A case study of an alien predator *(Felis catus)* introduced on Marion Island: Selective advantages

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The history and demography of the cat population on Marion Island is reviewed in an attempt to illustrate that the selective advantages possessed by the founder group contributed to the successful colonisation of the sub-Antarctic biome by cats. This in part resulted from the pleiotropic effects of coat colour alleles on physiological and behavioural characteristics.

'n Oorsig word oor die geskiedenis en demografie van die katbevolking op Marion-eiland gegee in 'n poging om te illustreer hoe selektiewe voordele waaroor die oorspronklike katte beskik het, tot die geslaagde kolonisering van die sub-Antarktiese bioom deur katte bygedra het. Dit is gedeeltelik aan die pleiotropiese uitwerking van haarkleurallele op fisiologiese en gedragskenmerke toe te skryf.

Introduction

The lack of competitors and the availability of 'vacant niches' often resulting from a low species diversity, generally appears to have favoured the establishment of exotic mammalian species on oceanic islands. Successful colonisation, however, depends not only on the characteristics of the ecosystem to be invaded but also on the characteristics of the invader and its reaction towards a new environment.

Successful colonisation of a wide variety of habitats suggests that the domestic cat as we know it today, is pre-adapted for successful colonisation. This adaptive ability probably results from flexibility in characteristics which enhance fecundity and survival in a variety of environs. Free-ranging populations are often fostered through the human-pet relationships but other populations exist successfully without direct association with man. At least eight sub-Antarctic islands are at present harbouring free-ranging cat populations (see Van Aarde 1979).

The present paper describes some of the characteristics of the feral cat population on Marion Island (46°52'S, 37°51'E), in an attempt to illustrate that the genetic constitution of the founder group, and the resulting flexibility in behavioural and physiological characteristics, predisposed them to successful colonisation.

The review is based on information collected during an ecological study on the Marion Island cat population between December 1974 and April 1976. Results of this study have been reported elsewhere (Van Aarde 1978, 1979, 1980, 1983, 1984, Van Aarde & Blumenberg 1979, Van Aarde & Robinson 1980, Van Aarde & Skinner 1981) and will be referred to when relevant in this review.

The concept of 'selective advantages' as used in this paper, is taken to mean the advantages accrued by individuals within the population through selection, which either affected them before or during colonisation, resulting in these individuals contributing more to the gene pool of the established population than those without the advantages. 'Advantages' is here taken to imply that the 'asset' involved was gained through selection.

History of the population

The establishment in 1948 of a permanent meteorological station on Marion Island was soon followed by two consecutive introductions of domestic cats as pets. By August 1949 there were five cats at the station. Offspring of this founder group turned wild and in 1951 the first feral cat was observed approximately 12,0 km west of the meteorological station (see Van Aarde 1979). Sixteen years after the introductions, cats and signs of their activity were recorded all around the island (see Van Aarde 1979) and by 1973 the population comprised an estimated 500 – 1 000 free-ranging and elusive feral cats (Anderson & Condy 1974).

Van Aarde (1979) estimated the 1975 breeding population at 2 139 ± 290 (S.E.) cats with population densities of 13,8 cats/km^2 in the coastal region (0 - 100 m a.s.l.) and 4,9 cats/km^2 in the interior. An attempt to control this population biologically in 1977 when the population was estimated at 3 400 (Van Aarde & Skinner 1981), through the introduction of the infectious viral disease feline panleucopaenia, resulted in a decline to 615 ± 105 cats in 1982 (Van Rensburg, Skinner & Van Aarde 1987). Mechanical control, through trial intensive hunting campaigns during this period, proved effective as an additional measure of control. Full-scale employment of hunting is planned for implementation over three consecutive summer seasons starting in 1986/87.

Colonisation and selective advantages

Adaptability either through variability in physiological and behavioural traits or selective advantages that they accrued, enabled some or all the descendants of the founder group of four (see Van Aarde & Robinson 1980) to adapt to the requirements of the sub-Antarctic environment. Inter-individual similarities in the genotypic constitution of the founder group, however, implies limited variability in terms of some physiological and behavioural parameters (see Van Aarde & Blumenberg 1979 for explanation of the pleiotropic effects of coat colour on physiology and behaviour). It may thus be argued that successful colonisation of the Marion Island biome resulted from selective advantages possessed by the founder group.

An outstanding feature of the founder group, and of the present-day population, is the high relative frequency of occurrence of darkcoloured phenotypes. This resulted in the 'coefficient of darkness' (Blumenberg & Lloyd 1980) for the Marion Island population being higher than that calculated for other populations (Van Aarde & Skinner 1981). This has been ascribed to the founder effect (Van Aarde & Robinson 1980) but the significant ($r = 0,89$; $t = 3,35$; $p < 0,05$) increase in the frequency of occurrence of non-agouti (black) individuals with an increase in age (Van Aarde & Skinner 1981), implies that dark coat-colour phenotypes have a selective advantage under the prevailing environmental conditions, with the rate

of survival of the mutant genomes being higher than that of wild-type individuals. The genetic profile of the present population is therefore not only the result of the founder effect, but also due to present day selection in favour of mutant phenotypes.

Advantages afforded to cats possessing the dark phenotype has provoked some speculation (Clarke 1975, Todd 1978), and a positive density dependent correlation for the frequencies of such coat colours (non-agouti and blotched tabby) has been identified for the United Kingdom/Eire region of northwest Europe (Blumenberg & 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 (low temperatures, high winds and a high rainfall), implies that dark cats are better adapted to cope, either with extremes associated with these situations, or with environments drastically different to that of their wild ancestors (i.e. *Felis lybica*).

Van Aarde & Blumenberg (1979) indicated a decrease in adrenal activity and body weight with an increase in 'darkness', clearly illustrating that coat colour genes have a pleiotropic effect on physiological parameters, which in turn may influence behavioural patterns (see Keeler 1970, 1975). The selective advantages for dark-coloured individuals under the conditions prevailing in the sub-Antarctic may, thus, be due to the pleiotropic effects of coat colour genes on physiological (and thus behavioural) parameters.

Of more importance to the original process of successful colonisation, however, might well be the advantages that the founder population had through the effect of coat colour on adaptability. All individuals in the founder group were 'dark-coloured' (non-agouti; Van Aarde & Robinson 1980), presumably resulting in them being better 'equipped' than the wild-type phenotypes to cope with the new environment.

Environmental resistance

Age specific productivity ($\bar{x}$ = 4,59 ± 1,12 kittens/litter; Van Aarde 1978) in the 1975/76 period, was close to the physiological maximum suggested for the species (see Robinson 1977), at the relatively low annual rate of population increase (23,3 %; Van Aarde 1978) due to a high first year mortality rate (Van Aarde 1983), suggests that the population experienced severe environmental resistance. This is supported by the finding that longevity in these cats (8 and 9 years for males and females respectively; Van Aarde 1983) was substantially lower than that reported for pets (21 years; Robinson 1977). This steep increase in mortality rate from five to nine years of age is indicative of the relatively harsh environment under which these cats live (Van Aarde 1983).

The intrinsic rate of increase estimated for the Marion Island cat population (23,3 % per year; Van Aarde 1978) is considerably lower than that estimated for the population on the sub-Antarctic Kerguelen Island (43 % per year; Derenne 1976), suggesting obvious differences in 'environmental resistance' experienced by these different populations. Differences in population growth rates may, however, also be due to the different genetic constitutions of the two populations. The Kerguelen population is characterised by the near absence of wild type phenotypes (Dreux 1974), but these do occur in the Marion population (Van Aarde & Robinson 1980).

Therefore it is concluded that in spite of severe environmental resistance, cats succeeded in colonising the Marion Island biome, possibly because of advantages possessed by the founder group acting favourably, through the pleiotropic effects of coat colour alleles, on physiological and behavioural characteristics.

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