DIET AND FEEDING BEHAVIOUR

OF THE

KEA (*Nestor notabilis*)

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Ria.

ABSTRACT :

A study was carried out in order to establish which foods are taken by the kea (*Nestor notabilis*). Published and unpublished literature was reviewed, and fieldwork was carried out at Craigieburn Forest Park for ten days during the period February - July 1987. Observations made at Craigieburn were backed up by observations from several other areas, made over 27 days during the period December 1986 - August 1987. A total of 27 feeding sessions was observed and both foods taken and feeding behaviour were recorded.

From published and unpublished literature and field observations, a total of 89 species of plants and nine species of animal were identified as food sources for the kea in the wild. For both plant and animal foods there were a number of instances where only the genus was recorded, so that the total number of species taken may be as high as 110 and 12 respectively. It was found that the diet of the kea is largely vegetarian (70.5 % of the food items taken at Craigieburn were plant material).

It was not determined if the foods taken by keas reflected preference or availability. Some foods taken were only seasonally available (berries, flowers, nectar,leafbuds). The importance of the same plant species as a foodsource for the kea varied with different localities. Observations on habitat use suggested that the movement of the kea between the forest and areas above the bushline was a function of food availability.

Keywords : Kea (*Nestor notabilis*), diet, feeding behaviour, Craigieburn Forest Park, habitat use.

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and from Craigieburn Forest Park archives.

1. INTRODUCTION

1. Introduction.

To many the kea (*Nestor notabilis*) is one of the most interesting members of the New Zealand avifauna. Some people consider the kea the most amusing bird they have encountered, while others ascribe to it the status of sheepkiller. It is one of the birds over which most controversy has arisen in New Zealand. Endemic to the mountainous areas of the South Island of New Zealand, the kea is the only highland parrot which includes the true alpine environment in its habitat. A large part of kea habitat lies within the boundaries of the National Parks and Forest Parks of the South Island. In these parks keas have proven to be both asset and liability. Their curiosity and playfulness are a source of amusement for many, but their strong, sharp beaks can be destructive. While those people who live, work and recreate in kea habitats get much pleasure from the birds, they also experience problems related to kea activity. Facilities, vehicles and equipment are investigated by keas. Many human-introduced structures and objects bear marks of kea activity, while some are permanently damaged or destroyed.

Since November 1986 the kea has become fully protected under the Wildlife Act 1953. The reponsibility to deal with kea related problems now lies with conservation officers in he Department of Conservation. To date very little scientific study has been done on either the biology, ecology or behaviour of the kea. The strategies for dealing with keas which are

identified as problem birds are limited to capture and relocation of such birds. As yet nothing is known about the possible home range and / or homing tendencies of the kea, or about specific habitat requirements. Thus relocation may not prove a satisfactory solution in the long term.

To manage the species effectively, an understanding of their population dynamics is necessary, and for any experiments to be meaningful, a basic understanding of kea behaviour is a prerequisite.

It has been speculated that keas visit human occupied sites to obtain foods. Little is known about the kea's natural diet and its feeding behaviour, and no conclusive evidence has been found that food is the main attraction for keas at such sites.

This dissertation deals with a descriptive study on foods and feeding of the kea and is aimed to form the base for further studies which may help produce guidelines for effective management of kea populations at human occupied sites.

fig. 1 problems due to kea activity include damage to vehicles.

1.1. Aims and objectives.

The initial study objectives focused on the management of keas, especially in parks. I identified a broad set of objectives, from which to choose main objectives once feasibility was assessed. These objectives were:

-The assessment of population size, territory size and movements of individual birds within and outside their territory.

- The monitoring of habitat use throughout the course of a year, to assess the relationship of seasonal movement and food availability in different habitats.

- A study on foods and feeding of the kea.

- Observations of keas at human occupied sites, in order to establish what attracts keas to such sites (eg. food or other factors).

- An inventory of problems experienced by people due to kea activity and an assessment of the extent of damage caused by keas.

Craigieburn Forest Park was selected as the study area, because of its proximity to Lincoln. The park features sites which are permanantly occupied by people (staff accommodation and amenity area), sites which are seasonally occupied by people (skifields) and remote areas which are infrequently visited by trampers and hunters. Keas occur throughout the park, and problems due to kea activity have been reported in the park and on farmland surrounding the park.

I worked in the park from July till December 1986. It was during this period that preliminary observations for this dissertation were made. It soon became apparent that surprisingly little is known about the biology, ecology or behaviour of the kea. Basic background information on keas was needed before their management in parks could be considered.

The initial investigation focused on establishing the size of the kea population in the park, the range and seasonal movements of the birds and the relationship of these movements with food availability.

The preliminary observations made between July and December 1986 showed that keas can be as elusive and secretive as they can be conspicuous. The behaviour of the birds was difficult to interpret, and no adequate method to census the population was possible given the current knowledge. The amount of time needed for field work would by far exceed the time available for study. Thus the aims and objectives were modified accordingly.

1.1.1. Aims.

The aim of this dissertation was to provide a non quantitative review study, which focused on aspects of the biology of the kea related to feeding. It was intended to be a reference for further more detailed and quantitative research. The study combines the review of published and unpublished information and the results of my own field observations.

1.1.2. Objectives.

The objectives of this dissertation were:

- To review published and unpublished literature dealing with the history, description, distribution, abundance, habitat and movement, nesting, social behaviour, and foods and feeding of the kea.
- To list plant and animal species eaten by the kea, followed by a list of parts of plants eaten and time of the year when foods were taken.
- To note kea behaviour and habitat use related to feeding.

This disseration is complementary to a research project which is currently underway, of which Graham J. Wilson (Department of Entomology, Lincoln College) is the principal investigator. One of the aims of his project incorporates the

gathering of data on foods and feeding of the kea, in order to establish seasonal changes in diet. This dissertation provided background information for, and helped frame some of the questions posed by Wilson.

Papers by Clarke (1970) and Jackson (1960-1969) and work by Campbell(1976) provided information on movements and feeding of the kea, and this information has been incorporated into this dissertation.

2. LITERATURE REVIEW

2. Literature review.

2.1. History.

It is generally assumed that the kea was named by the Maori, after its characteristic, long drawn out 'ke-a-a' call. The kea was a foodsource for the Maori and for the European settlers (Phillipps, 1947). That the flesh was considered tasty and palatable is confirmed by a more recent account, given by Francis (1983).

The first recorded description of the kea dates back to 1856, when W.B.D. Mantell obtained and described several specimens from West Otago. Meyers (1924) refers to the years following Mantel's description as a period during which most - if not all - interest in the kea was displayed by ornithologists. Interest in the kea became more widespread when in 1867 it was speculated that the birds killed sheep and caused stock losses on high country runs in the South Island. A detailed account of the early records concerning the sheep killing habits of the kea can be found in the work of Marriner(1908).

It took very few years before the kea's sheep killing reputation became established dogma. Round the turn of the century attempts were made to investigate the extent to which sheeplosses were due to kea attack. Marriner (1908) found it near impossible to verify the reports of kea attacks on sheep. He suggested that five percent of the flock would well cover the

annual loss due to keas, but found it difficult to estimate exact annual losses due to kea activity. The kea remained much maligned among the high country sheep farmers. The issue was an emotive one, and, as Meyers (1924) pointed out, it became an economic one. Private runholders and the government introduced bounties on kea beaks and heads. Both musterers and those hired to kill keas earned some - no doubt welcome - money. The government bounty scheme was introduced in 1890 and continued until 1971 (Anderson, 1986). At the beginning of the century the means of killing keas were many and varied from poisoned bait to special kea guns (Marriner, 1908). Records of bounty payments give some insight into the numbers of keas that were killed. In a nine year period (1920 - 1929) bounties were paid on 29,249 keas. During the period from 1860 to 1970 an estimated 150,000 keas were killed (Anderson, 1986).

It has been established that keas can injure sheep by landing on their back and tearing at the animals' wool and skin. Such injuries can lead to blood poisoning which may prove fatal. While high country farmers did experience sheep losses due to kea activity, other causes of mortality among sheep (eg: snowdrift, illness, flyblow etc.) were played down and the influence of keas elevated. Keas scavenged on sheep carcasses and were blamed for more than their share of sheeplosses. The image of the kea as a vicious killer was disputed by many, and the justification for a bounty scheme and the killing of keas was questioned repeatedly (Cockayne, in Meyers 1924; Jackson, 1963; Meyers, 1924 and Porter, 1934). None of these queries led to

halting the bounty scheme. Campbell (1976) included in his work a discussion on keas and sheep. He concluded that there was no doubt that keas did sometimes cause the death of sheep, and suggested various ways to improve stock management and reduce stock losses due to kea activity.

Previous to 1986 keas were partially protected under the Wildlife Act 1953. Effectively this meant that keas were protected everywhere except on those properties where they caused damage. Some 100 people held permits to keep keas in captivity. A small percentage of these birds were used as call birds, to attract other keas which subsequently could be destroyed by the permit holder(Anderson, 1986). In 1986 the kea was granted full protection under the Wildlife Act 1953. The kea has since been protected throughout the country. Any one who is seen to molest or kill keas is liable for prosecution. Those people who had a permit to keep keas in captivity are still entitled to do so, but a review of this matter is at present under consideration by the Department of Conservation. The responsibility for dealing with problem birds now lies with conservation officers from that department. The present means of dealing with problem birds involves their capture and possibly relocation. If no suitable place for relocation can be decided upon, the birds may be kept in a zoo or wildlife park. It is not yet known if relocated birds return to their capture site.

To date very little scientific study has been done on the kea. Only recent work departs from the debate on the kea as a sheepkiller and deals with various aspects of the biology,

ecology and behaviour of the kea in a more objective manner. Continued research, aimed at the provision of information which will aid the development of management strategies is of high priority.

2.2. Description.

Detailed descriptions of the kea may be found in Forshaw(1981) and Oliver (1955). The description that follows is taken largely from Forshaw and my own observations.

The kea is a robust bird, between 45 and 50 cm. long. Like other parrots, the kea has a downward curved upper mandible. The upper mandible is longer and the curve more pronounced in males than in females.The olive green plumage is edged with black and appears dull at first sight. However, the feathers under the wing and at the base of the tail (dorsal) are a vivid orange-red and make a kea in flight a spectacular sight. Both males and females have the same colouration. Immature birds fledge 13 weeks after hatching (Forshaw, 1981). They are the same size as adult birds, but not the full adult weight. Their colouration is slightly lighter than that of adults, especially on the crown which can have a near lime green shine. The cere, eyering and lower mandible are bright lemon yellow in fledgelings. This yellow darkens with age and it is thought to take ca.three years to become grey to charcoal in colour. In fledglings the relatively long legs are remarkably light in

colour, sometimes a pale yellow. Again this colour darkens with age and becomes a grey to olive green when the bird is mature. Due to its colouration, the kea can , like other parrots, be quite inconspicuous. Keas usually make themselves known by a long drawn out 'ke-a-a' call, used when in flight. Though not as melodious as its only close relative, the kaka (*N. meridionalis*), the kea has a large vocal repertoire. Fledglings can be heard to make warbling or cackling sounds, not unlike that of domestic fowl, while females reserve a soft mewing call for the fledgelings. Immatures sometimes have a call reminiscent of that of parakeets. Any excited or angry kea has an array of deafening screeching noises at its disposal.

The kea shares a common ancestor with the congeneric kaka. This ancestoral proto kaka ranged over the whole of the New Zealand landmass previous to the ice ages of the Early Pleistocene (1½ - 2 million years ago). The extensive glaciation during these ice ages had considerable effect on the climate in the south of the New Zealand landmass. This era saw alpine conditions close to sealevel along most of the coastline of the 'south island', and a sea barrier between the landmass of the north and south island. It was during this period that speciation occurred and kea and kaka evolved (Fleming, 1975). Forshaw (1981) classifies the genus *Nestor* as the only genus in the Nestorinae, a sub family of the Psittacidae.

2.3. Distribution.

The kea is endemic to the alpine areas of the South Island of New Zealand (fig 1). The area occupied by keas has its northern boundary in the Wakamarama range (north west Nelson) and its southern boundary in the Cameron Mountains (Fiordland) (Bull, *et al.* 1985), but keas have been sighted outside this range (Robertson, 1976). Keas occur right along the west of the Main Divide, occasionally down to sealevel, though they are most commonly encountered between 600 and 1700 m. asl. The eastern limits for keas (from north to south) are defined by the Kaikoura, Puketeraki and Barrier ranges and Dean Forest (Campbell, 1976).

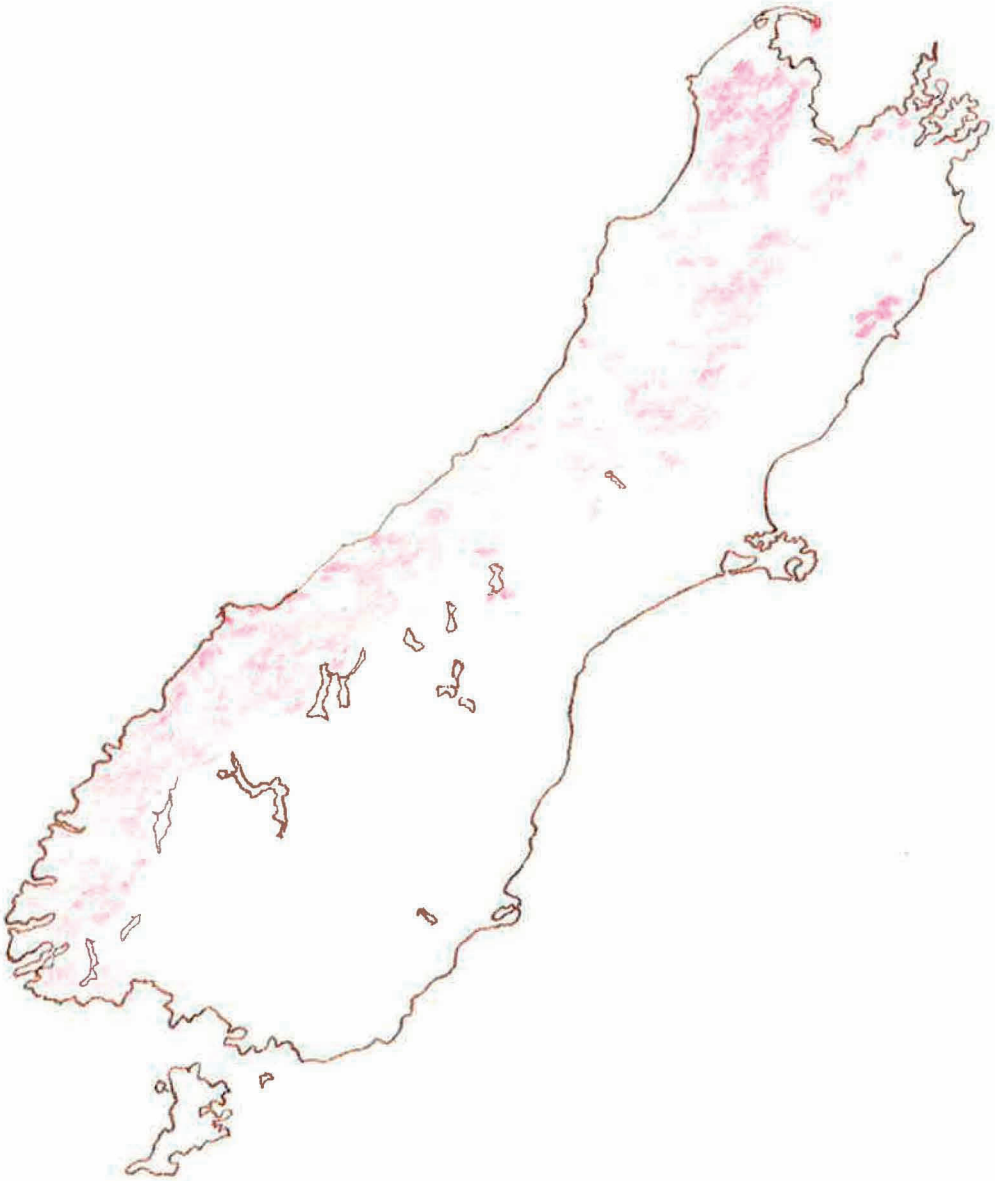
During 1987 keas were sighted in the Port Hills, Christchurch (Wilson, 1987), but these were believed to be escapees from captivity, rather than birds which had strayed across the Canterbury Plains. Sightings have been recorded also from the Tararua Range in the North Island (Cunningham, 1974), but it is believed that these keas came from a nearby wildlife park. Though keas are strong fliers, and capable of crossing Cook Strait or the Canterbury Plains, none are known to have done so.

In the first half of this century Meyers (1924) suggested that the kea was extending its range northward since its first discovery by Europeans in West Otago in the 1850's. He remarked that at the turn of the century no keas had been recorded in the Kaikoura's and the northern Nelson district and that while keas had been recorded in Marlborough around that time

(1900-1905), they had become increasingly plentiful. This may however reflect the distribution of the observers at that time, and not of the keas. At present there is no evidence that the kea is extending its range beyond the area of distribution outlined above.

2.4. Abundance.

It is not known how many keas remain in the South Island. Estimates for the total population are around 5000. (This figure is based on the number of 10,000yard grid squares in which keas have been recorded, and the assumption that each square could support two birds, Anderson, 1986). Though circumstantial only, evidence seems to suggest that the population is dwindling. Wilson (1987) is attempting to develop a census technique, so that the population size can be estimated, changes in numbers can be monitored, and the status of the bird understood.



= Kea (*Nestor notabilis*)

Fig 2. Distribution of the Kea.

Adapted from: 'The Atlas of Bird Distribution in New Zealand.'

2.5. Habitat and movement of the kea.

Keas generally occur in subalpine and alpine zones, between 600 and 2000 m. asl. Though most often associated with open country, tussock grassland and subalpine shrubland, the kea is equally much a bird of the forest. Jackson (1960 & 1963) showed that at Arthur's Pass keas use both the forest and the areas above the bushline for feeding, roosting and nesting. Work done by Collins et al. (1986) in South Westland showed keas to be most common and widespread in high country valleys, where they occurred from the valley floor to the bushline. In this South Westland study keas appeared to be present in greater numbers at higher altitudes (700 m. asl. and higher) and in steeper hill country. In general keas can be found most frequently near the interface of forest and alpine grassland zones (1250 - 1500 m. asl.). The birds use both the forest and open areas for feeding, nesting and roosting. The kea is thought to be a wide ranging bird, whose habitat stretches across broad environmental and altitudinal gradients, depending on food supplies and influences such as weather. Sightings of banded birds have shown that keas move between 20 and 30 kilometres (Campbell,1976; Clarke, 1970;). Jackson (1960) recorded a flight of 45 km. in one day. Two adult male keas which were radio tracked at at Mount Cook National Park showed a distinct pattern of daily activities, including flights of between 10 and 20 km(Wilson, 1987).

Keas are seen frequently at lower altitudes when the areas above the bushline and along the ridges are exposed to heavy snow, fog or strong winds (Jackson, 1963; Meyers, 1924). On several occasions keas have been known to come down to sealevel, commonly on the West Coast and in Fiordland (classified summarised notes, Notornis 1956; Wilson,1987). Keas are capable of flying at high altitudes, and occur on both sides of the Main Divide. While they must have crossed the divide on occasions, it is as yet unknown if they do so regularly.

On the west of the divide keas frequent predominantly mixed podocarp and hardwood forests, and silverbeech forests (Collins et al. ,1986; Jackson, 1960). On the east of the divide the forested part of the habitat is largely made up of mountain beech (*Nothofagus solandri var. cliffortioides*).

Both Clarke (1970) and Jackson (1960) concluded that the movement of keas between alpine shrubland and forests was a function of food availability (see 2.8.).

2.6. Nesting.

Marriner (1908) described several kea nests. He maintained that the nests were found well above the bushline, generally in highly inaccessible places. A nest described by Mc.Caskill (1954) was situated in the forest, close to the bushline. The most detailed account of nesting behaviour of the kea is by Jackson (1963). Between 1956 and 1963 Jackson found 36 kea nests in the Arthur's Pass area. All nests found by Jackson were between 600 and 1200 m. asl. Thirty two nests were in mountain beech forest, one in Westland rain forest and three in subalpine shrubland. Those nests which were in the forest were close to the bushline or to an open space or clearing. Thirty four of the 36 nests were situated on slopes with a sunny or warm aspect. Those kea nests found were on the ground in tunnels and cavities under boulders, ledges, logs, roots of shrubs and trees or crevices in the rock. For most a well worn narrow track led to the entrance of the nest. Often a rock or boulder nearby provided a roosting place for the adult birds. Such a site may be recognised by a pile of accumulated droppings.

The female builds the nest and incubates the two to four eggs, which may be laid anywhere between July and January (Jackson, 1963). Nesting materials identified by Jackson (1963) include lichens (*Usnea barbata* and *Anzea*), mosses, ferns and woodchips. Marriner (1908) found pieces of bark and tussock leaves in the nest chambers.

Jackson (1963) described the incubation period as three to four weeks, during which the female only left the nest two times a day to feed and/or to be fed by the male. When the chicks hatch, they are blind and covered with white down, which gets replaced by a dense greyish down. This in turn gives way to feathers (Forshaw, 1981). The chicks develop slowly. After one or two weeks the eyes open. The total period spent in the nest after hatching is 13 weeks. During the first four weeks after the chicks hatch, the male feeds the female, which in turn feeds the chicks. Thereafter both adults will feed the chicks (Jackson,1963). Jackson (1963) stated that fledglings are fed by the male. Jackson (1963) wrote of the male fledglings that they follow their father, two or three weeks after fledging. No reference was made about what happened to the female fledglings. A female which has not been breeding that season will guard the male fledglings and play with them, but will not feed them. Should this be true, than this would be highly unusual behaviour. Ordinarily individuals do not invest energy in young that are not their own offspring (Wilson, 1987). Fledgling males become independent some four weeks after fledging, while it takes six weeks for female fledglings to reach independence (Jackson, 1963) and they may remain with their parents unil the next breeding season (Forshaw, 1981). Wilson (1987) suggested that the fledglings may associate with their parents for several years.

Keas are thought to be sexually mature at the age of three or four years. Jackson (1963) suggested that young females may build nests for several succesive years before they

actually breed and that not all females breed every year. Jackson's (1963) observations led him to believe that keas are polygamous. This would be contrary to the habits of most parrots, but to date there is insufficient evidence to either support or refute this suggestion.

Very few nests have been recorded in the last twenty years. A nest found in Craigieburn Forest Park and described by Ledgard (1979), was in mountain beech forest, not far below the tree line, in a similar position to those described by Jackson.

A nest found at Mount Cook National Park in 1987, (fig. 3 & 4), was situated in subalpine shrubland. It was sheltered by some medium sized shrubs and was two metres from the edge of a canyon. Five metres above the nest was a large rock outcrop which provided a roosting place forthe adult birds. Like those nests referred to above, this nest had a well worn track, totally void of vegetation, leading to the entrance. The structure and appearance of the nest were much in accordance with descriptions by Jackson (1963) and Ledgard (1979).

2.7. Social behaviour of the kea.

The social behaviour of the kea has been little studied. Though the kea is of gregarious nature, flocks generally don't exceed 15 individuals. As many as 50 keas have been seen in a single flock, but such large flocks are rare, especially in the latter half of this century (Potts, 1972). There is little information of the age and sex composition of flocks, or the pecking order within flocks. Atkinson (in Leigh,1985) described flocks seen at Mount Cook village as groups of juveniles, and both Campbell (1976) and Clarke (1970) suggested that juveniles are more gregarious than adults. Jackson (1960) reported that breeding pairs may join flocks, but return to their roosts each night. Breeding pairs are thought to be territorial although Jackson (1960) suggested that territory holders allow other keas into their territory and even close to the nest.

Field observations by Wilson (1987) and myself recorded what appear to be family groups. These comprised of up to seven keas, including adults, fledglings and immatures of several cohorts (section 4.2.3.). While these observations are as yet too few to be conclusive, they tend to support Foreshaw's (1981) suggestion that immature birds remain with the parents until the next breeding season.

As outlined in 2.6, Jackson (1963) suggested that keas are polygamous and that females who did not breed, but did have a mate, took care of the male fledglings produced by their mate and another female. Wilson (1987) challenges the

plausibility of this theory, but more observations are needed to establish the relationships between the different individuals in a group. Atkinson (in Leigh, 1985) and Jackson (1969) both suggested that there is a pecking order within flocks. The former observed that birds which he described as being at the bottom of the pecking order often did not eat, even if food was available. Jackson described keas which he thought to be at the bottom of the pecking order as grossly under weight and prone to anaemia and starvation.

Studies on the behaviour of the kea in captivity were made by Potts(1977) and Zeigler(1975). Potts described antagonistic behaviour and threat and appeasement behaviour, as well as allopreening. Campbell (1976) briefly described antagonistic behaviour of keas in their natural environment. Zeigler's work is concerned with the development of feeding in keas in captivity. This work relates the feeding behaviour of three young captive keas over a period of eight weeks, following fledging. Behaviour of both parents and young are recorded and the development of species-typical feeding behaviour patterns are discussed. Jackon's (1963) work faciliates a comparison with the feeding behaviour of keas in their natural environment. Notes on feeding techniques can be found both in the work of Campbell (1976) and Jackson (1963).

2.8. Foods and feeding of the kea.

Many readings give clues as to what kea feed on. Most of the articles written in the first half of this century list foods taken by keas incidental to discussions on keas and sheep. While many food items are listed, these writings do not provide a framework which might help assess why keas eat the foods they do. A description of the resource and of alternative foods available in the kea's habitat is usually absent. Work of more qualitative nature has been done by Campbell (1976), Clarke (1970) and Jackson (1960). The general opinion is that keas are omnivorous, but predominantly vegetarian. A review of observations by Clarke (1970) show that 95.5% of the total food items observed to be taken by keas are plant material. The remaining 4.5% consists of insects and larvae. Other readings show that non vegetarian foods include mammalian carrion when available.

Jackson (1960) described foods eaten by the kea, and the time of the year when the different foods were taken. This account illustrated seasonal movement of the kea as a function of food availability. A similar conclusion can be found in Clarke's(1970) study.

Clarke (1970) not only listed foods taken by keas, and the seasonal variation in these foods, but he also provided an additional breakdown of the parts of the plants that were taken. Clarke (1970) identified 42 species of plants and two species of insects eaten by keas. Campbell (1976) indentified 23 species of

plants and an unknown number of insect species. Both Clarke (1970) and Campbell (1976) analysed faeces, in addition to field observations, to determine what keas feed on. Experiments on the viability of seeds found in kea faeces lead to Clarke's (1970) suggestion that keas may help in the dispersal of some alpine plants. Campbell (1976) estimated the total number of feeding hours availble to keas in the Routeburn Basin. He concluded that, during winter, keas spent 70% of their active hours feeding. I suggest that this figure would probably be much lower for those keas which spend time at human occupied sites, but research is needed to confirm this. Campbell (1976) described the kea's alleged preference for fat and fatty foods. He does not offer any conclusive results, but asked some interesting questions which need to be addressed in future. Those include; do keas show a preference for fatty foods,and if so, why?; is it a matter of taste or need?; and do wild keas obtain sufficient lipid nutrients from natural foods.

There are many notes to be found on the foods taken by keas in captivity (Campbell,1976; Marriner,1908; Zeigler,1975). The list is long and ranges from fat, meat, fruit, and vegetables to sweets. The kea's choice of foods due to preference rather than availability could be tested relatively easily with captive keas, but this has hardly ever been done. One subjective account of an attempt to assess the kea's tastes and preferences can be found in Marriner (1908 pp.43-45).A captive kea was put through a special course of foods by its owner, and the foods preferred and rejected were described. While the

fig. 5 preference or availability ?

results of this experiment can not be conclusive, one interesting observation emerged: the kea seemed to require roots (of *Bulbinella* sp.) for its digestion. The kea ".....never seemed so well, when he did not have them (*Bulbinella* sp.) two or three times a week". Only one record exists of roots of Bulbinella sp. taken in the wild. On the whole, roots do make up a large part of the diet of keas in the wild (section 4.1.). More recent records show that overall food preferences of captive keas seem to be for fatty foods. (butter, cheese, seeds with a high oil content) and carrots (Zeigler, 1975). It should be stressed that without a structured study, these records can not be regarded as conclusive.

3. FIELDWORK

3. Fieldwork.

3.1. Study area - description.

Craigieburn Forest Park was selected as the study area. The park is close to Lincoln and it has several easily accessible valleys inhabited by keas, with road access to the bushline.

With both permanent and seasonally human occupied sites within its boundaries, and damage due to kea activity reported from these and adjacent sites, the park made a good location for the study of management problems. While the objectives finally focused only indirectly on management (section 1.1.2.), the park was retained as the chosen study area. Within the park Craigieburn Valley was chosen as the site for most intensive observtions. Observations made at Broken River Valley (adjacent to Craigieburn Valley), were also incorporated.

The Craigieburn range lies 20 km. east of the Main Divide and 90 km. west of Christchurch. The range stretches for about 26 km. in a general direction NE - SW. The terrain is characterised by slopes of between 29 and 40 degrees, less steep and more open toward the south of the range and with more steepsided valleys in the north of the range. The Craigieburn Valley is such a steep sided valley, while Broken River is slightly more open. The area occupied by both valleys is approximately 3000 ha. Both valleys run in a general direction

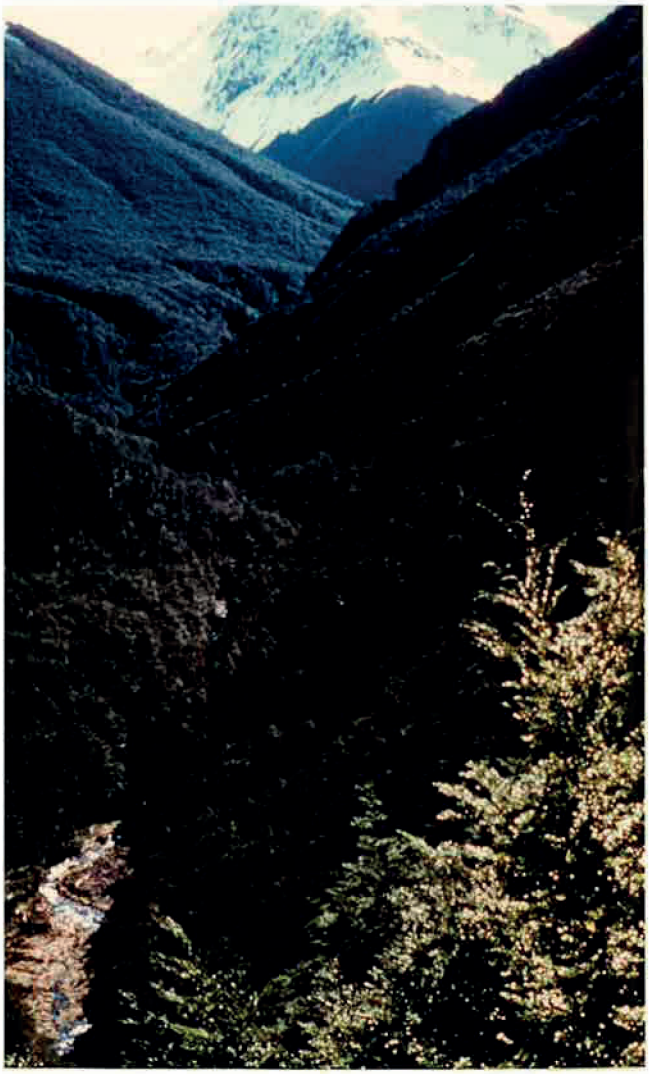


fig. 6 Craigieburn Valley

fig. 7 Broken River valley

E-SE to the east of the Craigieburn range. (fig.8, page 27: map of study area)

The rock type is Greywacke and the soils are described as mainly weakly developed types of yellow brown earths (Craigieburn Forest Park management plan, 1981). Mountain beech (*Nothofagus solandri var. cliffortioides*) clings to the sides of the valleys and between 1200 and 1300 m. asl. gives way to subalpine tussock grassland interspersed with shrubs and herbs. The height of the peaks surrounding the valleys varies between 1500 and 1850 metres. Large screes run down from the 1700 m. ridges to join the tussock areas on more shallow slopes. Bare rock outcrops break the surface of scree slopes and vegetated areas alike.

The climate is typically alpine and montane and can be quite harsh. The mean annual rainfall is 1700 mm. In winter the valleys are covered in snow, often down to 700 metres. Many of the steep slopes that are dried out by wind in summer, are windloaded with snow and are prone to avalanches during winter (Craigieburn Forest Park Management Plan).

fig. 8 a >>

locality map

fig. 8 b >>

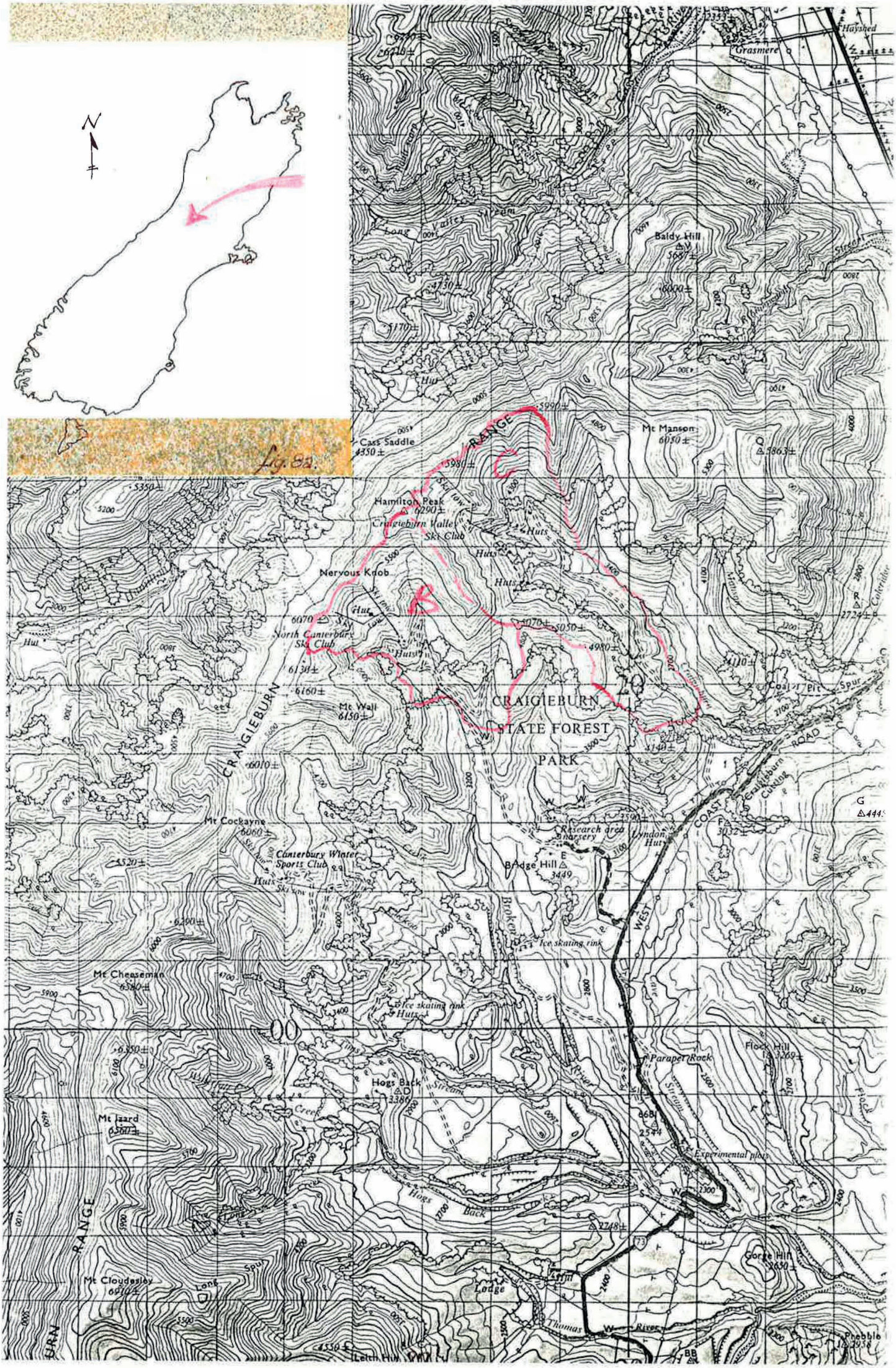
map of the study area,

from NZMS 1 S66

scale 1: 63,360.

C = Craigieburn valley

B = Broken River valley


N
Fig. 82.
Haysned
Grasmere
Long Valley
Baldy Hill
5687±
6000±
4730±
5170±
Hut
5990±
Cass Saddle
4350±
RANGE
5980±
Mt Manson
6050±
5863±
5350±
Hamilton Peak
6290±
Craigieburn Valley Ski Club
Huts
Nervous Knob
Hut
6070
North Canterbury Ski Club
5070±
5050±
4980±
6130±
6160±
Mt Wall
6150±
CRAIGIEBURN
STATE FOREST
PARK
4110±
Coal Pit Spur
2724±
4140±
6010±
Mt Cockayne
6060±
Canterbury Winter Sports Club
Research area
Nursery
Lyndon Hut
Badge Hill
3449
Broken River
Ice skating rink
WEST COAST ROAD
Craigieburn Cutting
3032±
Mt Cheeseman
6380±
Parapet Rock
Flock Hill
3269±
Hogs Back
3380
Mt Izard
6360±
Experimental plots
2748±
Gorge Hill
2650±
Mt Cloudesley
6910±
Lodge
Thomas River
Phebble Hill
2958
Leith Hut

3.2. Methods.

Initial observations were made while I was employed at Craigieburn Forest Park from July till December 1986. These observations enabled me to become proficient at ageing and sexing keas, gain knowledge of some individual birds and make preliminary observations on feeding and social behaviour.

Criteria used to age and sex the keas were :

- Length and shape of the bill, especially the upper mandible which is longer and has a more pronounced curve in the male than the female.
- Size of the bird. Generally the females are slightly smaller than the males, but this is discernable in the field only if male and female are side by side.
- Colouration of the cere, eyering, lower mandible and legs. Cere, eyering and lower mandible area bright lemon yellow in fledglings. The yellow darkens with age and probably at about the age of three cere and eyering become grey and the lower mandible becomes charcoal. The legs are a light grey, sometimes yellowish, in fledglings and darken to a grey-olive colour with age. In addition fledglings are readily recognised by their overall lighter plumage and the very light crown. In general both adult males and females have dark faces, sometimes the plumage on the cheeks is nearly brown. The age of the adults beyond four years is not possible to establish. The criteria for sexing have been checked only in three cases. The age criteria have not yet been checked.

An obvious means to help answer a lot of questions posed about the kea is the marking of individual birds with one or several leg bands. During the summer of 1986-1987 I was involved in the research programme of Wilson (section 1.2.2.). This enabled me to band birds in and in close proximity to my study area and to back up my Craigieburn study with observations from several other areas.

Between 7 December 1986 and 23 August 1987, a total of 37 field days were spent at various localities. Ten of these were devoted entirely to my study, while during the other field days priorities were different aspects of kea research but observations on feeding were made when possible. Location and objectives of the field days are outlined below.

Table 1. Summary of field work, Dec.1986- Aug. 1987.

location	no. of days	period	objectives
Craigieburn Valley	4	Dec. 1986	banding, feeding observations
Craigieburn Valley	10	Feb.-July 1987	feeding observations
Broken River Valley	8	Dec. 1986-Aug. 1987	banding, feeding observations
Arthur's Pass National Park	4	Dec. 1986-Feb. 1987	banding, feeding observations
Mount Cook National Park	7	Jan. 1987	banding, feeding observations
Fox Glacier	2	Jan. 1987	banding
Franz Josef	2	Jan. 1987	banding

In addition four days were spent at Mount Cook National Park in December 1987, the main aim of which was to make observations at a nest site and to track a kea fitted with a radio transmitter.

3.2.1. Observations

An effort was made to spend a minimum of 24 consecutive hours in a study area on each visit. At those study areas which were visited repeatedly (Craigieburn Valley and Broken River Valley), sites were chosen as observation points. These sites were points which afforded maximum visibility of the area and were accessible all year round. If no keas made their presence known on arrival at the study area, the observer(s) waited at fixed sites until keas were located. Once keas made their presence known, or if they were already present on arrival, observations centered around the sites where the birds were located. Flock size and composition were established, and then observations were recorded on types of activity and interactions. Every kea which left or joined the flock was recorded. Each time a kea was heard or seen this was recorded, but no kea was knowingly counted twice. When observations required close proximity to the birds, or when they came close to the observer(s), only those types of activity not directed toward or obviously influenced by the observer(s) or their equipment were recorded.

When the species of plant or insect keas were taking could not be identified with certainty, feeding site, plant or shrub were inspected as soon as feeding activity had ceased and the kea(s) had left the site. When food species could not be identified on site,a specimen was taken back to Lincoln Collge for identification. Plants were labelled and taken back in a plastic bag, while larvae and insects were preserved in 70 % alcohol. On several occasions of long distance observations it was not possible to establish what plant species the keas were taking.

For long distance observations, both binoculars (8 x 40) and a spotting telescope (20 x 50) were used.

3.2.2. Limitations.

Keas can be highly inconspicuous, and observing them turned out to be much more difficult than expected. To make best use of the time available, field days at Craigieburn Valley were arranged to coincide with reasonable weather. It is assumed that keas feed on the same foods during adverse weather conditions, except when weather was so bad that they were forced to lower altitudes where vegetation and thus foodsupply is different.

3.2.3. Banding

During the period of December 1986 - August 1987 a total of 73 keas were banded. Of these, seven were banded at Craigieburn Valley and an additional 17 at other locations in Craigieburn Forest Park.

The keas were initially banded with 12 mm. alloy bands. To facilitate easy identification, 12 mm. and 6 mm. plastic colour bands were used in conjunction with the alloy bands after June 1987. The birds were captured with a trap, consisting of soft nylon netting attached to a wooden frame. A string attached to a stick supporting the frame was pulled to bring down the frame. Usually butter or cheese were used a bait.

The advantages of the trap are :

- The netting is soft, so the keas can not damage themselves, yet the weight of the frame will keep the netting - and thus the bird - in place while those trapping the bird get to it.
- The string used to bring the trap down can be quite long (4.5 m.), and the trap can be brought down from inside a building, ensuring capture of some suspicious keas.

4. FOODS AND FEEDING OF THE KEA

4. Foods and feeding of the kea.

This section draws together data gathered through review of published and unpublished information and observations made during fieldwork at localities listed in 3.2. Both my own observations and those made by Wilson (1987) are incorporated. Observations on feeding behaviour and movement related to feeding are described in section 4.2. following the presentation of tables listing the foods of the kea (4.1.).

4.1. Foods of the kea.

All food items recorded in published and unpublished works and from personal observation as taken by keas are listed. Foods eaten by keas in their natural environment and in captivity are listed separately, as are plant and animal foods.

Table 2 is a taxonomic list of plants eaten by keas in their natural environment and shows the parts of the plant taken. Table 3 shows a breakdown into the part of the plant taken, and the time of the year when each food item was taken, thus allowing for seasonal comparison. Sometimes neither information on the part of the plant species taken, or time of year when it was taken was unknown. This is indicated in the tables in separate columns as appropiate.

Eighty nine species of plants have been identified as food sources for the kea. In addition to this there are 21 instances where only the genus is recorded, so that the total number of species taken may be as high as 110.

Table 4 and 5 list animal foods taken in the wild and foods recorded as taken by keas in captivity respectively. Both lists are short, few details are given and no further analysis is warranted.

4.1.1 Limitations.

It should be stressed that the list presented in Table 2 provides an overview only of which plants are known to be food sources for keas.

The list is compiled of records of foods taken by the kea over a large number of years (1908 - 1988) and from different localities throughout the South Island. For most records only foods taken were listed and no mention was made of the resource available. In addition, for many records the season during which the foods were taken was not recorded. Where records exist, the foods taken proved to be highly seasonal. This would imply that if observations were biased toward spring and autumn, a strong bias for flowers, shoots and fruits can be expected. Those foods recorded from non scientific observations could be subject to another bias, namely that of botanical knowledge of

the observers. It is easier to recognise and remember those observations where keas are seen feeding on a plant which is familiar to the observer, than when a kea is seen in vegetation unknown to the observer. There is also a bias toward larger plants. My own observations recorded keas eating small plants, but it was impossible to establish which species they were taking. Thus it is almost certain that there are plants eaten by keas, which are as yet unrecorded.

In Tables 2 and 3 the relative importance of the foods taken is indicated by symbols. The ranking used is based on the notes made with regards to importance by various authors of the readings consulted. It should be kept in mind that such remarks are highly subjective and may be valid only in those situations and localities where feeding was observed. Thus where food items have been ranked as both important and of minor importance, this is the result of remarks made by different authors who carried out their study in different localities. Such results may not be comparable between different studies and localities.

To translate the combined results of table 2 and 3 into a further or more definite ranking of importance would be inappropiate without taking into consideration the areas where observations took place. Where relevant, the matter of importance of different foods has been taken into account in the discussion (section 5.).

Where a season but not the exact month was mentioned, the letters *Sp, Su, A* and *W* indicate this. Finally, the

parts of the plants taken could be further specified. Field observations by both Wilson (1987) and myself show that keas can be quite particular about which parts of a plant are taken. E.g. keas were seen feeding on the leafbase rather than the whole leaf of *Celmisia* sp. and on the pith of the stem rather than on the whole stem of *Celmisia* sp. Because such information was lacking in most of the literature consulted, no breakdown into parts of leaves, stems, roots etc. is included in the tables.

Key to Tables 2 and 3 :

x = no mention of importance was made.

\- = food of minor importance.

o = food of average importance.

+ = important food.

*** = food of major importance.

The numbers and letters listed under *references* in the tables 2,3,4,and 5 correspond with those of the reference list on page 61 - 64.

Table 2.
Taxonomic list of plant species taken by keas in their natural environment.

species / part eaten	fruit	seed	roots	leaves & leafbuds	stems	flowers	nectar	entire plant	part of plant unknown	references
Aciphylla sp.	x	x								6,25,31,32
A. colensoi		x	x							6,8,19
A. ferox		x								8
A. monroi		x								8
A. squarrosa			x							6,19
Anisotome sp.			x							6
A. aromatica								x		8
A. pilifera			x							8
Aristotelia sp.	x									31
A. fructicosa	x									19,23
A. serrata	x									39
Astelia nervosa	x	x								8
A. nivicola	x									6
Bulbinella hookerii			x							39
Carmichaelia arborea						x				40
Celmisia sp.			x		x	x				4,6,25,31,39
C. coriacea			x		x	x				6,8,16
C. discolor var. ampla						x				8,16
C. du rietzii			x		x					6
C. lyallii				x	x					4,40
C. spectabilis			x							16
C. spectabilis var. angustifolia						x				8
C. viscosa				x	x					4,40
Chionochloa sp.				x						4,40
C. flavescens									x	19
Chrysobactron sp.			x							31
Coprosma sp.	x									6,31,39
C. cheesemanii	+									6
C. depressa	+									6
C. foetidissima	-									30
C. pseudocuneata	x*									6,8,16
C. pumila	x									6,8
C. repens	x									16
C. rotundifolia	-									30
C. serrulata	xo									6,8
Coriaria plumosa	x									27,40
Cotula sp.						-				6
C. pyrethrifolia						x				8
Cyathea sp.									x	15
Cyathodes sp	-									6
C colensoi	-x									6,8
C fraseri	xo									8
Dacrycarpus dacrydioides	x					x				30
Dacrydium bidwillii	x									31,39
D. biforme	x									23
D. cupressinum	x									30
D. laxifolium	x									6
Digitalis purpurea					x					27
Dracophyllum pronum						x				4,40
Dracophyllum longifolium									x	19
Euphrasia sp				-						6
E. zelandia				x						8
Fuchsia sp.	x									15
Fuchsia excoticata	x					x				30
Gaultheria sp.	x									23,31
G. antipoda	x									4,16,40
G. depressa	xo									6,8
Gentiana sp.				x		x				6,8
G. bellidifolia				x		x				8

species / part eaten	fruit	seed	roots	leaves & leafbuds	stems	flowers	nectar	entire plant	part of plant unknown	references
Gentiana montana			x		x					6
G. patula						x				8
G. spenceri				x		x				8
Gingindium species			x							6
G. montanum			x-							8
Gnaphelium traversii				x						8
Haastia pulvinaris						x				8
Hebe sp.				x						6
H. ciliolata		x								8
H. paucrimosa				x						8
H. vernicosa				x						8
Hormosira									x	20
Lagenophora petiolata				x						8
Leucopogon fraseri	x									16,23
Luzula campestris						x				6,8
Metrosideros umbellata						x	x			6,16,30
Muehlenbeckia axillaris	x									4,6,8, 27,40
Myrsine numularia	x									6
Nothofagus sp.				x						7
N. menziesii	x	x		+						30
N. solandri var. cliffortioides		x		x						4,6,8, 16,40
Nothopanax simplex									x	19
Notothlapsi australe			x							8
Olearia sp.				x	x					4,40
Ourisia sp.				x						6
O. caespitosa								x		8
O. macrophylla var. lactea								x		8
O. sessifolia								x		8
Panax sp.	x									6
Pentachondra pumila	x-									6,8,16
Phormium sp.							x			31,39
P. colensoi							x			4,6,7 16,19
P. tenax							x			23
Phyllocladus alpinus		x							x	27,40
Pimela oreophila		x								8
Pittosporum sp.		x								23
P. anomalum		x								8
Plantago raoulia		x								8
Poa sp.			x	x						6
P. colensoi		x		x						23
Podocarpus dacrydioides	x									16
P. nivalis	x*									4,6,16, 19,39,40
P. totara	x									4,23, 31,39
Pratia sp.	x									6
Pseudopanax crassifolius	x					x				30
Ranunculus sp.			x	x						4,31,39
R. enysii				x						4
R. haastii			x							2
R. insignis			x		x			x		6,8
R. lappaceus			x	x	x					6
R. lyallii			x							23
Senecio eleagnifolia				x						27
Sophora tetraptera	x									23
Taraxacum officinalis			x	x						4,40
Usnea									x	16
species unknown:										
Ferns									x	30
Grasses		x							x	16,40
Lichen									x	16
Moss									x	16,30

Table 3.
List of foods taken by keas in their natural environment.

part of plant taken	SPECIES	time of year unknown	SPRING S	O	N	SUMMER D	J	F	AUTUMN M	A	M	WINTER J	J	A	references
FRUIT :															
	Aristotelia sp.	x													31
	Aristotelia fructicosa											o	o	o	23
	A. serrata						Su								39
	Astelia nervosa									oA					8
	A. nivicola								-			*		*	6
	Coprosma sp.	x													3,31,39
	C. cheesemannii								*	*	*	*	*	*	6
	C. depressa		*						*	*	*	*	*	*	6
	C. foetidissima	-													30
	C. pseudocuneata			Sp			Su			*A			-W		6,8,16
	C. pumila			Sp					x						6,8
	C. repens	x													16
	C. rotundifolia	-													30
	C. serrulata								-	-A		*	*		6,8
	Coriaria plumosa						x								40
	Cyathodes sp.	-							x	x	x	*	*		6
	C. colensoi	x		Sp			Su			-A					6,8
	C. fraseri	x		Sp			Su	-x	-	-A	-	x	xW	x	8
	Dacrocarpus dacrydioides	x													30
	Dacrydium bidwillii	x													31
	D. biforme												xW		23
	D. cupressinum									xA			xW		30
	D. laxifolium	x													6
	Fuchsia excorticata	x													30
	Gaultheria sp.	x													3,23,31
	G. antipoda	-													4,16,40
	G. depressa						-			-A					6,8
	Leucopogon fraseri	x		Sp			Su			A			W		16
	Muehlenbeckia axillaris	-					x	x		xA					4,6,8, 27,40
	Myrsine numularia	x							x						6
	Nothofagus menziesii									xA			xW		30
	Panax sp.	x	x	x			x	x	x	x	x	x			6
	Pentachondra pumila						Su			-A					6,8
	Phyllocladus alpinus					x									40
	Podocarpus dacrydioides	-													16
	P. nivalis	x	+	+			Su	x	+	*	x				4,6,8, 16,39,40
	P. totara	x	x								x		xW		23,31,39
	Pratia sp.									A			W		6
	Pseudopanax crassifolius	-													30
SEEDS :															
	Acyphilla sp.	x										x			6
	A. colensoi						Su			xA					8
	A. ferox									xA					8
	A. monroi									xA					8
	Astelia nervosa									xA					8
	Dacrydium cupressinum									xA			xW		30
	Hebe ciliolata						Su								8
	Nothofagus menziesii									A			W		30
	N. solandri var. cliffortioides											x			40
	Phyllocladus alpinus	x													40
	Pimela oreophila						Su								8
	Pittosporum sp.											x	x	x	23
	P. anomalum						Su								8
	Plantago raoulia						Su								8
	Poa colensoi	x													23
	Sophora tetraptera	x										x	x	x	23
	Grass (unspec.)					x									40

part of plant taken	SPECIES	time of year unknown	SPRING S	O	N	SUMMER D	J	F	AUTUMN M	A	M	WINTER J	J	A	referen
ROOTS :															
	Acyphilla sp.	x													25,31,
	A. colensoi	x													6
	A. squarrosa	x													6
	Anisotome sp.	-													6
	A. pilifera									xA					8
	Bulbinella hookeri	x													39
	Celmisia sp	x				x									6,16,2 31,39
	C. coriacea			Sp						xA		x			6,8,16
	C. du-rietzii									A					6
	C. lyallii												x		40
	C. spectabilis			Sp						xA					16
	Chrysobactron	x													31
	Gentiana montana										x			x	6
	Gingidum montanum	-								xA					8
	Notothlapsi australum									xA					8
	Poa sp					x					x			x	6
	Ranunculus sp	x													25,31,3
	R. haastii		x												2
	R. insignis									xA					6,8
	R. lappaceus										x	x			6
	R. lyallii	x													23
	Taraxacum officinale						x								4,40
LEAVES & LEAFBUDS :															
	Celmisia lyallii				x								x		4,40
	C. du rietzii									-				-	6
	C. viscosa					x									4
	Chionochloa sp.														4,40
	Coriaria plumosa								x						27
	Euphrasia sp.	-													6
	E. zelandia						Su								8
	Gentiana sp.	-							x						6
	G. bellidifolia						Su								8
	G. spenceri						Su								8
	Gnaphalium traversii			Sp											8
	Hebe sp.	-													6
	H. pauciramosa			Sp											8
	H. vernicosa			Sp											8
	Lagenophora petiolata						Su								8
	Nothofagus sp.					x	x	x	x						7,17
	N. menziesii			Sp			Su			+A			+W		30
	N. solandri var. cliffortioides			Sp		x	x	x	x*	*	0	0	xW	0	4,6,8,16
	Olearia sp.						x								4,40
	Ourisia sp.	-													6
	Poa sp.			x	x										4,23,40
	Podocarpus nivalis					x									40
	Pododcarpus totara					x									4
	Ranunculus enysii					x									4
	R. lappaceus										x	x		x	6
	R. lyallii									x					6,27
	Senecio eleagnifolia									x					27
	Taraxacum officinale						x								4,40
STEMS :															
	Celmisisa sp.									A			W		4,6
	C. coriacea										x	x			6
	C. du rietzi										*			-	6
	C. lyallii				x	x									4
	C. viscosa					x									4
	Digitalis purpurea								x						27
	Gentiana montana									A			W		6
	Olearia sp.						x								4,40
	Poa sp.										x			x	6
	Ranunculus insignis									A			W		6
	R. lappaceus									A			W		6

part of plant taken	SPECIES	time of year unknown	SPRING S	O	N	SUMMER D	J	F	AUTUMN M	A	M	WINTER J	J	A	references
FLOWERS :															
	Carmichaelia arborea						x								4,40
	Celmisia sp.	-													6
	C. coriacea						Su								8
	C. discolor var. ampla						Su								8
	C. spectabilis var. angustifolia						Su		x	x	x				8
	Cotula sp.	-													6
	C. pyrethrifolia						Su								8
	Dacrycarpus dacrydioides	x													30
	Dracophylum pronum			x				x							4,40
	Fuchsia excorticata	-													30
	Gentiana sp.	-													6
	G. bellidifolia									xA					8
	G. spenceri									xA					8
	G. patula						Su			xA					8
	Haastia pulvinaris	-					Su			xA					6,8
	Lazula campestris						Su								6
	Metrosideros umbellata						Su								30
NECTAR :															
	Celmisia discolor						x								16
	Metrosideros umbellata	-				x	x	x							6,16,30
	Phormium sp.	x													31,39
	P. colensoi	-x					x								4,6,7,16,1
	P. tenax	x													23
ENTIRE PLANT :															
	Anisotome aromatica			Sp									xW		8
	Ourisia caespitosa			Sp											8
	O. macrophylla var.lactea			Sp											8
	O. sessifolia			Sp											8
	Ranunculus insignis			Sp											8
Species of which the part of the plant taken is unknown :															
	Chionichloa flavescens														19
	Cyathea sp.														15
	Dracophyllum longifolium														19
	Hormosira														20
	Nothofagus menziesii														19
	Nothopanax simplex														19
	Phyllocladus alpinus							x							27
	Usnea														16
Plants of which the species and part taken is unknown :															
	Ferns (unspec)	x													30
	Grasses (unspec)													x	16,23
	Lichens (unspec)					x									6,40
	Mosses (unspec)					x									6,16,30,40
	Tree fern (unspec)	x													30

Table 4.
List of animal foods taken by wild keas :

FOOD TAKEN	PART TAKEN	references
WORMS :		
worms unspecified	whole?	23,31,39
INSECTS :		
insects unspecified	unknown	6,23,30,31,39
beetles unspecified	unknown	7,16,23
grasshoppers unspecified	unknown	7,23
adult grasshoppers (*Brachaspis collinus*)	unknown	8
INSECT LARVAE :		
larvae unspecified	whole	4,7,16,23,27,39,40
larvae of ants unspecified	whole	23
larvae of grassgrubs (*Costelytra zealandia*)	whole	4
larvae of wetas *Deinacrida sp.*	whole	8
INSECT MATERIAL :		
Honeydew		4
BIRDS :		
racing pigeon unspecified	unknown	20
Hutton's shearwater (*Puffinus huttoni*)	eggs	15
Kea (*Nestor notabilis*)	eggs	18
MAMMALS :		
sheep (*Ovis aries*)	meat	3,17,23,25,31
	bone marrow	23
stoat (*Mustella erminea*)	dry matter of a dried carcass	4

Table 5
Foods taken by keas in captivity and at human habitation :

FOODS EATEN	references
FLOWERS :	
Griselinia littoralis	23
Hebe vernicosa	23
H. hulkeana	23
Parsonia sp.	23
Pseudopanax arboreus	23
Sophora tetraptera	23
FRUIT :	
banana (unspecified)	6,41
Citrus sp.	6,41
Coprosma sp.	23
Cyphomandra betacea	6
Fuchsia exorticata	23
Malus sp.	6,41
Prunus sp.	23
SEEDS :	
Arachis hypogaea	4,6,41
Cucurbita maxima	6
Helianthus anuus	6
Malus sp.	6,16
Panicum miliaceum	6
Zea mais	41
ROOTS :	
Bulbinella sp.	23
Celmisia sp.	23
Daucus carota	4,6,41
Ranunculus lyallii	23
Taraxacum officinalis	23
LEAVES & SHOOTS :	
Lactuca sativa	6,23
NECTAR :	
Phormium sp.	23
Hebe vernicosa	23
ENTIRE PLANT :	
Bulbinella sp.	23
MISCELLANEOUS :	
biscuits	4
bread	4,6
butter	4,6,40
cheese	4,40
egg	6
fat	4,6
meat	4,6
raisins	4
oats	4
scraps (from rubbish bins & tips)	4,40
soft confectionary	4,6
each other (presumably when fed this in captivity ?)	6

4.2. Feeding behaviour and movements related to feeding.

In this section observations of feeding activities of keas in their natural environment are described. Activities described as feeding were those where keas were seen to be searching for and seen to sample or take foods. Occasions where keas were seen to be searching for food but did not sample or take any are described as foraging. Feeding and foraging sessions lasted until either: the keas stopped feeding, flock composition changed or keas shifted to another area to resume feeding and foraging.

A total of 27 feeding sessions was observed. On average, keas spent 10.5 minutes feeding at any one time. The minimum time spent was three minutes, the maximum time spent 30 minutes. Thirty seven percent of the feeding sessions lasted for ten minutes or more. During the longer sessions the intensity of feeding waned after about 12 minutes. While the kea(s) continued to feed, they would take short breaks (usually no longer than one minute) and feed more leisurely. Periods of foraging never exceeded 15 minutes but sometimes proceeded or followed feeding. Only on two occasions (15 min. and 30 min.) was it impossible to distinguish between foraging and feeding. The maximum period over which keas were observed alternately foraging and feeding, without part taking in any other activities, lasted 50 minutes. Activities in which the birds engaged in between or after feeding and foraging sessions ranged from play, bill cleaning and

preening to roosting and sunning. A number of times the birds would disappear from sight. On such occasions the obervers(s) presumed that feeding had stopped.

4.2.2. Rate of feeding.

The rate of feeding could be assessed with accuracy in a few cases only. The findings of these are listed below.

Table 6. Rate of feeding.

species	part taken	amount taken	time spent
Celmisia species	stem (pith)	1 plant	3 minutes
C. species	stem (pith)	1 plant	3 minutes
C. hieracifolia	stem (pith)	6 plants	15 minutes
C. lyallii	stem (pith)	1 plant	2 minutes
	(at base of plant)	(6 mouthfulls)	
C. viscosa	leafbases	3 leaves	4 minutes
C. viscosa	stem (pith)+ leafbases	4 plants	7 minutes
Dracophyllum pronum	flowers	3	2 minutes
Nothofagus solandri var. cliffortioides	seeds	93	20 minutes
Podocarpus nivalis	fruit	5	1 minute
Larvae unidentified		2	2 minutes

fig. 9 adult kea feeding on alpine flowers

(species unidentified)

In addition to the above keas have been seen sampling foods, but it was not clear how much they ate on these occasions. One kea was seen to sample the leafbases of eight fresh plants (*Celmisia* species) and three previously rejected plants (*Celmisia* species) in nine minutes.On several occasions keas were observed probing and digging in the soil. One such occasion lasted 15 minutes, during which the bird only seemed to swallow something once. These findings do not stand by themselves and should be compared to the total time keas spend feeding at different rates per day.

4.2.3. Flock size and Flock structure.

Both field observations and written records show that keas may be found feeding and foraging by themselves, in pairs or in groups. It was found that not all keas present on one site would usually be feeding simultaneously or together. Once 12 keas were present on one site, but no more than five birds were seen feeding together at any one time. The largest group seen feeding together was seven keas, while the largest group seen foraging together was six. Of the 27 feeding sessions observed the flock structure was as follows:

individuals	(9)	33.3%
pairs	(5)	18.5%
groups of 3 or more	(13)	48.2%

The composition of these different groups is shown in table 7.

Table 7. Composition of flocks while feeding.

compositon	no. observed	percentage
individuals	9	100.
adult female	3	33.4
adult male	2	22.3
immature	2	22.3
fledgling	1	11.
unidentified	1	11.
pairs	5	100.
adult female + adult male	2	40.
adult female x 2	1	20.
adult female + immature female	1	20.
immature female x 2	1	20.
flocks of 3 or more	13	100.
-any group with one or more fledglings	7	53.8
-one adult pair with one or more immatures	4	30.8
-one adult female with immatures	1	7.7
-immatures only	1	7.7

fig. 10 two fledglings feeding on berries of

Podocarpus nivalis.

All but one (immatures only) of the flocks of three or more were regarded as 'family groups'. All groups with fledglings also had immatures among them. Family groups with two adult females present accounted for 8.3% of the total percentage of family groups (one out of 12).

4.2.4. Interaction during feeding.

In general little interaction was observed while the keas were feeding. Even within groups where keas were in close proximity to each other, individuals did not seem affected by each other's presence. If keas were calling elsewhere in the area, those that were feeding would sometimes pause, cock their heads and listen, but did not reply or stop feeding. On one occasion an adult male was seen feeding alone, but stopped feeding, called several times, and resumed feeding only when his calls were answered from down the valley.

Keas were seen feeding in areas of vastly different size. In open tussock areas, there could be up to 20 metres between individuals. On the forest floor under beech trees (*Nothofagus solandri var. cliffortioides*) two keas were seen feeding in an area of 10 m^2, sometimes they fed as close as 30 centimetres.

Generally interactions observed seemed to be related to the following categories: dominance, pair bond and adult fledgling contacts. Interaction related to dominance were

mostly characterised by the displacement of one or more keas by a dominant bird. Such a bird, generally a male,would take the food, while the others would disperse and feed elsewhere or sometimes stop feeding. On one occasion a female was seen to push a fledgling aside and take the food. Twice a female was seen to stop feeding, following agonistic behaviour of a male towards her. The male resumed feeding once the female stopped. A second male present kept on feeding the whole time, but further away.

A very different behaviour was observed on one occasion when an adult female and an adult male were seen feeding together. The male would make space for the female to feed, and take food only after the female had done so. Both stayed close together, also after feeding had ceased. This interaction was regarded as related to pair bonding.

Though fledglings were observed feeding individually and within a group, but independently from the adults they were with, there were also occasions of interaction between fledglings and adults. Generally fledglings stayed close to the adults or immatures they were with. Once an adult female adult was observed to communicate with fledglings through a low, soft mewing call, which was answered by the fledglings with a similar call. Both adult and fledglings fed close together. On three occasions fledglings were seen to pick up foods which were sampled and/or discarded by adults, and to follow adults around.

fig. 11 & fig. 12 keas feeding on forest floor.

4.2.5. Food gathering behaviour and feeding techniques.

Keas have various means of obtaining foods, namely.their strong bills (of which the upper mandible is hinged and allows for a great deal of movement), and their zygodactyl feet. The bill was used to obtain foods in most of the cases observed, while the feet were used also but to a lesser extent.

In feeding the bill has several functions. Where keas were seen in search of larvae, the bill was used extensively to probe and dig the soil and detritus for plant materials. The bill was used sideways as a spade to remove unwanted soil and to flick aside snow. Keas also used their bills to remove leavs from plants (e.g. *Celmisia* species), to bend over the blades of tussock and to scrape off the parts of the plants which they wanted for food (e.g. the base of leaves of *Celmisia* species). The uprooting or uplifting of plants was done mostly with the bill. The keas would grab the plant near its base and pull and tug until it moved.

A goup of three and a group of five keas were seen feeding on the forest floor. They used their bills to probe and dig, to pull at vegetation, and to flip over stones and bark in order to expose the soil underneath. Dead wood (logs and branches) was pulled apart and small objects (bark and twigs) were tossed aside. The bill was used for chewing, nibbling, rasping and scraping of foods before they were swallowed. The birds were seen repeatedly to roll foods around in their bills,

using their tongue. They did so with berries, the pith of *Celmisia* species and grassgrubs (*Costelytra zealandia*).

The feet were used to hold foods down to the ground and to hold foods and bring them to the bill. When holding foods down the keas used their bill to remove those parts of the food that they wanted. On three occasions keas were seen using their feet to scratch the soil surface before commencing to probe and dig with the bill. When feeding in trees the feet were used both to steady the bird, to maintain balance and to grab branchlets and pull them toward the bill.

When searching for larvae the keas probed holes which were on average three centimetres deep. They generally searched and probed in the top litter layer which consisted of moss, leaf litter or matted materials of roots of small plants. The birds would remove up to two centimetres of this layer (using both feet and bill) before probing and digging. Loose objects (stones and bark) were turned over and keas would search in the exposed soil. Surface areas scratched clear of any vegetation and litter measured up to 10 x 20 cm. Patches which were thoroughly dug over and which had many probe holes (some only five centimetres apart) measured up to 30 x 30 cm. Both scratched and dug over patches occurred in larger feeding areas in which usually moss, twigs , bark and stones were turned over. Keas sought out moist soil to probe and dig. In the forested areas they dug on the down slope side of logs and rocks, and under loose and movable materials. In one example keas probed and dug in an area which contained a small, relatively dry hummock.

Although there were probe holes in the hummock, there were not nearly as many as in the surrounding moister soil. In early summer keas were observed feeding in a tussock grassland. There were still patches of snow left in the basin. Keas consistently fed along the interface of snow and tussock, mostly on the downhill slope side of the snow. They probed in the freshly exposed soil, within 10 cm. of the snow, and occasionally in the snow. Where rocks, tussocks or shrubs were exposed, they would probe and dig along the base of these. No signs of digging were found through moss or layers of matted vegetation, but along side them and underneath where the keas had managed to lift the moss or other surface cover. In patches of vegetation which had been exposed for longer, old diggings were found.

4.2.6. Habitat use related to feeding.

During a total of 11 field days at Craigieburn Forest Park, 27 observations were made on feeding and foraging and 83 observations on other activities such as preening, roosting, and play. Analysis of these data show the following seasonal habitat use by keas:

Table 8. Habitat use by keas.

	% of feeding activities observed in :		% of non feeding activities observed in :	
season	tussock	forest	tussock	forest
spring (Sep. - Nov.)	100	-	100	-
summer (Dec. - Feb.)	85	15	68	32
autumn (Mar. - May.)	28	72	25	75
winter (Jun. - Aug.)	-	100	-	100

('tussock' refers to the area above the bushline and includes herbs and shrubs.)

Most observations were made during summer, and fewest were made during winter. Most movement of keas between the tussock areas above the bushline and the forested areas seemed a function of food availability. Twice when food was available at higher altitudes, but weather conditions were adverse, keas moved down to the forest. It is not known if they fed on those occasions.

5. DISCUSSION

5. Discussion.

The results of the study at Craigieburn Valley are in accordance with the general opinion that the kea is omnivorous, but predominantly vegetarian. Of the types of food taken, 70% consisted of plant material. Clarke(1970) observed the feeding of keas in Cupola basin, and his results show that 95% of the food items taken were plant material. At Craigieburn Valley a lot of probing activity, both in the soil, and to a lesser extent in dead wood, was observed. This activity seemed most likely to be associated with the search for insects. In those instances it could not always be established what food the keas took - if any. Thus the 70% is probably biased toward plants, and then toward larger plants at that. My own observations showed that it was at times impossible to establish what keas were eating, especially when they were taking small plants.

The importance of the same plant species as a foodsource for keas in different localities can be questioned. For example the leaves of mountain beech (*Nothofagus solandri var. cliffortioides*) were taken by keas at Craigieburn, but seemed of minor importance (recorded on two occasions only). Clarke(1970) found, in Cupola Basin (Nelson Lakes National Park) that keas fed on the leaves and leafbuds of mountain beech, in spring and to a lesser extent in winter. Campbell(1976) ascribed a seasonal importance to the foliage of mountain beech as a foodsource for keas. He found that in the Routeburn Basin keas

relied on buds and young leaves of this beech throughout autumn and again - but to a lesser extent - in winter. He suggested that the leaves may be more palatable in autumn, following the main growth period of the trees in summer. Contrary to these findings, Jackson(1960) wrote that keas at Arthur's Pass fed on the leaves and buds of the mountain beech all year round. In South Westland silverbeech (*N. menziesi*) was an important foodsource for keas all year round (Collins et. al 1986). There are insufficient observations on the relative importance of other food items at different locations to determine if importance varies between locations like it does with mountain beech.

Four species of plants are listed as a food taken by keas at several different locations (*Aciphylla* sp, *Celmisia coriacea, Gaultheria, and Podocarpus nivalis*). Mention of those species by many authors may reflect either of two things: the widespread distribution of those plants and their genuine importance as a foodsource for the kea in these locations, or that these are among the better known species of alpine vegetation.

Whether keas take foods because of preference or availability is not known. While it is obvious that some types of food (eg. flowers, fruit) are available seasonally only, when several foodspecies of each type are available simultaneously, keas are likely to display preferences. Clarke(1970) listed the fruits available and those taken and concluded that the frequency with which fruits were taken could have reflected either preference or availability. Questions about preference become

more complicated when foods taken at different localities are compared. Clarke(1970) observed high use of *Coprosma pseudocuneata* berries as a foodsource in Copala Basin, while Jackson(1960) found that keas at Arthur's Pass took these berries only in Winter, when heavy snow forced them to feed at lower altitudes. Similarly, Astelia fruits were found to be a favourite food for keas in the Routeburn Basin during winter (Campbell 1976), of minor importance in the Cupola Basin (Clarke 1970) and not recorded as eaten, despite their presence, at Arthur's Pass (Jackson 1960). To determine food preferences a detailed inventory of the resource in an area must be made. Foods taken can then be compared with those available. To allow for year to year variation in foods available due to weather and other factors, food preferences would have to be studied in one area for several consecutive years.

It has to be assumed that keas take foods according to their needs. Jackson (1963, 1969) suggested that keas starve during winter, and some may die. While no one else recorded keas starving in winter, winter and early spring are potentially lean times for keas, since a lot of areas above the bushline are covered with snow. Wilson (1987) has gathered nearly enough data on the weights of keas during various seasons, to make a comparison between the average weight of keas in summer and winter. These data are however from a variety of locations. Additional capture and recapture of keas in order to weigh them, in the same location during different seasons would help facilitate a comparison such as mentioned above.

Both Clarke (1970) and Jackson (1960) suggested that the movements of the kea between tussock grassland and forested areas was a function of food availability. Observations at Craigieburn Valley seemed in accordance with this. During spring and early summer, keas spent a lot of time feeding in tussock grasslands. Late summer, autumn and early winter saw the keas at lower altitudes. All feeding activity observed during winter was in the forest.

Keas did most of their feeding during the early morning or late afternoon and early evening. Kea activity decreased during the mid day period. Campbell's (1976) observations on feeding activity in the Routeburn Basin showed a peak in activity during the midday period. In both Craigieburn Valley and the Routeburn Basin keas commenced activity at dawn, but did not usually start feeding until about one and a half hours later. Campbell (1976) found that during winter keas spent 70 percent of their active hours feeding. My own observations at Craigieburn Valley did not allow for such an analysis.

Observations at Craigieburn showed that the effort involved in foraging, finding foods and obtaining them (digging etc.) can be quite time consuming. For example, one kea spent four minutes removing plant materials and dirt from around a *Celmisia lyallii* plant before uprooting the plant. In the two minutes following this, the bird ate six mouthfuls of the pith of the plant, after which it stopped feeding. Nothing is known about the calorific value of the foods taken, or whether or not the kea's feeding strategy is optimal.

Keas are known to congregate at human occupied sites, and food availability may be one of the things that attracts them. Observations of keas at such sites and records of keas in captivity show that the kea has a great ability to adapt to new foods. The kea seems to be an opportunistic feeder. While this may explain their scavenging for foods at human inhabited sites, several questions need to be asked. The foods they obtain at such sites may be of greater calorific value than those they obtain in their natural environment, or they may provide nutritional elements which might be missing from their natural diet. In case of the latter, the cause for the missing nutrients should be assessed. These could include competition for the same resources, such as is now known to exist between takahe (*Notornis mantelli*) and red deer (*Cervus elaphus*) (Mills,Lavers & Lee, 1984), or habitat destruction through increased development and use of the high country over the last century. Campbell (1976) commented in his work on the possible food competitors of the kea in the Routeburn Basin. He suggested that red deer, chamois (*Rupicapra rupicapra*) and the opossum (*Trichosurus vulpecula*) are potential competitors for kea foods, especially when present in large numbers. Further studies on foods and the feeding strategy of the kea could perhaps include an assessment of the impact such competitors may have. Analyses of the nutritional and calorific value of foods taken by keas in their natural environment and at human inhabited sites, as well as time and energy budgets on feeding in both types of environment, may provide detailed information on the kea's diet.

6. SUMMARY

6. Summary.

The aim of this study was to provide a base for quantitative research on the diet of the kea. Before it can be understood why keas eat the foods they do, it is necessary to know what foods they take. The lists in section 4.1 provide updated and collated information on foods taken by keas. The results of this study can be used as a reference for assessing the resources available to keas in various habitats. As such these results may contribute to the devising of guidelines for management of kea populations in their natural environment and at human occupied sites. In order for the food lists to be accurate, they need to be augmented as new information becomes available.

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