Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Ecology

The effect of agricultural land-use on bush-cricket and grasshopper diversity

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Bachelor's thesis

Uppsala 2017

Independent project/Degree project / SLU, Department of Ecology 2017:10

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Credits: 15 hec
Level: G2E
Course title: Degree project in biology
Course code: EX0689
Place of publication: Uppsala
Year of publication: 2017
Cover picture: Female great green bush-cricket – *Trettigonia viridissima.* Friedrich Böhringer, Wikimedia commons.
Title of series: Independent project/Degree project / SLU, Department of Ecology
Part no: 2017:10
Online publication: http://stud.epsilon.slu.se

Keywords: Orthoptera, grasshopper, bush-cricket, land use, land cover, agriculture, fragmentation.

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Abstract

Mängden lämpligt habitat för gräshoppor och vårtbitare har minskat på grund av människans utbredning och utnyttjande av det svenska landskapet för spannmåls- och foderproduktion. Denna litteraturstudie behandlar hur mångfalden hos vårtbitare och gräshoppor i jordbrukslandskapet kan påverkas av olika faktorer på åkerholmar och i det omgivande landskapet. Vad arterna har för krav på sitt habitat är viktigt att veta för att kunna vårda naturen på rätt sätt för att skydda arter från utdöende. Studiens mål är att få inblick i elva arter av rätvingars förekomst och mängd på åkerholmar utifrån sju variabler valda utifrån information om arternas ekologi. I förlängningen kan det ge en fingervisning om hur man ska vårda jordbrukslandskapet för att bevara arterna och deras habitat. Resultatet pekar på vikten av att bevara olika slags habitat, dels för att olika arter föredrar habitat med olika egenskaper men också för att olika individer troligtvis behöver habitat med olika egenskaper under de olika stadierna i sin livscykel. Resultaten pekar samtidigt på att närbesläktade arter har liknande krav på sitt habitat, vilket är en erfarenhet som kan ha betydelse för framtida naturvård. För att skydda arter från utrotning måste vi människor använda landet hållbart för att undvika fragmenterade landskap.

The amount of habitat suitable for grasshoppers and crickets has decreased due to the human expansion and use of the Swedish agricultural landscape. This literature study covers the effect on grasshopper – and cricket diversity from different features on grassy field islands and the surrounding agricultural landscape. Knowledge about species' requirements of their habitats is important for conservation management and to keep the species from going extinct. This study tries to get an insight in eleven species of orthopterans presence and abundance on field islands in Sweden according to eleven variables based on facts about the species ecology. This could give us an indication on how to manage agricultural land to protect the species and their habitats. The result of this study shows the importance of keeping various kinds of habitats since different species have different habitat requirements. Also the result suggests that closely related species prefers similar habitats, an experience that might affect future conservation and protection. To protect species from going extinct humans must use land with consciousness to avoid fragmentation.

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Introduction

Since the 1940s Europeans have gradually intensified farming practices, generally this has created a dramatic reduction in diversity of species inhabiting these landscapes. The agricultural areas are used to make human food but also for producing feed for farm animals (Robinson and Sutherland 2002; Marini et al. 2009). The loss of natural habitats and fragmentation of remaining areas has followed this intensification process. The result is that many animal populations in these landscapes are vulnerable to extinction and rely heavily on the preservation of remaining suitable habitats (Bender et.al. 1998;Berggren et al. 2001).

Individuals of species need to move to new locations if food resources decline. With an increasing fragmentation of suitable habitats, finding new locations will become more difficult. This means that even if suitable habitats remain, their use will be dependent on if animals can reach them (Begon et al. 2014). Smaller habitat areas may have harsher climate, less resources and restrict population sizes; this might lead to inbreeding and extinction of populations (Berggren et al. 2001).

The Orthoptera order includes grasshoppers and bush-crickets. These taxa are an important component of grassland communities and several species are recyclers of nutrients and food for birds (Badenhausser et al. 2015). Many species live in the agricultural landscape and in the grassland areas that are found there. Different species have different habitat requirements. The factors affecting mortality and reproduction can be both abiotic (e.g. weather, seasonal effects and humidity) and biotic (e.g. availability of food, predation and competition)(Benton 2012). Intensified use of grasslands has resulted in homogenous and crop dominated habitats, in other words habitats unsuitable for grasshoppers (Badenhausser et al. 2015; Marini et al. 2010). Species that can move well are likely to be less affected by fragmentation in the landscape, species that are not as good to move are more likely to decline due to fragmentation and habitat loss. The size of the habitat patch might have a big impact on the survival of a population (Bender et al. 1998).

A good understanding of orthopteran ecology and habitat requirements is needed to provide us with information on the importance of different features in the agricultural landscape. It also gives us an idea of what areas to conserve, and how to manage different habitat types, such as field islands to make them appropriate habitats for crickets and grasshoppers.

Furthermore, it may give us a hint how to manage the field islands to make them appropriate habitats for crickets and grasshoppers.

The aim of this thesis is investigate if local and landscape factors affect species of Orthoptera in the Swedish agricultural landscape. This is done by comparing data on species occurrence on 78 field islands located in the municipality of Norrtälje, Stockholm County, Sweden with environmental data gathered from digital maps. Several hypotheses were tested in the study based on knowledge of the ecology of different Orthopteran species. The hypotheses of this study were mainly based on facts about the species gathered from a number of books and articles (see below) limited by the time and scope of this thesis. The hypotheses were also made through discussions on ecology and the species with supervisor Åsa Berggren. An argument we repeatedly got back to was on how similar species can be affected in similar ways. See column H for each species and variable in Table 1, where it is also shown that all variables were run against all species in terms of both abundance and presence. All hypotheses are stated in Table 1 (below).

Material and methods

Study areas

Species and environmental data were gathered from 78 field islands in agricultural areas in the municipality of Norrtälje, Stockholm County in Sweden, (centre of the study area 59°50'28.9"N, 19°36'4.4"E). The agricultural landscape in this region is a mix of fields used for crop production, forest areas, pastures and grasslands.

Patch and landscape data

Environmental data was gathered both from the field and from digitised maps. In total information on about 20 different variables were collected; a subset of 7 variables was used for this study. The variables chosen were suitable for the hypotheses that I wanted to test. Four of the tested variables were gathered in the field: proportion of the island covered by 1) trees, 2) bushes and 3) grasses and herbs and 4) humidity (ranked from 1 – 5 with a low value being the driest). A hand being put on the ground inside grassy vegetation created an index of humidity. The value was then decided from the tactile sensation of moisture. Patch area was measured in m2, amount of grasses, bushes and trees in the patch was measured in percent (of the patch) and field margins were measured in kilometres. Patch means the actual field island on which the individuals were detected. Agricultural land-use data during the year of the survey were compiled from the Swedish Board of Agriculture's database (blockdatabasen) and values calculated in GIS.

Fig 1. One of the field islands in the Norrtälje region where orthopterans were censused.

Species census

The field islands were censused from 30 August to 25 September 2008 between 10 am to 5 pm for stridulating orthopterans. Censuses were only done when the weather was sunny or partly sunny and the temperature was above 18° C. This was to reduce the possibility of individuals not calling due to cold weather conditions. Each field island was censused by walking around and over the patch in a manner so that all areas could be reached. The census effort was kept the same across islands, i.e. time spent was correlated to island size.

Study species

In this study we focus on eleven species of Orthoptera. Below is detailed information on these species' ecology. The hypotheses of the study are formed with the help of what is known about the species (below). None of the species are currently considered to be vulnerable in Sweden according to The Swedish species information centre (Artdatabanken 2015). The hypotheses of this study were mainly based on facts about the species gathered from a number of books and articles (see below) and through discussions on ecology and the species with supervisor Åsa Berggren.

Great green bush-cricket – *Trettigonia viridissima*

A large species likely to be found in southern Sweden, the male individuals are between 28-35 mm whereas the females are 28-38 mm (ovipositor excluded). This species is recognizable by a light brown line along the back and otherwise all over green colour (Strid et al. 2010). The species is often found in bushes, ditches and gardens. They occur on the upper branches of bushes during sunny days (Benton 2012). The adult individuals occur in higher vegetation, bushes and leafy trees in grazing lands. The younger individuals prefer herbal meadows where they feed on pollen (Strid et al. 2010).

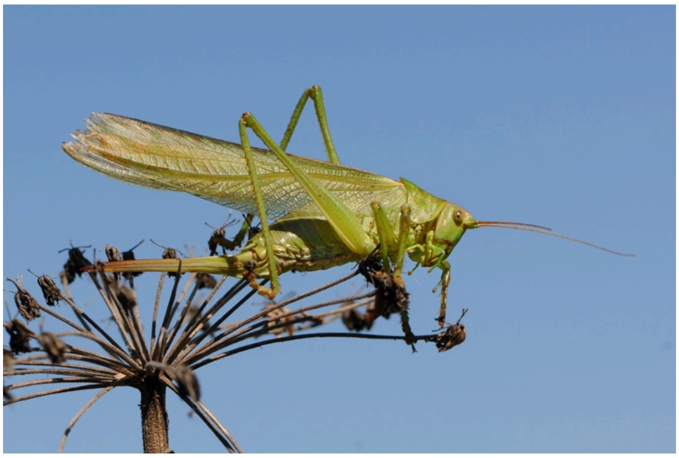

Fig. 2: Female great green bush-cricket – *Trettigonia viridissima.* Friedrich Böhringer, Wikimedia commons.

Wart biter bush-cricket – *Decticus verrucivorus*

The wart biters prefer grasslands but can also be found in heathlands, cutting areas and shores. The most usual colour of the species is green dappled, the male individuals do also occur in light dappled grey, brown or beige tones. The wart biter bush-cricket is a fairly large species; both the male and female individuals become 25-45 mm long (excluding the female ovipositor). This cricket is considered to be fairly common and is often found in the southern and eastern parts of Sweden (Strid et al. 2010).

Fig 3: Female wart biter bush-cricket – *Decticus verrucivorus*. Hans Hillewaert, Wikimedia commons.

Roesel's bush-cricket - *Metrioptera roeselii*

A small species where the male individuals become 12-18 mm and the females (ovipositor excluded) become 14-20 mm. This cricket is green, brown and grey. The serrated pattern on their hind legs is characteristic for the species (Strid et al. 2010). For a long time this species distribution have been limited to Mälardalen (the Mälaren valley) in the central east coast of Sweden. During the last decades the species has increased its distribution. It has been found in the northern east coast of Sweden but also in southern Sweden. The species mainly occurs in central and eastern Europe but the natural range of the species has extended to Denmark, England and Sweden. The species populations are geographically isolated and their origin remains unknown though it presumably first came to Sweden through transports of hay from Finland (de Jong and Kindvall 1991; Kaňuch et al. 2013). The cricket is common in lush high-grass vegetation, ditches, road verges and is often found high up in the grass (Berggren 2001; Strid et al. 2010).


Fig 4: Female roesel’s bush-cricket - *Metrioptera roeselii.* BJ Schoenmakers, Wikimedia commons.

Bog bush-cricket – *Metrioptera brachyptera*

A very common species, found in most parts of Sweden, prefers nearly any environments exposed to sun. This species only avoids arable land and pasture, other than that it is found in basically any habitat. Individuals of this species particularly prefer outcrops, swamps and cutting areas in the woods. The cricket is fairly small, the females are 13-21 mm (excluding the female ovipositor) and the males 12-16 mm. The species is green and dark brown, totally brown individuals also occur (Strid et al 2010).


Fig 5: Male bog bush-cricket – *Metrioptera brachyptera*. Ian Kirk, Wikimedia commons.

Dark bush-cricket – *Pholidoptera griseoaptera*

The species has a sturdy and broad body in brown nuances with a yellow and green belly and hardly any wings (Strid et al. 2010). The species enjoys the warmth of the sun to the extent it even swaps posture to expose each side of their body to the sunlight (Benton 2012). It occurs in southern and southeast parts of Sweden. The male individuals are 13-15 mm and the females (ovipositor excluded) 17-20 mm. As the name indicates this species prefers bushes and is likely to be found in parks, gardens and grazing lands (Strid et al. 2010).

Fig 6: Male dark bush-cricket – *Pholidoptera griseoaptera*. BJ Schoemakers, Wikimedia commons.

Large marsh grasshopper – *Mecostethus grossus*

This is a large and fairly colourful grasshopper, the body is greenish yellow or even olive green and on both sexes a yellow stripe runs alongside the margin of the long wings. Sometimes the heads of the female individuals may even be a bit dark red or purple (Marshall and Haes 1988). The male individuals are 16-25 mm and the females are as large as 22-39 mm. This species is endangered throughout Europe but in Sweden it is a common species found in most parts of the country (Strid et al. 2010). The species is found in wetlands, swamps, moorlands, shore meadows and lush meadows (Benton 2012).


Fig 7: Female large marsh grasshopper – *Mecostethus grossus*. Aiwok, Wikimedia commons.

Woodland grasshopper – *Omocestus viridulus*

The species is green all over but individuals in brown or yellow and brown do sometimes occur. Some of the female individuals are green on top with red and brownish sides. The male individuals are 13-17 mm whereas the females are 17-24 mm. The species is considered very common throughout Sweden and occurs in many types of habitats although it prefers lush rather than dry and bare habitats (Strid et al. 2010).


Fig 8: Female woodland grasshopper – *Chorthippus biguttulus.* Bernard Dupont, Wikimedia commons.

Field grasshopper – *Chorthippus brunneus*

This is one of the most common species of grasshoppers in Sweden, it occurs throughout the whole country except for the northern provinces of the country. Field grasshoppers prefer dry habitats and are less common in humid ones. The male field grasshopper is 14-18 mm and the female 19-25 mm (Strid et al. 2010). It is not unusual to find this species in dry rocky gradients, recently disturbed land and open areas in the forest. The colour of this species varies a lot, the three most common appearances of the species is mottled, striped and semi-mottled in straw-colour, grey and brown with an orange tip of their abdomen. The females also occur in green and lilac, purple or purple and brown. The male individuals also appear in brown, grey and black (Benton 2012).

Fig 9: Male Field grasshopper – *Chorthippus brunneus*. Ian Alexander, Wikimedia commons.

Bow-winged grasshopper – *Chorthippus biguttulus*

This is a fairly small species were the male individuals are 13-15 mm and the females are 16-22 mm. The body is mottled brown and green with a red tip of the abdomen. It is common in the southern parts of Sweden but further north it only occurs on the coast. The species is nearly as common as the field grasshopper (above), it prefers dry meadows and appears in both pasture and grasslands (Strid et al. 2010).


Fig 10: Bow-winged grasshopper – *Chorthippus biguttulus.* Quartl, Wikimedia commons.

Lesser marsh grasshopper – *Chortippus albomarginatus*

In Sweden the species is only found in the southern half of the country and occurs in both dry and damp grasslands. The male individuals are 12-16 mm and the females 17-22 mm. The species is light green and beige and the female individuals have a light coloured stripe alongside the margin of their wings (Strid et al. 2010).


Fig 11: Female lesser marsh grasshopper – *Chortippus albomarginatus*. Quartl, Wikimedia commons.

Rufous grasshopper – *Gomphocerus rufus*

The species is common throughout most parts of Sweden. The male individuals are 14-18 mm and the females 17-24 mm (Strid et al. 2010). The rufous grasshopper occurs in different grey, brown, green and even red patterns but is recognizable by their ostentatious, light-tipped and clubbed antennae (Marshall and Haes 1988). It occurs in most habitats but is found in woodlands more often than pure agricultural areas; herbal clearings, green roadsides and lush vegetation are preferred (Strid et al. 2010).

Fig 12: Female rufous grasshopper – *Gomphocerus rufus*. Björn S, Wikimedia commons.

Statistical analyses

Both presence and abundance for all 11 species was run against all environmental variables. Pairwise correlations was performed for all environmental variables, no correlations showed an $r > 0.43$. A general linear model (GLM) with a poisson distribution was used to analyse the relationship between number of individuals of one species with the different patch and landscape data. The relationship between the presence of a species and patch and landscape variables were analysed using a GLM with a binomial distribution. General linear models with poisson distributions were also use to analyse the effect of patch and landscape variables on number of species and number of individuals. Additionally, we analysed numbers of grasshopper and bush-crickets species separately with a GLM with a Gaussian distribution to see if the groups were affected differently from the patch and landscape variables. Some species were very rare. Only species that occurred in more than 5 locations were included in the analyses. All statistical analyses were made in R (version 3.2.2, R Development Core Team 2015).

Results

There were 14 different species of orthopterans on the islands, 11 of them were used in the analysis. In total 1453 individuals were found, 1 337 of these were used in the analyses. The islands had on average 17 individuals and minimum and maximum individuals found on an island were 1 and 56 respectively. The most common species was the Rufous grasshopper, were 452 individuals were found (fig 13). The "no effect" category means there were no previous studies found and that a hypothesis was not stated due to this.

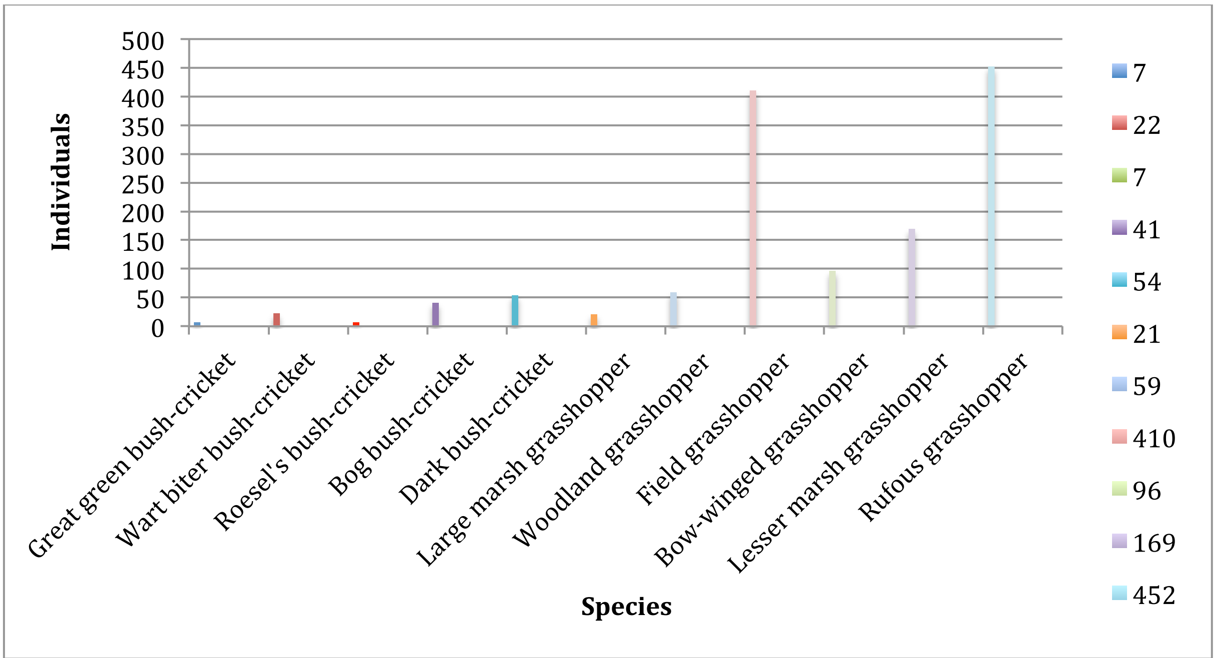

Fig 13. Shows the abundance of each species of the total of 1 337 individuals used in the analysis.

Many of my hypotheses of what affected the presence and abundance of species were confirmed (see Table 1, 2). Of the relationships between species presence and abundance and patch and landscape variables where I expected a positive relationship (in blue, 118 cases), I found a significant positive relationship in 34 cases (29%). In the cases where I expected a negative relationship (14 cases), I found no effect in my results. In 5 cases where I had no previous hypotheses on effect I found a positive relationship between species presence and species abundance.

The size of the patch and the amount of grassland in the landscape is important to the species. It is a logical result; the species in general prefer grassland to different extent during different parts of their life cycles (Table 1). According to my result (Table 1, 2) the humidity of the patch also seem to be of great importance to some species. Almost all of the predictions I had regarding negative impacts did not come out as significant results indicating that these variables may not be important for the species living in these patches and landscapes. The amount of herbs and grassland on the patch did not have an as large impact on the species as I predicted, only four species (Table 1) got a positive significant effect in terms of abundance. Again maybe the larger amount of individuals were adults and did not have as great use of this kind of vegetation as juveniles might.

Table 1. Hypotheses (H) of correlations between the presence (Pr) and abundance (Ab) of different Orthoptera species and different patch variables (PA = patch area, PB = amount bush cover on patch, PT = amount tree cover on patch, PG = amount grass and herb cover on patch) and landscape variables (GL = amount grassland in the landscape, FM = amount field margins in the landscape, HM = humidity).

Species	PA m2			PB %			PT %			PG %			GL			FM km			HM		
	H	E Pr	E Ab	H	E Pr	E Ab	H	E Pr	E Ab	H	E Pr	E Ab	H	E Pr	E Ab	H	E Pr	E Ab	H	E Pr	E Ab
Great green bush-cricket	Blue			Blue	Blue *	Blue *	Blue			Blue	Blue *	Blue *	Blue			Blue			Blue		
Wart biter bush-cricket	Blue	Blue *	Blue ***	Red			Red			Blue		Blue *	Blue			Blue			Blue		
Roesel's bush-cricket	Blue			Red			Red			Blue			Blue			Blue			Blue		
Bog bush-cricket	Blue	Blue **	Blue ***	Blue			Blue		Blue **	Blue			Blue	Blue **	Blue ***	Blue			Blue		
Dark bush-cricket				Blue		Blue **	Blue						Red					Blue *			
Large marsh grasshopper	Blue			Blue			Blue		Blue *	Blue			Blue			Blue			Blue		Blue ***
Woodland grasshopper	Blue		Blue ***	Blue			Blue			Blue			Blue		Blue **	Blue			Blue		
Field grasshopper	Blue			Blue			Blue			Red	Blue *	Blue **	Blue		Blue **	Blue			Red		Blue ***
Bow-winged grasshopper						Blue ***			Blue ***	Blue			Blue		Blue **	Blue			Blue		
Lesser marsh grasshopper	Blue		Blue *						Blue *	Blue		Blue **	Blue		Blue **			Blue **			Blue ***
Rufous grasshopper	Blue		Blue ***	Blue			Blue			Blue			Blue		Blue ***	Blue			Blue		Blue ***

Blue = positive effect, Red = negative effect. No symbol = Not significant relationship, * = p < 0.05, ** = p < 0.01, *** = p < 0.001

The red, blue and white boxes in the table (Table 1) show the variables tested and the hypotheses connected to these. Hypotheses on whether or not the variables would affect the occurrence and number of individuals per species in a positive (blue), negative (red) or unknown (white) way. The unknown, white boxes, is based on lack of information from literature.

Table 2. Results from the general linear models on the relationship between species presence and abundance and different patch and landscape variables.

Dependent variable	**Independent variable**	**Estimate**	**Std Error**	**P-value**
Abundance of great green bush-cricket	Proportion bushes on the patch	8.4624808	4.0452847	0.0364
	Proportion grass and herb cover on the patch	9.1588543	4.2197923	0.0300
Presence of great green bush-cricket	Proportion bushes on the patch	9.7824038	4.5145957	0,0302
	Proportion grass and herb cover on the patch	10.8226019	4.8401131	0,0254
Abundance of wart biter bush-cricket	Patch area	0.0014376	0.0004069	0.00041
	Proportion grass and herb cover on the patch	-4.8672136	2.3502561	0.03837
Presence of wart biter bush-cricket	Patch area	0.0014932	0.0007277	0.0402
	Amount of grassland in the landscape	-0.0318637	0.0551671	0.01833
Abundance of bog bush-cricket	Patch area	0.0026948	0.0004003	0.00
	Proportion trees on the patch	-5.6836303	1.8930666	0.00268
	Amount grassland in the landscape	-0.1950338	0.0446485	0.00
Presence of bog bush-cricket	Patch area	0.0023376	0.0008428	0.00554
Abundance of dark bush-cricket	Proportion bushes on the patch	2.460988	0.9007699	0.00623
	Amount field margins in the landscape	-0.1091693	0.0486844	0.02494
Abundance of large marsh grasshopper	Proportion trees on the patch	-11.244421	5.447550	0.039006
	Humidity on the patch	4.237326	1.003306	0.00
Abundance of woodland grasshopper	Patch area	0.0012057	0.0003026	0.00
	Amount grassland in the landscape	-0.0729617	0.0271269	0.00715
Abundance of field grasshopper	Proportion grass and herb cover on the patch	1.142e+00	3.606e-01	0.00154
	Amount grassland in the landscape	-2.066e-02	9.709e-03	0.03333
	Humidity on the patch	-1.983e-01	4.790e-02	0.00
Presence of field grasshopper	Proportion of grass and herb cover on the patch	7.0996125	3.4568458	0.04
Abundance of bow winged grasshopper	Proportion bushes on the patch	2.908e+00	6.643e-01	0.00

	Proportion trees on the patch	-1.071e+01	2.545e+00	0.00
	Amount grassland in the landscape	-8344e-02	2.766e-02	0.00255
Abundance of lesser marsh grasshopper	Patch area	0.0003526	0.0001782	0.04782
	Proportion trees on the patch	1.7617458	0.7360529	0.01669
	Proportion grass and herb cover on the patch	2.9103578	0.6115743	0.00
	Amount grassland in the landscape	0.0415071	0.0140503	0.00314
	Amount field margins in the landscape	0.1578199	0.0317192	0.00
	Humidity on the patch	0.3859352	0.0931556	0.00
Abundance of rufous grasshopper	Patch area	0.0005451	0.0001071	0.00
	Amount grassland in the landscape	-0.0342977	0.0092248	0.000201
	Humidity on the patch	-0.1749667	0.0474968	0.000230
Abundance of total number of individuals	Patch area	4.157e-04	6.486e-05	< 2e-16
	Amount grassland in the landscape	-1.916e-02	5.280e-03	0.00
	Proportion of bushes on the patch	1.02e+00	2.12e-01	1.91e-06
	Humidity on the patch	-5.948e-02	2.774e-02	0.031993
Presence of species	Patch area	0.00	0.00	0.11821

Discussion

I predicted that the Field grasshopper would be negatively affected by a larger amount of grasses and herbs on the patch, based on my research, and as my results states it came out to be the opposite. I have no conclusion on why this is, but I assume that with more literature to base my predictions on and thereby more knowledge about the species I would have had another prediction. Looking at my results (Table 1) the amount of bushes, humidity and trees on the field island and other open grasslands surrounding do not seem to have an effect on the presence of the species. Maybe I would have chosen other variables with more knowledge at hand. For the variables concerning the amount of trees and bushes on the patch area I based my predictions on facts that the wart biter bush cricket and Roesel's bush-cricket did not in particular occur in these habitats, or even that they preferred habitats opposite to these.

The literature on species ecology facts is obligated to present comprehensive information and cannot take every possible exception within the species into consideration. If the possibility to find a certain species in a certain habitat is not large enough it will not be printed as facts, this does not mean the species never occur in that habitat. Some external variable may affect the species occurrence, such as unusually hot, cold, dry or rainy seasons. Maybe some of these factors affected my results. A way to find out is to remake a study like this for several seasons.

The result of these predictions shows that I should either have read more literature before making a statement or have marked the hypothesis for the variable regarding these species as "no impact" due to equivocal information. I did believe that the amount of grasses on the patch would be of larger importance, but the amount of grasslands in the surroundings seem to be more important. Possibly due to the need to move between the habitats (Marini et al. 2010). Another reason could be the fact that the individuals need to be able to move around successfully, out of sight to predators and uses the grasslands and the vegetation for shelter and camouflage. Due to the need of ability to move between the habitats I thought that field margins would have a greater impact on the species but I guess it does not really affect their moving between areas. An after wise argument regarding this is that if the field margins did have a large impact, green corridors would not. Green corridors would probably not include the word 'corridors' if they had to be really wide to fulfil their purpose.

A surprising result regarding the humidity of the patch is especially regarding field grasshoppers. According to literature (Strid et al. 2010; Benton 2012) it is supposed to prefer dry habitats but here it is found in humid ones. Every season is different to the other, maybe the specific season when the orthopterans were censused were rainier than the average and the species lacked dry habitats. This study does not show at what time in their life cycle the individuals were present on the patches, just the total number of individuals. Changes in habitat use may change of over the individual's age; this might affect my results so that I do not estimate the value of different habitats correctly.

I based my predictions on facts about the species from three books about the species. *Gräshoppor i Sverige* (Strid et.al. 2010) by the entomological association of Stockholm, Sweden. It is a concise yet informative book about grasshoppers and crickets in Sweden. It contains photos and facts about where in Sweden and in which habitats they are usually found. The second book I used as a guide for my predictions was *Grasshoppers and allied insects of Great Britain and Ireland* (Marshall and Haes 1988). This book was also used to translate the names of the species from Swedish to English, this by comparison of the Latin names of the species. For more general information about the species and for a broader knowledge I used *Grasshoppers and crickets* (Benton 2012). The fact that my predictions do not perfectly match with the result of my study might depend on lack of full or proper information, either because some of the literature I used does not specifically cover the occurrence of the species in Sweden but more likely because there is more information out there that I have not yet taken part of. For a potential future study I would read more literature and look at more previous studies in order to gather more information for my hypothesis. Due to the limited amount of time and scope of this thesis the work had to be demarcated at some level.

A habitat can be suitable for various reasons; maybe it is not the best one for juveniles to feed in but instead be filled with bushes for adults to hide their eggs and larvae in. Thereby different kinds of habitats must be conserved. A take home message according the results of this study, although many previous studies show similar results, is to take serious action in avoiding fragmentation and loss of habitats (Berggren et al. 2001).
The relationship between species richness and habitat area is believed to be one of the most reliable of all ecological patterns (MacArthur & Wilson). The greater the area is the more room for species (MacArthur & Wilson 1967; Begon et al. 2014). The results from this study indicate that this is not of grater importance to all of the species. Only two of the species, Wart biter bush-cricket and Bog bush-cricket, showed a significant result of being dependent on a larger patch area to be present. Five of the species abundance, Wart biter bush-cricket, Bog bush, cricket, Woodland grasshopper, Lesser marsh grasshopper and Rufous grasshopper were found to be dependent on the patch area.

We use more and more land that could be suitable habitats for crickets and grasshoppers. Therefore precautions need to be taken for these species to not decline in number and finally go extinct (Collinge 2000). Except from preserving good habitats, leaving green corridors or make new ones where needed, could be a way to support the migration of crickets and grasshoppers (Kormann et al. 2015). Some species would rather use green corridors than try to move over the matrix while getting from one habitat patch to another (Berggren et al. 2002).

Because of global warming some of the species from this study may occur further north in Sweden in the future. The populations may even become larger because of longer growing season due to the same reason (Walther et al. 2002). This matches the results of my study since the Rufous grasshopper, the species with the highest abundance, seem to be very dependant on the occurrence of grasslands in the surroundings.

One thing to take in to consideration for future studies is the component that what the species feeds on probably affects what habitat they occur in. This in turn may affect how we think about conservation of habitats and the way to use agricultural land. Furthermore an extensive study considering the individuals needs for habitats with different features could be suitable for future studies.

Acknowledgements

I thank professor Åsa Berggren, for generously sharing her experience, previous studies, and knowledge. I also thank her for being a supportive supervisor throughout the work on my bachelor thesis. Additionally I would like to thank the department of ecology, Swedish university of agricultural sciences in Uppsala, for their hospitality and provision of workspace.

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