HABITAT SELECTION OF CATTLE IN A TRADITIONALLY FIRE-MANAGED LANDSCAPE IN THE BALE MOUNTAINS, ETHIOPIA

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SAMMANFATTNING

I det Etiopiska höglandet är jordbruk och boskapsskötsel oftast den enda inkomstkällan. På höjder över 3 300 m får man ibland minusgrader på natten varför det inte går att odla spannmål, men boskap ger både kött, mjölk och pengar. Om det inte skulle gå att hålla boskap vore det vara omöjligt att livnära sig på denna höjd.

När man når höjder på 3 500 möh är det ljung av de två arterna *Erica trimera* och *Erica arborea* som dominerar vegetationen. Om dessa arter får växa fritt kan de på tio år nå nära 2 meters höjd och bli trädlika. Nötkreatur, får och getter kan då inte nå grenarna och kan inte heller livnära sig. För att hindra att ljungen blir för hög bränns den vid en ålder av 5-10 år, varefter det kommer rikligt med nya stubbskott. Detta medför att det blir ett mosaikartat utseende på heden med ljungområden av olika ålder. Denna bränning är dock olaglig.

Huvudsyftet med min studie var att undersöka vilka åldersklasser av ljung som kreaturen utnyttjar, vilket kan indikera om bränning av ljung är nödvändig för att boskap ska kunna livnära sig i området.

En ko valdes ut vid varje observationstillfälle och sedan noterades var 5:e minut i maximalt 4 timmar vad denna ko gjorde och hur gammal ljungen var där hon befann sig. Dessa data gav information om hur djuren fördelade sin tid i brännor av olika ålder. Efter att sedan ha gjort linjetransekter på fotokartor kunde tillgången på de olika åldersklasserna i beteslandskapet räknas ut.

Sammantaget använde korna 78% av tiden under dagen till att beta, under långsam rörelse. De idisslade bara 2% av tiden. Korna befann sig oproportionerligt mycket i ung vegetation. Trots att bara 31% av ljungen var 1 år gammal uppehöll sig korna i denna ålder 44% av tiden. För den 3 åriga ljungen var proportionerna mer lika, 26% av observationerna var kon i 3 åriga brännor och 28% av ljungen var just 3 år. Däremot var 43% av ljungen klassad som gammal men korna tillbringade endast 19% av sin tid där. Det kan även tilläggas att korna var tvungna att passera gammal ljung för att komma till yngre varje dag. Detta medför att korna förmodligen hade tillbringat än mindre tid i gammal ljung om de hade kunnat välja att vara i ung ljung hela tiden.

Korna gick i flockar på 7-18 djur. Under betet förflyttade de sig vanligen i ganska rak riktning, med en medelhastighet av 0,25 km/h; under förmiddagen upp på berget och under eftermiddagen ner mot gården, oftast utan att bli drivna. Sammantaget gick de ofta kring 3 km/dag.

För att få ytterligare kunskap och förståelse för boskapsskötseln i området gjordes intervjuer med två boskapsägare. För dem är det självklart att ung, nybränd *Erica* är den viktigaste näringskällan för deras boskap. Mina resultat stödjer deras åsikt; den traditionella bränningsskötseln av vegetationen på höglandet tycks ge boskapen i området ett bra bete och gör det möjligt för invånarna att fortsätta livnära sig.

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

SUMMARY

In the Ethiopian highlands farming often is the only income. Above 3 300 m elevation however, cultivation is limited by the fact that it often is below 0 ˚C during night. This makes it even more important to keep livestock for meet, milk and as the main income. If it was impossible to keep livestock it would be hard to make a living up in the mountains.

When reaching 3 500 m elevation two species of *Erica*, *Erica trimera* and *Erica arborea* dominates the vegetation. If the *Erica*-bushes grow freely they can reach a height of 2 meters in less than 10 years. Cattle, sheep and goats can then not reach the branches to browse. To prevent the *Erica* to grow this tall and to make it re-sprout, the cattle owners burn the vegetation when necessary. This burning makes the landscape mosaic-looking with patches of different age class. This burning however is illegal.

The purpose of my study was to analyze which age-classes the cattle use, and how they move during grazing. This can indicate whether burning is needed to maintain a productive rangeland.

Every observation-session lasted maximum 4 hours and every time one cow was selected and each five minutes the activity of the cow and the age of the vegetation were noted. After making line transects on premade photomaps the access to the different age classes (time since burning) was made. The results showed that the time the cattle spent in one year old burns do not stand in proportion of the amount one year old vegetation available. Despite the fact that it is only 31% of the vegetation that is one year old the cattle spent as much as 44% of their time there. For three year old vegetation the time spent and the amount is almost equal, 26% of the observations were made in 3 years old and 28% of the vegetation is burnt three years ago. Forty-three % of the vegetation was classified as old; the cattle however only spent 19% of their time there. Further, the cattle had to pass by old vegetation to reach younger, it is therefore possibly that the cattle would spend even less time in old vegetation if they were free to choose.

The cattle moved in herds with between 7 and 18 animals. While grazing they moved in a quite straight direction with an average speed of 0,25 km/h; mornings up the mountain and afternoons down to the settlements, often without being herded. Altogether the cattle moved around 3 kilometers per day.

To add more information on the animal husbandry in the study area two interviews with cattle owners were made. To the cattle owners it was obvious that young *Erica* is the most important feeding source for their livestock. This study support their view; the traditional fire management seems to give the cattle in the area a good pasture and in that way make it possible for the inhabitants to maintain their living.

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

INTRODUCTION

Ethiopia is one of the world's poorest countries with 25 per cent of the 75.6 million inhabitants living on less than 1 euro per day. 85 per cent of the people live on the countryside and make their living as farmers (www.sida.se).

In the Bale Mountains, where the study took place, the people are dependent on the ability to have their cattle grazing on natural pastures above the tree line. The Bale mountain region is the largest subalpine heathland in the whole continent of Africa (Hedberg, 1951).

Above the tree line at 3 500 meters above see level *Erica arborea* and *Erica trimera* dominates the vegetation. This *Erica*-belt is characteristic for all mountain areas in the region (Wesche et al, 2000). The *Erica arborea* and *E. trimera* bushes can reach a height of 2 m in circa ten years in this area (M. Johansson, unpublished), cattle however are normally not capable of browsing higher than 1.5 m (Sanon *et al*, 2007). Therefore different patches of the uplands are burned by the cattle owners on a rotation of roughly ten years, to rejuvenate the grazing/browsing areas. This also makes it more difficult for the predators to get close to the cattle (M. Johansson unpublished). The burning, however, is illegal.

According to Wesche *et al* (2000) this anthropogenic fire regime helps to maintain a structurally diverse and species-rich environment and without the fires tall *Erica* scrub would totally dominate the areas that today have a mix of shrub, grass and herb vegetation.

The cattle, a local breed of *Bos taurus indicus* (Figure 3), which graze the highland during the day, are kept in enclosed pastures around the owner's houses during the night to protect them from predators. Every day the cattle are released and wander free without shepherd in the mountains. Sheep, goats and small calves are always kept relatively close to the dwellings and followed by a shepherd because of their much smaller size. Otherwise, they are easy targets for the different predators living in the area: hyenas, foxes and leopards.

I worked in this area parallel to another MSc-student, Jenny Gustafsson. Jenny focused on which plants the cattle preferred. Focus in my study was on the habitat use of cattle with respect to age and composition of burn patches.

The purpose of the study was to evaluate the relative use of different-aged burn patches by cattle and to learn more about their grazing and browsing behavior in an Afro-subalpine heathland. This knowledge will help management decisions in the area, particularly with regard to the traditional burning of the rangeland.

LITERATURE REVIEW

The cattle as a ruminant

In environments without human impact, herbivores constitute more than 95% of the total biomass of mammals (Björnhag, 2000). There are two different types of herbivores: those who feed from seeds, fruit, nuts etc. and those who feed from roughages (folivores). Roughages contain cellulose which only can be digested by

some microorganisms. To be able to feed on cellulose the folivores have to live in symbiosis with such microorganisms. In ruminants the rumen gives the microorganisms a perfect environment: oxygen-free and with the right temperature, nutrition and space. The microorganisms are responsible for an extensive degradation of roughages in an anaerobic environment (Sjaastad et al, 2004). This degradation is a type of fermentation and from fiber-containing food the ruminant gets several end products that they can use for energy, there among volatile fatty acids.

The ability to transport the content of the fore-stomachs, including the rumen, to the oral cavity several times for additional chewing characterizes the ruminants. Preferably cows should spend 10-11 hours of the day feeding and ruminating (Andrews, 2000).

All artiodactylid animals except the swine are ruminants (Björnhag, 2000). Cattle are among other large ruminants and the camelidae one of the most effective ruminants because their size makes it possible to keep the fibrous food in their rumen for a sufficient time. Rumination has several benefits compared to fermentation in the colon which is the other option if feeding on cellulose (Björnhag, 2000). For example it is good not to divide the fiber too much at first because then it stays longer in the rumen. When the long fibers have been chewed enough they continue through the digestive tract and once the fibers have left the rumen the fermenting microorganisms no longer can process it. Another advantage of ruminating is that the production of saliva increase. Saliva contains buffering ions that neutralize the acidic effect that volatile fatty acid have on the ruminal content. A further benefit of ruminating is that when the material is transported to the mouth microorganisms follows and by chewing the microorganisms are pressed into the material. This makes further fermentation easier.

According to Sjaastad *et al* (2004), ruminants spends as much as one third of their lifetime ruminating. The more fiber in the roughage, the longer time the animals have to ruminate. Rumination mostly takes place at night or at rest and for every kilo of roughage a cow eat they ruminate for 35-80 minutes.

In test situations were cattle can choose what they want to eat from grass, leaf or herbs the cattle spent 70% of their time eating grass, 20 % of their time eating herbs and 10 % of their time eating leaf (Björnhag, 2000). One disadvantage of being a ruminant is that there is no possibility to speed up the passing time from the rumen and further into the digestive track (Björnhag, 2000). Compared to the horse that can survive on roughage that is very hard to digest by speeding up the passing time of their colon, were they ferment fiber, and just eat more. Ruminants lack the ability to do so and can therefore starve to death with a rumen full of fiber that is to hard for the microorganisms in it to digest.

The effects of grazing

According to Bakker *et al* (1998) the easiest way to analyze the effects of grazing on plant communities is to compare grazed and ungrazed situations. Grazing has a big effect on woodland and is assumed to be crucial to keep pastures in a semi-open state (Putfarken *et al*, 2007). It's also shown that the number of plant-species decrease due to competitive exclusion when the pasture is not longer grazed

(Bakker, 1998). Multi-species grazing probably have several positive effects on the vegetation.

One positive effect from multi-species grazing is that different species have different preferences of which part of the plants to eat and in some cases what plants they prefer (Pehrson, 1991). Another positive effect is that the parasite-pressure decrease (Radostits *et al*, 2007). Because most parasites are host-specific an alternate grazing with cattle, sheep and horses reduces the amount of host-specific parasites for each species.

It is clear that herbivores are dependent on plant communities but they also have a strong influence on the plant community they live in (Augustine *et al*, 1998). It has been shown that selective grazing by ungulates leads to the dominance of low-palatable plants that defend themselves in some way (by thorns or toxic substances) or are hard to digest.

The effects of fire

All over the world fire is one of the most powerful tools to alter the vegetation on rangeland, by removing litter and killing off woody vegetation. In the high mountains of east Africa fires are set by man to keep the vegetation within reach of the grazing/browsing animals and to remove hiding places for predators which would otherwise be a threat to the livestock (Wesche, 2003). On the plant community the effects of fire is often a shift in species abundance. For example plants that resprouts after fire, as the *Erica,* benefits from fire at the expense of more fire-sensitive plants. An additional effect of fire is rejuvenation. This rejuvenation causes a change in the chemical composition of the plants (P. McDonald *et al*, 1995). Young plants have lower concentration of both cellulose and hemicellulose than older plants.

MATERIAL AND METHODS

Study area

The study area is located in Bale-mountains in the southeast of Ethiopia (N 06° 50´20´´, E 039° 14´41´´) 3 500-3 700 meter above see level and is part of the largest expanse of sub-alpine heathland in the African highlands. Bale-mountains are a volcanic plateau and have a generally moist climate with an annually distinct dry period from December to March (Wesche, 2003). The average temperature during the day is 13°C but often drop below zero at night. The *Erica*-species dominates the landscape at this altitude and the different burnt patches give the landscape a mosaic-looking appearance.

According to the locals the dry period proceeding the study period was extremely dry and lasted longer than normal dry periods. Because there is no weather station at these altitudes in the African mountains it is hard to say how unusual it is with such dry weather conditions (Wesche, 2003). However, our guide Ayano Abraham claimed that the drought was the worst in about 40 years, the longest ever experienced by many adults.

Animals and their management

When we arrived in Angafu in Bale our intention was to choose two different herds for our study, but soon we realized that it was impossible to do so. Some days we saw no cattle at all and other days more than 35 different cattle grazed in the valley. Instead, we choose different cows every day and in that way observed cows from about six different herds. Since cows move over quite a large area in four hours we could only pick out cows that had a particular mark or colour since they had to be easy to recognize again if they came out of sight. The cows we choose were representative of the large number of cattle in the area.

Two cattle owners were interviewed about the cattle and their management. They supplied information for example about the age structure of the cattle herds, their reproduction and how much milk the cows produce (see appendix 1 for the full questionnaire).

Figure 1 Interview with Obure, one of the cattle owners in the study area. 2008.10.20. ***Photo Anders Granström***

A local guide, Ayano Abraham, acted as an interpreter in order to better communicate with the local people. He is born in the area and has grown up with his mother who had a lot of cattle when he was young. Ayano also explained numerous details of animal husbandry customs. Ayano has worked as a guide in the Bale Mountains for more than ten years and his knowledge of the region was imperative for this study.

Because of some problems with the local security office in the town of Dodola at the base of the mountain we were not able to formally interview more than two cattle owners.

Observations

The Angafu area has free sight over long distances and by choosing three vantage points in the valley for observation, the travelling and activity of herds could be

followed during the day using binoculars (20 X). The observations took place between mid October and mid December in 2008.

The cattle left their pens in the morning at around 7 and were then herded up in the valley were the observations took place. The first week we had the opportunity to use a range finder, a Leica Vector 1000, to decide the range to the cow observed and the angle between north and the observation point.

Figure 2. Typical observation view from eastern viewpoint 2008-10-28. ***Photo Åsa Arvidsson.***

When the weather was clear the cows were observed from the vantage points. If the weather was foggy the cows were followed and observed closer up. The route of travelling was registered on pre-made photo-maps. At intervals of 5 min, the particular activity (feeding, ruminating, walking, drinking or others) of a pre-selected animal was noted (appendix 2). If the cow stayed in sight it was observed for four hours. Otherwise it was observed for as long as it stayed in the valley. For each session a new animal, a lactating female, was randomly selected for the observations of activity. The observations were limited to lactating females for the reason that they were in higher numbers than other categories. Also, because the observations took place in mating time, bulls were probably not behaving as in other, non mating seasons. Location of neighbouring herds and numbers of cows in the valley was also registered, whenever they were within sighting distance from the herd in focus.

Within the observation area, the age (time since burning) of the different burn patches, which are about 0.5-5 ha in size, was measured by cutting a representative bush and counting growth rings. In the dry period (December-March) the growth is arrested which leads to formation of annual growth rings (M. Johansson, unpublished). This was made the first week and then the patches were marked at the pre-made photomap. This made it possible from a distance to decide what age the Erica-bushes had in the areas the cattle spent there time and what they were doing in the different patches. The different classes were 1 year, 3 years and old (older than 3 years). There was virtually no burn patches in the valley that were aged 2 years, since there had been very little fire activity during

the dry period 2006/2007, due to frequent showers and foggy weather (Maria Johansson, personal communication).

RESULTS

Interviews

The people of Angafu

Ten years ago the people in Angafu usually spent the dry period in the Bikika area on the other side of the mountain. Now there are more fences there and not so much forest to give shade to the cattle. Therefore the people stay in Angafu all year around (Obure 2008.10.20). In Bale Mountain the grazing lands are used as a common land, no particular person can control it (Ayano 2008.11.10). However; if someone has fenced off a piece of land it is not allowed for anybody else to graze there.

Health problems of the cattle

The people we interviewed stated that their cattle had no particular health problem. However, the last dry season was extremely long and both cattle owners had lost some cows and calves to starvation (Obure 2008.10.20, Aliya Mudda 2008.11.10). The situation was nevertheless better in Angafu than down in the forest or on the grass plains were large numbers of cattle died.

The cattle are given minerals about once a month. One type is a soil dug out of the ground at a site further down in the valley. The other is soil brought from Wondo Genet.

Figure 3. A typical *Bos taurus indicus* cow in Angafu. *Photo Jenny Gustafsson*

Composition of herds

The herds are in general composed of 10-15 animals and about 5 of these are lactating females.The females are much smaller than the bulls and have a bodyweight of approximately 300 kg. Each lactating female give 1-3 litre of milk per day (Obure 2008.10.20). The cows are 4-5 years when they have their first calf and after that the cows give birth every 1,5-3 years. If there is more time between the calves, the cow gives milk longer. A cow can give birth to 15-16 calves and can live up to 20 years.

Male calves and old cows are sold as livestock or for meat production (Aliya Mudda 2008.11.10).

The bulls are selected depending on what colour they have; dark colours such as black or brown are considered good. Big size of the bulls is also a positive criterion. Alia Mudda considers that it is good to have different bulls in the same herd because if one of the bulls is unable to mate or is sterile, another bull can make the cows pregnant. Bulls are kept for 7-9 years and are then sold to be slaughtered.

The best season for the calves to be born in is in the beginning of the rain period (i.e. April-May) because the cows have a lot to eat at that time. The calves are totally dependent on milk the first two months of their life but drink milk as long as the cow produces any.

In the dry period the cows use the forest more because it gives shade and earlier it used to be more food there. Now there are more people, more animals and more fences in the forest (Obure 2008.10.20). Because of the fences the sheep and goats also have to graze further up in the valley.

The cattle are of local breed and are adjusted to the high altitude (Ayano 2008-10-20). The cattle market is also held at high altitude. If cattle are brought up from the plains (1000 m further down in elevation) they tend to die.

General management

The cattle spend the night in enclosed pens nearby the owners house and are released in the daybreak around 6.30 (Aliya Mudda 2008.11.10). They are then herded up in the valley where they wander free for the rest of the day. The young calves either stays in pens also during the day or are herded together with goats and sheep. This protects the calves from predators and also makes the cows come home in the evening.

Figure 4. Sheep and goats resting outside the pen were they spend the nights. ***Photo Åsa Arvidsson***

The best feeding area is in the *Erica* because the grass is better there and the young *Erica* bushes are good food for the cattle (Obure 2008.10.20). It is not good if the cattle feed in swampy areas because then they get liver problems. When asked why she explained that the cattle got some parasite in the liver and sometimes the cattle died from it. When a picture of a *Fasciola Hepatica* was shown she recognized it as the cause of the dead cattle's liver problems

Obure is not growing any extra food for the cattle and never cut branches for the cattle to feed from. If she cut branches for fences however, the cattle feed from these. The type of threes she uses for fences is: Hagenia, Hypericum and Shefflera. Sometimes she also cut *Urtica* (stinging nettle) that is good food for livestock if it is first allowed to dry in the sun for an hour.

In the rainy season the cattle drink water from the brooks and in the dry season people dig holes in the swampy areas and put fences around. The fences stop the animals from contaminating the water.

General field observations

Cattle seemed to move more in cold weather. When it was sunny the cattle tended to stop more frequently or move more slowly. When it is sunny in Bale Mountains it is also much warmer than when cloud or fog shades the sunlight. On sunny days two or more groups of cattle could stay in the valley for four hours or more and we had no problem making full observation sessions. When it was cold however we had problems to follow the cow's movement for more than an hour and sometimes the cows had left the valley in only 30 minutes, a walk that took them more than four hours on sunny days. Another thing that made the cattle move faster was if there was a lot of people moving in the valley, like during market day when people from Angafu walk through the valley to reach Bikika where the market is hold.

One of the herds that were grazing in the valley had two calves which were a couple of months old with them. This herd moved slower than the other herds and we could observe it for longer time. The two calves often rested together somewhere in the bushes close by and when the group of adult cattle had wandered too far the mothers of the calves called them in. We only observed the calves milk-feeding two times. Both these feeding sessions lasted approximately 6 minutes.

The cattle appeared to move in almost the same pattern and over the same distance every day which made it possible for us to find observation points that covered most of the cattle's home range. When the weather was sunny and warm the cattle sometimes rested for rumination. The only places they did this at were areas that had free sight over nearby surroundings.

We made all our observations in the mating season and we saw a lot of bulls fighting each other, especially if two herds of cattle came too close to each other.

Range utilization and pattern of movement

The number of cattle in one herd varied between 7 and 18 (Figure 5).

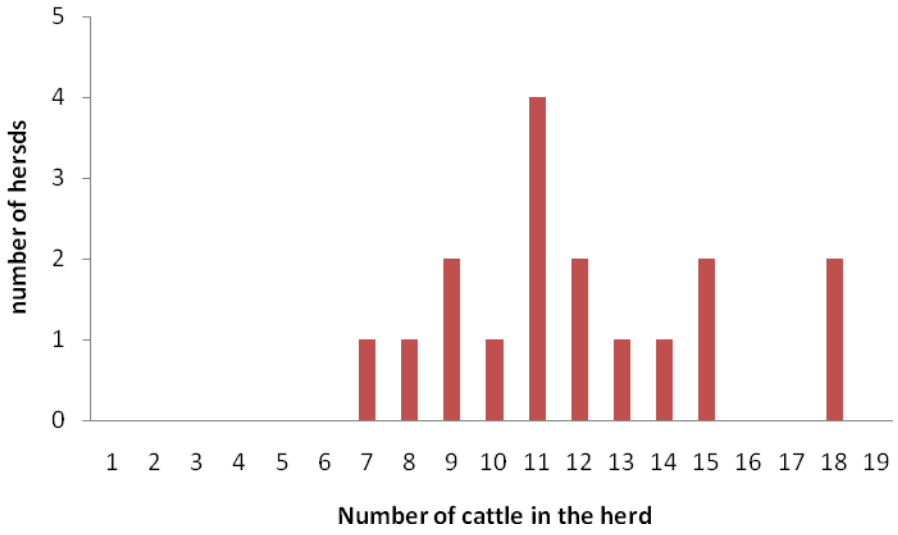

Figure 5. Number of cattle in different herds

The cows spent most of their time during day feeding (Figure 6). They were then slowly walking while continuously taking bites from the vegetation. Rumination was only observed 2% of the total observation time and drinking was only observed once. During about 10% of the time they were walking without feeding.

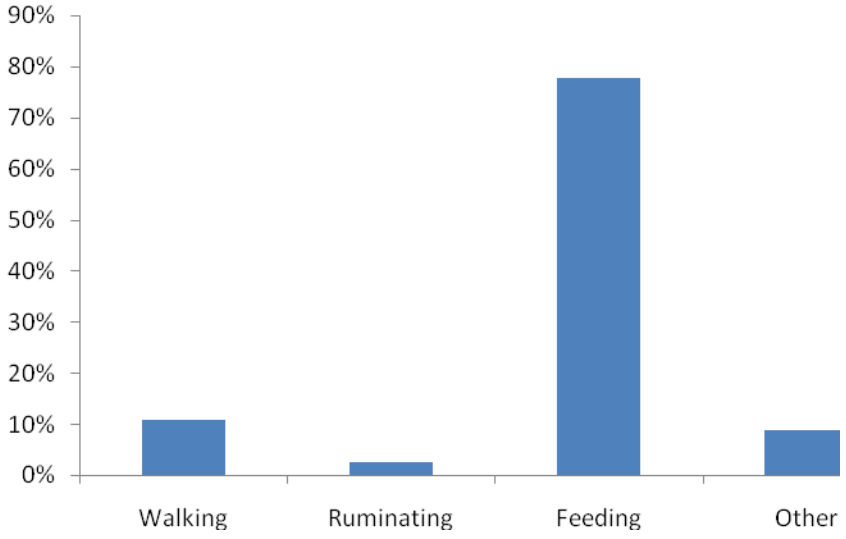

Figure 6. Percent of total observations spent on different activity

Over 40 % of the vegetation in Angafu was classified as old (i.e. older than 3 years); the cattle however only spent only 19 % of their time in old vegetation. Dividing the time spent in the habitat "old" with the amount of this habitat on the landscape gives a quota of 0,5. For the *Erica* that was burnt three years ago the quota is 1,0 and for one year old burns it is 1,5.

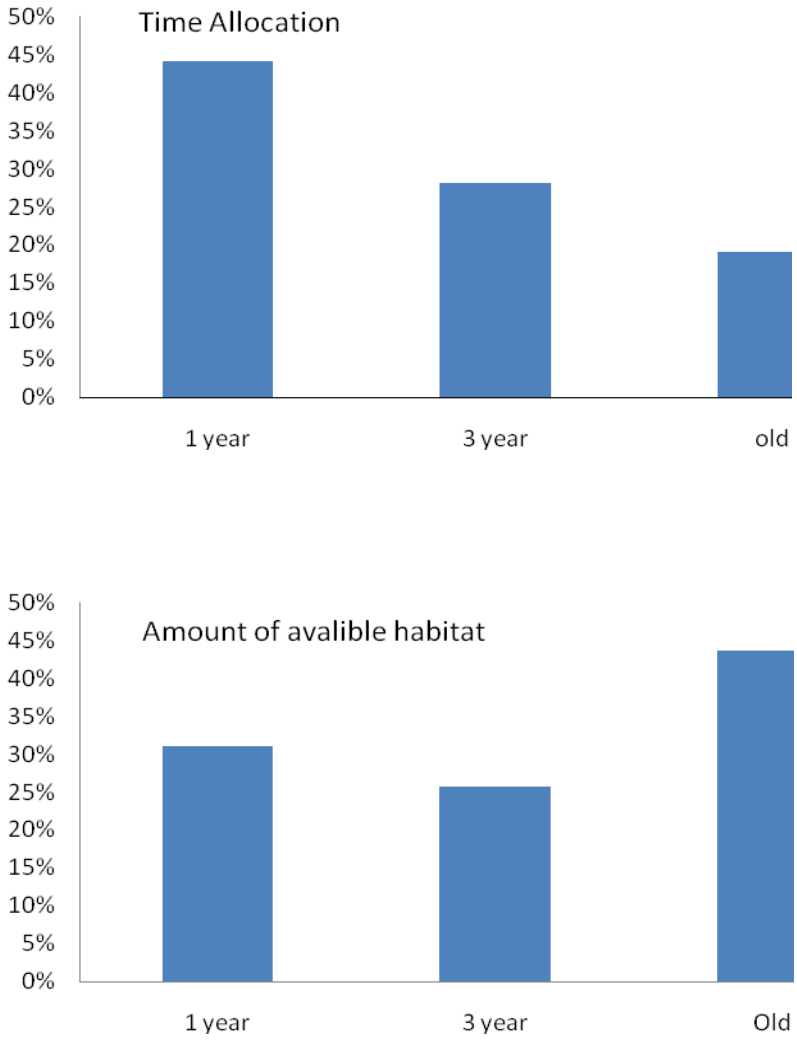

Figure 7. Allocation of time (above) and amount of available habitat (below)

The range finder made it possible to point out the cattle's movement pattern in a coordinate system (Figure 8). In most cases the animals moved in one general direction at a slow pace. Average speed was in the range 0,16 km/h to 0,38 km/h for the different cows we observed. There was no obvious daily pattern with respect to speed of movement. The herds generally moved uphill in the morning and then started to turn back at around 3 o'clock in the afternoon, resulting in a large loop with the turning point ca 2 km from their night quarters. In total they were out on the Erica heathland around 11 h each day.

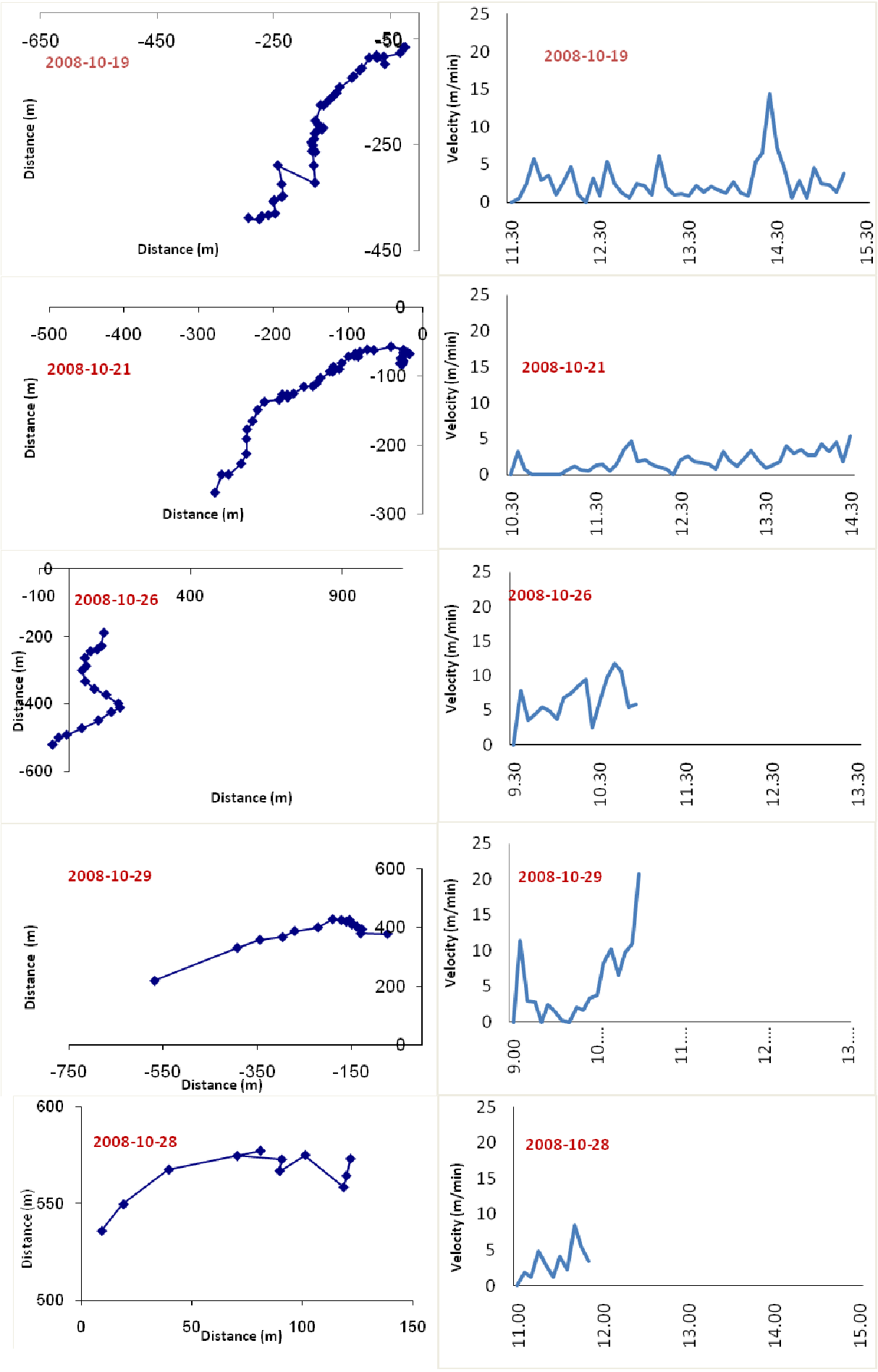

Figure 8. The distance and velocity of cows in five different observation periods. Every dot in the diagrams to the left represents one observation (spaced each 5-min). The diagrams to the right illustrate the velocity between every observation.

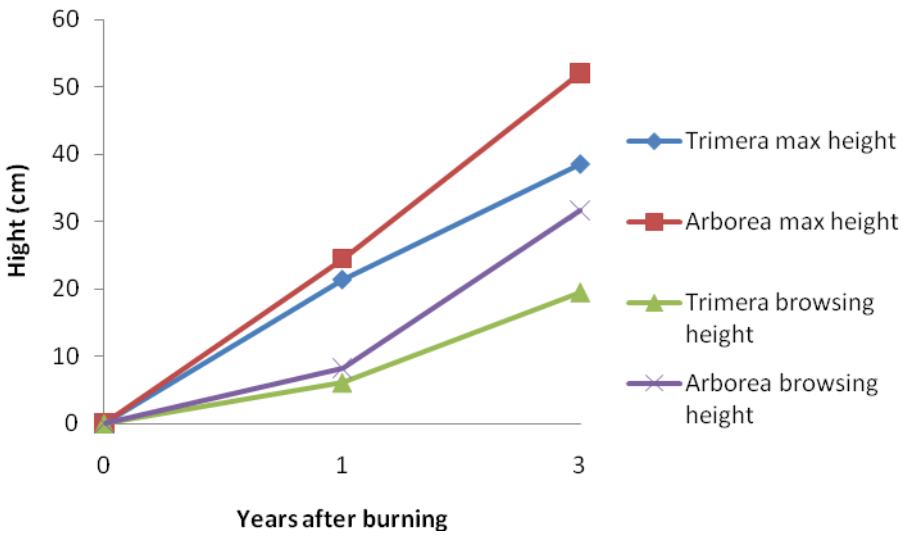

Figure 9. Relationship between time since burning and height of the two *Erica* species..

One year after burning the *Erica trimera* and the *Erica arborea* reach almost the same height, they are growing at the same pace. After three years however the *Erica Arborea* is higher, both the browsing height and the maximum height.

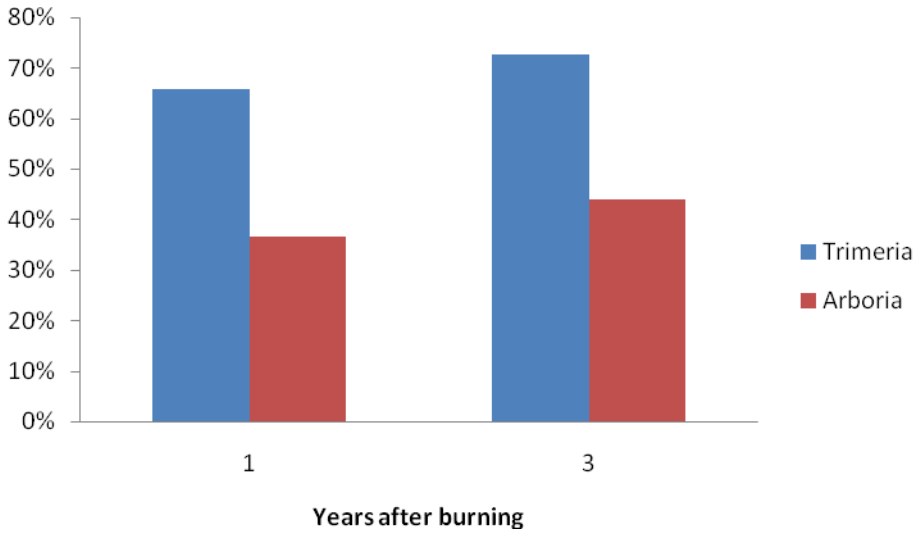

Figure 10. Average proportion of the surface of the two *Erica* species that had been recently browsed.

In line transects measurements were made on how much every bush was browsed, by estimating the proportion of the shoot tips that were recently browsed (i.e. where the bitten-off shoot tips were visible at the surface of the bush). In both age classes one and three years old, the *Erica trimera* was browsed more than the *Erica arborea* (Figure 9). In transects the amount of lawn, *Erica trimera* and *Erica arborea* was measured. The area cover of lawn in the patches with one year old bushes was around 65% and the area covered by lawn in 3 year old patches was around 50%. The composition of the lawn varied between the one and three

years old burns and one of the most striking differences was that there was more bare soil in the one year old (Table 1).

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)
Asteraceae 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)

DISCUSSION

Habitat selection

This study shows that cattle clearly prefer young recently burnt vegetation; one year old patches in front of three years old and three years old in front of old (>4 years). The cattle evidently made an active choice in selecting young *Erica* in front of old, as shown by the data in Figure 7. If the cattle just randomly grazed their way through the valley the time spent in the different age classes would have been proportional to the amount of that age class and the quota would have been one.

Cattle are ruminating herbivores, and according to data in the literature cattle are incapable of feeding on too rough roughage. Since they ruminate 80 minutes for every kilo of roughage, it will take too much time and not give enough energy to eat too rough food. Martinsson (1996) showed that if the chewing per kilo roughage increases too much it starts to cost more energy than it gives. This implies that cattle need roughage with some digestibility. This might be one of the reasons why cattle prefere younger *Erica* in front of older more woody plants.

According to a study made under Swedish conditions by Björnhag cattle eat grass 70% of their feeding time if they are free to choose between plants that normally are included in their food. When the *Erica* is old and hard to digest, herbs can hide inside and there is lawn between the bushes. This might be the reason why the cattle spent as much as 19% of their time in the old vegetation. Another reason

why the cattle appears to spend time at all in this older vegetation could be that they have to pass old vegetation every morning before they reach younger *Erica* higher up in the valley.

A question that came to mind was: How much can a cow eat? And when discussing how much a cow can eat the dry matter intake (DMI) is the most commonly measured variable (Andrews, 2000). The DMI is influenced by various different factors including body weight, milk production, and exercise, surrounding temperature, body conditions and the quality of the available food. The intake of food is also very dependent on the metabolic needs of the body, the size and capacity of the rumen and the palatability of the food. It is therefore impossible to say exactly how much a cow can eat. And in the case of the cows in Angafu the most probable answer is that they eat all they can when they have food available. They were only observed ruminating 9% of their time during the day. During night the cattle don't have anything to eat according to our interviews and that's probably also an answer to why they have most of their ruminating time during night. Another reason not to spend too much time ruminating on the mountain is the risk of becoming target to predators. The only time that the cattle lie down to ruminate during day in the mountains was during warm weather when they were on flat terrain overlooking a large area with short recently burnt vegetation. This made it possible to lay comfortable and make sure that no predators came unnoticed.

Drinking was only observed at one time during the observations and this was from a small creek on the mountain. During the observation time there was a lot of these small creeks on the mountain slopes but there was no bigger watercourse. Closer to the farms however there was some bigger streams and probably the cattle drank from these when passing in the mornings and in the afternoons.

Behaviour of movement

As shown in figure 6 cattle spent most of their time on the mountain feeding, but at the same time they continuously moved slowly in one direction. Episodes of pure walking were usually short. Only in afternoons the cattle were observed walking long distances and this was to reach home. Activities that were marked as other activities were scratching, feeding calves, standing resting (without ruminating).

In modern dairy industry cattle are often held within fences and it is therefore difficult to study their natural movement patterns. In Angafu however the cattle move free all day. It was therefore interesting to see the cow's pattern of movement in a coordinate system (Figure 8). These diagrams demonstrate that cattle prefer to move in a fixed direction instead of randomly moving around. Their velocity during grazing is relatively constant.

The height difference between *Erica Arborea* and *Erica Trimera* is bigger when the bushes grow older, and *Erica Arborea* is less browsed (Figure 9 and Figure 10). This indicates that the cattle prefer browsing the *Erica Trimera.* This may have long-term effects on the species composition, but is not directly influencing

the movement of the animals, since the two species grow intermixed all over the area

Group interaction

It was clear that the weather influenced the behaviour of the cattle. At this altitude rain and clouds also bring cold (daytime temperatures around 10 °C) while sun means warm whether (temperature around 20-22 °C). When it was rainy the cattle walked further and sometimes in other directions than normal to be sheltered from the rain. When the weather was sunny the cattle moved slower and they did also stop earlier to rest. It was observed that a number of different herds gathered down in the *Helichrysum*-belt to ruminate and rest early in the morning one sunny day. After half an hour they split up to their different herds and started grazing their way up the valley.

The numbers of cattle in the different herds vary a lot and after 5 weeks observations it was still impossible to say how many families that used the valley for grazing area and it was hard to say how many herds and cattle that altogether used the area. Figure 2 shows our typical view when sitting at the eastern viewpoint. This picture shows two herds passing each other during lunchtime. At one observation we counted as much as 35 cattle in the valley, other days the whole valley could be empty. The cattle owners who were interviewed also knew that their cattle mixed with other herds or sometimes divided into two or more groups.

The smallest calves never followed the herd during the day, but older calves did. The calves often lay hidden close by their grazing mothers. This is normal behaviour for cattle and is used in modern dairy industry where calves are kept in single boxes, only fed twice a day (Andrews, 2000). The cows of Angafu also showed that it was acceptable to leave calves in the pens during day, but the cows that had calves in the pen had a big tendency to lead the herd home in the afternoons. This arrangement is positive in two senses; the calves stays protected and the cattle come home in the evening without shepherding.

Small ruminants

According to Kampf (2002) is it more and more popular to mix different species of herbivores in large scale pastures. This is however not possible in Bale mountains due to the risk of predation. Even though goats and sheep are always herded by children, it is dangerous in the valley and even more dangerous up on the plateau. The fog can come fast and make hyenas braver and let them come closer to both the herd and the guarding children without being noticed. It is also very easy to get lost in the fog.

The access to younger *Erica* made it possible for goats and sheep to graze in the valley this year, but we never observed them up on the plateau. Probably because there was no need for them to leave the valley where there was sufficient amount of food. But as it gets dryer some months later the small ruminant probably will have to leave the valley and can therefore become easy targets for predators. This is a new problem to the people of Angafu. Earlier the small ruminants were

herded lower down in the forest were they did not compete with cattle for food and where there was a smaller probability to be killed by a predator. However, as Ethiopia's population increase more and more people live in the highlands, also in Bale. And more people means more fences and more fences dramatically reduces the grazing areas, according to the locals we have interviewed. According to them the grazing areas that are left are harder grazed now than just a couple of years ago.

Milk production

The cows in Angafu do not produce nearly as much milk as a Swedish diary cow, which of course is dependent on both breed and management. The management is difficult to improve under current conditions and the local breed is well adjusted to high altitude and poor grazing. According to our local guide, previous attempts to bring cattle from the lowlands up too Angafu have failed since the cattle from the lowlands always have died from problems with the altitude. The cows we have observed have not been tame enough to consider artificial insemination, which rules out that option for gene improvement. It is also, as usual, not recommended to bring in new livestock to an isolated group of animals because there is always a risk that the native animals will be infected with different diseases which are endemic in other regions.

Table 2. Production data for typical cows from Sweden and Angafu.

	Sweden	Angafu
Age at first calving (years)	2.3	2-3
Time between calving (years)	1.1	1.5-3
Annual milk production (kg)	9 214	1 200
Live span (years)	5	20

As shown in Table 2, there are big differences in the productivity of Swedish dairy cows and the cows of Angafu. The Swedish data is from the Cattle statistics of 2008 from Swedish Dairy Association. The biggest difference is in milk production but these numbers are somewhat misleading. The Swedish data is from highly productive dairy cattle that give no milk to their calves; the data from Angafu however is from cows that are also feeding one calf. According to Helmenius et al (1979) a dairy calve is drinking 4-5 liters per day for about 2 mounts. If adding 5 liters per day for one whole year to the annually milk production for the Angafu cow the production get up to 3 025 liters per day. This is still a lot lower than a Swedish dairy cow and this is probably because of the factors discussed above. The difference in milk production between a typical Angafu cow and a typical modern Swedish cow is also evident in the development of their respective udders (Figure 11).

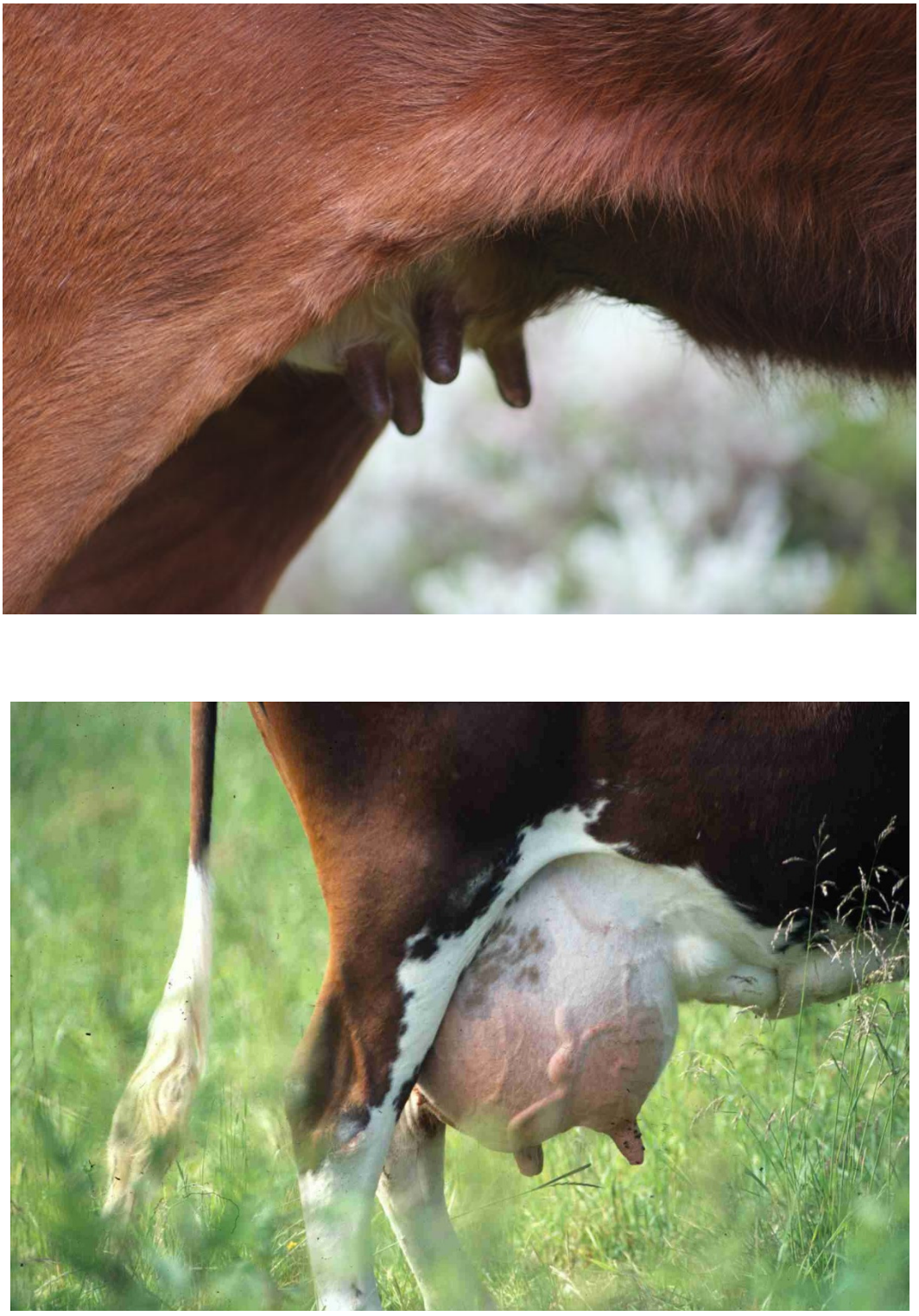

Figure 11. An udder from a cow in Angafu (above) and udder from a Swedish dairy cow (below)

Health status

Obure mentioned that cattle get liver problems from parasites if they graze in swampy areas. This is likely due to *Fasciola hepatica,* a platyhelminthes in the family Fasciolidae which is commonly called the liver fluke (G. M Urquhart, 1996). Cattle and sheep are the major hosts of *Fasciola hepatica,* but the lifecycle

is also dependent on a snail of the genus *Lymnaea* as an intermediate host. This snail spends most of its time in shallow water and that is why the cattle get infected in swampy areas. As an adult the flukes are found both in the bile duct and in the liver parenchyma of the cattle. According to Urquhart (1996) the acute and sub-acute form, which can lead to death, is only occasionally found in adult cattle. The most common form is a more chronic one with reduction of milk yield and quality as a consequence. Heavy and acute infection of *Fasciola hepatica* may cause anaemia and hypoalbuminaemia because of the damage the migrating young flukes causes to the liver and to the blood vessels.

The main problem for cattle however should be food shortage, particularly during the dry season. The weather of the year 2008 was according to the locals far from normal. The dry season was very dry and longer than usual. The rains did not start until mid June; normally the rains begin in the end of April. During the extended dry season a lot of cattle starved to death and it also resulted in more fires than normal.

The weather of 2008 was also different in that the rain season lasted longer than normal. There were still heavy rains during the afternoons at the end of November which is normally, according to locals, a dry month.

In the interviews we tried to ask if there was an upper limit to the number of livestock in the area. Since cattle starved in the dry season our thought was that if there were less animals grazing, maybe they would be healthier and live longer. What we did not consider is that livestock is the way of putting money in the bank. And to the question if there is any limit to how many cows somebody can have the answer was –Is there a limit to how much money you can have in the bank?

CONCLUSION

My data suggest that cattle prefer young, recently burned vegetation. The cattle in this study spend most of the daylight hours actively grazing and leave rumination and drinking until the dark hours. Further, cattle appear to have a focused moving pattern if they are not restrained by fences or shepherds. This information on the natural cattle behaviour in a free-ranging pasture can be valuable also when organizing industrial cattle husbandry.

The preference for recently burned vegetation suggests that fire is needed to maintain these high-elevation areas as productive rangeland.

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Appendix 1. Questionnaire used during the interviews with cattle owners.

What is your name?

Have you lived here all your life? If not: Where are you from?

Are the livestock in good health? If problems: What are they?

What age do the cattle have?

Do all female cows have a calf?

How old are the cows when they have their first calf?

How long is it in general between two calves from the same cow?

When are the cattle mating? When are the calves born?

What do the calves eat? How long do they drink milk?

Do you keep all calves?

How much milk are you getting from each cow per day?

What are the seasonal moving patterns for the cows?

What is the most valuable grazing land? Where are they?

What do the cows eat? What is their favourite food?

Do you grow anything for the cattle to eat or do they get everything they need from grazing, all year around? Do you cut any branches from trees to feed the cattle?

Where do the cattle drink? Where do they ruminate? How often do they ruminate?

Do the cattle use the plateau or do they stay in the valley? If they are using it: In what season?

What are the possible threats to the cattle during daytime? Are there any predators? Where are they?

Have you lost any livestock to predators?

Did you loose any livestock during last dry season since it was extremely dry?

Are the cattle herded in the morning? Do they come home by themselves in the evening?

How far do the cattle walk during one day? Do they mix with other herds?

How are the bulls selected? How long do you keep a bull? Is it important with different bulls?

Is there a limitation of how many cows you can have?

Are the cattle of local breed?

Do sheep and goat go up in the valley? Are the herded?

Have there been changes in the cattle business since you where young?

Appendix 2. Protocol for observations of cattle behaviour.

Number:									
Date:							Scale: Macro		
Cow no:							Description:		
							GPS:		
Burn ID:	**Burn age**	**time:** start:	**activity:** w	r	d	f	o		**Comments:**
w = walking without feeding, r = ruminating, d = drinking, f = feeding, o = other activity									