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THE DISTRIBUTION, NUMBERS AND MOVEMENTS OF MICE ON SELVAGEM GRANDE IN RELATION TO POSSIBLE FOOD RESOURCES.

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With 2 tables and 2 figures

SUMMARY. In August 1984, three sites on Selvagem Grande were found to support large populations of House Mice *Mus musculus domesticus*. The calculated home range lengths and the high survival rates for mice at every site indicate that the three populations were separate and fairly static. This is supported by evidence from a line of traps placed between two of the sites. Three lines of evidence indicate that the mice are not, as they are reputed to be, significant predators of Frigate Petrels on Selvagem Grande: 1) although there was a lack of mice around the island's houses in the spring, this was probably the result of high winter mortality, rather than the mice moving onto the Petrel colony to feed, as has been previously suggested; 2) many of the mice caught in August 1984 were probably weaned after the time when many Frigate Petrels would have been at their most vulnerable to predation by mice; 3) there was an abundance of other food suitable for mice, i.e. invertebrates and plant seeds, in the area around the Petrel colony. Such food supported a large population of mice at the edge of the island's plateau.

SUMÁRIO. Em Agosto de 1984, foram encontradas grandes populações de Murganhos, *Mus musculus domesticus*, em três locais da Selvagem Grande. A dispersão calculada em torno dos locais e as altas taxas de sobrevivência dos Murganhos em qualquer dos locais indicam que as três populações estavam separadas e razoavelmente estáticas. Isto é posto em evidência através dos resultados obtidos com uma linha de ratoeiras colo-

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cada entre dois dos referidos locais. Três outras linhas evidenciam que os Murganhos não são, ao contrário do que se diz, predadores significativos dos Calcamares na Selvagem Grande: 1) Embora durante a Primavera houvesse uma falta dos Murganhos à volta das casas da ilha, isto foi provavelmente consequência de uma mortalidade alta durante o Inverno e não uma deslocação dos animais para a colónia de Calcamares para se alimentarem, como foi anteriormente sugerido; 2) Muitos dos Murganhos colhidos em Agosto de 1984 foram provavelmente desmamados depois do tempo em que muitos calcamares estariam mais vulneráveis à predação por murganhos; 3) Existia uma abundância de outro tipo de alimentos próprios para serem consumidos pelos Murganhos como por exemplo, invertebrados e sementes de plantas à volta da colónia de Calcamares. Tais alimentos suportaram uma larga população de Murganhos na borda do planalto da ilha.

INTRODUCTION

Selvagem Grande lies 175 km north of Tenerife and 290 km south of Madeira, at 30° 09′ N, 15° 52′ W. It has an area of 160 hectares, and is the largest island in the Salvage group. It is a volcanic island, with steep cliffs rising to a dry rocky plateau some 80 metres above sea level. Vegetation on the island is sparse and stunted due to the combined effects of a dry climate and an introduced population of rabbits *Oryctolagus cuniculus*.

Among the few mammal species on Selvagem Grande is a species of mouse, which was identified by Baring and Ogilvie-Grant (1895) as a house mouse (genus *Mus*) of 'the same species as that met with in North Africa'. They also remarked upon the similarity between the mice they encountered and Wood Mice *Apodemus sylvaticus*. Lockley (1952) identified the mice on Selvagem Grande as a species of *Apodemus*, and this has been accepted by recent authors (Hartog *et al.* 1984).

Baring and Ogilvie-Grant (1895) reported that the mice prey upon Frigate Petrels *Pelagodroma hypoleuca* which breed on the island during the spring. They cited as evidence the discovery of dead birds in their burrows and smashed eggs with the tooth marks of mice on them. They accounted for the fact that Frigate Petrels are several times larger than House Mice and have strong, hooked bills by suggesting that 'no doubt the Petrels get caught in the end of their burrow, and being terrified, do not even try to defend themselves'. More recent authors (Bannerman 1963; Bannerman and Bannerman 1965; Hartog *et al.* 1984) have accepted this evidence, although Jouanin and Roux (1965) saw no mice among the colony and found no burrows containing dead Frigate Petrel adults or chicks when they visited the island during the Petrels' breeding season. They concluded that at the time of Baring and Ogilvie-Grant's visit there must have been a proliferation of mice not present during their stay on the island.

On Selvagem Grande, there are three buildings at Enseada das Cagarras (Figure 1) used by the island's wardens and visiting workers.

The mice are very numerous around these houses in July and October, but scarce or altogether absent from them in May and June (Lockley 1952; Jouanin and Roux 1965; Hartog *et al.* 1984). This has led to the suggestion (Hartog *et al.* 1984) that during the summer and autumn the mice feed around the houses, and during May and June they feed elsewhere, possibly on the Frigate Petrel colony.

In 1984, an expedition from Manchester University visited Selvagem Grande between 7th and 30th August, when the Frigate Petrels had recently completed their breeding season and deserted the colony for the year. This paper, which represents part of the work carried out by that

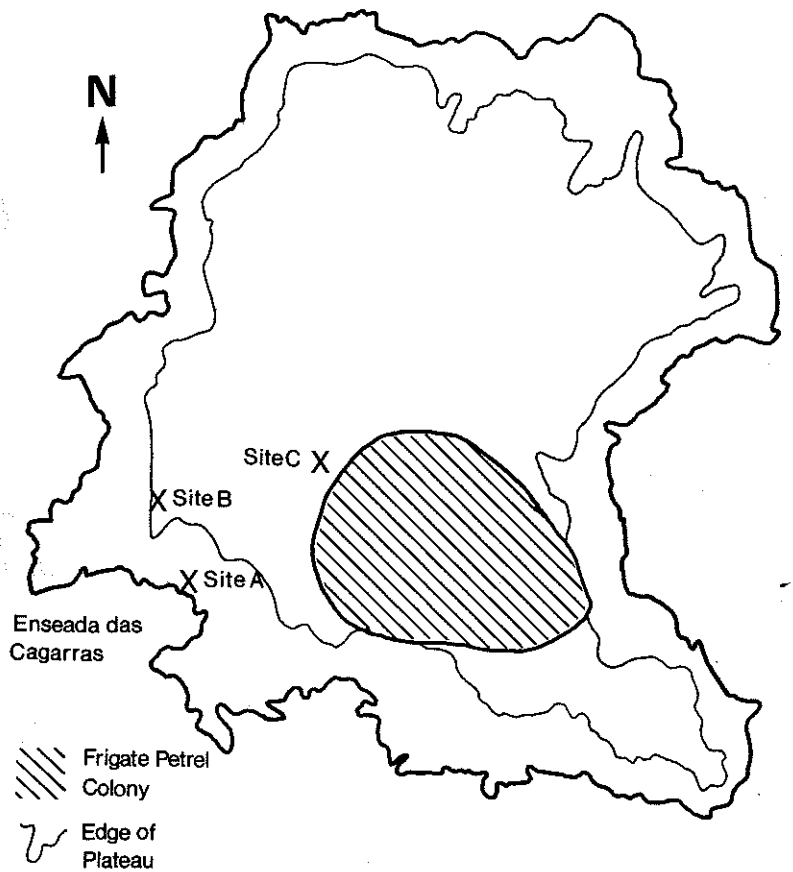

Fig. 1. — Selvagem Grande, showing the positions of the three sites and the Frigate Petrel colony.

expedition, is an attempt to provide some data concerning the biology of the mice on the island, and in particular to examine the distribution, movements, density and population structure of the mice in relation to their known and possible food resources.

METHODS

Between 8th and 26th August 1984, mice at three sites on Selvagem Grande (A, B and C in Figure 1) were studied using mark, release and recapture methods. Site A covered an area of shingle, concrete and volcanic rock at Enseada das Cagarras, between the houses and the sea; Site B was at the top of the cliff overlooking Enseada das Cagarras; Site C was on the plateau, near the Frigate Petrel colony. No traps were placed on the colony itself, because of the likelihood of damaging the burrows in which the birds nest. At each site, perspex «TRIP-TRAPS» containing straw for bedding and wheat for bait were placed at 10 metre intervals to form a grid. At site A, 16 traps formed a grid eight by two, while at sites B and C, 15 traps formed grids five by three. The traps were left in place from 7th to 13th August (6 nights) at site A, from 15th to 20th August (5 nights) at site B and from 21st to 26th August (5 nights) at site C. Each morning, captured mice were weighed, marked by fur clipping and released. Females which were pregnant, lactating or had perforate vaginae were recorded as adults, as were males with scrotal testes. Mice of either sex with juvenile pelage, and mice which did not appear mature from their external genitalia, were recorded as sub-adults.

At each site, population size and survival rate were calculated using methods described by Fisher and Ford (1947) and Jolly (1965). Survival in this context is reduced by both mortality and emigration (Blower, Cook and Bishop 1981). To give some indication of the distances moved by mice, home range was calculated at each grid as the mean of the greatest distances between sites of capture for individual mice (Dice 1938). Greatest distances of zero were not included in these calculations. Home ranges were then used to calculate the population density at each site; half the home range length on each grid was added to each axis of the grid, to produce the area captured mice might be expected to occupy (Miller 1958; Fullager *et al.* 1963); population size was then divided by this area.

To assess whether there was any movement between grids, 15 traps were placed at 17m intervals to form a single line stretching between sites A and B. The traps were left in place from 27th to 30th August (3 nights) and examined daily to see if they had caught any previously-marked mice.

Trapping success, (the number of mice caught expressed as a percentage of the number of traps) was calculated for each of the three grids plus the line of traps. Biomass was calculated for each of these four sets

of traps by summing the weights of mice caught on each night and finding the mean of these totals.

RESULTS

The mice we encountered on Selvagem Grande were House Mice (genus *Mus*). They were distinguishable from Wood Mice by the presence of the following characters: comparatively small eyes and short hind-feet; comparatively large ears and thick tail; absence of a chest spot; notched upper incisors; *Mus* molar cusp pattern. They appear to belong to the semi-species *Mus musculus domesticus*; in particular to the light-

Table 1. — Population size and survival for the mice on Selvagem Grande, calculated according to Fisher and Ford (A) and Jolly (B).

		Grid A	Grid B	Grid C
A.	Population Size	27	25	36
	Stardard Deviation	10.2	7.6	5.5
	Survival	0.87	0.89	1.28
	Standard Deviation	0.13	0.15	0.42
B.	Population Size	24	23	37
	Standard Deviation	5.0	4.7	29.0
	Survival	0.84	0.71	0.90

Table 2. — Home range and density for the three grids.

	Grid A	Grid B	Grid C
Home Range (m)	29.3	25.4	19.8
Standard Deviation	16.0	13.4	6.6
Density (per Ha.)	65.3	80.8	153.4

bellied morphotype (Thaler *et al.* 1981) or ecotype (Darviche and Orsini 1982) *brevirostris*. This form occurs throughout the western Mediterranean, including North Africa (Marshall and Sage 1981).

Between 8th and 26th August 1984, a total of 90 individual mice were handled in 155 captures. 36 mice were caught on grid A, 33 on grid

B and 21 on grid C. The numbers of mice caught more than once on grids A, B and C were 18, 12 and 9 respectively.

The three grids appear to support similar-sized populations of mice (Table 1) with similar home ranges and densities (Table 2). Trapping successes on grids A, B and C were 70%, 77% and 60% respectively. Correcting for traps which closed spontaneously, caught a lizard or caught a mouse which subsequently chewed its way out raised these values to 76%, 100% and 86% respectively. The figures for trapping success are the net result of some traps remaining empty and others catching more than one mouse per night. The biomasses on grids A, B and C were 241, 259 and 235 grammes respectively.

Mice had similarly high survival rates on all three grids (Table 1). The line of traps between sites A and B caught 16 mice, of which three were caught twice. Only three mice were caught which had previously been marked on one of the grids. Two were on the grid where they were first caught, well within their calculated home ranges. The third, a juvenile marked 18 days earlier on grid A, had moved approximately 230 metres up the cliff since its earlier capture.

Figure 2 shows, for adults and sub-adults, the frequency and distribution of the weights of animals when first captured. The histogram represents the weights of 87 mice, since 19 of the 106 mice caught were not weighed. The mean weight for adult House Mice was 24.4g.; for

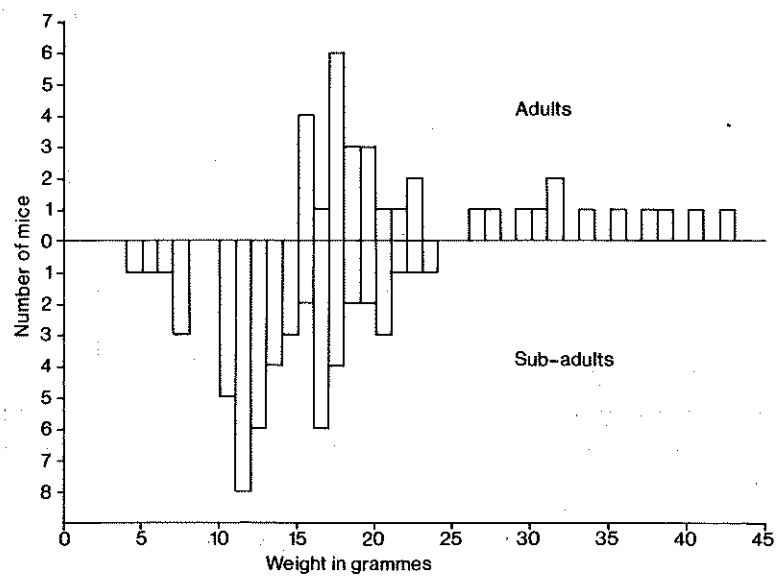

Fig. 2. — Histogram of the weights of 87 mice caught on Selvagem Grande between 8th and 29th August 1984.

sub-adults it was 14.6g. These weights are similar to those of House Mice on other islands in temperate climates (Berry *et al.* 1978; Berry and Jackson 1979). On grids A, B and C and the line of traps, the proportions of sub-adults handled in initial captures were 56%, 70% 62% and 50% respectively.

DISCUSSION

Population size, trapping success, biomass and density all indicate that the three sites supported similar numbers of mice (Tables 1 and 2, and see results). The home range lengths at all three sites (Table 2) were much smaller than the distances between sites. These, along with the high survival rates for mice on all tree grids (Table 1), indicate that the populations at the three sites were separate and fairly static.

Home range estimates can be unreliable (Jewell 1966). However, they are supported in this case, to some extent, by evidence from the line of traps. Only three previously-marked mice were caught on the cliff between sites A and B, two of them well within their calculated home ranges. There was no evidence that mice were moving down the cliff following the end of the Frigate Petrels' breeding season.

There was an abundance of plant seeds (particulary *Mesembryanthemum crystallinum*) and invertebrates at the edge of the plateau (site B). As part of a survey of invertebrates on the island (unpublished), a one metre square quadrat was placed at five sites chosen at random from the area enclosed by the grid. These sites contained an average of 5.4 invertebrate species and 58 individuals per square metre. Plant seeds, along with a wide variety of invertebrates, are an important part of the diet of non-commensal House Mice (Whittaker 1966; Berry 1968; Berry and Tricker 1969; Berry and Peters 1975). On Selvagem Grande, a diet of invertebrates and seeds supported a large population of mice at site B, where no other food resources were available. It would be interesting to take gut samples, to determine the contribution each of the available items makes to the diet of the mice.

Seeds and invertebrates were equally abundant at site C, near the Frigate Petrel colony. A one metre square quadrat placed five times at random in the area enclosed by the grid produced an average of 4.2 invertebrate species and 54.8 individuals per square metre. This area is probably as capable of sustaining a population of House Mice, in the absence of Frigate Petrels, as the site at the edge of the plateau. It would require gut samples taken from mice found on the colony during the Petrels' breeding season to determine whether these mice actually include Frigate Petrels in their diet.

At Enseada das Cagarras, observations at night confirmed that the mice make great use of food stored or discarded by Man. However, their diet at this site probably included some invertebrates. It appeared from the

remains of Cockroaches *Periplaneta americana* that some may have been eaten by mice.

It has been suggested (Hartog *et al.* 1984) that the low numbers of mice seen at Enseada das Cagarras during the spring may result from their moving elsewhere to feed. This is not supported by evidence concerning the structures of the populations at each site in August 1984. The high proportion (66%) of sub-adults in the sample suggests that the populations were gaining recruits, while the low weights of many sub-adults indicate that the populations contained a high proportion of young animals. Figure 2 shows a large overlap between the weights of adults and sub-adults. This suggests that many mice were breeding in their first year (Crawley 1970). The small number of heavier, presumably older, mice (12 out of 87) suggests that comparatively few may survive to breed from one year to the next. Non-commensal House Mice in seasonal climates have a well-defined reproductive period (Berry 1968; Berry and Peters 1975) and show marked seasonal fluctuations in numbers (Berry 1968, and see Berry 1981 for review). On Selvagem Grande, the changes in the number of mice seen at Enseada das Cagarras during the year are probably the result of fluctuations in the number of mice on the island rather than the movements of mice between feeding sites.

Mice are more likely to prey upon Frigate Petrel eggs or young chicks than upon older birds (Jouanin and Roux 1965), but there is some evidence to suggest that the population of mice on Selvagem Grande is comparatively low during the early stages of the Petrels' breeding season; the lowest adult weight recorded in August 1984 was 15 grammes. 37% of the mice caught (60% of sub-adults) were below this weight. They were probably sub-adult because they were not heavy (and presumably old) enough to breed, rather than because of any density-dependant checks on breeding. Female House Mice become mature at approximately six weeks (Berry 1970). Allowing for a margin of error, and for the slightly later maturity of males, 37% of the mice caught in August 1984 were probably less than two months old. They would not have been weaned until late June at the earliest, and by that time many Frigate Petrels would already have hatched (hatching lasts from May until mid-July: Jouanin and Roux 1965).

Previous visitors to Selvagem Grande (Jouanin and Roux 1965; Hartog *et al.* 1984) have found the mice to be absent from the Petrel colony in July and scarce at Enseada das Cagarras in June. This would suggest that the number of mice on the island does not increase significantly before June or July. Since the mice appear to start breeding before June, it may be that a small population overwinters in a restricted locality, and spreads to other parts of the island in the summer as the population density increases. This occurs on the island of Skokholm, off the coast of Wales (Berry 1968). On Selvagem Grande, mice may spread in this way onto the Frigate Petrel colony. However, there is no reason to assume that such movements should be related to the presence of Frigate Petrels.

Berry (1968) found no relationship between the spread of mice on Skokholm and the presence of a number of seabird colonies, even though the mice did spread onto areas where birds were nesting.

The mice at Enseada das Cagarras are apparently omnivorous. At the edge of the plateau they probably feed on a mixture of plant seeds and invertebrates. Such food is equally abundant near the Frigate Petrel colony as at the plateau's edge. In view of the availability of this food, and the probability that there are few mice on the Frigate Petrel colony during the Petrels' breeding season the suggestion that the mice on Selvagem Grande are significant predators upon Frigate Petrels seems unjustified. In a study of predation upon the nests of birds in New Zealand, Moors (1983) concluded that House Mice were not important predators, and that avian prey usually formed only a small proportion of their diets. However, laboratory experiments have shown that House Mice can successfully tackle small eggs and nestlings, and in the New Zealand region House Mice are recorded as preying upon the nests of South Island Robins *Petroica australis*, pipits and storm petrels (Moors 1983). Nonetheless, it is difficult to imagine a House Mouse successfully tackling a healthy adult Frigate Petrel, and it seems much more likely that the observations made by Baring and Ogilvie-Grant (1895) were the result of mice scavenging upon deserted eggs and dead or wounded adults.

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