

Consequences of Human Land Use for an Afro-alpine Ecological Community in Ethiopia

Zealelem Tefera Ashenafi^{a,b,c}, Nigel Leader-Williams^{b,d} and Tim Coulson^{a,e,#}

^aZoological Society of London, London, UK

^bDurrell Institute of Conservation Ecology, University of Kent, Canterbury, Kent, UK

^cFrankfurt Zoological Society, Addis Ababa, Ethiopia

^dDepartment of Geography, University of Cambridge, Cambridge, UK

^eDepartment of Biological Sciences, Imperial College London, Ascot, UK

[#]Corresponding author. E-mail: t.coulson@imperial.ac.uk

Abstract

The Guassa area of Menz in the Central Highlands of Ethiopia is an Afro-alpine ecological community with an indigenous resource management system. The local community harvest different resources including collecting grass and firewood from the Guassa area. Cattle and other livestock are also grazed in the Guassa area, especially during the dry season. Several sympatric species of endemic rodents dominate the small mammal ecological communities in the Guassa area, and form most of the diet of the endangered Ethiopian wolf. This study aimed to determine if current levels of resource use by the local community through the indigenous resource management system had any discernible effect on rodent community structure. We found that the structure of the rodent community differs between habitat types, and that different species of rodents show diurnal variations in their patterns of activity. We also found that populations of different species show variable responses to each type of resource use in different habitats; some species show increases in abundance in relation to use while others show decreases. Although the indigenous resource management system was not specifically designed to conserve wildlife, it has nevertheless allowed wildlife, specifically small mammals or rodent communities, to co-exist alongside the ongoing resource use by the local community. We conclude the Guassa area represents an interesting model of community-led resource management of an Afro-alpine habitat which supports populations of endemic and threatened species.

Keywords: Afro-alpine, rodent, conservation, human use, indigenous resource management, Guassa, Ethiopia

INTRODUCTION

Most terrestrial ecosystems are directly or indirectly affected by human activity. Therefore, it is important for conservation biologists to characterise patterns of land use and assess

human impacts on ecological communities. Recent research has demonstrated how different forms of land use can affect the community structure and the population dynamics of individual species (Liers et al. 1997; Keesing 1998; Kerley 1992; Grant et al. 1982; Avenant 2000; Hoffmann and Zeller 2005). Small mammals are an important component of the Afro-alpine community as consumers and dispersal agents of seeds (Price and Jenkins 1986).

The Ethiopian highlands have been the focus of a wide range of human land uses for at least four centuries, and probably for substantially longer, yet are rich in endemic species of plants, birds and mammals (Kingdon 1991) Indeed, the highlands support 60 per cent of Ethiopia's rodent fauna, among which

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at least 14 endemic species occur in the north-western, central and south-eastern highland plateaus (Yalden and Largen 1992). Six endemic species are confined to high altitude, Afro-alpine moorland 3000 m above msl, four endemic species occur in mountain grassland, and the remaining four endemic species occur in mountain forest areas.

Research on small mammal assemblages in the Ethiopian highlands has mostly focussed on the relationships between species distributions and geographical features such as altitude (Müller 1977; Yalden 1988; Yalden and Largen 1992; Sillero-Zubiri et al. 1995), and on the systematics and taxonomy of a few species (Bekele et al. 1993; Bekele and Corti 1994; Capanna et al. 1996; Bekele 1996; Capula et al. 1997). Previous research on small mammal communities elsewhere in Africa has examined the role of density-dependent, density-independent, and climatic factors on the population growth of single species (Liers et al. 1997), and on relationships between habitat and rodent distributions (Happold and Happold 1987; Kerley 1992; Monadjem 1997). However, the association between the patterns of land use and the population dynamics of small mammals in Africa has received less attention (Delany and Happold 1979; Keesing 1998), despite the potentially pervasive influence of human activity on the distribution and survival of rodent species, which might in turn affect the distribution and survival of their main predators.

Most landscapes in the Ethiopian highlands have been influenced by farming, grazing, firewood collection, and grass cutting over several centuries. The Guassa area has been managed under an indigenous resource management institution known as the 'Qero system'. The Qero system operates as an indigenous common property resource management institution that arose based on the existing land tenure system. Under the rules of this common property resource management system exclusion governing access to the use of the area resource were the main aspects of the Qero system. The Qero system conferred usufruct right on the living members of a group tracing their lineage to the two pioneer fathers. Only those persons who could prove their lineage to these two pioneer fathers were recognised as full members of the Guassa user community and allowed to exploit resources on an equal footing (Ashenafi and Leader-Williams 2005, 2006).

The Qero system could entail the closure of the Guassa area from any type of use by the community for as long as 3 to 5 consecutive years. The length of the closure largely depended upon the growth of the *Festuca* grass and the need felt by the community for livestock grazing and firewood collection. Several times, it was suggested that the length of the closure depended on the success of the crop harvest and on the frequency of drought in the area. The area was usually opened at the height of the dry season of that particular year, usually around February or March. Once the grass cutting was over it was the turn of the livestock for grazing the Guassa area, while firewood collection was feasible any time during the open season. When the wet season approached, the user community prepared to leave the Guassa area. The date of closing was culturally predetermined, by July 12th of the

opening year all use must be stopped. Rules that prohibited the use of the Guassa area during the closed season were in place. The user community enacted various by-laws and enforced them for the protection of the common property resources from any type of use during the closed season. This by-law was enforced by every able household head who is the member of the user group, and failure to participate could result in severe punishment for absentees (Ashenafi and Leader-Williams 2005).

Currently, the Guassa area is being managed traditionally by the local community for different uses, including grazing livestock, collecting firewood, and cutting Guassa grass. Nine farmers' associations now communally manage the area which is in the process of being recognised by the Amhara National Regional State as the Guassa Community Conservation Area. The Guassa area plays an important role in the livelihood and survival strategies of the local communities, particularly in times of drought, by providing a refuge for the livestock population—the *Festuca* grass provides a thatching material for houses, the shrubby vegetation provides wood for cooking and for keeping the households warm from the highland cold. These traditional practices of a common property resource management system have created a mosaic of different habitats arranged in intricate patterns at different spatial scales that are likely to have an effect on the associated small mammal communities (Ashenafi and Leader-Williams 2005, 2006).

In this paper, we aim to examine the distribution of different habitats in the Guassa area, characterise how each habitat type is utilised by people, the population structure and dynamics of the small-mammal community, and the response of the small-mammals to the patterns of human use of those habitats. This in turn helps in understanding the effect of human use on the endangered Ethiopian wolf (*Canis simensis*), a specialised rodent predator that survives only in isolated populations in Afro-alpine habitats in the Ethiopian highlands. The Guassa population is the second largest population of the Ethiopian wolf (Marino 2003), and the largest of nine populations of the Ethiopian wolf surviving outside a formally protected area (Ashenafi et al. 2005).

STUDY AREA

This study was conducted in the Guassa area of Menz, located in the central highlands of Ethiopia (Figure 1). Guassa is located in the Amhara National Regional State of North Shoa Zone, in the Menz-Gera Midir Woreda (District) popularly known as Menz. It is 265 km northeast of the national capital Addis Ababa by road; it lies at latitude 10° 15'–10° 27' N and longitude 39° 45'–39° 49' E. The total area of the Guassa is 98 sq. km, and its altitude ranges from 3200 m to 3700 m above msl.

The climate of the Guassa area varies considerably because of the altitudinal differences and the size of the mountain block. Temperatures are characterised by mild days and cold nights. In the driest months (from December to February), daytime temperatures can rise to 25°C while night time temperatures

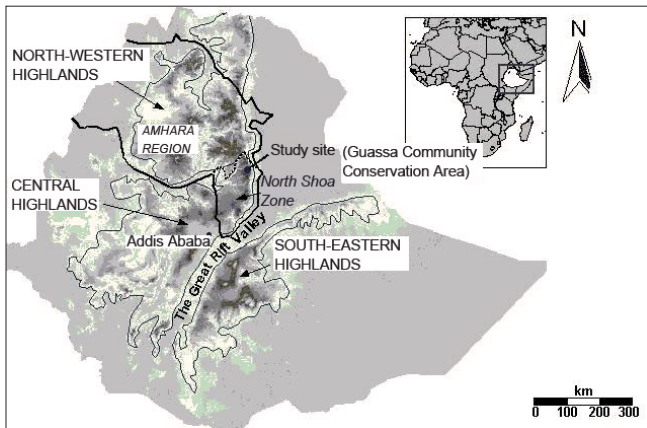


Figure 1
Map showing the highland blocks of Ethiopia,
and the location of the Guassa area

can fall to -7°C (a diurnal fluctuation of 32°C).

The vegetation of the Guassa area is characterised by high altitude Afro-alpine vegetation, with different habitat types namely, *Euryops-Alchemilla* shrubland (22 per cent), *Festuca* grassland (20 per cent), *Euryops-Festuca* grassland or Mima mound (16 per cent), and *Erica* moorland (10 per cent). The area derives its name from the so-called 'Guassa grass', which comprises four species of *Festuca* highly valued by the local community, among other uses, for thatching and manufacturing of household and farm implements. The area is rich in biodiversity and contains several endemic and threatened species of flora and fauna, including Ethiopian wolves and gelada baboons.

METHODS

Snap trapping of rodents was conducted bi-monthly for one year from June 1998 to May 1999 in the Guassa area. Trapping was conducted in six habitat types: *Festuca* grassland, *Euryops-Alchemilla* shrubland, Mima mound (*Euryops-Festuca* grassland), *Erica* moorland, *Helichrysum-Festuca* grassland, and swamp grassland. These habitats were selected on the basis of the surface area they occupy within the Guassa area, and because they are important habitats for the Ethiopian wolf. The first three represent the main habitat types of wolves, while the rest represent the minor habitat types. Snap traps were set in each habitat, in a 7×7 grid of 49 traps with 10m spacing between each trap. Trapping was replicated 6 times in each habitat type using 49 traps set in grid. Traps were baited using a mixture of peanut butter and barley flour. Traps were pre-baited for one day; trapping started the following day and continued for two consecutive days and nights in each trapping session. Trapping was conducted in both dry and wet seasons, within areas of habitat that were used and unused by the local community. Traps were checked each morning at 6 am and each evening at 6 pm.

The following data were collected from rodents caught in the traps: period of day (day/night), species, habitat, sex, age (adult, sub-adult or juvenile), weight (gm), body measurement,

and reproductive condition (position of the testes/pregnant or lactating). The study design also included examining the effects of the three main types of human use, namely, grass cutting, firewood collection, and livestock grazing. A paired sampling design was adopted—an area where grass had been cut was compared with an uncut area, an area where firewood had been collected was compared with an area where firewood was not collected, and finally, a grazed area was compared with an ungrazed area. Furthermore, sampling was conducted only in the habitat with the most use. Therefore, the effect of grass cutting was assessed by selecting two areas of predominantly *Festuca* grassland, one that had been cut and one that remained uncut as the community mainly cut the *Festuca* grass for thatching of houses. The effect of firewood collection was assessed by selecting two areas of predominantly shrubby vegetation which is *Euryops-Alchemilla* shrubland in the Guassa area, one that had been used and one was not used for firewood collection. Similarly, the effect of grazing was assessed by selecting one grazed and one ungrazed area of predominantly Mima mound as this habitat is particularly used for grazing livestock.

Data from the study were analysed using Generalised Linear Models (GLMs) (Dobson 1990; Crawley 1993). Our experimental design was such that we did not have sufficient degrees of freedom to examine species by habitat by time interactions. Consequently, we conducted various preliminary analyses of the number and proportion caught to identify key variables that explained variation in trapping success. To analyse the number of rodents caught we used GLMs with a Poisson error structure as this suitable for count data (Crawley 1993).

First, we analysed the total number of rodents of each species caught, independent of habitat and time of day. Following this, we analysed the total number of rodents, independent of species and time of day. We then analysed the total number of rodents independent of species and habitat, to determine if there was a difference in the mean number of rodents caught during the day and night. Following these preliminary analyses, the two independent habitat variables (expressed as variable with six categories: *Festuca* grassland, *Euryops-Alchemilla* shrubland, Mima mound (*Euryops-Festuca* grassland), *Erica* moorland, *Helichrysum-Festuca* grassland, and swamp grassland, and time (a variable with two categories: day and night) were fitted to the model to see if there was an interaction.

Second, a GLM with a binomial error structure was used to determine whether there was any difference in the proportion of individuals of each species caught in different habitats during different times of the day. The response variable was the number of individuals of each species caught in each trapping session in each habitat type at each trapping time (day/night). The binomial denominator was the total number of individuals, regardless of species caught in each trapping attempt in each habitat at each time. Initially, we fitted species, habitat, and time, and we later removed factors (species, habitat, time) that were not significant. The data were over-dispersed since the ratio of residual denominator to raised degrees of freedom was

>2, so the dispersion parameter was estimated (Crawley 1993). Factors that were not significant were removed. Significance was assessed using the method described above. A prediction was made to determine the proportional abundance, activity pattern and habitat preference.

Third, we analysed the proportion of rodents of each species caught in each habitat and for each treatment (use type) by using a GLM with a binomial error structure. The response variable was the number of each species caught in each replicate, and the binomial denominator was the total number of rodents caught in that replicate. Three independent terms and their interactions were fitted, comprising species (a variable with four categories), habitat (a variable with three categories), and treatment (a variable with two categories). Then terms were dropped from the full model, and their significance was assessed by examining the resulting change in deviance. Dropped terms were reinstated in the model if their removal led to a significant decrease in the regression analysis.

RESULTS

Ecological patterns

A total of 643 rodents were caught during this study. There was an overall difference ($\chi^2=15.9$, $df=3$, $P<0.05$) in the total number of each species caught across the habitat types (Figure 2), but no difference ($\chi^2=10.0$, $df=5$, $P>0.05$) between number of all species caught across different habitats (Figure 2) or by different seasons. Therefore, *Lophuromys flavopunctatus*, *Arvicanthis abyssinicus* and *Stenocephalemys griseicauda* were caught more often than *Otomys typus*, irrespective of habitat type, while *Euryops-Alchemilla* shrubland and Mima mound habitat types appeared to support more rodents than the other habitat types, regardless of species (Figure 2).

The number of different species of rodents caught across all six habitat types was further sub-divided into those caught during the day and the night. More rodents were caught during the day than at night ($\chi^2=23.97$, $df=1$, $P<0.001$). There was an interaction ($\chi^2=13.51$, $df=3$, $P<0.01$) between the number of each species caught and time of day. *L. flavopunctatus*, *A. abyssinicus* and *O. typus* are primarily diurnal, while *S. griseicauda* was almost exclusively nocturnal (Figure 3).

There was also an interaction ($\chi^2=13.14$, $df=5$, $P<0.05$) between the number of rodents caught in each habitat type and time. However, there was no interaction ($\chi^2=12.67$, $df=15$, $P>0.05$) when the three factors were considered together. The full model explained 75.5 per cent of the deviance and showed that there was an interaction between species and time ($\chi^2=179.6$, $df=3$, $P<0.001$), and an interaction between species and habitat ($\chi^2=79.3$, $df=15$, $P<0.001$).

The predicted mean proportional estimates of rodent abundance are shown separately for day (Figure 4) and night (Figure 5), based on the full model. In *Euryops-Alchemilla* shrubland, the model predicted more *L. flavopunctatus* and *A. abyssinicus* but few *O. typus* during the day (Figure 4), and

more *S. griseicauda* at night (Figure 5). In *Erica* moorland, the model predicted *L. flavopunctatus* as the most common diurnal rodent followed by *A. abyssinicus*, but predicted more *O. typus* on *Erica* moorland than on *Euryops-Alchemilla* shrubland (Figure 5). During the night, the model predicted more *S. griseicauda* than all other species in *Erica* moorland (Figure 5). The model predicted fewer *A. abyssinicus* during both day and night in *Erica* moorland than in *Euryops-Alchemilla* shrubland (Figures 4 and 5).

In *Festuca* grassland, the model also predicted that *L. flavopunctatus* was the most common diurnal rodent, while *O. typus* was the least common. The model predicted similar abundance of *L. flavopunctatus* and *O. typus* in *Helichrysum-Festuca* grassland and in *Festuca* grassland, but *A. abyssinicus* was more abundant in *Helichrysum-Festuca* grassland than in *Festuca* grassland (Figure 4). At night, the model predicted a higher abundance of *S. griseicauda* in all habitats, except for swamp grassland where it was least abundant (Figure 5).

The model predicted a similar abundance of *L. flavopunctatus* and *A. abyssinicus* in Mima mounds during the day, but a higher abundance of *L. flavopunctatus* and very few *A. abyssinicus* in swamp grassland during the day. However, relatively more *O. typus* occurred in swamp grassland than the other habitat types during the day (Figure 4). At night, the model predicted

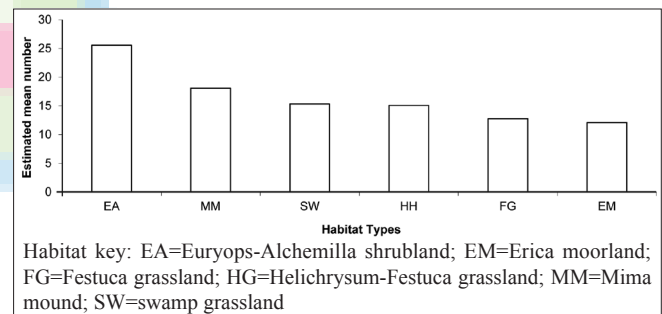


Figure 2
Estimated mean \pm SE number of all species caught across different habitat types

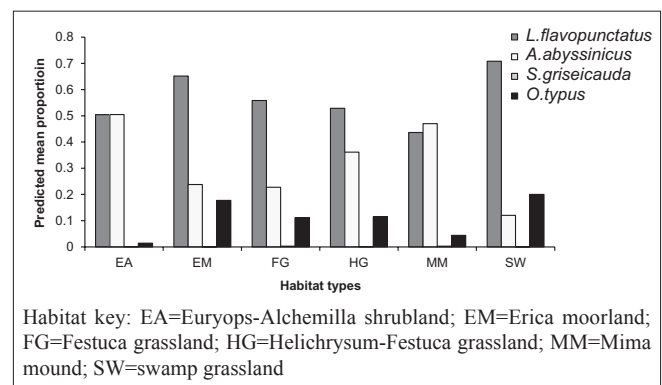


Figure 3
Estimated mean \pm SE number of rodents of each species during the day and during the night

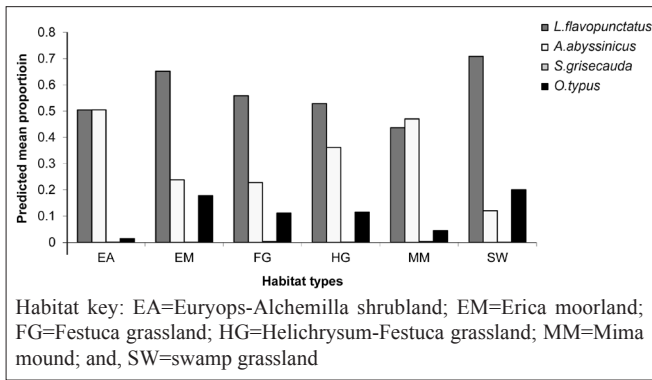


Figure 4
Predicted mean \pm SE proportion between habitat and species during the day

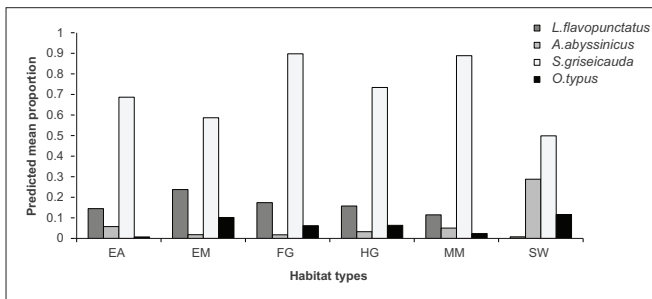


Figure 5
Predicted mean \pm SE proportion between habitat and species during the night

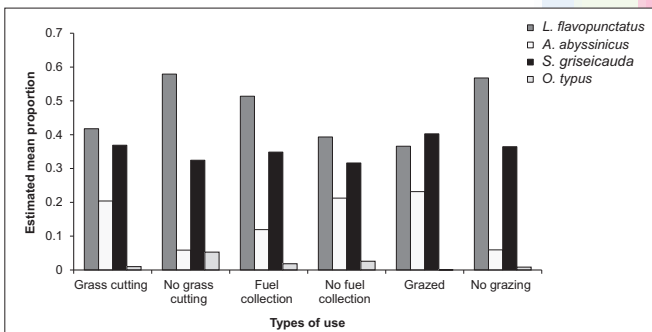


Figure 6
Predicted estimates of mean \pm SE proportion for each species of rodent caught in used and unused plots

higher abundance of *A. abyssinicus* and lower abundance of *S. griseicauda* for the swamp grassland than the other habitat types (Figure 5).

Rodent abundance and community resource use

The number of rodents caught in each age group did not differ ($\chi^2=6.08$, $df=2$, $P>0.05$) across habitats that were used and not used for resource collection. Similarly, the number of rodents caught of each sex ($\chi^2=1.32$, $df=1$, $P>0.05$), or in each season ($\chi^2=3.7$, $df=1$, $P>0.05$), did not differ across habitats that were used and not used for resource collection. Therefore, all subsequent analysis considered the total number of each

species caught, irrespective of age group, sex, or season.

The total number of rodents caught regardless of species did not differ ($\chi^2=0.55$, $df=5$, $P>0.05$) between habitat and treatment. The full model was significant ($\chi^2=276.9$, $df=23$, $P<0.001$), and explained 69.8 per cent of the deviance. However, the proportion of each species varied between habitat, and treatment. The full model indicated a significant interaction ($\chi^2=16.4$, $df=6$, $P<0.05$) between species, habitat and treatment (Figure 6). Therefore, each species in the rodent community of the Guassa area responded differently to the different forms of resource use.

L. flavopunctatus responded negatively to grass cutting and grazing, but positively to firewood collection (Figure 6). Hence, its abundance was higher where firewood collection had taken place than in areas where no firewood had been collected, but was lower in cut and grazed areas than in uncut and ungrazed areas. *A. abyssinicus* responded positively to grass cutting and grazing, but negatively to firewood collection. Hence its abundance was higher in cut and grazed areas than in uncut and ungrazed areas, but its abundance was lower in areas where firewood had been collected. *S. griseicauda* did not respond to any form of human use, and its abundance was similar across all treatments (Figure 6). *O. typus* appeared to respond negatively to all forms of human use, although as the least abundant of the four species in the Guassa area, any differences in abundance were hard to detect (Figure 6).

DISCUSSION

Many landscapes of biodiversity importance lie outside formally protected areas, and are subject to human use (Happold and Happold 1987; Hoffmann et al. 2003; Rosser and Leader-Williams 2010). A key question is whether those patterns of human use can remain, or become, sustainable over the long-term. Of particular interest is whether indigenous resource management institutions can be sufficiently resilient to successfully regulate resource use, such that common pool resources retain their constituent biodiversity. This study (the first study of rodent community structure in the central highlands of Ethiopia) took place in the Guassa, an area that has been managed under the common property resource management system for several hundred years. Besides describing the basic ecology of the rodent community, we have also shown that rodent abundance has not been adversely affected by current levels of grass cutting for thatch and firewood collection, and livestock grazing. Therefore, we conclude that local resource use should continue to allow the survival of Ethiopian wolves in the Guassa area as human use positively affected some prey species.

Rodent ecology

The Guassa area supports four species of Murinae, of which two (*A. abyssinicus* and *S. griseicauda*) are endemic to the Ethiopian highlands. *S. griseicauda* has been previously recorded in the Simien Mountains in the northwestern

highlands and the Bale Mountains in the southeastern highlands of Ethiopia (Yalden et al. 1976, 1996). *A. abyssinicus* has not been recorded in the Bale Mountains, but is only known to occur in the northwestern highlands. Rodent species diversity in the Guassa area was not as high as in Bale Mountains and other mountain blocks in the country (Yalden et al. 1976, 1996; Hillman 1993).

Habitat preference is one of the most important factors influencing species co-existence (Pimm 1991). Habitat selection may have evolved as a result of past competitive effects, but only weak inter-specific competition may now be necessary to maintain habitat selection. Therefore, the coexistence of species may be explained by resource availability and by the ways in which a species utilises its habitat and interacts with other species (Schoener 1983). Clear patterns of abundance and habitat use have been established for each of the four Murinae species found in this study. Each species is characteristic of Afro-alpine moorland rodent species in Ethiopia (Yalden et al. 1976; Yalden and Largen 1992, Sillero-Zubiri et al. 1995). More *L. flavopunctatus*, *A. abyssinicus*, and *S. griseicauda* were caught than *O. typus*, but all four rodent species were caught in all six habitat types found in the Guassa area. There was no difference in the number of rodent species caught in each habitat type, but there was a difference in the total number of each species caught in different habitat types. *L. flavopunctatus* was abundant in all six-habitat types, but it was most abundant in swamp grassland and *Erica* moorland. *A. abyssinicus* was most abundant in *Euryops-Alchemilla* shrubland and Mima mound, while it was least abundant in swamp grassland. *S. griseicauda* was abundant in all habitat types, but its abundance was highest in *Festuca* grassland and Mima mound. *O. typus* was most abundant in swamp grassland and *Erica* moorland.

Most rodents in Afro-alpine habitats show a diurnal activity pattern. Among the eight species studied in the Bale Mountains, only three were nocturnal (Yalden 1988; Sillero-Zubiri et al. 1995). The extreme low temperatures experienced at night at high altitude can impose limitations on the activity patterns of rodents. Thus, in the Guassa area, *L. flavopunctatus*, *A. abyssinicus* and *O. typus* were the predominantly diurnal species, although the proportion of *L. flavopunctatus* and *A. abyssinicus* caught at night was slightly higher than *O. typus*. In contrast, *S. griseicauda* is strictly nocturnal. Some rodent communities, including those of Afro-alpine habitats, adapt to extreme temperatures by burrowing underground. Different habitat types may also be associated with varying thermoregulatory functions. Hence, there was more pronounced activity of *L. flavopunctatus*, *A. abyssinicus* and *O. typus* at night in *Erica* moorland and swamp grassland, both of which support dense and tall vegetation, up to 50cm in height. In contrast, *S. griseicauda* has a larger body size and is active during night, and is fairly abundant in all habitat types except in swamp grassland. The thermoregulatory adaptation of *S. griseicauda* could be its thicker fur. In addition to environmental constraints, competition and predation may be important in determining the structure of the rodent

community. The diet of these species is poorly studied, but from general observations they are predominantly herbivores. However, *L. flavopunctatus* also takes a small proportion of invertebrates (Kingdon 1974; Yalden 1988).

Rodent responses to local resource use

Human activity can affect rodent populations in three major ways. First, direct alteration of habitat can destroy burrows and increase soil compaction. Changes in soil compaction in turn can result in vegetation changes (Keesing 1998; Mwendera et al. 1997; Hoffmann et al. 2003). Second, loss of vegetation cover can increase exposure of small mammals to predators and result in increased predation rates (Kotler 1984; Birney et al. 1976; Grant et al. 1982). Finally, human use can reduce vegetation biomass and forage availability. If human use involves sharing food resources, this would be an example of exploitative competition (Keesing 1998; Hoffman and Zeller 2005). Competition has been identified through laboratory and field experiments in which the exclusion of one resource user can result in the abundance of another (Schoener 1983). Human use as a competitor or as an agent of disturbance in the savannah ecosystem can cause local extinction of common small mammal species (Keesing 1998). In a long-term experimental study in a temperate desert assemblage, removal of a dominant competitor increased the species diversity of the remaining small mammal community (Valone and Brown 1995; Hoffman and Zeller 2005).

In the Guassa area, *L. flavopunctatus* is the common species in Mima mounds and *Euryops-Alchemilla* shrubland, indicating a preference for long vegetation cover. Consequently, grass removal due to cutting or grazing would be expected to cause a reduction in abundance grass, and indeed was found to have a negative effect on the abundance of *L. flavopunctatus*. In contrast, removal of firewood allows a more prolific undergrowth of herbs and forbs that are an important source of food resulting in increased abundance of *L. flavopunctatus*. Similar results have been observed on the Zomba Plateau, Malawi (Happold and Happold 1987). *L. flavopunctatus* was more common in young pine plantations than in older plantations, and was present only when the plantation was dominated by dense grass and herbs. Meanwhile, *L. flavopunctatus* no longer grew when the growth of dense grass and herbs was suppressed. *A. abyssinicus* generally avoids high altitude long grass and prefers short grass, open areas and drier sites (Güttinger et al. 1996; Kingdon 1974). In the Guassa area, *A. abyssinicus* is also common in *Euryops-Alchemilla* shrubland, and Mima mound. Grass cutting and grazing were found to have a positive effect on the abundance of *A. abyssinicus*. *A. abyssinicus* tolerates a certain degree of grazing impact, and even inhabits high altitude cultivated fields in the Simien Mountain National Park (Güttinger et al. 1996). The collection of firewood probably caused a reduction in the abundance of *A. abyssinicus* as the mode of firewood collection involved uprooting the *Euryops* shrub, which in turn, results in open areas or sometimes a bare ground, which totally alters

the habitat structure for the species and may increase the risk of predation.

In general the diversity of small mammal species has not been affected between the used and unused areas. But for the exception of *O. typus*, which was absent in areas where grazing had taken place. This species is typically adapted to long grass and humid areas, especially swamp grassland dominated by *Carex* sp. The disappearance of *O. Typus* from grazed land may be attributed to a decrease in moisture as a result of foliage removal by livestock grazing. Similarly, in other parts of Africa where human activity is high, it has been shown that the abundance of the genus *Otomys* decreases (Monadjem 1997, 1999).

The demographic factors responsible for fluctuation in the size of small mammal populations in the Guassa area are not clearly known, but the sex and age ratio (adult, sub adult and juveniles) of each species did not differ between used and unused habitats of each use type. Similar results have been observed in the highlands of Kenya, where no demographic changes in survivorship or any detectable differences in per capita recruitment had occurred between grazed and ungrazed land (Keesing 1998). Also, where the grass is more prone to fire, and when there is less secondary herbaceous growth, it has been noted that there is decline of *Otomys* species (Kingdon 1974). *O. typus* are naturally most vulnerable to aerial predators in habitats with more exposed vegetation (Kingdon 1974).

In the Central Highlands of Ethiopia, there is an increase in plant diversity following grazing, due to the activity of livestock (Mwendera et al. 1997). Therefore, livestock in free-grazing systems may have an important but little recognised influence on vegetation structure. Nevertheless, the influence of livestock on botanical composition and species richness will depend on stocking rates (Mwendera et al. 1997). Hence, grazing can have an insignificant effect on vegetation cover, particularly where soil moisture is high and where the slope is low. However, vegetation biomass is reduced significantly as grazing increases from moderate to very heavy (Mwendera et al. 1997). Where plants cannot compensate sufficiently for the biomass removed by grazing animals, net primary productivity (NPP) of plants consistently declines as the intensity of grazing increases. In some cases plants are able to compensate for biomass removal up to some level, and in such cases grazing enhances NPP (McNaughton 1983). Hence, we can conclude that the indigenous management of the Guassa grazing system has helped to maintain the structure and botanical composition of the vegetation community by putting in place various grazing management systems.

Woldu and Mohamed-Saleem (2000) found an increase in annual plants and a decline in perennials following grazing in their study on the central highlands in Ethiopia. In areas where livestock grazing occurs, grazing fields are continually reseeded by livestock manure and this favoured the growth of annuals in the families *Asteraceae* and *Fabaceae*, thereby increasing nutritious content for the rodent community. The pattern of occurrence of annual and perennial plant species clearly follow the rainfall pattern. The presence of rainfall for

most of the year in the Guassa area has probably encouraged the continuous availability of fodder for the rodent community.

These differences in rodent abundance are likely to have important consequences for predators such as the Ethiopian wolf, which is the dominant rodent predator within Ethiopia's Afro-alpine ecosystem. The Afro-alpine Murinae community accounts for more than 80 per cent of the diet of the Ethiopian wolf (Sillero-Zubiri et al. 1995; Ashenafi et al. 2005). *A. abyssinicus* in particular accounts for the largest proportion of diet by volume in the Central Highlands (Ashenafi et al. 2005). Therefore, the positive effect of grazing on the *A. abyssinicus* population will have a similar positive effect on the Ethiopian wolf population. A limited amount of grazing and/or cutting, which stimulates plant growth and benefits rodent communities, would have beneficial impacts on the Ethiopian wolf population. The current study has shown a different relationship between human use and rodent communities in the Guassa area of Menz. It was found that the total number of rodents, regardless of species, did not vary between habitats and use type, suggesting that human use does not affect total rodent biomass. However, it was found that the proportion of each species varied between different habitat types and use types. This has important implications on the Ethiopian wolf population, as some of these rodent species account for the largest proportion of the wolves' diet (Ashenafi et al. 2005). However, these positive outcomes would have to be weighed up against other human impacts on the Ethiopian wolves.

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