The mammals of Marion Island: a review

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Introduction

Research priorities on mammals have been set in accordance with the priorities of international programmes and international collaboration. In addition, at the outset basic biological information on population size, seasonal population fluctuations, natality and mortality schedules and intra- and interspecific relationships had to be obtained.

Marion and Prince Edward islands (46°52'S, 37°51'E) are situated in the southern Indian Ocean and are entirely volcanic in origin. The flora is typical for sub-Antarctic islands. Marion Island, the larger of the two, is approximately 19 km by 14 km, with an area of about 300 km². For further details of the environment *vide* Van Zinderen Bakker, Winterbottom & Dyer (1971).

Mice

The mouse, *Mus musculus*, was probably introduced through shipwrecks and sealer expeditions. A preliminary survey of the house mouse population was conducted on Marion Island between August 1973 and March 1974 (Anderson & Condy, 1974) and, from evidence of nests and runways, it is apparent that mice occur all over the coastal plains up to an altitude of about 300 m. Seeds of *Poa cookii*, *Acaena adscendens* and *Agrostis magellanica* were found in stomach contents and in nests, and mice are probably the most important vertebrate herbivores on Marion Island. However, research on the ecological role of mice has not yet commenced and studies so far have concentrated on genetic aspects, at the request of the Royal Free Hospital School of Medicine, London (Berry, Peters & Van Aarde, 1978), after it had been found that the population may have originated from Denmark. However, subsequent studies (Robinson, 1978) have shown that the Marion Island mice possess metacentric chromosomes, and the only other feral populations characterised by such chromosomes are found in southern Europe. Surprisingly, Berry *et al.* (1978) found that the Marion Island mice were smaller than northern temperature mice and entirely differently shaped to Macquarie Island mice, being 20 per cent heavier but 10 per cent shorter.

The limited comparisons that have been made between these two populations indicate clearly that the two islands support genotypically distinct populations. Although no obvious pattern in gene frequencies existed in the two sub-Antarctic populations compared, there is no reason to believe that the apparent inter-population genetic randomness should be regarded as evidence for the irrelevance of genetic constitution. This is due to the fact that natural selection influences the frequency of at least some genotypes under certain conditions (Berry *et al.* 1978).

The genetic adaptations undergone by mice living on Marion Island, as well as the occurrence of endocyclic selection, provide an excellent opportunity to determine those traits which limit survival at different times of life and the ability of a population to adapt to evolutionary challenges.

Cats

The cat, *Felis catus*, was introduced when five cats were taken to the meteorological station in 1949 to control the mice which had reasserted their commensal habit. However, mice have been found in only 16 per cent of the stomachs of feral cats on Marion Island (Van Aarde, 1977). At least one of the five cats introduced was a female because a preliminary survey conducted between August 1973 and March 1974 showed that the feral cat population was widespread (Anderson & Condy, 1974), particularly below the 150 m contour.

Man's concern about the possible destructive influence of the introduction of exotic species came to a head at the International Committee for Bird Preservation held in New York during 1962, when concern was expressed that the survival of many avian species was seriously threatened by introduced domestic animals. The urgent need for scientists to survey and define the vital requirements for conservation of the sub-Antarctic fauna and flora was then already stressed. However, it was only a decade later that increasing concern about the sub-Antarctic avifauna finally resulted in several intensive ecological studies on feral cat populations on Australian and French sub-Antarctic possessions. In this context a full-scale ecological study of the cats on Marion Island was initiated at the end of 1974 as a first step towards their removal from the island (Van Aarde, 1977).

During this study emphasis was first laid specifically on quantifying the cats' influence on the avifauna, and then on examining factors important to the control and eventual elimination of this feral population with minimum disturbance to the island.

Cats are the main terrestrial predators in the ecosystem, feeding on all species of burrowing petrel. They were found to be well established all around Marion Island over an area of 234 km² up to the 450 m contour line, their distribution and habitat preferences being strongly influenced by the distribution of the principal avian prey species, which in turn were influenced by the availability of soft soil for burrowing. Therefore, the majority of cats inhabited the coastal region, with highest densities occurring on grey lava slopes, followed by *Cotula*-hillocks and areas of vegetated black lava, whereas no cats occurred on barren black lava flows. There was an estimated population of 2 137 at the onset of the 1975 breeding season (Van Aarde, 1979), with crude and ecological densities of 3,65 and 10,61 cats per km² respectively, the latter being higher than for any other studied cat population in the sub-Antarctic.

Since their introduction in 1949, Van Aarde (1978) has shown that their intrinsic rate of natural increase has been 23,3 per cent per year. Seasonal changes in the age structure of the population as a result of seasonal breeding have been observed. From December to February the population consisted of adults and juveniles, from March to May adults, subadults and juveniles occur, and from May to September only adults and subadults, with a definite decrease in the number of subadults from May to September.

Table 1

Group sizes of feral house cats on Marion Island.

Number of cats per group	Observed frequency	Percentage of total
1	747	90,54
2	47	5,69
3	17	2,06
4	8	0,97
5	6	0,73
	825	99,99

Table 2

Age specific sex ratios for feral cats collected on Marion Island.

	Sample			Ratio		
Age class	♂♂	♀♀	Total	♂♂:♀♀	Chi-square value	*P*-value
Prenatal	21	14	35	1:0,66	1,40	$>0{,}05$
Juveniles	25	16	41	1:0,64	1,98	$>0{,}05$
Subadults	19	7	26	1:0,37	5,54	$<0{,}05$
Adults	89	49	138	1:0,55	11,59	$>0{,}005$
Total (postnatal)	133	72	205	1:0,54	18,15	$>0{,}005$

Female cats attain puberty at an age of nine (7-12) months and males at an age of 12 (10-14) months. An individual will therefore pass through all three age classes during the first year of its life.

Twenty-six per cent of the cats collected during the study period belonged to the pre-productive age class, indicating that 74 per cent of the population were either reproductive or post-reproductive. However, information available on reproductive senescence indicated that the post-reproductive age class is irrelevant at this stage.

Mean group size was $2{,}65 \pm 0{,}95$ ($n=79$). Group size frequency indicates that most cats observed were solitary but, although cats are asocial this does not indicate that they are not necessarily social (Table 1). Furthermore, group formation was not confined to the breeding season and groups consisting of 2-5 animals were observed throughout the study period. This grouping tendency may be related to thermoregulatory behaviour.

Prenatal and juvenile sex ratio did not deviate significantly from unity but in both subadults and adults a significant deviation in favour of males did occur (Table 2). This appears to be the result of an inequality in the sampling techniques employed.

Seals

A programme of seal tagging was first carried out on Marion Island in 1973 and was repeated in 1974 with the primary objective of determining the movement of pups during the winter season following their birth; the long-term objectives were to provide a future reservoir of known-aged seals for life history studies, known-aged skulls for collating age determination, information on the fidelity of parturient cows and territorial bulls to their birth-sites and information on long distance movements (Condy & Bester, 1975). Tagging continued until April 1978 (Table 3).

Table 3

Number of seals tagged on Marion and Prince Edward islands from November 1973 to May 1978.

Island	*Mirounga leonina*	*Arctocephalus* spp
Marion Island	1888	487* 1**
Prince Edward Island	216	— —

**Arctocephalus tropicalis*
***Arctocephalus gazella*

Rand (1955, 1956, 1962) and La Grange (1962) were the first to study the seals on Marion Island, while preliminary observations were made on fur seals in the summers of 1971/72 and 1972/73 by De Villiers & Ross (1976). In a unique situation two species of fur seal, the most southerly large population of *Arctocephalus tropicalis*, and possibly the most northerly population of *A. gazella*, breed, and appear to hybridise, on Marion Island, approximately 7 000 and 300 of each species respectively being found there (Condy, 1978). Body colour and flipper size are the most salient features by which to distinguish between adults but vocalisation is also different, particularly in the case of bulls. Condy (1978) has observed bulls with external characteristics representative of both species having crests and light-coloured faces as in *A. tropicalis*, but larger than this species and with the large flippers and less colourful coat characteristic of *A. gazella.* Moreover, on eleven occasions *A. tropicalis* bulls had *A. gazella* cows in their harems, while on three occasions *A. gazella* bulls were seen with harems containing *A. tropicalis* cows. Thus hybridisation may occur, and the relationship between these two species has been described as one of the most fascinating problems awaiting investigation (N. Bonner pers. comm.).

Ninety-one per cent of all fur seal breeding takes place along 5,0 km of boulder-strewn western coastline between Triegaardt Bay and Fur Seal Bay. However, small non-breeding colonies of immature seals occur right around the island from October to June, while solitary bulls are also scattered around the island in February and March after breeding. *A. gazella* seems to occur most often in small enclaves within beaches where the surface is flatter and smoother. This may indicate a habitat preference (Condy, 1978) although the actual site of parturition was not determined as no births were observed. On the other hand, parturition in *A. tropicalis* takes place in caves and crevices amongst the boulders on the tumbledown beaches preferred by this species.

The population of the southern elephant seal, *Mirounga leonina*, on Marion Island has been the subject of more intensive study than the fur seals (Condy, 1977). Laws (1960) has described three major stocks of elephant seals, namely the South Georgia stock, the Macquarie Island stock and the Kerguelen stock; the last includes not only the elephant seals in the Kerguelen archipelago but also those found at the Crozet islands and the Prince Edward islands.

Chromosome analyses have been carried out on elephant seal bone marrow cells, arm ratios for the different chromosomes being calculated to facilitate the classification of chromosomes into groups. The karyotype of this phocid differs from other species with 34 chromosomes, in the morphology of the Y chromosome and one of the autosomal chromosome pairs (Robinson & Condy, 1979).

Pregnant cows start hauling-out at Marion Island in late August, giving birth from early September to late November, and all had weaned their pups and departed by late November (Condy, 1979). Weaning occurred 22,5 ±3,5 days after birth and the pups completed their first moult at 28,3 ±5,7 days. There was no significant difference between body mass of males and females at birth and weaning. However, mass declined for up to six days after birth. Comparisons with the development and growth of pups at Signy, Macquarie and Kerguelen islands showed that at the colder, more southerly islands, birth mass and growth in mass were greater and moulting was delayed while age at weaning remained constant. These differences indicated that there may be population-specific growth potentials although climatic factors may be implicated (Condy, 1977).

It is of interest that the numbers of elephant seals in the Kerguelen stock have been declining at the Prince Edward, Crozet and Kerguelen islands. The reasons for this decline are as yet unknown, but investigations are continuing. At Marion Island, for example, the annual pup crop has declined from 3 662 in 1951 (Rand, 1962) to 1 115 in 1975 (Condy, 1977), a decline of 69,5 per cent since 1951, and has continued to decline since then, the census for 1977 providing an estimate of 1 056.

Another point of interest concerning the elephant seals is the annual regularity of their haul-out cycle from year to year. For instance, between 1973 and 1976 peak numbers of bulls, cows and pups during the breeding season occurred on Oct 24 ±3 days, Oct 17 ±5 days, and Nov 16 ±3 days respectively. For a species, which is dispersed in the oceanic environment before returning to the island to breed, to achieve such regularity, it would seem that photoperiod must act as an obligatory proximate regulator of the cycle (Condy, 1979). In addition, the sequence of haul-out of each age and sex class is adjusted so that all members of the population have a chance to breed and moult, or just moult, without conditions of overcrowding arising. Within the space of five months, starting in October, almost the entire population visits the island, but overcrowding never occurs.

Cetaceans

Apart from occasional cetacean visitors, such as the southern right whale, *Eubalaena australis* (Condy & Burger, 1976), to Marion Island, killer whales, *Orcinus orca*, show a regular annual visitation cycle, the frequency of observations of killer whales from the shore reaching a maximum from October to December (Table 4). This pattern is correlated with both the number of adult female elephant seals and those less than one year old (Condy, Van Aarde & Bester, 1978).

Parturient elephant seals start hauling-out in September when the number of killer whales present around the island begins to increase. At the same time all the 10 to 12-month-old seals which overwintered on the island depart, and there is therefore considerable movement of elephant seals in the sea around the perimeter of the island. Moreover, the number of killer whales reaches a peak in October and November when the newly weaned pups have to fend for themselves and begin to feed close inshore. In January the number of killer whales declines but by this time very few elephant seal yearlings occur on the beaches and most of the adult females are hauled-out for the moult (Condy *et al.* 1978). However, killer whale activity increases again in March when yearling elephant seals are very active around the island, but as the winter season (April-August) approaches the killer whales leave the island.

Table 4

Mean number of killer whale observations per month from October 1973 to April 1978.

Month	Number of months sampled	Mean (±S.D.) monthly number of observations
June	4	0,5±0,6
July	4	0,3±0,5
August	4	1,5±1,3
September	4	9,0±2,2
October	5	25,2±0,8
November	5	18,2±3,7
December	5	26,8±9,2
January	5	6,6±3,9
February	5	1,6±1,8
March	5	3,8±2,5
April	5	4,0±2,1
May	4	2,0±1,8
Monthly mean	55	8,8±10,3

The seasonal occurrence of killer whales is probably also related to the presence of migratory macaroni penguins (*Eudyptes chrysolophus*) and rockhopper penguins (*Eudyptes chrysocome*). However, king penguins (*Aptenodytes patagonica*) which are preyed on by killer whales occur on the island throughout the year, although numbers increase greatly in summer. Fur seals are probably eaten as well, but there is as yet no evidence for this (Condy, *et al.* 1978).

The largest herd of killer whales was also sighted in October — mean 4,8 ±4,3 individuals. The largest herd seen consisted of 25 individuals and was also observed in October. Of the 954 killer whales noted between October 1973 and November 1976, 28,7 per cent were adult males, 21,4 per cent adult females, 7,8 per cent calves, 24,7 per cent subadults while 17,4 per cent could not be classified. Although adult females were seen in all months except June, the 36,3 per cent which had calves were only seen between September and May (Condy *et al.* 1978).

The killer whale is at the top of the oceanic food chain and its behaviour when seeking food is quite distinct. Groups of two or more patrol the coast, within metres where depth allows, surfacing frequently. However, on reaching a cove or bay they submerge completely, moving in as close to the surf zone as possible and only surfacing on reaching the other side of this zone. They hunt offshore as well as close inshore. Three unsuccessful attacks were witnessed; in each case the whales moved at speed towards the shore, but the intended victims escaped. Killer whales have twice been seen feeding on elephant seals — a four-month old yearling and an adult female — as well as on king penguins and rockhopper penguins. On one occasion three killer whales were observed to dispose of a flock of 20 king penguins (Condy *et al.* 1978).

Acknowledgement

We are grateful to SASCAR and the Department of Transport for financial and logistical support of the Mammal Research Programme.

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Marine ecosystems of Marion Island

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Introduction

The vertebrate fauna of Marion and Prince Edward islands, including fur seals, elephant seals and 29 species of seabirds, depends upon the productivity of the seas surrounding the islands. Even the plants are influenced by nutrient inputs from guano and other excretions derived originally from marine organisms. All life on the islands is influenced by, if not entirely dependent upon, the surrounding sea. Thus marine biological studies must form an important part of the overall study of the ecology of these islands.

Intensive research has been carried out on the birds, mammals and plants of the islands but little is yet known of the fauna and flora of the adjacent sea. The sophisticated research being carried out in the fields of ornithology, mammalogy and botany now needs to be supplemented by comparable work on marine biology.

Not only is marine biological work required to obtain a clearer understanding of the functioning of these island ecosystems, but it may also be of academic significance. The flora and fauna of remote oceanic islands have always been of great theoretical interest and value to biologists. Charles Darwin wrote that 'It is my most deliberate conviction that nothing would more aid natural history than careful collecting and investigating all the productions of the most isolated islands, especially those of the southern hemisphere' (Darwin, 1857, in letter to C. Lyell). Much of our knowledge of biogeography, natural selection, ecology and other aspects of biological science has come from studies of islands which serve us as natural laboratories.

Today international interest is being focused on the Southern Ocean because of its exploitable natural living resources such as krill, squid and fish. The possibility of obtaining vast quantities of protein food from the Southern Ocean has given research in this area a new significance. It has been recognised that if the biological resources of these seas are to be wisely managed and exploited on a sustainable yield basis, a clear knowledge of their bionomics is required. If the tragedy of the great whales is not to be repeated, biological research must be concentrated on the Southern Ocean before the level of krill exploitation becomes excessive. In view of this, the international research pro-