Diet selection by sheep in two moorland sites: chapel fell and Monk's moor

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Diet selection by sheep in two moorland sites: Chapel Fell and Monk's moor

by

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CONTENTS

SUMMARY

1. The diet preferences by sheep have been measured on two typical moorland vegetation sites: Chapel Fell and Monk's moor. Botanical composition of each vegetation type was estimated using quadrats to establish species cover.

2. Three vegetation types were observed at each site: grassland, blanket bog and fen and flush, differing in botanical composition. The main differences between the two moor, lay in the blanket bog patches, *Calluna vulgaris* being characteristic on Monk's moor, while *Eriophorum vaginatum* was dominant on Chapel Fell.

3. Visual observations were carried out on each moor to define the sheep preferences for different vegetation types and species utilisation within the vegetation type.

4. Grazing sheep were mainly observed in the grassland patches on both sites, feeding on grass and sedge species and rejecting *E. vaginatum* and *N. stricta.*

5. Faecal analysis was carried out on dropping collected in each type of vegetation to assess the importance of major food types in the diet and the botanical composition on the diet selection.

6. Sedges and grass were mainly selected in Chapel Fell, while *C. vulgaris* and grass were selected Monk's moor.

7. Differences in species selected and amount consumed were found throughout.the study period. These were related to species availability, growth stage and sward structure.

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CHAPTER I

INTRODUCTION

The most important daily activity for animals is obtaining enough food, both in quantity and quality, for maintenance and reproduction. A habitat may contain much food resources, but only a certain percentage is available and preferred by a species. As a result of this, one of the main causes of animals' distribution is food distribution (Pyke, 1983).

Herbivores are able to utilise grasses and plants, however they tend to select the amount and species according to their availability. Even on grassy pasture, not all the areas will be grazed evenly by herbivores. Usually the younger and more succulent plants are eaten first, and some species of grasses or small plants before others (Schaller, 1977 and Parsons, Newmann, Penning, Harvey and Orr, 1994).

Grazing in ruminants in temperate climates on good pastures usually occurs within four to five periods per day, this activity being alternated with other activities such as, exploring, resting, and ruminating. However, the type or quality of food can dramatically affect the grazing pattern, shorter grazing time is spent when higher quality of food is available (Hart, 1985).

As a consequence of the high grazing pressures, the pasture is eaten down. Animals become less selective and thus the quality of the forage is reduced. On the other hand, when forage is plentiful, most herbivores will avoid grazing areas that have been recently contaminated by urine and faeces (Hart, 1985).

Several factors influence the quality of forage, the most important being the growth stage; young growing parts have the highest protein content and dormant and dead ones the lowest. Availability is another important factor; many kinds of plants are unavailable to herbivores in an area: some are too high above the ground, other protect themselves with thorns, and still others have chemical defences in the form of toxic substances which inhibit digestion (Schaller, 1977).

Exposure, altitude, and degree of slope affect the growing season of plants and hence their nutritional quality and availability. For these reasons, food selection studies must involve observations of feeding animals by checking sites at which they have foraged, and by analysis of either rumen or faeces samples (Hill, Evans and Bell, 1992).

In Britain, man's interest in moorland is associated particularly with two herbivores, grouse and sheep. Sheep are the dominant herbivore in upland grassland and play an important dynamic role in the ecosystem (Brasher and Perkins, 1978 and Dale and Hughes, 1978).

According to Welch and Rawes (1964) sheep were introduced by the Norse when they invaded the north-west of England about 900 AD. Thus the grassland sites may well have been grazed by sheep for the last thousand year.

Since then, moorland sheep management for sheep has become more intensively, in some cases, causing degeneration of the moorland vegetation. Hence, considerable conflict on how to use these moorlands is likely, and usage could fluctuate in time and space depending on economic trends, political decisions and ownership patterns. It is therefore important, to know how much grazing a moorland can support without the alteration of the ecosystem (Welch, 1984)

The rate at which a grazing animal ingests herbage is a central variable in any livestock-pasture system and is a major determinant of animal nutrition and hence of liveweight change, lactation and reproductive performance. The consumption process has a direct effect on leaf area and herbage mass, pasture growth rate, canopy structure and, in the longer term, on botanical composition (Ungar and Noy-meir, 1988).

The effects of grazing on successional relationship are understood in broad terms, but there is a lack of detailed knowledge of differences on diet selection according to different communities and the way that they might react to the changes of pasture conditions (Grant, Suckling, Smith, Torvell, Forbes and Hodgson, 1985).

Animals grazing selectively from a mixture of plant species are likely to encounter an almost infinite range of choices as the diet they select can alter the species composition of the sward and so the choices available subsequently (Parsons *et al*, 1994).

Diet selection by sheep operates at two levels, first the selection of a grazing site, and second the selection of what to bite (Arnold, 1987). According to this, to estimate diet selection by sheep, it is necessary to consider factors, such as, botanical composition, biomass and sward structure.

Arnold (1987) found that botanical composition may affect the selection of grazing patches. Sheep tend to select where biomass is high, but they avoid patches where less palatable species are present. He concluded that consumption is mainly determined by species availability, and may decrease where unpalatable species are present, being more efficient for them choose areas dominated by acceptable species than to spend time finding acceptable species in areas dominated by unacceptable species.

Hunter (1962) supports this point in his study of sheep grazing in south-east Scotland. He found that sheep show preferences for the species which are palatable, but the avoidance of unpalatable species, such as, *Nardus*, is the most powerful factor in determining the distribution of grazing within Nardus and bent-fescue sward types.

He also confirmed this statement considering the classification of sward types into mull and mor swards. The first group included bent-fescue and bracken, types associated with mull soil conditions, while the second, the mor group included *Molinia, Nardus*, heather, *Eriophorum vaginatum* and *Deschampsia caespitosa* sward, types associated with mor soil conditions. Mull sward was grazed more intensively than mor sward, but factors in addition to botanical composition defined the extent of grazing pressures between mull swards, such as, incidence of unpalatable species and vegetation structure.

The preferences by sheep also vary according to seasonal changes in botanical composition. Hunter (1954) and Rawes and Welch (1969) found that sheep select *Festuca*, *Nardus* and tall heather in winter, grass species in July and August, *Eriophorum* in February and March and the fern areas in October. Grant, Lamb, Kerrr and Bolton (1976), proposed that this preferential grazing of species depends on the changing relationship between quality, quantity and accessibility of the ungrazed material as growth, senescence and utilisation rates fluctuate with time.

During summer, grass and sedge species are more selected than others, such as *Calluna vulgaris* and *Nardus stricta*, because of their high digestibility. Towards winter, grass species die, reducing their availability and digestibility and *C. vulgaris* and *E. vaginatum* are the selected species (Grant *et al*, 1976).

Another important factor which has to be considered in diet selection is the sward structure defined mainly by herbage mass, plant height and accessibility and spacing (Allden and Whittaker, 1970).

Sheep tend to select feeds which can be eaten quickly, and they generally prefer long swards to short swards with the only exception being the rejection of very dense and long swards, such as *Nardus* or *Eriophorum* tussocks which make the preferred species inaccessible. They select places with dense plant material and intake rate is related to herbage mass on the area that can effectively covered by one bite, increasing the intake rate when the density and height increase (Black and Keneey, 1984).

In areas where unpalatable species are frequent, the height and biomass on the between tussocks areas is important to avoid grazing unpalatable species and select the palatable plants (Grant *et al*, 1985).

In addition, the growth stage of the plant influences its selection by sheep. Grant and Hunter (1968) found that young heather plants are selected more frequently by sheep in summer, however they are rejected in winter when they suffer browning more than older heather, affecting the sheep selection.

Moreover, the flowering and senescence period of species alters the selection by sheep, because they clearly avoid grazing grass flower stem and dry and dead material (Grant *et al*, 1985).

As well as botanical composition defining the sheep preferences, grazing by sheep is one of the main causes in the modification of moorland botanical composition and loss of important plant species, such as *C. vulgaris* (Parsons *et al*, 1994). For that reason it is necessary to carry out studies focusing on the ecology of hill-sheep pasture and the relationship between pasture and animal.

Welch and Rawes (1966) carried out a study of the intensity of sheep grazing in blanket bog vegetation by observing the site preferences according to botanical composition. Based on three different plots with different amounts of *C. vulgaris* and grasses, they established that sheep grazing can alter considerably the vegetation composition. Grazing of certain species reduced their cover in an area, being substituted by others. For instance, *C. vulgaris* was reduced under grazing pressure and replaced by *E. vaginatum* and *Juncus squarrosus*. In addition, their results indicated that on open moorland, the grazing pressure of an area is determined by its botanical composition, though stocking rates in surrounding areas may affect the pressure to a small extent.

Welch and Rawes (1964) and Rawes (1981, 1983) have also carried out most of the studies on changes of botanical composition after the cessation of sheep grazing. Exclosure on heather moor benefitted wildlife and heather communities. Changes in the structure of grasslands were also considerable, and the conditions for the invertebrate fauna were improved.

Although studies in moorland ecology are well advanced, the effects of larger herbivores have been investigated mostly in small experimental paddocks. To complement this, more research on open places where grazing is unrestricted, is necessary in order to estimate the real effects that large stocks of herbivores might cause on the moorland ecosystem (Welch, 1984).

The primary aim of this study was to determine the diet selection by sheep on typical moorland vegetation on two different sites: Chapel Fell and Monk's moor and to compare food availability in order to assess the degree of selectivity.

Sheep frequency was observed in order to define their preferences for different vegetation types. Botanical composition, species availability and utilisation and, faecal analysis was estimated in each type of vegetation to assess the importance of major food types in the diet, and the influence of botanical composition on the diet selection over a two month period from mid May to mid July 1994.

CHAPTER II

STUDY SITE DESCRIPTION

1.1. Location

The study was carried out from mid May to mid July 1994. The region chosen for the study was the moorlands of Upper Teesdale in the North Pennines, where the area is mainly used for sheep grazing. Two places were selected because of their different botanical composition, Chapel Fell and Monk's moor. The criteria used in the selection of the study areas in both places was that they include different patches of vegetation in order to evaluate the preferences by sheep.

Chapel Fell is located in the part at high altitude of the Pennines, about 6 km south-east of St John's chapel, and lying between the Tees and Wear (National grid reference NY 876338), and is representative of heavily sheep grazed moorland. The area selected on Chapel Fell was situated at 634 m of altitude, and extended to 10 ha (Fig. 1). This area included three types of vegetation; blanket bog, grasslands and fen and flush (Rawes and Heal, 1978).

Monk's moor is located in the eastern Pennines, 4 km north-east of Middleton in Teesdale (NY 980280). The area extended to 12 ha and was characterised mainly by heather with small patches of grasslands and fen and flush (Fig 2).

1.2. Vegetation description

Three types of vegetation were found in both area; grassland, blanket bog and fen and flush.

Grassland is the characteristic vegetation of mineral and well drained soils. These swards are commonly isolated by large areas of blanked bog. On Chapel fell, grasslands patches are located in soils with 58 % of moisture, covering 30 % of the study area. The common species are *Agrostis tenuis, Festuca ovina, Anthoxanthum odoratum, Deschampsia flexuosa* and *Juncus squarrosus* (Plate 1). This type of vegetation is commonly called Agrosto-Festucetum because of the dominance of *Agrostis* and *Festuca.* However, the grazing pressure by sheep has caused an important modification of this habitat, changing the botanical composition to a Nardetum, which is dominated by *Nardus stricta*, decreasing its productivity (Rawes, 1966).

On Monk's moor this vegetation type constituted only a small part of the total area (10%), located mainly in the burnt patches of *Calluna vulgaris* .

Blanket bog is the most widespread vegetation type characterised by deep peaty soils and high moisture content. The species composition varies according to the degree of soil moisture, altitude, the grazing pasture and the time it was last burnt (Rawes, 1966; Heal and Smith, 1978).

In high altitude places with a high moisture content as Chapel fell, *E. vaginatum* is the dominant species, while on Monk's moor at lower altitude the dominant is *C. vulgaris* (Plate 2). The type of vegetation is commonly called Eriophoretum because of the dominance of that species and this constitutes 60% of the area in Chapel Fell. *E. vaginatum* forms tussocks of vegetation, which makes the palatable species unavailable for sheep.

In Monk's moor, Callunetum cover constitutes 85% of the total area, which is extensively managed for Red grouse and has a high percentage of burnt patches, which together with sheep grazing constitute the main causes of the habitat destruction (Hudson, 1987).

The Fen and Flush vegetation type is small in extent and is associated with streams or flushes and calcareous soils, forming a strip of *Juncus effusus* and grass species. *J. effusus* is the dominant species distributed in clumps which give a certain amount of shelter to sheep from wind and rain. The occurrence of grass makes of this vegetation type an alternative grazing habitat to the grassland (Rawes and Welch, 1966 and 1969). This vegetation type constitutes 10% and 5% of the Chapel Fell and Monk's moor areas, respectively.

1.3. Management

The hills of northern England are mostly used for sheep grazing and in many places this is their sole use (Welch and Rawes, 1964). Grazing on the most of the area occurs only for a period of about seven months, from April to October. All sheep are removed in late October or early November, until following April. Sheep are maintained during winter in low lands or home farms, but in some fells they remain throughout the year except during the periods of severe winter. The common sheep managed in the area are Swaledales.

Moorlands dominated by *C. vulgaris* are also used for Red grouse. Here, management requires the burning of areas to favour the growth of young and nutritious shoots which are beneficial to the production of grouse and sheep (Welch, 1984).

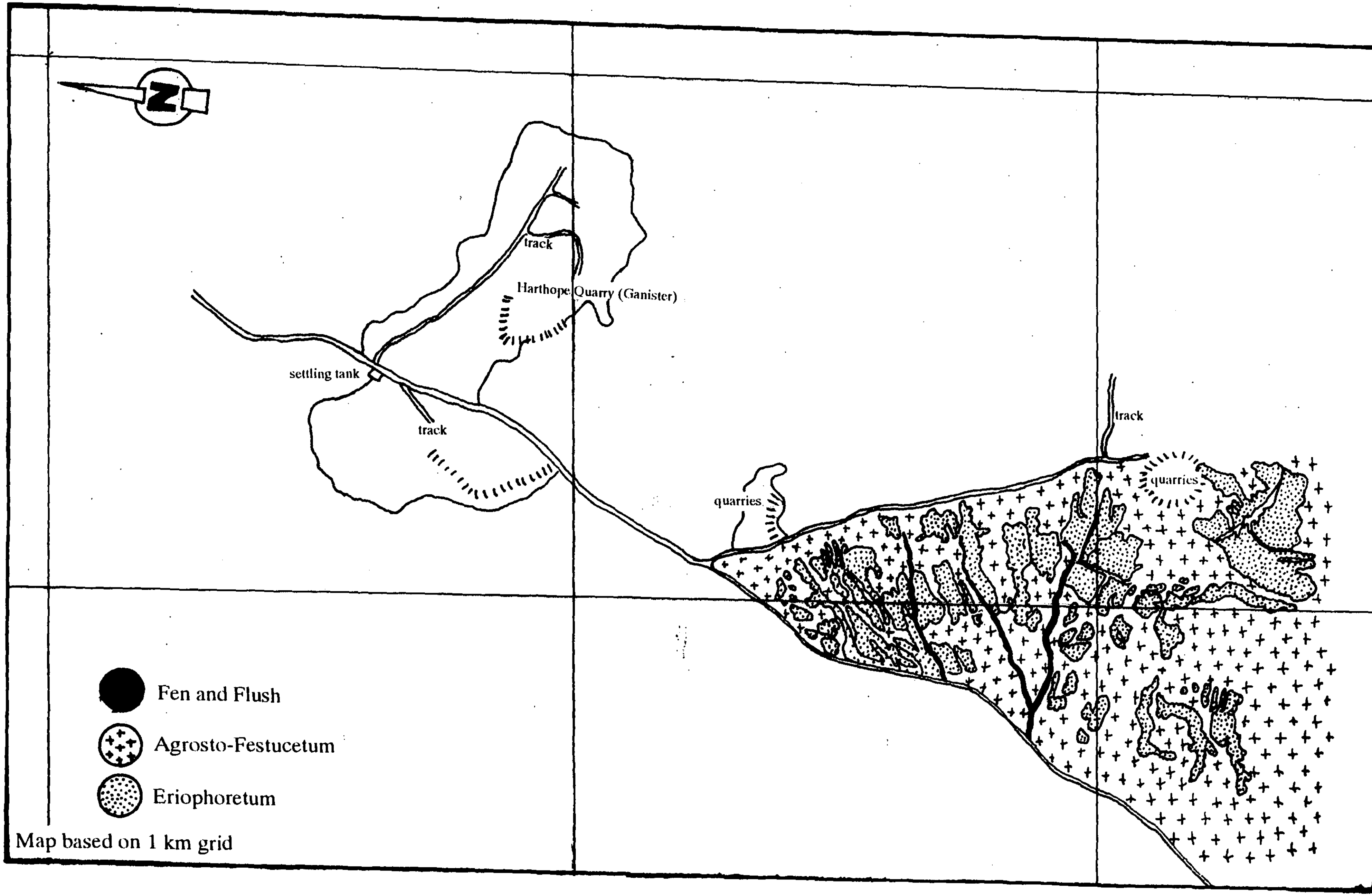
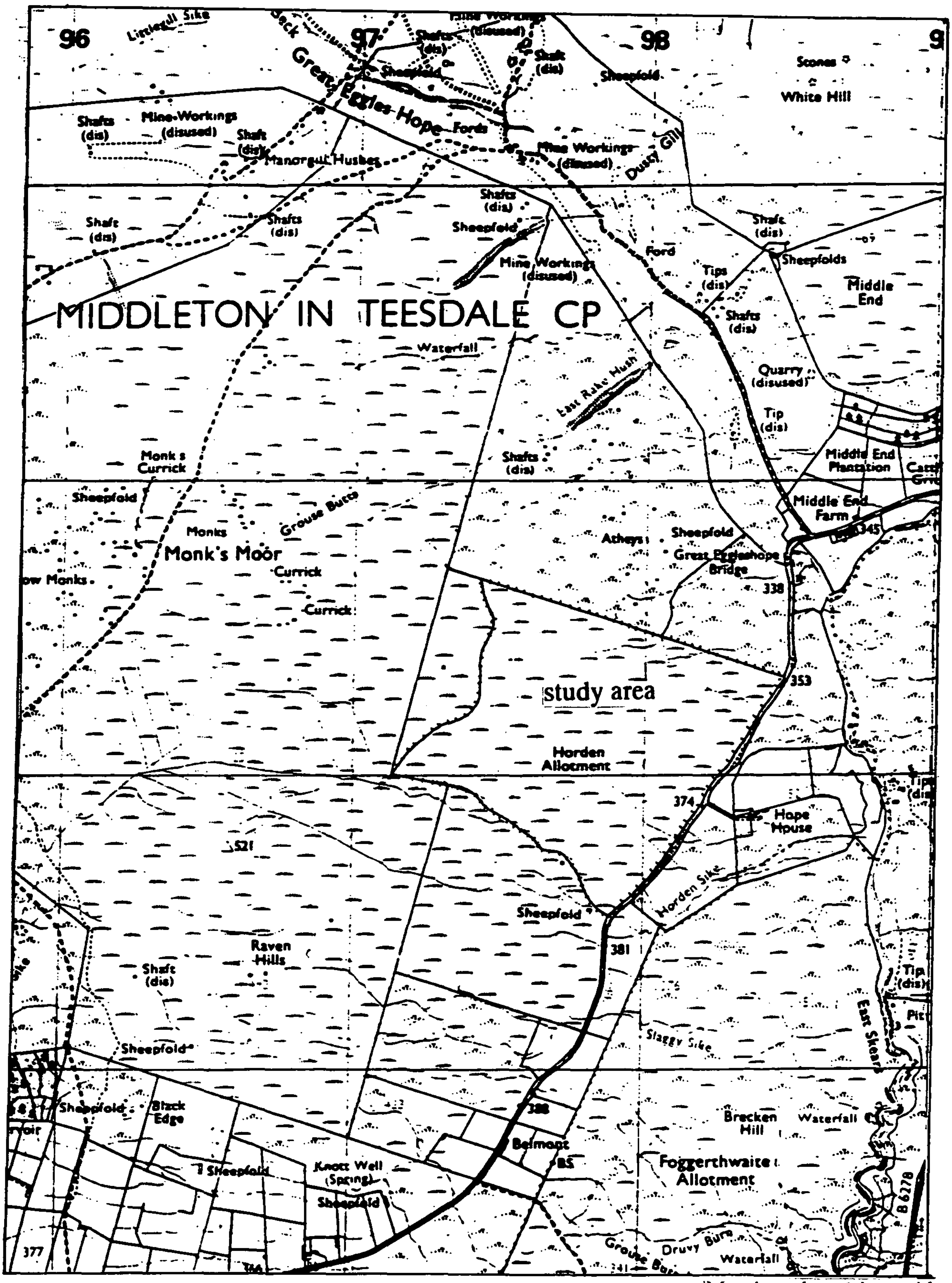


FIGURE 1. Map of Chapel Fell study area.



Map based on 1 km grid

FIGURE 2. Map of Monk's moor study area.

Heather

PLATE 1. Chapel Fell study area.

PLATE 2. Monk's moor study area.

CHAPTER III

METHODS

The study area was selected so as to include different types of upland vegetation, *i.e* blanket bog, fen and flush and grassland. The observations were carried out in two areas, Chapel fell and Monk's moor, from the end of May to the beginning of July at fortnightly intervals. The types of vegetation could be identified according to the differences of colour caused by the different botanical composition, green for grassland, light brown for blanket bog and green brown for fern and flush type. Following measures were taken into consideration:

1. Sheep location.

Sheep activity and preferred vegetation type were recorded through direct observation every 10 minutes over one hour, recording number of sheep in each type of vegetation and type of activity carried out, such as, eating, resting, (with and without ruminating) and walking.

2. Botanical composition and cover.

In order to analyse the botanical composition and cover in each type of vegetation, five 0.25 m^2 quadrats were established at random on each vegetation type each fortnightly sampling period. Plant species were identified according to Francis Rose, Collins and Hubbard identification guides. Species cover was estimated, giving percentage values for each species in the quadrat. The data obtained from the different grass species were grouped as grasses, in order to facilitate the analysis and because it was impossible to identify all species in faeces samples. The unpalatable grass, *Nardus stricta* was, however, classified separately. These data were combined to give 7 estimates of percentage cover for each species for each month.

3 Diet composition analysis

This analysis was carried out in two ways:

3.1. Direct analysis

This consisted mainly of visual observations of plants part eaten by sheep, recognised by the removal of the tip of leaves. The amount of each species grazed in 6 quadrat was recorded as percentage of the total species cover each moth. In the case of species such as *Calluna vulgaris, Galium saxatile* and the three moss species, the estimation of percentage grazed could not be recorded because the parts of the plant eaten were not evident.

3.2. Indirect analysis

Dung collection

Dung samples were collected from each type of vegetation, close to the quadrat for analysis of its botanical composition. Dung was placed into a plastic bag using a trowel, and the date of collection and the type of vegetation where it was found was recorded. Collected dung was then placed in a freezer as soon as possible to preserve it for subsequent analysis. A total of 6 samples for each vegetation type was collected every survey.

Dung analysis

In the laboratory, the samples were defrosted in 2% formalin and broken up. From each sample, six slides were examined under the microscope. Counts of cuticle samples were made and faecal composition was estimated through the identification of species by the cellular structure.

To carry out the species identification in faeces with regard to cellular structure, a reference collection was prepared, making slides of each plant species found in the study area, in order to identify species in faeces slides through comparison between them (Plates 3 and 4). The percentage contribution of each species was then calculated.

Some species could not be distinguished in the faeces, because of the close similarity of the cellular structure with other species. Therefore, species with similar cellular structure were grouped, such as, *Nardus stricta* with *Festuca ovina, Agrostis* spp with *Deschampsia caespitosa, Anthoxanthum odoratum* with *Poa* spp, all moss species, *C. vulgaris* with *G. saxatile* and Sedge species (*Eriophorum vaginatum, Carex* spp and *Luzula campestris*).

4. Comparative analysis

In order to compare the diet preference by sheep between sites with different botanical composition, three sets of samples from each vegetation type were collected on Monk's moor.

The same measures were taken into consideration, such as, botanical and species cover analysis, direct observations of sheep in the area, and diet analysis including, direct observation and faecal analysis.

5. Statistical analysis

5.1. Sheep location

Chi-squared analysis was applied to the total number of observations of sheep activity and distribution in order to estimate the vegetation types preferred and main activities.

5.2. Botanical composition and cover.

ANOVA was applied to the percentage cover data, comparing the different species cover from the three vegetation types. In addition, t-tests were applied to define the significant differences of spatial and temporal changes of plant species. Angular transformation was applied to the percentage data.

5.3. Faeces composition.

ANOVA was applied to faeces composition in order to analyse the differences between the samples taken from the different vegetation types and temporal changes.

5.4. Comparative study.

T-test analysis was applied in a comparison between Chapel Fell and Monk's moor botanical composition and the faeces composition in the two areas in dung collected on the same vegetation type. This was carried out to analyse the differences between sites.

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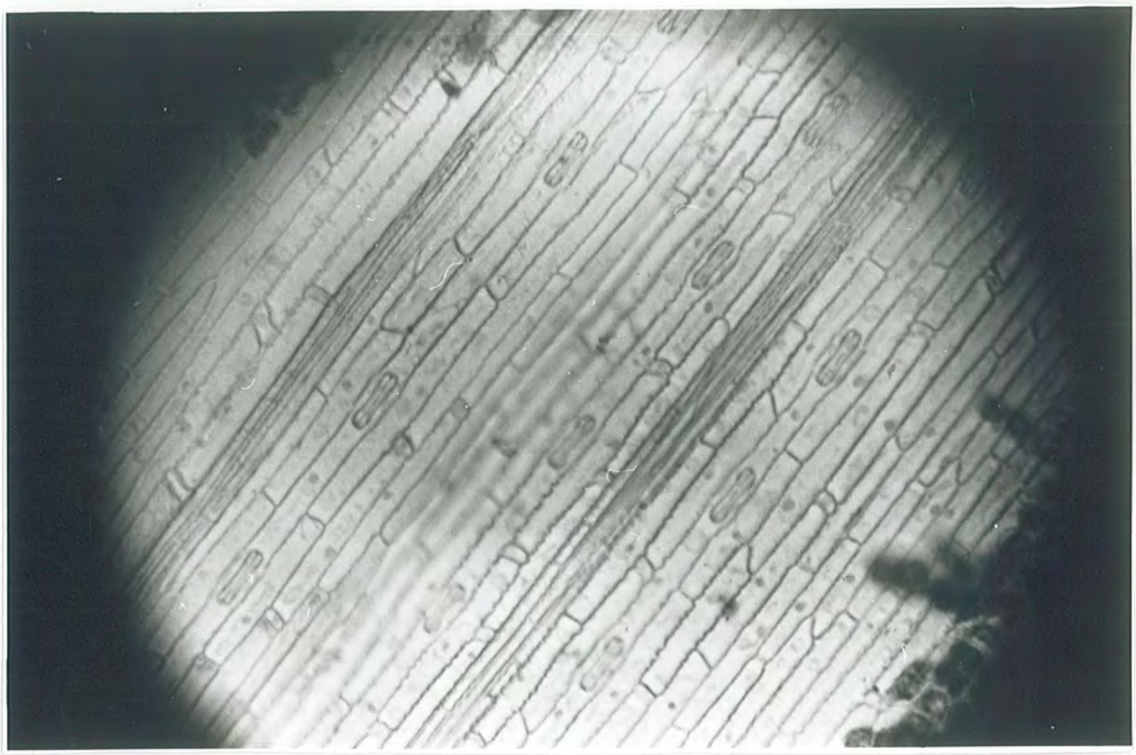

PLATE 3. Cellular structure of *Carex nigra*.

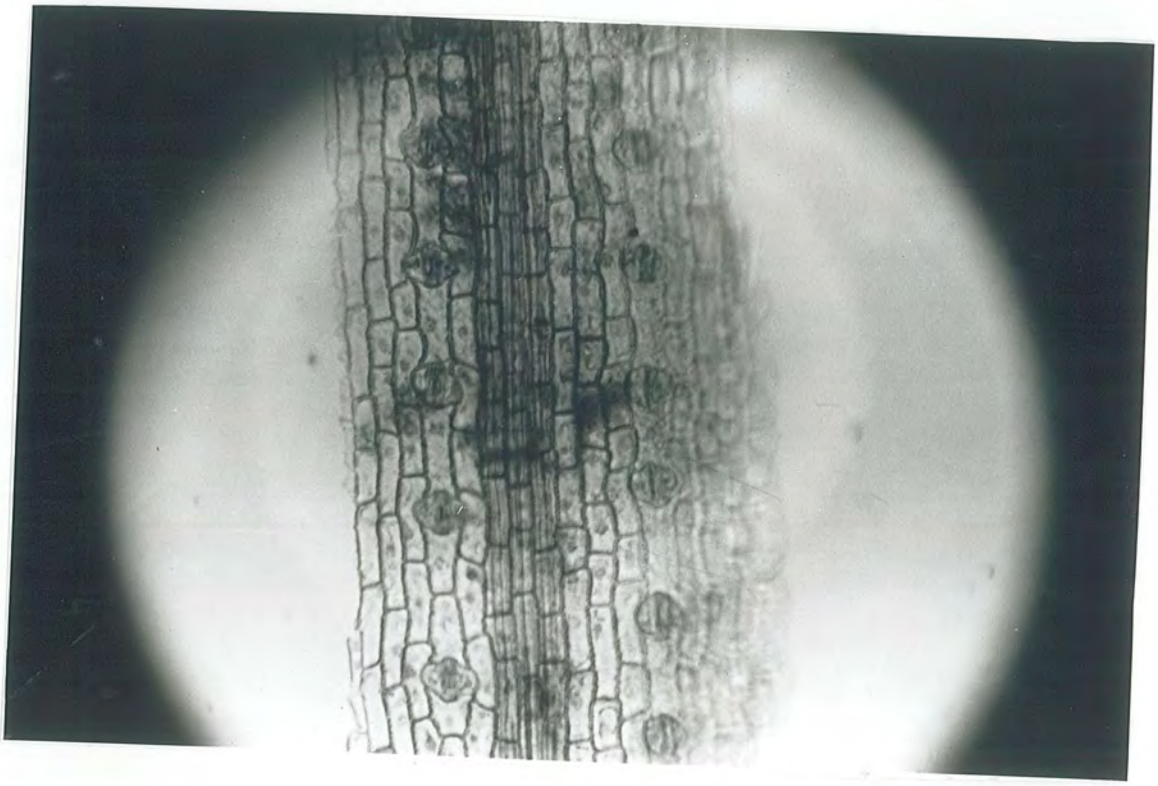

PLATE 4. Cellular structure of *Agrostis tenuis*.

CHAPTER IV

RESULTS

1. Chapel Fell

1.1. Botanical composition

1.1.1. Description of vegetation types

The types of vegetation were classified with regard to the most abundant plant species as described by Rawes and Welch (1964). According to this, three types of vegetation were found within the study area. Seventeen species of plants were recorded, including six species of grasses, two *Carex* and three mosses, showing spatial and temporal patterns. Table 1 shows the average percentage cover of species in the three vegetation types for each month.

Vegetation type	Agrosto-Festucetum (± S. E.)			Eriophoretum (± S. E.)			Fen and Flush (± S. E.)		
Species/ Month	May	June	July	May	June	July	May	June	July
Nardus stricta	0.7 (0.4)	4.1 (1.3)	2.2 (2.0)	22.6 (0.5)	0.3 (0.3)	9.7 (7.7)	0.0	0.4 (0.4)	2.4 (1.2)
Grasses	45.1 (1.5)	48.8 (4.5)	57.5 (8.2)	16.7 (0.7)	13.6 (5.1)	20.7 (5.2)	31.7 (7.4)	42.4 (9.5)	6.7 (2.4)
Carex spp	23.6 (2.8)	9.4 (1.2)	18.4 (5.1)	4.1 (1.5)	0.7 (0.7)	9.0 (1.4)	14.8 (2.3)	3.8 (2.2)	19.2 (3.3)
Juncus squarrosus	13.4 (1.5)	12.7 (1.1)	3.8 (3.8)	10.2 (0.9)	0.0	2.7 (2.7)	13.7 (6.5)	0.0	3.3 (1.2)
Eriophorum vaginatum	0.0	0.0	0.0	19.1 (2.5)	34.6 (4.2)	32.1 (3.6)	0.0	0.0	0.0
Mosses	9.9 (0.7)	10.4 (1.7)	0.9 (5.1)	15.2 (2.6)	23.6 (4.4)	6.2 (3.2)	4.7 (2.7)	12.6 (5.3)	41.2 (2.7)
Calluna vulgaris	0.0	0.0	0.0	5.7 (1.9)	20.1 (4.6)	10.6 (5.4)	0.0	0.0	0.0
Galium saxatile	7.3 (2.9)	11.7 (2.8)	6.3 (0.3)	0.0	0.9 (0.9)	7.6 (2.2)	9.6 (5.6)	16.9 (5.6)	0.0
Juncus effusus	0.0	0.0	0.0	0.0	0.0	0.0	24.1 (1.4)	21.7 (7.7)	27.2 (1.5)
Luzula campestris	0.0	2.5 (0.9)	6.3 (4.6)	6.2 (2.1)	0.9 (0.9)	0.0	0.6 (0.3)	2.0 (1.2)	0.0
Vaccinium myrtillus	0.0	0.4 (0.4)	0.0	0.2 (0.1)	5.3 (1.4)	1.3 (1.3)	0.8 (0.4)	0.0	0.0

TABLE 1. Mean percentage cover of species in each vegetation type on Chapel Fell throughout the study period (N= 7).

Type I Agrosto-Festucetum

Eleven genera of plants were recorded in this type of vegetation, which was dominated by grasses (45.1-57.5%). The grass species were *Festuca ovina, Agrostis tenuis, Agrostis stolonifera, Poa pratensis, Deschampsia flexuosa* and *Anthoxantum odoratum.* Also some sedge species contributed to the total cover such as, *Carex nigra* (9.4-23.6%) and *Luzula campestris*, with *Juncus squarrosus* (3.8-13.4%) three species of mosses (*Sphagnum* sp., *Polytricum* sp. and *Hypnum* sp.) with a cover between 0.9 and 10.4%, and *Galium saxatile* (6.3-11.7%).

Type II Blanket bog

This type of vegetation is called "Eriophoretum" because it is dominated by *Eriophorum vaginatum* (19.1-34.6%) with *Calluna vulgaris* (5.7-20.1%) contributing a low cover value. *Nardus stricta* (0.3-22.6) and *Vaccinium myrtillus* (0.2-5.3%) also contributed to the total cover. Species found in type I, were also present, but in lower amounts. Six species of grass gave 13.6-20.7% cover, *J. squarrosus* (0-10.2%), the three species of moss (6.2-23.6%), *G. saxatile* (0-7%), *L. campestris* (0-6.2%) and *Carex bigelowii* (0-8.3), the last of which was found mainly in July.

Type III Fen and Flush

This vegetation type was characterised by a large proportion of *Juncus effusus* (21.7-27.2%), a species not found in type I or II. The same grass species but with different proportions (6.7-42.4%) were also found here, both species of *Carex* were present 3.8-19.2% cover. The three species of mosses contributed 4.7-41.2% and *G. saxatile* 0-16.9%. This Type of vegetation was found mainly near streams and was the smallest in extent, but it provided alternative grazing habitats.

ANOVA has been used to compare the percentage scores of the different species (and species groups) in the three vegetation types. Each month has been analysed separately to avoid any effect of temporal changes. In each case, the species composition of the three vegetation types showed significant differences (May $F_{10,22}=23.83$, June $F_{10,17}=9.34$ and July $F_{10,11}=5.8$, $P<0.001$).

The mean differences in cover of each species over the whole time period have been compared using t-tests.

Species/veg.type	I-II (d.f.= 19)	II-III (d.f.= 17)	I-III (d.f.= 16)
Nardus stricta	2.7 + *	3.2 - **	1.1
Carex spp	6.8 - **	3.9 + **	1.5
J. squarrosus	3.4 - **	0.2	3.1 - **
Grasses	4.5 - **	1.0	4.4 - **
J. effusus	---	20.8 + **	20.8 + **
E. vaginatum	12.6 + **	12.6 - **	---
V. myrtillus	2.9 + **	2.4 - *	0.6
C vulgaris	5.4 + **	4.9 - **	---
G. saxatile	4.0 - **	2.1 + **	0.9
L. campestris	0.02	1.2	1.3

TABLE 2. Comparision between vegetation types percentages indicating the significant differences between them. The symbols + and - indicate an increase or decrease in cover from the first to the second vegetation type (* = P< 0.05; ** = P< 0.01; d.f. = degrees of freedom).

Table 2 shows that the grass cover was significantly higher in type I than type II and III, which characterised type I, while *E. vaginatum* and *C. vulgaris* cover were significantly higher in type II than III and I, characterising this vegetation type. *J. effusus* cover was significantly higher in type III than type I and II, species which characterised this vegetation type.

1.1.2. Temporal changes in botanical composition

The proportions of the different species in each type of vegetation showed changes in cover throughout the study time. These changes became evident through observing the differences between the grass and *E. vaginatum* and moss cover, following opposite patterns. *J. effusus* and moss cover also showed the opposite pattern to that of grass, increasing at the expense of grass, possibly as a result of the differences between soil humidity (Perkins, Jones, Millar and Neep, 1978)

The temporal and spatial changes in the three types of vegetation are shown in Figures 3-8.

In order to estimate the temporal changes in botanical composition, t-test analyses were carried out on the percentage cover of plant species between months for each type of vegetation shown in Table 1. The results of the t-tests are summarised in Table 3 and referred to in the following descriptions.

Veg. type	Type I		Type II		Type III	
Species/Month	May-June (d.f.= 14)	June-July (d.f.= 8)	May-June (d.f.= 15)	June-July (d.f.= 9)	May-June (d.f.= 6)	June-July (d.f.= 8)
N. stricta	2.4 + *	0.9	8.4 - **	1.7	1.0	1.1
Grasses	0.9	1.0	1.4	1.7	0.9	4.12 - **
J. squarrosus	0.3	3.3 - *	18.2 - **	1.4	3.2 - *	2.4 + *
Carex spp	4.5 - **	2.6 + *	1.7	2.7 + *	2.9 - *	3.7 + **
V. myrtillus	1.5	0.0	4.9 + **	2.4 - *	1.7	0.0
G. saxatile	1.3	0.6	1.2	2.3 + *	1.1	6.1 - **
L. campestris	4.0 + **	2.6 + *	1.8	0.7	0.7	2.2
E. vaginatum	---	---	3.3 + **	1.3	---	---
J. effusus	---	---	---	---	0.5	1.0
C. vulgaris	---	---	3.3 + **	2.0	---	---
Moss	0.1	4.6 - **	1.8	3.6 - **	1.1	4.1 + **

TABLE 3. T-test values comparing the percentage cover between month for each type of vegetation on Chapel Fell throughout the study period. The symbols + and - indicate an increase or decrease in cover from the first to the second month (* = P<0.05; ** = P<0.01; d.f. = degrees of freedom).

Agrosto-Festucetum

Figure 3 shows the changes of the species percentage cover in Agrosto-Festucetum between May and July. Figures 6-8 show a comparision of the cover proportion of each species in each type of vegetation in each month.

The cover of *N. stricta* showed a significant increase between May and June (t_{14}=2.36 P<0.05), from 0.7 to 4.1%, but there was a gradual drop at the end of June and July from 4.1 to 2.2% because of the vegetative parts diminishing during the flowering period. However, the cover tended to increase as a consequence of overgrazing by sheep, reducing the competition with other species selected by them. It is important to note that *A. odoratum* was an important species throughout the three months, making a strong contribution to the total grass cover.

With regard to sedges, the cover of *C. nigra* showed a significant decrease from 23.6 to 9.38 % between May and June (t_{14} = 4.5, P< 0.05) and a increase from 9.38 to 18.4% between June and July (t_9 = 2.5, P<0.05). The *L. campestris* cover increased significantly between May and June from 0.0 to 2.5% and between June and July from 2.5 to 6.3%.

J. squarrosus cover decreased signicantly between June and July from 12.7 to 3.8 % (t_9 = 3.3, P<0.05) , as a result of the increase of grazing pressure.

Moss cover decreased significantly in July from 10.4 to 0.9% (t_9 = 4.6, P<0.01) because of the increase in grass cover, which possibly reduced light penetration and soil humidity, and affected the moss growth (Perkins *et al*, 1978).

Eriophoretum

Figure 4 shows the proportion of the total cover of each species occuring in this type of vegetation during the study period. Taken together, figures 6 to 8 show that *E. vaginatum* was one of the most important species in type II. Its cover increased signifcantly from 19.1 to 34.6% through May into June, due to its being one of the most unpalatable species (t_{15} = 3.3, P< 0.05). In July a high proportion of the cover was dead material causing a small decline of the cover from 34.6 to 32.1%. This species creates tussocks, while overgrow the grasses making theses less available to sheep (Rawes and Welch, 1969).

C. vulgaris cover showed a significant increase between May and June from 5.7 to 20.1% (t_{15}= 3.3, P<0.05), but no change between June and July. However, an increase in height of 3-8 was evident.

From June to July *C. nigra* cover increased significatly from 0.7 to 9.0 (t_9= 2.7, P<0.05), probably because the decrease of *E. vaginatum* cover reduced competition and permitted the growth of this species (Rawes, 1966).

J. squarrosus decreased significantly from 10.2 to 0.0 % from May to June (t_{15}=18.1, P<0.01), again probably as a response to the increase of *E. vaginatum*, which inhibits the growth of other species.

N. stricta cover was linked to *E. vaginatum* cover, being almost enterely replaced by it in June, but when the *Eriophorum* died the grass tended to occupy the site. There were significant differences between May and June, with a peak in May (22.6%) and a lowest value of 0.3% in June (t_{15}=8.4, P<0.01).

The percentage cover of bilberry increased significantly between May and June, from 0.2 to 5.3% (t_{15} = 4.9, P<0.01) and decreased between June and July from 5.3 to 1.3% (t_9= 2.4, P<0.05).

The Moss cover cover decreased significantly between June and July from 23.6 to 6.2% (t_9 =3.62, P<0.05), following the same pattern as *E. vaginatum* probably because the latter permitted the maintenance of humidity close to the ground surface, where mosses were found. *G. saxatile* cover increased significantly between June and July from 0.9 to 7.6% (t_9 =2.3, P<0.05) because this species can grow at lower levels of humidity than moss (Perkins et al , 1978)

Fen and Flush

This type of vegetation consisted mainly of *J. effusus* (24%) which, although it showed a gradual decrease in cover throughout the study time, showed no a significant monthly differences.

Grass cover showed the opposite trend to type II, peaking in June (42.4%) exhibiting its lowest value in July (6.7%), with the significance difference between these two months (t_8.= 4.1 $P<0.01$).

C. nigra was recorded in the three months, but *C. bigelowii* was only found in July. The lowest sedge cover was recorded in June (3.8%) showing a significance decline from May cover (t_6= 2.9, $P<0.05$), and a increase towards July from 3.8 to 19.2 % (t_8= 3.7, $P<0.05$).

J. squarrosus decreased significatly in June from 13.7 to 0.0% (t_8= 3.2, $P<0.05$), and an increased from June to July (t_8= 2.44, $P<0.05$), following the opposite pattern to grass cover.

Moss cover increased significantly towards July, from 4.7 to 41.2, because of the increase of humidity in this type of vegetation (t_8 = 4.0, $P<0.01$), while *G. saxatile* decreased from 16.9 to 0% (t_8 = 6.1, $P\leq0.01$)

N. stricta tended to increase in cover towards the flowering time in July. There was a general trend in the grass species that the palatable species reduced their cover under grazing and gave place to *N. stricta* which is a unpalatable species.

1.2. Sheep location and activity

The sheep preference for the different vegetation types included in the study area was estimated by recording the number of sheep and their activity in each vegetation type at 10 minutes intervals. The number of sheep in the area varied from 2.9 in May to 1.3 per ha in July, having a peak in June with 3.0 per ha.

Chi-squared analysis was applied to the total number of observations recorded in each type of vegetation (Table 4) to estimate the distribution of sheep in the study area.

Vegetation type	Agrosto-Festucetum			Eriophoretum			Fen and Flush		
Activity/month	May	June	July	May	June	July	May	June	July
Eating	190	352	51	30	32	6	10	6	0
Resting/ruminating	59	69	8	10	35	9	0	3	3
Walking	7	6	0	14	33	0	0	2	0

TABLE 4. The number of observations of sheep engaged in three activities in the three vegetation types during the study period.

Figure 9 shows the percentage of grazing sheep recorded on each vegetation type throughout the study period. Sheep preferred to graze over Agrosto-Festucetum patches with 64% of the feeding observation being on the grassland (X^2_4 = 185.3, $P<0.001$), Fen and Flush being the least preferred vegetation type. ANOVA has been used to compare sheep activity frequency in each vegetation type and month. There was a significant difference between activities ($F_{3,2}$ = 4.96, P<0.05), but not between types of vegetation and time.

In order to calculate the differences between activities chi-squared analysis was applied to the total observations from the three types of vegetation. There was a significant difference between activities (X^2_4= 180.9, P<0.01), grazing being the most frequent activity during the period of observation (10:00 to 12:00 in the day).

In summary, sheep tended to prefer the sites where palatable species were available, with Agrosto-Festucetum patches the most preferred sites, because of the high cover and availability of grass species.

1.3. Diet selection

1.3.1.Temporal change in sheep's diet preferences

The temporal pattern of diet preferences in sheep was estimated by observing in each quadrat the percentage of the total cover of each plant that had been chewed. It was not possible to record parts eaten in the case of *Calluna vulgaris, Galium saxatile, Vaccinium myrtillus* or the moss species.

The data showed that there were strong preferences for some species and small changes in preference through the study time (Table 5).

Type of vegetation	Agrosto-Festucetum			Eriophoretum			Fen and Flush		
Specie/ Month	May	June	July	May	June	July	May	June	July
Nardus stricta	0.0	0.7	0.2	0.0	0.05	0.5	0.0	0.0	0.0
Grasses	7.7	17.3	12.5	0.0	2.4	0.0	12.2	4.7	1.5
Carex spp	19.0	3.6	10.4	0.0	0.0	0.0	4.4	0.1	0.0
Juncus squarrosus	12.4	8.2	0.1	2.6	0.0	0.0	6.9	0.0	0.0
Eriophorum vaginatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juncus effusus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Luzula campestris	0.0	0.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 5. Mean percentage of the plant parts eaten observed on Chapell Fell throughout the study period (N= 6).

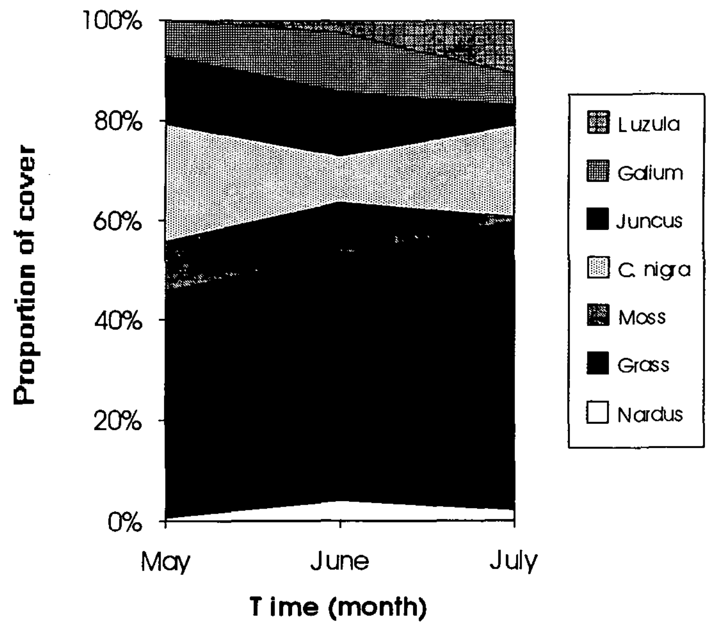

FIGURE 3. Comparison of species cover in Agrosto-fetucetum vegetation type for each month throughout the study period.

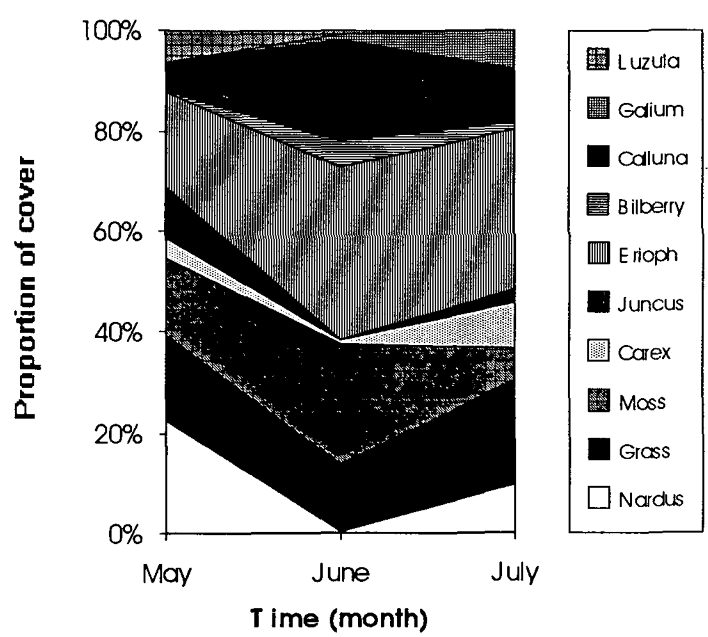

FIGURE 4. Comparison of species cover in Eriophoretum vegetation type for each month throughout the study period.

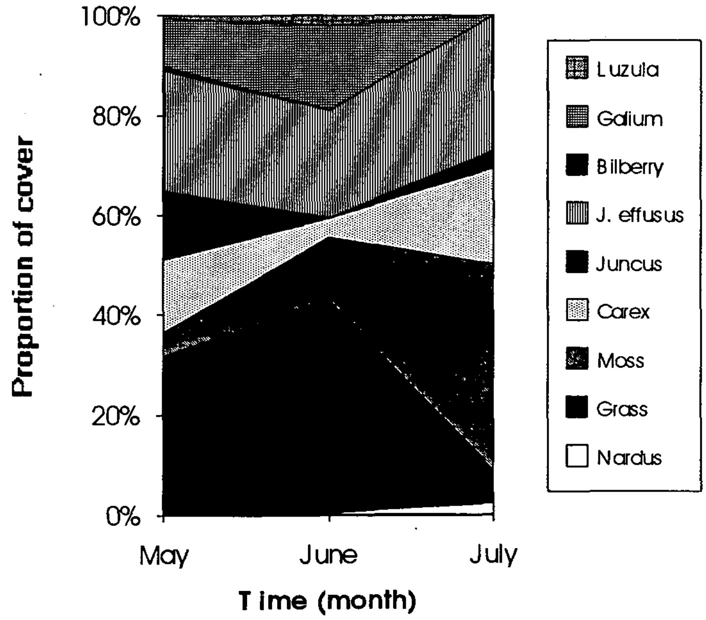

FIGURE 5. Comparison of species cover in Fen and flush vegetation type for each month throughout the study period.

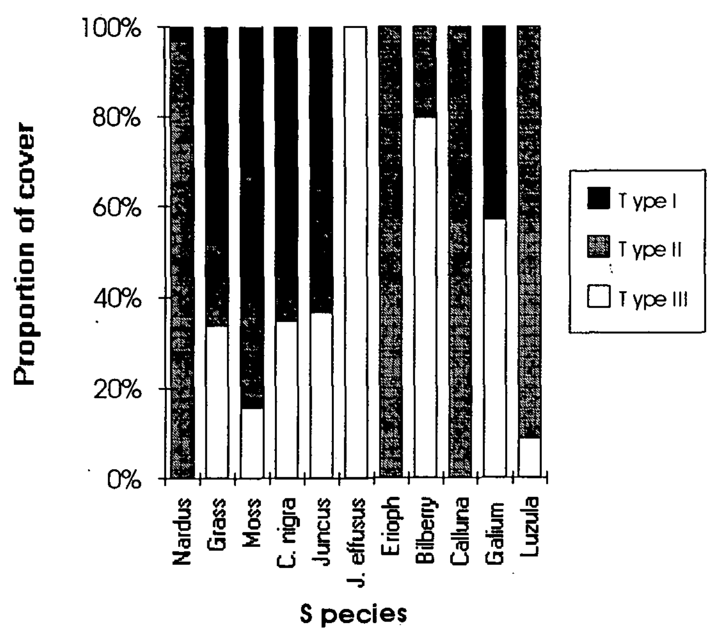

FIGURE 6. Comparison of proportion of species cover between types of vegetation in May.

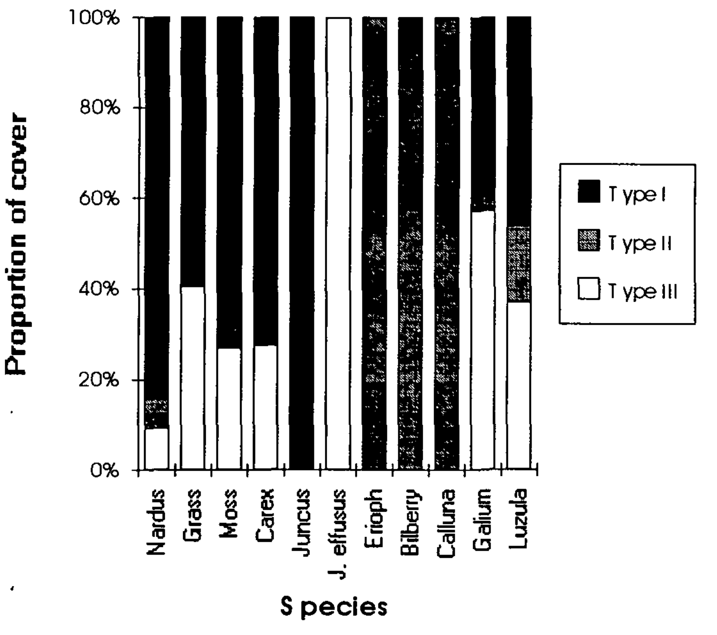

FIGURE 7. Comparison of proportion of species cover between types of vegetation in June.

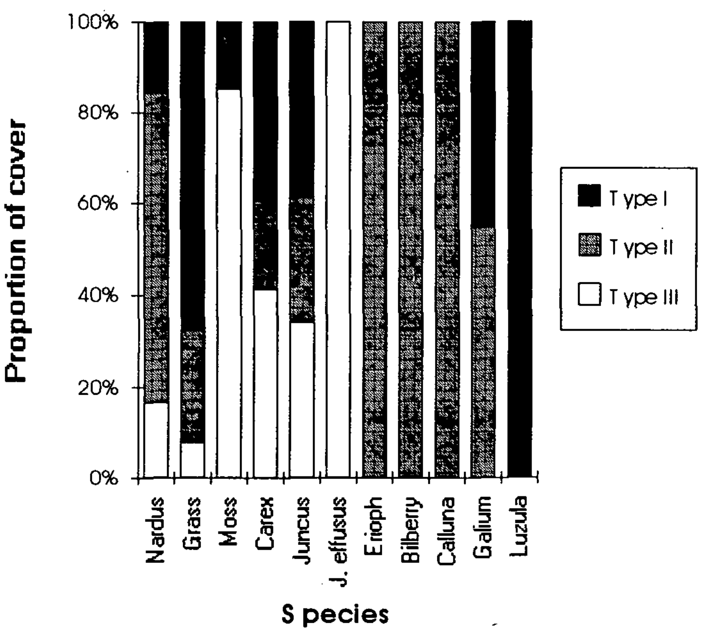

FIGURE 8. Comparison of proportion of species cover between types of vegetation in July.

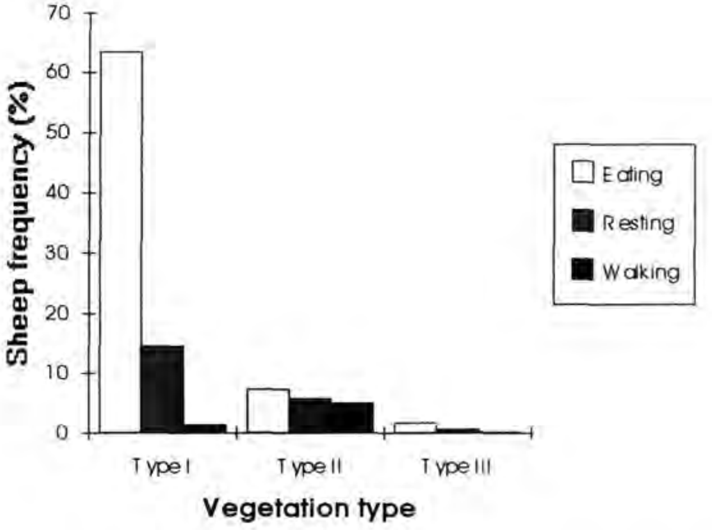

FIGURE 9. Percentage of sheep frequency and activities in each vegetation type on Chapel Fell throughout the study period.

ANOVA was applied to the percentage of species eaten. There were differences between the amount of each species eaten ($F_{4,45}$ = 25.65, P<0.001) and between month and type ($F_{4,15}$=1.88, P<0.04). These values show that there are significant differences between species selected according to the time and type of vegetation.

T-tests were carried out on percentage of species selected from each vegetation type between the three months. The differences obtained for each vegetation type between moths are shown in Table 6, and explained in the next section.

Veg. type	Type I		Type II		Type III	
Species/Month	May-June	June-July	May-June	June-July	May-June	June-July
N. stricta	2.87+ *	2.26	2.51	2.01	----	----
Grasses	5.38 + **	7.24 - **	5.38 + **	5.38- **	8.98 - **	2.95 - *
J. squarrosus	1.12	8.49 - **	3.56 - *	----	19.50 - **	----
Carex spp	7.51 - **	4.02 + *	----	----	8.66 - **	1.00
L. campestris	1.58	1.08	----	----	----	----

TABLE 6. T-test values with 10 degrees of freedom, obtained from a comparison between plants selected by sheep in each vegetation type throughout the study period. The symbols + and - indicate an increase or decrease in proportion eaten from the first to the second moth (*= P<0.05; **= P<0.01).

Agrostis-Festucetum

Figures 10-12 show the diet preferences, estimated from the proportion of damaged shoots, of sheep in Agrostis-Festucetum (type I) in each of the three months. The points which are located in the upper left part of the graph indicate the preferred species. According to the figures, sheep tended to prefer species such as, *Carex nigra* and *Juncus squarrosus.* Figure 13 shows the proportions of plant parts eaten recorded in this type of vegetation throughout the study period. Figures 14-16 show the percentage of cover and parts eaten of the different species in Agrostis -Festucetum type for each month. Table 5 indicates a strong preference for *C. nigra*, followed by *J. squarrosus* and grass species. In addition, Figure 10 shows that *C. nigra* and *J. squarrosus* were the most preferred species with 19.0 and 12.4 %, respectively.

According to Figures 13 and 15, there was a preference for the same three species in June, but in different amounts. In this month, an increase of grass preference was recorded, from 7.75 to 17.3 % (t_5= 5.38, P<0.001), this coincidence with an extension of grass cover from 45-48.8%. *N. stricta* was selected in low amounts, increasing significatly from May to June (t_5.=2.87, P<0.05) but decreasing towards July; while *J. squarrosus* selection decreased significantly between June and July, from 8.15 to 0.05 (t_5.= 8.49, P<0.001). Presumably, a consequence of its decrease in cover and the increase in availability of more preferred species, such as *C. nigra* (Table 1 and 5).

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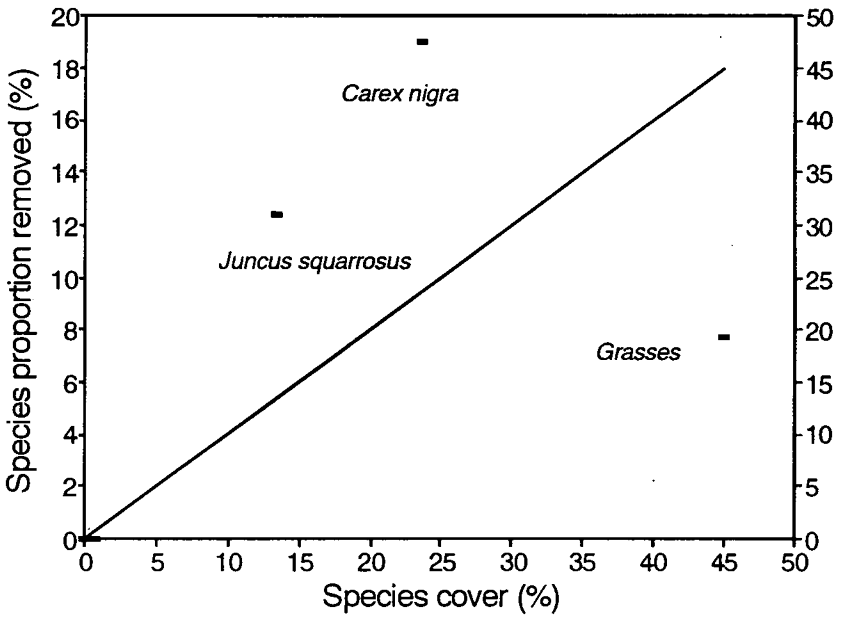

FIGURE 10. Species selected in relation to vegetation cover in May in type I. The trend line indicates no preference with the points that fall above.

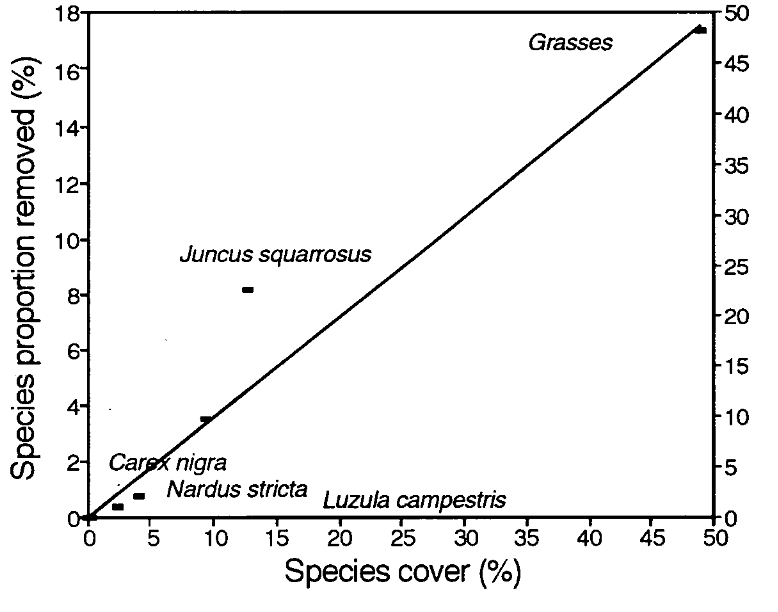

FIGURE 11. Species selected in relation to vegetation cover in June in type I. The trend line indicates no preference with the points that fall above.

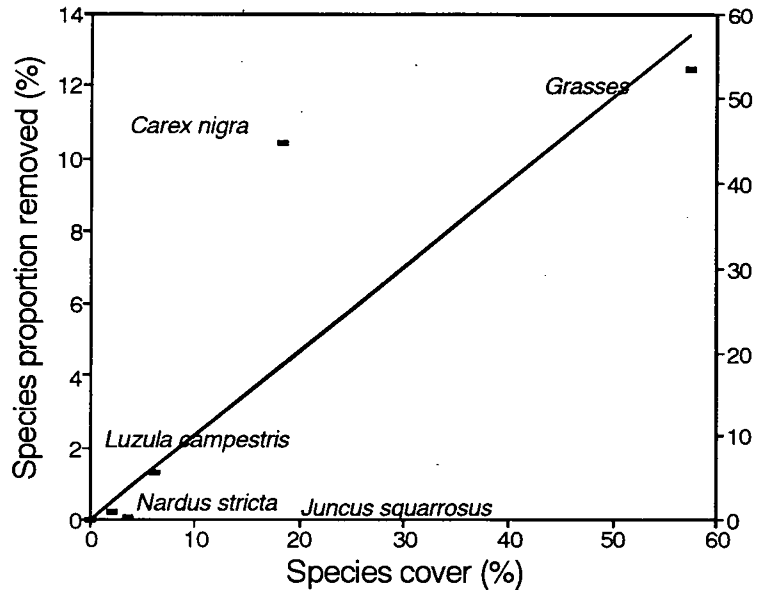

FIGURE 12. Species selected in relation to vegetation cover in July in type I. The trend line indicates no preference with the points that fall above.

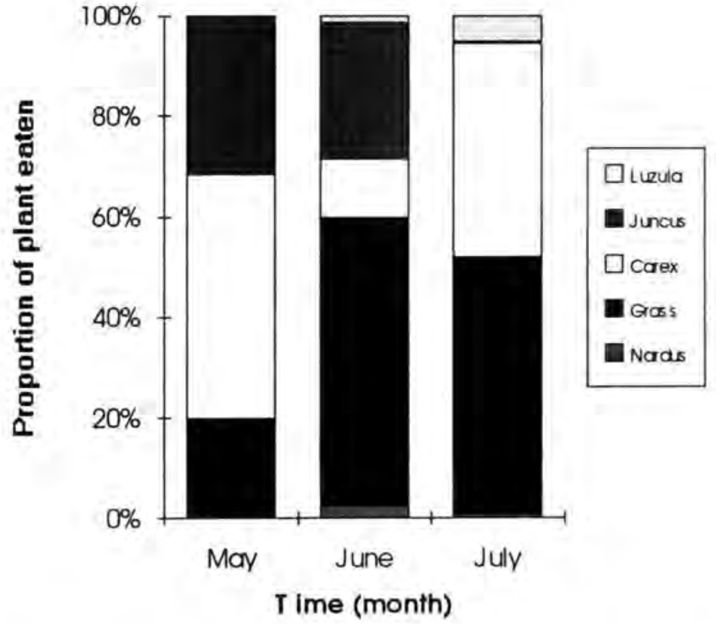

FIGURE 13. Comparison of the percentage of chewed stems as a proportion of the total cover of each group of species in Agrosto-festucetum throughout the study period.

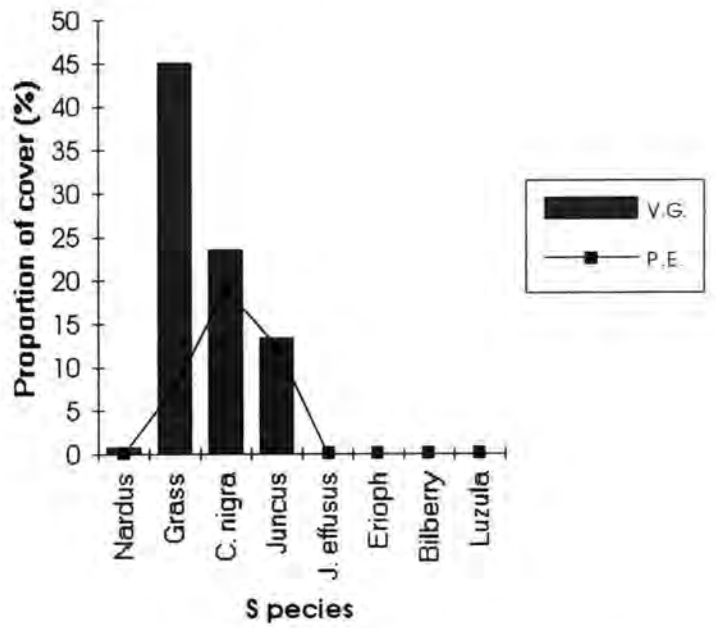

FIGURE 14. Comparison of species cover and percentage damage for Agrosto-Festucetum vegetation type in May (V.G. = vegetation cover and P.E. =percentage of plants eaten).

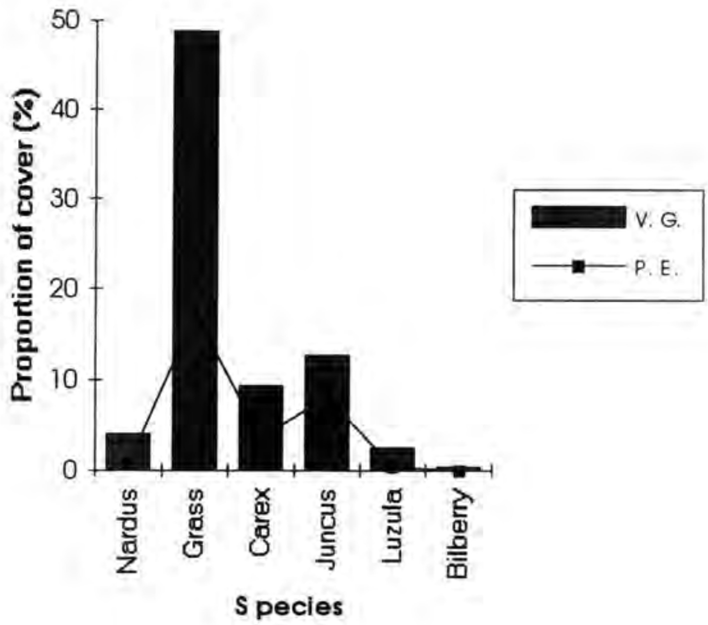

FIGURE 15. Comparison of species cover and percentage damage for Agrosto-Festucetum vegetation type in June (V.G. = vegetation cover and P.E. =percentage of plants eaten).

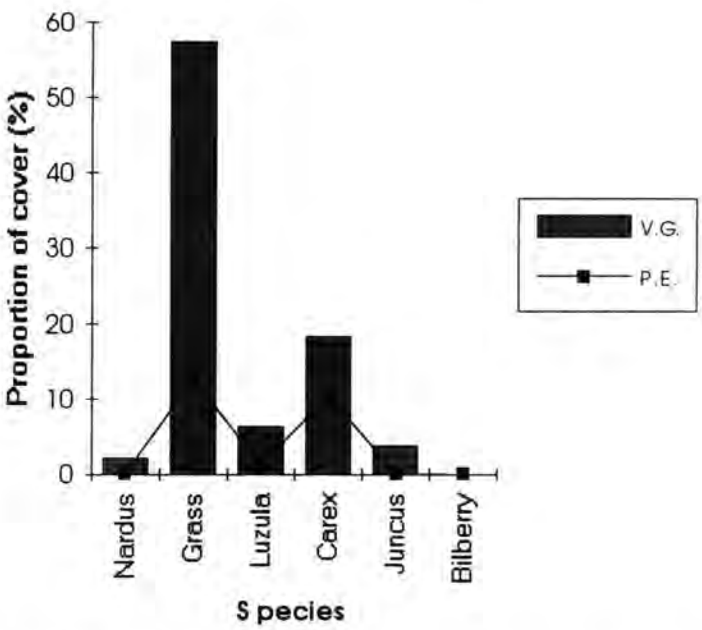

FIGURE 16. Comparison of species cover and percentage damage for Agrosto-Festucetum vegetation type in July (V.G. = vegetation cover and P.E. =percentage of plants eaten).

C. nigra showed a significant decrease between May and June (t_{5}.= 7.51, P<0.05) and a significant increase between June and July (t_{5}.=4.02, P<0.05), selection decreasing as the cover declined.

In July, Table 5 values show that there were preferences for *C. nigra*, grass and *L. campestris* (Figures 13 and 15), the latter being selected in small amounts. *C. nigra* selection increased in this period as a result of a cover increment while, in contrast, grass preference was diminished during of the flowering period (t_{5}.= 7.24, P<0.001).

Eriophoretum

Based on the evidence of damaged plants, the type of vegetation in which *E. vaginatum* is dominant was grazed with the lowest intensity. Table 5 shows the relationship between the percentage of cover and species eaten, indicating that *J. squarrosus* and grass species, including *N. stricta*, were the most preferred species (Fig. 17-19). Although sheep were more frequent in this type of vegetation than fen and flush, they fed in lower amounts in Eriophoretum patches, which it was evident by the plants damaged proportion.

Figure 20 shows the proportion of species eaten in this type of vegetation in the different months and Figures 21 and 23 show the percentage of cover and species selected by sheep. Taken together both figures, it can be seen that the only species eaten in May was *J. squarrosus* (2.56 %), but its availability and abundance declined. There was a significant decrease towards July (t_5 =3.56, P<0.01). It is important to note that both *Eriophorum* and *Nardus* were the less preferred species

Figures 21 and 22 show that grass species and *J. squarrosus* were mainly selected by sheep (2.39%). However, Table 5 shows that there was very little damage on type II in any month.

Fen and Flush

Figures 24-26 plot the percentage of species cover against species eaten throughout the time, showing that grass species and *J. squarrosus* were the preferred species. The amount of damage decrease with time in relation to the decrease in cover of both species.

According to Figure 27 which shows the percentage of species eaten, the most preferred species were grass, *J. squarrosus* and *C. nigra*. Figures 28-30 show the percentage of species cover and species eaten. From this, it can be seen that in May, preference for the three species was recorded, with a strong selection of grass (12.2 %) followed by *J. squarrosus* (6.85%) and *C. nigra* (4.44%). The preferences by sheep were related to species availability (Table 1 and 5).

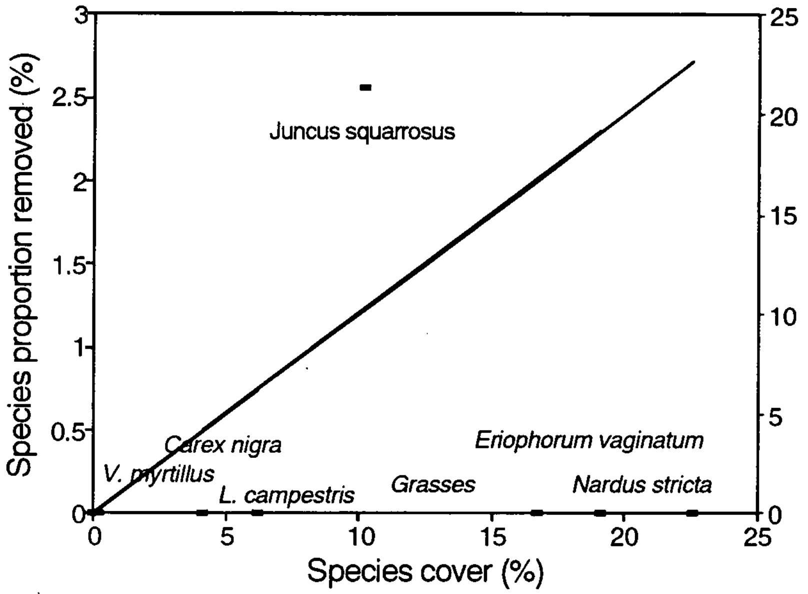

FIGURE 17. Species selected in relation to vegetation cover in May in type II. The trend line indicates no preference with the points that fall above.

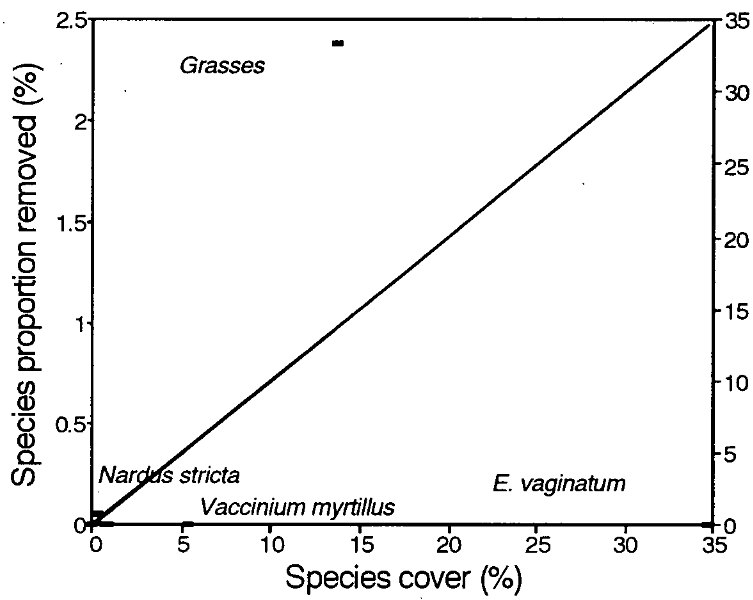

FIGURE 18. Species selected in relation to vegetation cover in June in type II. The trend line indicates no preference with the points that fall above.

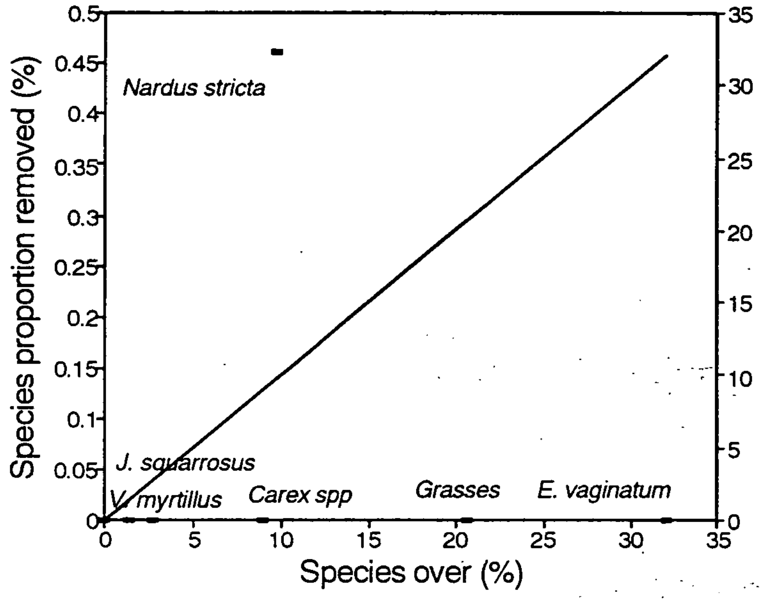

FIGURE 19. Species selected in relation to vegetation cover in July in type II. The trend line indicates no preference with the points that fall above.

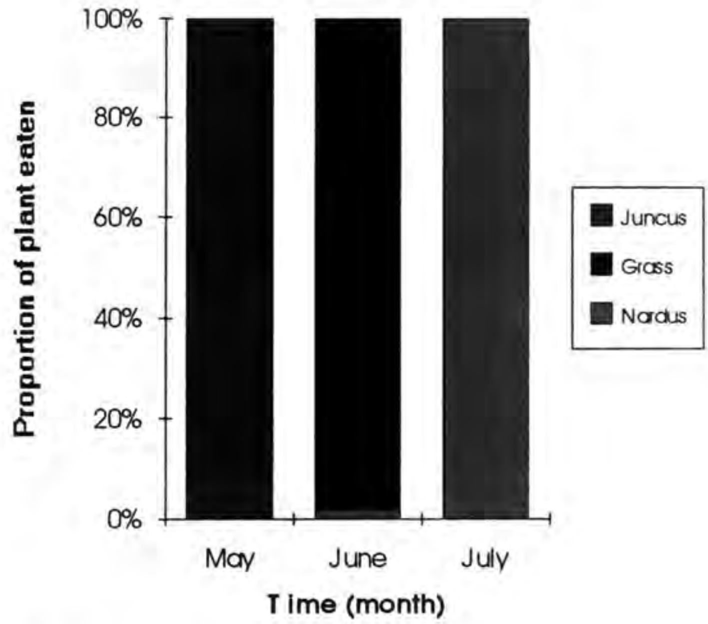

FIGURE 20. Comparison of the percentage of chewed stems as a proportion of the total cover of each species in Eriophoretum throughout the study period.

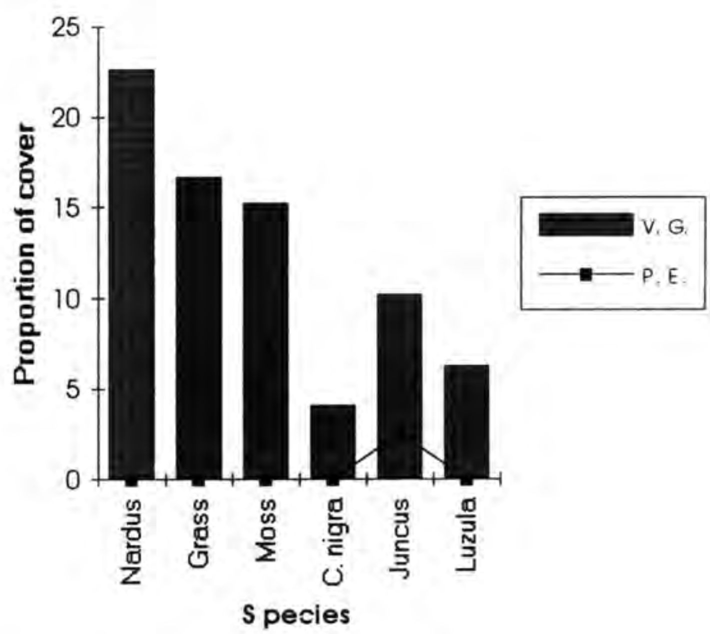

FIGURE 21. Comparison of species cover and percentage damage for Eriophoretum vegetation type in May (V.G. = vegetation cover and P.E. =percentage of plants eaten).

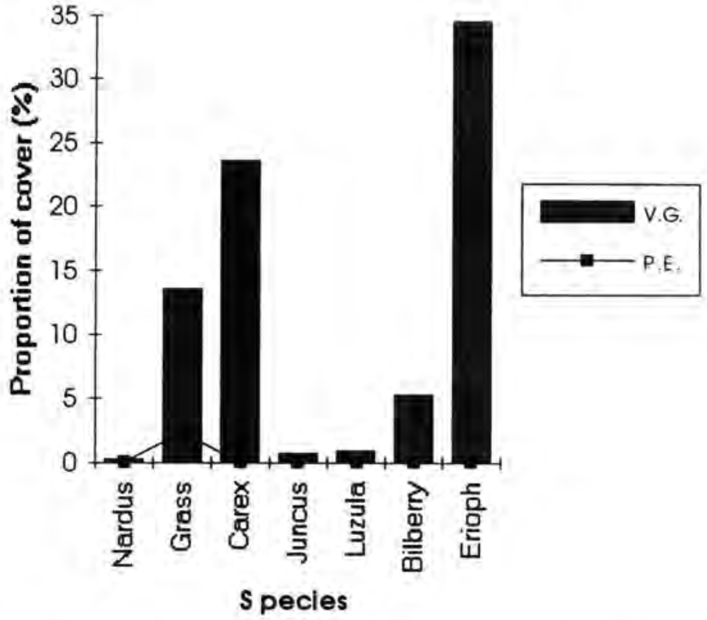

FIGURE 22. Comparison of species cover and percentage damage for Eriophoretum vegetation type in June (V.G. = vegetation cover and P.E. =percentage of plants eaten).

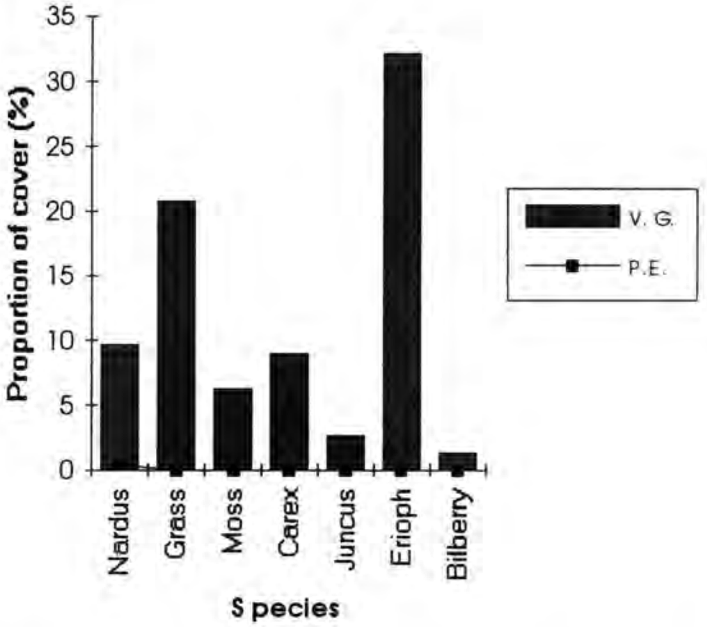

FIGURE 23. Comparison of species cover and percentage damage for Eriophoretum vegetation type in July (V.G. = vegetation cover and P.E. =percentage of plants eaten).

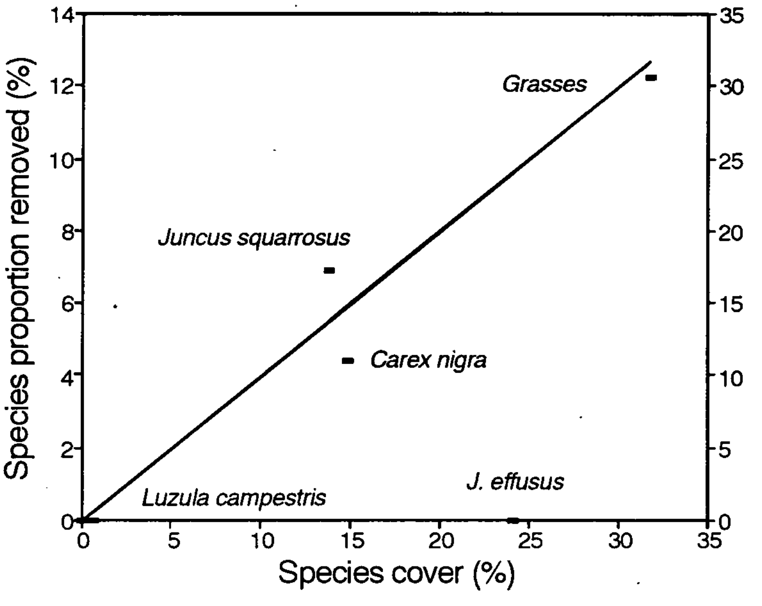

FIGURE 24. Species selected in relation to vegetation cover in May in type III. The trend line indicates no preference with the points that fall above.

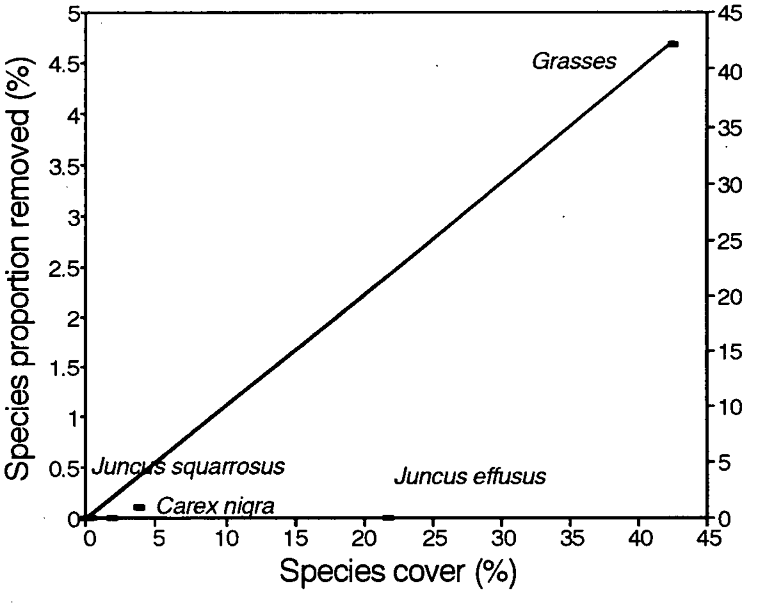

FIGURE 25. Species selected in relation to vegetation cover in June in type III. The trend line indicates no preference with the points that fall above.

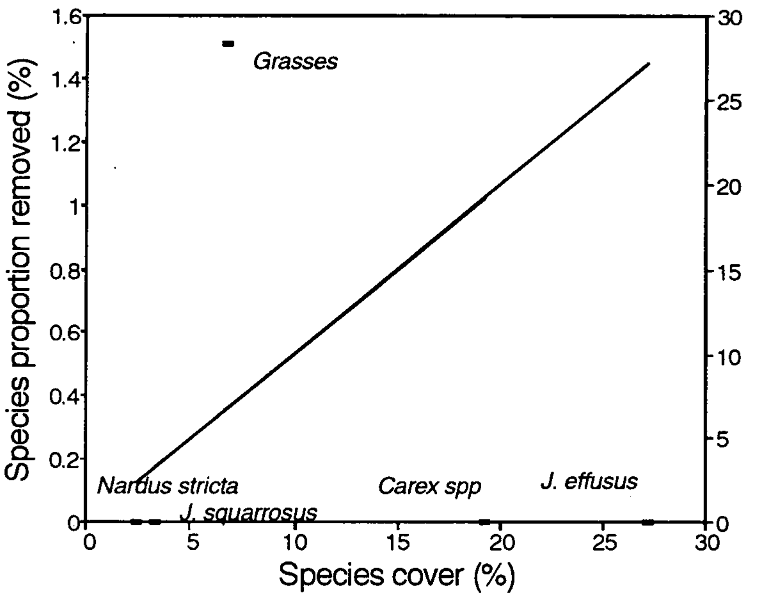

FIGURE 26. Species selected in relation to vegetation cover in July in type III. The trend line indicates no preference with the points that fall above.

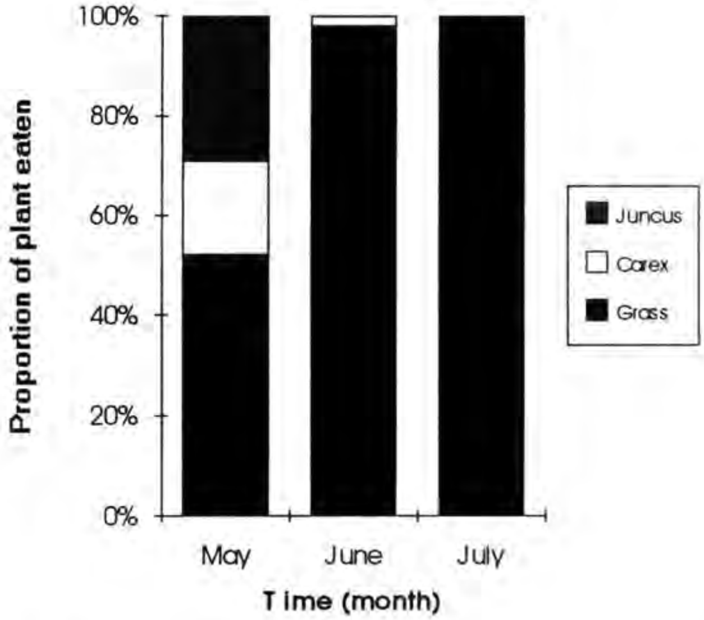

FIGURE 27. Comparison of the percentage of chewed stems as a proportion of the total cover of each group of species in Fen and Flush throughout the study period.

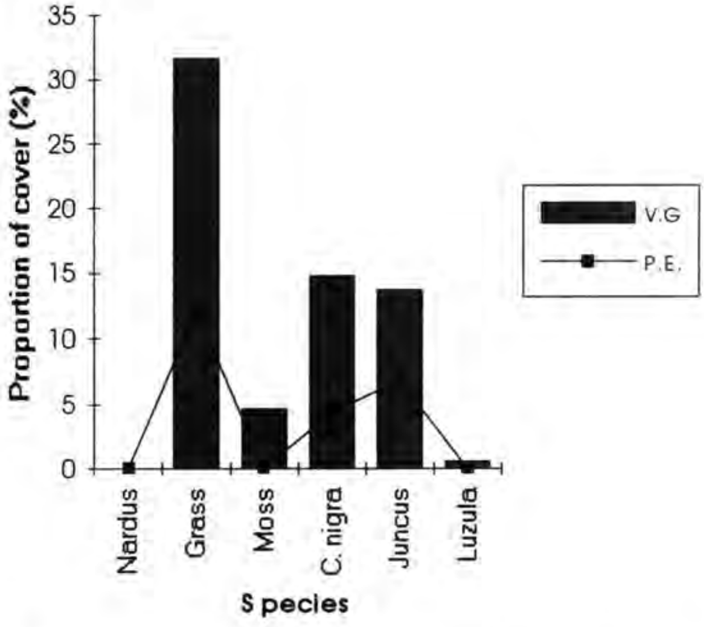

FIGURE 28. Comparison of species cover and percentage damage for Fen and Flush vegetation type in May (V.G. = vegetation cover and P.E. =percentage of plants eaten).

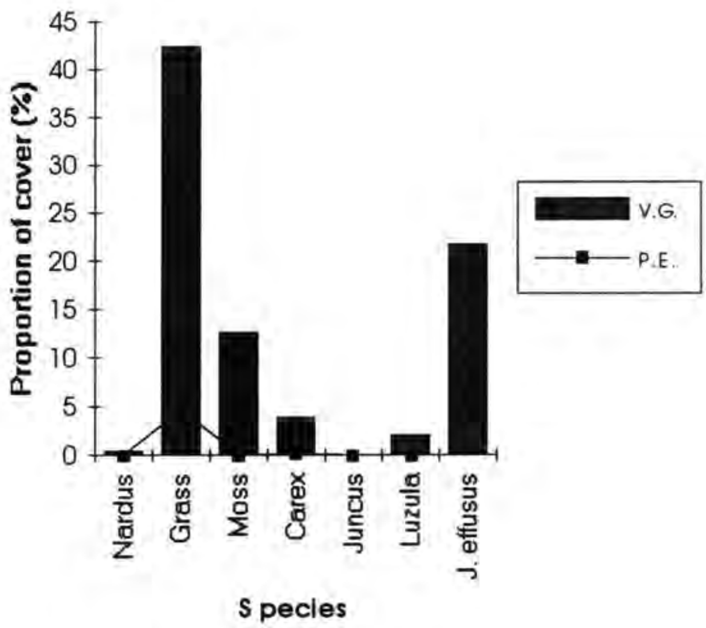

FIGURE 29. Comparison of species cover and percentage damage for Fen and Flush vegetation type in June (V.G. = vegetation cover and P.E. =percentage of plants eaten).

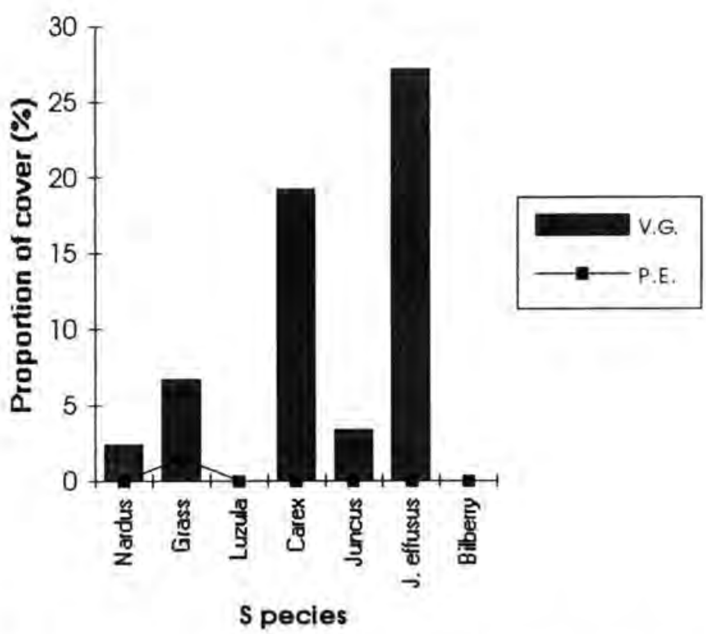

FIGURE 30. Comparison of species cover and percentage damage for Fen and Flush vegetation type in July (V.G. = vegetation cover and P.E. =percentage of plants eaten).

In June and July grass was mainly selected by sheep, with 4.7 % and 1.5 % respectively, decreasing in July as grass cover declined (t_5= 2.95, P<0.01).

There is a discrepancy between the higher amount of plants eaten in Fen and Flush but lower sheep frequency recorded in this vegetation type than in the Eriophoretum. It is possible that as the Fen and Flush patches were small and located close to Agrosto-Festucetum patches. Some observations of seep were misclassified or, alternatively, the seep may have been eating in the Fen and Flush outside the observation period.

In summary, sheep tended to exhibit strong preferences for some plant species, such as, *C. nigra, J. squarrosus, L. campestris* and grass species with the exception of *N. stricta*, which is only selected in young vegetation stage.

1.3.2.Composition of faeces

a) Frequency of species in faecal analysis

Data were obtained from fragment counts in faeces samples collected from each type of vegetation throughout the three months (Table 7). Because the identification of some species was difficult, they were grouped in the analysis. Hence, *N. stricta* and *F. ovina* were grouped as *Nardus-Festuca* group, *Deschampsia caespitosa* and *Agrostis spp* as Deschampsia-Agrostis group, *A. odoratum* was grouped with *Poa* spp, both *Carex* species, *Eriophorum* and *Luzula* as Sedges group, and Mosses species as Moss group. *C. vulgaris* and *G. saxatile* were also grouped together.

Type of vegetation	Agrosto-Festucetum			Eriophoretum			Fen and Flush		
Specie/ Month	May	June	July	May	June	July	May	June	July
Agrostis/Deschampsia	8.64	7.1	4.6	6.0	4.0	4.0	7.3	6.0	2.6
Nardus/Festuca	48.8	40.8	38.6	53.5	43.2	29.6	52.3	44.2	23.3
Anthoxanthum/Poa	5.4	4.1	4.2	3.7	1.2	8.4	3.6	4.1	2.4
Sedges	21.2	42.2	42.4	19.0	33.2	21.9	31.7	39.8	41.9
Galium/Calluna	3.6	3.1	7.3	11.0	10.8	39.4	2.1	2.4	27.7
Juncus spp	3.6	1.5	1.07	3.7	2.9	0.3	2.30	1.3	0.1
Mosses	8.3	2.2	1.4	3.6	3.6	0.7	2.4	1.6	1.8

TABLE 7. Mean percentages of the species frequency obtained from faeces analysis of Chapel Fell samples throughout the study period (N= 12).

The frequency of each group in the pellets was recorded throughout the time and was compared using ANOVA, which showed significantly high differences in diet composition for pellets collected from each vegetation type (Type I $F_{5,36}$=99.34, Type II $F_{5,36}$=124.2 and Type III $F_{5,36}$=141.1 P<0.001).

In order to estimate differences between species frequency in the diet for each type of vegetation, t-tests were applied between vegetation types from each month in table 7. The t-values for each comparison are shown in Table 8 and are referred to in the following section.

Month	May (d.f. = 11)			June (d.f. = 17)			July (d.f. = 5)		
Spec./type	I-II	II-III	I-III	I-II	II-III	I-III	I-II	II-III	I-III
Agr/Desc	1.7	1.9	3.5 -**	2.6 -*	1.6	2.6 -*	0.5	1.0	2.6 - *
Nard/Fest	1.0	0.4	1.3	0.9	0.3	1.9	4.8 -**	2.8 -*	6.1 - **
Anth./Poa	2.3 -*	0.1	2.3 -*	2.7-*	2.9+**	0.0	0.9	1.6	2.4 - *
Sedges	0.8	6.0+**	5.0+**	2.0	1.6	0.9	5.4 -**	5.7+**	0.2
Call/Gal	2.2	3.3 -**	1.4	3.4+**	3.4-**	0.8	8.7+**	6.2 -**	7.2+**
Juncus	0.0	1.3	1.6	2.4+*	3.5-**	0.7	1.6	1.0	2.3 -*
Moss	1.8	1.3	2.9-*	1.5	3.6-**	0.7	0.7	0.7	0.6

TABLE 8. T-test values from a faeces composition analysis between types of vegetation for each month. The symbols + and - indicate an increase or decrease in occurrence from the first to the second vegetation type (*= P<0.05; **= P<0.01; d.f. = degrees of freedom).

Regarding faeces analysis, there was a higher percentage of *Nardus-Festuca* and sedge species in the sheep diet (23.3-53.5% and 19.0-42.4%, respectively). There were differences in the proportion of plants species fragments in the dung collected from the different vegetation types (Table 8).

Figure 31 shows a comparison of faeces composition between types of vegetation in May. There were significant differences in *Anthoxanthum-Poa* between type I and II from 5.4 to 3.7% (t_{11}= 2.31, P<0.05), in sedges from 19.0-31.7% (t_{11}= 6.01, P<0.01) and *Calluna-Galium* from 11.0 to 2.1% (t_{11}= 3.35, P< 0.01), between type II and III , and between type I and III, there were in *Agrostis-Deschampsia* from 8.6 to 7.3% (t_{11}= 3.54, P<0.01), in sedges from 21.2 to 31.7% (t_{11}= 4.96, P<0.01) and moss from 8.3 to 2.4% (t_{11}= 2.87, P< 0.05).

Figure 32 shows a comparison of faeces composition between types of vegetation in June, where there were significant differences between type I and II in *Agrostis-Deschampsia* (7.1 to 4.0%)(t_{17} = 2.6, P<0.05), *Anthoxanthum-Poa* from 4.1 to 1.2% (t_{17} = 2.95, P<0.05), *Calluna-Galium* from 3.1 to10.8% (t_{17} = 3.37, P<0.01) and *Juncus* from 1.5 to 2.9% (t_{17} = 2.38, P<0.05), between type II and III, in *Anthoxanthum-Poa* from 1.2 to 4.1% (t_{17} = 2.95, P<0.01), *Calluna-Galium* from 10.8 to 2.4% (t_{17} = 3.37, P<0.01)), *Juncus* spp from 2.9 to 1.3% (t_{17} = 3.46, P<0.01) and Moss from 3.6 to 1.6% (t_{17} = 3.56, P<0.01), while between type I and III, there was a significant difference only in the *Agrostis-Deschampsia* frequency from 7.1 to 6.0% (t_{17} = 2.6, P<0.05).

Figure 33 shows a comparison of faeces composition between types of vegetation in July, where there were significant differences in *Nardus-Festuca* from 38.6 to 29.6% (t_5= 4.76, P<0.01), sedges from 42.4 to 21.9 (t_5= 5.41, P<0.01) and *Calluna-Galium* between both type I and II, and type II and III (Table 7 and 8), while between type I and III, *Agrostis-Deschampsia* from 4.6 to 2.6% (t_5= 2.6, P<0.05), *Nardus-Festuca* from 38.6 to 23.3% (t_5=6.1, P<0.01), *Anthoxanthum-Poa* from 4.2 to 2.4% (t_5= 2.41, P<0.05), *Juncus* from 1.1 to 0.1% (t_5= 2.26, P<0.05) and *Calluna-Galium* from 7.3 to 27.7% (t_5= 7.17%, P<0.01) were significant different.

Figure 34-36 show the species frequency in pellets in each month for Type I, II and III, respectively. According to Figure 34, in type I, Agrosto-Festucetum, sedge species (including both *Carex* species, *E. vaginatum* and *L. campestris*) and grass species (*N. stricta* and *F. ovina*) occurred with high frequency from 42 to 20 % for sedges and from 59 to 38 % for *Nardus-Festuca.*

It can be seen from Figure 35 that the faecal samples from Eriophoretum type showed high frequencies of *Nardus-Festuca* (29.6-53.5%), *Calluna-Galium* (10-39%) and sedge species at lower amounts (19-33%).

Figure 36 shows that the composition of faecal samples in type III exhibited a similar patterns to type I, but with an increase of *Calluna-Galium* group frequency from 2 to 42 % (t_5=7.17, P<0.01).

b) Seasonal pattern in faeces composition

T-tests were applied to species frequency recorded in each type of vegetation between the three monthsin in Table 7, in order to estimate the differences throughout the study period (Table 9).

Veg. type	Type I (d.f)		Type II (d.f.)		Type III (d.f.)	
Spec/Mon.	May-June	June-July	May-June	June-July	May-June	June-July
Agros/Desch	0.9(28)	1.5 (20)	2.0(23)	0.1(09)	1.1(24)	2.3(22) -*
Nar/Festuca	1.8(24)	0.4 (22)	4.4(20)-**	7.5(16)-**	2.6(27) -*	6.5(21) -**
Ant./Poa	1.1(27)	0.1 (22)	3.5(27)-**	1.6(05)	4.4(20)+**	1.5(21)
Sedges	3.5(21)+**	0.1 (22)	4.3(28)+**	3.9(22)-**	1.7(21)	0.4(22)
Call/Galium	0.4(26)	2.1 (07)	0.3(21)	10.8(16)+**	0.5(25)	17.6(18)+**
Juncus	2.5(13) -*	1.4 (11)	0.9(15)	5.9(22)-**	1.8(20)	3.3(21)-**
Moss	2.8(13) -*	0.8 (15)	0.1(23)	3.9(21)-**	1.4(15)	0.7(8)

TABLE 9. T-test values with the degrees of fredom in parenthesis, obtained from the faeces composition analysis for each type of vegetation between months. The symbols + and - indicate an increase or decrease from the first to the second month (*=P<0.05 and **= P<0.01).

There were seasonal patterns in the proportions of the different species fragments in the faeces samples.

As can be seen from figures 31-33, all the dung samples from May and July showed a high percentage of grass species. Sedge frequency was also high, while *Calluna-Galium* frequencies changed with time, having the highest percentage during July increasing from 2.1% to 39.4%. This group showed the higher frequencies in type I throughout the period, while type I and III exhibited the lower percentages. The *Juncus* and moss groups, showed the lowest frequencies of all species, diminishing throughout the time.

Taken together, Figures 31-36 show the pattern for each species group throughout the study period. The changes in each vegetation type for each month are compared below (Table 9).

Agrostis-Festucetum

Sedges

There was a a highly significant difference between May and June (t_{21} = 3.52 P<0.01), increasing the occurrence from 21.2 to 42.4%.

Juncus

There was a significant decrease between May and June from 3.6 to 1.5 % (t_{13}= 2.52 P<0.03) .

Moss

The frequency of moss fragments peaked in May, decreasing significantly in June from 8.3 to 2.2 % (t=3.54 P<0.01) from 5% to 0.1%.

Eriophoretum

Nardus-Festuca

The proportion of fragments decreased throughout the time, showing significant differences from May to June, with a decrease from 53.5 to 43.2 % (t_{20}= 4.4, P<0.01) and from June to July decreasing from 43.2 to 29.6 % (t_{16}= 7.51, P<0.01).

Anthoxanthum-Poa

There was a significant difference between May and June, decreasing from 3.7 to 1.2 % (t_{27}= 3.49, P<0.01).

Sedges

The percentage of occurrence varied throughout the three months, having a peak in June (21.9%), with significant differences between May and June (t_{28}= 4.27 P<0.01) and

June and July (t_{22}= 3.93, P<0.01). The proportion of sedges in faeces samples was lower in the Eriophoretum than in type I or type III.

Calluna

The frequency of *Calluna vulgaris* fragments increased significantly in July (t_{16}=10.8 P<0.01) where it is clearly evident that its frequency was higher in Eriophoretum than in type I or II.

Finally Moss and *Juncus* frequencies were higher in May and June, but they decreased significantly in July (t_{21}= 3.92 and t_{22}= 5.87, P<0.01, respectively).

Fen and Flush

Agrostis-Deschampsia

The presence of *Agrostis-Deschampsia* fragments decreased with time from 6.0 to 2.6%, there being significant difference between June and July (t_{22}= 2.28, P<0.03).

Nardus-Festuca

The fragments frequency tended to decline towards July from 52.3 to 23.3%, differing significantly between the months (t_{27}= 2.6, P<0.02 and t_{21}= 6.47, P<0.01).

Anthoxanthum-Poa

The frequency of this group decreased significatly from May to June (t_{20}= 4.4, P<0.01). The values exhibited by this group were lower than the first two grass groups (1.4-8.1%).

Calluna

There was a significant difference between June and July (t_{18}= 17.61, P<0.01) increasing in proportion from 2.4 to 27.7%.

Juncus

J. squarrosus frequency decreased throughout the time, from 1.8 to 0.7 %, showing a significant difference between June and July (t_{21}= 3.35, P<0.01).

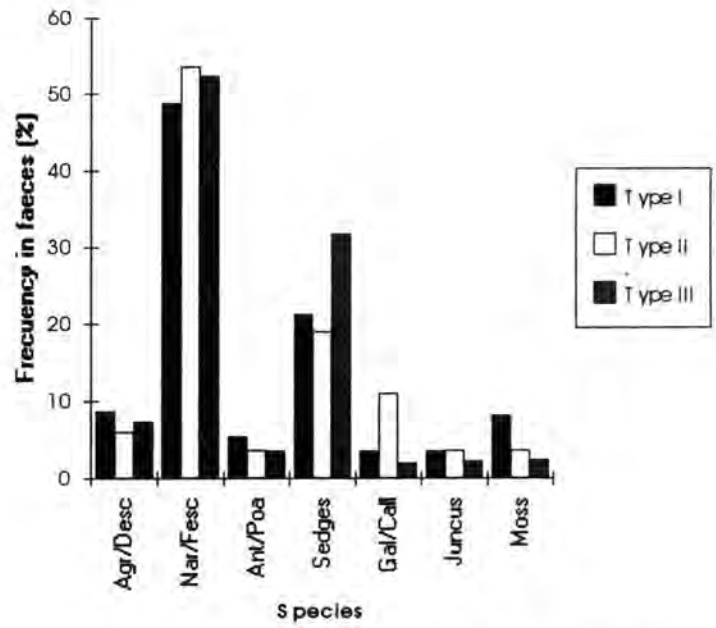

FIGURE 31. A comparison of faeces composition collected on the three different vegetation types in May on Chapel Fell.

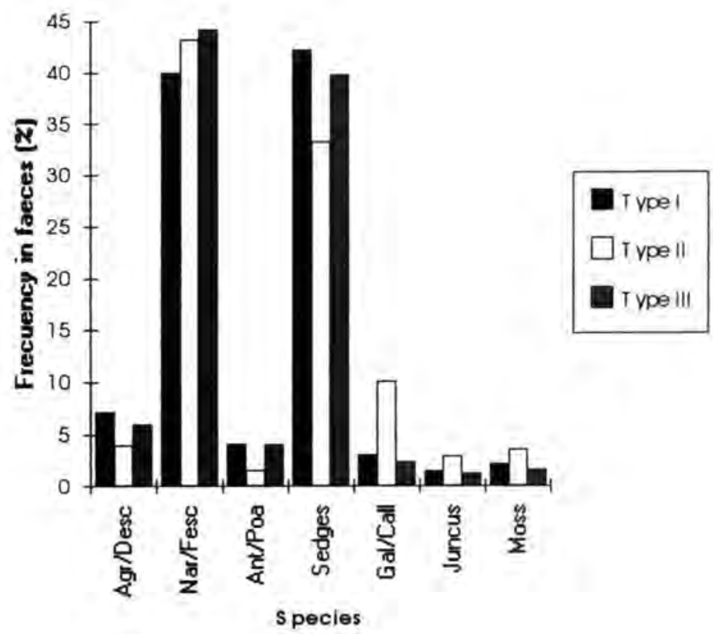

FIGURE 32. A comparison of faeces composition collected on the three different vegetation types in June on Chapel Fell.

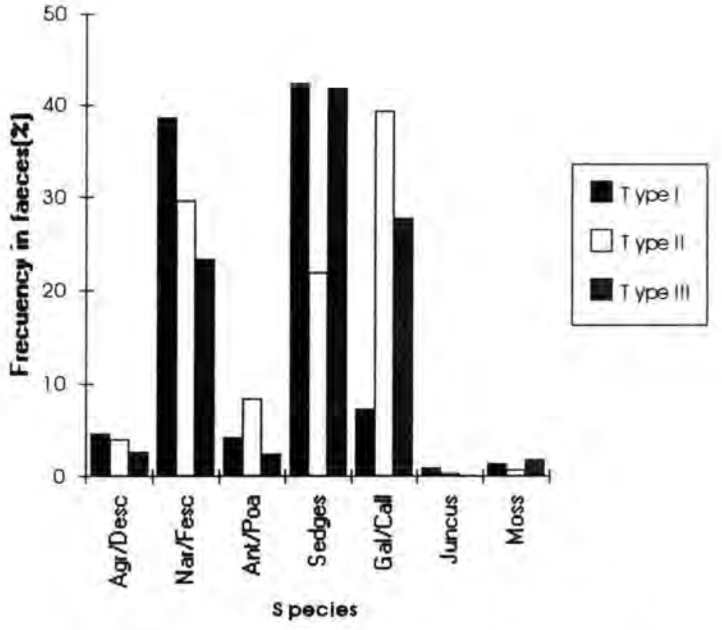

FIGURE 33. A comparison of faeces composition collected on the three different vegetation types in July on Chapell Fell.

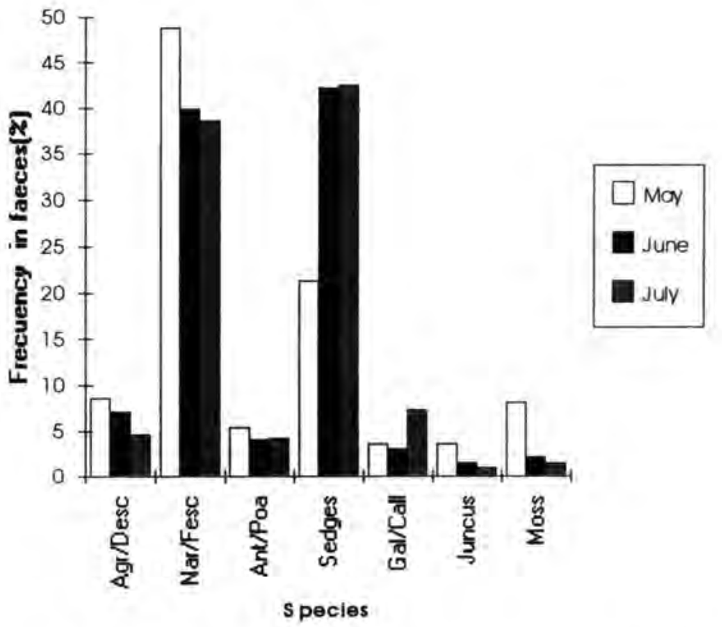

FIGURE 34. A comparison of faeces composition collected on Agrosto-Festucetum vegetation type on Chapel Fell throughout the study period.

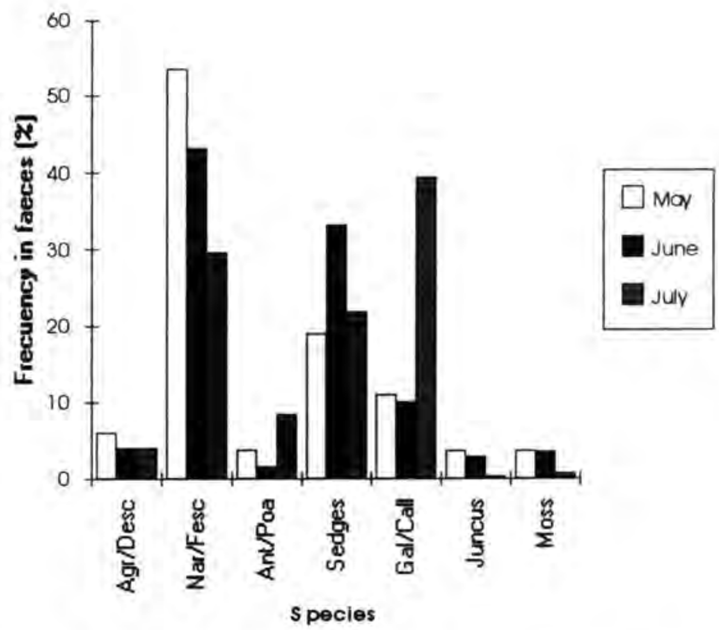

FIGURE 35. A comparison of faeces composition collected on Eriophoretum vegetation type on Chapel Fell throughout the study period.

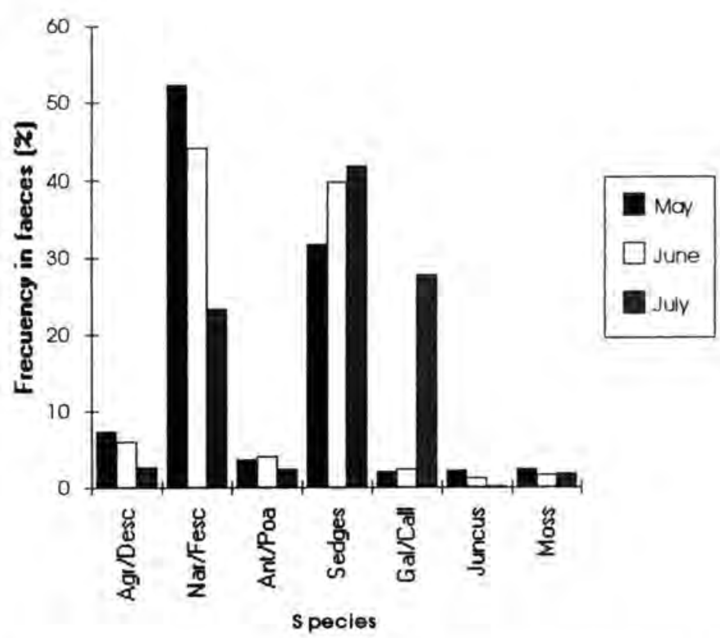

FIGURE 36. A comparison of faeces composition collected on Fen and Flush vegetation type on Chapel Fell throughout the study period.

2. Monk's moor

2.1. Botanical composition

Three types of vegetation were recognised in Monk's moor, grassland, Callunetum and Fen and Flush (Table 10).

Species/Veget. type	Agrosto-Festucetum	Callunetum	Fen and Flush
Nardus stricta	1.7 (±1.7)	0.0	0.0
Grass	52.6(±9.1)	22.8 (±6.3)	23.8 (±3.4)
Juncus squarrosus	12.0(±2.9)	17.0 (±7.1)	6.1 (±4.3)
Carex nigra	0.0	2.7 (±1.9)	0.0
Galium saxatile	19.1(±9.2)	14.4 (±6.9)	6.7 (±2.7)
Calluna vulgaris	2.1(±1.6)	37.7 (±8.0)	9.1 (±6.4)
Luzula campestris	2.4 (±2.1)	0.0	0.0
Juncus effusus	0.8 (±0.8)	0.0	30.5 (±8.4)
Moss	9.3 (±4.7)	5.4 (±2.3)	23.8 (±8.1)

TABLE 10. Mean percentage cover and Standart error in parenthesis, of species in each vegetation type on Monk's moor (N= 3).

Figure 37 shows the botanical composition for each vegetation type, type I being similar to type I on Chapel Fell, type II to Eriophoretum, and Type III to Type III in Chapel Fell. T-tests were carried out between vegetation types in order to estimate the statistical differences between the proportion of species cover on the vegetation types in Monk's moor.

Species/Veg. type	I-II	II-III	I-III
Nardus stricta	1.0	0.0	1.0
Grass	2.2	0.2	2.8 -
Juncus squarrosus	0.0	0.8	1.3
Carex nigra	1.0	1.0	0.0
Galium saxatile	0.6	0.5	1.4
Calluna vulgaris	3.7 +	2.1	0.5
Luzula campestris	1.0	0.0	1.0
Mosses	0.4	0.9	0.6
Juncus effusus	1.0	3.5 +	3.0 +

TABLE 11. T-test values comparing botanical composition between vegetation types on Monk's moor with 5 degrees of freedom. The symbols + and - indicate an increase or decrease from the first to the second type of vegetation (*=P<0.05 and **= P<0.01).

The results of t-tests are summarised in Table 11 and referred to in the following description.

Type I (Agrosto-Festucetum) at Monk's moor, consisted mainly of grass species (54%), *Juncus squarrosus* (12%), *Galium saxatile* (18%) and the same three species of moss as on Chapel Fell (18%). The percentage of grass was significantly higher than on type III (t_5=2.8, P<0.05).

Type II (Callunetum) consisted mainly of *C. vulgaris* (36%), *J. squarrosus* (18%), grass species (23%), and *G. saxatile* (16%). The percentage of *Calluna vulgaris* was higher than on type I (t_5= 3.7, P< 0.05).

Type III (Fen and Flush) consisted of *Juncus effusus* (32%), moss (24%) and grass species (25%). The percentage of *J. effusus* was higher than on type I or type II (t_5= 3.5 and t_5= 3.0, P<0.05, respectively).

2.2. Sheep Location and activity

The number of sheep was lower on this site than Chapel Fell, being 1.3 per ha (Table 12).

Activity/Veg. type	Agrosto-Festucetum	Callunetum	Fen and Flush
Eating	51	33	13
Resting/ruminating	8	24	3
Walking	3	12	6

TABLE 12 . The number of observations of sheep engaged in three activities in the three vegetation types on Monk Fell.

Table 12 shows the number of observations of sheep behaviour on the three vegetation types. As on Chapel Fell, sheep were most frequently observed on the Agrosto-Festucetum with Fen and Flush being the least preferred vegetation type ($X^2{}_4$= 21.14, P< 0.001). Eating was the most frequent activity ($X^2{}_1$ = 64.15, P< 0.001). See figure 38.

2.3 Composition of faeces

Table 13 shows the percentage occurrence of species fragments in faeces samples collected from the different vegetation types on Monk's moor (Fig. 39).

ANOVA was applied to the percentage ocurrence of plant species fragments from different vegetation types on which the dung was collected, showing significant differences between vegetation types($F_{7,18}$= 45.96 P<0.01)

Species/Veg. type	Agrosto-Festucetum	Callunetum	Fen and Flush
Nardus/Festuca	5.54	3.5	4.4
Agrostis/Deschampsia	15.4	13.4	18.4
Anthoxanthum/Poa	1.8	0.9	2.8
Sedges	2.7	6.4	3.9
Galium/Calluna	58.8	63.4	59.6
Juncus spp	6.5	7.2	2.7
Mosses	9.1	5.2	6.6

TABLE 13. Mean percentage of the species fragments ocurrence in pellets from the different types of vegetation on Monk's moor.

T-tests were used to estimate the significance of the differences for each species ocurrence between vegetation types (Table 14)

Species/Veg. type	I-II	II-III	I-III
Nardus/Festuca	2.4 - **	1.4	1.3
Agrostis/Deschampsia	0.9	1.6	2.4 + *
Anthoxanthum/Poa	1.9	1.3	2.4 + *
Sedges	3.3 + **	1.5	2.0
Galium/Calluna	1.9	0.5	2.1
Juncus spp	0.5	4.3 - **	3.2 - **
Mosses	3.8 - **	1.9	1.2

TABLE 14. T-test values for the comparison between species fragments occurrence in pellet collected from the three types of vegetation on Monk's moor with 17 degrees of freedom. The symbols + and - indicate an increase or decrease from the first to the second type of vegetation (*= $P< 0.05$ and **= $P< 0.01$).

Figure 39 shows the faeces composition in the samples collected in Monk Fell, showing significant differences between type I and II in *Nardus-Festuca*, sedge and moss species fragments occurrence, between type II and III, in *Juncus*, while between type I and III, *Agrostis-Deschampsia*, *Anthoxanthum-Poa* and *Juncus* exhibited significant differences. *Calluna-Galium* and *Nardus-Festuca* fragments exhibited the highest frequencies in the samples.

The higher frequency of *Calluna-Galium* fragments indicates that these species were consumed in larger amounts.

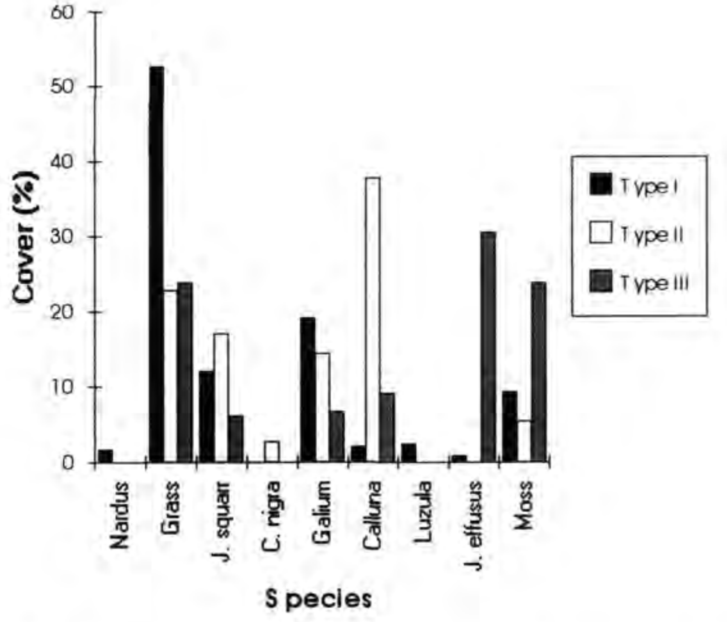

FIGURE 37. Percentage cover of species on the different vegetation types on Monk's moor.

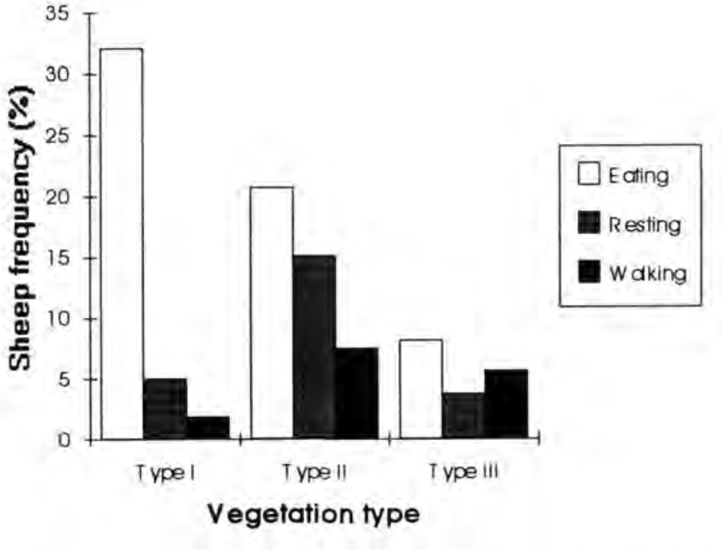

FIGURE 38. Percentage observation of the different activities carries out by sheep on each of the three vegetation types on Monk's moor.

3.Comparison between Monk's moor and Chapel Fell

3.1. Botanical composition

T-tests were carried out on the cover percentages for each species (Table 1 and 10) to compare the botanical composition between Chapel Fell and Monk's moor.

Species/veg. type (d.f.)	I (d.f.= 20)	II (d.f.= 21)	III (d.f.= 15)
Nardus stricta	0.3	1.9	1.0
Grasses	0.6	0.9	0.3
Carex spp	5.8 - **	0.4	3.4 - **
Juncus squarrosus	0.3	1.5	0.1
Juncus effusus	2.9 + **	---	0.6
Vaccinium myrtillus	---	1.4	0.7
Calluna vulgaris	2.9 + **	2.8 + *	2.5 + *
Luzula campestris	0.1	1.1	1.0
Galium saxatile	1.6	2.9 - **	0.2
Mosses	0.2	2.1 - *	0.1

TABLE 15. T-test values obtained from the comparison of species cover between the three different sites both on Chapel Fell and Monk's moor. The - and + indicate a increase or decrease in Monk's Fell. The symbols + and - indicates an increase or decrease from first to second site (*= P< 0.05 and **= P< 0.01).

Table 15 gives the t-values from the comparison between vegetation types from both study sites, and will be referred to in the next section.

The main differences between Type I Chapel Fell and Type I Monk's moor, was that *Carex* spp was less frequent while *Juncus effusus* and *Calluna vulgaris* were more frequent on Monk's Fell. Between Type II at Chapell Fell and Monk's moor was that *C. vulgaris* was more frequent at Chapell Fell while *Galium saxatile* and moss species were less frequent; and between Type III was that *C. vulgaris* was more frequent at Chapel Fell and *Carex* spp in Monk's moor. Hence, the main difference in botanical composition were the *C. vulgaris* and *Carex* spp cover, the first being higher at Monk's moor and the second at Chapel Fell, respectively.

3.2. Sheep location

Chi-squared was applied to compare the vegetation types preferred by sheep by comparing the frequency of the observations on the vegetation types. The proportions of time the sheep spent on the different vegetation types in the two areas did not differ (type

I X^2_2= 2.88, types II X^2_2= 2.93 and type III X^2_2= 3.48, P<0.05), which indicates that in both sites they tended to select Agrosto-Festucetum vegetation type.

3.3.Composition of faeces

The results of t-tests applied to a comparison of the percentage of fragments from each plant species occurrency in the pellets are shown in Table 16.

Species/Veg. type	I (d.f.)	II (d.f.)	III (d.f.)
Nardus/Festuca	2.9 (51) -	0.9 (30)	1.3 (31)
Agrostis/Deschampsia	9.5 (52) + **	11.3 (40) + **	12.0 (51) + **
Anthoxanthum/Poa	2.1 (44) - *	1.9 (43)	4.5 (52) - **
Sedges	9.3 (37) - **	12.3 (42) - **	12.0 (48) -
Galium/Calluna	29.6 (22) + **	13.5 (45) + **	23.8 (44) + **
Juncus spp	0.1 (30)	3.8 (23) + **	4.0 (18) + **
Mosses	2.1 (49) + *	5.8 (24) + **	4.8 (20) + **

TABLE 16. T-test values obtained from the comparison between species fragments occurrence in pellets collected from Chapel Fell and Monk's moor. The symbols + and - indicate an increase or decrease from first to second site (*= P< 0.05 and **= P< 0.01).

The species fragment occurrence in pellets from Chapel Fell (Table 7) and Monk's moor (Table 13) differed significantly, showing higher frequency of *Calluna-Galium, Agrostis-Deschampsia,* mosses and *Juncus* fragments in Monk's moor samples, while in Chapel Fell samples sedge fragments were more frequent. This is a consequence of the plant species availability, sedges (*Carex* spp) were more available on Chapel Fell in comparison with *C. vulgaris*, which is more available on Monk's moor.

CHAPTER V

DISCUSSION

The selection of different types of vegetation by sheep was assessed by visual observation in two different sites in order to evaluate the selection according to the botanical composition.

1. Chapel Fell

Chapel Fell is characterised by three types of vegetation: Agrosto-Festucetum (type I), Eriophoretum (type II) and Fen and flush (type III). The first type of vegetation is characterised mainly by the high percentage of grass cover. In the second type, *Eriophorum vaginatum* and *Nardus stricta* are the most abundant species, while in the third, *Juncus effusus* cover is the highest. In addition this last type of vegetation includes important amounts of grass cover.

1.1. Sheep Location

Sheep were observed more frequently in Agrosto-Festucetum patches and less frequently in Eriophoretum and Fen and flush. This agrees with the findings of Hunter (1962) who estimated intense utilisation of species-rich grassland and neglect of dwarf-shrub heath with flocks of hill sheep in southern Scotland.

Although the grass species selected by sheep were also abundant in the other types of vegetation, sheep did not select those patches because of the dominance of unpalatable species, such as, *N. stricta* and *E. vaginatum.* Arnold (1987) found that the presence of less acceptable or unacceptable species deters the use of a patch. Moreover, Hunter (1962) found that in the patches where *N. stricta* or *Calluna vulgaris*, were dominant, the grazing pressure was low. He also demonstrated that when the grazing pressure was low, *Nardus* formed dense tussocks, suppresing competitors which also suffered the further handicap of being preferentially grazed.

Futhermore, avoidance of vegetation type II and type III can be explained by the physical structure of sward, making the species preferred inaccesible. *Eriophorum, Nardus, Calluna* and *J. effusus* tend to grow to a greater extent than the more selected species, forming tussocks which make the shorter and more preferred species inaccesible (Arnold, 1987 and, Hodgson, Forbes, Amstrong, Beattie and Hunter, 1991).

Fen and Flush is frequently located close to Agrosto-Festucetum patches, and includes an important proportion of grass cover which makes them available grazing habitats (Rawes and Welch, 1964,1969).

Rawes and Welch (1966) found a higher number of sheep in this type of vegetation than in the blanket bog. My lower sheep frequency record may have been because the patches of this vegetation type were small and located close to Agrosto-festucetum patches, and the limits between them were not well defined. As a consequence, sheep occurence in Fen and Flush could have been overlooked and recorded in type I. It was, however, evident that sheep grazed preferentially on the grassy parts in this vegetation type and not less in the *J. effusus* clumps.

1.2.Utilisation and availability

Sheep diet selection was assessed and compared with the food availability. This was carried out by visual observation of the plant species eaten in the field and the content of faeces.

It is well documented that sheep selectivity depends on the botanical composition and species availability of an area, in other words, the presence of less acceptable or unacceptable species may deter the use of a patch. Moreover, the physical structure of a sward influences the consumption rate and selectivity (Arnold, 1987). Although sward structure was not estimated in this work, field observations and species fragment frequency helped to explain the species selection by sheep according to botanical composition and species availability.

The results of the visual observations show that grass species, with the exception of *Nardus stricta*, and *Carex nigra* were the most selected species and this agrees with the findings of many other studies of sheep diet preferences in different types of vegetation (Brasher and Perkins, 1978; Grant *et al*, 1976 and Rawes and Welch, 1969).

The utilisation of grass, *J. squarrosus* and *Carèx* species was mainly related to their availability throughout the study period, but this relationship changed according to the type of vegetation, sheep making a selection between species with regard to availability, growth stage, species frequency and spatial arragement. (Grant *et al,* 1976 and Rawes and Welch, 1966).

Type I. Agrosto-Festucetum

Observation of chewing damage in the field indicated that sheep selected mainly grass, *C. nigra* and *J. squarrosus* in Agrosto-Festucetum patches, increasing the preference when their cover increased. Grant *et al*, (1976) found the same preferences in a study of a blanket bog in Scotland, where sheep selected *Carex* spp and *Molinia caerulea* in summer.

In May, the preferred species were *C. nigra* and *J. squarrosus*, while grass species were less often selected , even though, their availability was higher than the last two (Fig. 14). Towards June, grass species increased their cover, while *J. squarrosus* and *C. nigra* cover decreased, resulting in the reduction of the selection for these two and the increase for grass (Fig. 15). In July, *J. squarrosus* cover decrease acompanied by a decrease in selection by sheep, while *C. nigra* cover and selection by sheep increased. Although the grass cover increased, its selection decreased because of the changes in digestibility associated with the flowering period (Fig.16). Grant *et al*, (1985) found that sheep tended to avoid grass flowers , because they reduce the nutrient intake of sheep.

The results from the faecal analysis showed a different pattern throughout the study period, with a decrease of grass fragments and a increase of sedges (including *Carex* spp and *Luzula campestris*) towards July, while *J. squarrosus* fragments were minimal throughout the study period..

This can be explained with regard to availability, growth stage and structure of plant species. In May, grass species showed a higher cover than *C. nigra* and *J. squarrosus*, in other words, grass had a higher availability, followed by *C. nigra*, the grass biomass being higher than sedges and *J. squarrosus* biomass. As a consequence of this, grass species fragments were more frequent in faeces than segdges and *J. squarrosus* fragments. However, the vegetation structure was different, *C. nigra* and *J. squarrosus* being taller than grass species, and sheep tend to prefer these species because of their accesibility. This can be supported by the findings of Black and Kenney (1984), in which they demonstrated that the vegetation structure influences the species selection, the intake rate being higher in a less dense tall pasture than in short, closely spaced pasture with the same herbage mass per area.

Although in June, grass increased in availability and utilisation and *C. nigra* decreased both in availability and utilisation, the fragments of this last were more frequent than grass, which can be explained with regard to sward heights. *C. nigra* plants were taller than grass and *J. squarrosus*, and the species biomass eaten by sheep was greater for sedges than grass and *J. squarrosus*. Moreover the *L. campestris* cover increased the occurence of sedges in faeces. The results of Ungar and Noy-Meir (1988) confirm the above; they found that the increase of sward height or bulk density increases bite weight and as a result of this, the intake rate increases.

This was also supported by the occurrence of moss fragments in faeces, which indicates that sheep were feeding on short grass, and ate moss unintentionally because of the spatial arragement. In May moss fragment frequency was higher because of the sward height, and it decreased towards July as sward height increased. Arnold (1987) demostrated that the proportions of species removed depends on their proportion in the biomass of the patch, however, the consumption was sometimes influenced by the presence of other species. In this case, moss was consumed more frequently in May frequently in May when grasses, the selected species, had the same height. For that reason, although moss cover increased towards June, its consumption diminished because of the arragement of grasses grew above it.

In July, the reduction of *J. squarrosus* cover decreased its availability and its utilisation, while *C. nigra* and *L. campestris* cover and height increased, resulting in an increase of sedge availability and utilisation. Grass species availability and utilisation decreased because of the nutrient quality decrease associated with the flowering period.

Type II. Eriophoretum.

The sward height and the species cover played an important role in species availability and accesibility. *N. stricta* and *E. vaginatum* tended to grow to a greater extend because of their rejection by sheep (Hunter, 1962).

In May, *N. stricta* and *E. vaginatum* cover was higher and the plants were taller than the grasses, making the preferred species, such as, grass, *C. nigra* and *J. squarrosus* unaccesible. Sheep selected *J. squarrosus* but the low cover and height did not offer a good food source, which is reflected in the low frequency of fragments in faeces. *Nardus-Festuca* and sedge fragments occurrence was higher in this period, which suggest that sheep, in an atempt to feed on shorter grasses, consumed *N. stricta* plants and *E. vaginatum* (fig. 35). Grant *et al*, (1985) found that the herbage height and biomass between tussocks areas influenced the relative ability of sheep to avoid grazing *Nardus*.

In June, *E. vaginatum* increased in cover and height, resulting in an increase of its fragments frequency in pellets. In July *E. vaginatum* cover and height decreased allowing access to the preferred species (Grant *et al*, 1976).

Although *C. vulgaris* decreased in cover in July, it increased in height, resulting in an increase of its consumption by sheep because of its accessibility. Some grass species, such as *Anthoxanthum odoratum*, were also more available and accesible, increasing in cover and height, which favoured their consumption. This was evident in the increase of their fragment frequency in the dung (Fig. 35). Although *J. squarrosus* cover increased in July, its low fragment frequency, indicated that *J. squarrosus* was selected only when grass and sedges species were not available or accesible (Fig. 23 and 35).

Type III. Fen and Flush.

Grass species and sedges were also the most frequently selected species in this vegetation type. In May, sheep selected more *J. squarrosus* and grass species, followed by *C. nigra*, because of their availability. Sedge species tended to grow faster than grass species because of the grazing pressure on grass species. Towards June, although grass cover increased, sedge species (*C. nigra*) were taller than grass species, which increased the biomass consumed by sheep, resulting in a high frequency of sedge fragments in faeces (Arnold, 1987).

In July, grass cover decreased, diminishig its availability, resulting in a consumption decline. Sedge species cover increased (*C. nigra and C. bigelowii*), their consumption by sheep increased.

C. vulgaris fragments occurence in faeces in the three types of vegetation increased probably, as a consequence of its height increase, which made it accesible to sheep. Grant *et al*,(1985) and Welch (1984), found that *C. vulgaris* preference increased by autumn, when grass and sedge species digestibility decreased.

This agrees with Hunter (1962), who said that the proportion of heather in the diet tends to be low when the preferred grasses are available, but as these are exhasted or die back in late summer, so heather becomes a main stay of the sheep's diet over winter.

2. Monk's moor

Three types of vegetation were also found in this area, Agrosto-festucetum, Callunetum and Fen and Flush. Type I was characterised by a high grass cover, while type II and III, were characterised by the high cover of *C. vulgaris* and *J. effusus*, respectively (Fig. 37).

As with to Chapel Fell, sheep were mainly observed in Agrosto-festucetum patches, where grass species were more available and accessible, and less frequently in Fen and Flush patches. However, sheep were observed more frequently in Callunetum than Eriophoretum on Chapel Fell (Fig.38) .It is important to note that sheep tended to select burnt areas where young heather was available, which supports Grant and Hunter's (1968) findings that sheep tend to prefer young heather in summer.

On Monk's moor, *C. vulgaris* fragments showed the highest frequency in faeces from the three types of vegetation, which indicates a strong relationship with the availability and utilisation (Fig. 39).

Grass species cover was higher in Agrosto-festucetum than in Fen and Flush, but plants were taller in the latter, which explains the higher frequency fragment of grass in faeces from Fen and Flush. This assumption is also supported by the high frequency of moss fragments in faeces from Agrosto-festucetum patches, even though than moss availability was higher in Fen and flush. The presence of the moss fragments indicated that the grass had been chewed down almost to the soil surface (Fig. 37 and 39).

J. squarrosus was consumed with regard to its availability, being more available in Agrosto-festucetum, and this was reflected in the higher frequency of the fragments in faeces collected from the Agrosto-Festucetm patches. Sedge fragment frequency was related to its cover, being higher in type Callunetum where its cover was higher than Agrosto-festucetum and Fen and Flush faeces (Fig. 37 and 39).

3. A comparison between Chapel Fell and Monk's moor

According to these results, sedge and grass species were the preferred species on Chapel Fell and *C. vulgaris* and grass species on Monk's moor. This was directly related to the availability and biomass of the plants in the two areas. This conclusion is supported by Hunter (1954) argued that the value of an area is influenced by the nature of the species present and by the proportions in which they occur.

Both areas Eriophoretum/Callunetum and grasslands can support grazing by sheep, but this can vary according to the different species present and season. In other words, *Calluna* and *Eriophorum* can support sheep grazing in autumn and winter, while grasslands in late spring and summer (Hunter, 1987).

Although direct observations of chewed plants were important to identified the plants selected by sheep, faecal analysis were more reliable in this work than evidence of chewed leaves.

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