Examensarbeten **2009:6**
Institutionen för skogens ekologi och skötsel

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Sveriges Lantbruksuniversitet Skogligt magisterprogram/Jägmästarprogrammet
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Habitat och växtselektion hos boskap i en Etiopisk brandpåverkad Afro-alpin ljunghedsmiljö

Jenny Gustafsson

Nyckelord / *Keywords:*

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I denna rapport redovisas ett examensarbete utfört vid Institutionen för skogens ekologi och skötsel, Skogsvetenskapliga fakulteten, SLU. Arbetet har handletts och granskats av handledaren, och godkänts av examinator. För rapportens slutliga innehåll är dock författaren ensam ansvarig.

This report presents an MSc/BSc thesis at the Department of Forest Ecology and Management, Faculty of Forest Sciences, SLU. The work has been supervised and reviewed by the supervisor, and been approved by the examinator. However, the author is the sole responsible for the content.

Abstract

In the Ethiopian highlands cultivation is dominant up to 2700 m elevation, higher up on the mountain slopes there are numerous scattered farms with little cultivation due to the harsh climate. Here, the economy is based on animal husbandry, with cattle as the most important livestock species. The dominant vegetation above 3500 m is a treeless heathland with *Erica arborea* and *Erica trimera* as dominant woody plants. Between the *Erica* bushes is a lawn of herbs and grass. To give the livestock a better diet and protection, the local people burn the vegetation on a rotation of less than 10 years. This traditional fire management creates a mosaic of patches in the heathland. My purpose of this study was to analyze habitat use and plant selection of free-ranging livestock in these burnt and patchy sub-alpine *Erica* environments.

The cattle's foraging behavior and selection of forage species were recorded continuously during 7 minute observation periods. All observations were paired with a line transect that followed the cows path. The results show that the cattle spend most of their time actively foraging and use varied foraging strategies in different-aged patches. In 1 year old burns grass/herb "Lawn" covered 65 % and *Erica* shrub 35 % of the patch. In 3 year old burns Lawn and *Erica* covers approximately 50 % of the vegetation respectively. The cattle spend most of their time grazing Lawn and the *Erica* shrub was mainly browsed in the 1 year old patches. The bite size of the *Erica* shoots varied from 0.4-1.8 mm in diameter, with *E. trimera* browsed at slightly larger diameters. The cattle moved with an average speed of ca 300 m/hour and most of the walking episodes were 2-10 seconds long. Their time spent on browsing *Erica* were longer in the younger patches and the Lawn-grazing episodes were longer in the older patches, up to over 200 seconds per episode.
Interviews with two cattle-owners revealed that they had an intimate knowledge of their cattle's daily movements and foraging behavior. They knew of important forage species on the mountain and emphasized the importance of newly burned areas for the cattle's nutrition.

This study shows the importance of the Ericaceous belt for the availability of forage with the right quality and quantity for the cattle herds. Access to fresh shoots of *Erica* shrub and Lawn species is very important and constitutes the greatest amount of the cattle's diet. Traditional fire management of *Erica* vegetation creates good pasture land and the study supports decisions for this management of grazing areas in the Ethiopian highlands.

Keywords: *Erica trimera, Erica arborea,* Afro-alpine heathlands, Habitat preference, Foraging, Foraging behaviour, Livestock, Fire Management, Bale Mountains, Ethiopia

Sammanfattning

I de Etiopiska höglandet dominerar jordbruk upp till 2700 meter, högre upp längs bergssluttningarna finns flera utspridda gårdar med liten grad av jordbruk på grund av det hårda klimatet. Här baseras inkomsten på boskapsskötsel. Den dominerande vegetationen över 3500 m.ö.h. är ljunghed med *Erica arborea* och *Erica trimera* som de dominerande vedartade växterna. Mellan *Erica*-buskarna finns en gräsmatta av gräs och örter. För att ge boskapen en bättre födotillgång bränner lokalinvånarna ljungheden, med en rotation på mindre än 10 år. Denna traditionella bränningsskötsel skapar en mosaik av olikåldrade fläckar inom hedlandskapet. Mitt syfte var att analysera habitatanvändning och växtselektion av fritt betande kreatur inom detta landskap.

Kontinuerliga iakttagelser av kors betesbeteende och val av växtarter gjordes under 7 minuter långa observationsperioder. Alla observationer parades ihop med en linjetransekt som följde djurens gång. Resultaten visade att boskapen spenderade mesta delen av sin tid på att aktivt beta och använde olika betesstrategier i olika gamla fläckar. I 1 år gamla brännor täckte gräsmattan 65% och *Erica*-buskarna 35% av vegetationen. I 3 år gamla brännor täckte gräsmatta och *Erica*-buskarna ca 50% vardera. Boskapen spenderade mesta delen av sin tid med att beta gräsmatta och *Erica*-buskar betades främst i 1 år gamla brännor. Diametern på de *Erica*-skott som betades varierade från 0.4-1.8 mm och *Erica trimera* betades i något grövre diametrar. Boskapen rörde sig med en medelhastighet av 300 meter per timme och de flesta av gångepisoderna var 2-10 sekunder långa. De episoder som spenderades på att beta *Erica* var längre i de yngre brännorna och de episoder där korna betade gräsmatta var längre i de äldre brännorna, upp till 200 sekunder per episod.

Intervjuer med två boskapsägare visade att de hade god kunskap om deras boskaps rörelsemönster och betesbeteende. De kände till viktiga arter på berget och betonade vikten av tillgång på nybrända områden för boskapen.

Studien visar den stora betydelse som ljungheden har för tillgång på foder med rätt kvalitet och kvantitet för boskapsflockarna. Tillgången till nya skott av *Erica*-buskar och arter i gräsmattan är väldigt viktiga och utgör den dominerande delen av boskapens diet. Traditionell bränningsskötsel av *Erica*-vegetation skapar bra betesmarker och studien stödjer den här typen av skötsel i de Etiopiska höglandet.

Keywords: *Erica trimera, Erica arborea*, Afro-alpint hedlandskap, Habitatpreferens, Bete, Betesbeteende, Boskap, Fire Management, Bale Mountains, Etiopien.

Introduction

Large mammalian herbivores are assumed to allocate the time they spend in an area in relation to available resources (Senft et al. 1987). The optimal habitats for livestock vary with abiotic (topography, availability of water and thermal cover) and biotic (forage quality and quantity) factors (Senft et al. 1987, Bailey 2005). These factors can be connected with protection from predators, stress, hunger and excessive temperatures (Senft et al. 1987, Schetchter and Calganetti 1998). For foraging cattle, the selection between different patches with different forage quality and quantity is the main tool to influence the forage intake rate and value (Wallis de Vries & Daleboudt 1994). Cattle use combinations of sight, taste, smell and tactile feel to make diet selection and develop a spatial memory (Provenza et al. 1998, Dougherty and Collins 2003). This means that the spatial grazing patterns of free-ranging herbivores may result from cattle returning to nutrient-rich areas more frequently than nutrient-poor ones (Bailey et al. 1996, Bailey & Sims 1998). Spatial variation in habitat quality is not static. Fire is a powerful disturbance agent that can transform ecological conditions and influence the habitat, predation, visibility, food availability and nutritional and toxicological characteristics of the plants (Provenza et al. 1998, Wronski 2003). Historically, prescribed fire has probably been the main tool to increase the amount of livestock pasture (Vermeire et al. 2004, Bond & Keeley 2005). Fire leads to spatially subdivided units in the vegetation that have different grazing quality of grass and browse forage (Searle and Shipley 2008). It is this spatial variation that the cattle have to exploit in order to increase foraging efficiency and diet quality (Vermeire et al. 2004).

The Ethiopian highlands are defined as the area located at altitudes above 1500 meter and it covers an area of 490 000 km^2 or 40% of the Ethiopian landmass (Constable 1984). The highlands in Ethiopia account for about 95% of all cultivated land, support 88% of the total human population and 70% of the total livestock population (Daniel 1988). The Ethiopian highlands are characterized by high population densities and stocking rates, scarcity in animal feeds and generally a low quality diet for the livestock. Cultivation is dominant up to 2700 m elevation, but higher up on the mountain slopes there are numerous scattered farms with little cultivation due to the harsh climate (Woldu & Saleem 2000). In these areas cattle (*Bos taurus indicus*), sheep (*Ovis aries*) and goats (*Capra hircus*) provide the major basis for subsistence and are freely ranging. Cattle are the most important livestock species in the Ethiopian highlands and they are kept mainly for traction and milk production, but also for meat.

The dominant vegetation above 3500 m is *Erica* heathlands. These heathlands have together with the subalpine *Erica* forest been termed the Ericaceous Belt (Hedberg 1951) and the vegetation is mostly *Erica* shrub; the dominating woody plants are *Erica arborea* (L.) and *Erica trimera* (Engl.) Beentje. Between the *Erica* bushes is a lawn of herbs and grass. This vegetation is regularly burnt to improve pasture. When old (>10 years) the *Erica* bushes are tall and dense and such areas are un-attractive to the cattle according to the local human population (Johansson et al. unpublished). The explanations are several: the cattle can not reach the green shoot tips, the ground-layer vegetation below the bushes (herbs and grass) is poorly developed due to competition for light and nutrients. Further, the shrubs are said to harbour toxic larvae that can affect the cattle and the shrubs are also a good hiding place for predators like the hyenas (*Crocuta crocuta*) (Wesche et al. 2000, Johansson unpublished).

Repeated burning controls the composition of the vegetation over most the upper Ericaceous zone today (Miehe & Miehe 1994). To give the livestock a better diet and protection, the local human population burn patches to improve the forage quality, on a rotation of approximately

ten years (Wesche 2003, Johansson et al. unpublished). This traditional fire management creates a mosaic of patches within the ericaceous scrub (Miehe & Miehe 1994), ca 0,5-5 ha in size, differing in age since fire and with different vegetation composition (and presumably different forage value). Nothing is known of the foraging potential and habitat preferences for cattle in these systems, which leads to problems for the local people who like to uphold their traditional land management. There is a general ban on vegetation fire, although the authorities can not effectively enforce it.

My study focused on the cattle's foraging strategies, plant selection and how they chose between different-aged patches. It is unknown how important the different-aged burnt areas are and there is a lack of basic knowledge about animal movement and selection for different graze/browse species within this landscape mosaic. Our purpose was to analyze habitat use and plant selection of free-ranging livestock in burnt and patchy sub-alpine *Erica* scrub.

Methods

Study area

The study was carried out in the grazing areas of Angafu (N 06° 50´20´´, E 039° 14´41´´), Bale Mountains, Ethiopia. Bale Mountains is situated 400 kilometres southeast from Addis Ababa. The study area is at an altitude of circa 3500 meters a.s.l. The landscape is nutrient-poor and dominated by Ericaceous scrubs. The climate is relatively cool and wet (precipitation ca 1800 mm, average year temperature ca 10 °C). Frosts are frequent during clear nights (Wesche et al. 2008). Small homesteads are scattered just below the tree line in the valley area named Angafu. Cereal production is not possible due to the frequent frosts at this high altitude and the farmers have the traditional livestock management as their major economical income. The cattle are released from the farmhouses in the morning and move freely on the mountain during the day, without any surveillance. Calves are kept close to the farm in small pens. Every evening the cattle return home by themselves and the cows are milked.

Interviews

By interviewing one male and one female farmer cattle-owner data was collected about sex and age composition of the herd, seasonal patterns in the use of grazing areas, health status etc. The informants also answered questions about what they know of movement patterns of the livestock and what patches and plant species the cattle normally prefer. The interviews were interpreted from Oromo language to English by a local guide. Each interview lasted for about 1.5 h.

Field observations

The data collection took place in the early part of the dry period, in October - December 2008. Our team consisted of two undergraduate students, a supervisor and the local guide who also functioned as an interpreter.

The observations were made during different parts of the foraging day. In total ca 20 days of observations was carried out, each day with different randomly selected animals. Herds were selected depending on their accessibility. The herds represented “normal” groups of cattle in this area, which implies a herd size of 8-15 head.

Foraging behaviour

When a herd of cattle was seen, we slowly approached it and waited until the cattle showed no signs of being disturbed by our presence and were foraging normally. In the current patch, one mature lactating female of the herd was randomly chosen and monitored by two observers during ca 7 minutes. One observer had binoculars; the other was using a stopwatch and continuously making recordings about the different activities: grazing on the grass/herb vegetation, browsing on *Erica* shrubs, walking without feeding and other activities. The stopwatch contained a memory so every activity episode from the cow was saved and after the observation period was finished, the times were noted in the protocol. The position of the cow at the start and at the end of the observation period was noted. In some cases this was done with the aid of laser-finding binoculars with built-in compass and range-finder (Leica Vector 1000, Leica Geosystems AG, Heerbrugg, Switzerland). In other cases location was determined by taking digital photos at the start and end of the period and later relocating these positions.

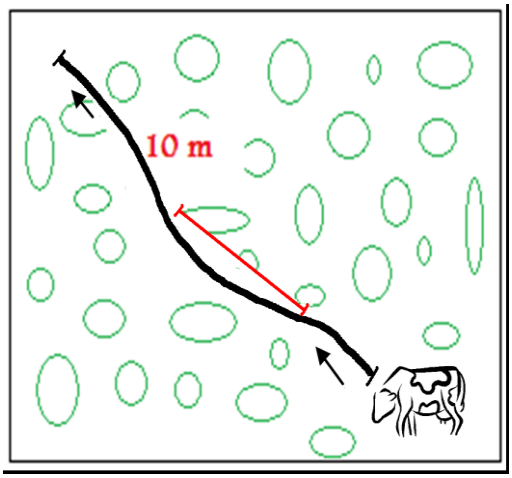

Fig. 1. Schematic example of a patch with *Erica* schrubs shown as circles and lawn vegetation in between. The movement of the cow is illustrated with a black line and the randomly placed transect in red.

After the observation period, the net distance travelled by the cow was measured with a tape measure and the starting position was noted with a GPS. To quantify the vegetation along the route, a 10 meter line transect was randomly placed along the cows path (Fig. 1) and the presence of *Erica* shrubs and grass/herb vegetation and bare soil was continuously noted along the transect. Further, for each *Erica* bush, the maximum, average and browsing height was measured and a visual estimation of the percentage of the area of the bush that was recently browsed was carried out. To see if stumps from previous bushes (killed by the last fire) had an impact on the browsing pressure they were counted and their height measured. For the grass/herb sward, height and relative cover of different species (in % of the total herb/grass cover) was estimated by eye. Visible signs of foraging on the different herb/grass species were also noted.

In total 50 separate cow observations were made: 25 in 1-year-old burns and 25 in 3-year-old burns. The observations were made during different parts of the foraging day during 20 different days, each time with a different randomly selected animal. A few observations in 2 year old vegetation and vegetation classified as old were also made but excluded since they were too few for statistical analyses.

To estimate if the two *Erica* species were handled differently by the cows, shoots from different randomly chosen 1-year-old and 3-year-old burns were collected and the diameter of the Erica shoot stem at the bite was measured with a digital calliper.

Data analysis

In the analysis of the results, the feeding behaviour and plant selection was compared for the two age classes of time since burning: 1 year and 3 years.

Statistical analyses were made using Minitab 15. The different heights of the *Erica* shrubs were tested with t-tests. The comparison between the species of the same age was made with paired t-tests and the comparison between different ages was carried out with two-sample t-tests. The bite size and the cattle's average speed was analysed with ANOVA, General Linear Model. The relationship between vegetation composition and foraging time allocation was tested with regression analyses.

Results

In total 50 observations were made of foraging behavior and selection of forage species. They were equally distributed between 1 and 3 year old burned patches. All time observations were paired with their corresponding vegetation transect (Fig.1 and 2).

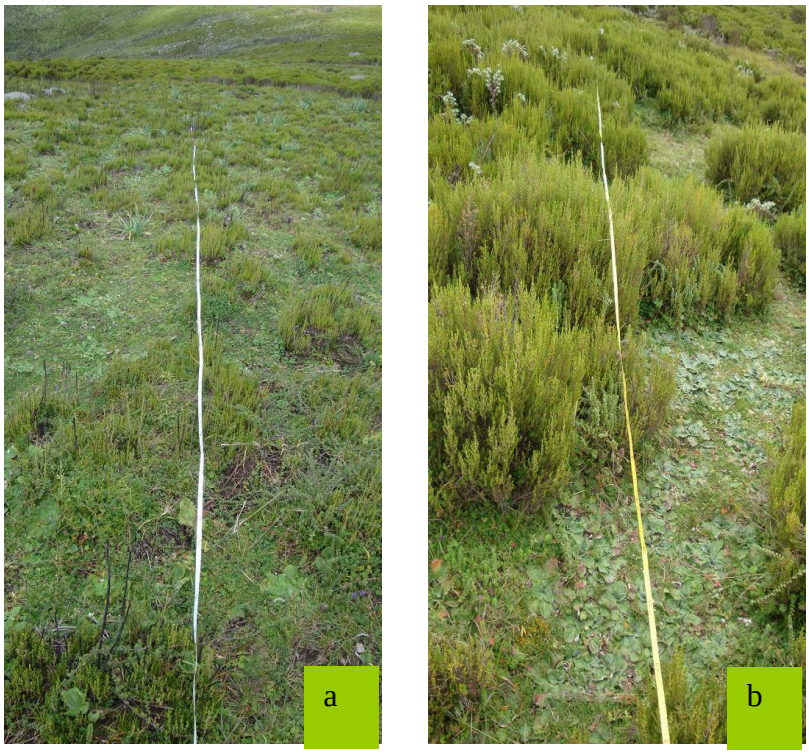

Fig. 2 a and b. Typical pictures of transects in 1 year old (a) and 3 year old (b) vegetation. The measure tape is placed along the cows foraging path.

Composition of the vegetation

The transect data showed that the vegetation in the different-aged patches varied (Fig. 3). In the one year old patches there was a dominance of grass/herb vegetation here after called "Lawn" and the *Erica* shrubs were mainly *Erica trimera*. In the 3 year old patches there were an almost equal division between Lawn and *Erica* shrub cover, both *Erica trimera* and *Erica arborea* cover had increased at the expense of the lawn.

The Lawn was composed of herbs and grasses (including sedges) (Table 1). Grasses had an average height of 1.8 cm and a maximum height of in 2.5 cm in both burn age classes. The area cover of vegetation was marginally higher in the older patches. There was also less exposed soil in the older patches (14 vs. 33 %).

Various herbs comprised the dominant part of the lawn cover and it increased from the 1 year old to the 3 year old patches. Among the herbs *Trifolium* spp. covered the main area but there were many other species almost always present such as *Alchemilla* spp., *Haplocarpha schimperi* and *Thymus schimperi* (Table 1). Less frequent species were *Bidens* spp., *Geranium* spp., *Agrocaris incognita* and others. All the herb species mentioned here had signs of being grazed by cattle.

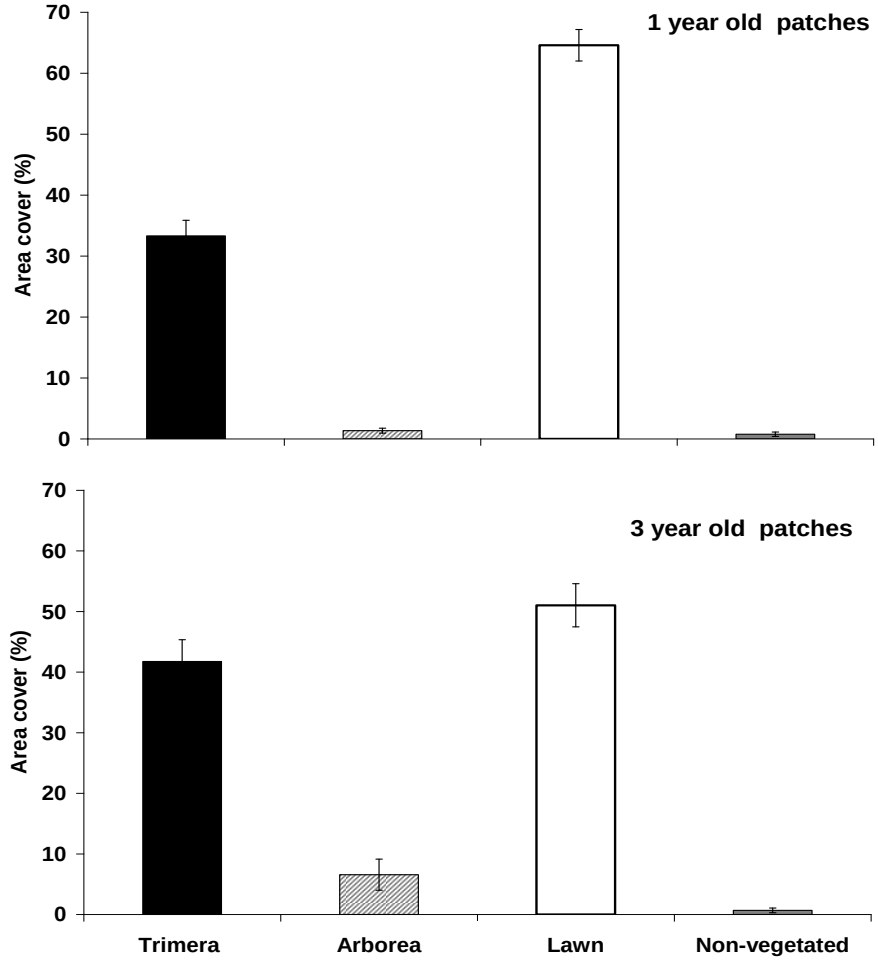

Fig. 3. The vegetation cover of the burnt patches. Lawn includes grasses, sedges and herbs.

Table 1. Cover of the Lawn in 1 and 3 year old burns. The proportion of the Lawn area covered by grasses, herbs and bare soil in percent with standard error within brackets.

	1 year old burn		**3 year old burns**	
	%	S.E.	%	S.E.
Grasses/Sedges	**21.1**	**(1.73)**	**29.0**	**(2.03)**
Herbs	**46.1**	**(2.32)**	**56.7**	**(2.76)**
Alchemilla haumanii	1.6	(0.31)	4.7	(0.64)
Alchemilla spp.	2.7	(0.36)	4.5	(0.93)
Bidens spp.	0.4	(0.18)	0.1	(0.11)
Geranium spp.	0.6	(0.25)	0.3	(0.14)
Haplocarpha schimperi	5.4	(1.10)	4.0	(1.21)
Agrocaris incognita	0.7	(0.23)	0.7	(0.20)
Thymus schimperi	2.1	(0.35)	2.8	(0.25)
Trifolium spp.	30.0	(2.33)	37.5	(2.20)
Other herbs	2.5	(0.34)	2.2	(0.42)
Soil	**32.9**	**(2.67)**	**14.3**	**(2.09)**

Both *Erica* shrub species showed the same growth patterns in the different aged patches, 3 year old shrubs were more than two times taller than the 1 year old (Fig. 4). There was a significant difference between the two species in heights, *Erica arborea* was always taller in average than *E. trimera*. The average height for *E. trimera* was 10 cm and *E. arborea* ca 14 cm (P= 0,004) in 1 year old patches. In the 3 year old patches *E. trimera* had an average height of 24 cm and *E. arborea* 39 cm (P= 0,001).

The average height in both 1 and 3 year old patches for dead stumps of *E. trimera* was ca 25 cm and for *E. arborea* ca 66 cm (Fig. 4). There was a significant difference in the height of remaining stumps between *E. arborea* and *E.trimera* for both 1 (P= 0,008) and 3 (P=0,015) year old patches.

The browsing pressure on the species was estimated as a visual percentage of recently browsed shoots of every individual. *Erica trimera* shrubs were consistently more browsed than the *Erica arborea* in both 1 (P= 0,012) and 3 (P=0,003) year old patches (Fig. 4). The highest browsing pressure were on the 3 year old trimera (72%) then came the 1-year old trimera (66%) followed by 3 years old arborea (44 %) and finally the least browsed was the 1 year old arborea (37%). There was a significant difference in browsing pressure between 1 and 3 year old *E. trimera* (P=0,023) but no difference between the different-aged *E. arborea* (P=0,409).

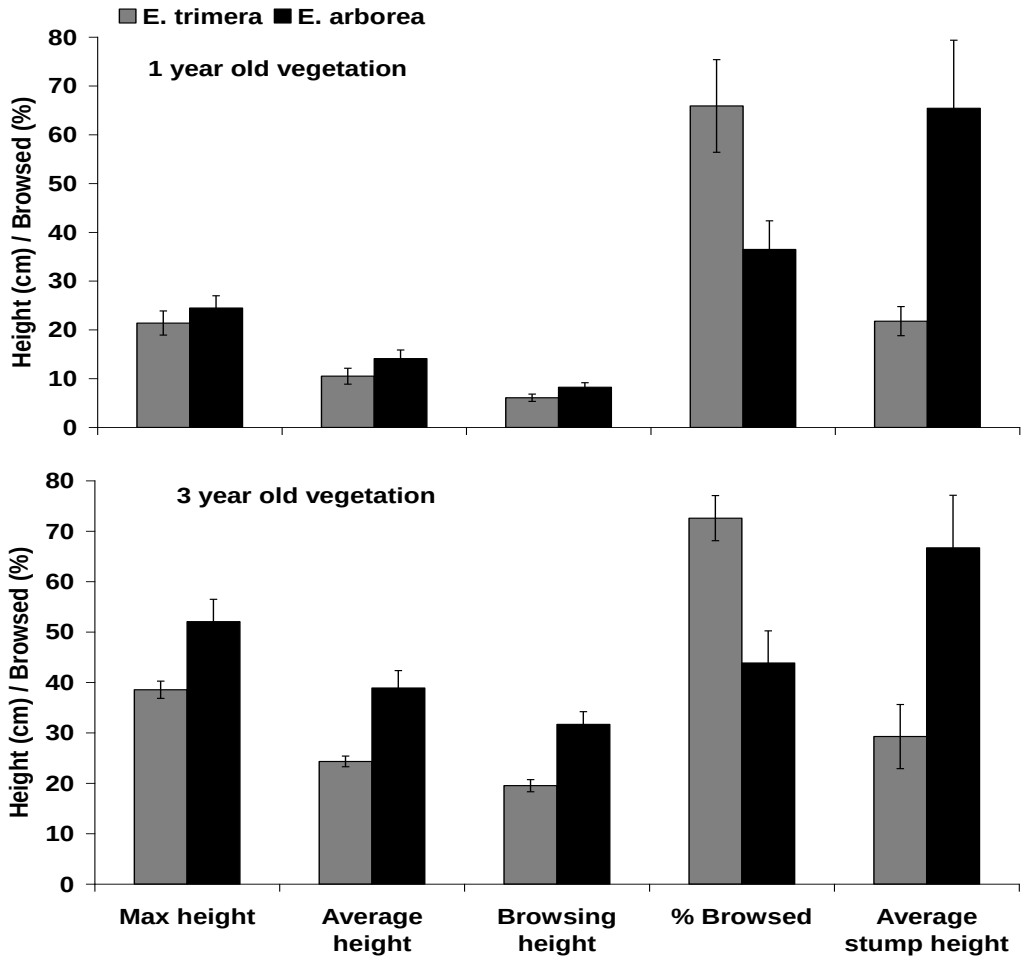

Fig. 4. The characteristics of the Ericaceous vegetation for 1 and 3 year old burns with standard error bars. Note that all bars except browsed (%) are in cm.

When it comes to handling the different *Erica* species differently, the results in this study show that the cattle browsed bites off *Erica* shoots with a diameter of between 0,4 mm to over 1,8 mm (Fig. 5). There was no significant difference in browsed diameters between the different ages for *E. arborea* (P=0,8279). The bite diameters for 3 years old *E. trimera* were however significantly larger compared to both 1 and 3 years old shoots of *E. arborea* (P=0,0031 and P=0,0009).

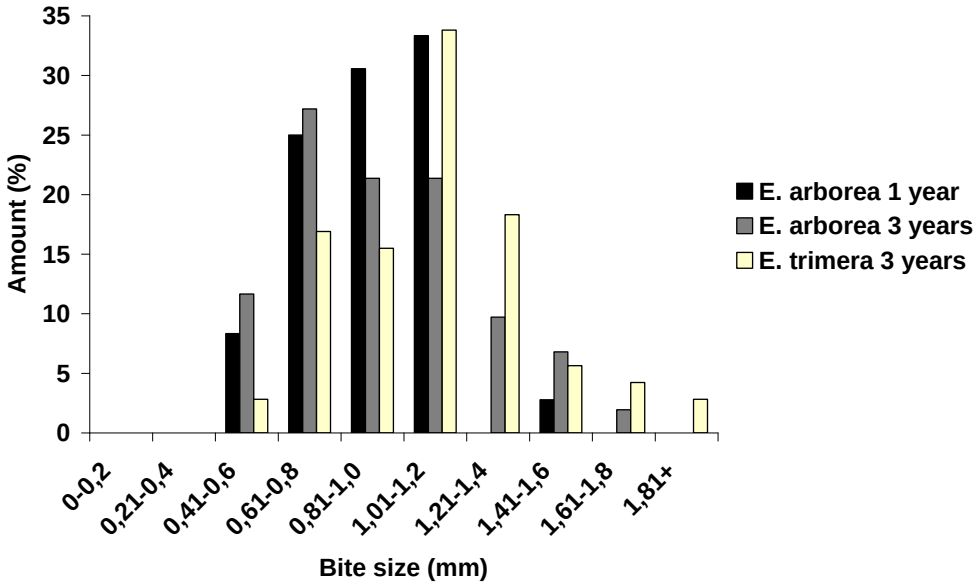

Fig. 5. Frequency distribution of bite sizes on fresh shoots from patches of *E. trimera* 3 years old and *E. arborea* 1 and 3 years old.

Fig. 6. *Erica trimera* with a browsed shoot, marked with a black arrow.

Cattle time allocation

The cattle spent most of their time foraging: ca 90 % of the total observation time in the 1 year old burns and 87 % in 3 year old burns (Fig. 7). The rest of the time there were other activities: walking, standing, looking, scratching etc. More time was spent foraging on the Lawn vegetation than on *Erica* vegetation in both age classes.

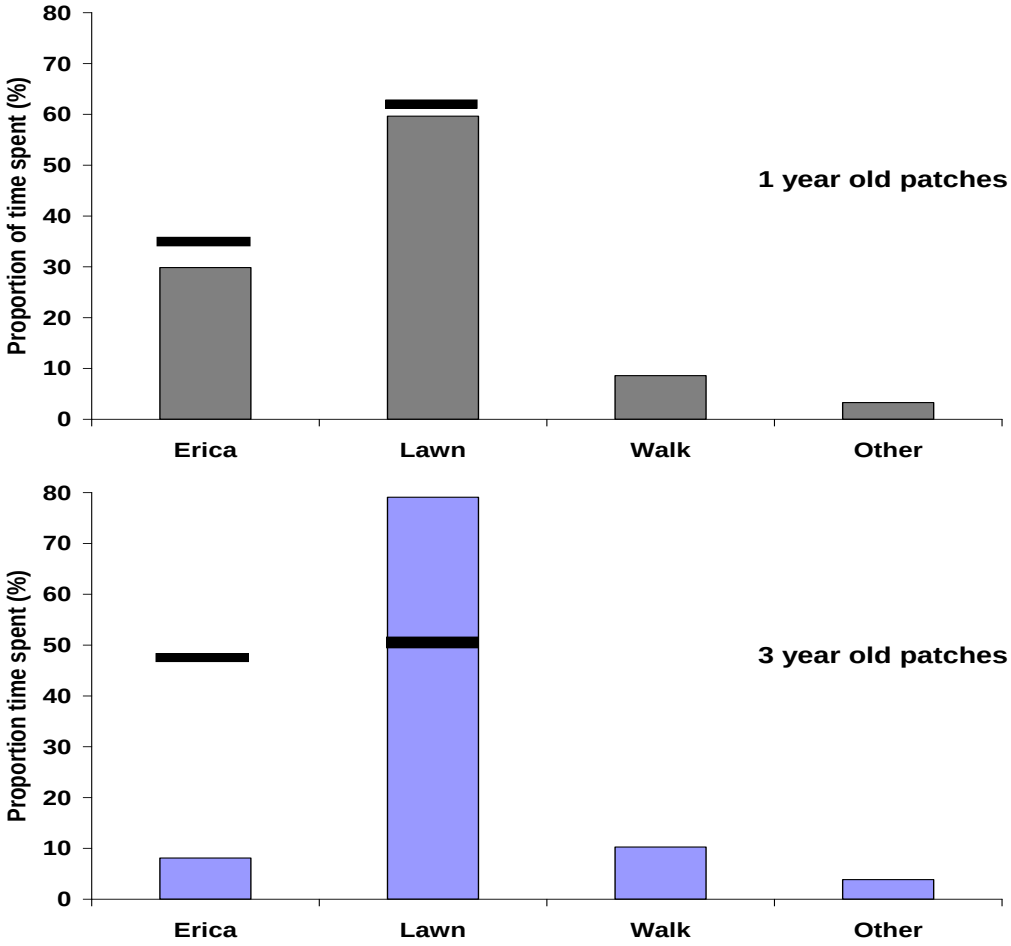

Fig. 7. Average amount of time spent on foraging, walking and other activities in 1 and 3 year old patches respectively. The black blocks are the proportion of *Erica* shrubs and Lawn cover that was available out of the total vegetation cover.

The difference between the two age classes were that in the one year old patches the cows selected feed almost according to what was available but in the 3 year old patches they spent more time on Lawn (Fig. 7). About 62 % of the area in the 1 year patches was covered with Lawn, and the cows spent 60 % of their time grazing Lawn, giving a time/vegetation quota of 0,933 (Table 2), there was ca 35% cover of *Erica* and they browsed *Erica* during ca 30% of their time (quota 0,911). Contrary for the 3 year old patches, the time spent on grazing lawn was much higher (79%) than the lawn cover (49%), leading to a quota of 1,739 and the *Erica* shrubs which covered ca 50% of the vegetation was only browsed during ca 8% of the time (quota 0,182). There was a significant difference in quota for both Time spent/Lawn (P=0,000) and Time spent/*Erica* (P=0,000) between the different ages.

Table 2. The quota between Time spent / available area cover of Lawn or *Erica* (%). Standard Error within brackets.

	Time spent /Lawn	**Time spent/*Erica***
1 year old patches	0,933 (0,06)	0,911 (0,11)
3 year old patches	1,739 (0,14)	0,182 (0,04)

Fig. 8. A cattle herd foraging in a one year old burnt patch

Fig. 9. Cow browsing *Erica* shrub (left), and cow grazing Lawn (right), in a one year old burnt patch.

The time spent on foraging Lawn or *Erica* shrubs was mainly dependent on the availabilty. In the case of grazing Lawn there was a significant linear regression (P= 0,017 for 1 year old patches and P=0,001 for 3 year old patches) between amount of Lawn per transect and the time spent grazing on the Lawn (Fig. 10). The trend was the same for *Erica* cover but the regression was only significant (P=0,002) for the 1-year old patches (Fig. 11).

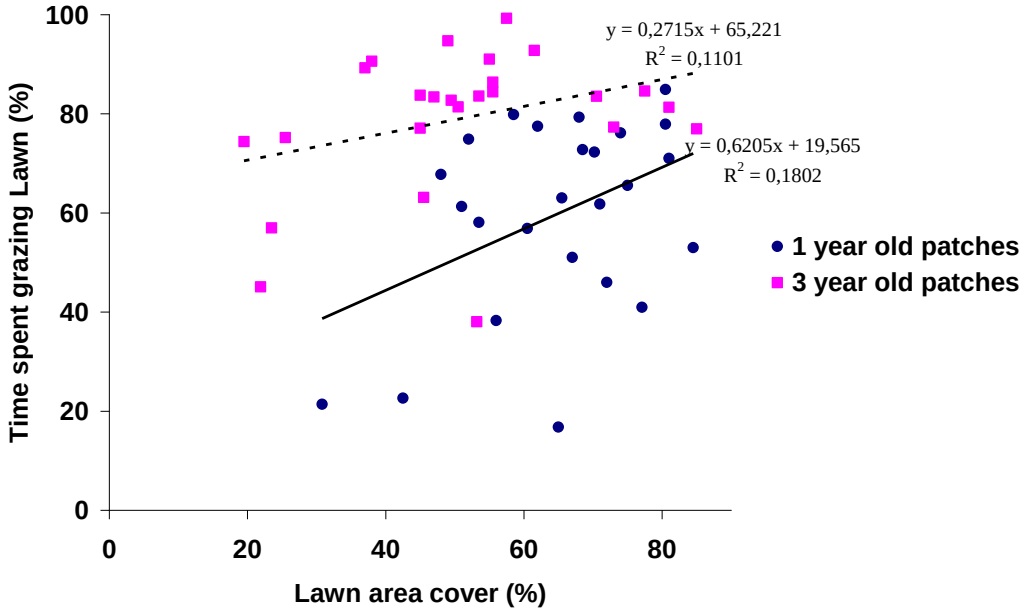

Fig. 10. The amount of time spent grazing Lawn in relation to how much Lawn that was available in 1 and 3 year old burned patches.

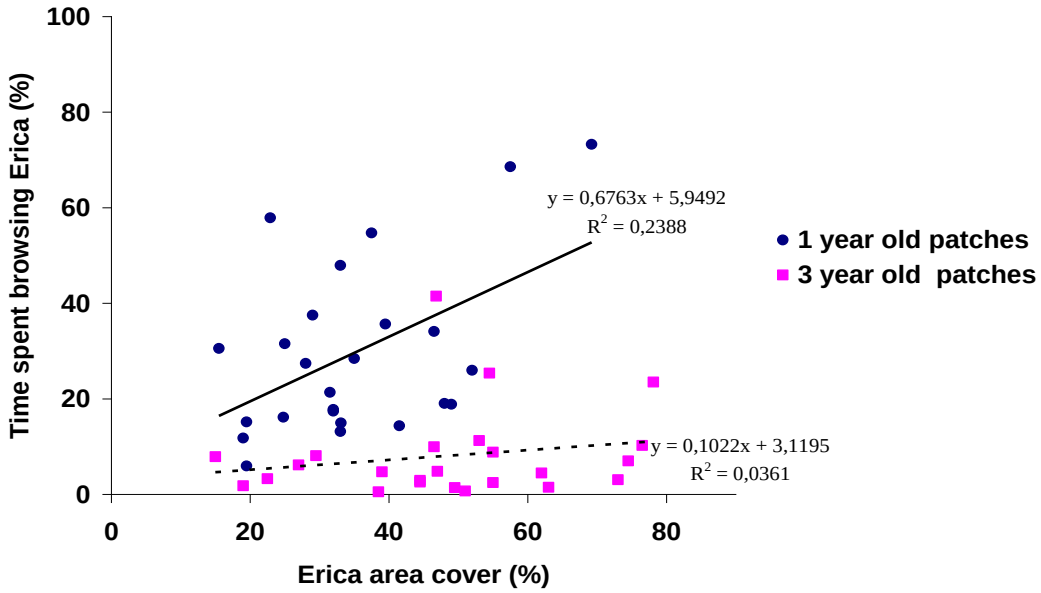

Fig. 11. The amount of time spent browsing Erica in relation to how much Erica that was available in 1 and 3 year old burned patches.

Movement of the cattle

The cattle started their day at sunrise and set off towards the mountain pasture at about 7 am. They then ranged freely during the day and returned to their homes at ca 5 pm. The movement pattern was very different in the beginning and the end of the day. In the morning the cows moved slower, made more feeding stops and in the late afternoon they had a faster pace, particularly if they were far from home (Å. Arvidsson unpublished). Most of the time they were moving and it was not very common to see any ruminating cattle during the day. The normal movement pattern of the cattle was that they were slowly walking over the Lawn with their heads down, grazing at the same time as they moved forward. Momentary they lifted their head a little and browsed from an *Erica* shrub for a short while or they just walked without feeding (Fig. 12).

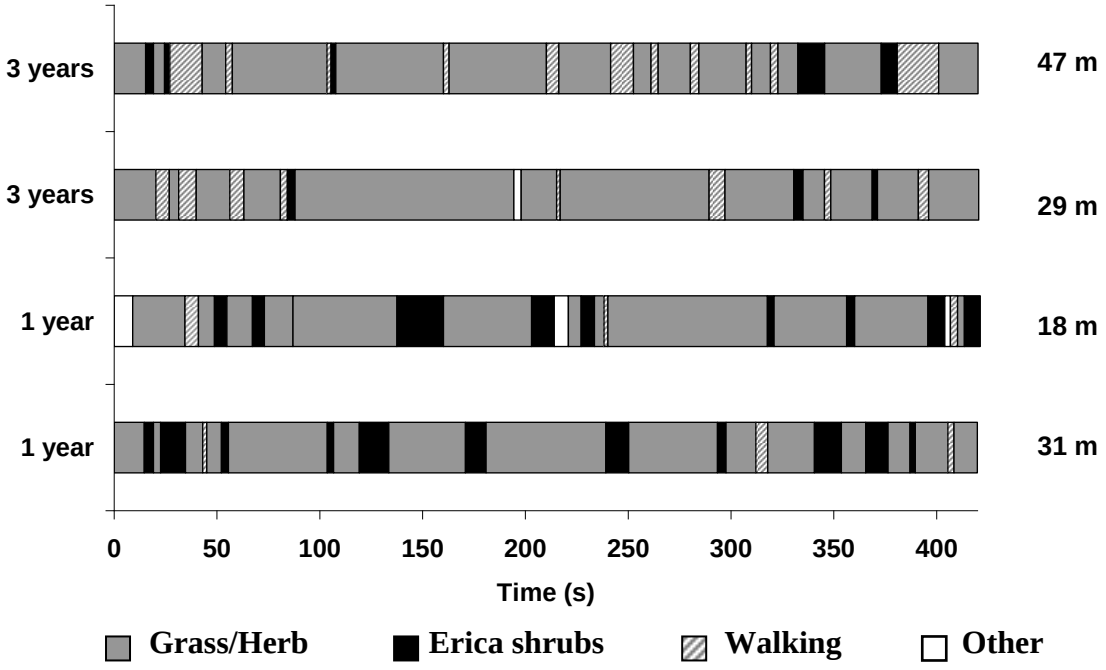

Fig. 12. Four different observation examples of cows foraging behavior and movement between different vegetation in 1 and 3 year old burned patches during 7 minutes. The distance moved by each cow is showed to the right of the bars.

The average distance that the cows moved during the 7 minute observation period was 32,7 m with an average speed of 4,5 m/min in 1 year old burns and 34,4 m with a speed of 4,8 m/minute in 3 year old burns. The speed range was broad and there was no significant difference (P= 0,673) between the different-aged patches. Based on these results the cattle move with an average speed of approximately 300 m/h. Most of the episodes when the cows walked were 2-10 seconds long and there was no significant difference between ages (P=0,152) (Fig. 13).

There was a significant linear regression (P=0,000) between proportion of the time spent walking and total distance reached (Fig. 14). The regression suggests that the speed of movement during "pure feeding" was 14 m/7 min = 2 m/min and ca 25 m/min when the cows were walking without feeding.

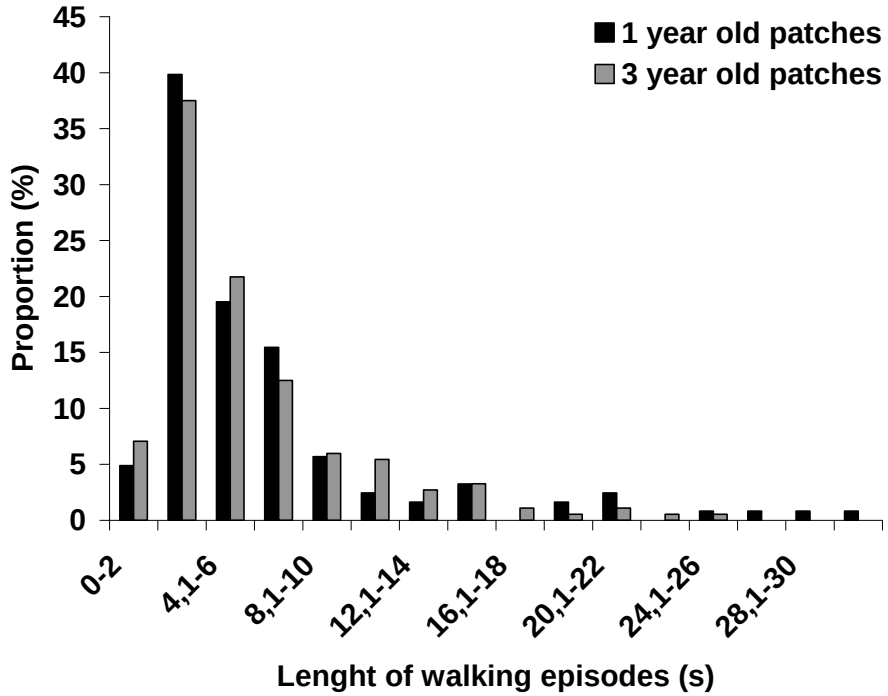

Fig. 13. Frequency distribution of the walking episodes in 1 and 3 year old burned patches.

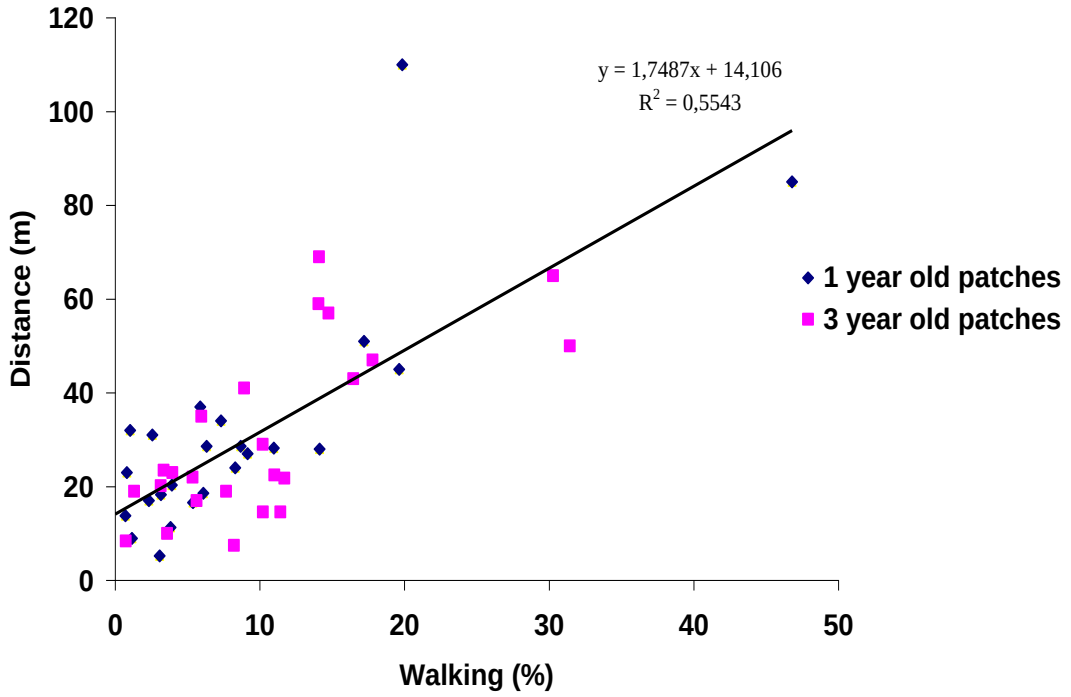

Fig. 14. The relationship between the proportion of walking per transect and total distance travelled during the observation period, for 1 and 3 year old burned patches.

The episode length spent on browsing *Erica* was significantly different (P= 0,0128) between the different aged patches (Fig. 15 a,c). In the younger burnt areas there was a greater span in browsing episode length. In the older patches the time spent was more focused on shorter episodes between 0-10 seconds. For the Lawn, the relation was reversed. Grazing episodes were shorter in the young patches and longer in the older patches, up to Lawn grazing for over

200 seconds per stop (Fig. 15 b,d). There was a significant difference (P=0,000) between different-aged *Erica* and Lawn episodes.

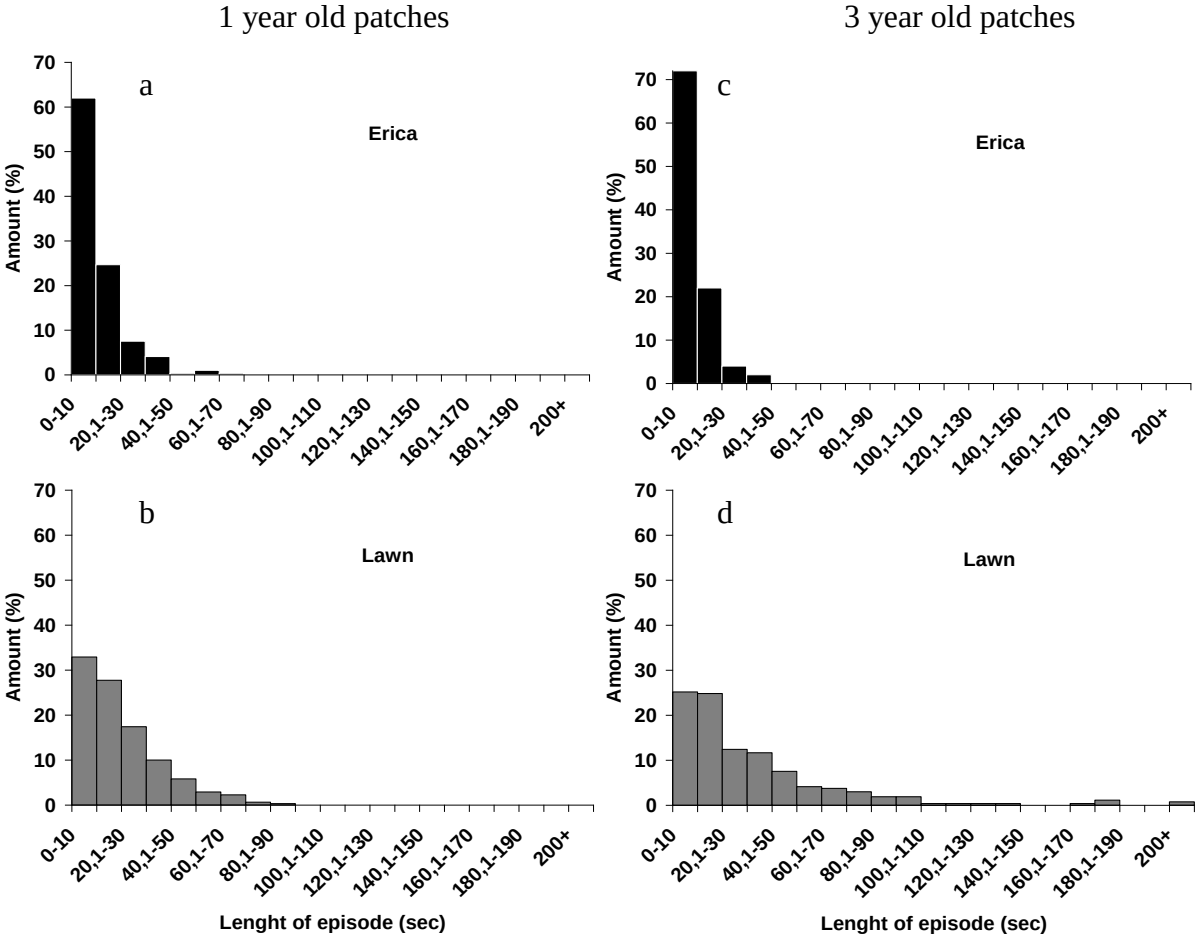

Fig. 15. Frequency distribution of length of episodes (s) of foraging Erica (a, b) and Lawn (c, d) in 1 and 3 year old burned patches.

Interviews

Two interviews were carried out in Angafu; one with a man named Aliyi Mudda and the other with a woman named Obure. Both live in Angafu and use the valley where we have carried out our study for their cattle. Aliyi Mudda lives with his wife and children and he is about 30-36 years old. Aliyi has a herd of cattle composed of 4 calves, 10 cows, 10 younger individuals and about 6 bulls. Obure is approximately 35-40 years old, married and has many children. She is responsible for 10 cattle. The herd has 4 calves, 3 heifers and 2 cows that are older than 4 years. There is also one bull. Until recently they had more cattle but, due to the very long dry season 2007/2008, they lost some head due to starvation.

The day for a cattle herd starts in the morning with the group being herded a short way up the mountain (Fig. 17). The day ends with the herd being collected from nearby the house to keep them safe from hyenas within the fenced farmed area. The cattle can mix with other herds during the day, especially in the morning because they all travel up the mountain the same way; usually they split up when they reach the plateau. Aliyi stated that his herd can split up into 2-3 sub-herds.

Fig. 16. The farm of Obure and her husband. In the centre of the picture is the dwelling-house. The structure to the left is an animal pen for sheep and calves. Surrounding the farm are small cultivated areas with mainly spring onions and cabbage. The milking takes place in the open space to the right of the dwelling house. The wood leaning against a tree in the middle are poles for building houses, made out of *Hypericum revolutum*.

Fig. 17. Early morning when the cattle is herded off up the mountain valley. The cattle-owner Obure is seen in the central part of the picture.

There are seasonal patterns for the herd regarding herd management. During the dry season the cattle is herded more to help them find water and shelter in the forest. During the rainy season they may go wherever they prefer (Aliyi). According to Obure the cattle use the entire plateau and have a home range that reaches from Sorboa, Iresa, Wagebeta ridge and towards the slopes of Bikika, i.e. around 2 km from the homestead.

The cows spend most of their time grazing a little bit up in the valley and also on the plateau. Both informants suggested that the cattle move in total 1-3 km/day. When they have plenty forage they will not walk far, but during the dry season when forage is more limited they travel further. The movement pattern of the herd is mostly decided by the cattle themselves and Aliyi had no explanation to why they choose different sides of the valley on different days.

According to both informants the most valuable grazing land in Angafu is the *Erica* heathland. *Erica* shoots are very important for the cattle, especially in the recently burned patches. They consider the 1-2 year old burned patches to be very important. When up in the *Erica* zone the cows have *Erica* shrubs, grasses and herbs, like *Trifolium spp*., *Alchemilla spp.* and *Thymus schimperi* on the menu. Aliyi could not say what they prefer the most when it comes to grass, sedges and herbs but he thought that they are all good forage.

Neither of the families cultivates any extra feed for their cattle at their farm but they cut tree branches as extra fodder. The most commonly used species are *Hagenia abyssinica*, *Hypericum revolutum*, *Erica trimera* and *Schefflera spp*. Cows can also eat *Urtica spp.* which are seen as very good feed, especially the roots (Obure). This extra forage collection only occurs during the dry season (Ayano).

Discussion

The results show that the cattle use varied foraging strategies in different-aged patches. The Lawn vegetation was definitely most popular and *Erica* was browsed mostly in the younger burned patches. On the other hand, speed of movement, or proportion of time actually spent eating did not differ between 1 and 3-year old burn patches. In both cases very little time was spent on other activities than feeding.

Vegetation composition and allocation of feeding time

In one year old patches the time the cattle spent foraging on *Erica* and lawn was proportional to their respective cover, but in the three year old patches there was a completely different scenario. Very little *Erica* was browsed compared to its vegetation cover and most time was spent on grazing the Lawn, even though it only covered 50% of the surface area. The grazing episodes were also longer for the Lawn, sometime as long as over 3 minutes, during which time they slowly walked past several *Erica* bushes without taking a single bite. Overall, the foraging results show that at the beginning of the dry season the cattle prefer Lawn before *Erica* shrub.

Theory suggests that cattle choose feeding areas based on its species composition, nutritive value and sward height (Milne 1991). However, there were few substantial differences in species composition within the lawn between 1 and 3-year old burns that could explain the changing preferences. *Trifolium* spp. was dominant in both cases. One reason for the popularity of the Lawn in Angafu could be the increasing density of grasses and herbs from 1 year to 3 year old burn patches, which gives the cattle more biomass to forage even though the total area covered by lawn vegetation decreases. This is corroborated by the fact that sward height was similar in both 1 and 3-year old burns, indicating that virtually all available grass/herb forage was used.

The popularity of grazing Lawn could also be explained by the amount of secondary metabolites in the *Erica* shoots. Woodward and Coppock (1995) found that food preferences in cattle tend to be related more according to tannin and nitrogen content than the amount of fibres and digestibility. Browse plants, compared to grasses, contain higher levels of cell contents, lignin, secondary compounds and nitrogen (Gordon 1989).

The fact that there was a linear relationship between availability of *Erica* and time spent, and that cattle used more time browsing *Erica* in the younger patches, can be an effect of the fire. After an area has burned the fresh shoot biomass is significantly greater and the grazing intensity responds to the increased biomass and the amount of nitrogen present in the fresh shoots (Wallace and Crostwaite 2005). Fresh shoots could also be more tasty.

There was also a difference between the two *Erica* species. *Erica trimera* was shorter than the *Erica arborea* and *E. trimera* also had a higher degree of the surface area recently browsed. Finally, *E. trimera* shoots were on average bitten off at a slightly larger diameter than the *E. arborea*; all this indicate that the cattle prefer *E. trimera*. Johansson et al (unpublished) compared the forage value of the two *Erica* species. Surprisingly, they found substantially higher tannin activity in *E. trimera*, and suggested that there might be an unknown chemical browser-deterrent in *E. arborea*.

Theories about forage selection matches with the fact that cattle's ability to avoid or select feeds comes from the integration of sight, smell, taste, texture and postingestive effects (Provenza et al. 1998, Dougherty and Collins 2003). Processes like fire within an ecosystem, alter the distribution, abundance, nutritional, and toxicological characteristics of plants and fire can thereby be a useful tool to create optimal foraging conditions for domestic cattle.

The cows spent 87-90% of the observed time actively foraging. The remaining time they spent on other things, mostly short episodes of walking. The observations of cattle behaviour in this study were conducted when the animals were not occupied with fighting, ruminating etc. However, also when considering a longer time frame (Å. Arvidsson unpublished), there were very few longer stops during the day, and nearly no ruminating. Therefore, my data should be representative for the average feeding behaviour.

This study was conducted right at the end of the rainy season and the beginning of the dry season which means there was still a lot of available green grass. What happens later during the dry period when the grasses have dried and turned brown we can only speculate about. Most likely the importance of *Erica* as forage will increase and the cattle's moving pace will decrease due to the weather. Sanon et al. (2007) noticed that when the season shifted from rainy to dry there was a decline in cattle feeding activity in a Sahelian area. They also saw, at the same time, an increase in resting and ruminating activity.

Movement of the cattle

The cattle spent most of their time moving between 1 and 3 year old patches which were dominating the valley landscape. In the dry season of 2008, most of the older vegetation had been burnt. This is the reason why foraging data was only collected from 1 and 3 year old burns, despite our original plans to include also older vegetation. Likewise, the small amount of burning during the dry season 2006/2007 resulted in very few available 2 year old patches. When it comes to patches older than 3 years, there were some activity in four year old patches but not enough to gather any data, Cattle were rarely seen foraging in patches older than 4 years.

The movement pattern was somewhat variable seen over the entire day, which makes the total movement distance a bit longer or shorter depending on herd, weather and other factors The speed of movement had a span of 80-1500 m/hour, with an average of about 300 m/h. If this is extrapolated to a full 10 hour day, the distance that the cattle travelled was ca 3 km/day. This is roughly equivalent with to the information gained by the interviewed farmers and our own field observations (Å. Arvidsson unpublished).

Traditional ecological knowledge

The interviews showed that the cattle owners had an intimate knowledge of the cattle and their foraging behavior. They knew the important forage species on the mountain and emphasized the importance of newly burned areas for the nutrition of the cattle.

Both informants emphasized that the cattle have a much rougher period towards the end of the dry season and they then need some help to locate and obtain enough forage. Normally the dry period lasts approximately 3-4 months (Nov-Dec to Feb), but occasionally it extends much further. 2007/2008 was such an extreme dry period and there were several losses within the herds. The farmers in Angafu, as seen in several places, for example by Sanon et al. (2007) in

the Sahelian land, used branches from various tree species as extra forage for the animals during the dry season. There are virtually no other possibilities to obtain supplement feed. In cereal-producing areas at lower elevations there is a possibility to feed with straw. Here the only available substitute resource is tree branches. Informants also stressed the importance of *Erica* during the dry period.

Conclusions

The results show the importance of the Afro-alpine heathlands for the availability of forage with the right quality and quantity for the cattle. Access to fresh shoots of *Erica* shrub and Lawn species is very important during this time of year and constitute the greatest part of the diet. Traditional fire management of *Erica* vegetation creates good pasture land and the study supports decisions for this management strategy of grazing areas in the Ethiopian highlands.

Further studies focusing on the quantity, amount produced biomass of *Erica* shoots and grass per day, and quality of the forage would be helpful. An explanation to the foraging behaviour and why the cattle choose to mix their diet would increase the understanding.

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