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THE FERAL CAT POPULATION AT MARION ISLAND : CHARACERTISICS, COLONIZATION AND CONTROL

BY

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Résumé

Une colonisation réussie ne dépend pas seulement des caractéristiques de l'écosystème envahi mais aussi des caractéristiques du « colonisateur » et de ses réactions envers son nouvel environnement. Cet article décrit et quantifie quelques-unes des caractéristiques de la population de Chats de l'Ile Marion qiu paraissent jouer un grand rôle dans leur installation et dans la colonisation réussie de cette île. En faisant ainsi l'histoire de la population, sa constitution génétique, son mode de reproduction, ses caractères démographiques et sa sensibilité aux agressions sont discutées. Quelques allusions sont aussi faites à propos du contrôle de la population, en particulier sur l'effet du virus *Feline panleocopaenia* sur les estimations de densité.

Abstract

Sucessful colonization depends not only on the characteristics of the ecosystem to be invaded, but also on the characteristics of the « invader » and its reactions towards its new environment. This paper describes and quantifies some of the characteristics of the Marion Island cat population thought to be of importance in the establishment of cats and the successful colonization of the Island. In doing so the history of the population, its genetic constitution, pattern of reproduction, demographic characteristics and susceptibility to stress is discussed.
Some reference is also made to the control of the population with emphasis on the effect of *feline panleocopaenia* on density estimates.

INTRODUCTION

Most introductions of mammalian species to foreign ecosystems have failed (DE VOS & PETRIDES, 1966) and those that were successful have proved detrimental to man or existing natural communities (HOLDGATE, 1966). The lack of competitors and the availability of vacant ecological niches, often resulting from a low species diversity, appear in general to have favoured the establishment of exotic mammalian species on oceanic islands. The history of most of these have been reviewed by HOLDGATE (1966) and LESEL & DERENNE (1975). The reasons for their successful establishment are, however, not so obvious when one considers that sucessful colonization depends not only on the characteristics of the ecosystem to be invaded, but also on the characteristics of "invader" and its reactions towards its new environment.

Domestic cats *Felis catus* show a large variation in spatial organization (MACDONALD & APPS, 1978; CORBETT, 1980; DARDS, 1978), food selection (FITZGERALD & KARL, 1979; VAN AARDE, 1980) reproductive patterns (VAN AARDE, 1978) and genetic constitution (TODD, 1978). Such variation can be regarded as being preadaptive and therefore of importance in the successful colonization of an ecosystem.

Domestic cats became established through human activities on nine temperate and sub-Antarctic islands (HOLDGATE, 1966). The present Marion Island cat population represents the descendants of a tiny, urban, founder population (VAN AARDE & ROBINSON, 1980), ubruptly exposed to a relaxation of possible urban selective pressures and forced to adapt to the requirements of the sub-Antarctic environment. Their successful adaptation must have resulted from the genetic and other characteristics of the founder group and their offspring, reflecting those of the species as a whole.

The present paper describes and quantifies some of the characteristics of this population thought to be important in the establishment of cats, and the successful colonization of the Island. In doing so it discusses the history of the population, genetic constitution, its reproductive patterns, demographic characteristics, susceptibility to disease, as well as control measures. This review is based on published accounts of the Marion Island cat population and data collected between December 1975 and July 1980. The study areas have been previously described (VAN AARDE, 1978, 1979). No reference will be made to the methodology involved in the collection or analysis of data as this has been published elsewhere (VAN AARDE, 1978, 1979, 1980; VAN AARDE & BLUMENBERG, 1979; VAN AARDE & ROBINSON, 1980; VAN AARDE, *in prep.*).

THE HISTORY OF THE POPULATION

The South-African annexation of the Prince Edward Island group during 1947/48 was soon followed by the establishment of a permanent meteorological station. Available information suggests that there were two consecutive introductions of domestic cats, the first early in 1949 comprised an orange striped tabby tom and a black and white (nonagouti, piebald spotted) female; the second followed in August 1949 and comprised three siblings (VAN AARDE & ROBINSON, 1980).

Some of the offspring of this founder group turned feral and in 1951 the first feral cat was observed approximately 12.0 km west of the meteorological station (VAN AARDE, 1979). Sixteen years after the introduction feral cats and signs of their activities were recorded all around the periphery of the Island, thereby suggesting an average minimum dispersal rate of 2.0 km per year (VAN AARDE, 1979). A preliminary survey conducted during 1973 suggested that the population was by then well established and comprised approximately 1,500 (500 — 1,000) free-ranging and elusive feral cats (ANDERSON & CONDY, 1974). Increasing concern about the possibly destructive influence of these cats, especially with reference to the island's avifauna, resulted in the initiation of a full-scale investigation of this population. VAN AARDE, 1979, estimated the 1975 breeding population at 2 139 ± 290 cats, with population densities of 13.8 cats/km^2 in the coastal area (0-100 m.a.s.l.) and 4.9 cats/km^2 in the interior. Approximately 450 000 burrowing petrels had to be killed annually to provide for the minimum energy requirements of the 1974/75 cat population (VAN AARDE, 1980). At that stage no numerical data were available from which to define the status of the petrel populations and thereby to give some indication of predation pressure (rate) on the petrel populations. The sensitivity of these insular populations to induced predation has, however, been discussed elsewhere (HOLDGATE, 1966; WILLIAMS *et al.*, 1979; VAN AARDE, 1980).

CHARACTERISTICS OF THE POPULATIONS

GENETIC CONSTITUTION.

The domestic cat is polymorphic for a number of pelage characteristics for which the pattern of inheritance is well documented (ROBINSON, 1977). Coat colour gene frequencies for the Marion Island population could therefore be calculated with relative ease (VAN AARDE & ROBINSON, 1980). An interesting aspect of this population was that the phenotypic and genetic constitution of the founder population for two autosomal traits was known. No indication could be found that frequencies for these loci for the 1975 population differed from that of the founder group, therefore suggesting that the founder effect predominates on Marion Island (VAN AARDE & ROBINSON, 1980). Approximately 24 generations had elapsed from the time of introduction to the time of the 1975 survey and it might be argued that these were not enough to bring about obvious changes. It was for this reason, therefore, of interest to compare the sub-Antarctic Marion Island population's genetic profile with that of a population related to the founder group, but not exposed to similar environmental pressures. Such a comparison with a South-African urban population from Pretoria (VAN AARDE *et al.*, 1981) for four autosomal loci revealed that on Marion Island gene frequencies for the mutant allele conferring dark phenotypes (nonagouti) were significantly higher, and for those conferring light coloured phenotypes (maltese dilution and piebald spotting) were significantly lower, than in the Pretoria population (VAN AARDE & ROBINSON, 1980).

It can be argued that these differences are due to differences in the fitness of different phenotypes, the darker phenotype being better adapted to the cold, wet, harsh environment of the sub-Antarctic, than the lighter coloured phenotypes. This is supported by the fact that higher grades of piebald spotting resulting in the lateral and/or dorsal parts of the body being white, are absent from the phenotypical composition of the present population on the Island.

It is furthermore, of importance to note that the "Coefficient of Darkness" calculated for the Marion Island population was higher than that calculated for any urban population (BLUMENBERG & LLOYD, 1980). This may have resulted either from the founder effect, or from selection due to an adaptive advantage conferred upon individuals with a dark coat colour under environmental conditions on Marion Island (VAN AARDE & ROBINSON, 1980).

Advantages accruing to cats possessing the dark phenotype have provoked some speculation (CLARKE, 1975; TODD, 1978) and positive density dependent correlations for the frequencies of such coat colours (nonagouti and blotched tabby) have been identified for the United Kingdom/Eire region of northwest Europe (BLUMENBERG and LLOYD, 1980). The association of high frequencies of these mutants with dense urban populations, or in the case of the Marion Island population, with severe environmental conditions, implies that "dark" cats are best adapted to cope with stress presented by either situation. This may not necessarily result from the dark coat colour as such but rather from pleiotropic effects of such mutants on physiological variables which may in turn have an influence on behaviour patterns (see KEELER, 1947 ; 1970 ; 1975).

Van AARDE & BLUMENBERG (1979) indicated a decrease in adrenal mass (decreased adrenal activity) and body weight, with an increase in "darkness". This suggests that pleiotropic effects of coat colour genes on physiological parameters result in a "selective advantage" for dark over light coloured individuals, or conversely a "selective disadvantage" for light coloured individuals as opposed to dark coloured cats.

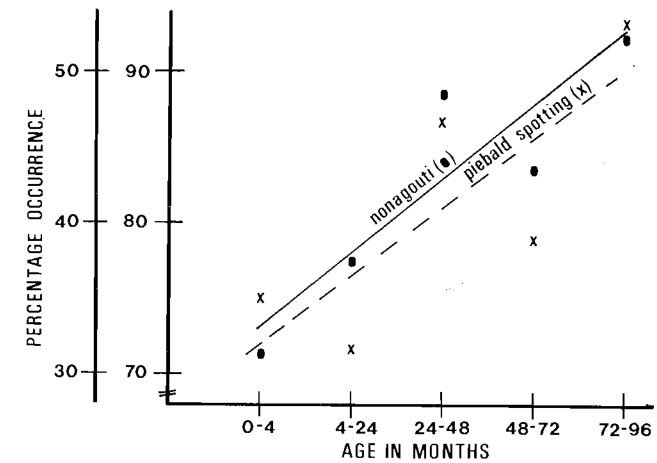

FIG. 1. — Relationship between age and frequency of occurence of mutant coat colour phenotypes.

An analysis of the age specific frequency of occurrence of the nonagouti mutant suggested a significant increase in the frequency of occurrence of black (nonagouti) cats with age ($r = 0.89$; $t = 3.35$; $p < 0.05$). It would therefore appear that the rate of survival of dark cats is higher than that of the wild type genomes. A similar pattern could however also be illustrated for piebald spotting ($r = 0.73$; $t = 3.22$; $p < 0.05$) (Fig. 1). VAN AARDE & BLUMENBERG (1979) illustrated that adrenal mass (= adrenal activity) was lower in individuals displaying this mutant phenotype than in the wild type phenotype. It would therefore appear that genomes displaying mutant phenotypes do have a "selective advantage" under sub-Antarctic environmental conditions, this being either the result of advantages accrued through the pleiotropic effect(s) of coat colour mutants on the individuals' physiology and behaviour, or of the colour of the coat itself.

Of more importance in the original colonization, however, might well be the advantages that the founder population had through the effect(s) of coat colour and/or genomes with mutant alleles. Four of the five individuals in the founder group were of the mutant phenotypes discussed above (either nonagouti or nonagouti with piebald spotting) which probably resulted in their offspring being better "equipped" than the wild type phenotypes to cope with the new environment. The observed endocyclicity, however, also suggests that the wild type genomes of the loci nonagouti and piebald spotting are still selected against under the prevailing environmental conditions, which, together with the founder effect, has resulted in the genetic profile of this population being different from that expected, i.e. a prevelance of wild type genomes (VAN AARDE & BLUMENBERG, 1979).

REPRODUCTION AND DEMOGRAPHY

Seasonality in the breeding activities of feral domestic cat populations (DERENNE, 1976; DERENNE & MOUGIN, 1976; PASCAL, 1980; van AARDE, 1978), stem mainly from the influences of photoperiodism (Van AARDE, 1978), resulting in litters being produced during the summer months, which are usually characterized by an increase in food diversity and/or availability. Females are polyoestrus but commonly produce only one or two litters per year. Mean prenatal litter size for the Marion population was 4.59 (van AARDE, 1978) and age specific fecundity increased to a maximum from an age of 24 months onwards (van AARDE & SKINNER). An adult female therefore produced 9 kittens per year but a high rate of kitten mortality (42 percent before weaning) resulted in the intrinsic rate of natural increase, based on the survival and fecundity schedules of the population, being approximately 17 percent per year (van AARDE, *in prep.*). By being polyoestrous and capable of producing two litters during the 'optimal' part of the year the domestic cat would therefore appear to be pre-adapted to establishment and colonization.

The social organization of this species, where groups mainly comprise related females (mothers and their female offspring) (DARDS 1978 ; LAUNDRE 1977) with young males being excluded from the group through the direct action of females or adult males, would enhance survival of young females thereby increasing the "reproductive value" of that part of the population reproducing for the first time. This would increase and improve colonizing ability. Maximum age for cats in this population is nearly 50 percent lower than that reported for pet cats, resulting in a majority of the adult population being reproductively active — another factor which would be of importance in the colonization of a new environment.

The observed annual rate of increase of this population (17.1-23.3 percent; van AARDE, 1978; van AARDE *in prep.*) was lower than that estimated for the cat population at Kerguelen (43.0 percent; DERENNE, 1976) and the potential rate of increase of this species. These differences apparently are due to some form of environmental resistance having an influence on either the fecundity and/or survival schedule of the population. We do not have any information on litter size at birth but mean prenatal litter size (4.59 ± 1.12; van AARDE, 1978) approximated litter size at birth (5.0) suggested for urban populations (ROBINSON, 1977). Rate of survival until weaning (when newborn individuals enter the population) was however relatively low (58 percent; van AARDE, *in prep.*). This high rate of mortality during the first few weeks after birth, resulted in a low fecundity and thus a relatively low rate of increase. Mortality rate from 4 to 24 months of age is also high (59 percent; van AARDE, *in prep.*) which would have an additional influence on the rate of increase. This high early mortality is an illustration of the environmental resistance experienced by the 1975 population. No quantitative information is as yet available on the form(s) that such environmental resistance(s) may take.

In kittens it may be due to inability to obtain food, while seasonality in prey abundance and disease may influence both kitten and adult survival. In spite of this the observed rate of increase was high enough to result in a population of approximately 2,100 adult cats only 26 years after the introduction of the founder group.

SUSCEPTIBILITY TO DISEASE

Serological investigations of serum samples collected from cats during 1975 showed no evidence of the presence of specific antibodies to the contageous disease, *feline panleocopaenia*. This virus disease is worldwide in its distribution, host-specific, resistant to environmental factors and known to produce high mortality in susceptible feline colonies. The absence of the disease in the Marion Island population can either be ascribed to the founder group not having been exposed to the disease, resulting in them not being carriers of the virus, or to the relatively long isolation of the population from other felids.

Serological surveys furhermore indicated that feline herpes virus (feline viral rhinotracheitis) is present in this population. Detectable levels of antibody were found in 51.7 percent of the population (ERASMUS, 1979). The extent to which this factor may have influenced colonization, or even regulated the population is unknown. BITTLE & PECKHAM (1971) showed high mortality in kittens of females infected by herpes virus and HOOVER & GRIESEMER (1971) have indicated abortion and foetal death as a result of virus infection. Death of young adults may also occur from secondary infection (SHIELDS & GASKIN, 1977) and it is therefore obvious that this factor could have acted as an additional mortality factor.

In considering the relative "sterility" of the ecosystem entered by the founder population (absence of related species, possible competitors and disease), the variability and therefore adaptability of the species reproductive characteristics and the genetic constitution of the founder group and its resulting offspring, it can be concluded that the characteristics of this species would favour colonization and establishment.

CONTROL

The undesirable presence of a well-established feral cat population with the resultant adverse effect on the Island's burrowing avi-fauna resulted in a decision to exterminate these cats. Several control techniques have been tested and evaluated. These were outlined by ERASMUS (1979). The decision to attempt to reduce the population through biological control using *feline panleocopaenia* (FLP) virus was based on the following:

a) Serological tests indicated that the 1975 population was fully susceptible to FPL (ERASMUS, 1979).

b) The virus producing the disease is host-specific, highly contagious, resistant to environmental factors and produces high mortality in susceptible feline populations.

c) The disease-producing agent has the advantage of involving an ever-increasing number of individuals in an artificially created epidemic within the population without disrupting the environment. (P.G. HOWELL, *pers. comm.*).

d) The disease is world-wide in distribution and occurs in most natural feline populations.

The research involved before the introduction of this factor, the preparation of the virus, its introduction to the island and its effect on some population parameters has been outlined by ERASMUS (1979).

The result of FPL introduction on estimated densities is illustrated in Fig. 2. These density estimates were based on line transect surveys of indefinitive width conducted along a predetermined route of 15 km on the northeastern part of the Island. Data analysis followed EBERHARDT (1968) and is based on a negative exponential detection curve. Limitations in the data did not permit the calculation of standard errors of the density estimates. Of importance, however, is that, in spite of variability, the general trend for the estimated density was upwards from 1975 to March 1977 when the control factor was introduced, and downwards after introduction of the virus. Density estimates for October 1978 (19 months after the introduction of FPL)

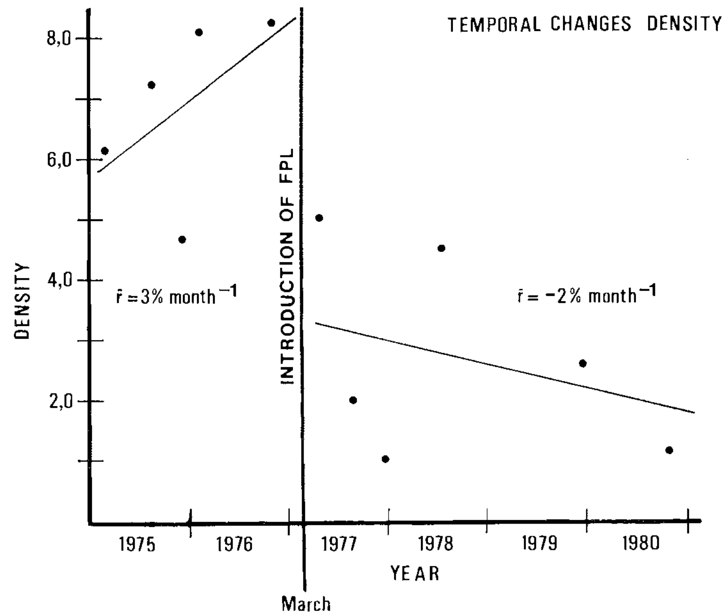

FIG. 2. — Temporal changes in density before and after the introduction of FPL.

were 54 percent lower than the estimate for October 1976 (5 months before the introduction). That for June 1980 38 months after introduction) was 65 percent lower than that for June 1976. Despite the failure to isolate the virus or antibodies from samples collected after the introduction, the decrease following the introduction (Fig. 2) strongly suggests that the disease was effective in reducing the population in the short term. Continuing investigations of its effect are being undertaken at present.

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DISCUSSION

Question (R. I. Lewis Smith) : *Since the rapid reduction of cats due to FPL is there any evidence yet of an increase in the burrowing petrel populations ?*

Réponse (M. Bester) : We do not have information on this aspect as yet.

Question (M. Pascal) : — *The size of the sample which have been used to determine the structure of the populations;*
— *Have the animals been trapped or shot ?*
— *What part of the animal has been used to determine the individual age ?*

Réponse : (M. Bester) : I do not know the sample size used for determining the population structure ; the cats have been both trapped and hunted, and age determination was based on incremental lines from tooth sections.

Question (M. Voisin) : *Why did you choose panleucopaena to reduce — or perhaps eradicate — the cat population on Marion Island ?*

Réponse (M. Bester) : A few reasons can be forwarded for the choice of FPL. Serological tests indicated that the 1975 population was fully susceptible, the virus producing the disease is host-specific, highly contagious, resistant ot environmental factors, and produces high mortality in susceptible feline populations. The disease- producing agent has the advantage of involving an ever-increasing number of individuals in an artificially created epidemic within the population without disrupting the environment. The disease is furthermore, world-wide in distribution and occurs in most natural feline populations.

Note. — The analyses were based on 205 animals killed over a one year period.