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Population biology and the control of feral cats on Marion Island

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Predation by feral cats *Felis catus* on burrowing birds of southern temperate and sub-Antarctic islands has resulted in their presence being considered undesirable. Attempts to eradicate or control these cats have included control by trapping and hunting and lately biological control through the introduction of a viral disease. Estimated at 2139±290 adults in 1975, at least 20 % of the Marion Island (46°54'S, 37°45'E, 290 km^2) cat population would have to be "removed" annually to stabilise the otherwise increasing population. In spite of relatively high mortality during the first year of life, the high fecundity and increased survival after 12 months of age, resulted in this population with its stable age distribution increasing at a rate of 17—23 % per annum of the 26 years. In an attempt to reduce the rate of increase, the fully susceptible population had been exposed to the host-specific, contagious disease feline panleucopaenia during March 1977. Data obtained through transect surveys before and after suggest a continued decrease in population size since 1977. The mean cat density in October 1978 was 54 % lower than in October 1976, and in June 1980 it was 65 % lower than in June 1976.

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1. Introduction

The accidental and/or deliberate introduction of exotic predators such as domestic cats *Felis catus* and rats *Rattus norvegicus* to several of the 19 principal groups of southern temperate and sub-Antarctic islands affected the birds breeding on these islands. Increased scientific activity on islands in the southern oceans since the early 1970s and an increasing concern about the influence of exotic predators on ground-nesting seabirds, resulted in several studies being undertaken on some of these cat populations. Surveys initiated by Australian, French and South African authorities controlling sub-antarctic research confirmed earlier speculations (Holdgate 1966) of the effect of these cats (Derenne 1976, Derenne & Mougin 1976, Jones 1977, van Aarde 1980) and indicated that on some islands other introduced species formed an important component of the diet of cats.

Attempts to eradicate or control certain of these populations followed some of the original surveys and in the case of the population at Marion Island the evaluation of the effect of control on the target population was based on changes in the population's age structure and density (Erasmus 1979, van Aarde & Skinner 1981). The present paper reports control of the population using a biological control technique and provides preliminary results of its effect(s). Most of the background data available for this population has been published elsewhere (van Aarde 1978, 1979, 1980, van Aarde & Blumenberg 1979, van Aarde & Robinson 1980, van Aarde & Skinner 1981). The present paper emphasizes aspects of reproduction and seasonal changes in density related to population control. The sub-Antarctic Marion Island (46°54'S, 37°45'E, 290 km^2) is situated in the Indian Ocean 2100 km south-southeast of Cape Town (South Africa). It is volcanic in origin and continuously subjected to low temperatures, strong westerly winds, and a high humidity. Aspects of the study area related to the cat population have been described elsewhere (van Aarde 1979, 1980).

2. Material and methods

This paper is based on material collected during January 1975—April 1976 and during short visits to Marion Island in October 1979 and June 1980. The original population estimates were based on surveys of selected grids (van Aarde 1979) and density indices for long-term population trends were based on line transects of indefinite width and 15 km in length conducted at irregular intervals. The analysis of the line transects followed the methods suggested by Eberhardt (1968) and Caughley (1977). Age determination was based on tooth eruption and counts of cementum incremental lines (van Aarde 1978 and in prep.). The calculation of several population statistics was described by van Aarde (in prep.) and followed Caughley (1977) and Michod & Anderson (1980).

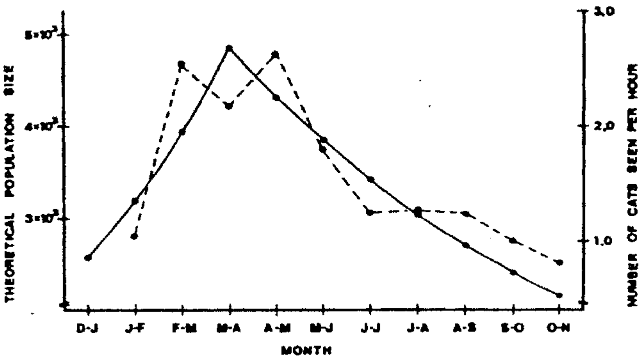

Fig. 1. Annual changes in population size based on specific parameters of the population and the number of cats seen per hour during each sampling period.

3. Results and discussion

3.1. History and establishment

The present population of cats originated from a founder group of five introduced during 1949, soon after the South African annexation of the Prince Edward Island group. Offspring of the founder group turned feral within a few years and indirect evidence suggested a minimum dispersal rate of 2.0 km/year. Results obtained during 1975/76 showed a stratified but clumped pattern of distribution with the highest crude densities (9.75 adults/km^2) on the coastal plains. Although 87 % of adults were observed solitary, observed group size varied from 1—5 with a mean of 2.65±0.95 (S.D., $n = 79$). 75 % of all groups included an adult.

3.2. Influence on the avifauna of the island

Estimated at 2139±290(S.E.) adults in 1975 this population had to consume an estimated 450 000 burrowing petrels annually to provide for 96 % of its minimum energy requirements (van Aarde 1980). An analysis of stomach contents and remains of prey indicated 15 different prey items, including eight burrowing petrel species and the house mouse *Mus musculus*. No evidence of predation on the surface nesting albatross and penguin species was obtained. Predation on burrowing petrels overlapped that of the only natural predator the Antarctic skua *Stercorarius skua* but was not considered indicative of interspecific competition. Results of recent research on these petrels have not yet been published. The fact that at least one species previously recorded as breeding on the island is now only recorded breeding on the neighbouring Prince Edward Island, suggests that its near elimination was due to cat predation. Of the 12 petrel species known to breed on the island group, three are now thought to be confined to the cat-free Prince Edward Island, only 22 km from Marion Island. Only *Pachyptila turtur* is likely to remain unaffected by cat predation due to its habit of nesting on sheer cliffs.

Data on the breeding success of five petrel species suggest a fledgling success varying from 0—53 % (M. Schramm pers comm.). Chicks of all species are extremely vulnerable to predation just prior to flying when they tend to leave their burrows to exercise their wings. Cats are also known to enter burrows to prey on nestlings.

3.3. Population characteristics

On attaining sexual maturity at an age of 9—12 months most female cats start reproducing during the first breeding season following their birth. Seasonality in breeding, with litters being produced between September and March with a peak in October, results in seasonal changes in the age structure of the population. Kittens spend the first two months in sub-terranean dens and are only observed between December and May. Subadults (4—8 months of age) are present in the population only between February and September. Seasonal breeding also results in seasonal changes in the abundance of cats, with peak numbers immediately after the birth season (March/April) and a trough at the onset of the birth season (October) (Fig. 1). The theoretical curve of annual change in population size presented here is based on an annual intrinsic rate of growth of 23.3 % (van Aarde 1978), an adult population size of 2139 cats at the onset of the 1975 breeding season, an adult sex ratio of 1 ♂: 0.55 ♀ (van Aarde 1978) and the fact that adult females produce two litters per breeding season. It is assumed that the rate of increase during the breeding season and of decrease between breeding seasons are exponential. The suggested seasonal changes in population numbers are supported by the seasonal trend in the number of cats observed per unit effort (Fig. 1). This model suggests an increase in population size of 21.2 % per month during the breeding season followed by a decrease of 11.8 % per month between breeding seasons.

Observed differences in prenatal and postweaning litter sizes based on an analysis of the age structure of the population indicated a neonatal and preweaning (weaned at an age of two months) mortality rate of 42 %. Yearling (4—12 months of age) mortality has been estimated at 37.9 %, suggesting an overall mortality rate of 79.9 % during the first year of life. Approximately 20 % of the annual kitten crop therefore survive to reproduce during the season following their birth. This figure approximates a calculated annual rate of increase of 17.1—23.3 percent.

Further analysis showed that 54 % of the population was less than 24 months of age and 71 % less than 36 months of age. Survival rate attained a maximum (93.7 %) at an age of 36—48 months and longevity for males and females was nine and eight years respectively.

3.4. Control

Being an exotic predator pre-adapted to fast colonization (van Aarde & Skinner 1981) and having a deleterious influence on the burrowing petrel species on the island, it has been decided to either exterminate or control the cat population. Control operations are in reality harvesting programmes aimed at stabilising or reducing numbers.

In considering the population characteristics of the cats at Marion and following the model $h = 1—e^{-r}$, where h = harvesting or control rate, and r = intrinsic rate of natural increase as suggested by Caughley (1977), it became evident that the cat population could only be kept stable if 20.8 % of the cats were removed annually.

This suggested that control of the 1975 population could only be achieved if 445 cats were "removed" from the population during that breeding season. The methods selected to control the population also had to be target-specific and their implementation had to result in minimal disturbance to the environment. Various methods were tested on the island (Erasmus 1979), but none proved adequately efficient.

Biological control through the introduction of a host-specific contagious disease was then considered. The advantage of using an artificially created epidemic is that it would affect an ever-increasing number of individuals in the population without disrupting the environment; but the target population must be fully susceptible to the disease.

Seriological investigations of cats collected at random before the introduction of biological control showed no specific antibodies to feline panleucopaenia virus, suggesting that the population was susceptible. They also indicated that feline herpes virus (feline viral rhinotracheitis) was present in the population. In realizing that the virus producing feline panleucopaenia is host-specific, highly contagious, resistant to environmental factors, that it induces high mortality in susceptible populations throughout the world, and that the cat population at Marion Island was susceptible, the first major effort to control the cats was the introduction of the virus to the island. The strains of virus selected produce only a short illness, with a minimum of clinical signs, terminated by acute death (Erasmus 1979). In contrast to urban populations with variable levels of immunity, it was anticipated that the course of the disease would continue to be peracute for at least the first few years.

The preparation of the challenge virus and its introduction on the island have been described by Erasmus (1979). Two strains of virus were distributed within a five day period (17—21 March 1979) over the total area (234 km^2) inhabited by cats. Ninety-six cats of mixed sexes captured on the island were exposed to the disease through intraperitoneal injections and released around the island. More carriers were released in low density areas.

3.5. The effect of feline panleucopaenia on density estimates

Density estimates based on the models suggested by Eberhardt (1968; see also Caughley 1977) for directly comparable sections of a transect line of 15.0 km for a number of surveys between 1975 and 1980 are presented in Table 1. The observed and fitted probabilities of seeing a cat at various distances from the transect line (see Caughley 1977) were calculated by pooling the data obtained during all transect surveys between February 1975 and June 1980. The calculations indicated that the detection curve is concave. The applicability of this curve to the data base was tested by regressing the log of the number of cats seen per interval of distance against the mid-points of these intervals. As the regression was approximately linear ($r = 0.70$), it was decided that the linear model should yield a satisfactory estimate of density.

The large variation in the density estimates, especially

Table 1. Density estimates for the Marion Island cat population based on data obtained during transect line surveys.

Date	Number of cats observed	Mean right-angle distance (m)	Density per km^2
01.02.1975	7	110.7	6.16
30.07.1975	8	106.3	7.34
04.11.1975	6	133.3	4.38
12.01.1976	8	93.8	8.31
24.02.1976	8	106.3	7.34
30.05.1977	5	97.4*	5.00
18.07.1977	2	97.4*	2.00
19.11.1977	1	97.4*	1.00
06.10.1978	5	105.0	4.64
25.05.1980	3	333.3	0.87
26.05.1980	1	75.0	1.30
30.05.1980	3	41.7	7.01
31.05.1980	1	25.0	3.89
02.06.1980	1	175.0	0.56

*Mean right-angle distance not measured and therefore considered as being the mean for all the other surveys.

for those surveys conducted after the introduction of feline panleucopaenia (30 May 1977 to 2 June 1980; Table 1) is ascribed to the low number of cats observed.

By pooling the estimates for 1975 and 1976 (before the introduction of feline panleucopaenia) and by comparing these with the pooled data for 1980, it can be seen that the mean 1975/76 estimate (6.71 ± 1.51 cats/km^2) was significantly higher than the mean (2.73 ± 2.37 cats/km^2) for the 1980 surveys ($t = 2.85$, $P < 0.01$). This suggests a 65 % decrease three years after the introduction of the disease. Only 4.9 % of all cats observed during the 1980 survey were kittens compared to 26.0 % during the same months in 1976.

4. Conclusion

Control of cat populations depends on the rate of natural increase, with control only being achieved when its rate is higher than that of population increase. Estimated annual rates of increase varied from 17.1—23.3 % (Marion Island) to 43 % (Kerguelen Island; Derenne 1976), suggesting that at least an equal percentage of the population had to be removed annually to achieve control.

Seasonal breeding makes the time of the year selected for control of the utmost importance. The removal of cats at the onset of the birth season would have a greater effect than their removal just after the birth season. A biological control method such as a contagious disease, which depends on direct contact for transmission, will be most effective at peak densities. Feline panleucopaenia was therefore introduced to Marion Island at the end of the 1976/77 birth season. Despite the failure to isolate the virus or antibodies from samples collected after the introduction, the decrease in density estimates following the introduction strongly suggests that the disease was effective in reducing the population in the short term. The investigation is being continued.

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