THE DIET OF FERAL GOATS (*Capra hircus* L.)

IN THE RIMU-RATA-KAMAHI FOREST OF MOUNT EGMONT

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FRONT PIECE

The lowland forest of the study area on Mt Egmont in January 1984; looking from the north-east.

ABSTRACT

The diet of the feral goat (*Capra hircus*) in rimu-rata-kamahi forest on Mount Egmont was examined by sorting monthly rumen samples for one year. Seasonal changes in diet, relative plant palatabilities, differential fragmentation and digestion rates of plant species, nitrogen and mineral levels in principal foods, and several aspects of population biology were measured.

Results show that individual goats contain at least 19 plant species on average and some more than 30. Presumably, they eat about this number daily. However, just two species (*Asplenium bulbiferum* and *Ripogonum scandens*) make up 44.8% of the total amount eaten over the year.

There are significant seasonal changes in the amounts eaten for *Coprosma grandifolius*, *Coprosma tenuifolia*, *Griselinia littoralis*, *Melicytus ramiflorus*, *Ripogonum scandens* (fruit and vine) and *Weinmannia racemosa*.

Goats clearly select or reject different plant species. Thus use of species is largely independent of availability. The most preferred foods are probably *Schefflera digitata* and *Ripogonum scandens* fruit and vine. In contrast the very abundant *Microlaena* spp., *Uncinia* spp., moss, *Alsophila smithii* and especially *Blechnum fluviatile* are among the most unpalatable.

The low and probably variable availability of many species within the study area obscures their seasonal trends and palatability ratings.

Asplenium bulbiferum, and probably *Melicytus ramiflorus*, are underestimated in the diet, whereas *Ripogonum scandens* vine may be overestimated. However, the magnitude of error is not sufficient to be a problem in this study.

There is no obvious correlation between diet selection and the levels in plants of N, K, Ca, Mg, P, S, Cu, Zn, Fe and Mn. Only Na is deficient enough to possibly be selected for and highest levels occur in the very palatable *Schefflera digitata*.

Age structure, body condition and reproductive data suggest a predominantly young, healthy population that is reproducing rapidly.

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CHAPTER 1

INTRODUCTION AND AIMS

1.1 GENERAL EATING HABITS OF GOATS

Throughout the world goats (Capra hircus L.) are valued because they continue to be productive in range conditions where other domestic herbivores cannot (Campbell et al 1962, Devendra 1978, Huston 1978) or because they largely eat weeds or plants that other stock do not want (Rolston et al 1981, 1983, Clark et al 1982, McKinnon 1982, Wilson 1982). On the other hand goats are often disliked because they deplete vegetation and promote erosion in areas too infertile to carry domestic stock (Campbell et al 1962, Huston 1978).

The tenacity of goats, compared to other domestic or feral ruminants, is probably associated with their eating habits, described by Huston (1978) as being different from sheep and cattle, but similar to deer. Major factors which probably contribute to these differences are:

1) Acceptance of a wide variety of feeds, especially browse (Campbell et al 1962, Coblentz 1977,1978, Devendra 1978, Huston 1978 and Devendra and McLeroy 1982).
2) The ability to digest tough feeds (Devendra 1978, Huston 1978, Devendra and McLeroy 1982, D.Dellow pers.comm.).
3) Energetic and versatile food gathering habits (Huston 1978) including limited tree climbing ability (Atkinson 1964, Sykes 1969). They are much more inquisitive than other ruminants and will walk long distances in search of food. This behaviour helps them meet their nutrient requirements (Devendra and McLeroy 1982).
4) A mobile upper lip, allowing closer feeding and better selection of the palatable plant parts (Campbell et al 1962, Atkinson 1964, Huston 1978).
5) A high tolerance of bitter tastes (Bell 1959, Devendra and McLeroy 1982).

Although goats occupy a wide variety of habitats in tropical to temperate climates. they perform best in the dry tropics (as opposed to wet humid areas). This is because of their resistance to

dehydration, preference for browse and wide ranging feeding habits which may include poorer feeds (Devendra and McLeroy 1982).

1.2 NEW ZEALAND STUDIES REFERING TO FERAL GOAT DIET

The destructive influence of feral goats on New Zealand's native flora has caused a number of biologists to comment on goat dietary habits. Most of these works have been based on observation of goat browse sign (Turbott 1948, Atkinson 1964, Sykes 1969, Rudge and Campbell 1977, Russell 1981, Parkes 1982, 1983a, 1984b); or changes in the composition of plant associations within goat inhabited areas in comparison with uninhabited areas (Atkinson 1964). In some cases stomach contents were examined (Laing 1947 in Asher 1979, Turbott 1948, Asher 1979, Parkes 1983a, 1984b). The two studies that actually quantified the intake of plant species by goats were by Rudge and Campbell (1977) using faecal analysis, and Parkes (1983, 1984b) using macro-rumen analysis. However, neither of these studies considered seasonal changes in diet or measured palatability by comparing plant use with plant availability. Also both were on outlying islands. Hence there is no accurate description of seasonal diet or preference for feral goats in New Zealand. All the studies were on islands except for Atkinson (1964), Asher (1979) and Russell (1981), but most of the islands' floras were broadly similar to the mainland and thus carried implications about goat diet in New Zealand.

The above studies are briefly described below in chronological order. In the main, only common, widely distributed plant species will be mentioned.

1) Turbott (1948) commented on diet while describing the impact of goats over a sixty year period on Great Island, Three Kings. He observed browse sign and the browse induced plant communities compared with earlier descriptions and goat inaccessible areas. He made several rumen examinations and found they were full of grasses, sedges and herbs, i.e. the goats had been grazing. However palatable tree and shrubs were eaten to a high browse line implying goats had little choice except to graze. Seemingly more palatable species included *Metrosideros excelsa*, *Melicytus ramiflorus*, *Paratrophis smithii* and native grasses. Species which were hardly eaten or avoided, included *Leptospermum scoparium*, *L.ericoides*, *Myoporum laetum*, *Coprosma*

rhamnoides and various grasses and sedges.

2) Atkinson (1964) presented lists of low preference species and unpalatable species based on comparisons of goat inhabited versus uninhabited areas and browse sign from various regions in New Zealand. He found that goats browsed many species but only barked a few in any one area. On Cuvier Island seaward slopes were modified more than anywhere else. Zotov (1949 in Atkinson 1964), mentioned this phenomenon occuring in parts of the Tararua and Rimutaka Ranges. In each case aspect did not seem important and Atkinson thought perhaps foliage bearing wind-carried salt was being sought after.

Common species of apparently low palatability included Blechnum fluviatile, Alsophila smittii, Leptospermum scoparium and Leptospermum ericoides, Gaultheria antipoda, Uncinia spp. and Microlaena spp.. His proposed unpalatable species included Cardiomanes reniforme, Hebe odora, Histiopteris incisa, Hymenophyllum spp. and Pseudowintera colorata. He also implied Griselinia littoralis, Weinmannia racemosa, Coprosma tenuifolia, Coprosma robusta and some Blechnum spp. were palatable to goats on Mt Egmont.

3) Sykes (1969) visited the Kermadec Islands to assess the impact of goats on the vegetation. Like Turbott (1948) he looked at browse and regeneration and compared earlier descriptions with the present state of the vegetation. Sykes noted goat browse sign up to 10m above the ground on trees with leaning trunks. Similarly Atkinson (1964) concluded that Mt Egmont goats climbed into scrub and ate the crowns.

Although Sykes did not aim to describe goat diet he suggested the following species were palatable: Pittosporum eugenioides and Kermadec varieties of Pseudopanax arboreus, Metrosideros (Similar to M.excelsa) and Coriaria arborea. Two species which had increased and therefore were probably unpalatable were Ascarina lucida var.lanceolata and Myrsine kermadecensis.

4) Parkes (1983a, 1984b) measured goat diet on Raoul Island as part of an experiment on the application of 1080 poison gel to standing plants. A random 200ml rumen sample was collected from each of 103 goats shot in June - December 1982 and April - December 1983. Particles catching on a 4mm sieve were macroscopically sorted to species or type (e.g. grasses). The rumen samples, and to some degree permanent vegetation plots, gave indications of which species were

palatable. Parkes (1984b) suggested that the goats were selective feeders, although without measurements of plant availability he could not assign palatabilities to plant species. However, the fungus Auricularia sp. was obviously preferred because of its low abundance and high use. Seven species made up 89% of the diet. Parkes (1983a) thought most of these species were probably palatable, although he felt the high proportion of ferns in the diet (18%) may have reflected a lack of choice. The seven foods included Kermadec varieties of Metrosideros (Similar to M.excelsa), Coriaria arborea, Melicytus ramiflorus and Rhopalostylis, and a number of grasses and sedges. Other palatables listed by Parkes (1984) included Alsophila sp., Pseudopanax arboreus var.kermadecense, Coprosma sp., and Melicope ternata which was considered only slightly palatable by Turbott (1948) and Sykes (1969). Unpalatables included the two species listed by Sykes (above).

5) Rudge and Campbell (1977) looked at the impact of feral goats and pigs on the largest of the Auckland Islands. The harsh environment appeared to have restricted goat distribution and therefore diet selection since goats used but few of the plant communities rich in palatable species. Rudge and Campbell determined an approximate scale of palatability by measuring browse sign within a range of plant communities. Also diet was measured more precisely by analysing faecal samples collected in different plant communities. The following species were eaten out below the browse line of 1.25m and were likely to have been highly palatable: Blechnum durum, Asplenuim oblongifolium and Phymatosorus diversifolium. Pseudopanax simplex var.simplex had 79% of tufts browsed, Polystichum vestitum 79%, Metrosideros umbellata 38% and Coprosma foetidissimma 37%, suggesting that they were fairly palatable. Blechnum procerum, Uncinia spp. and Histiopteris incisa were never recorded as browsed and were probably unpalatable.

6) Asher (1979) roughly sorted the contents of 69 rumen samples from one island and 11 mainland populations. Different areas would have varied in species abundance, therefore species which were consistently eaten in many different areas were probably palatable. Asher found that goats ate large proportions of exotic grasses when available and suggested that goats are predominantly grazers, as did Riney and Caughley (1959), Atkinson (1964), Malechek and Leinweber (1972) and Coblenty (1977). In contrast other researchers suggest that

goats are mainly browsers, e.g. Campbell et al (1962), Yocom (1967), Devendra (1978), Rudge (1979), Sidahmed et al (1981), Clark et al (1982) and Devendra and McLeroy (1982). More recently goats have been classified as adaptive mixed feeders (Sidahmed et al 1983).

In two of Asher's study areas that were eaten out to the browse line, over 50% of the diet was Griselinia littoralis litter. The leaves "had the appearance of decomposing litter" (Asher 1979). Similarly Turbott (1948) found two goats contained large amounts of palatable browse (Melicytus ramiflorus, Metrosideros excelsa and lichens), only after strong winds had blown it to the ground. Laing (1947 in Asher 1979) found dead leaves of Fuchsia excorticata in the rumen of Mt Egmont goats. Rumen samples collected by Asher were dominated firstly by exotic pasture grasses and secondly by Chionochloa and Poa species. However, the dominant trees and shrubs were similar to those in other studies and were as follows: Griselinia littoralis, Coprosma spp., Melicytus ramiflorus and Pseudopanax spp..

7) Russell (1981) described the state of the Mount Egmont vegetation in relation to goats and possums. The browse index of Wardle et al (1971) was used to calculate the percentage contribution of each species to the diet. Unfortunately the browse index does not take into account availability and therefore did not measure palatability. The five most important species in the diet according to the browse data were Asplenium bulbiferum 35%, Astelia fragrans 21%, Blechnum discolor 5%, Griselinia littoralis 3% and Microlaena spp.3%.

The above studies did not consider seasonal changes in intake or provide any clear indications about species palatabilites, because they did not measure plant availability. However, they probably represented a large range of availabilities for many species. Therefore species which consistently made up large proportions of the diet were probably palatable (preferred). On this basis a minimum list of suspected palatable species is extracted.

Griselinia littoralis
Melicytus ramiflorus,
Metrosideros excelsa
Pseudopanax spp. (five-fingers)

1.3 THE MODIFICATION OF HABITATS BY GOATS

The destructive impact of goats, especially on the vegetation of islands, has frequently necessitated their being controlled or exterminated. Goats are probably more destructive than other feral herbivores (Roots 1976) because they continue to thrive in habitats with little remaining vegetation (Campbell et al 1962, Devendra 1978 and Huston 1978).

Wallace (1911) and Roots (1976) briefly described the devastation of vegetation and fauna by goats on St Helena and the Galapogas Islands respectively. Within the Hawaiian Halekala National Park, feral goats caused some plant species to vanish, many to change in distribution and abundance and promoted the establishment of exotic herbs that no longer prevented erosion (Yucom 1967). Research by Coblentz (1977) compared habitat modification by goats with that due to deer, bison and sheep combined, on Santa Catalina Island. Goats degraded their habitat when compared with the other animals because of their tendency to eat plants to ground level, or to pull them out of the ground.

Mainland and island studies from New Zealand recorded similar devastation. Goats were barely exterminated in time to save the few climax forest remnants on Great Island, Three Kings (Turbott 1948). Merton (1970) wrote of "spectacular regeneration of forest species" on Cuvier Island once sheep, cattle and especially goats were gone. Regeneration of many plant species, including the dominant canopy species Metrosideros sp. (similar to M.excelsa) was prevented by goats on Raoul Island (Sykes 1969). Now that most, if not all of the goats are gone (J.Parkes pers.comm.) many once declining species are regenerating well (Parkes 1984b). On mainland New Zealand only a few high priority feral goat populations are controlled (Parkes 1982). Most populations continue to modify their habitats by eating palatable species leading to the dominance of unpalatables. They eventually open up the understory and prevent canopy regeneration which enables a dense ground cover of harsh grasses and sedges to develop (Atkinson 1964).

1.4 GOAT CONTROL IN NEW ZEALAND, PAST AND PRESENT

Traditionally, goats have been controlled by foot hunting with or without dogs. The Department of Internal Affairs first began large scale and systematic feral goat control in 1937 after an already long

period of damage by goats in New Zealand. This government control was subsidized by bounty payments and free ammunition to encourage private hunters to kill feral goats. Responsibility for goat control was taken over by the New Zealand Forest Service in the 1960s. Rudge (1979) stated that despite about a million goats having been shot in New Zealand to date, their mainland distribution had not altered much in the last 30 years. However, some populations have been greatly reduced (Parkes 1982).

Goat control by foot hunting is a continual and expensive process with a few top priority areas exhausting the available money and man power; so many areas remain unmanaged. Hence there is a very real need to establish more cost-efficient methods of control.

1.5 UNDERSTANDING GOAT DIET COULD HELP CONTROL GOATS

A method of feral goat control showing considerable promise is the application of 1080 gel to the underside of leaves of palatable food species. The method probably has the greatest potential in densely populated areas with a shortage of preferred species within the browse range. Branches of highly preferred species can be bent down to within reach of goats and poisoned with 1080 gel. Thus goats will concentrate their feeding on poisoned plants.

So far the method has been tried on feral goats in the Raukumara Ranges (Parkes 1982, 1983b), on Raoul Island (Parkes 1983a), and also on white-tailed deer on Stewart Island (Challies and Burrows 1984). On Raoul Island the abundance of palatables and the effects of high humidity on the 1080 gel meant the time was best spent hunting (Parkes 1983a). In contrast, the Raukumara trial produced an estimated 97.5% reduction in goat numbers with poisoning in one area and a 94.5% reduction by hunting in another similar area for much the same effort. This was despite a lot of the poison gel probably being ineffectively applied to non-preferred species or laid in low use areas. Also the gel was phyto-toxic and quickly caused browning or abscission which reduced bait life from many weeks down to a matter of days. Parkes (1982) concluded by saying "where suitable these preliminary trials suggest that very encouraging results can be obtained for less effort than traditional methods." Challies and Burrows obtained similarly favourable results for white-tailed deer, with pellet density counts indicating a 90% kill.

It appears that poisoning natural vegetation can be a "useful alternative or addition to hunting as a goat control method" (Parkes 1983b). However, an obvious step to improve the method is to obtain more precise knowledge of goat dietary preferences through the year. This could also help in assessing which plant species and communities are at risk and how they might be modified by feral goats.

1.6 AIMS OF THE STUDY

1.6.1 Diet

The method of controlling goats by applying 1080 poison to the underside of edible foliage (see problems found by Parkes 1982 in Section 1.5) cannot be most efficiently applied without a good knowledge of goat dietary habits. Thus the principal aim of this study was to gain a greater understanding of goat diet within a typical New Zealand goat habitat.

1.6.1.1 Seasonal Changes in Diet

As the season changes, so may the foods selected by goats (Cory and Fraps 1940 in Huston 1978, Malechek and Leinweber 1972, Devendra 1978, Devendra and McLeroy 1982 and Sidahmed *et al* 1983). Diet studies of large herbivorous mammals suggest that seasonal variation in diet occurs because of changes in availability (McCaffery *et al* 1974, Ellis *et al* 1977, Sexson *et al* 1981 and Baranga 1983) or because of changes in plant quality including digestibility (Drozdz 1979, Schwartz and Ellis 1981), the levels of nutrients in the plants (Mills and Mark 1977, Leader-Williams *et al* 1981, Baranga 1983 and Pellew 1984) and levels of secondary compounds on the plants (Freeland and Janzen 1974, Bryant and Kuropat 1980 and Pellew 1984). Also the needs of the animal may change seasonally, causing it to favour different foods (Pellew 1984). Hence the second important objective was to describe seasonal changes in diet.

1.6.1.2 Variation in Diet with Sex, Age, and Time

The plant species eaten by a herbivore may vary according to sex (Dzieciolowski 1970, Leader-Williams *et al* 1981, Staines *et al* 1982, Pellew 1984); age (Dzieciolowski 1970, Leader-Williams *et al* 1981, Kossak 1981) and time of day (Gaare 1977, Leader-Williams *et al* 1981,

Savory 1983). The third aim of this study was to test whether goat diet varied with any of the above factors. Also the effects of altitude and area (locality) (see Figure 2.1) on diet (probably through changes in availability) were examined to enable more accurate interpretation of the results.

1.6.1.3 Preference :The Use of Plant Species in Relation to their Availability

The palatability or preference rating of a plant species cannot be established on the basis of how much of it is eaten. Large amounts of a species in the diet may simply result from lack of choice, as was possibly the case for ferns on Raoul Island (Parkes 1983a). It is usual to have measurements of both species use (in the diet) and availability in the field to show selection for particular species (Crawley 1983). The fourth aim of the study involved estimating the relative standing crop of each plant species within the browse range and relating this to the average amount of each species eaten, using an appropriate preference index.

1.6.2 Differential Fragmentation and Digestion

Previous diet studies indicated that the proportions of plant species found in the rumen of a herbivore may not accurately reflect the proportions of those species eaten (Bergerud and Russell 1964, Staines 1976, Gaare *et al* 1977, Owaga 1978). Plant species probably fragment and digest at different rates so that some disappear faster than others from the rumen. A fifth aim of this study was to briefly examine the effects of goat chewing and digestion on some principal dietary species to detect any gross differences in species breakdown rates. This would allow more accurate interpretation of the rumen results.

1.6.3 Nitrogen and Mineral Levels in Principal Dietary Species

Many studies of herbivore diet and nutrition suggest that the animals adapt their food preferences in response to food quality (nutrient levels, digestability and levels of secondary plant compounds; for references see Section 1.6.1.1).

A sixth aim of this study was to discover any correlations between

the use of species and their nitrogen and mineral levels.

1.6.4 Population Biology

The seventh and final aim of the study was to briefly describe population parameters including age structure, reproduction and body condition. These measurements may be informative with respect to the type of pressures influencing the population and may imply something about the diet in terms of food quality and abundance.

1.6.5 Summary of the Aims

1) The overall aim of the study was to describe feral goat diet in a native forest, in order to improve efficiency of goat control by applying poison to edible natural vegetation.
2) To describe seasonal changes in the use of plant species.
3) To describe how diet varies with sex, age and time of day.
4) To establish relative palatability ratings (seasonal if possible) for plant species
5) To see whether principal dietary species fragment and/or digest at different rates.
6) To find any correlations between plant species use and plant nitrogen and mineral levels.
7) To describe population parameters including age structure, sex ratios, reproduction and body condition.