Microhabitat, phenology and diversity of Orthoptera in a seminatural pasture

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”Hopprätvingars (Orthoptera) mikrohabitat, fenologi och diversitet i en naturbetesmark”

Sammanfattning

I detta examensarbete har jag som en del i HagmarksMistra undersökt hur livsbetingelserna för hopprätvingar (orthoptera) skiljer sig i två olika betesregimer i en naturbetesmark i Harpsund, Södermanland. De två regimerna bestod av kontinuerligt bete som bedrevs under hela betessäsongen samt sent bete som påbörjades i slutet av juli. Det sena betet är tänkt att fungera som en ersättning för den traditionella slåttern som på grund av rationaliseringar inom jordbruket i stort sett övergetts. Slåtterängar har länge varit kända som artrika lokaler speciellt med avseende på kärlväxter. Även andra organism-grupper anses gynnade av denna hävdmetod. Den minskning av antalet slåtterängar som sker i Sverige idag innebär ytterligare en minskning av redan få lokaler med hög biodiversitet.

Totalt i studien observerades 12 hopprätvingearter, 5 gräshoppor, 2 torngräshoppor och 5 vårtbitare. Gräshoppor visade sig vara vanligare där det fanns många betesrator. Vårtbitarna var vanligare där det fanns många betesrator, högre vegetation, många blommande växter och lite beskuggning. Mellan betesregimerna var det skillnad på vegetationshöjd, antal blommande växter och förnalagret, alltid med högre värden i den sena betesregimen. Det var fler vårtbitararter och individer vårtbitare i det sena betet. Detta kan förmodligen förklaras med att de faktorer som var positivt korrelerade med vårtbitare hade högre värden i det sena betet. För gräshoppor fanns det ingen signifikant skillnad mellan de olika betesregimerna. Resultaten erbjuder en möjlighet att planera för hopprätvingar i naturbetesmarker.

Agrovoc: *Orthoptera*, habitats, grazing systems, grasslands, *Chorthippus parallelus*, *Omocestus viridulus*

”Microhabitat, phenology and diversity of orthoptera in a seminatural pasture”

Abstract

I have, as a part of HagmarksMistra, studied how conditions for orthopterans differ between two grazing regimes in a seminatural pasture in Harpsund, Södermanland, Sweden. The two grazing regimes were continuous grazing during the whole season and late grazing starting in late July. The late grazing is considered as a possible substitute to traditional mowing as the time-consuming mowing is largely abandoned due to rationalizations in the Swedish agriculture. Meadows are known to contain a high diversity, especially of vascular plants. Other organism groups are also thought to be favoured by this management. The reduction in meadows that are mowed and extensively grazed pastures is hence a threat to biodiversity.

In total 12 orthopteran species were recorded in this study, 5 grasshoppers, 2 groundhoppers and 5 bush-crickets. Grasshoppers were more abundant where there were many ungrazed left-outs. Bush-crickets were more abundant where there were many ungrazed left-outs, a higher vegetation, many flowering plants and no shading. Between the two grazing regimes there were differences in vegetation height, number of flowering plants and litter layer, in every case with higher values in the late grazing. There were more bush-cricket species and individuals in the late grazing regime. This can be explained by the fact that the factors that were positively correlated with bush-crickets had higher values in the late grazing regime. For grasshoppers there were no significant differences between the grazing regimes. The results suggest a possibility to manage seminatural pastures to favour orthopterans.

Agrovoc: *Orthoptera*, habitats, grazing systems, grasslands, *Chorthippus parallelus*, *Omocestus viridulus*

1 Introduction

In Sweden there has for a long time, been a general trend of declining numbers of farms. The decreasing numbers can partly be explained by urbanisation but perhaps to a larger extent by the fact that it has become increasingly harder to make a profit from farming in Sweden (Emanuelsson *et al*. 2003). Farmers are forced to either intensify or to leave the business. With the decline in the number of farms, especially milk producing ones, comes a decline in the number of grazing animals and managed grasslands. On the remaining farms there has been an intensification in order to increase the production of grains, meat, etc. One of the earliest consequences of this intensification involved the usage of fertilizers and pesticides on many nutrient poor grasslands. This had a very negative impact on diversity since many organisms like plants and species of butterflies are restricted to a few remaining unfertilized grasslands, i.e. seminatural pastures and meadows. These seminatural grasslands are known to contain a high biodiversity (Weibull *et al*. 2003). About 50 % of all vascular plants and 40 % of all vertebrates are found in the agricultural landscape many of them in semi-natural non-fertilized grasslands (Emanuelsson *et al*. 2003). Therefore a decline in the number of grassland areas will probably result in a decrease in biodiversity in the agricultural landscape.

Benton *et al*. (2003) expressed worries on how farming procedures in Europe and North America has become more intensified over the past 60 years. This intensification is one of the reasons for the reduction in farmland biodiversity worldwide. The authors suggest that some kind of “cross-cutting policy framework and management solutions” must be put forward in order to sustain biodiversity. HagmarksMistra is a Swedish programme aiming at such a solution. In HagmarksMistra farmers, economists, biologists and ecologists try to find solutions on how farms with seminatural grasslands can combine an ecological and economical management. Within the programme a number of different projects are running, some of them study how grazing affects diversity of plants and population dynamics of the pollinators. As a part of this I have studied how orthopterans in a seminatural grassland respond to environmental variation and how their abundance differs in two different grazing regimes, continuous and late grazing. Continuous grazing started in May and continued during the whole season whereas late started in late July (further details in 4:2).

Mowing is known to increase plant diversity and in particular favour small vascular plants (Simán *et al*. 1998) and has been used in Sweden since the early bronze age (Westman 1998). The practice is however time- and personnel consuming and as farmers have to rationalize they abandon such practices. This is economically efficient but maybe not wise if the aim is to preserve biodiversity. Instead late grazing is hypothesized to be a possible replacement of mowing since the vegetation still is allowed to grow until later in the season when it would normally have been cut. This will then be positive for vascular plants but what effect does mowing/ late grazing have on other organisms? Vessby *et al*. (2002) and Söderström *et al*. (2001) showed that in seminatural grasslands the diversity of butterflies and bumblebees was negatively affected by shorter grass. So butterflies and bumblebees might benefit from late grazing because the vegetation will be higher at least until the grazers are allowed to enter the area. Guido and Gianelle (2001) showed that orthopteran dispersal patterns changed as a result of mowing.

Several studies have found that insect diversity and plant diversity are tightly linked (e.g. Haddad *et al*. 2001, Knops *et al*. 1999, Siemann *et al*. 1998) and that orthopterans are affected by the plant-community in terms of species diversity, abundance and fitness (e.g. Evans 1987, Pfisterer *et al*. 2003, Siemann *et al*. 1999). However, the mechanisms behind the interactions between insect- and plant communities are not yet fully understood (Jonas *et al*. 2002). Is it the species composition, the floral structural diversity, density, diversity of functional groups or something else that is more important, or is it the joint outcome that delivers the insects response? Jonas *et al*. (2002) suggests that the question should be less ambiguous if a comparatively small organism group is studied. A smaller group is often taxonomic stable and is not as diverse as a large group and all species function more or less the same. Orthoptera is a small group at least in Sweden and should therefore be an interesting group to study. According to Baldi and Kisbenedek (1997) and Jonas *et al*. (2002) orthopterans are especially interesting to study in relation to seminatural grasslands due to four reasons. First, the structure of orthopteran communities is sensitive to environmental changes. Second, they are almost always present in grassland habitats. Third, they are easy to sample and there are not too many species to keep track of. From Sweden there are 39 species reported, 9 of them are red-listed (Gärdenfors 2000). Fourth, orthopterans have a key role in grassland ecosystem because they constitute a large proportion of the arthropod biomass.

2 Orthopteran biology

There are three superfamilies of orthoptera occurring naturally in Sweden, *Tettigonioidae* (bush-crickets), *Acridoidae* (grasshoppers) and *Tetrigoidae* (groundhoppers). More information on these groups can be found in Holst (1986), Kindwall *et al*. (1987) and in Fogh-Nielsen (2000).

2:1 Life-cycles

2:1:1 Tettigonioidae (Bush-crickets)

In Sweden there are 10 species of bush-crickets and all but one, *Leptophyes punctatissima*, are omnivorous and feed on plant parts such as pollen, petals and juicy leaves as well as on other insects. Bush-crickets lay their eggs in the ground, on ground surfaces or in plant tissue one by one so that the nymphs will not predate on each other when they hatch. They hatch from their eggs in May and usually pass through five or six nymph-stages. Eggs of *Tettigoniidae*-species sometimes remain in their egg stage for two to three years (Brown 1990). Depending on species, temperature, food resources etc. the number of stages can vary between four and eight (Marshall *et al*. 1990). Just as the adults the nymphs are omnivorous but consume a higher proportion of plant parts in comparison to the adults. In July the first adults usually emerge from the last nymph instar. The males start producing a species specific song, known as stridulation, by rubbing the wings together. This song attracts females of the same species. Once a female has found a male they mate and the she oviposits her eggs. Bush-crickets can be seen and heard late in the autumn but in Sweden they can only hibernate as an egg.

2:1:2 Acridoidae (grasshoppers)

There are twenty-one grasshopper species naturally occurring in Sweden. They are herbivores, generally feeding on grasses, but also other plants, on which they bite holes in the leaves (Brown 1990). Grasshopper eggs are laid in egg-pods which contain between six and eighteen eggs and are species specific. The pods are laid in the ground or, more seldom, in the stems of plants. Grasshoppers hatch from eggs in May and develop through four to five nymph instars before reaching the adult stage. The first adults emerge in June and the first species to be seen and heard is usually *Omocestus viridulus*. Contrary to the females of bush-crickets, grasshopper females have the ability to produce sound. However the female song is thought to be more of a response to male singing and the main rule that males attract females is still valid. Grasshoppers are often able to produce more than one type of song, one for attracting the opposite sex, one for courting each other before mating and one during the act of mating (Brown 1990). Grasshoppers can only hibernate as eggs.

2:1:3 Tetrigoidae (groundhoppers)

In Sweden there are four species, all belonging to the genus of *Tetrix*. Groundhoppers are herbivores and feed on mosses, algae and soft plant tissue. This group of orthoptera is special in that they hibernate as adults or in the last nymph stage. The adults start to mate in April or May. The mating is not preceded by any stridulatory courtship since groundhoppers lack hearing abilities. The females lay their egg-batches in the ground, each batch contains up to twenty eggs. All adults die shortly after mating and egg laying. The first instar nymphs start to emerge in July (Kindvall and Denuel 1987). All Swedish *Tetrix* species have the same number of nymph stages, males having five and females six. The adult hibernation makes it difficult to observe groundhoppers at the same time as with grasshoppers and bush-crickets.

2:2 Predators

There are numerous enemies to orthoptera, both vertebrates and invertebrates as well as fungal and bacterial diseases (Brown 1990, Belovsky *et al*. 1990, Ingrisch and Köhler 1990). Of the invertebrates there are some parasitic insects and a number of generalistic predators e.g. carabids, spiders, ants and bush-crickets. Among the vertebrates, birds seem to pose the greatest threat but also rodents and amphibians feed on orthoptera. All stages, from egg to adult, suffer from predation but often there are different predators connected to each of the different stages. It is often very hard to distinguish between mortality due to climatic factors, food resources or predation, unless animals are closely monitored (Brown 1990) but in Belovsky *et al*. (1990) the susceptibility of grasshoppers to predation was analyzed. They found that small sized nymphs were more at risk of being predated whereas the opposite was true for adults. Invertebrates were the main predators on nymphs and vertebrates were the most important predators on adults. Further, adult males were more likely to suffer predation compared to females. This might be a result of males exposing themselves during stridulation and also that males seem to jump more than females which crawl or walk. Another danger for stridulating bush-cricket males are some parasitoid flies that are attracted to their song (Lehmann *et al*. 1998).

2:3 Effect of livestock grazing

The most obvious effect of livestock grazing is low vegetation and comparatively few flowers as most flowers get eaten. Some of the less obvious effects are trampling, seed dispersal, fertilization by the grazers and uneven grazing resulting in ungrazed left-outs. Ungrazed left-outs are the tussocks that grazers have left behind for various reasons. These left-outs result in a vegetation heterogeneity with patches of higher and denser vegetation. Moderate trampling can result in small openings in the grass turf that can make establishment of seedlings possible, but more intense and localized trampling can cause barren areas that are hard for most plants and insects to re-colonize. This allows only trampling tolerant specialists to survive (Pehrson 2001). For sluggish insects, grazing animals can act as unintended predators if they get eaten together with the grass. Instead of competing for light, many small, non-tasty, tolerant and light loving vascular plants are favoured by grazing. The timing of grazing is an important factor to consider with regard to vegetation structure (Pehrson 2001). If the grazing animals start to graze early in a pasture the vegetation height will be kept relatively low throughout the season and favour a plant diversity with smaller vascular plants, assuming there are a sufficient number of grazers. If grazers, on the other hand, are allowed to graze only in the later part of the season this will have a positive effect on vegetation height and large vascular plants.

3 Vegetation and orthoptera

3:1 VEGETATION AS HABITAT

Vegetation composition and structure is important for insects like orthopterans who live among and feed of plants (Fielding and Brusven 1993). Vegetation structure affects food abundance, temperature, humidity, sun radiation reaching the ground, wind and may constitute refuges from predators. All these factors create microhabitats for different species, however there are still general principles on how species react. If there is a high humidity content in the microhabitat insects are more likely to suffer from fungal attacks (Brown 1990). The vegetation structure can provide shelter from predators by being high and/or dense and thus making it easier to hide. It is also important to remember that vegetation is not only a structure that interacts with other variables, it is also the food source for all orthopterans. Bush-crickets have a mixed diet that to a large extent also consists of other insects, e.g. grasshoppers, but also flower parts such as pollen and petals.

3:2 VEGETATION AND TEMPERATURE

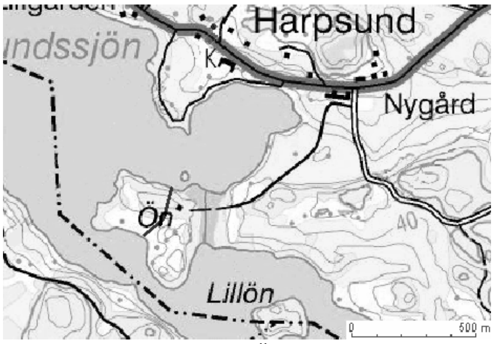
In general, insects develop faster at higher temperatures (Speight *et al*. 1999). For orthoptera temperature is deemed to be the most important factor for development (Cherrill and Brown 1990a). Temperature at ground level has the greatest impact until the eggs hatch, adults and nymph stages can actively seek warmer spots if preferred (Van Wingerden *et al*. 1991). Cherrill *et al*. (1990b) suggest that temperature differences due to vegetation matters the most during the period just prior to egg hatching. The lower temperature beneath the more dense and high vegetation might even be inadequate for the completion of egg development. In at least one study, temperature differences have been observed between microhabitats (Monk 1985). Also, grasshopper nymphs hatched later from eggs laid in a habitat with lower surface temperatures. During summer shorter vegetation that leads to higher temperatures since there is less vegetation to block the radiation (Cherrill *et al*. 1990a).

3:3 HYPOTHESIS

The above resulted in the following six hypothesis: 1) There will be more flowers in the late grazing regime since they will not be eaten. 2) The abundance of flowers will not be a major concern for grasshoppers or groundhoppers since they mostly feed on grasses but bush-crickets might respond negatively to intensive grazing since they feed on flowers (Siemann *et al*. 1999). 3) Orthopterans should on the other hand be favoured by the higher vegetation in the late grazing regime since there will be more food and possibly better protection from predators. 4) An increase in heterogeneity should result in an increase in orthoptera abundance and 5) the single most important heterogeneity factor is ungrazed left-outs because of their multifunctions, e.g. food and protection 6) Ground temperatures will be higher in the continuous grazing regime because of the shorter vegetation. 7) Eggs of orthopterans laid in the continuous grazing with its shorter vegetation should develop faster due to the higher temperatures and hence hatch earlier.

4 Methods

4:1 STUDY SITE



Map 1. The study site, Ön, Harpsund, Sweden

The present study was carried out on Ön, Harpsund (E153860/N655226), about seven kilometres NW of Flen, Sweden, a part of the Harpsund estate farm (map 1). Ön consists of a meadow-like pasture of about 10 hectares with stands of oak (*Quercus robur*), junipers (*Juniperis communis*), hazel (*Corylus avellana*), lime-tree (*Tilia cordata*) and birch (*Betula pendula*). Junipers and oaks are the dominating species. The area has a history of mowing but is now used as a pasture with cattle. The pasture has the form of a small peninsula surrounded by water on three of four sides thus making a well defined area to work in.

4:2 TREATMENT

The pasture was divided into two areas with two treatments, one where grazing started early, in the middle of May (continuous grazing) and one area where grazing started later, usually around the middle of July (late grazing) but in the summer of 2003 not until July 30. The treatments were initiated in 2000. The areas are approximately 5 ha each and separated by a barbed wire fence. When late grazing started, parts of the fence were removed to allow the cattle to move freely between the two treatment areas. An earlier study by Widén (2003) on vegetation preference for cattle grazing on Ön shows that they visited both sides of the fence equally after the fence was opened.

4:3 *SPECIES EXPECTED TO OCCUR IN THE STUDY SITE*

Before the study started a review of Holst (1986) and Kindvall and Denuel (1987) was made to sort out what species that might be found in the county of Södermanland and in a pasture habitat (table 1). This constituted our expectation list, which was compared to what was actually found.

TABLE 1. List of species expected to occur on Ön, Harpsund

Species	Habitat requirements
Tettigonia viridissima L.	Pastures or grasslands with trees, bushes and taller vegetation
Dectius verrucivorus L.	Dry and damp places in fields and meadows and by roadsides
Metrioptera brachyptera L.	Grasslands preferably with bog vegetation, moorlands
Pholiodoptera griseoptera De Geer	Gardens, parks, roadsides and grasslands
Tetrix subulata L.	Damp places, often near lakes and rivers
T. undulata Sow.	Meadows, bogs and at the edges of wood clearings
T. bipunctata L.	Dry, warm and open places in the woods or in meadows
Mecostethus grossus L.	Damp grassy spots in meadows or woodland
Omocestus viridulus L.	Damp, dry places in wood clearings or meadows, besides ditches etc.
O. ventralis Zett.	Dry, warm localitites covered with grass such as meadows and pastures
Chorthippus brunneus Thnbg.	The most tolerant grasshopper and can be found in a variety of biotopes
C. biguttulus L.	Dry, grasslands where plants like *Trifolium arvense* and *Galium verum* grows
C. albomarginatus De Geer	Dry and damp grasslands often grazed pastures
C. parallelus Zett.	Damp grasslands and on the shores of lakes
Gomphocerus rufus L.	In open grasslands and at the edges of wood clearings, rare in damp places

4:4 *PLOTS*

I used 20 randomly distributed plots in each treatment. With help of a GPS, each plot was found and marked with a plastic tube (see below). The plots were circluar with a radius of 1 m. In the middle of each plot a plastic tube was placed reading 20-30 cm above the ground. Each plot was described as regarded to its micro-climate by recording the following variables: moisture, shadiness, ungrazed left-outs, litterlayer and distance to nearest trees. Moisture was estimated on a three level scale as being wet, moist or dry. Shadiness was divided into three classes depending on an estimate on how much the surrounding trees and bushes interfered with the sun's radiation of the plot during the day (1= <20%; 2= 20-80%; 3= >80%). The number of ungrazed left-outs in each plot was counted on August 21. The depth of the litter-layer was measured by sticking a pencil down into the litter until the pencil hit hard ground, the depth was marked and measured by a ruler. The distances to the nearest trees and shrubs were measured by recording the distance to the five nearest trees and/or large bushes and then the average distance per plot was calculated for further analysis. The plots were visited each week between June 17 and August 21 the present year, 2003.

4:4:1 Flowering plant abundance and vegetation height

Once a week I counted the flowering species in each plot. Each species was recorded and the number of flowers counted. Since bush-crickets feed on flowers I also counted the number of *Ranunculus* flowers that had petals with bite marks. The *Ranunculus* flowers were used because they were present and flowering in many of the plots during the whole season and are not eaten by the cattle. The height of vegetation was measured by using a rising plate (Sanderson *et al*. 2001). This method has been found to be the most accurate for measuring vegetation height in Swedish pastures (Nordahl 2001). Measurements of vegetation height were made in four spots within the plot, not exactly the same four spots from recording to recording.

4:4:2 Orthopteran abundance

Orthopterans were counted by attaching a 1-meter long string with a loop at the end to the plastic tube in the middle of the plot. The string was pulled in a circle around the tube (picture 1). The position of the string was adjusted heightwise on the tube, to make it easier to pull it around in a circle through the vegetation. The lower and less dense the vegetation, the lower the string could be attached to the tube. The "moving" string frightened the orthopterans which tried to evade it. In order not to frighten the orthopterans before counting I approached the plot carefully so that they would remain within it. I pulled the string in a complete circle for each plot. The orthopterans present and visible were counted and recorded by species, nymph stage and sex (where possible). Species identification was made using Kindvall and Denuel (1987) and Fogh-Nielsen (2001). On the last four occasions, I listened for stridulating individuals within a 5 m radius from the centre of each plot. All stridulating individuals were counted and determined to species.

Picture 1. The string- method. Photo E. Sjödin

On every visit to a plot I also recorded time of the day, wind, and cloud cover. On five out of the total seven visits temperatures above the vegetation and on ground level were recorded. Temperature was measured by using a common household electronic thermometer. Wind was recorded on a scale ranging from 1-4 where 1 meant no winds, 2 slight winds, 3 moderate winds and 4 strong winds. Cloud cover was recorded by the percentage of the above sky covered by clouds.

In each treatment the 20 plots were divided into 4 groups of 5. After recording the results from the first 5 plots in one of the treatments I went over to the other and recorded the results from 5 plots there and then went back to the first one again. This was made to get more similar weather conditions between treatments. I also tried to make sure that one plot was not recorded at the same time of the day from occasion to occasion.

4:4:3 Phenology of two common grasshopper species

As I observed the number of individuals in each nymphal stage it could have been possible to follow the development for all species in the two grazing treatments. However I chose two grasshoppers; *Omocestus viridulus* (picture 2), which is a very early species (Holst 1986, Kindvall and Denuel 1987, Fogh-Nielsen 2000), and *Chorthippus parallelus* (picture 3) which is a somewhat later species (Marshall and Haes 1990, Fogh-Nielsen 2000) to see if the grazing regimes affected their development in any way. One good reason to compare these two species is that according to my study they were also the two most common ones on Ön this summer.

Picture 2. *Omocestus viridulus*. Photo B. Forsberg

Picture 3. *Chorthippus parallelus* Photo B. Forsberg

4:5 Climate

Data on temperature, precipitation, hours of sunshine, time of dawn and sunset were obtained through the Swedish National Institute of Meteorology and Hydrology (SMHI).

4:6 Statistics

To test if the abundance of bush-crickets and grasshoppers was correlated to some of the investigated variables I used the Spearman rank correlation coefficient test (Baldi *et al*. 1997). For every visit, all in all seven, I ranked each plot with respect to vegetation-height, the number of flowering plants, the number of flowering plant species, the number of bitemarks in *Ranunculus* flowers, the number of bush-crickets and number of grasshoppers. The continued ranking throughout the season was made to capture possible fluctuations due to e.g. weather conditions between visits. I then used the total sum, for the whole season, of each parameter (per plot) to re-rank the plots according to the total sums. The ranking of the abundance of bush-crickets and grasshoppers were then correlated against the continued ranking of the variables and also against litter depth, shadiness, ground moisture, the number of ungrazed left-outs and distance to trees/bushes.

I examined the effects of the mean treatment on a number of variables. The number of species (bush-crickets, grasshoppers and flowers); number of individuals (bush-crickets, grasshoppers and flowers); the number of ungrazed left-outs; average vegetation-height (both with and without plots that contained left-outs); average litter depth; average distance to trees and shrubs; number of bite-marks in *Ranunculus*. The data were tested for normality using the Anderson-Darling normality test with a 95 % confidence level. I used the plots in the two treatments as replicates even though they were not real replicates. This means that the analyses do not constitute an explicit test of treatment effects but only tests of site differences which may or may not be caused by the treatments. When data were normally distributed and had equal variances one-way ANOVA was used and when data were not normally distributed but had equal variances I used Mann-Whitney U-test (Fowler et al. 1998), both tests were made in Minitab, version 13.31. Soil-type and shadiness between treatments were analyzed by a chi square test.

5 Results

A total of 49 flowering species and 12 orthopteran species (5 bush-crickets, 5 grasshoppers and 2 groundhoppers) were found during seven visits to Ön, Harpsund, during June 23 to August 21 2003 (tables 2&3). Since there were only two observations of groundhoppers they will from now on be regarded as grasshoppers in all further analysis and discussions. The total number of flowering species recordings and orthoptera recordings were respectively 8772 and 1188. Out of those 1188 orthopteran recordings 95 were bush-crickets and 1093 were grasshoppers.

Since it seems reasonable to assume that most flowers are eaten in the continuous grazing regime, compared to the late grazing regime, it is probably more interesting to mention the few species that were more common in the continuous grazing. The following species showed tendencies, although not significant, to occur in higher numbers in the continuous grazing (table 2); *Antennaria dioica*, *Trifolium repens*, *Ajuga pyramedalis*, *Prunella vulgaris* and *Veronica officinalis*. The other species showed tendencies, not significant, to a higher occurrence in the late grazing regime, similar abundance between treatments or data were too scarce to draw any further conclusions.

The following orthopteran showed tendencies, although not significant, to be more abundant in the late grazing regime (table 3); *Omocestus viridulus*, *Chorthippus parallelus*, *Tettigonia virridisima*, *Metrioptera roeseli* and *M. brachyptera*. Only *Chorthippus brunneus* showed a tendency, though not significant, to be more abundant in the continuous grazing regime. For the other orthopterans data were too scarce or there were no differences between treatments

TABLE 2. Flowering species and the number of times they were recorded on Ön, in two treatments, from June 23 to August 21 2003

Family	Species		Late grazing	Continous grazing
Apiaceae	*Anthriscus sylvestris*		206	88
*	*Pimpinella saxifragra*		12	11
Asteraceae	*Antennaria dioica*		3	15
*	*Hieracium sect. Vulgata*		26	2
*	*Hieracium pilosella*		48	9
*	*Scorzonera humilis*		3	0
*	*Achillea millefolium*		77	10
*	*Centaurea jacae*		53	0
*	*Hieracium umbellatum*		2	0
*	*Leontodon autumnalis*		40	2
*	*Lecanthemum vulgare*		6	5
Boraginaceae	*Myosotis laxa*		54	0
Brassicacaeae	*Cardamine pratensis*		0	4
Campanulaceae	*Campanula persicifolia*		7	3
*	*Campanula rotundifolia*		42	1
Carophyllaceae	*Stellaria graminea*		791	117
*	*Cerastium fontanum*		50	23
*	*Dianthus deltoides*		11	0
Dispacaceae	*Scabiosa columbaria*		4	0
Fabaceae	*Trifolium pratense*		1574	468
*	*Trifolium repens*		132	291
*	*Lotus corniculata*		263	50
*	*Lathyrus pratense*		225	88
*	*Lathyrus linifoilius*		3	0
*	*Vicia cracca*		45	32
Geraniaceae	*Geranium sylvaticum*		48	2
Hyperiaceae	*Hypericum maculatum*		58	0
Lamiaceae	*Ajuga pyramedalis*		1	8
*	*Prunella vulgaris*		10	23
*	*Mentha arvensis*		13	0
*	*Lycopus europaeus*		3	0
Plantaginaceae	*Plantago lanceolota*		41	0
Polygonaceae	*Rumex acetosa*		115	14
*	*Bistorta vivipara*		6	2
Ranuculaceae	*Ranuculus acris*		540	499
Rosaceae	*Potentilla erecta*		874	342
*	*Geum rivale*		107	78
*	*Geum urbanum*		9	0
*	*Alchemilla vulgare*		67	0
*	*Fragraria sp.*		15	7
*	*Filipendula vulgaris*		45	0
*	*Filipendula ulmaria*		10	12
Rubiaceae	*Galium aparine*		116	99
*	*Galium boreale*		160	39
*	*Galium verum*		30	0
Scrophulariaceae	*Veronica chamaedrys*		240	65
*	*Veronica officinalis*		18	58
*	*Melanpyrum pratense*		74	4
Urticaceae	*Urtica dioica*		24	0
		Sum	6301	2471

TABLE 3. Species of *Orthoptera* and the number of times they were recorded on Ön, in two treatments, from June 23 to August 21 2003

Family	Species	Late grazing	Continous grazing
Catanotopidae	*Omocestus viridulus*	222	156
*	*Chorthippus brunneus*	53	138
*	*Chorthippus albomarginatus*	2	0
*	*Chorthippus parallelus*	292	204
*	*Mecostethus grossus*	18	7
Tetrigidae	*Tetrix undulata*	0	1
*	*Tetrix bipunctata*	0	1
Tettigoniidae	*Tettigonia viridissima*	17	8
*	*Dectius verrucivorus*	2	0
*	*Metrioptera roeseli*	23	10
*	*Metrioptera brachyptera*	15	7
*	*Pholidoptera griseoaptera*	9	5
	Sum	652	536

TABLE 4. Spearman rank correlation between grasshoppers or bush-crickets against measured factors

Factors	Coefficient
Grasshoppers vs:	
vegetation-height	0.33
no. of flowering plants	0.05
litter	- 0,02
shadiness	0.33
soiltype	- 0,03
Ungrazed leftouts	0.38*
distance to trees/bushes	0.24
Bush-crickets vs:	
vegetation-height	0.67***
no. of flowering plants	0.61***
no. of flowering species	0.65***
litter	0.10
shadiness	0.66***
soiltype	- 0.22
Ungrazed leftouts	0.48**
distance to trees/bushes	0.29
no. of bitemarks in *R.acris*	0.27

* P< 0,05 ** P< 0,02 *** P< 0,01

In table 4 the results from the Spearman rank correlations are displayed. Grasshoppers were more abundant when there were more ungrazed left-outs. This was also true for bush-cricket abundance. Bush-crickets were also more abundant in plots with high vegetation, many flowering plants, many flowering species and little shade.

The results are further displayed in appendix 1-6, this time with regard to treatment. Both for grasshoppers and bush-crickets a higher number of left-outs produced a higher orthopteran abundance and out of the two treatments consistently more in the late grazing regime (appendix 1&2). Bush-cricket abundance increased with vegetation height. There was almost no difference in the relation between treatments (appendix 3). When it comes to the number of flowering species and plants it seems as if bush-crickets have a stronger response in the continuous grazing regime (appendix 4&5). Finally appendix 6 shows that bush-crickets have a higher abundance in less shaded areas and in the late grazing regime compared to the continuous.

TABLE 5. Comparisons of mean values on measured factors between treatments, numbers are per plot.

Factor	DF	F	Late grazing	Continous grazing	P	Statistic
Temperature above ground	1	-	25.2±1.3	26.9±1.4	0.051 n.s.	Mann-W
Temperature at ground	1	-	22.9±1.2	22.2±1.2	0.372 n.s.	Mann-W
Flowering spp.	1	-	15.2± 1.1	8.0± 0.6	0.000 ***	Mann-W
Flowering spp recordings	1	16.23	314.9± 42.7	123.6± 18.9	0,000 ***	ANOVA
Vegetation height, cm	1	16.82	11± 0.3	7.3± 0.4	0,000 ***	ANOVA
Vegetation height in plots without left-outs, cm	1	33.23	10.2± 0.8	5.4± 0.4	0,000 ***	ANOVA
Litter-layer (all plots), mm	1	6.11	8.4± 0.9	6.1± 0.6	0.018 *	ANOVA
Distance to trees and shrubs, m	1	0.29	9.6± 1.0	10.8± 1.4	0.591 n.s.	ANOVA
Number of leftouts	1	0.47	0.7± 1.1	1.3± 0.4	0.505 n.s.	ANOVA
Number of bitemarks on R.acris	1	0.06	2.7± 0.9	1.9± 0.7	0.805 n.s.	ANOVA

* P< 0,05 ** P< 0,01 *** P< 0,001 n.s. P>0,05; ±SE

There were more flowering species per plot in the late grazing regime (table 5) and also a higher average of recording per plot. The vegetation was higher in the late grazing regime, both when analyzing all the plots and for plots with left-outs excluded from the analyses. The litter-layer was deeper in the late grazing regime. There was no significant difference in plot distance to trees/shrubs, number of left-outs or bite-marks in *Ranunculus* between treatments. In a chi square test no significant differences were found between treatments regarding soil-type (p= 0.935) or shadiness (p= 0.793). There were no significant differences between treatments regarding the number of grasshopper species per plot. Neither did the number of grasshopper recordings per plot differ significantly between treatments (table 6). The results were also consistent on the species-level for the three most common grasshopper species *Omocestus viridulus*, *Chorthippus brunneus* and *C. parallelus* (table 7). The number of bush-cricket species per plot were higher in the late grazing regime as was also the case for as the number of recordings per plot (table 6).

TABLE 6. Comparisons of mean number of recordings and species per plot between treatments. Each value is an average of seven visits per plot during the summer 2003.

No. of species	DF	F	Late grazing	Continous grazing	P	Statistic
Bush-cricket spp.	1	-	1.7± 0.3	0.9± 0.2	0.0256 *	Mann-W
Grasshopper spp.	1	-	2.7± 0.3	2.8± 0.2	0.8993 n.s.	Mann-W
No. of recordings						
Bush-cricket spp.	1	-	3.3± 0.8	1.6± 0.5	0.0497 *	Mann-W
Grasshopper spp.	1	0.08	30± 7.6	25.9± 5.6	0.7840 n.s.	ANOVA

* P< 0,05 ** P< 0,01 *** P< 0,001 n.s. P>0,05; ±SE

TABLE 7. Comparison of grasshopper abundance for the three most common species.

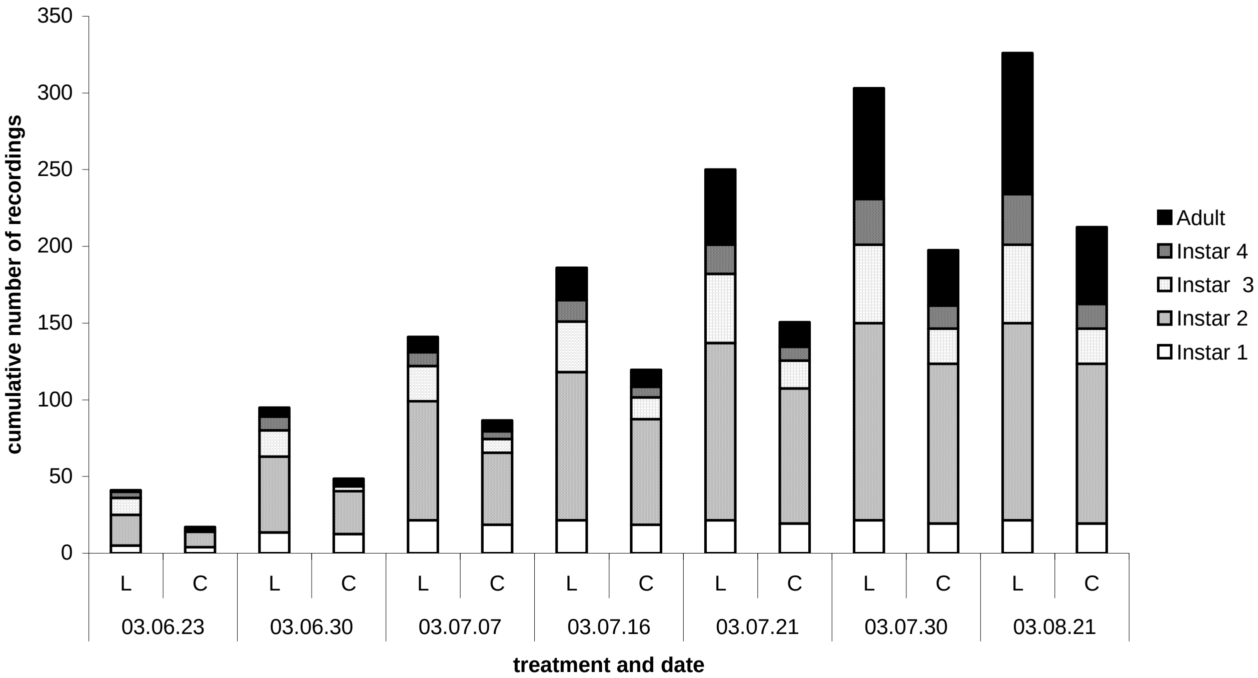
Species	DF	F	Late grazing	Continous grazing	P	Statistic
Omocestus viridulus	1	-	11,1± 2,3	7,8± 1,8	0.372 n.s.	Mann-W
Chorthippus brunneus	1	1.77	2,6± 0,7	6,9± 4,7	0.193 n.s.	ANOVA
Chorthippus parallelus	1	1.68	14,6± 2,0	10,2± 3,1	0.206 n.s.	ANOVA

Average number of recordings per plot ± SE; n.s. P>0,05

In figure 1 a-b the phenology and abundance over time is displayed for *Chorthippus parallelus* and *Omocestus viridulus* together versus treatment (fig 1a) and divided by species (fig 1b).

The first feature is that the abundance of the two grasshoppers is always higher in the late grazing regime, figure 1a. The second feature is that individuals in the adult stage appear two weeks earlier in the late grazing regime compared to the continuous. The early adult development in the late grazing regime was due mainly to one species, *O. viridulus*, figure 1b. It was not until the third week that *C. parallelus* adults were recorded. There was also a trend regarding the abundance of the two species, where *O. viridulus* was more abundant early but *C. parallelus* becoming most common from July 16.

(1a)



(1b)

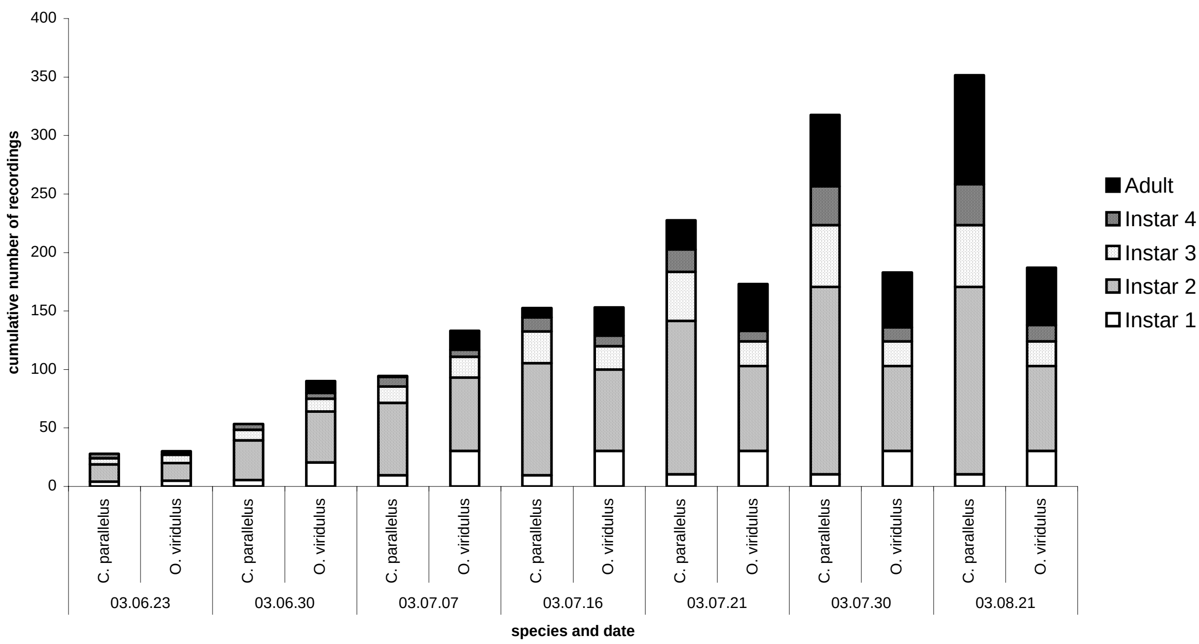


Fig. **1**. The cumulative number of instars recordings of *Chorthippus* parallelus and Omocestus *viridulus* between treatments (L= late grazing, C= continous grazing) together (a) and compared to each other (b).

6 Discussion

Since all, except the last, visits were made before the cattle were allowed to enter the late grazing part of the pasture, my data do not really show what happens during the late grazing period. However, the treatment had been going on since 2000, and hence the results represents the effects of previous years grazing regime.

6:1 Likely or possible errors in methodology

The single largest problem in this study is the one of pseudoreplication. Pseudoreplication was first described by Hurlbert (1984) and has since become a norm of which any experimental design or results are checked against. Basically Hurlbert (1984) states that in an experiment without replication of treatments it is impossible to interpret the results in any other way than descriptive because a test like analysis of variance would only reveal spatial differences between the experimental units that are in the treatments and not any effects of treatments. In some recent articles (Oksanen 2001, Cottenie and De Meester 2003) it is argued that as long as the author, with this problem, is aware of the pseudoreplication issue and clearly states so in the text, it is acceptable to perform and show the results of tests like analysis of variance and t-tests. The results cannot on the other hand be interpreted as anything else but information on the values given in the descriptive data (Cottenie and De Meester 2003), i.e. few generalizations can be made about the processes studied. In terms of my study this means that the results I display will only be concerning the pasture on Ön and the orthopterans that live there. It would have been nice, of course, to have more pastures, replicates, to analyze in this experiment but there were none within reasonable distance that we knew of and no funds available to rent any pasture-land nearby. Having said all the above I also want to stress that the basic result, the spearman rank test as shown in table 3, originates from all plots discarding treatment as a variable. The tests of vegetation height, number of flowering individuals etc were made to investigate if these variables differed between the two areas on Ön. Nonetheless I recognize it as pseudoreplication and remind you of all the above considerations when interpreting the results.

When I recorded the number of ungrazed left-outs on August 21 the cattle had been there for about three weeks. The recorded left-outs might in other words have been created after my recordings of orthopterans. However my impression is that most left-outs remain a left-out from year to year. An opinion supported by Gunnela Gustafson (pers. comm.).

As I was moving around the plots pulling the string I created a trampled “corridor” around the plot, especially if there was high and dense vegetation surrounding. It is possible that this “corridor” created an artificial boundary that somehow affected the orthopterans or predators searching for orthopterans. Still, the trampled area was relatively small and it would probably just have an effect on the very young nymphs and not older and larger ones who walk and jump longer distances with more ease.

There is a well-known difficulty with grasshopper and bush-cricket nymphs, they can display a variety of colours within the same species and nymph stage (Kindvall and Denuel 1987). Thus it is possible that I have misidentified individuals to both species and nymph stage. The only way to overcome this is experience and hopefully I got better in my recordings as the season progressed. The impact on my results may have been a more scattered picture of occurrence and abundance than the naturally occurring especially in the beginning of the study. I doubt, though, that the general trend is misleading.

6:2 METHODOLOGY

The string method seemed to be accurate as most of the grasshoppers jumped and were therefore easy to spot. The bush-crickets usually climbed downwards into the vegetation but due to their larger body size they were relatively easy to spot anyway. To have small plots where all individuals are recorded is preferable as an inventory method compared to stridulation transects. Mainly because one can not expect good stridulating conditions to occur throughout the field season and stridualtion transects do not record females and species that does not stridulate.

The attempt to estimate the abundance of bush-crickets by counting bite-marks in *Ranunculus* (mainly *R. acris*) was not a success. The most likely explanation is that there are other insects that make similar or identical bite-marks and perhaps also in higher frequencies than do bush-crickets. But since bush-crickets feed from a wide variety of plant species (B. Forsberg unpublished data) it is possible that the *Ranunculus* fraction of their diet is to small to produce a clear and measurable response.

6:3 UNEXPECTED AND MISSING SPECIES

There was one unexpected species found in this study, *Metrioptera roeseli*. This bush-cricket is only recorded from the county of Västmanland according to Kindvall and Denuel (1987) and Holst (1986). It seems to have spread since then and is now reported from both south and north Sweden (Ahlén 1995, Ivarsson 1998). There were four expected species missing, *Omocestus ventralis*, *Chorthippus biguttulus*, *Tetrix subulata* and *Gomphocerus rufus*. The pasture has habitat features that suit the four species and they are distributed in this and more northern regions of Sweden, both *T. subulata* and *C. biguttulus* have previously been observed in a nearby meadow (E. Sjödin pers. comm.). Two possible explanations for the absence of these four species are that they have more specific demands on the habitat or the isolation of Ön on three sides has prevented individuals from immigrating.

6:4 PHENOLOGY OF CHORTHIPPUS PARALLELUS AND OMOCESTUS VIRIDULUS

The predicted pattern of *O. viridulus* being the earlier species was accurate. *C. parallelus* was the most abundant of all orthopteran species and *O. viridulus* was the second most abundant. I found almost no individuals in the first instar compared to the second. It is likely that the first instar nymphs were most abundant before my study started. Alternative and less likely explanations for this could be mislabelling first instars to second instars, or that the first instars are easy to miss and that the second have a longer development time which make their abundance over time appear large.

Van Wingerden *et al*. (1991), Cherrill and Brown (1990a) and Monk (1985) report field and laboratory results showing that grasshopper eggs laid in a short turf grassland develop faster than eggs laid in higher vegetation. If that trend is persistent throughout the season then grasshoppers developing in the continuous grazing regime should reach the adult stage earlier than those developing in the late grazing regime. This seems to be the case in figure 1a where adults are recorded a week earlier in the continuous grazing regime.

Both species showed constant higher abundance in the late grazing regime, suggesting that there is something in that treatment that is preferable for these two species. Most likely it is the higher vegetation that explains their tendency to occur in that grazing regime, as was hypothesized.

6:5 Grasshoppers and ungrazed left-outs

The only significant result for grasshoppers, as a group, in this study was that they were favoured by ungrazed left-outs, no matter treatment. This is probably an effect of their biology being more or less generalistic. The left-outs provide a sheltered microhabitat, away from large predators and from harsh climatic conditions such as strong winds and rain. However, there was a trend of more observations in the late grazing regime, except for *Chorthippus brunneus* that showed tendencies to be more abundant in the continuous grazing regime. In other words, the hypothesis that the higher vegetation in the late grazing regime would benefit grasshoppers, with more food and shelter, was not accurate, at least not on grasshoppers as a group. Of course different grasshopper species react differently to vegetation height.

6:6 Microhabitats

The factors correlated with bush-cricket abundance are ones that contribute to an increase in habitat heterogeneity. There are many articles on how habitat heterogeneity affects local populations of organisms in terms of refuges, food sources, dispersal, oviposition sites etc. (e.g. Guido and Gianelle 2001, Jeanneret *et al*. 2003). In line with those Hart and Horwitz (cited in Dennis *et al*. 1998) put forward the "habitat heterogeneity hypothesis" that predicts an increase in arthropod species when there is an increase in different forms and plant species that make up a more heterogeneous habitat. Kindvall (1996) showed that as habitat heterogeneity increased for bush-cricket *Metrioptera bicolor*, the temporal population variability decreased. In my plots ungrazed left-outs were one of the contributing heterogeneity factors and as hypothesized ungrazed left-outs proved to be important for both grasshoppers and bush-crickets. That ungrazed left-outs, or tussocks, are important have been reported earlier by e.g. Dennis *et al*. (1998) who found that tussocks in a grazed grassland consistently held more species and had a higher abundance of the 81 studied arthropod species. A more heterogeneous vegetation structure associated with low grazing intensity was the most favourable for arthropods. Isaksson (2004) speculated that tussocks might have a positive effect on the diversity of ground beetles. Cherrill and Brown (1990b) found *Decticus verrucivorus* more frequently in tussocks than anywhere else in a grazed pasture. In a Swedish study, Tussocks offer bush-crickets and grasshoppers shelter from predators, not bush-crickets though, and perhaps also from rain and strong winds. Since grasshoppers also are more abundant in left-outs it seems plausible to assume that bush-crickets had access to more food in the left-outs than outside.

High vegetation has some similar features with left-outs in that it offers protection from predators and climatic conditions. High vegetation might also be an indication of that the area is not grazed, and maybe that is what is important. As mentioned before, bush-crickets are not just insectivores but they feed from flower parts as well. How important flowers are as a food source has not been fully evaluated. That I found bush-crickets to be more abundant where flowers were more abundant could result from any of three things. Firstly, flowers could be a very important food source. Secondly, many flowers in a patch usually means low or no grazing. This would mean that bush-crickets are disturbed by grazing. Thirdly, patches with many flowers might have something, other than flowering plants, in their environment that attracts bush-crickets. I consider that the first and second suggestions are most likely to be accurate (see below 6:8) which means that flowers should be considered more important as a food source than has before. It should be remembered that these correlations have been made with bush-crickets as a group and that within the group different species may show different habitat preferences.

That shading has a negative effect on orthopterans has been reported earlier (e.g. Holst 1986, Gustafsson 1997, Fogh-Nielsen 2000) but these authors have not really explained why. Insects in general develop slower where there is less light and thus lower temperatures so it seems likely that individuals in shaded areas will actively search and move to sunnier areas or conditions.

Gustafsson (1997) correlated a number of factors against orthopteran abundance in some Swedish pastures. Among these factors were vegetation height, indirect and direct shading, number of plant species and flowering frequency. Consistent with my results, Gustafsson found more orthopterans in areas with high flowering frequency, high number of plant species and in areas low in shadiness. However, opposite to my results, she found a negative correlation with vegetation height and orthopteran abundance. Her findings might be a result of that some of her study sites lacked grazers. If there are no grazers present the vegetation will gradually change to one with less herbs and a higher proportion of grasses and bushes. In such a site orthopteran species will disappear not because the vegetation is higher but mainly because it is never grazed or cut. This links back to the question of the traditional mowing. Both Gustafsson and I found less orthopterans/ bush-crickets when shading increased. When mowing was used the pastures were also cleared of twigs, old leaves and bushes every spring, a management known as "*fagning*" in Swedish . As mowing was abandoned as management practice so was *fagning*, and cattle grazing does not have the same effect on a pasture. So the amount of bushes contributing to shadiness are likely to increase and with that a decrease in the number of bush-cricket individuals seems likely. However, there are some species such as *Pholiodoptera griseoaptera* that depend on bushes and trees to oviposit (Fogh-Nielsen 2000, Guido and Gianelle 2001).

Neither group of orthoptera seemed to react to variation in litter-layer, soil-type or distance to trees and shrubs. These factors can maybe reflect the distribution of single species but not that of an entire group. It is interesting to see, however, that the distance to trees and shrubs does not seem to affect bush-crickets even though they had decreasing numbers of observations in shaded areas. This might be explained by that the distance to trees was an average of the nearest five trees and/or bushes. It might suffice that just one or two trees are close to a plot for it to be shaded but as the distance is an average there might not be a correlation between those factors. Maybe it would have been better to just measure the distance to the nearest tree or bush to get more precise readings.

6:7 Grazing regime variation

The differences between grazing regimes is a site effect that, in my opinion, is also reflecting an effect of grazing treatment. Some variables did not differ between the two areas. Temperature, for example, did not differ at ground level between treatments, which is a bit surprising considering earlier studies (Monk 1985, Cherrill and Brown 1990a, Wingerden *et al*. 1991). Perhaps the late and early grazing regimes did not differ enough in microhabitat structure to generate any temperature differences. The other studies however applied a different method, they used Berthet tubes (Berthet 1960) whereas I used a thermometer. The tubes are filled with a sucrose solution and put in the soil for some days after which they reveal the temperature sum over that period of time. With my thermometer I got very precise recordings and always during the day. The Berthet tubes would have been preferable since they would take night temperatures into consideration as well.

The higher abundance of flowers, individuals as well as species, in the late grazing regime was expected. The flowers in the early grazing regime are simply eaten by the cattle. The same goes for the vegetation height. As a result of the higher vegetation and a higher plant biomass, the litter layer also becomes deeper in the late grazing regime.

Ungrazed left-outs were created in equal numbers between treatments and that it is probably the way it should be. The left-outs are created by mainly two things, patches with feces and distasteful or indigestible grasses/ herbs (G. Gustafson pers. comm., Cherrill and Brown 1990b.). Most animals show a behaviour of not feeding near their own species feces in order to avoid parasites or other contaminants. But there is no avoidance of feeding near another species feces so with mix of grazing animals e.g. sheep and cattle the left-outs will be eaten. Another effect of animal feces is a sudden outburst of plant nutrients which leads to very thick stands of vegetation that cattle often leave. Grazing animals in general are very good at distinguishing between digestible and indigestible vegetation and stands of indigestible grasses and herbs are left to form left-outs. From what I could see in the field it seemed like the many of the left-outs were present from year to year which seems to be the a common feature (according to Gunnela Gustafson at the department of Animal Nutrition and Management, Swedish University of Agriculture).

6:8 Orthoptera and grazing regimes

Since three out of five of the factors that favour bush-cricket abundance were most common in the late grazing regime it was no surprise to find that bush-crickets were more abundant in that treatment. From appendix 2-6 some differences can be seen to how they respond to variables between the two treatments.

Bush-cricket did not seem to respond differently to shading or number of ungrazed left-outs between treatments. Bush-cricket abundance was higher in the late grazing regime but the slopes of the lines are very similar (appendix 2 & 6). This is probably a reflection of that bush-crickets react in a similar way to shading and left-outs no matter treatment. The influence of vegetation height on bush-crickets was very similar between treatments (appendix 3). This is a bit unexpected since it seems reasonable to assume that it would be of greater importance in the continuous grazing where high vegetation was more scarce. It can perhaps be explained by the fact that, there were ungrazed left-outs in sufficient numbers to compensate for lack of larger patches with high vegetation.

Flower richness, both species and abundance, seems to affect bush-crickets differently depending on treatment (appendix 4 & 5). In the flower poor continuous grazing regime every flowering individual is of greater importance than one in the flower rich late grazing regime. As a consequence, bush-crickets display a stronger response to flowers in continuous grazing treatment. This is one of the few reported observations suggesting that flower abundance may be an important factor for bush-cricket abundance. Since there is no significant difference in number of plant species between the treatments, it suggests that species richness is less important than flower abundance or plant biomass. The high diversity in vascular plants reported from grasslands with haymaking, mowing and early grazing (Simán and Svensson 1998, Pehrson 2001) might in other words be irrelevant to bush-crickets. Instead a higher and more heterogeneous vegetation with few but more abundant flowering species could be preferable, as long as the pasture is mowed or grazed during part of the season. Perhaps bush-crickets develop better when they have greater access to a mixed diet and therefore require a large proportion of flowers as well as insects, this behaviour has been shown for other orthoptera (Bernays *et.al* 1997).

6:9 IMPLICATIONS FOR MANAGEMENT

If these results apply to Swedish pastures in general, remember the pseudoreplication issue, then it is clear that to maintain bush-cricket abundance and diversity in pastures, there has to be patches with higher vegetation and flowers in sufficient numbers. This seems to be in shortage when there is continuous grazing throughout the season and every year as a result of the more intensified grazing managements. It also appears that grazing affects bush-crickets more than grasshoppers.

6:10 FUTURE WORK

Due to the fact that most of this study is a classic pseudoreplicate it would be appropriate to see if my results describes a general relation between orthopterans and microhabitat just the situation in the studied pasture. Something that I was in great need of this summer was a key to the different instars. It should not be too hard to construct one that can give information on what species and instar individuals are. Such a key would be perfect now that technology has made it possible to use small palm pilots with interactive keys it would be the gadget to bring on field excursions instead of heavy literature.

7 Summary

The present study focuses on orthopterans in relation to timing and intensity of grazing. The study takes place in Harpsund, Ön, where two grazing regimes had been established, one with continuous grazing and one with late grazing. In general, orthopterans seem to respond numerically to microhabitat heterogeneity, which in this study is measured as number of ungrazed left-outs. Bush-crickets show a numerical response in relation to heterogeneity, vegetation height and flower abundance. These factors are negatively affected by grazing, which make number of bush-crickets to be more abundant in the late grazing regime. Grasshoppers do not show any preference for either grazing regime. The timing of grazing

might however affect different grasshopper species differently because of their different phenology.

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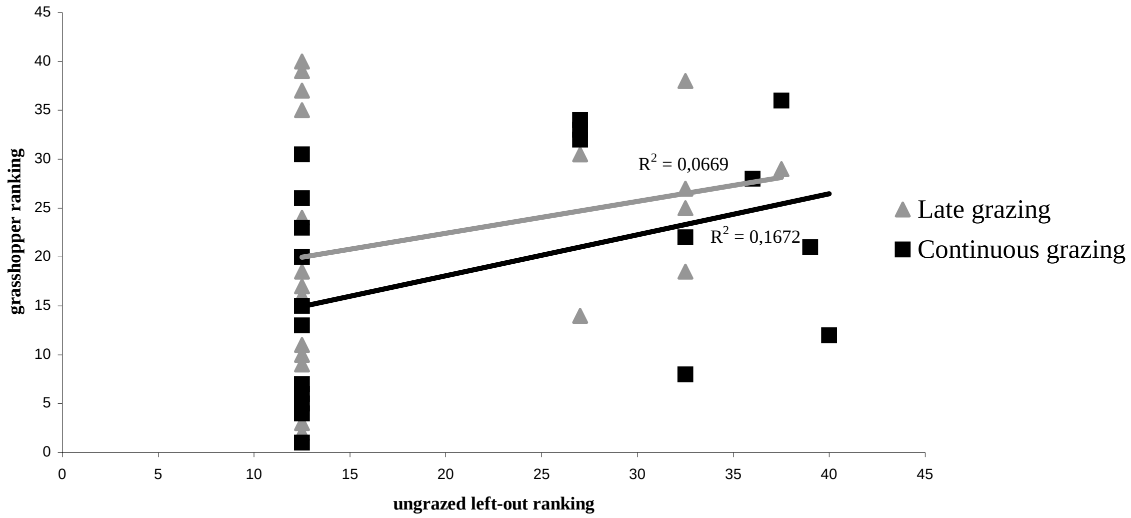
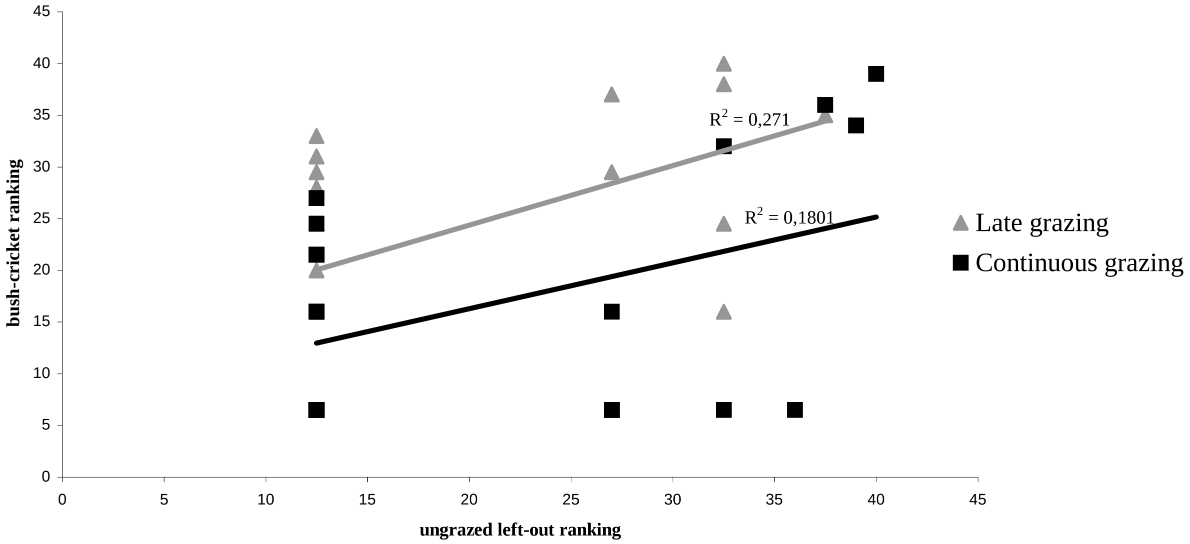
Appendix 1



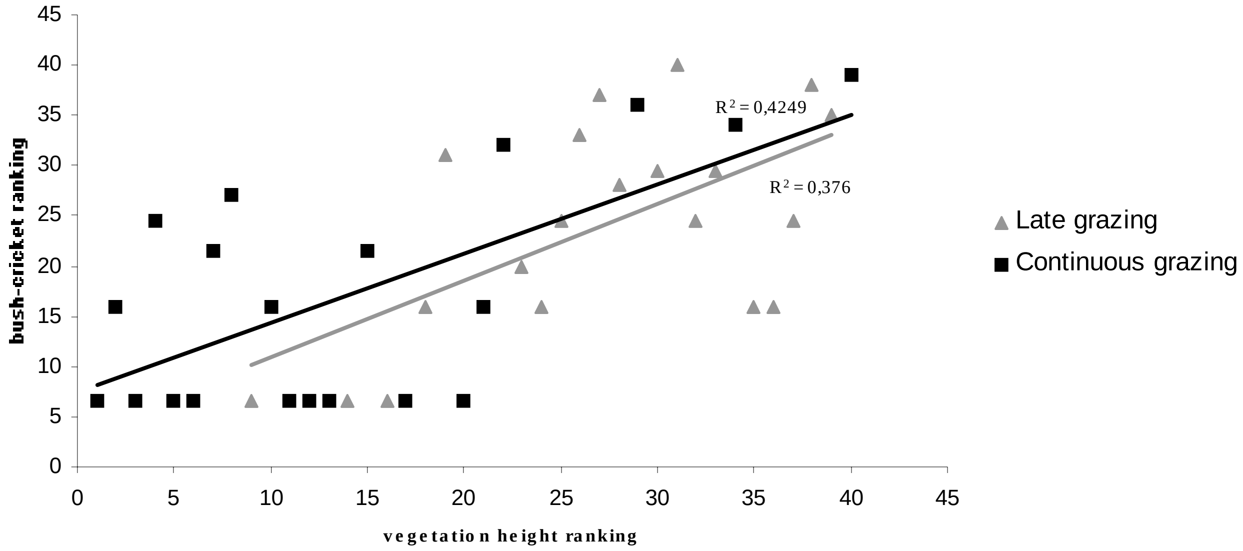
Grasshopper ranking correlated with ungrazed left-out ranking in the two treatments late and continuous grazing.

Appendix 2



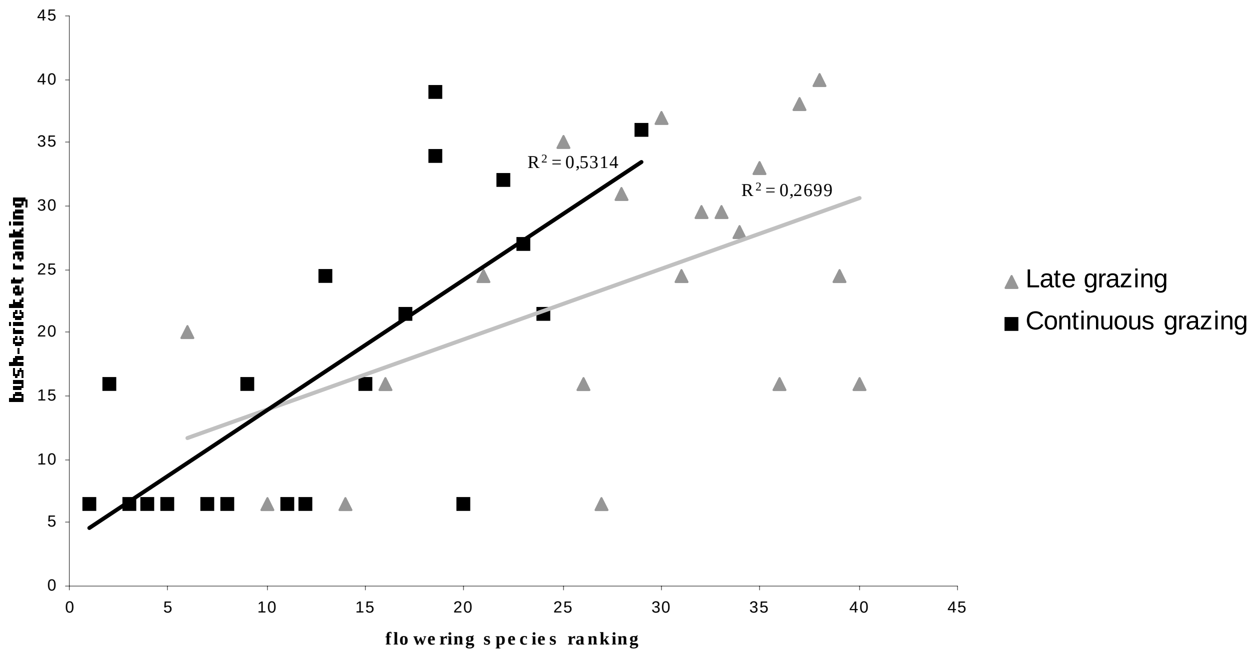
Bush-cricket ranking correlated with ungrazed left-out ranking in the two treatments late and continuous grazing.

Appendix 3



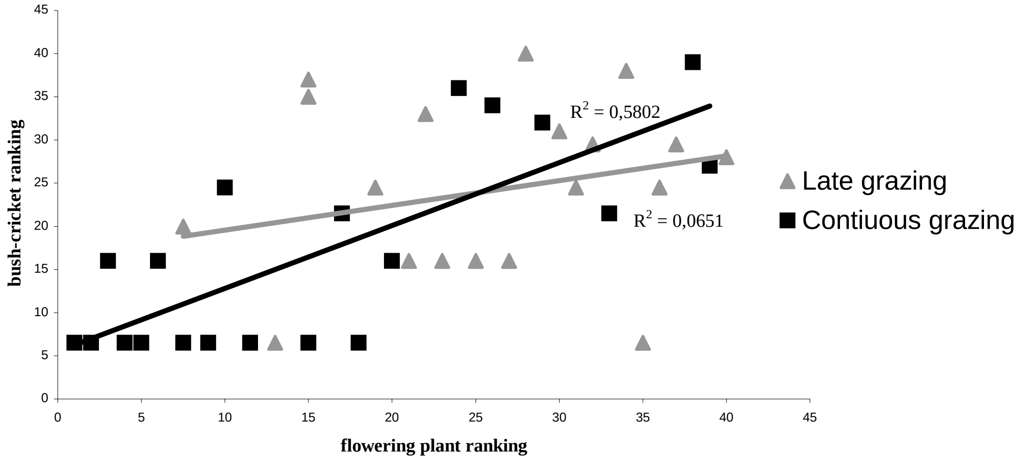
Bush-cricket ranking correlated with vegetation height ranking in the two treatments late and continuous grazing.

Appendix 4



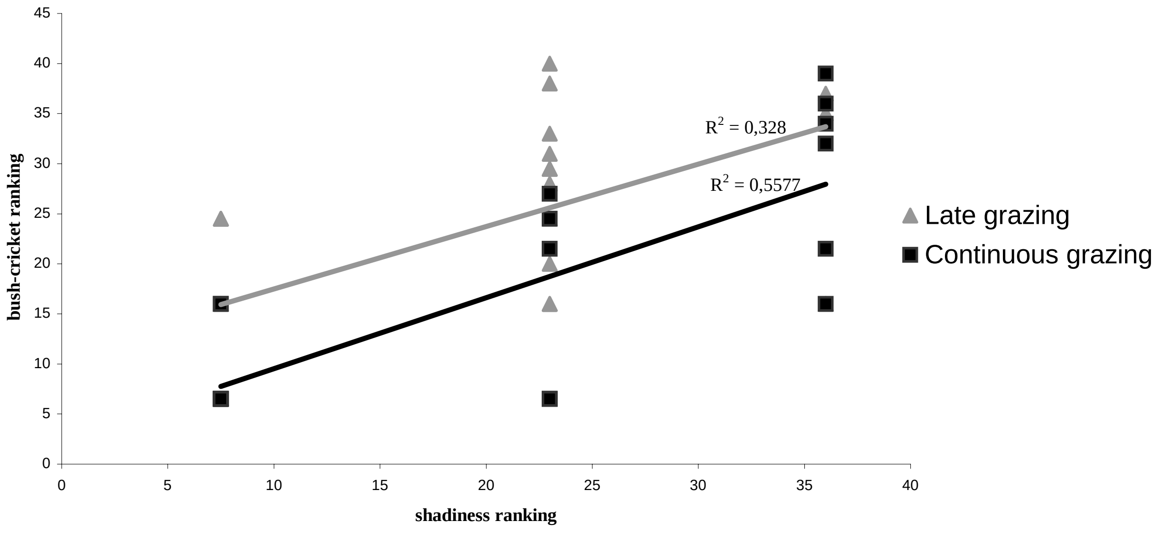
Bush-cricket ranking correlated with flowering species ranking in the two treatments late and continuous grazing.

Appendix 5



Bush-cricket ranking correlated with flowering plant ranking in the two treatments late and continuous grazing.

Appendix 6



Bush-cricket ranking correlated with shadiness ranking in the two treatments late and continuous grazing.