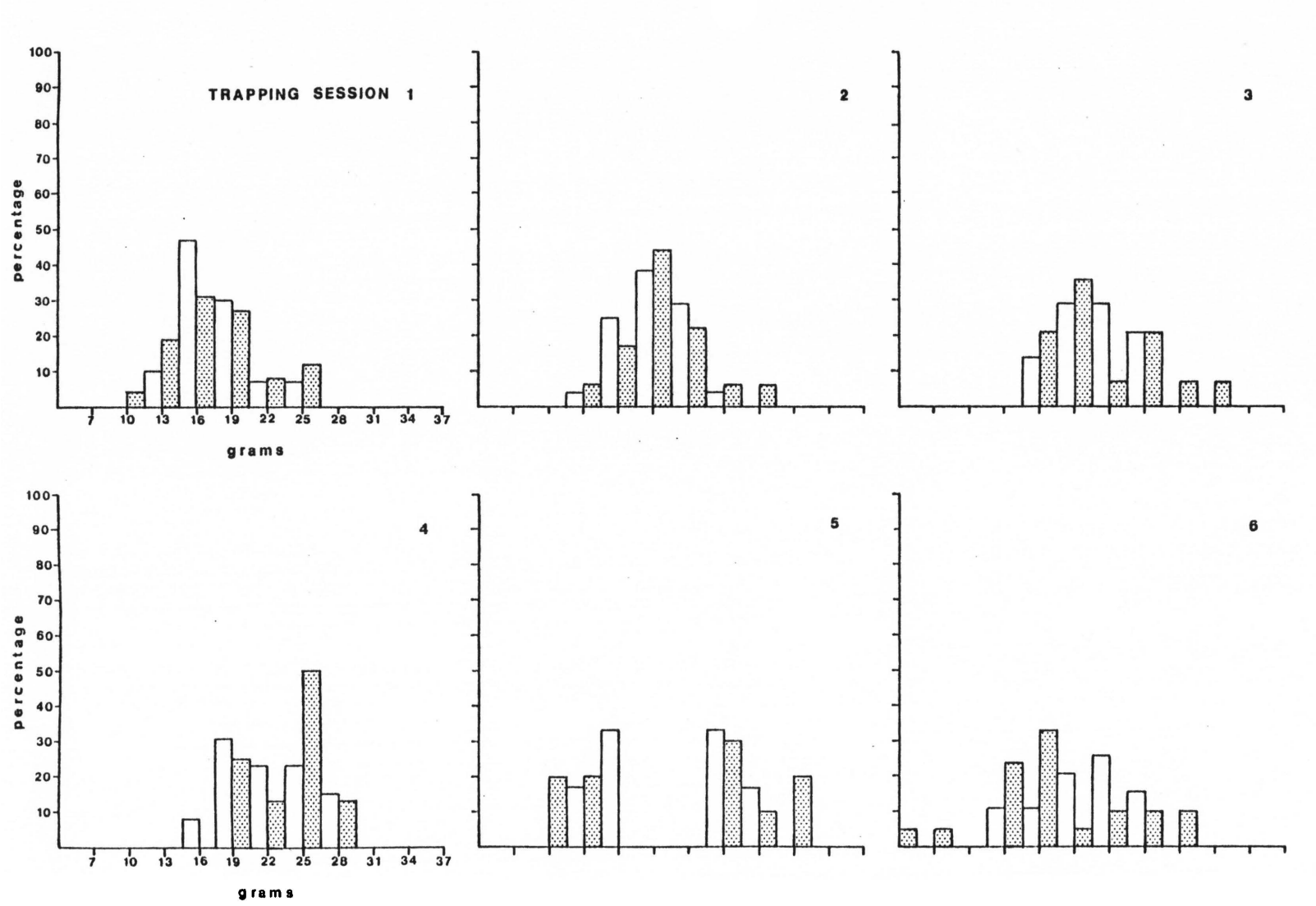

Figure 14: Relative percentage frequency histogram, with 3 g weight class intervals, for each trapping session, of male (stippled) and female (open) house mice on Grid 2 on Marion Island during 1979-1980.

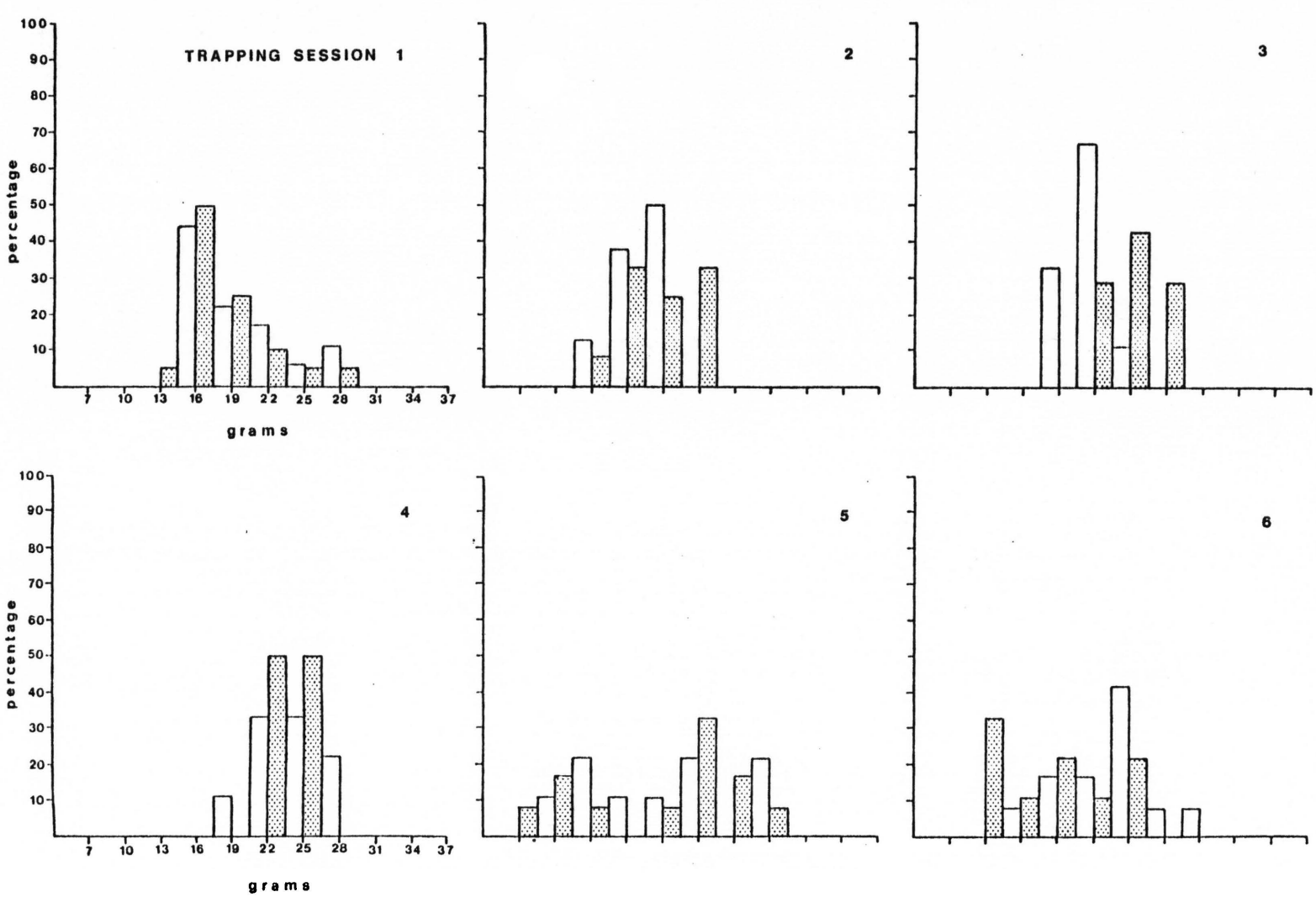

Figure 15: Relative percentage frequency histograms, with 3 g weight class intervals, for each trapping session, of male (stippled) and female (open) house mice on Grid 3 a on Marion Island during 1979-1980.

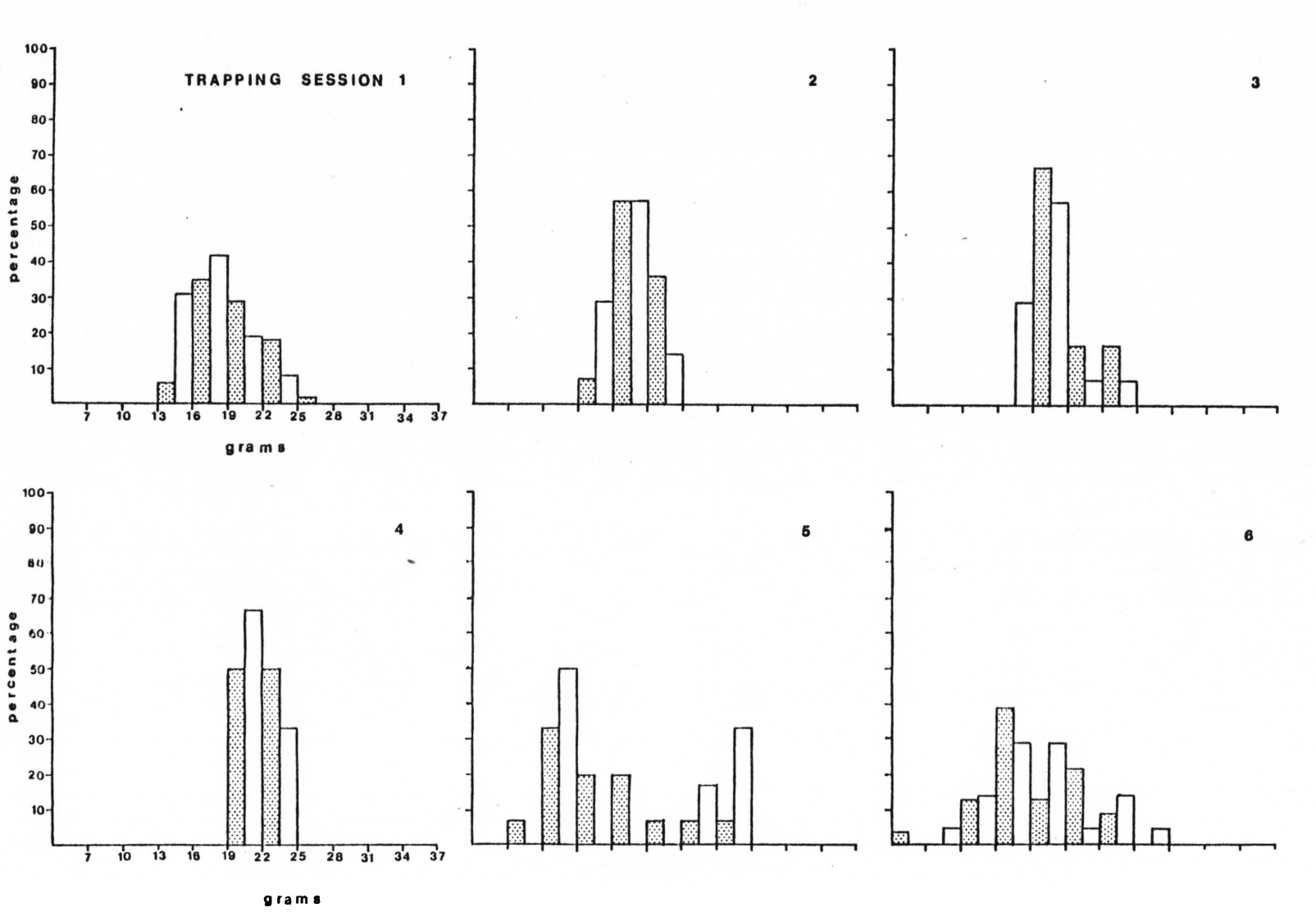

Figure 16: Relative percentage frequency histogram, with 3 g weight class intervals, for each trapping session, of male (stippled) and female (open) house mice on Grid 3b on Marion Island during 1979-1980.

occurred during Sessions 3, 4 and 5, with most females being pregnant in Session 4. If half an intertrap session period is added to either side of the trapping sessions in which females were found to be reproductively active, then the reproductive season would be found to span six months, on Grid 1.

The greatest number of pregnant females were found during Session 5, on Grids 2, 3a and 3b, while most females were reproductively active during Session 5, on Grids 2 and 3a, and during Session 4 on Grid 3b. The reproductive season would then span six months on Grid 2, four months on Grid 3a and eight months on Grid 3b, if those incidental cases of females being parous were ignored for some of the grid trapping sessions.

JUVENILES

The percentage of juveniles, mice that were less than or equal to 12,5 g, of the total number of mice trapped during each of the trapping sessions is shown in Fig. 19. Juveniles were caught on Grid 1 during five trapping sessions, with a peak in captures during Session 4, in mid-summer. Juveniles were trapped on Grid 2, during Sessions 1, 2, 5 and 6, with the greatest number being caught during Session 5. While most juveniles were caught on Grids 3a and 3b during Sessions 5 and 6, with a peak in the number of juveniles captured occurring during Session 5.

SURVIVAL

The mean percentage survival (as determined by trapping) of mice in the following trapping sessions, was calculated on the basis of recaptures of mice on Grids 1, 2 and 3a. Data from Grid 3b were not used as mice were not actually resident on the grid, Fig. 12, thus the effect of the particular habitat on survival was not for the grid habitat, but for that of the surrounding area, while on the other three grids mouse survival was affected by the grid habitat type. Survival of mice on Grids 1, 2 and 3a decreased exponentially, and there was no significant difference in the survival rates between the grids ($p<0,05$), thus the mean percentage

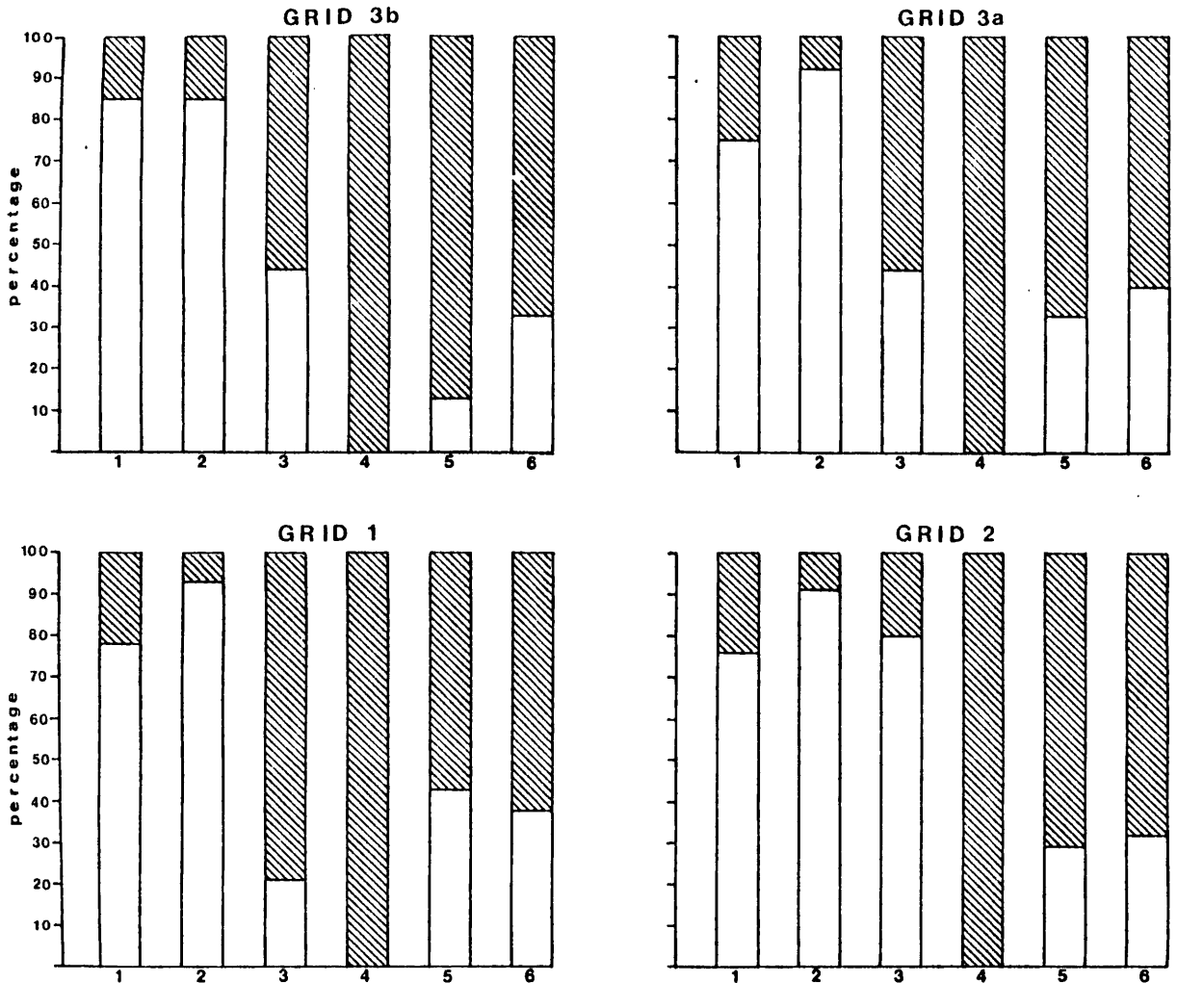

Figure 17: The relative percentage scrotal (crosshatched), and non-scrotal males (open) during each trapping session on Grids 1, 2, 3a and 4, on Marion Island during 1979-1980.

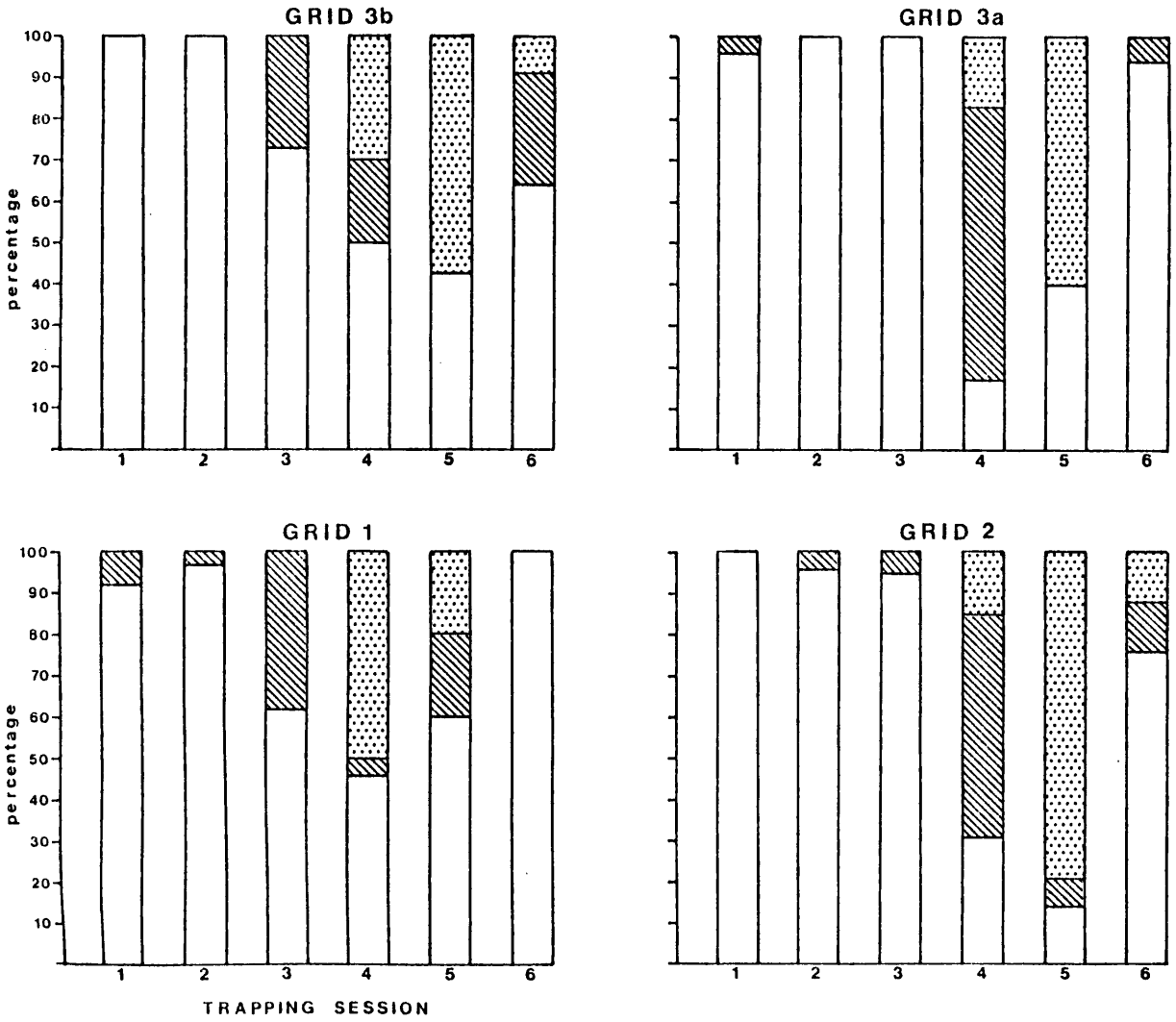

Figure 18: The relative percentage pregnant/lactating (stippled), parous (crosshatched) and non-parous (open) females during each trapping session on Grids 1, 2, 3a and 3b on Marion Island

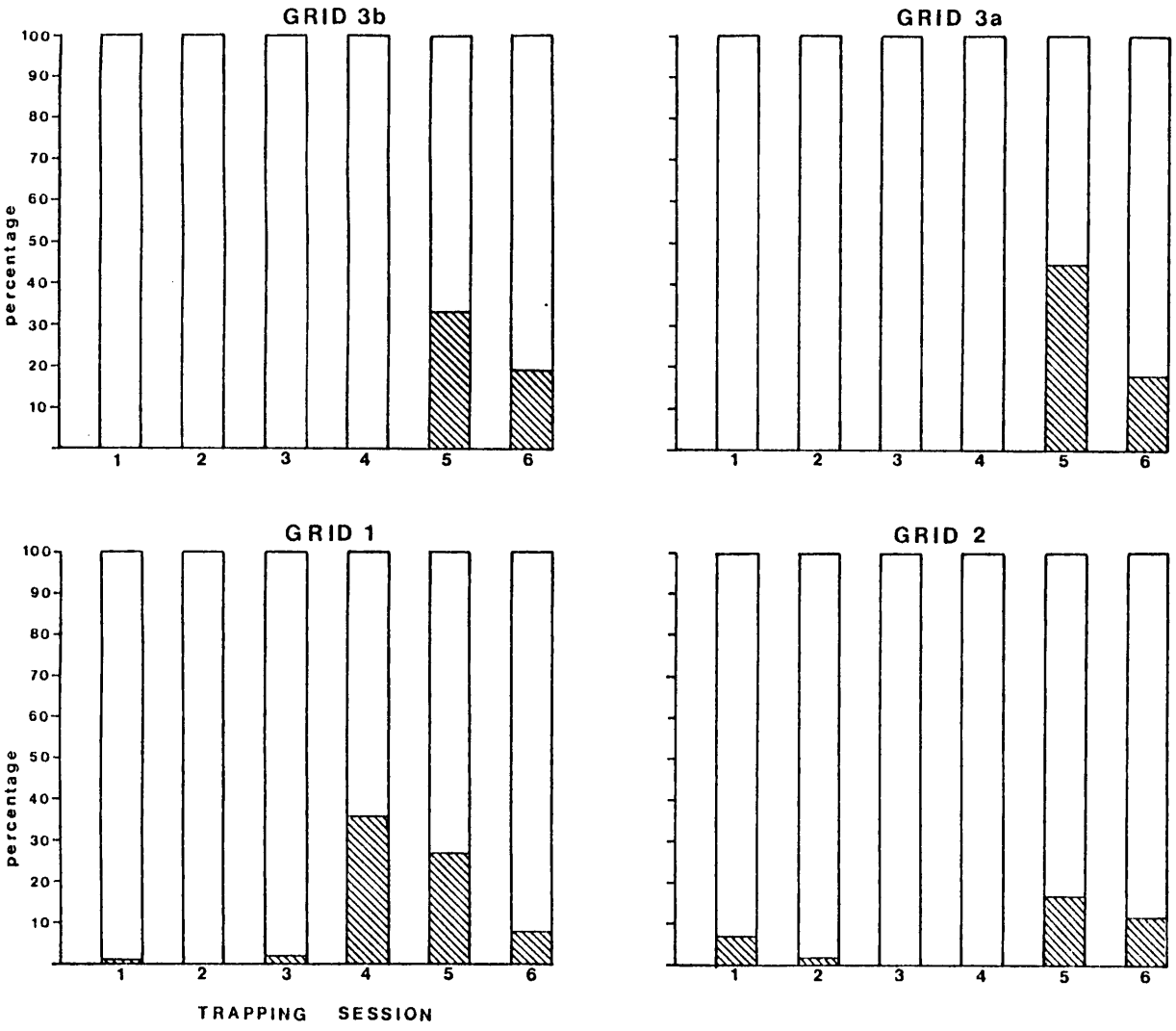

Figure 19: The relative percentage juveniles (crosshatched) of the total number of mice caught during each trapping session on Grids 1, 2, 3a and 3b, on Marion Island during 1979-1980.

survival was calculated as $y = 80,23^{-0,53x}$ $r = 0,97$. Thus the chance of survival, to the following trapping sessions, increased as the mice were caught more often and were thus subsequently older.

REFUGE AVAILABILITY

The number of grid blocks with refuge sites, which were seen during the year, is shown in Table 5. This was then used to calculate a percentage of the total of the grid that was available to mice as a potential refuge. Grid 1 had the greatest percentage of the grid available as refuges, with Grid 3b having the lowest available number of refuges.

Table 5: The number of grid blocks in which refuges were seen and this represented as a percentage of the grid available for refuges, on Grids 1, 2, 3a, 3b and 4, on Marion Island during 1979 - 1980

Grid	Number of grid blocks with refuges	Percentage of the grid with available refuges
1	66	81%
2	55	68%
3a	19	23%
3b	4	5%
4	19	23%

DISCUSSION

Populations of house mice found on sub-Antarctic islands have up to now only been studied for each particular island as a whole (Anderson & Condy 1974; Berry & Peters 1975; Bonner & Leader-Williams 1977; Berry *et al.* 1978), yet each of these islands presents a range of habitat types. Five habitat types, of which three were examined more intensely, were studied to compare changes in numbers and reproductive activity of house mice living in each area. Grids 1, 2 and 3a were examined more closely than Grids 3b and 4, for which only estimates of numbers of mice and not densities were available.

Grids 1 and 2 were in areas that provided a potentially large number of refuges for mice (Table 5). On Grid 1 mice were able to easily burrow into the peaty soil, as well as utilising some of the bird burrows in that area (M. Schramm, *pers. comm.*). On Grid 2 a large number of refuges were available in the black lava, while in addition mice were also able to burrow into the vegetated slopes. Refuges on Grids 3a and 3b were fewer than on Grids 1 and 2, as mice were not able to burrow into the substrate, with the water table being only just sub-surface. A few refuges were available on Grid 3a in the rock intrusions, but no substantial refuges were available on Grid 3b, and mice appeared to move onto this grid from the surrounding areas in which potential refuges were to be found. Refuges were found on Grid 4 in the *Azorella selago* cushions, into which the mice burrowed, as well as under some of the rocks found in that area. Thus mice on Grids 1 and 2 were able to find more and better shelter than mice on Grids 3a, 3b and 4, where fewer refuges were available (Table 5). The availability of home sites (refuges) has been found to be a limiting factor in the occurrence of mice (Delong 1967; Newsome 1969; Briese & Smith 1973). While changes in numbers of mice in an area have been found to be closely related to changes in calorific intake (Newsome 1969; Lø_mnicki 1978; Steuck & Barrett 1978; Taitt 1981).

Calorific intake is dependent on the availability of food, and on the prevailing temperature which induces cold stress (Hart 1971; Jansky 1973; Jakobsen 1971 & 1978). House mice respond to cold stress by undergoing various physiological adjustments, and by increasing metabolic rate, which increases calorific requirement and intake (Jakobsen 1971 & 1978). Thus mice living in areas with fewer refuges will have a higher

calorific requirement, due to increased cold stress, than mice living in areas with a greater number and more protected refuges.

All grids showed a decrease in mouse numbers from Session 1 to Session 2, Fig. 10, which corresponds to a decrease in the primary invertebrate prey availability, Fig. 6, as well as to a decrease in the grass minimum temperature to below $0^{\circ}C$, Table 1, both of which will affect the nett calorific intake. The density of mice on Grids 1 and 2 continued to decrease from Session 2 to Session 4, Fig. 11. While the grass minimum temperature increased slightly during this period, but remained below $1^{\circ}C$, the rate of decrease in numbers was lower than the initial decrease from Session 1 to Session 2, yet the availability of invertebrate prey items continued to decline. This together with the fact that the survivorship curve decreased in a negatively exponential manner could account for this lower rate of decrease in number, with no recruitment into the populations at this stage, Figs 13, 14, 15, and 16. Shelter in the refuges, and huddling by mice (Myrcha 1975) would reduce their energetic requirements, and thus possibly increase their chance of survival.

The numbers of mice on Grids 3a and 3b continued to decrease from Session 2 to Session 4, yet the invertebrate prey biomass continued to increase. Even with this increase in prey biomass the availability of these prey types to the mice in these wet mire conditions is not known, and the increase may not be sufficient to offset the increased calorific requirements imposed by the lower temperatures. More refuges were available on Grid 3a than on Grid 3b, yet mouse numbers are similar on these two grids. Mice on Grid 3b probably only utilised the grid for foraging and used refuges outside the grid area, as can be seen from the pattern of grid utilisation, Fig. 12. Thus the changes in numbers of mice on Grid 3b are in fact changes in numbers of mice utilising the area but not inhabiting it. Care must thus be taken in interpreting results from this grid.

A very low invertebrate prey biomass was found on Grid 4, and in addition few refuges were available, these two factors would thus affect the nett calorific intake of the mice, which would result in the low number of mice found on this grid. A similar trend to that found on Grids 2, 3a and 3b is found on Grid 4, which suggests that similar factors could be responsible for the changes in the numbers of mice observed.

For recruitment to occur into a population, in this case the mice inhabiting a grid, immigration and natality must exceed emigration and mortality. The effect of immigration cannot be excluded, but the main component of recruitment into the populations on Grids 1 and 3a is through natality, while on Grid 2 immigration is an important factor in recruitment.

House mice are short cycling spontaneous ovulators, and as such are able to react rapidly to changes in their environment (Conaway 1971; Bronson 1979). They are potentially continual breeders, unless breeding is inhibited by one or more of the following environmental factors: photoperiod, temperature, calorific intake (Delong 1967). Photoperiod would appear to have little effect on the seasonality of breeding (Laurie 1946; Bronson 1979). Temperature was found to reduce reproduction at $5^{o}C$ and markedly depress it at $-3^{o}C$, in the laboratory (Barnett 1973). Barnett *et al.* (1975), however, showed that wild mice improved productivity, if kept at $-3^{o}C$ for eight generations. Although mice on Marion Island are subject to a mean annual low temperature there are fluctuations from $-2^{o}C$ in winter, to $3,5^{o}C$ in summer, of the grass minimum temperature, which might suggest that temperature is a controlling or a contributing factor in depressing reproduction in the colder months. On the other hand, Laurie (1946) found that mice remained reproductively active at $-10^{o}C$, if sufficient energy (food) was available. Thus temperature depresses reproduction indirectly by causing an increase in calorific requirements, and with a concomitant decrease in food supply, this results in a situation of food deprivation. Nevertheless this increase in calorific requirement was not sufficient to affect body condition, as mice increased in weight during Sessions 2, 3 and 4 (Figs 13, 14, 15 & 16).

At least some of the males appeared to be capable of reproducing during all trapping sessions on all of the grids, Fig. 17, and these were probably the socially dominant males in the area. The peak in male reproductive activity occurred during Session 4, the session prior to the increase in numbers of mice caught, on the Grids 1, 2, 3a and 3b. A greater percentage of males were in a reproductive condition, on Grid 1 in Session 3, than on any of the other grids, which may be a contributing factor to the high rate of increase in numbers of mice between Sessions 4 and 5.

It would appear that the season of reproductive activity of mice on Marion Island is dependent on the reproductive activity of the females, as females have been found to be more subject to changes in calorific requirement than were the males (Ball, Barnes & Visscher 1947; Steuck & Emlen 1953).

The effect of nutrition *per se* on the breeding season of mice should be discussed. The diet of the mice did not vary significantly during the year, with the exception of plant material being slightly more prevalent in summer (*vide* Food, feeding and stomach content analysis, in Chapter 10). Although "flushing" has been found to influence reproduction in sheep (Laing 1957), and in desert rodents (Reichman & Van De Graaff 1975), no need has been found for green vegetation in the diet of house mice for breeding to occur (Bronson 1979). It should, however, be noted that while mice become reproductively active in summer when it is warmer, and the calorific requirement is thus lower, this time also corresponds with the period when a significant increase in the size of the *Pringleophaga marioni* larvae occurs, which is the principal food of the mice. A further indication of the importance of energy on the length of the season of breeding is indicated by variation in the reproductive activity of the females between the different grids, Fig. 18. Grid 1 contained a high percentage of reproductively active females in Session 3, with reproductive activity peaking in Session 4, while no females were reproductively active in Session 6. The earlier occurrence of reproductive activity of females on this grid probably occurred due to the greater availability of food and refuges. Although reproductive activity was first observed in Session 3, a change in density was first apparent in Session 5, with the first juveniles being caught in Session 4. This becomes apparent from the frequency diagram, Fig. 13, which shows a positive skewness in Session 5, which suggests that younger (smaller) mice were on the grid in Session 4, but had at that stage not yet entered the trappable population. These, however, then entered the trappable population in Session 5, which resulted in the apparent high rate of increase from Session 4 to Session 5. There could in addition be immigration onto the grid, as it may have presented a more favourable area due not only to high available invertebrate material, but also due to the influence of bait in the traps.

The high density of mice during Session 5, on Grid 1, apparently resulted in over-utilisation of the food resources, and the population decreased to Session 6. The invertebrate prey biomass increased from Session 5 to Session 6, with a corresponding decrease in mouse density, which would apparently be in agreement with the concept of over-utilisation of food resources. Emigration, at high densities, has often been found in rodent populations, yet no evidence was found of this on Grid 1, based on the absence of marked mice caught at any distance away from the grid on the assessment lines. Lømnicki (1978) found that populations inhabiting a spatially homogenous area did not tend to display any evidence of emigration, as it is individually more beneficial to remain in a known area than to emigrate into unknown area of similar density.

No reproductively active females were found in Session 6, Fig. 18. The high densities of mice found during Session 5 would have led to an increased amount of interaction among the mice, which would increase the incidence of possible agnostic encounters which would depress reproduction by affecting the oestrous cycle of the females (Bronson 1979). In addition the over-utilisation of food resources would lead to a reduction in the calorific intake per individual, which would also cause a depression in the reproductive activity, which would affect the females more than the males, Figs 17 & 18 (Steuck & Emlen 1953). A small percentage of females were found to be reproductively active in Sessions 1 and 3, and thus a few juveniles were caught in Session 3, which suggests that some females, on Grid 1, were less energetically stressed, and were thus able to remain reproductively active and successfully raise young during the colder months.

Females on Grid 2 were primarily reproductively active in Sessions 4 and 5, with some females being pregnant in Session 6, while females on Grid 3a were primarily reproductively active during Sessions 4 and 5, Fig. 18, and with fewer females pregnant in Session 5 than on Grid 2. The length of the reproductive season, on Grid 2, is longer, especially if the incidental cases of reproductively active females found during the winter months are considered, and is possibly due to the better shelter afforded by the greater number of refuges, than on Grid 3a, which would also account for the higher density found on Grid 2. Densities are similar on these two grids during Session 4, and although a greater number of females were pregnant during Session 5, on Grid 2,

a lower number of juveniles were caught during Sessions 5 and 6, than on Grid 3a. This suggests that there is immigration of adult mice onto Grid 2 from the surrounding areas resulting in the higher densities found on Grid 2 in Sessions 5 and 6. The immigration of adult mice would bias the adult to juvenile ratio, resulting in the lower percentage of juveniles caught in Sessions 5 and 6, while on Grid 3a increase in numbers of mice is primarily due to natality, with minimum immigration.

Changes in numbers of mice on Grid 3b, Fig. 10, followed a similar trend to those shown on Grids 2 and 3a, yet mice appeared to only utilise this grid while not actually inhabiting it, as was previously discussed. Thus few refuges were available on the grid, but with potentially many available on the periphery of the grid, mice only utilised the grid as a foraging area, and this could account for the early incidence of reproductively active mice in Session 3, as was found on Grid 1, which had potentially good abundant available food and refuges. A greater percentage of females were pregnant in Session 4 than on Grids 2 and 3a, suggesting that females were less energetically stressed and were probably able to become reproductively active earlier, as was discussed for Grid 1. Although females were reproductively active earlier, juveniles were only caught in Sessions 5 and 6, which may be due to the fact that females have to move to the grid to forage, while not actually residing there, and this distance might be further than the foraging range of the juveniles. The juveniles that were caught in Sessions 5 and 6 could be mice that had been pushed out of the optimal habitats where breeding took place into the sub-optimal habitats with few, if any, refuges.

The survival of mice decreased exponentially with time, thus the rate of mortality or emigration from the grid decreased as the mice got older. Yet emigration was not found to take place from any of the grids as based on data from the assessment lines. The concept of unequal resource partitioning of Lømnicki (1978) could result in the higher rate of juvenile and young adult mortality, as younger mice are less experienced in foraging and in general at surviving, thus when food resources become limited older mice would be more successful and thus out-compete the younger mice.

House mice on Marion Island would appear to support the concept of food, or calorific intake, dependency for reproduction to occur and for survival. Grid 1 had both high food availability and good refuges, which

resulted in a great number of mice inhabiting that habitat, while Grid 2, which appeared to have a lower food availability, but good refuges, had lower numbers of mice than on Grid 1. Grids 3a and 3b would appear to have had good available food but poor refuges, which resulted in similar but lower numbers than on Grid 2. While on Grid 4, with low food availability and relatively few available refuges, resulted consequently in the lowest number of mice per grid area. Thus mice, due to their great adaptiveness, are able to react differently in various habitats to maximise their survival potential.

CHAPTER 8

SNAP TRAPPING PROGRAMME: RESULTS AND DISCUSSION

REPRODUCTIVE DATA

Males:

A paired t-test for the difference between the means of frequency data indicated that there was no significant difference ($t<0,01$), between the left and the right testes indices, for any of the sampling periods. Thus, only data from the right testes index was used, and an analysis of variance test for the difference in testicular index between the periods showed a significant difference ($p<0,0001$).

	SUM SQUARES	MEAN SQUARES	d.f.	F
Between Groups	2,065	0,4130	5	0,00001
Within Groups	2,1455	0,0099	216	
Total	4,2105		221	

The programme grouped sampling periods most significantly similar into pairs, and then determined pairs significantly different ($p<0,05$). Sampling periods 1 and 2, 3 and 6, and 4 and 5 were paired, and pair 1 and 2 was significantly different from pairs 3 and 6, and 4 and 5, but no significant difference was found between pairs 3 and 6, and 4 and 5. Fig. 20 shows the means with one standard error for testes indices for the sampling periods. In using an index as a measure of change, the relative change in size of the testes may be monitored, which is unaffected by the changes due to size or age of the mouse. Thus, it would appear that the relative size of the testes changed, it increased, significantly during a part of the year. Laurie (1946) found that all males with testes weighing over 30 mg were fecund, those with testes weighing between 20-30 mg were occasionally fecund while those with testes weighing below 20 mg were never fecund. Table 6 shows the percentage of mice fecund, occasionally fecund or never fecund in each sampling period.

The greatest percentage of males were fecund in periods 3, 4, 5 and 6, if this is considered in conjunction with the increase in testes index in these periods, then the season of peak productive activity occurred at this time. If half a sampling period is added to either side of this period, the season of peak reproductive activity was 10 months long.

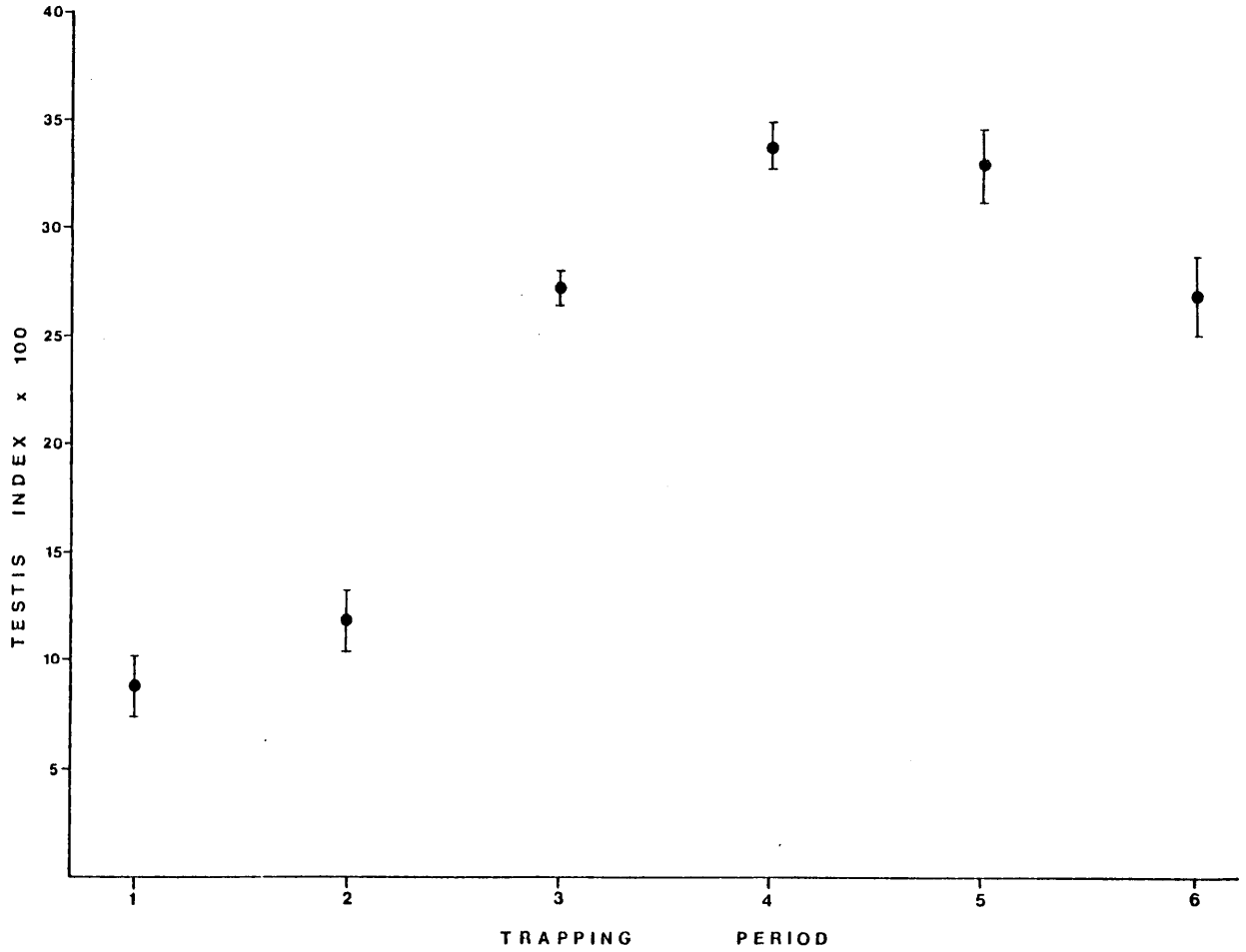

Figure 20: The mean (± S.E.) of the right testis index x100, for each trapping period on Marion Island during 1979-1980.

Table 6: The percentage of male mice, based on right testis weight, that were not fecund (testis less than 20 mg in weight), occasionally fecund (testis between 20 - 30 mg) and fecund (testis over 30 mg), during each trapping period on Marion Island during 1979 - 1980

	Testis weight		
Trapping Period	<20 mg	20 - 30 mg	30 mg >
1	65%	10%	25%
2	45%	3%	52%
3		3%	97%
4			100%
5	3%	3%	94%
6	24%	5%	71%

There were, however, at least some fecund males during all times of the year. Relative testis size increased during this period, as indicated from the testes index, which suggested that testes increased in size with increased activity found during the reproductive season.

Females:

The percentage of pregnant females of the total number of reproductively active females per trap period is shown in Table 7. It can be seen that there were only a low number of pregnant females in any of the sampling periods, and non-pregnancy has been suggested to be a selectively adverse factor in short-lived species (Conaway 1971). Yet a low percentage pregnancy for mice has been reported by several authors (Smith 1954; Lidicker 1966; Delong 1967), and has been suggested to be due to shifting in home ranges as is found in mouse populations during the breeding season (Bronson 1979). The season of births was calculated (Caughley 1977), using the incidence of pregnancy rather than the actual births. As pregnancy can be detected for 13 of the 19,5 days (Brown 1953; Theiler 1972), this will lead to an error of 13 days in the calculation of the season of births, which is equivalent to 21% of each sampling period. Thus a pregnancy recorded in one sampling period should perhaps have been recorded as a birth in the following period. This was ignored and the midpoint of births was calculated as the 10th January, in Period 5. The actual season during which all the births were recorded fell within two standard deviations from the midpoint, equalling a total of 264 days, which is 73% or 8,7 months of the year during which females were found in a fecund condition. Seasonality in breeding of house mice populations has often been found (*vide* Bronson 1979). Feral house mice were found to breed throughout the year at Macquarie Island (54°S) (Berry & Peters 1975), while Berry *et al.* (1978) found that mice at Marion Island also bred all year round. Both of these studies extrapolated the age of mice caught, using the molar tooth wear characteristics of Lidicker (1966), to determine the date of birth of the mice. While this may be true for the Macquarie Island population this is not true for the Marion Island population, as the molar tooth wear does not follow the same pattern as that described by Lidicker (1966) (see Age and age structure of the population, Chapter 9). Thus, house mice on Marion Island follow the general trend of other feral populations, in that they undergo seasonal breeding, which in many cases has been found to be due to the effect of nutrition on the breeding cycle

Table 7: The percentage and age distribution of pregnant female mice of the total number of reproductively active females, during each trapping period on Marion Island during 1979 - 1980

Trapping period	Age classes				Total number of females pregnant	Total number of reproductively active females	% of females pregnant
	3	4	5	6>			
1							
2							
3		3		1	4	16	25%
4		9		1	11	19	58%
5	1	1			3	29	10%
6	5	7			15	51	29%

of the females (Bronson 1979).

The frequency of births for the Marion Island population of mice was calculated (Caughley 1977). Pregnancy can be detected during 13 of the 19,5 days of pregnancy, the season of reproductive activity lasted 8,7 months, during which time females were able to produce 3,94 (4) litters. This is a lower number of litters than that found by Laurie (1946) for mice living in urban environments (5,52), and in high density feral hay rick populations (10,22), but these populations experienced yearly breeding. It is also, however, lower than in another feral population, Breakey (1963) studied a population with 10,90 litters per annum and a breeding season of 8 months in California, and Berry (1968) studied a population with 5,46 litters per annum and a breeding season of 8 months on the island of Skokholm (51^{o}N). Thus, it can be seen that the number of litters produced per annum varies between the various mouse populations, and is a consequence of a variety of factors experienced in those environments.

The effect of low temperatures on the reproductive cycle of female house mice has been well documented by Barnett (1965, 1973), who found that cold could: (1) delay the occurrence of first oestrus, (2) increase the length of oestrus from the typical 4,8 days to 8,5 days, (3) reduce the number of effective post-partum pregnancies, thus more females would conceive post-lactationally. These effects and the fact that pregnancy can be extended for up to 26 days if the female is nursing could account for the reduction in the number of litters produced per annum in this environment, with its low mean annual temperature.

The mean number of foetuses per pregnant female was 6,91, standard deviation (S.D.) = 1,16, n = 33. This is lower than that found by Berry *et al.* (1978) of 7,5 (n = 8), for Marion Island. It is also lower than that found by Pearson (1963) of 7,7, but is similar to that found in several populations of mice on islands (*vide* Batten & Berry, 1967), and higher than that found by Lidicker (1966), of 3,0. These litter sizes are in general smaller than those found in some laboratory populations (*vide* Bronson 1979), but as Lack (1948) states that litter size is dependent on genetical factors, and that through natural selection optimum litter size is often less than the maximum potential litter size for that animal, as survival is reduced in larger litters in certain environments. Mice in island situations are usually more stressed than mice living in urban environments, which results in their litter size being selected for

the optimum for that environment (Gliwicz 1980). Barnett (1973) found that wild mice living at -3°C produced fewer litters than at higher temperatures, and in addition had a higher nestling mortality, due in general to loss of the whole litter.

There was no significant difference (t>0,0001) in the number of foetuses between the left ($\bar{x}$=3,43 ± 1,35 S.D. n=33) and right uterine horns ($\bar{x}$=3,42 ± 1,23). All uterine deaths were excluded from the calculation. Laurie (1946) found a difference in the number of foetuses found in each uterine horn, but this has apparently not been found in other populations (Lidicker 1966; *vide* Bronson 1979).

The mean number of placental (uterine) scars per non-pregnant female was 7,21 ± 2,71 n=77. This is higher than the 5,6 found by Lidicker (1966), but the mean number of embryos he found per female was only 3, which suggests a foetal loss of 2,6 per female. Foetal loss was calculated in the present study as the difference between the mean number of placental scars and embryos, and was only 4%. Nevertheless this is 1% more than Laurie (1946) found for mice living in a variety of environments. No significant difference (t>0,001) between the number of scars found in the left (3,49 ± 1,92 S.D.) and the right (3,75 ± 1,25 S.D.) uterine horns were found. If two or three sets of scars were found the mean number of scars per set was used.

The age of foetuses was estimated following Theiler (1972). The mean crown-rump length of all foetuses, over the age of nine days, was determined for both horns. A linear regression of length against age of foetuses, gives y=1,99x - 15,76 r^2=0,96 n=18. The mean weight of all foetuses, over the age of 11 days, was determined, and a linear regression of $\sqrt[3]{\text{weight}}$ against age gave, y=0,107x - 0,99 r^2=0,95 n=17. This was similar to that given by Huggett & Widdas (1951) for development of mouse embryos older than nine days, but differs in slope by 0,005. A linear regression of $\sqrt[3]{\text{weight}}$ against length gave, y=0,05x - 0,04 r^2=0,99 n=18. It is apparent from this that foetal development in the last half of pregnancy proceeds arithmetically.

Temperature was not found to affect foetal development at -3°C (Barnett 1973), as foetus weight at day 16 of gestation was not significantly different to that of foetuses from mice reared at 21°C. Mean litter weight at birth was unaffected by cold, but the post-partum growth rate up to 21 days was lower in mice raised at 3°C than in mice raised at 21°C

(Barnett 1973). This in turn lengthening age at sexual maturity in colder habitats.

A fecundity schedule (Caughley 1977) was determined for 11 reproductively active females, Table 8. Age of the pregnant females was determined from the molar tooth wear (see Age and Age structure of the population, Chapter 9). The mean number of live births per female was taken as 6,91, as has been calculated. A sex ratio at birth of unity was accepted, yielding 3,45 females per litter. The absence of pregnant females in age class 5 cannot be explained, but it is possible that females in this age class were never caught. Females in age class 4 had the highest level of fecundity, while the level of fecundity declined in the lower and higher age class in the typically mammalian pattern. Laurie (1946), using weight as an indicator of age, found that fecundity increased to a certain weight class and then decreased in the heavier weight classes.

Table 7 shows the number of females pregnant in each age class in each trapping period during the breeding season. To facilitate calculation age classes 4, 5 and 6 were grouped, and trap Periods 3 and 4, and 5 and 6 were grouped, thus forming a 2 x 2 contingency table, giving a X^2 value of 7,68 and p>0,01. This indicates that there was a significant dependence (interaction) between age class in which mice are pregnant and the trapping period in which they are caught. There are significantly less age class 3 females pregnant in trapping Periods 3 and 4 than in trapping periods 5 and 6, and less 3+ age classes females pregnant in period 5 and 6 than would be expected if no interaction existed, (p>0,05). This indicates that females pregnant earlier on in the breeding season are older, while it would appear that their progeny are predominantly breeding during the later half of the breeding season. Although Lidicker (1966) found that few females appeared to reproduce in the same season in which they were born, this has not been found in another population studied (Delong 1967). In addition there were significantly (p>0,05) less age class 3 females pregnant than age class 3+ females pregnant in the population, indicating that females are less likely to be pregnant at a younger age.

Table 8: The number of pregnant females, of the total of reproductively active females, in each age class, with a fecundity schedule for all age classes of house mice on Marion Island during 1979-1980

Age class	Age in months	Number of reproductively active females	Number of pregnant females	% of pregnant females	Number of births per female
2	>1≤2	11	0	0	-
3	>2≤4	27	6	22	3,07
4	>4≤9	57	20	35	4,85
5	>9≤11	15	0	0	-
6	>11≤13	11	2	18	2,51

MORPHOMETRIC PARAMETERS AND INDICES

The means and standard deviations of the various morphometric parameters and indices are shown in Table 9. Frequency classes for the following body parameters: total body weight, total body length and organ indices; brown fat index, inguinal fat index and kidney index were constructed, and a t-test for the difference between the means of males and females, for each sampling period, was determined. Table 10 shows the periods and the level of significance in which a difference in the means was found between males and females. A two way analysis of variance to test the effect of sex and trapping period and the interaction of sex x trapping period on the body parameters and organ indices above was carried out, the level of significance is given in Table 10.

Total body weight

Fig. 21 shows the relative frequency of each body weight class interval for males and females in each trapping period. Body weight of mice increased during periods 1, 2, 3 and 4, during the winter months, with a new cohort entering the trappable population during Periods 5 and 6. Males were significantly heavier in Periods 3 and 4 ($p<0,01$). However, both sex and trapping period had a highly significant ($p<0,001$) effect on the body weight of mice. Males tended to be heavier than females, as has also been found in other feral populations, when the weight of the gravid uterus was excluded (Lidicker 1966; Laurie 1946). The weight of the heaviest male caught was 34,5 g, while that of the heaviest female caught was 35,0 g, which is similar to weights of the heaviest mice living in cold stores and heavier than that of some mice living in some urban and feral environments (Laurie 1946). This follows the trend of "Bergmans Rule" as Marion Island has a cold environment, even though this concept has been disproved by Scholander (1955).

The increase in weight, during winter, is not due to increased deposition of inguinal and visceral fat reserves, as these decrease during the winter months, Table 9. Thus, growth was not retarded during winter and mice increase in size (weight), although only the mice that grow and survive the winter would be caught.

Table 9: The mean (±S.d.) of the morphometric parameters, organ weights and organ indices (sample size in brackets) of house mice for each trapping period on Marion Island during 1979-1980

x	Sex	Total weight	Total length	Tail length	Kidney weight	Brown fat wt	Inguinal fat wt	Adrenal wt
1	♂	183.38±43.06 (68)	164,50±15,15 (68)	81,56±8,35 (68)	162,42±61,69 (45)	75.26±25,74 (47)	232.49±109.91 (35)	6,87±1,99 (39)
	♀	178,88±38,16 (63)	159,44±23,24 (62)	79,96±7,33 (61)	149,40±48,28 (45)	79,86±40,69 (44)	302,00±272,12 (34)	7,70±2,17 (46)
2	♂	223,59±48,54 (39)	170,03±29,00 (40)	85,90±7,60 (39)	206,82±72,89 (28)	96,58±31,58 (26)	285,25±217,59 (28)	7,65±3,21 (26)
	♀	197,56±30,35 (41)	164,65±11,24 (40)	81,32±6,88 (41)	186,16±46,48 (19)	78,95±32,37 (19)	345,47±190,60 (17)	7,63±2,24 (19)
3	♂	217,67±37,09 (45)	177,79±10,92 (48)	88,40±7,05 (47)	230,97±83,92 (37)	87,74±21,08 (31)	141,90±78,49 (30)	7,42±2,12 (33)
	♀	195,97±41,68 (39)	171,11±13,73 (38)	85,89±7,41 (38)	207,25±54,20 (32)	83,71±27,75 (28)	145,73±197,08 (30)	8,10±3,33 (30)
4	♂	251,67±29,15 (27)	182,48±7,20 (27)	90,04±4,60 (27)	306,09±56,48 (23)	87,35±21,90 (20)	115,45±77,07 (22)	7,77±1,82 (22)
	♀	210,03±27,55 (31)	176,40±8,78 (30)	86,93±4,65 (30)	233,28±45,58 (29)	78,22±14,47 (23)	69,30±43,13 (27)	9,48±2,42 (25)
5	♂	194,19±77,76 (43)	169,88±20,72 (43)	83,16±9,93 (43)	226,52±93,43 (27)	87,09±21,84 (22)	166,96±109,00 (26)	6,67±1,69 (24)
	♀	186,56±67,52 (36)	162,29±21,47 (36)	80,00±7,57 (35)	190,03±99,66 (29)	86,68±50,70 (28)	73,11±61,95 (27)	8,89±4,11 (27)
6	♂	195,29±54,59 (68)	171,49±15,50 (67)	83,70±7,62 (62)	215,91±96,02 (54)	67,57±21,92 (51)	80,57±54,56 (56)	5,91±1,56 (46)
	♀	184,16±51,76 (62)	170,06±16,11 (63)	81,93±7,28 (62)	179,35±62,82 (57)	71,18±23,35 (56)	83,72±111,92 (53)	9,00±3,81 (54)

x Trapping period

Table 9 continued overleaf . . . .

Table 9: Continued from previous page . . . . .

Trapping period	Sex	Right testis weight	Brown fat index	Inguinal fat index	Kidney index
1	♂	19,48±25,50 (48)	4,04±0,82	12,92±58,70	8,86±1,92
	♀		4,27±1,39	14,84±154,61	8,54±1,55
2	♂	29,32±22,16 (31)	4,45±0,77	13,42±99,22	9,35±9,90
	♀		4,12±1,98	12,06±2,06	9,15±3,71
3	♂	59,82±18,57 (34)	4,25±0,94	7,00±22,82	10,63±4,82
	♀		4,10±0,94	6,43±51,37	10,15±1,52
4	♂	85,00±10,34 (23)	3,43±0,56	4,86±8,23	12,20±4,04
	♀		3,88±0,80	4,30±2,63	11,02±3,76
5	♂	72,83±27,91 (29)	4,23±0,82	7,48±16,18	10,33±5,15
	♀		4,29±1,63	9,28±3,54	10,13±5,47
6	♂	57,68±34,38 (57)	3,70±1,26	4,04±5,72	10,61±3,62
	♀		4,04±1,56	4,29±20,82	9,61±1,84

Table 10: The level of significance of difference (a) between the morphometric parameters and indices of male and female mice, and the trapping period when different, (b) the effect of sex, trapping period and the interaction of sex x trapping period on these parameters and indices, of house mice on Marion Island during 1979-1980

Parameter/Index	Trapping period	Sex	Trapping period	Sex x T.P.	Level of significance
Total Body Weight	3^{xx} 4^{xx}	xxx	xxx	+ +	x t/p<0,05
Body Length	2^{x} 3^{o} 4^{xx}	xxx	xxx	+ +	xx t/p<0,01 xxxt/p<0,0001
Adrenal Weight	4^{xx} 5^{x} 6^{xxx}				o t/p<0,10
Kidney Index	4^{x} 6^{xx}	xxx	xxx	+ +	
Brown Fat Index	-	+	x	+ +	+ t/p>0,05
Inguinal Fat Index	-	+ +	xxx	xx	++t/p>0,10

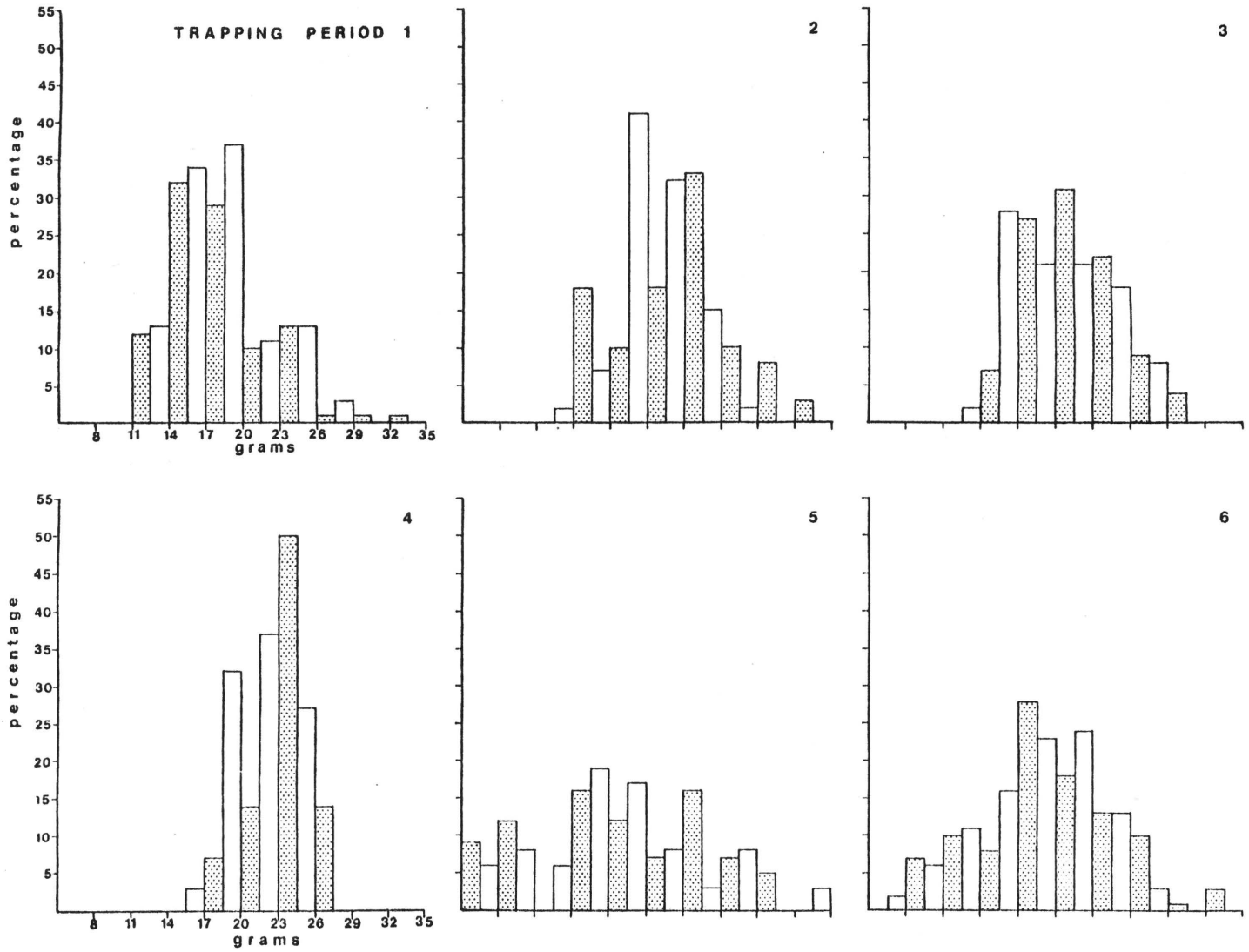

Figure 21: Relative percentage frequency histogram, with 3 g weight class intervals, for male (stippled) and female (open) house mice for each trapping period, on Marion Island, during 1979-1980.

Total body length

Male and female mice were significantly different in length in Periods 2 and 4 ($p<0,01$), and slightly different in Period 3 ($p<0,10$). That females are significantly different in length in Period 2, but not in weight, is reflected in the amount of inguinal fat, which is greater, although not sifnificantly so, in females than in males in Period 2. While the slight significant difference in body length, but highly significant difference in body weight in Period 3, is also reflected in the weight of inguinal fat, which is similar in males and females. Thus, males tend to be longer and heavier than females, on average, but females tend to have a higher inguinal fat index at the beginning of winter, during Periods 1 and 2.

The head and body to tail ratio is, on average, 1,05 for males and females combined, which is slightly higher than that found by Berry *et al.* (1978) of 1,00. This ratio is much lower, indicating longer tails in mice from Marion Island, than for other populations of mice studied (*vide* Berry & Jakobsen 1975), and very much shorter than that, 1,22, for mice from Macquarie Island (54°S). Allen's rule, although also disproved by Scholander (1955), does not seem to apply to the mice from Marion Island. Environmental temperature has been found to affect the relative growth of body parts, yet Barnett (1965) found that mice kept at -3°C increased their tail length over 18 generations. So it would appear that there is a dichotomy in the findings, as well as to the reasons for differences in tail length, which could suggest that mice on Marion Island, with their long tails are not as thermally stressed as might be imagined, considering the climate.

Kidney Weight and Index

Kidney weight was higher in males than in females during all trapping periods, Table 9. Kidney weight has, however, been found to be directly related to body weight (Barnett 1965), and males were heavier than females during all trapping periods. The male's kidney index, which compensates for weight, was still, however, higher during all trapping periods and significantly so in Periods 4 ($p<0,05$) and 6 ($p<0,01$). This indicates that male mice have heavier kidneys than female mice on Marion Island, which was also found by Berry *et al.* (1978). Barnett (1965)

found that kidney weights, in cold situations, were higher in females of certain mouse strains, while other strains did not show this trend, with in fact both males and females having an increased kidney weight. It is possible that the strain, or population, of mice on Marion Island had kidney weights genetically fixed, with males having larger kidneys than females.

Both sex and trapping period had a significant ($p<0,0001$) effect on the kidney index, Table 10. The effect of trapping period is probably an artifact of the change in the weight of mice during the trapping periods, this being reflected in the change in kidney weight. Yet there is an increase in the index, which is independent of weight, during the winter months, Periods 1 to 4, and there is a decrease to Period 6. Colder environments impose a greater work load on the kidney, and other organs, due to the higher rate of heat production, which would be reflected in the organ weight (Barnett 1965), which could result in the change, during winter, in the kidney index. The mean kidney index for males is 10,33, and for females 9,77, which is higher than that found for most other mouse populations studied (Berry & Jakobsen 1975), with the kidney index of mice from Macquarie being most similar, 8,99, for males and females together. Increased kidney weight was found to be a factor increasing survival in two British populations of mice (Berry *et al.* 1978). Thus mice on Marion Island with their high kidney index and heavy kidneys, are perhaps maximising their survival potential in this environment.

Inguinal Fat Weight and Index

Although only the inguinal fat bodies were measured, it is probable that this will give an indication of the general state of the lipid reserves in the bodies of the mice at any specific time. There are two basic types of adipose tissue in mammals: (1) a labile food reserve, which is readily utilised, and to which the inguinal fat bodies belong, and (2) a mechanical tissue which is not readily utilised.

There was no significant difference between the mean inguinal fat indices of male and female mice in any of the trapping periods. This was also found for another population of feral mice (Bellamy *et al.* 1973), although Lidicker (1966) found a difference in the amounts of visceral

fat in male and female mice. Thus sex did not appear to have any significant effect ($p>0,10$) on the inguinal fat index of male and female mice, although there was a significant difference ($p<0,001$) in the inguinal fat index between trapping periods. The mean inguinal fat index was higher, but not significantly so, for females than for males in Periods 1 and 2, but there was a high variance, indicating a great individual difference in the amount of fat deposited. Females in Period 2, however, had a lower variance, indicating that a greater proportion had higher fat reserves. Thus inguinal fat, and probably all other labile adipose tissue, would appear to be heavily utilised during the winter months, as the mean index in Period 3 was approximately half that of Period 2. This adipose tissue was probably being utilised to offset nutritional stress imposed by the colder winter months, which was also suggested by Lidicker (1966), that fat reserves would be mobilized after the metabolically strained conditions of winter. Only mice that actually survive are caught, thus mice that are more heavily stressed, and die during winter, are not caught, which results in this index only being an indication of the more "fit" mice, although the basic trend of changes in inguinal fat index would undoubtably remain the same.

The increase in adipose tissue deposition in winter has been found not to be for increased insulation, although some decrease in heat loss will occur, as small rodents combat thermal stress more successfully by increasing metabolic rate than by increasing insulation, which would result in their becoming too fat (Barnett 1965). Adaption to the cold does, however, result in an increased ability to oxidise and synthesise fat resources, which can be viewed as food reserves.

Brown Adipose Tissue Weight and Index

Cold tolerance may be reflected in the ability to mobilize body reserves, which may be indicated by the amount of brown fat (Berry & Jakobsen 1975), brown fat hypertrophies with cold adaptation, with a corresponding elevation of the endogenous respiratory rate of this organ (*vide* Smith & Horowitz 1969). Thus brown fat was suspected to be one of the most important organs in which non-shivering thermogenesis (NST) took place. Jansky (1973), however, found that brown fat only contributed 10% of NST in adult rats. The amount of brown fat relative to body weight decreases

with age, or size, thus the NST induced in brown fat in new born mammals is of greater importance than in adult mammals (Smith & Horowitz 1969). Brown fat was able to induce the total amount of NST found in rats in their first three weeks of life, before homeothermy was achieved, this corresponds to the period that rats are found in the nest (Jansky 1973). Nest temperatures vary more in colder than in warmer environments in mice (Barnett 1973), suggesting that the NST induced by the brown fat in newborn mice is of great importance in their survival during this period on Marion Island, with its colder environment. Mean brown fat index for mice smaller than 14 g was 0,46 $\pm$ 0,12 S.D. n=38, while that of mice heavier than 14 g was 0,40 $\pm$ 0,13 S.D. n=92, which suggests that smaller mice had a higher brown fat index than the larger mice, although the smallest mouse measured weighed 5,5 g, with a brown fat index of 0,36. But few mice of this size were measured, and no new born mice were measured.

The mean brown fat index was not significantly different ($p>0,05$) between males and females in any of the trapping periods, which has also been found in other feral populations (Bellamy *et al.* 1973), although a difference has been found in a population of shrews (*vide* Smith & Horowitz 1969). The brown fat index was found to change significantly between the trapping periods ($p<0,05$) with the highest indices being found during winter, Period 2, and mid-summer, Period 5. The increase in index in winter is probably due to hypertrophy of the brown fat in response to cold stress, but the second increase in mid-summer is probably due to the influx of smaller mice into the sample, which confounds the mean, which is reflected in the higher variance in Periods 5 and 6. The female mice had a higher variance, in general, than the males, which may be related to sexual activity (Smith & Horowitz 1969), but Bellamy *et al.* (1973) found no difference in the amount of brown fat in pregnant and non-pregnant females.

Brown fat weight varies widely between the populations of mice studied, and also seasonally within a population studied (*vide* Berry & Jakobsen 1975). Seasonal variation was found in the mice on Marion Island, and in general these mice had similar, although generally higher, mean weights of brown fat than the other populations of island mice. Mice from Macquarie Island (54^{o}S), however, with a lower mean annual temperature of 4,7^{o}C, had a higher mean brown fat weight than the mice from Marion Island, while brown fat indices of mice from South Georgia, with a mean annual temperature of 2^{o}C, show the highest mean values of 11,22 in males and 10,68 in females, of any population of mice studied (Berry, Bonner & Peters 1979).

Adrenal Weight

The mean adrenal weights of male and female mice were compared for each trapping period using Students t-test. Table 10 shows the periods when the mean weights were significantly different, with the level of significance. The adrenal weights between the trapping periods were tested for any significance of difference, using a one way analysis of variance, for both males and females. The adrenal weights of the males were significantly different ($p<0,01$) between the trapping periods.

	SS	df	MS	F
TREATMENTS	86,48	5,00	17,30	3,97
ERRORS	797,33	183,00	4,36	
TOTAL	883,81	188,00		

The adrenal weights of the females did not vary significantly between the trapping periods

	SS	df	MS	F
TREATMENTS	30,79	5,00	6,16	0,37
ERRORS	3386,33	204,00	161,60	
TOTAL	3417,12	209,00		

Changes in adrenal weight have been used to compare levels of environmental stress in populations of mice (Lidicker 1966; Berry & Jakobsen 1975), as it was found that adrenals hypertrophied in response to stress, and especially to cold (Barnett 1965). This was then used as an indication of the level of activity in this organ, indicating the level of activity of synthesis of hormones (Berry & Jakobsen 1975). Yet Feist & Feist (1978) found that in voles, and Barchas, Ciarnello, Kessler & Hambug (1975) in mice that enzyme activity could not be directly related to adrenal weight. But adrenals do hypertrophy in response to cold stress, and although this is not directly related to enzyme activity, there is an increased ability of cold acclimated voles to be able to synthesise adrenal enzymes (Feist & Feist 1978).

The mean adrenal weights of the male and female mice were significantly different in Periods 4, 5 and 6. Lidicker (1966) found that adrenal weight of mice differed, with females occasionally having larger adrenals,

but on pooling his data no statistical significance was found. Bellamy *et al.* (1973) found no statistical significant difference in adrenal weights when related to age of mice.

The adrenal weights of males changed significantly ($p<0,01$) between the trapping periods, increasing in winter and decreasing again in summer. This decrease in summer, during Periods 5 and 6, is not completely due to the influx of small mice, with their smaller adrenals, into the sample as there was no significant increase in the standard deviation of the sample, when compared to the mid-winter samples, Periods 2 and 3.

There was no significant change in the weight of the adrenals of the females between the sampling periods. There was, however, a large variation in the weights of the adrenals measured, which was reflected in the high standard deviation from the means of the sampling periods. Lidicker (1966) did not find any changes in adrenal weight as a result of reproductive activity, yet Feist & Feist (1978) found that in voles females had significantly heavier adrenals during the breeding season ($p<0,001$), and this trend was also found in other rodents (*vide* Lidicker 1966). Barnett & Munro (1971) found that not only did pregnancy increase adrenal size, but that cold stressed pregnant mice had even larger adrenals. Thus the stress induced by pregnancy caused adrenal hypertrophy in some females, during Periods 4, 5 and 6 (the breeding season), which resulted in the significantly higher adrenal weight of females during these periods. But, as not all females were pregnant this would result in a high standard deviation of the mean, as was found. While the mean adrenal weights of the males and females were not significantly different during the winter months, this was probably due to effect of cold stress affecting both the males and females. The females still display a larger standard deviation from the mean than the males during winter, which could be due to the effect of stress induced by the continued oestrous cycling of the females, while the males have reduced reproductive activity.

The mean weight of the adrenals of the males is 7,05 mg, while that of the females is 8,83 mg, both of which are lower than the value of 9,60 mg for males and females combined given by Berry *et al.* (1978). The mean adrenal weight of males and females combined is 7,94 mg, which is higher than that of most feral populations of mice studied (Berry & Jakobsen 1975), but is lower than that of mice from Macquarie Island (Berry & Peters 1975), and those from South Georgia (Berry *et al.* 1979), both of which

represent more climatically stressed habitats. Thus it would appear that environmental stress does appear to have an effect on the weight of adrenals of house mice from different habitats. Berry & Jakobsen (1975), Berry & Peters (1975) and Berry *et al.* (1978), however, stress the importance of genetic history and its influence on gene frequencies, with the resultant effect on organs, and their weights, of isolated populations, which should be taken into account when comparing various parameters between populations. Thus although the trends in adrenal weight may give an indication of stress, environmental or otherwise, comparison between populations with no knowledge of the genetic history of the founder populations should be viewed with caution.

CHAPTER 9

AGE AND AGE STRUCTURE OF THE POPULATION: RESULTS AND DISCUSSION

Various methods are available for determining the age of mammals (*vide* Morris 1972). Changes in age as a function of molar tooth wear were used in this study, primarily as this method has been most commonly been used by a variety of workers investigating house mouse populations (Breakey 1963; Lidicker 1966; Berry 1968). Although this method has been criticised as being useful only for a rough estimate of age (Morris 1972), mainly due to the effect of various diets and genetic variation on the rate of attrition, it has been found to be the most reliable method in any particular habitat for house mouse populations when compared to measurements of the body length or weight (Cowcroft & Rowe 1961) and eyelens weight (Berry & Trueslove 1968).

The description of age classes, based on molar tooth wear, of Lidicker (1966) was the most commonly used method. This was found to be inapplicable to the mouse population on Marion Island, as not only were the wear characteristics different, although only slightly, but the absolute ages related to the age classes were different as determined from animals of known ages, as was suggested might occur in different populations by Lidicker (1966). The difference in the wear characteristics is probably due to the genetic isolation of this population of mice (Gruneberg 1956), while the difference in absolute age, based on the degree of molar wear, may be attributed to both genetic difference, and/or to the difference in the diet, which is also known to affect the rate of attrition (Morris 1972; Andrzejewski & Liro 1977). Use of the molar tooth wear system of ageing does, however, tend to underestimate the age of older mice (Lidicker 1966). This was, however, largely eliminated in the statistical analysis by dividing the six age classes into three age groups. Age classes 2 and 3 being group 1, age class 4 being age group 2 and age classes 5-7 being age group 3. In doing this the span in age length of each age group became approximately the same, four to five months, which also increased sample size and facilitated statistical analysis. A log linear model of contingency tables was used to test the three variables age, sex and trapping period. The three variables were found to be not independent of each other ($p>0,05$; $df=27$), thus indicating interactions of a higher order, which occurred as second order interactions ($p>0,05$; $df=10$), namely sex x age; age x season; sex x season, while no third order interactions were found to occur, namely sex x age x season.

Table 11: The level of significance that an age group of house mice was caught more (+), equal (=), or less (-) than expected during each trapping period on Marion Island during 1979-1980

Trapping Period	Age Group 1	2	3
1	+ **	=	- **
2	=	=	=
3	- *	+ *	=
4	- *	- *	+ *
5	+ **	- *	=
6	+ **	- **	=

* $p>0,01$ ** $p>0,001$

No significant difference was found ($p<0,05$) in the sex ratio between the age groups, in any of the sampling periods. A stable sex ratio suggests that there are no age specific sex related mortality (survival) factors affecting the house mouse population on Marion Island. Laurie (1946) found that there was a preponderance for females among nestlings, but this could not be tested in this study, while Evans (1949) found that there were more females among the young mice in a population. Laurie (1946) found that the sex ratio varied in favour of males or females in various environments and size classes, while females were significantly more numerous in the heavier (equated to older) classes. But as weight is not a good indicator of age, this is not a good measure of differences in an age specific sex ratio. Lidicker (1966) found that there was no evidence to suggest a difference in birth or survival between the sexes as based on sex ratio data, although Brown (1953) found a significant difference ($p<0,01$) between the sex ratios of older and younger mice. Thus the presence or absence of age specific survival/mortality factors would appear to be related to specific populations. Age related differences in allotype loci have been found in two populations of mice on sub-Antarctic islands (Berry & Peters 1975; Berry *et al.* 1978), while these age related changes were found to move in opposite directions for male and female mice in another population of sub-Antarctic island mice (Berry, Bonner & Peters 1979; Berry, Sage, Lidicker & Jackson 1981). This movement of allotype loci has been suggested to illustrate stabilising selection in a population, and would appear to be sex specific, thus affecting them differentially. Any sex related change that might be found in the allele frequency for the mice on Marion Island, would not appear to have any age specific effect on the survival of either sex.

There was also no significant difference ($p<0,05$) in the sex ratio of the specific age groups between the sampling periods, which suggests that there are no seasonally related mortality factors selecting against a specific sex. Although Smith (1954) found variations in the sex ratio between the seasons, with either males or females being more prevalent, both Lidicker (1966), in one population studied, and Laurie (1946), in three environments studied, did not find any seasonally related differences in the sex ratio. Thus it would appear that the presence or absence of a variation in the sex ratio between the seasons is specific for a population, within its environment, and in addition may be specific for that time of the year in that population.

A significant difference ($p>0,05$) was found between the age groups and the trapping periods, indicating that there was a change in the age structure of the population during the year. Table 11 shows the level of significance of probability that an age group was caught either less or more than expected for any specific trapping period, and the relative percentage frequency of each age group in the population is shown in Fig. 22. From these it becomes apparent that it is only during Period 2 that there is a normally distributed age structure in the population, and that all the age groups were caught in the expected frequency, with the population neither in a state of increase nor decrease during this period, while during Periods 1, 5 and 6 the population was increasing in size, as more young mice were caught than was expected. This corresponds to the period of reproductive activity, as was described in Chapter 8. During Period 1, fewer group 3 class mice were caught, which is to be expected towards the end of summer, with the greater number of younger animals competing for resources with these older mice, and perhaps being more successful and outcompeting them. In addition these group 3 mice would have been approaching one year of age, which approaches the maximum age found in most feral populations of mice (Lidicker 1966; Delong 1967; Berry 1970).

Fewer age group 2 mice were caught in Period 5 and 6 than was expected. As the breeding season only begins in Period 5, and the rest of the population was old from mice surviving the winter, it can in fact be expected that age group 2 would be under-represented in Period 5. This trend continued into Period 6, as there would be no recruitment into this age group yet, as age group 1 spans a four month age period, thus animals born in Period 5 would only eventually enter the second age group in Period 1, as was found. This recruitment into age group 2 continued into Period 3, when significantly more age group 2 animals were caught than was expected, while age group 1 mice were under-represented due to the cessation of recruitment into the population which stopped during Period 2, at the end of the breeding season.

The population structure in Period 4 indicates an old declining population, with no age group 1 mice present, relatively few age group 2 mice (Fig. 22) and an overabundance of age group 3 mice.

Thus the house mouse population on Marion Island displays a typical cyclic population trend, with a portion of the population surviving the winter and getting older, these forming the reproductive nucleus in the following

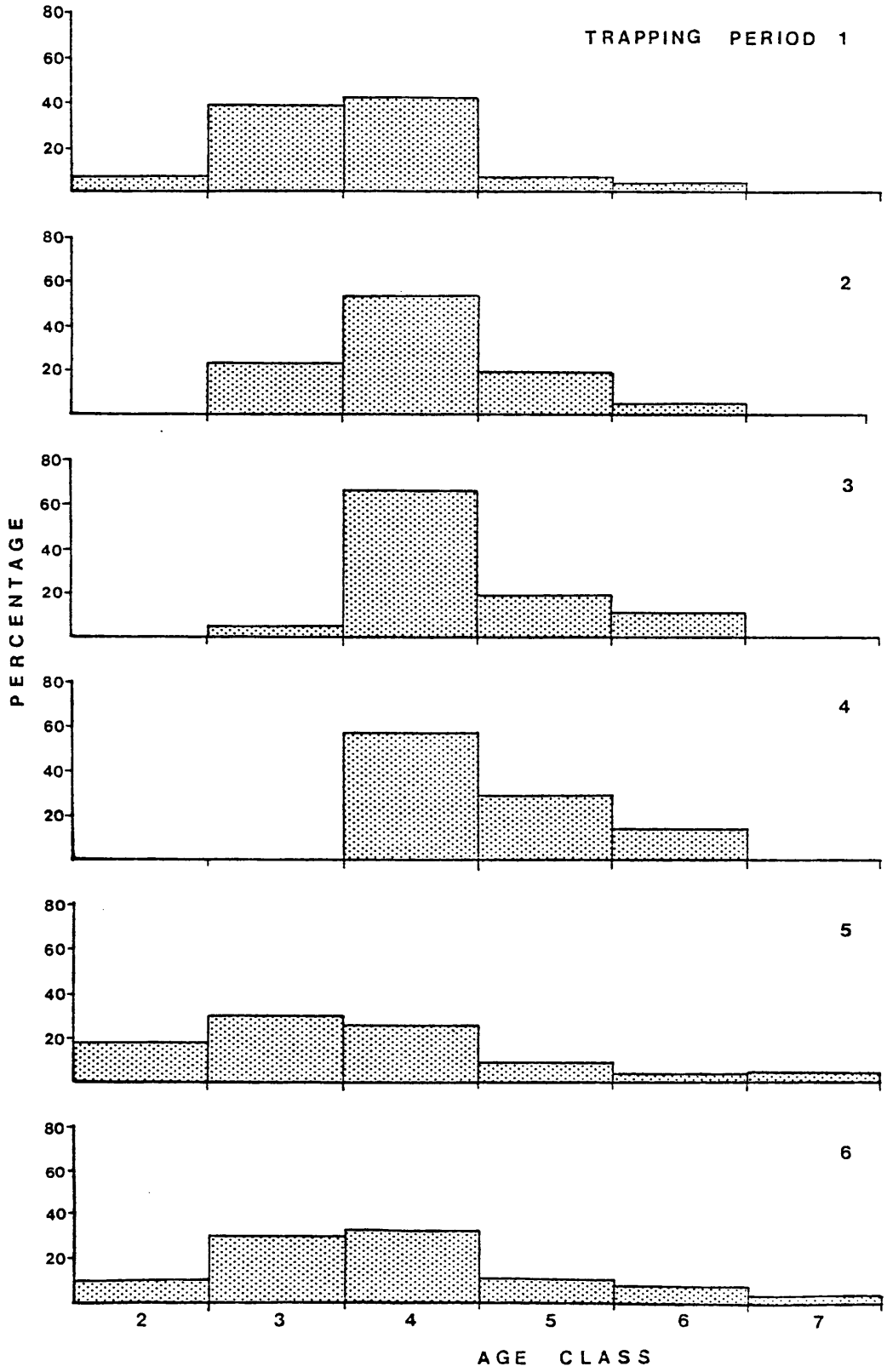

Figure 22: Relative percentage frequency of age classes 2 to 7 for male and female mice together, for each trapping period, on Marion Island, during 1979-1980.

summer, with a new cohort entering the population, resulting in the age structure being biased towards the younger age classes. These mice then growing older, with a resultant change in the age structure towards that of an older population in the winter, thus completing the cycle.

CHAPTER 10

FOOD, FEEDING AND STOMACH CONTENT ANALYSIS: RESULTS AND DISCUSSION

The mean stomach content weight and standard error are shown in Fig.23 and a one-way analysis of variance test showed that mean stomach content weight varied significantly between the trapping periods ($p>0,001$).

	S.S.	df	M.S.	F
TREATMENTS	8,97	5,00	1,79	8,81
ERROR	73,69	362,00	0,20	
TOTAL	82,66	367,00		

Mice were found to have a heavier stomach content weight during the colder months, Periods 2, 3 and 4, indicating that either mice were eating more before getting caught, or they were foraging longer than in summer, before getting caught, which could result in their having fuller stomachs. No data are available on the foraging times of mice in summer and winter, but as mice are nocturnal, and night is approximately 15 hours long in mid-winter and 9 hours long in mid-summer (Schulze 1971), mice would have a longer time available to forage in winter than in summer, which may be reflected in the amount eaten (stomach content weight) before being caught.

Increased consumption of food by mice at colder temperatures was found by Prychodko (1958), and this may also be expected in order to offset the energetic demands of a higher metabolic rate induced by colder temperatures (Barnett 1965; Myrcha 1975). Thus although this increase in stomach content weight in winter may be due to increased duration of foraging, it is more probable that the mice are eating more food to offset the higher energetic demands of the colder temperatures experienced during Periods 2, 3 and 4.

The percentage contribution of each food type per trapping period is shown in Fig. 24. *Pringleophaga marioni* larvae represented the greatest percentage contribution for any trapping period, which was as high as 55% in Periods 2 and 3, during winter, and decreased in percentage contribution to 35% in Period 6, during summer. Fig.25 shows that *P. marioni* larvae represented the greatest percentage occurrence of any food type in the stomach contents in any trapping period. Although *P. marioni* larvae numbers per m^2 were lower than that of weevil larvae and pupae, Fig. 27, their biomass per m^2 was similar, although generally higher, Fig. 28.

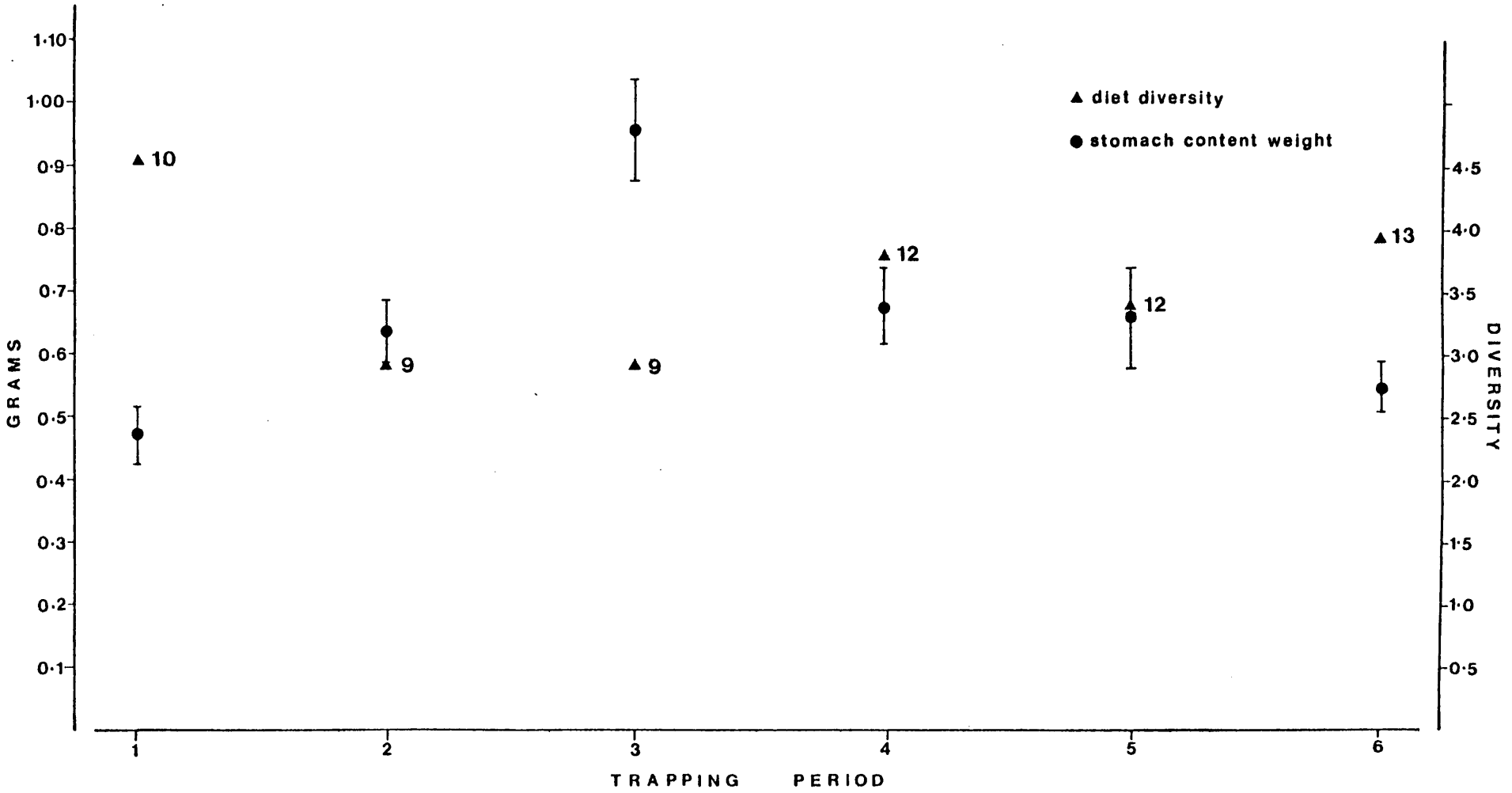

Figure 23: Mean stomach content weight (± S.E.) (circles), diet diversity (triangles) and diet variety (figures), of house mice for each trapping period on Marion Island, during 1979-1980.

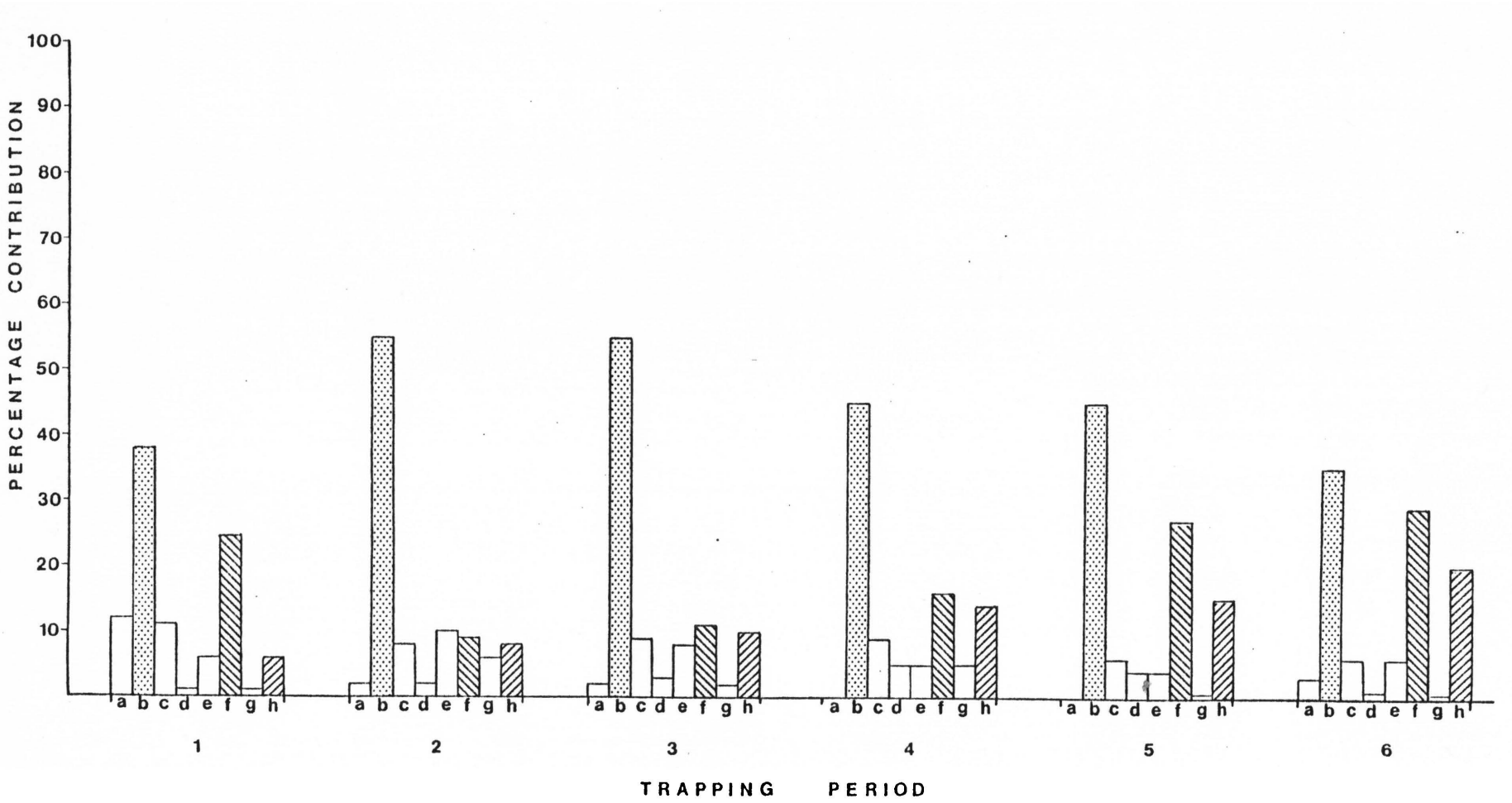

Figure 24: The mean percentage contribution per trapping period, of eight food types: (a) *Pringleophaga marioni* adult, (b) *P. marioni* larvae, (c) weevil adult, (d) weevil larvae, (e) spiders, (f) plant material, (g) earthworms, (h) others, in mouse stomachs on Marion Island, during 1979-1980.

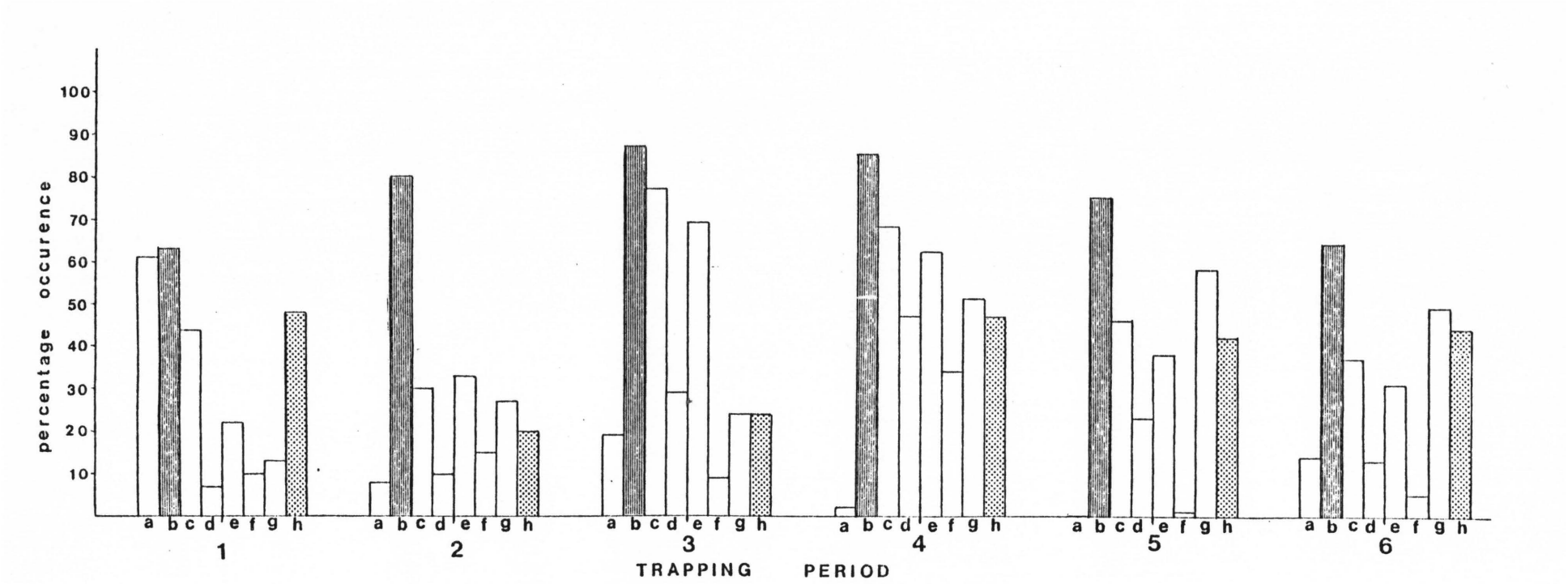

Figure 25: The mean percentage occurrence per trapping period, of eight food types: (a) *P. marioni* adult, (b) *P. marioni* larvae, (c) weevil adult, (d) weevil larvae, (e) spiders, (f) earthworms, (g) others, (h) plant material found in mouse stomachs, on Marion Island, during 1979-1980.

This disparity in the percentage contribution and occurrence can be attributed to the behaviour and difference in size of these two food types. *P. marioni* larvae were found to be primarily nocturnally active, during which time they moved around on the vegetation, while weevil larvae were inactive and often subsurface (Kuschel 1971). This difference in behaviour would result in mice being able to find the *P. marioni* larvae more easily than the weevil larvae, which would result in their having a higher food rank than that of weevil larvae. The disparity in the size of the two prey types, as can be seen in Fig. 19, would further lead to mice capturing *P. marioni* more easily than the weevil larvae. Little is known of the life history of *P. marioni*, but is probably similar to that of *P. kerguelensis* (Vari 1971), and has been fully described by Paulin (1953).

Adult *P. kerguelensis* have a short life span of approximately 20 days, and are found primarily in the late summer, which is similar to *P. heardensis* (Brown 1964). This is slightly different to that of *P. marioni*, as adults were caught by mice during all trapping periods, except Period 5, Fig. 24 The greatest number of adults were, however, caught by mice in the late summer, Period 1, Figs 24 and 25. The larval stage of *P. kerguelensis* is approximately two years long (Paulin 1953), and *P. marioni* would also appear to have a long larval stage as larvae are present throughout the year.

The weevil adults, larvae and pupae that were found in the stomach contents probably belonged primarily to the species *Ectemnorrhinus similis*, although there are in total five known weevil species on Marion Island (Kuschel 1971), thus all the weevil species were lumped together as a single food type. The percentage occurrence of both weevil adults and larvae and pupae food types, showed a trend of increasing occurrence in the diet during the winter months, to Periods 3 and 4, and then decreasing during the summer months, Fig. 25. This was reflected in the percentage contribution of these two food types in the diet of the mice, with them having a greater percentage contribution in the colder Periods 2, 3 and 4 than in the warmer Periods 1, 5 and 6. The low percentage occurrence in the diet of mice, of weevil larvae, even though they have high numbers and biomass/m^2 has already been discussed. Weevil adults although they represented a low biomass/m^2, occurred in similar numbers/m^2 to *P. marioni* larvae, yet they had a lower percentage occurrence in the diet. Mice are opportunistic feeders, they would thus feed on all food types encountered, thus if both weevil adults and *P. marioni* larvae were encountered in similar numbers, why would

they not represent an equal percentage contribution in the diet? This can probably be explained on the basis of the difference in behaviour and size of these two prey types. Kuschel (1971) notes that on Heard Island weevil adults are nocturnally active, while on Marion Island the adults are primarily seen to be active during the day. Thus if weevil adults are diurnally active, and in addition very much smaller than *P. marioni* larvae, they are far less likely to be preyed on by the nocturnally active mice, and this would result in their lowered occurrence in the diet. Little is known of the life histories of the weevil species, but adults were present the whole year round. The larvae were also found all year round, but how long the larval stage persists is not known, it would appear that the larvae pupate during the warmer months, as more pupae were found during the summer months than otherwise.

The araneid fraction of the stomach contents consisted primarily of the spider *Myro paucispinosis*, which although very similar to the other large spider on the island *M. kerguelenensis*, is more common than the latter on Marion Island (Lawrence 1971). *M. kerguelenensis* and the other two smaller araneid species *Erigone vagans* and *Porrhomma antarctica*, were undoubtedly preyed on by the mice, and thus all the spider remains in the stomachs were lumped as a common spider food type. Little is known of these spiders, but they must be present throughout the year, as is indicated by their numbers and biomass/m^2, Figs 27 and 28. Smith (1977) reports that spiders occasionally fed off beetles (weevil adults), and were observed to be cannibalistic on other spiders. They were also seen to feed of *P. marioni* adults and weevil adults (*Pers. obs.*). The percentage occurrence of spiders in the stomach content of the mice increased during winter and was lower in the summer months, yet the percentage contribution remains similar throughout the year, which suggests that the mice are eating more smaller spiders in winter, and the mean size of individual spiders in winter, Fig. 19, also suggests this trend.

Although earthworms, of both species (Sims 1971), and snails *Notodiscus hookeri* formed the greatest percentage of biomass in any area (Burger 1978), mice were only found to feed occasionally on earthworms, and no snail remains were found in any of the stomachs examined. Broken snail shells were found under rocks in some areas, notably the feldmark wind-desert, this was also found by Smith (1977). Yet occupied mouse nests were found with live snails in the entrance tunnel and in the nest itself,

but without any evidence of broken shells around. Thus it is possible that mice only feed on snails when little else is around, as is the case in the Feldmark areas. Earthworms represented only a low percentage contribution and occurrence in the diet, Figs 24 and 25. This is due to the subterranean habits of the earthworms, which would result in their not being available to the mice as prey.

In addition to the above food types an additional eight other invertebrates were found in the stomach contents. These consisted of:

(a) *Embryonopsis halticella* adults and larvae
(b) Kelp fly (probably *Practora dreuxi mirabilis*) adults and larvae (Seguy 1971)
(c) Oligochaetes, from the beach area
(d) Ticks (probably *Ceratixode uriae*) (Theiler 1971)
(e) Aphids (unknown species)
(f) Orabatid mites (unknown species)
(g) Marine amphipods (probably *Hyale grandicornis*) (W. Blankly *Pers. comm.*)
(h) Slugs (unknown species).

Vertebrate muscle was found in only four of the stomachs examined, which represents 1% of the stomachs examined. It did, however, contribute to approximately 90% of the stomach content, in these stomachs. One of the stomachs contained a neonate mouse, while the remaining three appeared to contain bird muscle, as pieces of feathers were found in the stomachs, and these mice were caught in areas with a high Procellariid density. No evidence was found of mice predating on the adults, chicks or eggs of the following Procellariid species: *Pterodroma macroptera, P. mollis, P. brevirostris, Pachyptilla salvini vittata, Halobaena caerula* and *Procellaria aequinoctialis*, although there was evidence of mice scavenging on the carcasses of a *P. brevirostris* chick and a *P. macroptera* chick (M. Schramm *Pers. comm.*). Thus it is probable that the vertebrate muscle found in the stomachs came from scavenged bird carcasses, rather than from predated birds. It is unlikely that mice would be able to kill chicks of the above bird species, as most are greater than 50 g in weight (*P. salvini* and *H. caerula* chicks are heavier than 30 g), and all are aggressive (M. Schramm *Pers. comm.*).

The main constituents of the plant material food type were *A. magellanica* and *P. cooki* seeds, which were positively identified in several of the stomachs, while young shoots of the above two species, and possibly seeds and young shoots of *A. stolinifera* and *P. annua*, may also have contributed to this food fraction in some areas. Mice did not appear to eat *B. penna-marina*, which could be due to the possible presence of phenols and tannins (V. Smith *Pers. comm.*), although *Rattus rattus* were recorded eating *Blechnum* spp. rhizomes on the Galapogos islands (Clark 1980). Mosses which are a very common plant species on the island (Huntley 1971), were never found in any of the stomachs examined, although Watts & Braithwaite (1978) found that house mice utilised mosses heavily, up to 53% by volume of the stomach contents, during the winter months in south Australia. Plant material was least heavily utilised during the winter months, when there was relatively little available, especially of the seed material. The percentage occurrence of plant material in the stomach contents showed a similar trend to that of the percentage contribution, but although the percentage occurrence is similar in Periods 4, 5 and 6, the percentage contribution increases, which indicates that a greater amount of plant material was being eaten per feeding session.

Fig. 23 shows the diet diversity for each trapping period, calculated using the eight principal food types. The total number of different food types, diet variety, found in the stomachs is also shown. The diet diversity and variety were lowest during the winter, Periods 2 and 3, and higher during the summer months. This suggests that mice are finding and consuming a wider variety of food during the summer months than in the winter months, and do not appear to be specialising in any particular food type, and are displaying an opportunistic omnivorous feeding strategy. Clark (1980), however, found that different foraging strategies, resulting in different foods being consumed, were employed by different sections of a population of rats, *Rattus rattus*. She found that younger animals were eating greater amounts of animal food than older rats, thus rats were adjusting their diet to the dietary needs according to their stage of development. The increase in the diet diversity and variety could be an artifact of the younger mice entering the foraging population during the summer months, and with their differing foraging strategy are consuming a wider range of prey. Or else the adult animals are specialising during the winter months on particular prey, foods with a higher food value, as would be suggested by optimal foraging strategy (Pyke, Pulinam, & Charnov 1977). It should, however, be noted that berries formed an important abundant alternative food source for the rats of Clark, and there was not this

alternative abundant high energy food source available to mice on Marion Island, to allow this switching mechanism to occur. Mice could alternatively be opportunistic in their feeding habits and are eating all foods encountered, and thus if there were relatively more food types available in summer, this would be reflected in the mice consuming a wider variety of foods, illustrating a greater diet diversity and variety. Mice are able to live off a wide variety of food types (Laurie 1946; *vide* Landry 1970), and as a diet of invertebrates has been considered to be "balanced" (Landry 1970), and in addition there is no evidence of mice switching diets at different stages of development, it would appear that mice are opportunistic in their feeding strategy.

Mice have been claimed to be granivorous (Lidicker 1966), but have in general been found to consume a wide variety of foods (Laurie 1946; Landry 1970; Watts & Braithwaite 1978), and their diet may be described as omnivorous as is suggested by the present study. Landry (1970) proposed that the dental and mandibular structure of rodents has preadapted them to such a wide range of ecological niches, and this adaptation in conjunction with their dietry flexibility found in house mice has resulted in this species of rodent being so successful, which is reflected in the adaptation of mice on Marion Island, in utilising an opportunistic omnivorous diet.

CHAPTER 11

MOUSE DENSITY AND DISTRIBUTION: RESULTS AND DISCUSSION

It would appear that the upper altitudinal limit at which mice are able to survive is at approximately 450 m, as very little evidence of mouse activity was found at or above this altitude. A mouse was, however, seen by Smith (*in* Anderson & Condy 1974) at 1000 m, this could be due to some suitable habitat being found there, and mice, due to their adaptability, could have inhabited this area, but how these mice could have travelled to an area more than 500 m higher than their observed upper distribution is a moot point.

It is apparent from Fig. 5 that the density of mice in all the upper reaches of the island is low, approximately 10 mice / hectare. Low densities of mice are also found on the grey lava areas, those that are predominantly *A. selago* wind deserts, similar to that found on Grid 4, as these areas tend to have both a low availability of refuges, Table 5, and a very low density of invertebrates (*vide* Invertebrate investigation: results and discussion, in Chapter 5).

Medium densities of mice, between 20 and 60 mice / hectare, tend to be found in those unglaciated black lava areas that, due to weathering of this black lava, have become vegetated, as is the case with Grid 2, or have become mires to a lesser or greater degree, as with Grids 3a and 3b. This vegetation provides microclimates that are suitable for the invertebrates that are predominant in the diet of the mice. In areas in which the black lava is apparently younger and unweathered, and thus not able to support much vegetation, and consequently fewer invertebrates, there is a low density of mice.

The areas of highest mouse density, more than 80 mice / hectare, are those that are in some way biotically influenced; either, as in the case of Grid 1, near the landing beaches of seals and penguins, or else in the *Poa cookii* tussock grasslands, normally found at the edge of the grey lava areas. Both of these areas are heavily influenced by the manuring action of the respective seal and bird species that inhabit these areas (Smith 1977), this manuring causing enhanced growth of some of the plant species in these areas (Huntley 1971), which results in a higher biomass of invertebrates (Burger 1978). Both of these areas, in addition to supporting a high invertebrate biomass, also have a deep layer

of peat (Huntley 1971) into which the mice are able to burrow and form refuges.

Thus it would appear that the distribution and density of mice on Marion Island is dependent on:

1. the substrate, which supports varying amounts of vegetation, and affords varying degrees of refuge availability;

2. the vegetation which in turn influences the biomass of invertebrates in a habitat, which provide food for the mice;

3. the interaction of other species, either plant or animal, that have an effect on the vegetation, and thus indirectly affect the availability of the invertebrates that are utilised by the mice.

CHAPTER 12

CONCLUSION

In the 100 - 150 years that mice have probably been resident on Marion Island, they have managed to successfully colonise a wide variety of habitats, due to their ability to adapt to a wide ecological range including substrate, ground moisture, temperature and food. They are thus found in habitats ranging from the beaches to approximately 450 m above sea level. Within this range of habitat types, however, the density of mice was found to vary greatly, due not only to the availability and quality of refuges in each area, but primarily to the available invertebrate biomass, which is their preferred food. It is this ability to prey on invertebrates that has enabled the mice to survive to heights of up to 450 m, as any dense vascular plant growth, apart from *Azorella selago* which is found up to 500 m (Huntley 1971), is not found much above 200 m. In addition mice are also able to survive successfully in the *A. selago* wind deserts on the exposed grey lava areas. Mice would not have been able to survive in these areas of poor plant growth if they were primarily herbivorous, as was previously thought (Anderson & Condy 1974; Berry *et al.* 1978).

The density of preferred invertebrates was found to vary between the various vegetation types (Burger 1978), and thus the highest densities of mice were found in those areas with vegetation that supported high densities of these invertebrates. Such areas are biotically influenced, due to the manuring action of either seals and penguins or Procellariid birds, which caused enhanced plant growth (Huntley 1971; Smith 1977). Not only did the density of available invertebrates determine the density of mice in the various habitats, but the relative change in invertebrate biomass was found to cause seasonal breeding in the mice, resulting in fluctuations in the numbers of mice in an area. Female mice are more sensitive to changes in their calorific requirement, than are males (Steuck & Emlen 1953), thus the seasonality in breeding of mice on Marion Island, typical of most populations of feral house mice, is regulated by the cycle of reproductive activity of female mice, which lasted 8,7 months. With a mean litter size of 6,9 and an average of 3,9 litters per annum, which are of the same order as other feral house

mouse populations studied, females would appear to have fully adapted to Marion Island's environment

Further evidence for this is that both males and females are heavier than mice found in warmer environments, yet they have a high head and body to tail ratio, of 1,05, which may indicate that they are less thermally stressed than imagined, perhaps due to other physiological adaptations. The population has the highest kidney index of any population of house mouse studied, being highest during winter. Males and females increase the deposition of inguinal fat before winter, and utilise this fat during winter. Moreover, brown adipose tissue, which is higher in this population than most other populations, hypertrophies during winter. Adrenal mass is also higher than that found in most populations of mice, with the males having a greater adrenal mass during winter than in summer. It would appear therefore that these house mice have adapted physiologically to the inclement climate of Marion Island by increasing total weight, kidney weight, brown adipose tissue weight and adrenal weight when compared to populations of mice found in warmer environments.

The age structure of the population varied during the year, and was only normally distributed during June and August, which is thus the most suitable time to sample the population in order to monitor any changes that may take place in the population due to changes in natality or mortality, due to any changes in the environment or availability of food.

Finally it would appear that mice are opportunistically omnivorous in their foraging strategy, as they appear to feed on any food type available, either faunal or floral, with *Pringleophaga marioni* larvae predominating in the diet. Their effect on the plants of Marion Island would appear to be minimal in most areas, although it is possible that in areas of high mouse density, they may have an effect on the vegetation by consuming seeds and young shoots of these plants. Thus mice, although previously thought to affect the island's ecosystem at the first trophic level, that of plants, are in fact entering the ecosystem at the second trophic level, by preying on the invertebrate herbivores, mainly *P. marioni* larvae, weevil larvae and adults, and at the third trophic level, by preying on the invertebrate carnivores, the spiders. Mice on Marion Island are thus one of the more important carnivores in the terrestrial ecosystem.

Mice do not appear to have any significant effect on the present avifaunal populations on the island, for no evidence was found of their preying on eggs of any avian species, and although there was some evidence of avian tissue in 4% of the stomach contents examined, this was probably from scavenged material.

Mice thus appear to be firmly entrenched in the ecosystem of Marion Island, and have successfully adapted physiologically to cope with the environmental conditions experienced there. They do not appear to greatly affect the vegetation of the island, and in addition do not prey on the current populations of avifauna on the island. Mice in turn are preyed on by cats *Felis catus* (van Aarde 1977), and incidentally by gulls *Larus dominicanus* and skuas *Catharacta antarctica*. The greatest effect of the mice on the island's ecosystem is in their preying on the various invertebrate species, primarily that of the larvae of the flightless moth *P. marioni*. It is, however, suspected that due to the length of time that mice have been present on the island, a dynamic ecological equilibrium exists between the mice and their invertebrate prey.

SUMMARY

House mice, which were probably introduced onto Marion Island by the sealers during the early 1800's, have since colonised the whole island below 450 m above sea level. The density of mice varies according to the vegetation type and invertebrate biomass found in the various habitats, with the highest density of mice being found in those areas that are biotically influenced.

In every habitat the numbers of mice fluctuated during the year, peak numbers occurring at the end of summer, and lowest numbers occurring at the end of winter. Food was an important extrinsic factor influencing reproduction which was thus confined to the warmer months, females being reproductively active for 8,7 months, and producing an average of 3,9 litters per annum. A mean litter size of 6,9 was found for this population, with a foetal wastage of 4% and no difference occurring in the number of foetuses in either of the uterine horns. Females in age class 4 had the highest fecundity, with a lower fecundity before and after this time. At least some males were in an active reproductive state during all the trapping sessions, although there was a significant difference in the testis index between trapping periods.

Males and females differed significantly in body weight during some trapping sessions, with males being heavier than females. The head and body to tail ratio was 1,05 for males and females combined. Males tended to have heavier kidneys than females, and there was a difference in the kidney index between the trapping periods, with the kidneys being heavier during the winter months. The amount of inguinal fat differed significantly between the trapping periods for females but not for males. Males and females did not differ significantly in the amount of brown adipose tissue. However, the amount of brown adipose tissue did differ significantly between the trapping periods, being heavier for males and females during winter. Adrenal weight varied significantly between the trapping periods for males, being heavier in winter, but not for females.

The age structure of the population varied during the year, being biased towards the older age classes during the winter, with new mice entering the population during the summer months. There were no sex specific mortality factors as the sex ratio of the population remained constant through all the age classes.

Mice tended to eat more during winter months, and they tended to consume predominantly invertebrate material during all the trapping periods, with *Pringleophaga marioni* larvae being the predominant food type in the diet of the mice. Plant material was eaten during the summer months, when it was more available, but never contributed to more than 30% of the total stomach content. Mice thus appeared to display an opportunistic omnivorous type of feeding strategy on Marion Island.

OPSOMMING

Huismuise, wat waarskynlik deur robjagters gedurende die vroeë 18de eeu op Marioneiland gevestig is, het sedertdien die hele eiland onder 450 m bo seevlak gekoloniseer. Die digtheid van muise varieer met die tipe plantegroei en invertebraat biomassa wat in die verskeie habitatte gevind is, met die hoogste digtheid van muise in die gebiede wat bioties beinvloed word.

Die aantal muise wat in die verskeie habitatte gevind is het gedurend die jaar gewissel met 'n piek in getalle gedurende die laat-somer, en die laagste getalle gedurend laat-winter. Voortplanting was afhanklik van voedselbeskikbaarheid, en was gevolglik tot die somermaande beperk, met wyfies wat vir 8,7 maande reproduktief aktief was. Gemiddeld 3,9 werpsels per wyfie word per jaar geproduseer. Gemiddelde werpselgrootte was 6,9, met 'n fetale verlies van 4% en geen verskil in die hoeveelheid fetusse per baarmoederhoring nie. Wyfies van ouderdomsklas 4 het die hoogste vrugbaarheid gehad, met 'n afname in vrugbaarheid in die jonger en ouer ouderdomsklasse. Daar was ten minste sommige mannetjies in 'n reproduserende toestand gedurende al die vangsessies, alhoewel daar 'n betekenisvolle verandering in die testisindeks was tussen die vangperiodes.

Mannetjies en wyfies het betekenisvol verskil in liggaamsmassa tussen die verskillende vangsessies, en mannetjies was swaarder as wyfies. Die kop en lyf tot stert verhouding was 1,05 vir mannetjies en wyfies gesamentlik. Mannetjies het geneig om swaarder niere te hê as wyfies, en daar was 'n verskil in die nierindeks tussen die vangperiodes, met niere swaarder in the winter maande. Die hoeveelheid liesvet was betekenisvol verskillend tussen die vangperiodes vir wyfies maar nie vir mannetjies nie. Daar was nie 'n betekenisvolle verskil in die hoeveelheid bruin vetweefsel tussen die mannetjies en die wyfies nie, maar wel in die hoeveelheid bruin vetweefsel tussen die vangperiodes, waar dit swaarder was gedurende die winter vir beide die mannetjies en die wyfies. Die byniermassa het betekenisvol gevarieër tussen die vangperiodes vir die mannetjies, waar dit swaarder was gedurende die winter, maar nie vir die wyfies nie.

Die ouderdomsstrukture van die bevolking het gevarieër gedurende die jaar, met meer muise in die ouer ouderdomsgroepe gedurende die winter, en met jong muise wat by die bevolking aansluit gedurende die somer.

Daar was geen geslags spesifieke mortaliteitsfaktore nie.

Muise het geneig om meer gedurende die wintermaande te vreet, en het hoofsaaklik op invertebraat materiaal gedurende al die vangperiodes gevoed, met die larwes van *Pringleophaga marioni* die mees algemene voedselitem. Plantmateriaal was meer gedurende die somermaande geëet wanneer dit meer beskikbaar was, maar dit het nooit tot meer as 30% van die totale maaginhoud bygedra nie. Dit wil dus voorkom asof muise 'n opportunistiese omnivoor voedingsstrategie op Marioneiland het.

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