Feeding ecology of the house mouse *Mus musculus* on Marion Island

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The house mouse Mus musculus *at Marion Island are predominantly insectivorous but opportunistically omnivorous in their foraging strategy.* Pringleophaga marioni *larvae predominated in their diet, and these as well as adult weevils, their larvae and pupae* (Ectemnorrhinus similis) *and arachnids were preyed upon more intensely during winter. The main constituents of plant food types were* Agrostis magellanica *and* Poa cookii *seeds, the greater amount of plant material being taken during summer. Diet diversity and variety were moreover lower during winter as mice are apparently finding and consuming a wider variety of food during summer. Mice are therefore entering the ecosystem at the second (invertebrate herbivores) and third (invertebrate carnivores) trophic levels and have successfully adapted to cope with the high latitude insular terrestrial environment.*

Die huismuis Mus musculus *te Marion-eiland is oorwegend insektevretend maar 'n opportunisties omnifoor in sy voedingstrategie.* Pringleophaga marioni *larwes het hul dieet oorheers, en hulle sowel as volwasse kalanders, hul larwes en papies* (Ectemnorrhinus similis) *en arachnida meer intensief op geprooi gedurende winter. Die hoofsamestelling van plantvoedsel was sade van* Agrostis magellanica *en* Poa cookii, *en die meerderheid plantmateriaal is gedurende die somer ingeneem. Die uiteenlopendheid en verskeidenheid van dieet was vervolgend laer gedurende die winter aangesien muise klaarblyklik 'n groter verskeidenheid voedsel vind en inneem gedurende die somer. Muise betree die ekosisteem dus op die tweede (invertebraat plantvreters) en derde (invertebraat karnivore) voedingsvlakke en het suksesvol aangepas om die landelike eilandomgewing in die hoër breedtegrade die hoof te bied.*

Introduction

House mice are known for their reproductive 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 °C (Laurie 1946), to hot semi-arid areas (Newsome & Corbett 1978). The dentition and gastric morphology of rodents presumably adapted them to a wide range of trophic niches and considering the dietary flexibility found in house mice, these (i.e. trophic/reproductive) adaptations resulted in their being successful colonisers (Landry 1970). It is therefore not surprising that although sub-Antarctic islands seemingly present an unfavourable habitat for small mammals, house mice have successfully colonised at least eight of these islands, these being Amsterdam, St. Paul, Crozet, Kerguelen, Macquarie, South Auckland, South Georgia and Marion islands (Holdgate & Wace 1961, Prevost & Mougin 1970, Anderson & Condy 1974, Bonner & Leader-Williams 1977, Pye & Bonner 1980).

The present paper forms part of a broader investigation into the autecology of house mice and reports on the feeding ecology of the species. No information on the time of introduction of mice to the island is available. Since Moseley (1892) reported indications of activity after a visit to the island during 1873, it is assumed that mice have inhabited the island for at least the last 100-150 years.

Study area

Marion Island (46°54'S, 37°45'E) represents the peak of a volcano approximately 2 300 km SSE of Cape Town. It is approximately 290 km² in area and can be divided into five physiographic regions: coastline, coastal plain, inland slope, central highland and an escarpment (Verwoerd 1971). It has been described as a tundra biome and five major vegetation complexes have been recognised (Huntley 1971).

The climate of the island is typically oceanic and characterised by strong westerly winds, high precipitation and low temperatures (Schulze 1971).

Trapping of mice was largely confined to the eastern side of the island below the 150 m contour line (Fig. 1). With regard to research on mice, six habitat types were recognised, these being hummocky beach areas (1), hummocky vegetated black lava areas (2), swamp areas (3), vegetated grey lava slopes (4), grey lava flats (5), and scoriae cones (6) (*vide* Gleeson 1981).

Material and Methods

Trapping programme

Trapping was conducted on a bi-monthly cycle, with trapping periods starting on the 21st of a month and ending on the 20th of a month two months later. Six trapping periods were completed between April 1979 and May 1980 (Table 1).

Traps (Baby Victor snap traps and Museum Special snap traps) were laid on grids with 5 × 5 to 10 × 10 trap stations, and an interstation distance varying from 5 to 10 m, depending on the suspected density in the area sampled. A total of 7 304 trap nights yielded 612 mice, which represents an 8,4 per cent snap trap success. Live trapping of mice was conducted in habitat types 1 – 3 and 5, whilst snap trapping was done in all habitat types (1 – 6).

Table 1
The dates and duration of the grid live trapping sessions, and the snap trapping periods of house mice on Marion Island during 1979-1980.

Session/Period	Live trapping session	Snap trapping period
		21/07/1980 – 20/05/1980 &
1	10/05/1979 – 24/06/1979	21/05/1979 – 20/06/1979
2	27/06/1979 – 28/08/1979	21/06/1979 – 20/08/1979
3	31/08/1979 – 26/10/1979	21/08/1979 – 20/10/1979
4	04/11/1979 – 15/12/1979	21/10/1979 – 20/12/1979
5	31/12/1979 – 10/02/1980	21/12/1979 – 20/02/1980
6	02/03/1980 – 09/04/1980	21/02/1980 – 20/04/1980

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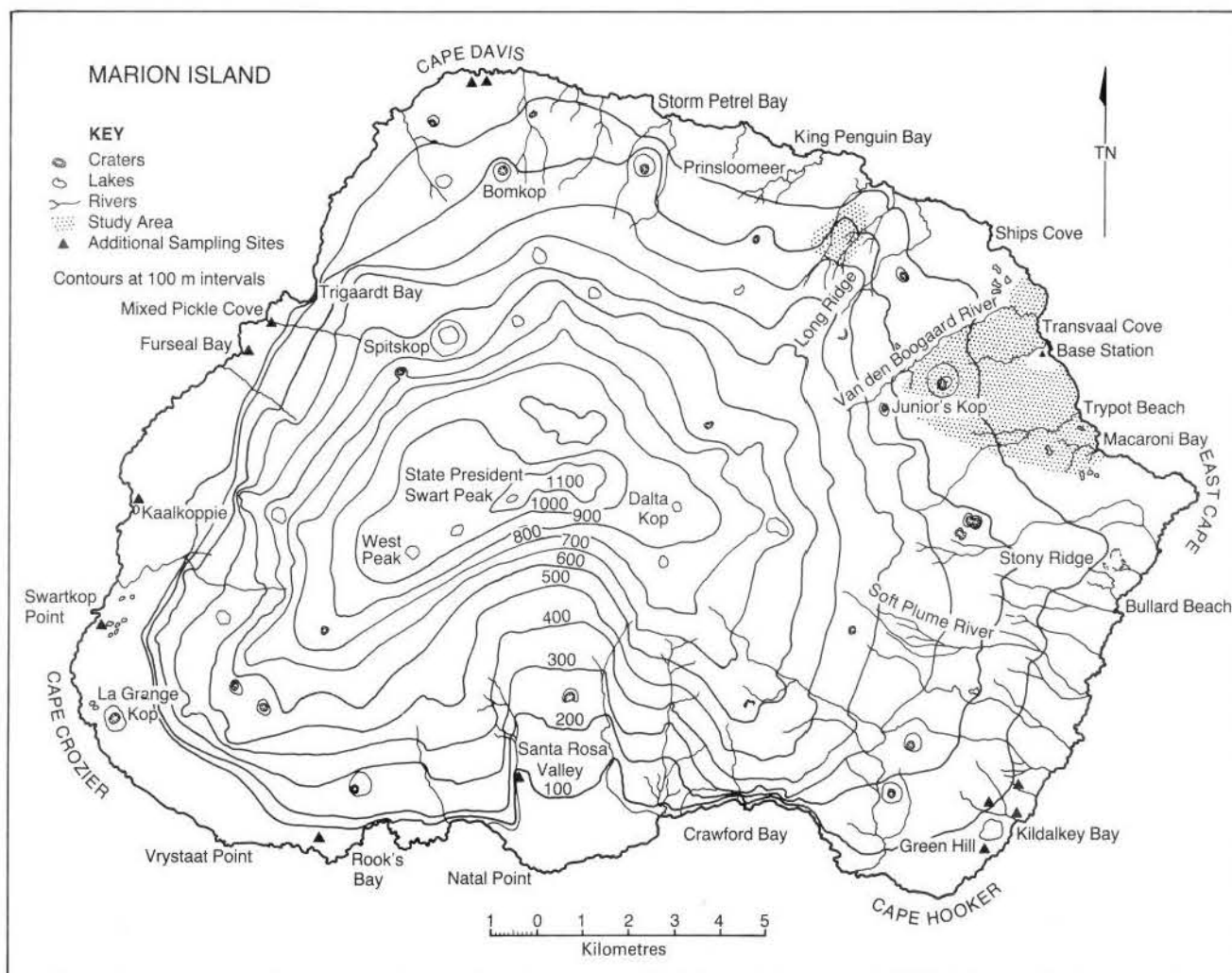
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Fig. 1. Topographic map of Marion Island, showing the main trapping area and additional trapping sites of mice on the island during 1979-1980.

Stomach content analysis

Stomachs of 405 snap trapped mice were weighed wet and examined as follows: after weighing, the stomach contents were removed and spread out in a petri dish, examined under a stereo microscope (maximum magnification 25 ×) and sorted into the following food types; *Pringleophaga marioni* larvae, *P. marioni* adults, weevil adults, weevil larvae, spiders, earthworms, plant material (white and green material together) and other, the latter being all unidentifiable foods occurring infrequently in the contents.

The percentage contribution of each food type to the total contents was estimated on the basis of per cent volume on a scale of 1 – 10, and the mean percentage contribution of each food type per individual per trapping period 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 was expressed as the number of different foods found in all the stomachs during a trapping period, and diet diversity (D) (Ebersole & Wilson 1980) was calculated from:

$$D = \frac{1}{2}\Sigma p_i^2,$$

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

Invertebrate investigation

Soil cores 70 mm in diameter and up to 100 mm in depth, including the vegetation above the soil, were taken at 25 set sampling sites, these being located randomly at trap stations on each of the grids during each trapping session (live trapping conducted on five 10 × 10 station grids with an interstation distance of 10 m). The presence and identity of vegetation in each core was noted and the macro-invertebrates (visible to the naked eye) in the soil and vegetation removed. Macro-invertebrates from each vegetation type and of the same species were lumped, oven-dried at 60 °C for approximately 96 h, and their dry mass determined.

The dry mass and density per m² of the four commonest invertebrate prey species of mice were determined for each vegetation type on each grid. The percentage contribution of each vegetation type to each grid was determined and used to estimate the total dry biomass of each species for each grid.

Results and Discussion

A one-way analysis of variance showed that mean stomach content weight varied significantly between the trapping periods (F = 8,81; P<0,001). Stomach contents of mice were heavier during the winter months (for example, periods 1, 3 and 4) suggesting that mice either ate more and/or were

foraging longer than in summer before being trapped. The high latitude of the island, and therefore the longer dark regime in winter, would result in nocturnal mice having more time to forage in winter than in summer. Increased consumption of food by mice at colder temperatures has been reported by Prychodko (1958), and this may be expected in order to offset energetic demands of a higher metabolic rate induced by lower temperatures (Barnett 1965, Myrcha 1975).

Pringleophaga marioni (Lepidoptera, Tineidae) larvae represented the greatest percentage contribution to the diet of mice for all trapping periods (Fig. 2), which was on average approximately 55 per cent in periods 2 and 3 during winter, and decreased to 35 per cent in summer (period 6). *P. marioni*

larvae represented the greatest percentage occurrence of any food type in the stomach contents in all trapping periods (Fig. 2).

Most adult weevils, their larvae and pupae, identified in stomach contents, were *Ectemnorrhinus similis*. The percentage occurrence and contribution to the diet of mice of both adult weevil and larvae increased in periods 3 and 4 during winter and decreased during summer (Fig. 2).

Although the numbers/m² of larval *P. marioni* were lower than those of weevil larvae and pupae, their biomass/m² was generally higher (Fig. 3). The disparity in percentage contribution and occurrence can be ascribed to differences in behaviour and size of the two food types. *P. marioni* larvae
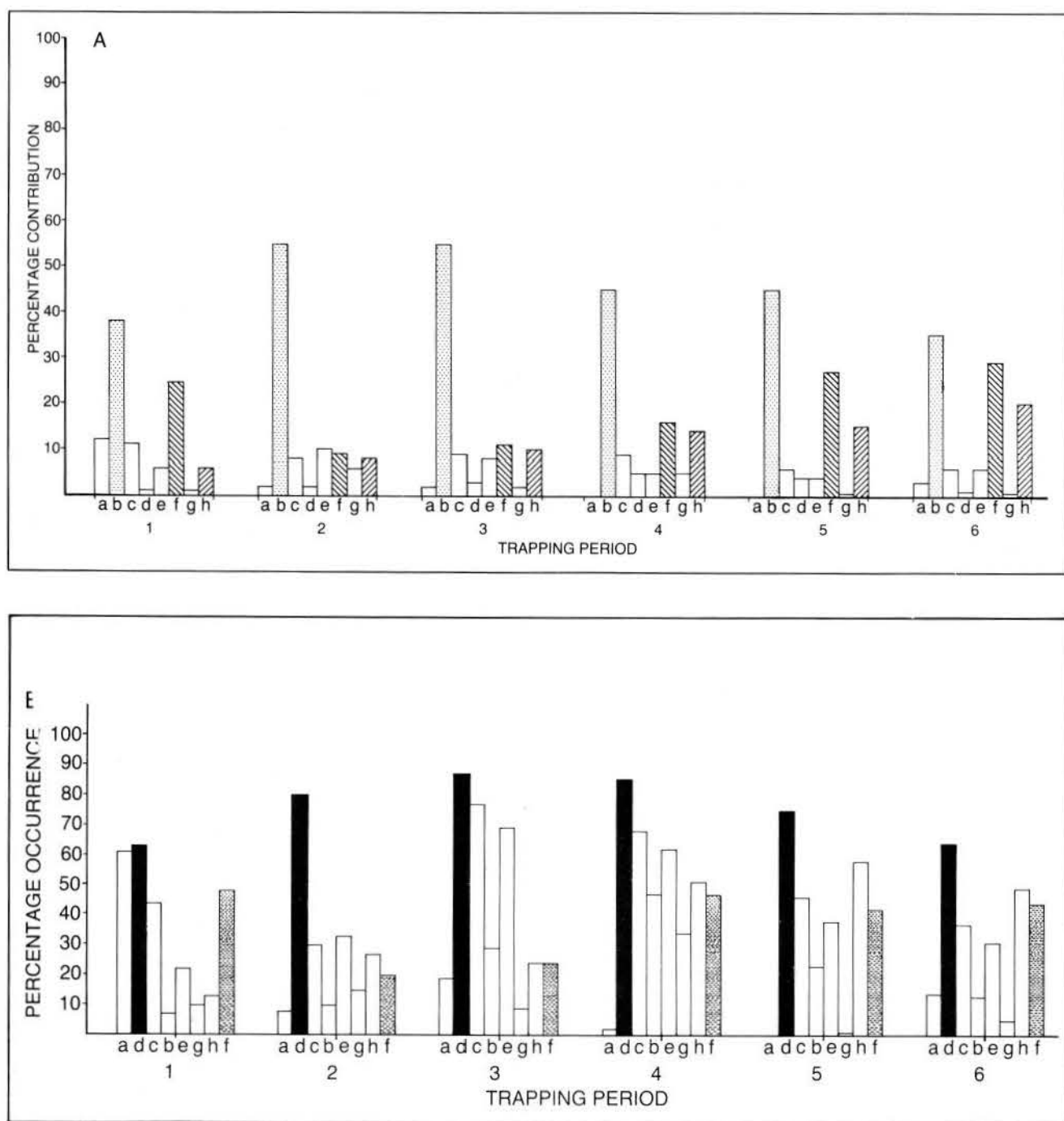

Fig. 2. The mean percentage contribution (A) and mean percentage occurrence (B) per trapping period, of eight food types: (a) *Pringleophaga marioni* adult, (b) *P. marioni* larvae, (c) weevil adult, (d) weevil larvae, (e) spiders, (f) plant material, (g) earthworms, (h) others, in mouse stomachs on Marion Island, during 1979-1980.
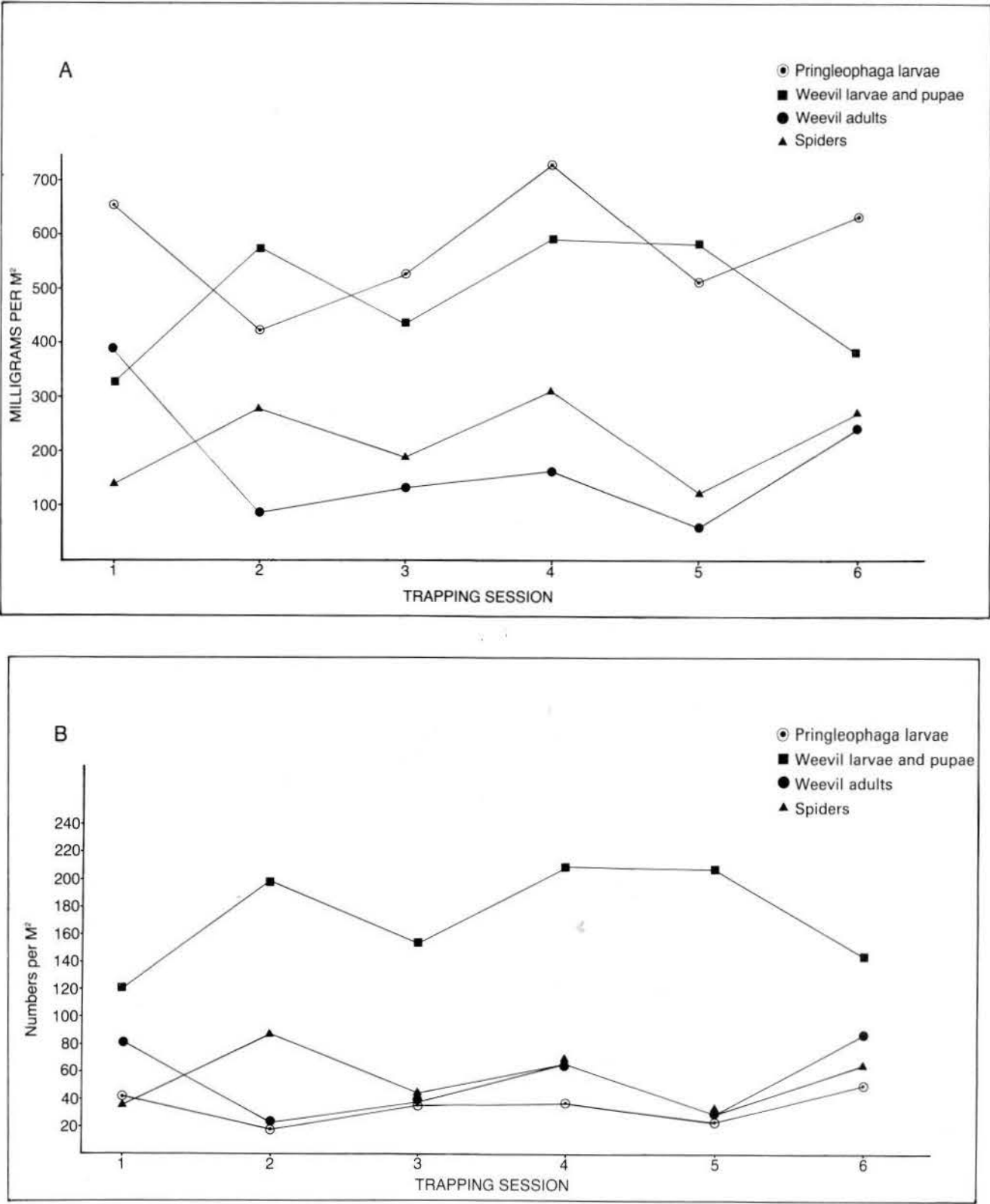
Fig. 3. The mean biomass (A) and mean numbers (B) per m², for the sum of the grids of habitat types 1, 2 and 3 of the four main invertebrate prey species of mice for each trapping session on Marion Island during 1979-1980.

were found to be primarily nocturnal and active on the surface of the substrate, while weevil larvae are inactive and often occur subsurface (Kuschel 1971). These differences would result in mice being able to find *P. marioni* larvae more readily than weevil larvae. Differences in size of these prey types would further result in mice catching *P. marioni* more easily than weevil larvae. Weevil adults represented a low biomass/

m² and occurred in similar density to *P. marioni* larvae, but had a lower percentage occurrence in the diet of mice. On Marion Island adult weevils are primarily diurnally active and are therefore far less likely to be preyed upon by nocturnal mice. Little is known of the life histories of *P. marioni* and weevil species. Weevil adults and larvae were present the whole year round and it is not known how long the larval stage

persists. It would appear that larvae pupate during the warmer months as more pupae were found during the summer. The life history of *P. marioni* is probably similar to that of *P. kerguelensis* (Vari 1971) which has been described by Paulian (1953).

The arachnid fraction of the stomach contents consisted primarily of the spider *Myro pancispinosis. M. kerguelensis, Erigone vagans* and *Pershomma antarctica* were undoubtedly also preyed on and all spider remains in the stomachs were therefore combined as a single food type. The percentage occurrence of spiders in stomach contents increased during winter, while the percentage contribution remained similar throughout the year (Fig. 2).

Although earthworms and snails, *Notodiscus hookeri* formed the greatest percentage biomass in any area (Burger 1978), no snail remains were found in the stomachs of mice, and earthworms were present only occasionally. The subterranean habits of earthworms results in them seldom being available for mice as prey. Other invertebrate food types identified in the stomachs were *Embryonopsis halucella* adults and larvae, adult kelp flies (probably *Practora dreuxi mirabilis*), and larvae (Seguy 1971), oligochaetes, ticks (probably *Ceratixode uriae*, Theiler 1971), aphids, arabatid mites, marine amphipods (probably *Hyale grandicornis*, W. Blankley, pers. comm.) and slugs.

Vertebrate muscle occurred in one per cent of the stomachs but it contributed to nearly 90 per cent of the contents of these stomachs. One of the stomachs contained a neonate mouse, while the other three contained bird muscle. These mice were caught in areas with high procellariid density although no evidence was found of mice preying on the adults, chicks or eggs of procellariid species. Mice are however known to scavenge on carcasses of *Pterodoma brevirostris* and *P. macroptera* chicks (M. Schramm, pers. comm.).

The main constituents of the plant material food type were *Agrostis magellanica* and *Poa cookii* seeds. Young shoots of these species and possibly seeds and young shoots of *A. stolinifera* and *P. annua* may also have contributed to this food fraction. The percentage occurrence of plant material in the stomach contents showed a trend similar to that of its percentage contribution. Although the percentage occurrence is similar in periods 4, 5 and 6 (summer), the percentage contribution increased during the same period (Fig. 2) indicating that a greater amount of plant material was taken during the summer. Fig. 4 shows the diet variety and diversity for each trapping period, calculated by using the eight principal food types.

Diet diversity and variety were lower in periods 2 and 3 during winter, suggesting that mice are finding and consuming a wider variety of food (and not apparently specialising in a particular food type) during the summer. Lidicker (1966) claimed some mouse populations to be granivorous, but mice have in general been found to consume a wide variety of foods (Landry 1970, Watts & Braithwaite 1978).

Mice at Marion Island are predominantly insectivorous but opportunistically omnivorous in their foraging strategy, with *Pringleophaga marioni* larvae predominating in the diet. Their effect on the plants of Marion Island would appear to be minimal in most areas, but in areas of high mouse density they may have an effect on the vegetation by consuming seeds and young shoots. Although previously thought to affect the island's ecosystem at the first trophic level, mice are in fact entering the ecosystem at the second trophic level by preying on invertebrate herbivores (*P. marioni* larvae, weevil adults and larvae) and at the third trophic level by preying on the invertebrate carnivores (spiders). No evidence was found of mice preying on avian species or their eggs.

Mice furthermore appear to be firmly entrenched in the island's ecosystem and have successfully adapted to cope with the environmental conditions experienced there. An important effect of the mice on the ecosystem is in their preying on the various invertebrate species. It is, however, suspected that due to the length of time that mice have been present, a dynamic ecological equilibrium exists between the mice and
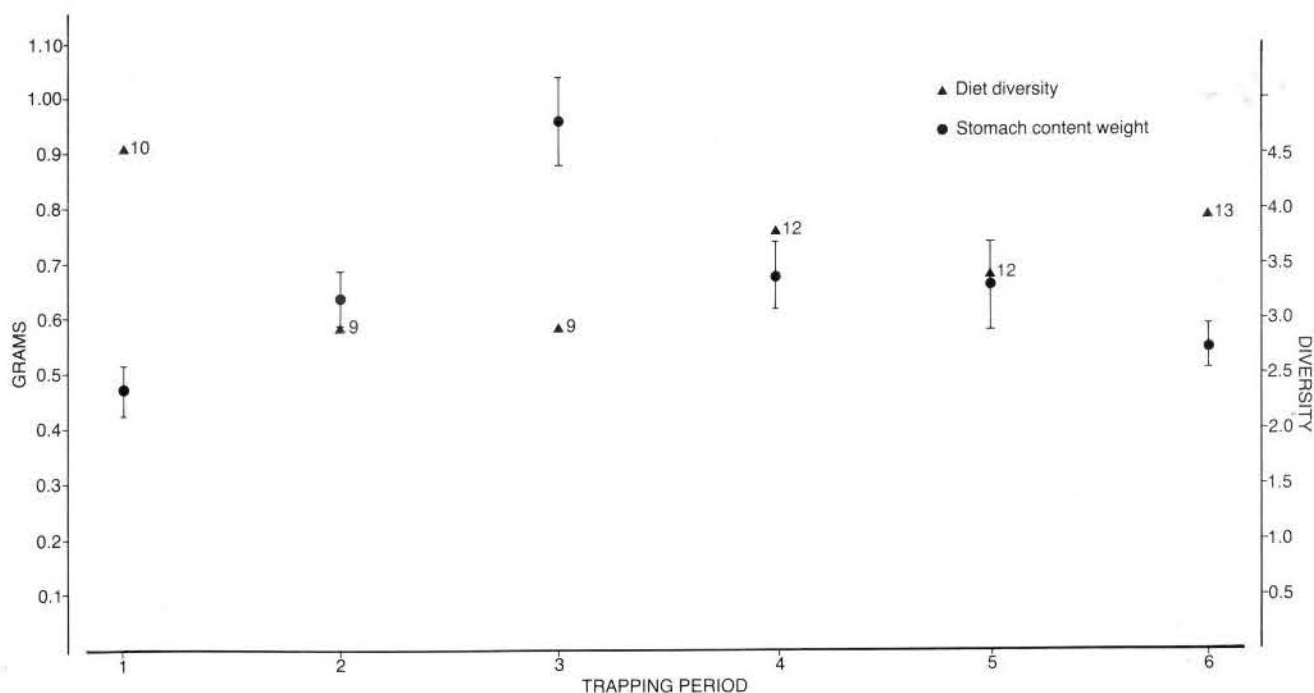

Fig. 4. Mean stomach content weight (±S.E.) (circles), diet diversity (triangles) and diet variety (figures), of house mice for each trapping period on Marion Island, during 1979-1980.

their invertebrate prey, although no data on the prey species dynamics are available.

Acknowledgements

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