Management of Thar

Part I: Thar—Vegetation—Harvest Model Development

Part II: Diet of Thar, Chamois, and Possums

SCIENCE FOR CONSERVATION: 7

J.P. Parkes and C. Thomson

Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

Science for Conservation presents the results of investigations contracted to science providers outside the Department of Conservation. Reports are subject to peer review within the Department and, in some instances, to a review from outside both the Department and the science providers.

ISSN 1173-2946
ISBN 0-478-01680-8

This publication originated from work done under Department of Conservation contract Nos. 531 and 532, carried out by J.P. Parkes and C. Thomson, Manaaki Whenua - Landcare Research, P.O. Box 31-011, Christchurch. It was approved for publication by the Director, Science and Research Division, Department of Conservation, Wellington.

Cataloguing-in-Publication data

Parkes, John P.
Management of thar. Part I, Thar-Vegetation-Harvest model development. Part II, Diet of thar, chamois, and possums / J.P. Parkes and C. Thomson. Wellington, N.Z. : Dept. of Conservation, 1995.
1 v. ; 30 cm. (Science for conservation, 1173-2946 ; 7.)
Includes bibliographical references.
ISBN 0478016808

1. Tahrs. I. Thomson, C. II. Title. III. Series: Science for conservation ; 7.
333.9540993 20
zbn95-017185

CONTENTS

PART I: THAR–VEGETATION–HARVEST MODEL DEVELOPMENT

PART II DIET OF THAR, CHAMOIS AND POSSUMS

Part I Thar–Vegetation–Harvest Model Development

1. Introduction

The Department of Conservation (DoC) intends to control Himalayan thar (*Hemitragus jemlahicus*) to protect indigenous ecosystems affected by these introduced mammals. The department has reviewed the strategic options it has to do this, and has decided on a policy to limit the spread of thar and to restrict their numbers to below various nominated densities in different parts of their present range. A management plan has been prepared. This sets the densities at which DoC will intervene to control thar in each of nine management units and sets some rules for DoC and private hunters. This research aimed to provide some of the ongoing ecological and management information to verify that the nominated thar densities were tolerable and that the capabilities of the different types of hunter to kill the required number of thar were realistic. The emphasis of the research work changed as the strategic policy and management plan clarified the aims of DoC, and although the report is technically a final one, many of the results are interim because the outcomes of the proposed management regimes will often take many years to be expressed. The results also need to be read in conjunction with a companion report on the diet of alpine herbivores. The research covered in this report began in 1989 and was commissioned from Weeds and Pests Division of Manaaki Whenua - Landcare Research by the Science and Research Directorate of the Department of Conservation.

2. Background

Himalayan thar were introduced into New Zealand at Mt Cook in 1904 (Donne 1924), and have established breeding populations over about 7000 km^2 of the Southern Alps. They were completely or partially protected until 1930, then treated as pests and culled by Government employees from 1937. During the 1970s, a market for thar meat was established and many thousands of animals were shot from helicopters; their population being reduced by about 90% (Tustin & Challies 1978). In 1983, commercial exploitation of thar for meat was banned (it was only marginally economic) and a process to manage the "thar problem" was begun. After a census of thar in 15 catchments in 1984 (Parkes 1984, unpubl. FRI report), a proposal for a Recreational Hunting Area under the Wild Animal Control Act 1977 was developed by the New Zealand Forest Service. This lapsed with the demise of that agency. The Department of Conservation inherited the problem and commissioned a review of the strategic options (eradication, sustained control or harvesting, or no action) it had to manage thar (Parkes 1988, unpubl. FRI contract report). The department decided it must control thar to fulfill its conservation obligations. As it was not possible to eradicate thar from New Zealand, its policy is to "ensure that hunting and other control pressure is maintained at levels which provide protection to natural values" (Marshall 1991). The policy statement also required DoC to produce a management plan to give effect to this aim, and a plan has been prepared and subjected to public scrutiny (Anon 1993). Thar have been increasing throughout this decade of vacillation and consultation and, to some extent, the opportunity to maintain low animal densities at minimal cost to the taxpayer has been lost.

Of all the introduced ungulates in New Zealand, thar are one of the simplest to manage in a rational way. They are restricted to a relatively small area, they are particularly vulnerable to a cost-effective control technique (aerial shooting), they are sought by an even more cost- effective control agent (recreational hunters), they are easy to count, and there is some information on their biology and a little on their impact on natural resources. There is not enough of such information to devise a management plan for all time, or even to satisfy all people at this time, and all good plans ought to have provision for sceptical reassessment from time to time. This research aimed to provide some improved or more up-to-date information on the management and biological parameters of the management plan.

3. Objectives

- To establish baseline vegetation plots in five catchments to monitor the impact of known densities of thar.
- To count thar in 21 representative catchments and estimate rates of increase of the population.
- To estimate present harvests of thar.
- To estimate the numbers of thar that must be killed in excess of present harvests.

4. Methods

4.1 BASELINE VEGETATION PLOTS

Variable-area permanently marked plots were established in five catchments where regular censuses of thar have been (or will be) conducted. The plots were sited in areas with palatable species of snow tussock, i.e., *Chionochloa* *flavescens, C. pallens*, and *C. rigida*. Plot areas were large enough to include at least 20 adult tussocks.

Each plot was divided into 1-m^2 quadrats, and the number, basal area, height, and percent crown death were measured for all live individual snow tussocks. These data form one part of the baseline information against which trends can be measured. Cover class information on other plants was collected on each quadrat, and the number and size of other species particularly likely to be affected by thar (e.g., shrubs, large *Aciphylla* spp., and large *Ranunculus* spp.) were recorded. Brief descriptions of selected plots are presented.

The size and height frequencies of tussocks (see Rose & Platt 1990 for an explanation) on plots selected because they are predicted to either remain stable or to change are presented in this report.

4.2 DENSITIES AND RATES OF INCREASE OF THAR

The number of thar and other ungulates present in February - March (i.e., before the rut and long enough after the season of births for most surviving kids to be visible) were counted in 21 catchments at various times since 1965. Rates of increase are calculated from those catchments for which a long series of annual counts are available. The census method follows that recommended by Challies (1992, unpubl. report), with counts being made, from a number of fixed vantage points generally from late afternoon to dusk when most thar are active (Tustin & Parkes 1988).

4.3 PRESENT HARVESTS OF THAR

Trends in hunting pressure and success rates were estimated from permit returns from the Rangitata catchment. Additional published and anecdotal information is used where nothing better existed.

5. Results

5.1 BASELINE VEGETATION PLOTS

Fifty-six vegetation plots were established in five catchments during the summers of 1991-92 and 1992-93 (Table 1). The data are held in the NIVS database at Landcare Research, Christchurch.

All tussock species showed a range of size class distributions, with plots ranging from those with only a few large individuals to those with numerous seedlings. It could be predicted that, if thar densities are not too high, snow tussocks on plots with numerous seedlings will increase in cover but numbers of individuals will diminish due to natural thinning. Predictions about the plots with a few large tussocks and few seedlings are more difficult, although it is presumed the lack of seedlings is caused by too many thar or other herbivores (e.g., see the effect of sheep on *Chionochloa rigida* regeneration; Lee, Fenner & Duncan 1993).

TABLE 1. SUMMARY OF SITE AND DOMINANT TUSSOCK SPECIES (*CHIONOCHLOA PALLENS, FLAVESCENS, RIGIDA*, AND *CRASSIUSCULA*) ON 56 PERMANENT BASELINE VEGETATION PLOTS.

CATCHMENT	NO. OF PLOTS	DATE EST	MAIN TUSSOCK			
			CHI PAL.	*CHI FLA.*	*CHI RIG.*	*CHI CRA.*
Carneys Creek	20	Jan 1992	14	4	0	2
North Branch	6[1]	Feb 1992	0	0	6	0
Hooker Valley	9	Feb 1992	9	0	0	0
Landsborough R.	9	Dec 1992	7	0	0	2
Whymper Glacier	12	Mar 1993	12	0	0	0

[1] *Fifteen similar plots were established in the catchment in 1990 (Rose & Allen 1990, unpubl. FRI contract report.*

A selection of plots from each area are described to show the range of size distributions of snow tussocks or some detailed size-frequency description of the species counted and measured.

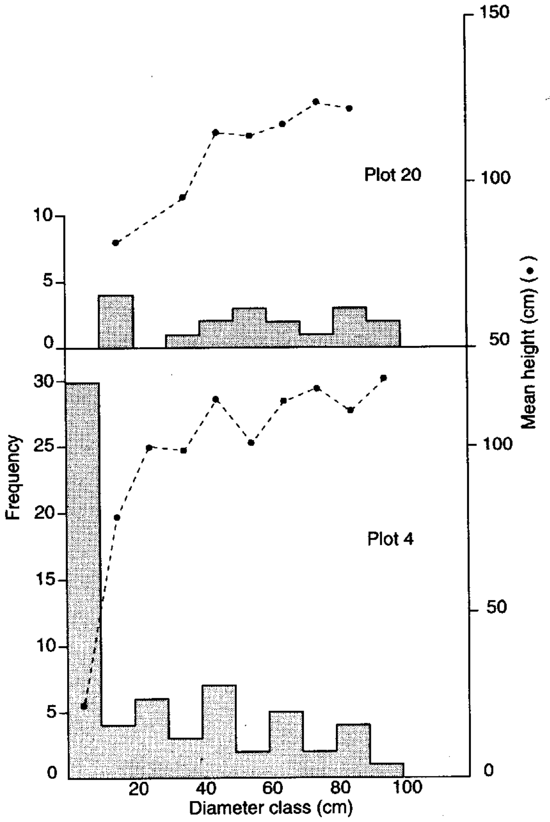
Carneys Creek

Plot 4

This 8 x 10 m plot is on a 30° colluvial sideslope on mixed greywacke and argillite bedrock. It is at 1380 m a.s.l. and is well drained. The dominant tall vegetation (>0.3 m) was *Chionochloa flavescens* (Fig. 1a) with a scattering of four species of *Dracophyllum*. The 0.1 to 0.3 m tier was dominated by *Celmisia lyalli* and *C. coriacea*, and the ground tier (<0.1 m) was dominated by *Blechnum penna-marina, Gaultheria depressa, Rytidosperma setifolium*, and *Hypochoeris radicata.* The weed *Hieracium pilosella* was present. In all, about 60% of the plot was vegetated, 20% was exposed soil, 15% was litter, and 5% broken rock. The snow tussocks were regenerating on this plot; 10 seedlings of *C. flavescens* and a single seedling of *C. pallens* with a single tiller were counted.

Mammal browse sign was classed as low, and the only faecal pellets recorded were of hares.

FIGURE 1. REGENERATING AND NON-REGENERATING *CHIONOCHLOA FLAVESCENS* COMMUNITIES, PLOTS 4 AND 20, CARNEYS CREEK.



Plot 20

This 6 x 7 m plot is on a 10° colluvial debris fan derived from greywacke. It is at 1410 m a.s.l. and is well drained. It is probably subjected to snow avalanches as tall vegetation was sparse. About 85% of the plot was vegetated, 10% was in rock and broken rock, and 5% in litter. The dominant tall vegetation was *C.flavescens* but no regeneration was apparent (Fig. lb). There was little present in the 0.1-0.3 m tier, and the ground tier was dominated by *Agropyron scabrum, Viola cunninghamii, Acaena anserinifolia,* and *Uncinia divaricata. Hieracium pilosella* was common.

Thar or chamois had browsed the snow tussocks, but the only faecal pellets present were those of hares.

The density of thar in Carneys Creek exceeds the average threshold density specified for the area in the management plan (see section 6.2). If this threshold density is correct, there should be no regeneration on plot 20 and the seedlings on plot 4 should not survive.

North Branch

Plot 16

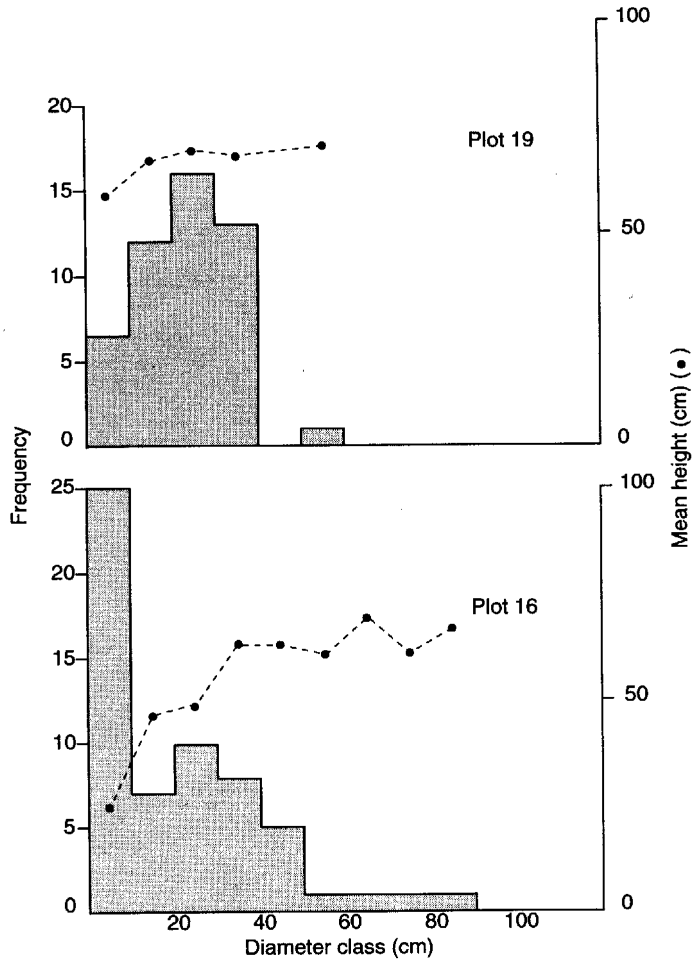
This 4 x 5 m plot is on a 30° colluvial spur with greywacke bedrock. It is at 1100 m a.s.l and is well drained. About 75% of the plot was vegetated, 10% was litter, 10% broken rock, and 5% exposed soil. *C. rigida* dominated the plot and appeared to be regenerating (Fig. 2a). Five large plants and 22 smaller individuals of *Aciphylla aurea,* and three shrubs of *Discaria toumatou* dominated the 0.3 - 1 m tier along with *Luzula crinata, Leucopogon sp.,* and *Festuca novae zelandiae. A* variety of small herbs and grasses were present in the ground tier, but none dominated. The introduced weed, *Hypericum perforatum* was common on the plot and in the catchment.

Most of the snow tussocks and many of the small herbs and grasses were browsed, and both thar and hare pellets were present (thar pellets being noted on 12 of the 20 subplots).

Plot 19

This 4 x 4 m plot is on a 15° colluvial sideslope in a tussock basin with greywacke bedrock (Fig. 2b). It is at 1640 m a.s.l. and is well drained. About 80% of the plot was vegetated, 10% was litter, 5% was broken rock, and 5% exposed soil. *C. rigida* alone dominated the tall vegetation and regeneration was poor. *Celmisia lyalli* alone dominated the 0.1 to 0.3 m tier, and *Poa colensoi* and *Aciphylla montana* dominated the ground tier, moss being the only other vegetation present.

FIGURE 2. REGENERATING AND NON-REGENERATING *CHIONOCHLOA RIGIDA* COMMUNITIES, PLOTS 6 AND 19, NORTH BRANCH.

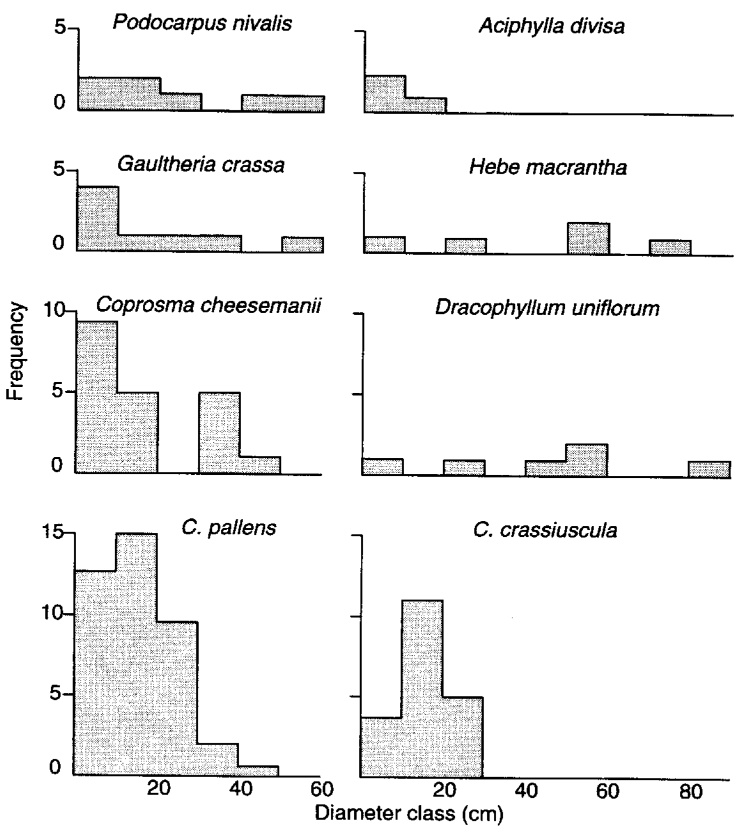


Most of the snow tussocks showed signs of browse, and thar and hare pellets were common (thar pellets being noted on 10 of the 16 subplots).

The density of thar in this area (see section 6.2) is about 3 times the threshold identified in the management plan. If this threshold density is currect and there are too many thar in North Branch, snow tussocks should decline and shorter, less palatable grasses such as *Festuca novae-zelandiae* should increase on the sample plots.

Hooker Valley

FIGURE 3. SIZE DISTRIBUTION OF SNOW TUSSOCKS AND OTHER DOMINANT SPECIES, PLOT 8, HOOKER VALLEY.



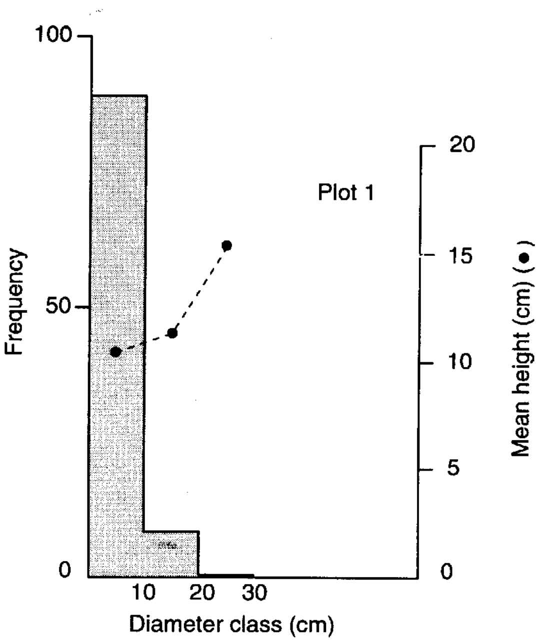
Plot 8

This 5 x 5 m plot is on a bedrock spur of greywacke. It is at 1250 m a.s.l. and is a damp site. The snow tussocks (C. pallens and C crassiuscula) were mixed with scrub vegetation (Fig. 3). The short vegetation was species-rich and was dominated by Celmisia petiolata and Poa colensoi. Ranunculus lyallii was present.

Hare pellets were common and they had browsed Celmisia lyallii, but thar pellets occurred on only one subplot.

Thar are at low densities in the Hooker Valley (see section 6.2) and are unlikely to have much impact on the sample plots.

FIG 4. STUNTED *CHIONOCHLOA PALLENS* COMMUNITY, PLOT 1, LANDSBOROUGH RIVER



Landsborougb River

Plot 1

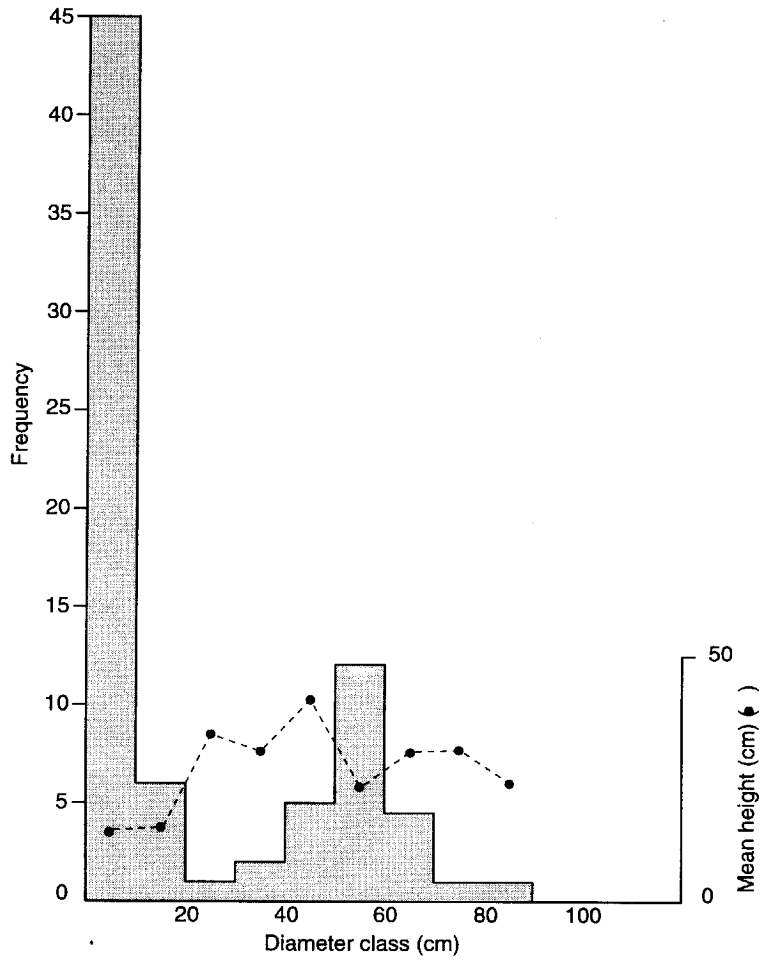
This 3 x 2 m plot is on the side of a spur in an area of greywacke and schist mudstone. It is at 1190 m a.s.l. and is well drained on a slope of 30°. The vegetation rarely exceeded 30 cm in height and was dominated by Marsippospermum gracile and C. pallens in the 0.1 to 0.3 m tier, and by Poa colensoi in the ground tier. Vegetation covered 95% and litter 5% of this plot.

The snow tussock was heavily browsed and thar pellets were recorded on every subplot. Despite this browse, snow tussocks were common in the seedling size class (Fig. 4), and will presumably survive and grow if thar numbers are held at the "correct" levels (set for $<1.5/km^2$).

However, this interpretation needs caution for two reasons: the tussocks, although small, had many more tillers than "normal" seedlings, suggesting that they may be stunted rather than young. Whether this stunting is caused by browse (thar pellets were on all subplots) or by the effect of snow lying on the site longer than average (the snow-bank tussock *C. oreophila* was present) is debatable. However, this pattern of many "seedlings" of *C. pallens* but few large plants (at least when compared with plots in other areas) was repeated on all Landsborough plots, suggesting browse may be the cause.

Whymper glacier

FIGURE 5. BIMODAL DISTRIBUTION OF *CHIONOCHLOA PALLENS*, PLOT 10, WHYMPER GLACIER



Plot 10

This 4 x 4 m plot is on a colluvial spur in schist bedrock. It is at 1355 m a.s.l. on a 15° slope and is well drained. Only 45% of the plot was vegetated, 50% being covered by litter and 5% by broken rock. *C. pallens* dominated the tiers over 0.1 m, and *Poa colensoi* and *Acaena sp.* the ground tier.

This plot had two size cohorts of snow tussocks (Fig. 5), with numerous small plants and a group of larger (but rather stunted) tussocks. Browse was common on the tussocks and thar pellets were present on six of the 16 subplots.

5.2 THAR DENSITIES

The number of thar (and other ungulates) counted in 21 small study catchments at various times since 1965 are shown in Appendix 11.1.

Counts of thar in 14 catchments surveyed at least once since 1990 averaged 2.5/km2, but were extremely patchy, ranging from 0 to 24 animals/km2 (Table 2).

There are too few sample catchments to determine whether average thar densities in each of the management units exceeded the threshold densities set in the management plan, but as many sample catchment densities exceeded the limit, extra control action is needed.

TABLE 2. AVERAGE ANNUAL DENSITIES OF THAR COUNTED IN ANNUAL SURVEYS MADE AT LEAST ONCE SINCE 1990 IN 14 CATCHMENTS COMPARED WITH DENSITIES IDENTIFIED FOR THE WHOLE MANAGEMENT UNIT AT WHICH DOC MUST INTERVENE ACCORDING TO THE MANAGEMENT PLAN.

CATCHMENT	AREA (KM^2)	AVERAGE DENSITY OF THAR/KM^2	INTERVENTION DENSITY FOR MANAGEMENT UNIT
Carneys Creek	22	3.4	2.5
Frances R.	4	2.8	2.5
Bettison Stream	15	1.7	2.0
Price Stream	24	1.9	2.0
Wilkinson Stream	10	3.2	2.0
North Branch	19	7.9	2.5
Ailsa Stream	11	5.7	2.5
Forest/Rawtor Creek	40	0.8	2.5
Hooker Valley	22	0.3	<1.0
Douglas River	22	2.1	<1.0
Whymper Glacier	61	0.6	<1.0
Stony River	27	0.8	2.5
Fred's Stream	20	0	2.5
Landsborough River	9	24.1	1.5

The three study areas in which thar far exceed the threshold densities (North Branch, Aisla River, and the area in the headwaters of the Landsborough River) are all exclusively occupied by females and associated juveniles during February - March, and all three are hunted only occasionally, either because the landowner restricts access (North Branch) or because of their remoteness (Ailsa and Landsborough Rivers).

5.3 RATES OF INCREASE

Annual counts of thar have been made with sufficient frequency to estimate rates of population increase in five areas (Figs ,6 - 10). Two general patterns of increase are apparent: in areas where hunting access is restricted (i.e., in North Branch and the Ailsa River; Figs. 6 and 7) thar are increasing at an average annual rate since 1984 of about 30% (r = 0.26) for the North Branch and 46% (r = 0.38) for the Ailsa. Immigration as well as reproduction by the residents was responsible for the increase in some years (see Appendix 11.1). In three other areas where ground hunters had easier access, thar populations were increasing less rapidly by about 14% per annum (r = 0.13, Carneys Creek; Fig. 8) or were stable or declining (Stony Creek and the Hooker Valley; Figs. 9 and 10, respectively).

It is difficult to estimate an average actual rate of increase for the whole thar population under present harvesting conditions, but I guess it to be about 15% per year. If all hunting stopped, the population would increase by about 30% per year until the lack of food began to limit the herd - probably in about 4 years from now, when the population would be approaching 30 000 animals. The rate would then decline until the population stabilised at the carrying capacity, estimated to about 50 000 (Parkes 1988, unpubl. FRI contract report).

FIGURES 6-10 CHANGES IN THE DENSITIES OF THAR AND OTHER UNGULATES IN: CARNEYS CREEK (RANGITATA CATCHMENT); NORTH BRANCH (GODLEY CATCHMENT); STONY CREEK (DOBSON CATCHMENT); PART OF THE HOOKER VALLEY; AND THE AILSA RIVER ID IS THE THRESHOLD DENSITY FOR THAR IN THE LARGER MANAGEMENT UNIT AT WHICH DOC WILL INTERVENE TO CONTROL NUMBERS.

FIG. 6 CARNEYS CREEK (22 KM²)

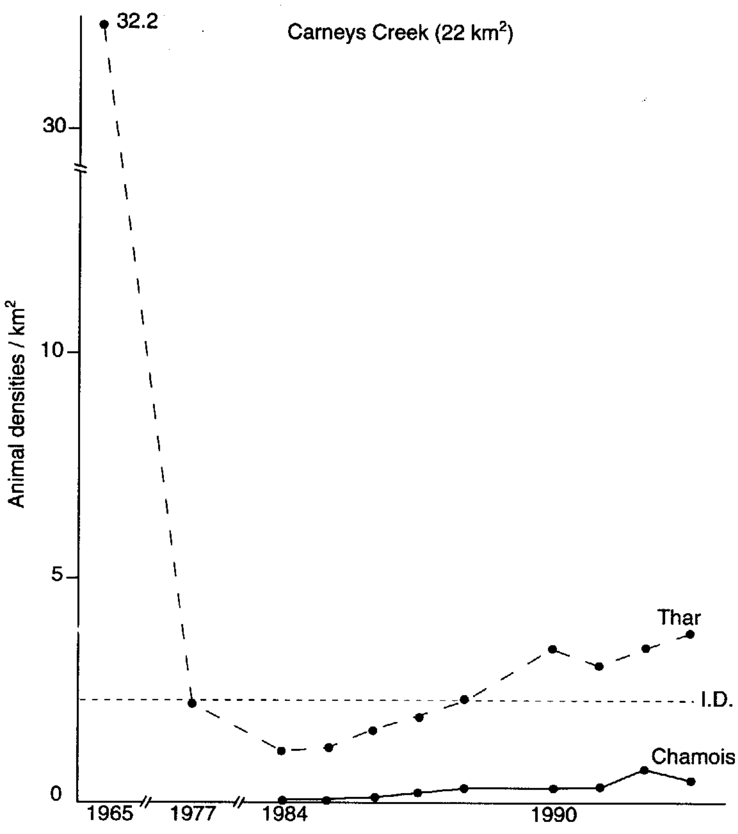


Fig. 6

FIG 7. NORTH BRANCH (19 KM²)

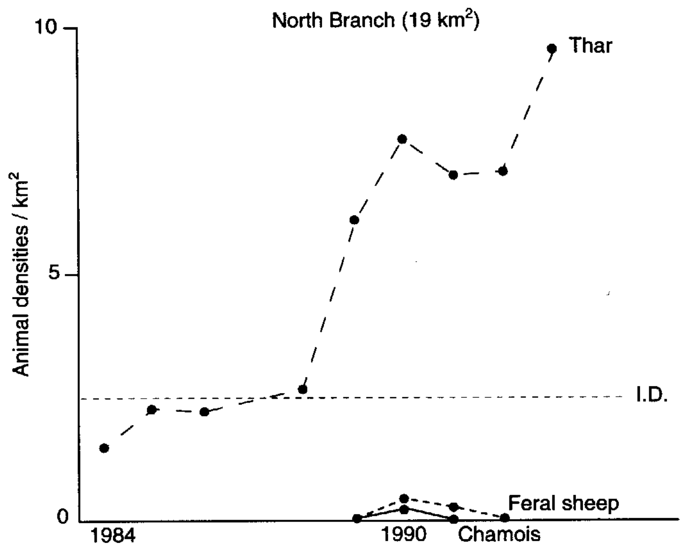


Fig. 7

FIG. 8 STONY CREEK (27 KM²)

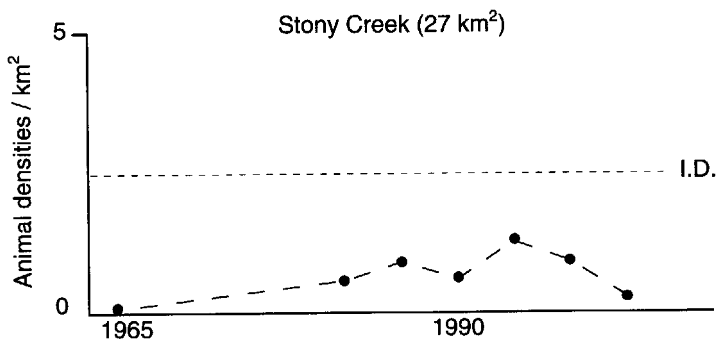


Fig. 8

FIG. 9 HOOKER VALLEY (22 KM²)

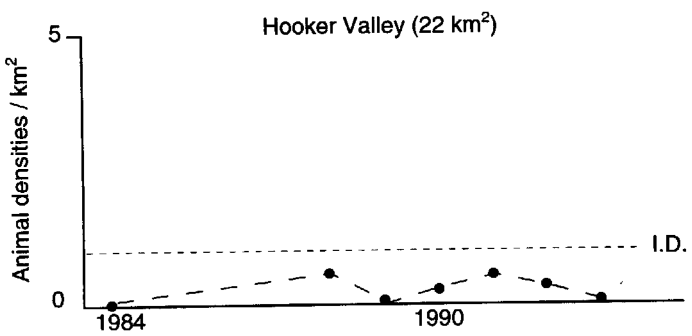


Fig. 9

AILSA (11 KM²)

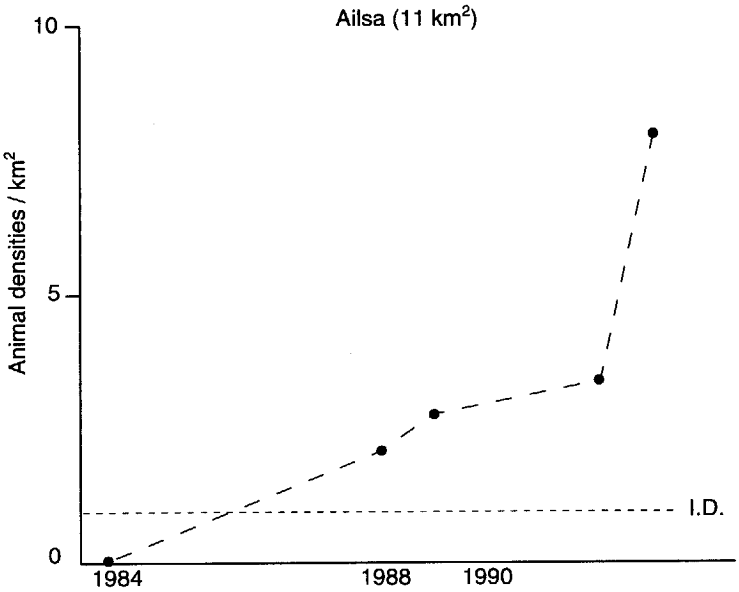
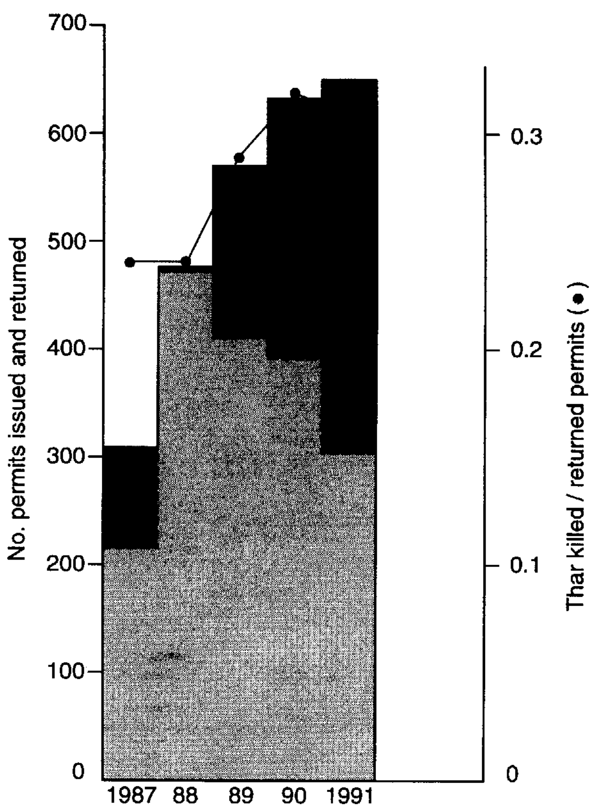


Fig. 10

5.4 HARVESTS OF THAR

FIG 11 HUNTING PERMITS ISSUED AND KILL RATES OF THAR FROM THOSE RETURNED BY THAR HUNTERS ON THE DEPARTMENT OF CONSERVATION ESTATE, RANGITATA CATCHMENT, 1987-91



All commercial hunting of thar for meat ceased in 1983 when a moratorium was put in place. The number of thar passing through the game factories had declined from a peak of about 10 000 in 1974 (Parkes & Tustin 1985) to 328 in 1982. In contrast, the harvests taken by recreational and guided hunters has probably been increasing.

An estimated 750 thar were shot by about 1250 recreational hunters, and an additional small number (perhaps another 100) animals were shot by guided hunters from overseas in 1988, according to a survey of firearm owners (Nugent 1992).

There is some evidence that the hunting effort is increasing. The number of permits issued for hunting land administered by the Department of Conservation in the Rangitata catchment has doubled since 1987 (Fig. 11). It is likely that the number of thar killed has also increased proportionately as the kill rate for those hunters who provided a return remained similar (Fig. 11). However, the proportion of hunters who bother to return their permit is highly variable, from 99% in

1988 when researchers pestered those who had not (Challies & Thomson 1989, unpubl. FRI contract report) to 46% in 1991. The kill-rate for hunters in 1988 who did not return permits until contacted was 0.21, that for those who did was 0.33. Assuming the non-return rate has been the same in all years, the annual estimated kill of thar from the DoC estate in the Rangitata was 72 in 1987, 112 in 1988, 151 in 1989, 177 in 1990, and 167 in 1991.

The 1991 data are typical. Hunters spent an average of 3.5 days hunting per trip, and shot mostly males (72% of those whose sex was recorded).

5.5 A HARVESTING MODEL FOR THAR

A logistic model can be used to predict the number of thar that will result from continuation of the present harvesting regimes, or the annual harvest that must be taken to keep the thar population at some limit.

The model is: $N = K - Kh/r_m$

Where: N = the equilibrium population size

K = the carrying capacity

h = the annual harvesting rate, and

r_m = the intrinsic rate of increase.

Estimates for the parameters we cannot manipulate (K and r_m) can be made. Carrying capacity (K) of thar in their present range was estimated as 50 000 from the effect of known harvests on the population during the 1970s (Parkes 1988, unpubl. FRI contract report). The intrinsic rate of increase was estimated from the observed rate in North Branch as 0.26. The other two parameters (N and h) can be manipulated by management.

How many thar will result under the present harvesting regime? It is assumed that the present population size is 10 000 thar, with an annual harvest by all sources of 1000 thar. Such a population will increase to a stable size of 30 700 in about 8 years.

How many thar must be shot to keep the population at 10 000? The required harvest rate is 0.208, or an annual kill of 2080 thar, or about twice as many as is estimated to be shot at present.

However, it is likely that most of the thar shot at present are males (72% if the reported sex ratio of the kills from 1991 in the Rangitata is general). Because thar have a polygynous hierarchical mating system, and assuming the surviving males can still impregnate all the females, it is likely that a harvest of 2080 thar will not be sufficient to maintain the present population below the required size of 10 000 animals. The answer is to kill more females.

6. Conclusions

It is likely that all threshold densities set in the draft thar management plan will be sufficiently low to allow snow tussocks to remain healthy and to reproduce, and as these form the bulk of thar diet (see Part II), this should also protect all natural resources less susceptible to the effects of browsing by thar. Validation of this conclusion can only be made empirically by observing the impact on the vegetation of thar at known densities.

Notwithstanding this general conclusion, thar are likely to be adversely affecting conservation values in local areas where they are at much higher densities than the threshold densities set in the whole management units defined in the draft plan.

Present harvests are insufficient to keep the thar population below the overall maximum determined by the draft plan. About 1500 more thar per year will have to be shot to achieve this. There are several good reasons why this additional harvest should be mostly of females. Firstly, evidence from the three high-density survey catchments suggests that such "hot-spots" are created in areas of good female range that is inaccessible to recreational hunters, and secondly, any cull of females will not be at the direct expense of mature bulls which are the target of the principal harvesting group, recreational hunters.

7. Recommendations

- The permanent vegetation plots should be remeasured over 1994-95 and 1995-96 to validate the threshold densities of thar set in the draft management plan.
- Censuses of thar and other ungulates should be continued in the 21 study catchments on a planned timetable. Those in catchments with vegetation plots should be done at least once every 2 years.
- An additional 1500 thar must be shot each year to keep the population below 10 000 animals. These 1500 should be mostly females and the known high-density patches of thar should be targeted first.

8. Acknowledgements

We thank the Department of Conservation staff who helped with counting thar, particularly J. Mead, N. Bolton, D. Anderson. We thank the landowners who gave us permission to count thar on their land. J. Orwin provided comments on drafts of this report.

Part II Diet of Thar, Chamois, and Possums

1. Introduction

The Department of Conservation (DoC) must manage Himalayan thar (*Hemitragus jemlahicus*) in the Southern Alps to protect indigenous resources. It intends to do this by restricting the number of thar to below set densities in different management units and by managing hunters to kill enough thar to achieve these densities. These densities must be based on some understanding of the impact of thar and the other introduced herbivores present. As a first step to understanding these impacts it is necessary to know what the herbivores eat. This report describes the diets of three sympatric herbivores - thar, chamois (*Rupicapra rupicapra*), and possums (*Trichosurus vulpecula*) to indicate the vegetation communities and plant species likely to be affected by the presence of these animals. The study was commissioned by the Department of Conservation from the Weeds and Pests Division, Manaaki Whenua - Landcare Research, Christchurch. The study began in 1990 and finished in 1994.

2. Background

This study arose out of an ongoing debate over the fate of Himalayan thar. Liberated at Mt Cook in 1904 (Donne 1924), these alpine goats have subsequently spread over about 7000 km^2 of the Southern Alps. They passed through a typical eruptive oscillation in numbers after liberation (Caughley 1970), reaching densities in excess of 30/km^2 at its peak. The population was reduced by about 90% by commercial hunting during the 1970s (Parkes & Tustin 1985), but has increased since this industry ceased in 1983 to a size of about 10 000 animals in 1993 (see Part I).

The impact of high densities of thar on the alpine vegetation, and presumably on the fauna dependent on that vegetation, was severe, with tall snow tussock grasslands being changed in places to a grassland dominated by short-sward species (Caughley 1970). The low densities resulting from commercial hunting allowed the snow tussock communities to recover some of their vigour, e.g., threatened herbs such as *Ranunculus godleyanus* recovered (Douglas 1984), and snow tussocks recovered to be the dominant plants on many sites where they had been reduced to stumps (Anon 1993). All this may be at risk unless the present increase in thar numbers is at least halted.

However, thar share their range with chamois, possums, hares (*Lepus europaeus*), red deer (*Cervus elaphus*), domestic sheep (*Ovis aries*), and more rarely feral goats (*Capra hircus*). Eventually, protection of the valued indigenous resources in the Southern Alps will require management of the impacts of all these herbivores.

The recent debates on DoC's policy and National Control Plan for thar have been hampered in their rigour (but not their vigour) by a lack of data about which herbivores were responsible for which observed changes in the flora. Most past studies on the impacts of thar were qualitative and made during the period of high densities of thar (and chamois and red deer). This study aims to provide some baseline information about which herbivore eats which plant species, and so which plants are likely to be most useful as bioindicators to validate the target densities of thar (and eventually other herbivores) set in the National Thar Control Plan.

3. Objectives

- To identify and compare thar diet by season, sex, and area.
- To identify and compare sympatric chamois diet by season, sex, and area and to compare chamois diet sympatric and non-sympatric with thar.
- To identify and compare possum diet by season.
- To compare thar, chamois and possum diet.
- To compare plant availability with thar, chamois, and possum diets in Carney's Creek, Rangitata catchment.

4. Methods

Samples of stomach contents were collected from thar, chamois, and possums by private, DoC, and Landcare Research workers. The number of samples analysed from the eastern side of the Southern Alps was: 209 thar and 69 chamois (38 sympatric with thar). The number from the western side was 44 thar and 64 chamois (51 sympatric with thar). Forty possum samples from the Rangitata catchment were analysed.

Each rumen sample was sub-sampled and washed over a 4-mm sieve, then the plant fragments retained were sorted into species. Early trials had showed that the 4-mm mesh sieve was the most appropriate for thar and chamois samples, but because it was difficult to sort grass-filled thar samples, we needed to ascertain the minimum sub-sample size and effort required to give a reasonably unbiased result. As 5 and 10 ml of sieved material (100 and 200 ml unsieved) gave 95% and 98%, respectively, of all species present in the gut for most thar samples, we sub-sampled to 5 - 10 ml or greater. Chamois samples consisted of larger leafy material and were easier to sort, so we used a sieved sub-sample of 10 - 20 ml.

Possum samples were sorted by washing the entire contents of each stomach over a 2-mm sieve and then randomly selecting and identifying 100 of the remaining plant fragments by a point sub-sampling method. This sieving method for possums has subsequently been shown to produce some bias (particularly for herbs and fruits) as possums chew different food species to different degrees, resulting in some species passing through the sieve mesh (P. Sweetapple unpubl. data).

Plant species were then dried and weighed, and means were calculated to give estimates of combined annual and seasonal diets for animal species, sexes, and areas. These were converted to logarithmic values and tested for significant differences using ANOVA and t-tests.

The diet of thar was compared for three areas (Fig. 1); the Rangitata and Rakaia catchments, areas south and east of Mt Cook, and all catchments west of the Main Divide. These divisions were based on general vegetation similarities backed up by dietary similarities (e.g., the diet of chamois and thar from the Rangitata catchment showed few differences from that of animals from the Rakaia catchment).

Seasonal differences in thar diet are analysed in detail for the Rangitata/Rakaia area, where adequate numbers were sampled throughout the year and there was little within-area variability in diet. Seasons were defined as summer (December to February), autumn (March to May), winter (June to August), and spring (September to November). The diet of female and adult male (3 years old) thar were compared during April to September (just before the rut until the start of spring) when adult males live in female - juvenile range, and October to March when they are segregated.

Chamois diet was compared between the east and west of the Main Divide and within and outside thar range. All eastern areas were combined to compare seasonal differences in diet.

Possum diet was analysed for the Rangitata catchment during autumn and spring only, because of limited resources.

Dietary preferences of thar, chamois, and possums in Carneys Creek were established by comparing the percent of each food item in samples taken from this area with an index of plant availability based on percent cover data collected from 102 reconnaissance survey plots in the summer of 1991 and the mapped area of each vegetation association.

5. Results

5.1 THAR DIET

Thar generally ate more grass, particularly snow tussocks, than herbs or woody plants. Depending on the area, grasses made up between 48% and 66% of thar diet.

Differences to tbar diet between areas

Total grasses and herbs eaten was similar in all eastern areas (Table 1), but significantly less woody plants were eaten in the Mt Cook area than in the other two areas. The grass species eaten varied in the three areas; e.g., Poa colensoi/ Rytidosperma setifolium` was 23% of the diet at Mt Cook, 13% in the Rangitata/ Rakaia, and only 4% on the West Coast, but thar on the West Coast ate significantly more Chionochloa spp. than did eastern (Rangitata/Rakaia or Mt Cook) thar (Table 1). Woody plants, such as Carmichaelia spp. and Gaultheria crassa, appeared less in the diet of Mt Cook thar than in those from the Rangitata/Rakaia. Some dietary items more common in the west included Astelia and ferns, perhaps because of the higher rainfall, and Coprosma spp.

(Note: It was not possible to distinguish between the two fine-leaved grasses Poa colensoi and Rytidosperma setifolium in the samples unless flowers were present. Both species were eaten.)

FIG. I THAR BREEDING RANGE AND SAMPLING AREAS IN THE SOUTHERN ALPS OF THE SOUTH ISLAND.

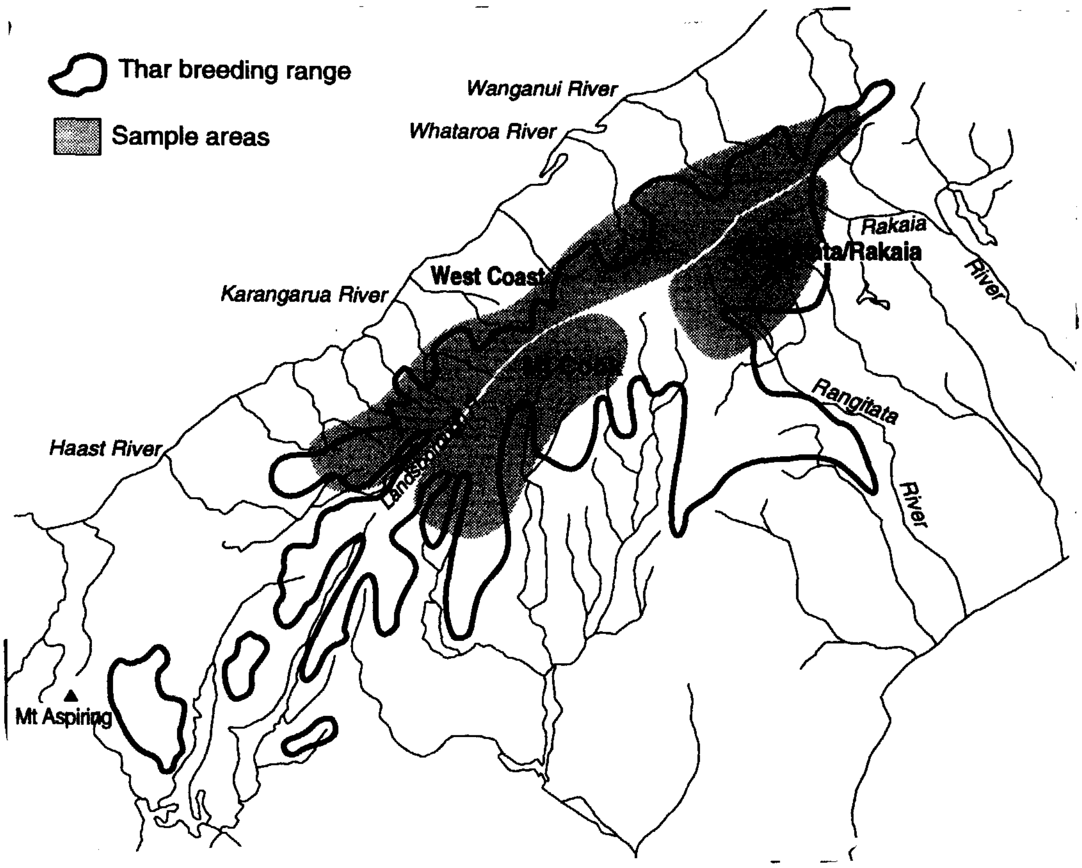


TABLE 1. DIFFERENCES IN THAR DIET BETWEEN THREE AREAS OF THE SOUTHERN ALPS. ONLY FOOD ITEMS COMPRISING ≥2% (MEAN % DRIED WEIGHT WEIGHTED BY SEASONS) IN THE DIET IN ANY ONE AREA ARE SHOWN, WITH THE REMAINDER INCLUDED ONLY IN THE TOTALS. IDENTIFIED EXOTIC GRASSES WERE *ANTHOXANTHUM ODORATUM* AND *AGROSTIS CAPILLARIS*.

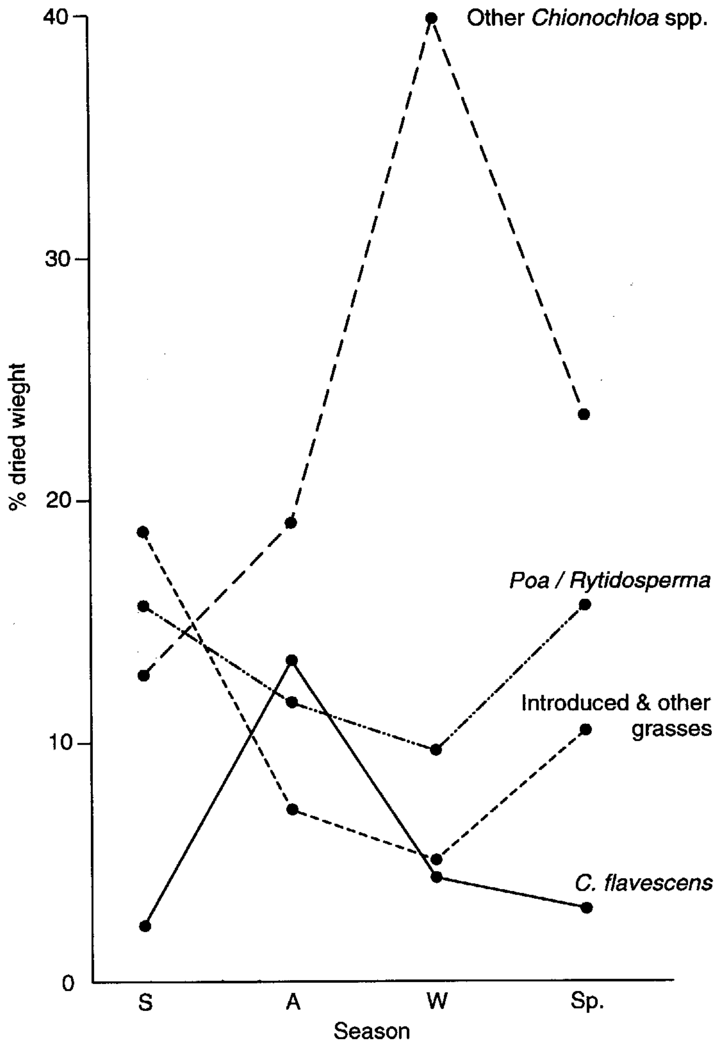
FOOD SPECIES OR GROUP	RANGITATA /RAKAIA (N = 134)	MT COOK (N = 43)	WEST COAST (N = 44)	P
Other *Chionochloa* spp.	23.9	23.9	42.5	0.05
Poa/Rytidosperma	13.0	23.1	4.3	0.001
Chionochloa flavescens	5.9	1.4	0.5	0.05
Identified exotic grasses	2.5	1.1	0	0.05
Schoenus pauciflorus	1.9	0.9	3.4	NS
TOTAL GRASSES	55.7	65.9	56.8	NS
Celmisia spp.	3.6	5.0	5.0	NS
Aciphylla spp.	4.3	4.7	1.9	0.05
Ranunculus lyallii	1.8	2.6	1.5	NS
Astelia spp.	0.9	<0.1	3.4	0.001
TOTAL HERBS	16.3	18.1	16.4	NS
Carmichaelia spp.	8.7	3.7	8.7	NS
Gaultheria crassa	6.8	2.6	1.6	0.001
Hebe spp.	3.7	1.7	3.2	0.05
Coprosma spp.	0.9	0.8	2.5	0.001
Podocarpus nivalis	<0.1	3.3	0.8	0.01
TOTAL WOODY PLANTS	26.6	15.1	22.3	0.001
TOTAL FERNS	1.1	<0.1	3.5	0.05

Seasonal differences in thar diet in the Rangitata/Rakaia

The total amount of grass eaten did not change with the seasons, although the species composition did (Table 2). *Chionochloa* spp. other than *C. flavescens* were eaten most in winter (40%) and least in summer (13%) but *C. flavescens* was eaten most in autumn (13%) (Fig. 2). The shorter-sward grasses (*Poa colensoi, Rytidosperma setifolium*), and the introduced grasses

(Anthoxanthum odoratum and *Agrostis capillaris* were the only species identified) showed the reverse pattern, with most being eaten in spring and summer (Fig. 2). Some of these patterns conform to the observed seasonal coincidence of thar range use and plant distributions. For example, the short-sward and introduced grasses occur most at lower altitudes where they flush early in spring and summer, and thar descend to take advantage of the new growth (Tustin & Parkes 1988).

FIGURE 2. SEASONAL CHANGES OF GRASSES IN THE DIET OF THAR IN THE RANGITATA/RAKAIA CATCHMENTS.



Woody plants and herbs were eaten in significantly different amounts over the seasons. Woody plants were eaten least in summer, increasing over successive seasons to highest use in spring. The proportion of woody plants such as *Gaultheria crassa* and *Dracophyllum spp* in the diet increased in winter and spring (Table 2). Other species did not always follow this pattern, e.g., *Hebe* spp. were eaten more in spring and summer. Herbs showed the reverse of this trend, forming a significantly higher proportion of the diet in summer (particularly *Ranunculus lyallii)* and autumn *(Aciphylla montana* and

Epilobium spp.) than in the other two seasons. However, one of the main herbaceous genera eaten, *Celmisia*, showed no seasonal changes (Table 2).

Differences between the diet of adult male and female thar in the Rangitata/Rakaia

The diets of female and adult male (3 years old) thar were similar during April to September when adult males moved into the female-juvenile range just before the rut (taken as May - July) and remained there until the snow retreated in early spring, but differed significantly for some species when the two groups were segregated outside the breeding season and after the snow retreated during October to March (Table 3). Generally, adult males ate significantly less grass and sedge (particularly *Poa/Rytidosperma* and *Schoenus pauciflorus*) when segregated than females. Both sexes ate similar amounts of snow tussock (*Chionochloa* spp.) throughout the year, but males ate more *Chionochloa flavescens*. Males generally ate more herbs than females, particularly *Aciphylla montana, Ranunculus lyallii,* and *Carmichaelia* spp. when segregated. Females ate more *Hebe* spp. throughout the year and *Celmisia* spp. than males when segregated.

Because the diets of the two sexes were similar when they occupied the same area during April to September, we conclude that the differences in diet when the sexes are segregated must be due to differences in habitat use, reflecting the different availability of plant species. Males move into the often more difficult female range just before the rut and remain while snow makes feeding difficult until September. After September they move out to a larger range than that occupied by the females, that includes more open snow tussock and herbfields where preferred species such as *Ranunculus lyallii, Carmichaelia* spp., and *Chionochloa flavescens* are more abundant.

TABLE 2. SEASONAL DIFFERENCES IN THE PERCENTAGE OF FOODS EATEN BY THAR FROM THE RANGITATA/RAKAIA AREA. ONLY FOOD ITEMS 2% OF THE DIET IN ANY ONE SEASON ARE SHOWN, WITH THE REMAINDER INCLUDED ONLY IN THE TOTALS.

FOOD SPECIES OR GROUP	SUMMER (N = 30)	AUTUMN (N = 29)	WINTER (N = 21)	SPRING (N = 54)	P
Poa/Rytidosperma	15.7	11.3	9.4	15.4	0.01
Other *Chionochloa* spp.	12.8	19.0	40.0	23.6	0.01
Schoenus pauciflorus	2.9	1.0	0.2	3.5	0.05
Agrostis sp.	2.7	0.9	0	0	NS
Chionochloa flavescens	2.3	13.4	4.6	3.0	0.01
Anthoxanthum odoratum	2.3	0.7	0	3.5	NS
Other grasses	14.3	7.7	5.7	7.0	0.01
TOTAL GRASSES	53.0	54.0	59.9	56.0	NS
Hebe spp.	5.2	2.3	2.4	5.1	0.01
Gaultheria crassa	5.0	5.2	8.2	8.9	0.05
Carmichaelia spp.	4.6	12.3	7.9	9.9	NS
Helichrysum selago	1.0	0.1	3.1	1.2	0.001
Dracophyllum spp.	0.4	1.0	2.1	2.5	0.001
Hoheria lyallii	0	2.9	0	<0.1	NS
TOTAL WOODY PLANTS	18.1	27.6	27.9	32.8	0.01
Ranunculus lyallii	7.1	0.2	0	<0.1	0.001
Aciphylla montana	4.5	6.8	<0.1	2.4	0.001
Celmisia spp.	3.1	2.3	4.5	4.5	NS
Epilobium spp.	2.3	2.3	<0.1	<0.1	0.001
TOTAL HERBS	28.3	18.2	7.7	11.0	0.001
TOTAL FERNS	0.2	0.0	3.9	0.0	NS

5.2 CHAMOIS DIET

Chamois from alpine habitats generally eat more woody plants and herbs than grasses. Depending on the area, grasses made up between 9% and 23% of chamois diet.

Differences in chamois diet between areas within thar range

Chamois diet appeared to be more variable between areas than that of thar, possibly because chamois used a much wider range of altitudes and therefore habitats than thar. The greatest differences were between chamois shot either side of the Main Divide (Table 4). Western chamois ate significantly more woody plants, particularly forest species and *Carmichaelia*, and less grasses than eastern chamois. The rare *Ranunculus godleyanus* was found in chamois diet (1%) in the west but not in the east.

Differences in chamois diet inside and outside thar range

Chamois do not usually live in the same areas as female thar (Parkes 1988, unpubl. Landcare Research contract report). To test whether this is due to exclusion or habitat preference, we compared the diet of chamois sampled from within thar range with that of chamois sampled in similar habitats just outside thar range. If chamois diet in thar range is determined by their exclusion from parts of the range, we would predict that their diet outside and inside thar range should differ.

However, we found no significant differences between the diets of chamois living within thar range and those living just outside thar range on the eastern side of the Main Divide. Those outside thar range did eat more grasses (26% of the diet of 27 chamois) than those inside thar range (19% of the diet of 39 chamois), but the difference was not significant.

Seasonal differences in chamois diet

Chamois from the east of the Main Divide ate less grass and herbs and more woody plants in winter and spring than in other seasons (Table 5). Some important seasonal differences were shown for species such as *Ranunculus lyallii* (9% of the total diet), which dies back in winter. *Coprosma* spp. formed an important food item in winter.

Differences in the diet of male and female chamois

No significant differences were found in the percentage of any food item between the diets of male and female chamois.

TABLE 3. COMPARISON OF THE COMPOSITION OF THE DIET OF FEMALE AND ADULT MALE (3YEARS OLD) THAR WHILE TOGETHER IN MIXED SEX GROUPS (APRIL-SEPTEMBER) AND SEGREGATED (OCTOBER-MARCH) IN THE RANGITATA/ RAKAIA CATCHMENTS. ONLY FOOD ITEMS 2% OF THE DIET OF EITHER SEX ARE SHOWN, WITH THE REMAINDER INCLUDED ONLY IN THE TOTALS.

FOOD SPECIES OR GROUP	ADULT MALE APR-SEP (N = 29)	FEMALE APR-SEP (N = 20)	P	ADULT MALE OCT-MAR (N = 29)	FEMALE OCT-MAR (N = 30)	P
Other *Chionochloa* spp.	28.5	30.6	NS	10.6	23.2	NS
Chionochloa flavescens	13.2	1.6	0.05	7.8	1.4	0.05
Poa/Rytidosperma	7.2	11.5	NS	10.5	19.7	0.05
Schoenus pauciflorus	1.0	0.1	NS	2.0	4.5	0.05
Anthoxanthum odoratum	0.1	0	NS	6.4	1.3	NS
Agrostis capillaris	0	0	-	2.8	0	NS
TOTAL GRASSES	54.1	53.3	NS	48.8	61.7	0.05
Carmichaelia spp.	15.3	7.3	NS	11.3	3.5	0.05
Gaultheria crassa	6.7	7.8	NS	5.6	8.5	NS
Hebe spp.	2.3	5.2	0.05	2.4	6.6	0.05
Dracophyllum spp.	1.4	2.3	NS	0.8	1.0	NS
Helichrysum selago	0.6	3.7	0.05	0.6	0.8	NS
Coprosma spp.	0.5	2.5	NS	0.2	0.7	NS
Hoheria lyallii	0	4.2	NS	<0.1	0	NS
TOTAL WOODY PLANTS	29.6	36.3	NS	24.6	23.5	NS
Aciphylla montana	3.8	1.3	NS	6.5	2.1	NS
Celmisia spp.	3.3	2.7	NS	2.1	4.7	0.05
Ranunculus lyallii	<0.1	0.2	NS	6.1	0.1	0.01
TOTAL HERBS	13.2	9.9	NS	26.1	14.6	NS
TOTAL FERNS	2.8	0.1	NS	0.2	0.1	NS

TABLE 4. DIFFERENCES IN CHAMOIS DIET (WEIGHTED BY SEASON) FROM ANIMALS SHOT IN ALPINE AREAS EAST AND WEST OF THE MAIN DIVIDE. ONLY FOOD ITEMS 2% OF THE DIET IN EITHER AREA ARE SHOWN, WITH THE REMAINDER INCLUDED ONLY IN THE TOTALS.

FOOD SPECIES OR GROUP	EAST (N = 66)	WEST (N = 51)	P
Poa/Rytidosperma	4.7	0.7	0.001
Agrostis sp.	2.7	0	0.05
Chionochloa spp.	1.5	0.8	NS
TOTAL GRASSES	21.0	9.3	0.001
Ranunculus lyallii	8.9	4.1	NS
Anisotome spp. (*haastii, pilifera*)	3.7	3.7	NS
Celmisia spp.	3.4	4.5	NS
Epilobium spp. (*macropus, alsinoides*)	3.2	0.9	0.01
Astelia spp.	0.9	2.7	0.05
Ourisia lactea	0.2	2.5	0.01
TOTAL HERBS	29.1	26.3	NS
Gaultheria crassa	15.6	8.1	0.01
Carmichaelia spp.	14.0	22.0	0.001
Coprosma spp. (*serrulata*)	4.8	5.5	NS
Hebe spp. (*subalpina, macrantha*)	4.5	5.4	NS
Griselinia littoralis	0	3.8	0.001
Melicytis ramiflorus	0	2.9	0.01
Weinmannia racemosa	0	2.3	0.001
TOTAL WOODY PLANTS	48.8	61.5	0.001
TOTAL FERNS	0.1	2.0	0.001

TABLE 5. SEASONAL DIFFERENCES IN THE PERCENTAGE OF FOOD EATEN BY CHAMOIS FROM THE EAST OF THE MAIN DIVIDE. ONLY FOOD ITEMS 2% OF THE DIET IN ANY ONE SEASON ARE SHOWN, WITH THE REMAINDER INCLUDED ONLY IN THE TOTALS.

FOOD SPECIES OR GROUP	SUMMER (N = 22)	AUTUMN (N = 19)	WINTER (N = 15)	SPRING (N = 10)	P
Poa/Rytidosperma	7.5	3.3	3.7	4.4	NS
Chionochloa spp.	0.1	4.6	0.6	0.8	NS
Agrostis sp.	0	4.4	6.4	0	NS
Unidentified grasses	19.3	8.1	1.1	14.6	0.001
TOTAL GRASSES	28.9	21.4	12.8	20.8	0.01
Gaultheria crassa	18.1	9.3	18.2	16.9	0.05
Carmichaelia spp.	6.9	10.5	22.3	16.5	NS
Hebe spp.	4.4	4.3	4.6	4.7	NS
Brachyglottis bidwillii	2.2	0	0	0	NS
Dracophyllum spp.	1.6	0.8	3.9	1.0	NS
Helichrysum selago	0.7	<0.1	3.2	2.4	0.05
Coprosma spp.	0.1	1.6	12.2	5.3	0.001
Clematis marata	<0.1	0	2.4	0	NS
TOTAL WOODY PLANTS	39.4	32.0	69.3	54.7	0.01

TABLE 5 (CONT'D)

FOOD SPECIES OR GROUP	SUMMER (N = 22)	AUTUMN (N = 19)	WINTER (N = 15)	SPRING (N = 10)	P
Ranunculus lyallii	15.4	13.5	<0.1	6.9	0.01
Epilobium spp.	2.9	7.9	1.7	0.2	0.001
Coriaria spp.	2.2	1.6	<0.1	<0.1	NS
Anisotome spp.	1.8	3.5	4.0	5.6	NS
Celmisia spp.	1.7	3.9	5.0	3.0	NS
Hieracium spp.	1.4	0.3	0	3.1	NS
Leucogenes grandiceps	0.7	3.2	0	2.0	0.05
Astelia spp.	0.2	0.3	2.7	0.5	NS
Ranunculus repens spp.	<0.1	5.5	0.4	0	0.01
TOTAL HERBS	30.9	46.1	16.7	22.4	0.01

5.3 POSSUM DIET IN THE RANGITATA

Possums from alpine areas in the Rangitata ate little grass in the two seasons sampled, but ate equal amounts of woody plants and herbs. Fruits of *Podocarpus nivalis*, *Muehlenbeckia axillaris*, and *Coriaria angustissima* made up half of the autumn diet (Table 6). One possum had eaten a small bird, probably a greenfinch.

TABLE 6. DIET OF POSSUMS FROM ALPINE AREAS OF THE HAVELOCK RIVER (RANGITATA CATCHMENT) IN AUTUMN AND SPRING. ONLY FOOD ITEMS 2% OF THE DIET IN EITHER SEASON ARE SHOWN, WITH THE REMAINDER INCLUDED ONLY IN THE TOTALS.

FOOD SPECIES OR GROUP	AUTUMN (N = 11)	SPRING (N = 28)	P
Muehlenbeckia axillaris (fruit)	16.2	0	0.001
Podocarpus nivalis (fruit)	15.2	0	0.001
Podocarpus nivalis (leaves)	12.6	15.4	NS
Hoheria lyallii	8.9	3.1	NS
Muehlenbeckia axillaris	3.1	2.1	0.05
Aristotelia fruticosa	1.2	4.9	NS
Pseudopanax sp.	0.4	5.5	0.01
TOTAL WOODY PLANTS	28.3	36.7	NS
Coriaria angustissima (fruit)	19.3	0	0.001
Epilobium spp.	4.5	1.3	NS
Celmisia spp.	2.6	0	NS
Hieracium spp.	1.7	14.7	0.05
Anisotome spp.	1.3	2.4	NS
Viola cunninghamii	0.4	2.0	NS
Trifolium repens	0.2	9.2	0.001
Raoulia tenuicaulis	0	7.1	0.01
Leucogenes grandiceps	0	3.3	NS
TOTAL HERBS	18.2	51.6	0.01
Blechnum penna-marina	0	4.0	NS
TOTAL FERNS	0.6	4.9	0.05
TOTAL GRASSES	0.3	2.6	0.001
TOTAL ANIMAL MATTER (Insects, birds)	0.1	2.4	NS
TOTAL FRUITS	51.6	0	0.001

5.4 COMPARISON OF THAR, CHAMOIS, AND POSSUM DIET

Thar, chamois, and possums that live in the same alpine catchments partition their food resources as though they had evolved together. Thar eat mainly grass, chamois eat mainly shrubs and herbs, and possums eat different species of shrubs, more herbs, and a lot of fruit when it is available (note that the possum data includes only autumn and spring) (Table 7; Fig. 3).

We suggest that the reason the two ungulates have different diets in the areas studied is that they are pre-adapted to different diets by their natural relationships with sympatric competitors in their natural range, rather than because of a presumed exclusion of chamois by female thar. The evidence for this comes from the natural experiments provided by the sexual segregation of adult male thar and the presence of chamois outside the range of any thar. Chamois diet did not change in the absence of female thar, indicating their diet is due to preference, whereas, male thar diet differed, indicating availability rather than preference is involved.

FIGURE 3. COMPARISON OF THE DIETS OF SYMPATRIC THAR, CHAMOIS, AND POSSUMS FROM THE RANGITATA/RAKAIA CATCHMENTS.

The only non-significant difference for a dietary grouping is that between cbamois and possums for woody plants.

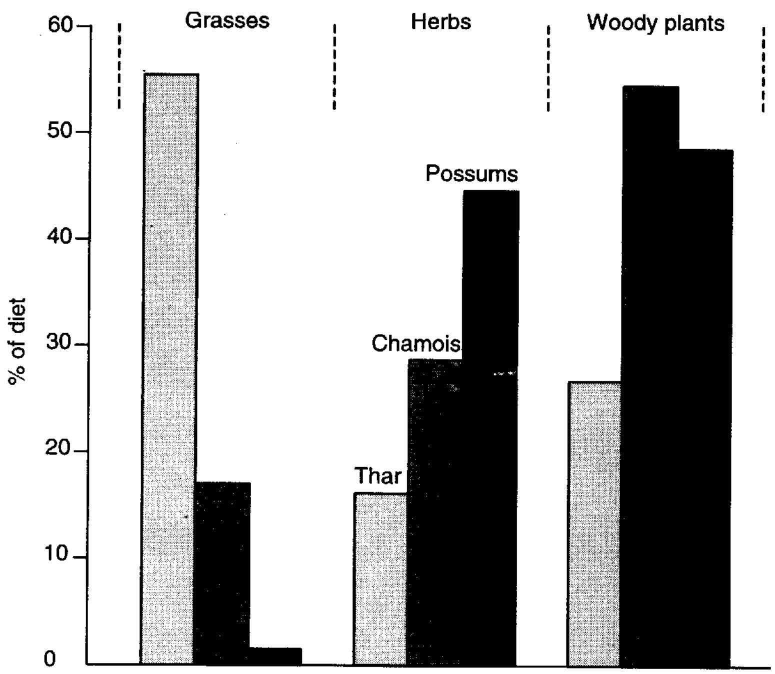


TABLE 7. DIETS (MEAN % WEIGHTED BY SEASONS) OF SYMPATRIC THAR, CHAMOIS, AND POSSUMS FROM THE RANGITATA/RAKAIA CATCHMENTS. OCCURRENCES OF <2% ARE INCLUDED ONLY IN THE TOTALS. "+" INDICATES THE SPECIES WAS PRESENT IN THE DIET.

FOOD SPECIES OR GROUPS	THAR (N = 134)	CHAMOIS (N = 33)	POSSUMS (N = 40)	P
Chionochloa spp.	29.7	2.0	0	0.001
Poa/Rytidosperma	12.9	4.6	+	0.001
Unidentified grasses	7.7	8.4	+	0.001
TOTAL GRASSES	55.7	17.0	1.4	0.001
Carmichaelia sp.	8.7	19.4	0	0.001
Gaultheria crassa	6.8	15.2	+	0.001
Hebe spp.	3.7	6.8	0	0.001
Helichrysum selago	+	2.9	0	0.001
Dracophyllum spp.	+	2.6	0	0.001
Podocarpus nivalis (leaves)	+	0	14.0	0.005
Muehlenbeckia axillaris (fruit)	0	0	8.1	0.001
Podocarpus nivalis (fruit)	0	0	7.6	0.001
Hoheria lyallii	+	+	6.0	0.001
Aristotelia fruticosa	0	0	3.0	0.001
Pseudopanax spp.	+	0	2.9	0.001
Muehlenbeckia axillaris (leaves)	+	+	2.6	0.001
TOTAL WOODY PLANTS	26.6	54.3	48.2	0.001

TABLE 7 (CONT'D)

FOOD SPECIES OR GROUPS	THAR (N = 134)	CHAMOIS (N = 33)	POSSUMS (N = 40)	P
Celmisia spp.3.6	+	+	NS	
Aciphylla montana	3.4	+	0	0.001
Ranunculus lyallii	+	9.8	0	0.001
Anisotome spp.	+	5.5	+	NS
Hieracium spp.	+	2.5	8.2	0.001
Epilobium spp.	+	2.2	2.9	0.001
Coriaria angustissima (fruit)	0	0	9.6	0.001
Unidentified herbs	+	+	6.3	0.001
Trifolium repens	+	0	4.7	0.001
Raoulia tenuicaulis	0	0	3.5	0.001
TOTAL HERBS	16.3	28.4	44.5	0.001

5.5 RELATIVE FOOD PREFERENCES OF THAR AND CHAMOIS

The amount of any plant species in the diet of a herbivore will depend on its availability and its palatability, i.e., its preference. Comparison of the rough index of plant species biomass made from reconnaisance plots in Carney's Creek (average percent cover of species x area of habitat type) with the proportion of the plants in the diet of thar, chamois, and possums allows a first attempt at measuring the animals' dietary preferences.

In Carney's Creek, chamois appeared to actively select food species that are not particularly abundant, whereas thar fed on more abundant food types. Possums fed on the abundant *Podocarpus nivalis* but were also selecting other less abundant species. We conclude that the habitat in Carney's Creek is more suitable for thar than chamois or possums (Table 8).

TABLE 8. THE HIGHEST RANKED SPECIES (SEASONALLY WEIGHTED) THAT MAKE UP ABOUT 70% OF THE DIET OF THAR, CHAMOIS, AND POSSUMS COMPARED TO A PREFERENCE INDEX (% OF DIET/INDEX OF PLANT SPECIES BIOMASS). A SPECIES WITH A HIGH INDEX IS MOST PREFERRED. THE CHAMOIS SAMPLE WAS TAKEN OVER THE WIDER RANGITATA/RAKAIA AREA, BUT THE TWO CHAMOIS FROM CARNEYS CREEK HAD A SIMILAR DIET.

Note: Chionochloa flavescens is included with Chionochloa spp. for thar in Carney's Creek, as it is only 4.4% of thar diet. It is however, a preferred species with a preference index of 4.9.

FOOD SPECIES OR GROUP	% OF DIET	PREFERENCE INDEX
THAR: CARNEY'S CREEK (N = 25)		
Chionochloa spp.	33.5	1.7
Poa/Rytidosperma	16.7	0.9
Carmichaelia spp.	11.5	3.9
Gaultheria crassa	8.4	2.6
CHAMOIS: RANGITATA/RAKAIA (N = 33)		
Carmichaelia spp.	19.4	6.6
Gaultheria crassa	15.2	4.7
Ranunculus lyallii	9.7	6.7
Hebe spp.	6.8	1.3
Anisotome spp.	5.5	1.8
Poa/Rytidosperma	4.6	0.2
Helichrysum selago	2.9	48.3
Dracophyllum spp.	2.6	0.3
Hieracium spp.	2.5	0.3

TABLE 8 (CONT'D)

FOOD SPECIES OR GROUP	% OF DIET	PREFERENCE INDEX
POSSUM: CARNEY'S CREEK (N = 18)		
Podocarpus nivalis	19.6	1.5
Hieracium spp.	17.4	2.3
Coriaria angustissima	10.5	17.8
Muehlenbeckia axillaris	10.0	9.0
Aristotelia fruticosa	6.3	8.8
Raoulia spp.	5.7	5.2

6. Conclusions

Thar, chamois, and possums are sympatric throughout the range of thar and generally all eat similar species of plants. However, the principal food species occur in significantly different proportions in the diets of the three animals. Thar eat mostly grasses, particularly snow tussocks (*Chionochloa* spp.); chamois eat woody plants, particularly native brooms (*Carmichaelia* spp.), and herbs such as the Mount Cook lily (*Ranunculus lyallii*); and possums eat different woody plants, particularly snow totara (*Podocarpus nivalis*), and fruits in autumn. This corresponds, in general, with the types of habitats each species is observed using (from animal census studies and habitat data from samples for this study). Thar are generally found in the alpine grassland zone, chamois in the sub-alpine scrub/alpine grassland margins, and possums within and below the sub-alpine scrub zone. Impacts on the vegetation are therefore likely to be cumulative. This has important consequences for managers, not least because it shows that all herbivores must be managed if all natural resources are to be protected.

Although there is some overlap between thar and chamois diet, the major food species eaten by thar, chamois, and possums could be useful bioindicators for validating target densities of animals. For instance, *Chionochloa* spp. (particularly *C. flavescens*) could be used for thar, *Carmichaelia* spp., *Gaultheria crassa*, and *Ranunculus lyallii* for chamois, and *Podocarpus nivalis* for possums.

The reasons why the three species partition the food resource are unclear. Female and male thar are segregated outside the breeding season and after winter, so that differences between the sexes probably depends on species availability. Both sexes eat similar foods when they live together during April to September. Chamois are segregated from female thar throughout the year but availability is unlikely to be the explanation for the difference in diet between the species as chamois eat the same foods both outside and inside the range of thar. The difference between thar and chamois diets is more likely to be one of food preference rather than different habitat use caused by exclusion.

Thar have similar diets in all areas, but show distinct seasonal and sexual patterns. In contrast, chamois show more regional variations but within an area show less seasonal and no sexual differences. Possums apparently rely on mainly scrubland species and specialise in fruits in autumn.

Generally, chamois appear more likely than thar to be affecting alpine herbs (such as *Ranunculus* spp.) thought to be at risk to introduced herbivores. However, because thar are often at higher densities than chamois and are more social animals, their overall impact on local vegetation is likely to be greater.

7. Recommendations

The Department of Conservation should integrate its management of alpine herbivores if it wishes to maximise the conservation benefits as one species targeted separately may not achieve the desired result.

8. Acknowledgements

We thank the many private hunters who went out of their way to provide us with rumen samples (in particular Stuart Walkham and Don Greig who provided the most samples), the many safari hunters and the DoC hunters from Geraldine, Twizel, Wanaka and Westland. Thomas Pearson drew the figures, Jim Coleman commented on early drafts of this report, and Joanna Orwin provided helpful editorial assistance.

9. References

Anon 1993: Himalayan thar control plan. *Canterbury Conservancy miscellaneous planning series no. 3.* 68 p.

Caughley, G. 1970: Eruption of ungulate populations, with emphasis on Himalayan thar in New Zealand. *Ecology 51:* 53-73.

Challies, C.N. 1992: Thar monitoring in Carneys Creek, Rangitata catchment: a plan for small catchment surveys. Unpublished report to the Department of Conservation, 10 p.

Challies, C.N.; Thomson, C. 1989: Survey of recreational hunting of thar on conservation land in the Rangitata catchment. Forest Research Institute contract report (unpublished). 9 p.

Donne, T.E. 1924: *The game animals of New Zealand*. John Murray, London. 287 p.

Douglas, M.H. 1984: The warning whistle for the Himalayan tahr. *Forest and bird 15:* 2-6.

Lee, W.G.; Fenner, M.; Duncan, R.P. 1993: Pattern of natural regeneration of narrow-leaved snow tussock *Chionochloa rigida* ssp. *rigida* in Central Otago, New Zealand. *New Zealand journal of botany 31:* 117-125.

Marshall, D. 1991: Himalayan thar management policy. Department of Conservation, Wellington. 11 p.

Nugent, G. 1992: Big-game, small-game, and gamebird hunting in New Zealand: hunting effort, harvest, and expenditure in 1988. *New Zealand journal of zoology 19*: 75-90.

Parkes, J.P. 1988: A review of the options to manage Himalayan thar *Hemitragus jemlahicus* in New Zealand. Forest Research Institute contract report (unpublished) 43 p.

Parkes, J.P.; Tustin, K.G. 1985: A reappraisal of the distribution and dispersal of female Himalayan thar in New Zealand. *New Zealand journal of ecology 8*: 5-10.

Parkes, J.P. 1984: Distribution and density of thar in New Zealand. Forest Research Institute report (unpublished) 39 p.

Rose, A.B.; Allen, R.B. 1990: Impact of Himalayan thar on vegetation of the North Branch, Godley Valley, Canterbury. Forest Research Institute contract report FWE 90/32 (unpublished) 14 p.

Rose, A.B.; Platt, K.H. 1990: Age-states, population structure, and seedling regeneration of *Chionochloa pallens* in Canterbury alpine grasslands, New Zealand. *Journal of vegetation science 124*: 89-96.

Tustin, K.G. 1990: Himalayan tahr. *In:* C.M. King *ed.* The Handbook of New Zealand Mammals. Oxford University Press, Auckland, 600 p.

Tustin, K.G.; Challies, C.N. 1978: The effects of hunting on the numbers and group sizes of Himalayan thar (*Hemitragus jemlahicus*) in Carneys Creek, Rangitata catchment. *New Zealand journal of ecology 1*: 153-157.

Tustin, K.G.; Parkes, J.P. 1988: Daily movement and activity of female and juvenile Himalayan thar (*Hemitragus jemlahicus*) in the eastern Southern Alps, New Zealand. *New Zealand journal of ecology 11*: 51-59.