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SHORT COMMUNICATION

DIET OF FERAL GOATS AND FERAL PIGS ON AUCKLAND ISLAND, NEW ZEALAND

Summary: The diets of feral pigs and feral goats shot on the main Auckland Island in 1989 are described from analyses of stomach and rumen contents. Feral goats ate at least 50 species of plants, but only three, *Metrosideros umbellata, Chionochloa antarctica,* and *Durvillea antarctica* made up over 50% by dried weight of the food eaten. Feral pigs ate a mixed plant and animal diet, of which plants made up 61% of the diet, with the megaherb *Anisotome antipoda* being the largest dietary item at 38% by dried weight. The animals eaten by pigs were mostly annelids, at 26% by dry weight of their diet, and there was little evidence of predation or scavenging on birds. Goats have subsequently been eradicated from the island, but feral pigs remain arguably a potential threat to current conservation values and certainly an impediment to any restoration of the island's natural values.

Keywords: Feral goats; feral pigs; diet; impacts; conservation; subantarctic; control.

Introduction

Auckland Island (50° 45' S) is the largest (46 000 ha) of New Zealand's subantarctic islands. It is relatively unmodified by humans and introduced biota (Johnson and Campbell, 1975; Fraser, 1986). There are about 320 raindays per year, about 1780 mm of rainfall, a mean monthly summer maximum of about 10.5°C in January and mean minimum winter temperatures of about 5.5°C in June (De Lisle, 1965).

There are no native terrestrial mammals, but 10 species of exotic mammals were liberated or established last century. Dogs (*Canis familiaris* L.), horses (*Equus caballus* L.), sheep (*Ovis aries* L.), cattle (*Bos taurus* L.) and brushtail possums (*Trichosurus vulpecula* Kerr) were liberated but subsequently died out, whereas mice (*Mus musculus* L.), cats (*Felis catus* L.), feral pigs (*Sus scrofa* L.) and feral goats (*Capra hircus* L.) persisted. Surprisingly, rats have not established despite at least seven shipwrecks on the main Auckland Island since 1833 (Ingram, 1990). Despite the climate, both feral pigs and feral goats established from liberations in 1807 and 1865, respectively. The goats occupied only about 4000 ha in the Hooker Hills in the north of the island, perhaps because the climate there was marginally more clement (De Lisle, 1965; Rudge and Campbell, 1977). However, after a vegetation survey in 1983, and concern that the population could spread (Campbell and Rudge, 1984), the population of 105 goats was eradicated in 1992 (Williams, 1994). Feral pigs are at low densities over the whole island, and their eradication is currently being considered by the New Zealand Department of Conservation (W. Shaw, *pers. comm.*).

Previous dietary information on Auckland Island pigs and goats has been indirect, relying on observations of feeding sign or on inferences drawn from changes in the condition and structure of vegetation plots (Challies, 1975; Campbell and Rudge, 1984). Direct measures of pig and goat diets have been made from analysis of plant cuticles or animal remains in faecal pellets (Rudge, 1976, for pigs, and Rudge and Campbell, 1977, for goats). These estimates are biased by different digestibility of foods and thus can mislead unless corrected by pen trials, as attempted for goats (Rudge and Campbell, 1977). The only previous direct measurement of diet from analysis of stomach contents was made from 16 pigs shot in February 1973 (Challies, 1975).

This paper describes the diet, as revealed from stomach contents, of feral goats and feral pigs from larger samples than previously available, and discusses the likely impact of feral pigs on the native biota apparently at risk should they be allowed to persist.

Methods

About 200 cm^3 of rumen contents from 49 adult goats and 1000 cm^3 of the mixed stomach contents

from 33 adult pigs were collected in November 1989 (late spring) and preserved in formalin. Most pigs were shot in the same area as the goats, i.e., in the Hooker Hills at the north end of the island (see Rudge and Campbell, 1977, for a map). Each sample was washed through a 4 mm sieve, and about 10 g of the larger fractions sorted, oven-dried at 80°C for 3 days, then weighed. Most plants were identified to species level, but most animals were grouped into higher-order taxa.

Results

Diet of feral goats

Woody plants (41%) and grasses (39%) made up the bulk of the diet of goats, with only minor quantities of seaweeds (13%), ferns (4%), and herbaceous species (3%). At least 40 plant species were eaten by goats, but only three species, rata (*Metrosideros umbellata*; plant nomenclature follows Johnson and Campbell, 1975), snow tussock (*Chionochloa*

Table 1. *Diet (% dried weight and % of goats eating the food) of 49 goats shot on Auckland Island, spring 1989.* [1] = *Includes* Poa *spp.* [2] = Blechnum procerum, B. capense, B. durum, *and* B. penna-marina. [3] = P. vestitum *and* P. cystostegia.

Food items	% of total sample by dry weight	Frequency (%)
Metrosideros umbellata	26.4	90
Coprosma foetidissima	4.4	80
Pseudopanax simplex	2.7	76
Hebe elliptica	1.7	18
Hebe odora	1.0	27
Coprosma cuneata	0.7	35
Dracophyllum longifolium	0.7	47
Myrsine divaricata	0.4	53
Cassinia vauvilliersii	0.3	20
Coprosma pumila	0.2	16
Hebe benthamii	0.2	6
Coprosma ciliata	0.1	10
Total woody plants	**40.5**	
Montia fontana	0.6	6
Anisotome latifolia	0.3	20
Ranunculus hirtus	0.3	8
Anisotome antipoda	0.2	8
Acaena media	0.2	14
Plantago triantha	0.1	16
Epilobium sp.	0.1	12
Cotula sp.; *Pratia arenaria; Ranunculus acaulis; Helichrysum bellidioides; Hierochloe* sp.	traces	2
Total herbs	**2.8**	
Chionochloa antarctica	11.7	59
Unidentified grasses[1]	21.4	100
Carex appressa	6.0	69
Bulbinella rossii	0.2	8
Colobanthus muscoides; *Aporostylis bifolia*	traces	2
Total monocotyledons	**39.4**	
Blechnum spp.[2]	3.0	
Polystichum spp.[3]	1.0	
Cyathea smithii	0.3	8
Phymatosorus diversifolium	0.2	18
Hymenophyllum multifidum; Asplenium obtusatum	traces	2
Total ferns	**4.5**	
Durvillea antarctica	12.4	43
Macrocystis sp.	0.3	6
Total algae	**12.8**	
Moss, fungi, insect larvae	**traces**	

antarctica), and kelp (*Durvillea antarctica*), make up half of the total (Table 1). An average of 11 (range 5 - 20) different food items was found in the rumen of each goat. Rata, *Coprosma foetidissima*, and *Pseuodopanax simplex* were each found in over 75% of the animals sampled (Table 1). Nearly half the goats had visited the beach as they had eaten seaweeds.

Diet of feral pigs

Plants made up 61% of the diet of pigs, and herbaceous species formed the major food class at 44%. Leaves of *Anisotome antipoda* were the largest single food item (Table 2). Annelids were the most common animal food at 26% of the diet (Table 2).

Table 2. *Diet (% dried weight and frequency of occurrence) in 33 pigs shot on Auckland Island, spring 1989.*

Food items	% of total sample by dried weight	Frequency %
Metrosideros umbellata	2.8	18
Coprosma foetidissima; C. ciliata; C. pumila; C. cuneata	traces	3
Total woody plants	**3.3**	
Anisotome antipoda	37.8	70
Stellaria decipiens	3.9	27
Acaena media	1.6	9
Stellaria media; Tillaea moschata; Ranunculus sp.	traces	
Total herbs	**43.8**	
Unidentified grasses	4.4	
Carex appressa	0.9	9
Total monocotyledons	**5.3**	
Blechnum spp.	1.9	
Polystichum spp.	0.1	
Total ferns	**2.0**	
Durvillea antarctica	0.2	6
Fungi	3.7	6
Unidentified rhizomes and starchy plant material	8.4	
Annelids	26.3	76
Molluscs	0.6	9
Crustaceans	0.5	12
Insect larvae	0.4	6
Feathers/birds	5.4	12
Total animals	**33.2**	

An average of 4.6 (range 2 - 10) different food items was found in each pig stomach, but only *A. antipoda* and annelids were each found in 76% of the animals sampled (Table 2). At least 20% of the pigs had visited the beach, as their stomachs contained seaweed or marine animals.

Discussion

The reliance of goats from the Auckland Island on just a few species as food is not simply a reflection of the small choice available on remote islands. Other dietary studies in New Zealand have shown similar patterns of two or three species forming the bulk of the diet, e.g., on Raoul Island (Parkes, 1984), on Mt Egmont (Mitchell, Fordham and John, 1987), and to a lesser extent in the Raukumara Range (Parkes, 1993). The previous study of the diet of the Auckland Island goats was done by identifying plant cuticles in faecal pellets sampled in summer 1973 (Rudge and Campbell, 1977). Among principal foods, no algae were identified from pellets, presumably because they did not survive digestion, but other main food species were present, albeit in different proportions. For example, rata (12% in faecal pellets and 26% in rumen samples) and snow tussock (1% in faecal pellets and 12% in rumen samples) are underestimated by faecal sampling.

A previous diet study of Auckland Island pigs, using stomach samples of 16 animals shot during summer of 1972-73, suggested pigs using the coast had a more varied diet than those feeding further inland, with the former eating more birds and seaweeds, and the latter more annelids (Challies, 1975). We did not record where our pigs were shot, so the difference in the amount of annelids in the two samples (26% *vs.* 14.5% in Challies, 1975) may reflect differences in where the pigs were feeding. The importance of *Anisotome antipoda* in the diet in 1989 was not noted by Challies in 1973. However, he did observe that pigs had dug up and eaten the roots of *Bulbinella rossii, Pleurophyllum hookeri,* and *Ranunculus* sp., which we suspect are included in the unidentified rhizomes and amorphous starchy plant material making up 8.4% of pigs' diet in 1989.

Examination of pig faeces during the 1972-73 expedition showed a few food species not recorded in our study (Rudge, 1976). These included scavenged items such as cephalopods and echinoids, and the hair and skin of cats and other pigs. Birds identified in the 1972-73 studies included yellow-eyed penguin (*Megadyptes antipodes* Hombron and Jacquinot) and Auckland Island prions (*Pachyptila desolata* Gmelin), but whether these were scavenged or preyed upon was not known.

Dietary studies can indicate likely impacts of the animals on conservation values, although the results need to be interpreted with some care depending on the abundance and vulnerability of the species being eaten.

Goats were suggested as the main culprits in the reduction of *Chionochloa antarctica* and its replacement with woody vegetation, particularly at low altitudes (Campbell and Rudge, 1984). The proportion of tussocks in goats' diet, and the lack of tussocks in pigs' diet, support this concern. Campbell and Rudge (1984) measured only slight changes between 1973 and 1983 in the tussocks on the single plot they established in an area with pigs and no goats. However, others have argued that the tussocks at low altitude were induced by 19th century fires and colder temperatures and are now being replaced by woody plants more adapted to the absence of fires and to slightly warmer temperatures (M.S. McGlone, *pers. comm.*). Therefore, the ultimate cause of the decline in tussock habitats (if it is due to herbivory) will need to be answered by further remeasurement of the tussock plots within previous goat range.

Of more interest to managers is the past, current, and future impact of pigs. Challies (1975) claimed pigs had passed through an eruptive oscillation (see Caughley, 1970), reaching peak densities about 30 - 45 years after their liberation, and then declining to their present low densities. Their impacts were assumed to be greatest during the eruptive and peak phases of this process, and in 1973 were claimed to be no longer changing the general status of the vegetation or birds (Challies, 1975). Eradication of pigs could not therefore be justified to stop further degradation, but might be considered to restore habitats. Further, as pigs and their resources were assumed to be in some dynamic equilibrium there was no need for urgent action. In contrast, Campbell and Rudge (1984) claimed pigs were still changing the vegetation, particularly low-altitude *Chionochloa antarctica* habitats, and their eradication was more urgent than suggested by Challies.

There is some empirical evidence that pigs did pass through an eruptive oscillation and have changed the vegetation (and perhaps other biota) during this process. Pigs were reported to be damaging two megaherbs either by eating the leaves (*Stilbocarpa polaris*) or by eating the roots and using the leaves as bedding material (*Pleurophyllum criniferum*) (Hooker, 1844). These two megaherbs were described by Hooker (1844) as abundant in moist areas, and they are still abundant on the mammal-free islands (Adams and Disappointment) in the Auckland group (Challies, 1975). Their leaves do not appear in the current diet of pigs as they are restricted to inaccessible places (Johnson and Campbell, 1975). This impact appears to have been apparent by 1907, when Tennant (reported in Cockayne, 1909) claimed that "... pigs have worked much havoc since Hooker's time ..", although Cockayne himself thought .. "pigs do not appear to have brought about any appreciable change."

One way for pig impacts to be ongoing during an apparent post-eruption, low density, stable population phase is for the pigs to change their diet to less preferred and more robust species. Campbell and Rudge (1984) use a quote from a 1907 expedition to the island that added *Bulbinella* to Hooker's list of plants being "turned over" (Waite, 1909) to argue that "as large-leaved herbs were eliminated, *B. rossii* roots became a favourite". The general lack of attention to animals in Hooker's (1844) taxonomic records suggests a large risk in assuming that *B. rossii* was not previously eaten by pigs. The unexpected result from our pig diet study is the importance of *Anisotome antipoda* despite its supposed early reduction (Challies, 1975; Campbell and Rudge, 1984) and present claimed restriction to cliff crevices (Johnson and Campbell, 1975; Sherley, 1988). This, and the equivocal evidence of the early botanists leads us to favour Challies' view that the pigs are not an urgent problem, although their eventual eradication would allow restoration of past damage. However, the 10 species of annelids from Auckland Island include eight species endemic to the Auckland Island group (Lee, 1959). Whether any species are threatened with extinction by pigs is unknown, but the number eaten by pigs is cause for concern.

A second way for impacts to be ongoing is via density-independent damage, e.g., the damage to tussocks might not be related to tussocks as food but to tussocks as cover for food such as earthworms, which might be in balance with the pigs.

In summary, interpretation of the data on pig diet as an indication of their impact on conservation values is risky in the absence of related evidence on trends in these values. This uncertainty means that it is difficult to argue, on the evidence, that pigs are a threat to current values, although they are a threat to any plans to restore the island's natural values. The management implication of these conclusions is that the pigs should be eradicated, but there is time to plan this properly.

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