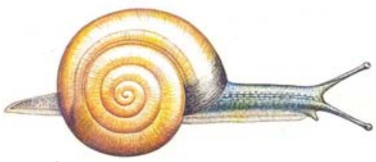
Institute of Environmental Sciences University of Zurich

The over-wintering abundance of arthropods within rotationally mown meadows

Master Thesis of Andres Overturf



Resubmitted: May 23, 2007

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Abstract: In order to find ways to enhance the arthropod diversity in the Swiss agricultural landscape, we investigated if uncut vegetation in rotationally mown meadows is beneficial for the arthropod community as over-wintering sites. With rotational mowing techniques, farmers mow only parts of their meadows at each harvest event. This results in having a refuge of tall vegetation in the meadow at any time of the year. To test our hypothesis, we conducted a pair-wise comparison of the arthropod diversity in the cut and uncut meadow parts within each selected meadow. At three locations in Switzerland, we selected a total of twenty meadows. By using emergence traps, we were able to collect arthropods that emerged in the spring and summer from the soil and vegetation, where they spent the previous winter. A total of over 25'000 arthropods were collected and sorted either into orders or families and spiders into species. With linear regression tests we found that certain groups, such as the Diptera, Coleoptera, Staphylinae, Auchenorrhyncha, Symphyta had significantly more individuals in the uncut than cut meadow parts. Also significantly more spider families and species were found in the uncut parts. We recommend to rotationally mow meadows in order to create over-wintering habitat for various arthropods, which are important for either biological pest control, pollination services or as food sources for insectivorous vertebrates.

Keywords: arthropod richness, disturbance, meadows, rotational mowing, grass strips, Switzerland, uncut vegetation, vegetation height, winter.

Since the intensification of farming several decades ago, biodiversity in the agricultural landscape of Switzerland decreased drastically. Once common and widespread wild plant and animal species became increasingly rare. To counteract this trend, the Swiss people voted in 1996 for a law that financially compensates the farmers to cultivate some of their land in such an order that should be beneficial for the environment. Today a total of 8% of the utilised agricultural area of Switzerland is cultivated as extensively managed meadows in order to increase biodiversity (BLW 2005). To ensure that a wide variety plants can reproduce, the farmers have to wait to cut the meadows until June 15th at lower elevation and later in the season at higher elevations. After these dates the farmers can cut all the meadows as frequent as they want until the end of the growing season.

Since those meadows are managed extensively, the biodiversity increased (Herzog & Walter 2005). However, this increase was below expectation. Especially the meadows in the Swiss central valley (the Mittelland), which are situated within an intensively cultivated agricultural landscape, were of poor biological quality and did to some extent biologically not differ from traditional intensively used meadows (Dreier & Hofer 2005, Herzog & Walter 2005).

Several studies indicated why the plant diversity did not expand as hoped for (Koch 1996, Lehmann et al. 2000, Bosshard 2001). However, there are only a few indications why the animal diversity did not increase as expected. The type of mowing equipment, the time interval between the harvests, and the availability of a diverse plant community are some known factors that influence the faunal diversity (Knop 2005). These are all factors that influence the fauna mainly during the summer half year. To understand any other potential factors, we looked for influences in the winter.

The winter is a challenging time for animals because of food shortage and unfavourable climatic conditions. As an adaptation, various arthropod species over-winter either as eggs or larvae (Chinery 1984, Curry 1994). Before the adults die in fall, they deposit eggs into places, such as soil or vegetation that protect them from the harsh winter (Bürki and Hausamann 1993,Völkl et al. 1993, Müller and Mouci 1995). Other species, that over-winter as adults, select microclimatically favourable places, such as dense vegetation that reduce their mortality (Wratten 1992, Bürki & Hausamman 1993, MacLeod et al. 2004). Therefore, parts of meadows, that are not cut over the winter, can offer over-wintering refuges which the arthropods might select. The idea of leaving small parts of the meadows uncut in order to provide the fauna a refuge is suspected to be beneficial by various grassland experts (Meier 2000, Bosshard 2002, NFÖA 2004). To create such habitat conditions, rotational moving techniques can be used.

Rotational mowing is a harvesting technique in which the farmer leaves by each harvesting cut a portion of the meadow uncut at alternating (rotation) locations within the same meadow. As a result, small uncut meadow parts are present throughout the entire year. In few locations of Switzerland this method is used in connectivity projects (Kt. Schaffhausen 1999, Kulab 2002). Rotational mowing has already been tested in wetlands and it has been shown to be beneficial for the invertebrate diversity (Bosshard et al. 1988). We hypothesized that this method might yield similar results for meadows.

In our study we tested the prediction that uncut parts of rotational mowed meadows harbour more arthropods than cut parts within the same meadows during winter. We selected the arthropods as our study objects because of three reasons. First, arthropods make up for 65% of the world's biodiversity and are good biodiversity indicators (Hammond 1992, Duelli & Obrist 1998). Second, arthropods have a big economic impact on agriculture, as biologic pest control and pollinators. Third, arthropods are ecologically important for other animals such as insectivorous birds, small mammals and reptiles.

Study area:

We conducted the study at three sites in Switzerland: the Klettgau valley of northern Switzerland, the Ergolz valley in the lowlands of the Jura mountains in the canton of Baselland and the Tösstal in the Zürich uplands. The Klettgau valley is situated in the northernmost part of Switzerland in the Kanton of Schaffhausen. It is a flat valley at an elevation of 400 to 500m with a dry and mild climate, where cereal and grapes are cultivated. The Ergolz valley, in northwestern Switzerland, is at an altitude between 400 and 800m. The hilly landscape allows mainly cattle ranching, cherry tree cultures and some grain production. The Tösstal in the uplands of Zürich, at an elevation between 600 and 1300m, is characterized by steep and narrow valleys, where only livestock ranching is possible.

Methods:

To test our hypothesis that uncut meadow parts in rotationally mown meadows are preferred by arthropods during the winter, we set up the following experiment. At each of the Ergolz and Tösstal region we selected seven meadows but only six meadows in the Klettgau valley. On each of the twenty meadows we set up two emergence traps just after snowmelt in 2006. One trap was in the cut part where the vegetation was short and one in the higher vegetation, which was not mowed during the last harvest cut of the meadow. The tent-like emergence traps are devices that collect arthropods that emerge from the soil and vegetation after the winter is over (Picture 1 & Fig. 1). With these traps the arthropods are qualitatively and quantitatively sampled. Each trap sampled an area of one square meter. The traps were placed away from landscape structures such as hedges, field margins and creeks in order to reduce the spill-over effect of arthropods that over-wintered in these structures.

Picture 1. *Emergence traps in the Ergolz valley. The trap to the left is in the uncut part; the trap to the right in the cut part.*

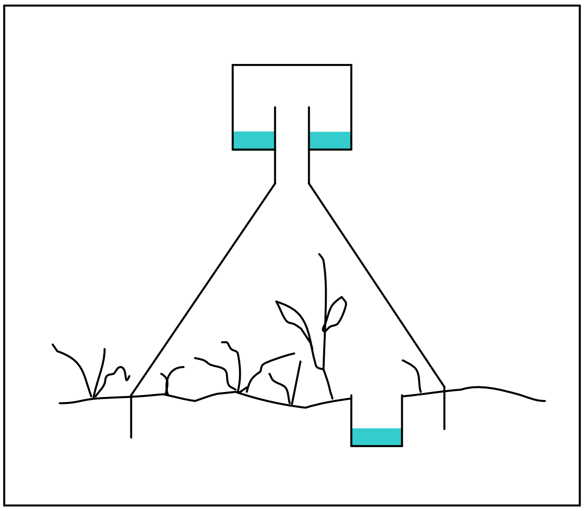

Fig. 1. *Cross-section through emergence trap. Animals were either trapped on the ground with a pitfall trap or above the ground with an eklektor trap. Traps were filled with preserving fluids.*

Within a 3 x 3m area around each trap, the mean vegetation height was estimated by measuring 25 randomly selected plants at the time when the traps were set. Within the same squares all flowering plant species, except grasses, were recorded at least two times during the growing season. Exposition, altitude, inclination and dates of harvest cuts were documented for each meadow.

The trapped animals were collected from the emergence traps once a week, during a period of 10 weeks. The catch was stored in 70% alcohol. With the help of a binocular with 10-50 times magnification, the caught animals were sorted either into the level of families, orders or suborders (see Appendix A, B & C). Only the spiders were identified to the species level. The insects were classified according to Stresemann (2000) and the spiders by the internet identification key by Nentwig (2003). Ants and aphids were not counted due to their social structures or the ability to reproduce at a fast rate inside the traps. The slugs were not documented since their bodies deformed and so their identification was difficult.

General linear regression, log-linear regression and negative binomial distribution tests were conducted with the GenStat statistical package (Payne & Arnold 2000). The factor in the treatment model consisted of the vegetation state (cut or uncut). The error model consisted of the study region (Klettgau, Ergholz, Tösstal), the meadow and trap. Covariables included at the level of the meadows: altitude, exposition, inclination and at the level of the traps: plant species diversity, vegetation height and date when vegetation within trap was cut last time. No test was conducted for the ear wigs since it was suspected that they were the only individuals to squeeze into the trap from the outside. Since we could not set up the traps in the Tösstal valley just after snowmelt, we only took the Klettgau and Ergolz valley data to conduct tests on the spiders. For all other arthropods we included all three study sites for statistical tests, since these groups were not as active just after snowmelt as the spiders were.

Results:

From a total sampling area of 40m² from twenty meadows, a total of over 25’000 animals were collected: 24’588 insects, 870 spiders and 198 snails. An average of 635 arthropods were collected per square meter (Table 1&2). The members of the order Diptera made up the majority of the samples followed by the order Coleoptera and suborder Apocrita (Table 1&2).

	Mean individuals per m²		Total numbers	
Insects	**uncut** (taller) **vegetation**	**cut** (shorter) **vegetation**	**Uncut** (taller) **vegetation**	**cut** (shorter) **vegetation**
Diptera (Flies & Midges)	545.6	412.6	10912	8252
Coleoptera (Beetles)	26.5	18.35	530	367
Staphylinidae (Rove Beetles)	20.8	10.55	416	211
Apocrita (Wasps: smaller individuals)	16.5	19.5	335	378
Apocrita (Wasps: bigger individuals)	12.25	10.55	245	211
Auchenorrhyncha (Frog& Leafhoppers)	37.8	9.6	756	192
Lepidoptera (Butterflies & Moths winged)	5.85	6.3	117	126
Lepidoptera (Butterflies & Moths wingless)	1.85	0.55	37	11
Psyllina (Jumping Plant Lice)	4.3	1.85	86	37
Larvae & Caterpillars & Maggots	3.3	2.25	66	45
Heteroptera (Bug: adults)	1.35	1.55	27	31
Heteroptera (Bug: juveniles)	1.05	0.7	21	14
Symphyta (Sawflies)	0.9	0.4	18	8
Apidae (Bees)	0.7	0.25	14	5
Saltatoria (Grashoppers)	0.3	0.65	6	13
Shelled Gastropods (Snails)	5.65	4.25	113	85

Table 1. *Mean densities per m² and total numbers in cut and uncut vegetation of all insect groups and snails. Ordered by abundance. Staphylinidae are separately listed and not included in the Coleoptera. Wasps are divided into two size classes. Bees are separately listed and not included in the Apocrita. Larvae, caterpillars and maggots were not sorted into certain arthropod families. Groups written in italics yielded significant results.*

	Mean individuals per m²		Total numbers	
Spiders	**Uncut** (taller) **vegetation**	**Cut** (shorter) **vegetation**	**Uncut** (taller) **vegetation**	**Cut** (shorter) **vegetation**
Spider total individuals	25.3	21.2	329	276
Clubionidae (Sac Spider)	0.4	0	5	0
Dictynidae (Mesh-webbed Spider)	0.5	0	6	0
Gnaphosidae (Ground Spider)	1.2	0.5	15	7
Linyphiidae (Sheet-web Spider)	8.5	10	110	131
Lycosidae (Wolf Spider)	9.2	6.4	119	83
Pisauridae (Nursery-web Spider)	0.9	0.2	12	3
Tetragnathidae (Big-jawed Spider)	1.6	1.9	21	25
Thomisidae (Crab Spider)	2	1.9	26	25
	Mean families per m²		**Total different families**	
Spider Families total	5.7	4.1	15	8
	Mean species per m²		**Total different species**	
Spider species total	9.7	7.2	45	28

Table 2. *Mean densities per m² and total numbers in cut and uncut vegetation of all spiders combined and for members of families with 5 or more individuals. Hatchlings from egg cocoons are not included. In addition, mean and total numbers of families and species are presented. Data come from only the Klettgau and Ergolz valley.*

General trends:
Log-linear regression tests showed that significantly more individuals ($p<0.05$) were in the uncut taller vegetation for the following arthropod groups: Diptera, Auchenorrhyncha, Staphylinidae, Symphyta (Table 3, Appendix D). A general linear regression test yielded the same trend for the Coleoptera excluding the Staphylinidae ($p=0.025$). The Psyllina and wingless Lepidoptera might prefer the uncut meadow parts but since the data were neither normally, nor Poisson, nor negatively binomial distributed, statistical tests could not be trusted. For all other arthropod groups and snails no significance could be proven. On the diversity level, the log-linear regression test showed that significantly more spider families and species were found in the uncut taller vegetation ($p=0.004$, $p=0.036$). A total of 45 different spider species from 15 families were found in the uncut vegetation, whereas only 28 different species from 8 families were found in the cut meadow parts. In two traps —both were in the uncut vegetation— dozens of newly hatched *Araneidae* spiders were encountered, which indicated that they came from previously deposited egg cocoons.

Insects	Probabillity
Diptera (Flies & Midges)	***0.032***
Coleoptera (Beetles)	***0.025***[a]
Staphylinidae (Staphylid beetles)	***<0.001***
Apocrita (Wasps: smaller individuals)	**0.5**
Apocrita (Wasps: bigger individuals)	**0.3**
Auchenorrhyncha (Leafhoppers)	***0.001***
Lepidoptera (Butterflies & Moths winged)	**0.75**
Larvae & Caterpillar & Maggot	**0.23**
Heteroptera (Bug: juveniles)	**0.4**
Symphyta (Plantwasps)	***0.02***
Spider individual numbers	**0.7**
Spider families	***0.016***
Spider species	***0.036***
Shelled Gastropoda (snails)	**0.22**

Table 3. *Probability levels for only those groups that yielded trustworthy statistical results. All tests were conducted with log-linear regression tests, except those marked with an " a " , which were conducted with a general linear regression test. Results in italics are significant. Staphylinidae are separately listed and not included in the Coleoptera. The spider hatchlings from egg cocoons are not included. Tests done about spiders included only data from the Klettgau and Ergolz valley.*

Explainatory covariables:
a) Time after disturbance

The time span between the dates of the last two rotation cuts, which equals the time difference of the cuts of the short and tall vegetation within the same meadow was around one year for 8 meadows and 1-3 months for 12 meadows. The wingless Lepidoptera and Auchenorrhyncha might prefer meadows that have not been cut recently, but results are doubtful because of odd data distributions. Despite the fact that the abundance of snails and winged Lepidoptera was not significantly different for the cut and uncut parts, they yielded significant results ($p=0.037$ and $p=0.04$) depending when the meadow parts were cut the last time. The longer a place in a meadow was not cut, the more likely it was that it hosted snails (Fig. 2). The opposite was true for the winged Lepidoptera; there it was more likely to find them in a place in a meadow, which was cut more recently (Fig. 3).

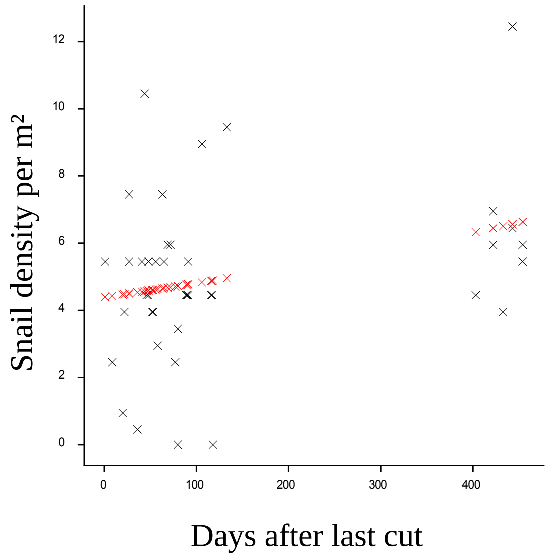

Fig. 2. *Snail density per m² in relation to amount of time passed after a location was cut last time. Snail density is corrected for differences between meadows. Crosses in red indicate the trend line.*

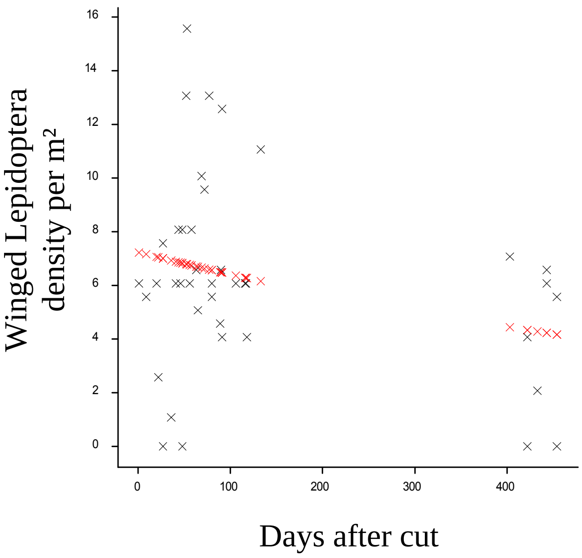

Fig. 3. *Winged Lepidoptera density per m² in relation to amount of time passed after a location was cut last time. Winged Lepidoptera density is corrected for differences between meadows. Crosses in red indicate the trend line.*

b) Vegetation height

The average measured vegetation height was 11cm for the cut meadow parts and 27cm for the uncut parts (Table 4). By testing for the vegetation height, it could be explained why the Staphylinidae had more individuals and the spiders more families in the uncut meadow parts (p=0.002, p=0.004, Fig. 4&5). The wingless Lepidoptera and Auchenorrhyncha abundance might also be influenced by the vegetation height, but results are doubtful due to odd data distribution. The order Coleoptera yielded marginal results (p=0.088 for negative binomial distribution and p=0.027 for Poisson distribution, Fig. 6). For the Diptera and Symphyta the vegetation height (p>0.05) could not explain the significant abundance differences between the cut and uncut vegetation (p=0.032 and p=0.02, see Table 3).

Meadow	Vegetation height in cm		Plant species flowering	
	uncut	cut	uncut	cut
1	33.4	16.1	5	5
2	36.4	22.2	12	14
3	33	11.2	7	9
4	51.7	9.5	2	7
5	43.2	9.8	3	8
6	24.7	5.7	9	10
7	20	9.9	5	7
8	27	10.6	16	14
Average	*33.7*	*11.9*	*7.4*	*9.3*
9	23.9	6.9	9	6
10	21.7	12.9	9	8
11	15.8	8.5	10	8
12	22.7	16.6	10	14
13	13.5	6.2	12	11
14	22.9	9.7	5	6
15	34.7	13.6	10	13
16	22.5	15	10	11
17	28.6	5.7	16	12
18	26.4	14.7	15	14
19	29.8	12.2	10	14
20	12.5	5.3	9	10
Average	*22.9*	*10.6*	*10.4*	*10.6*
Overall Average	**27.2**	**11.1**	**9.2**	**10.1**

Table 4. *Vegetation height in cm and numbers of plants that produced flowers for each trap location. The first 8 meadows were cut once the previous year (uncut parts were not cut the previous year). The last 12 meadows were cut twice the previous year ("uncut" parts were cut once, the "cut" parts were cut twice).*

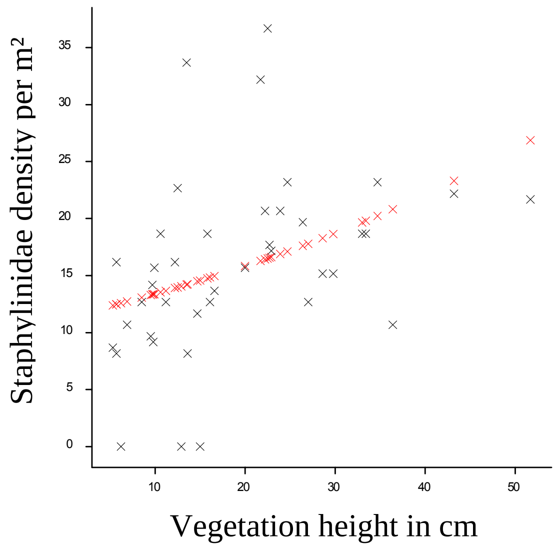

Fig. 4. *Staphylinidae density per m² in relation to vegetation height in cm. Staphylinidae density is corrected for differences between meadows. Crosses in red indicate the trend line.*

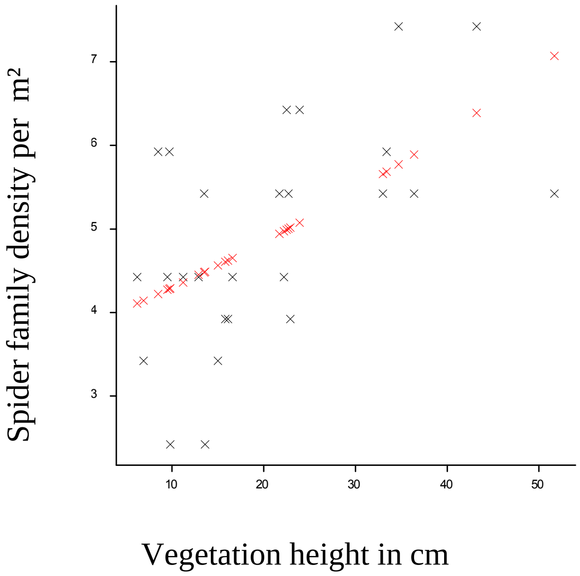

Fig. 5. *Spider family density per m² in relation to vegetation height in cm. Spider family density is corrected for differences between meadows. Crosses in red indicate the trend line.*

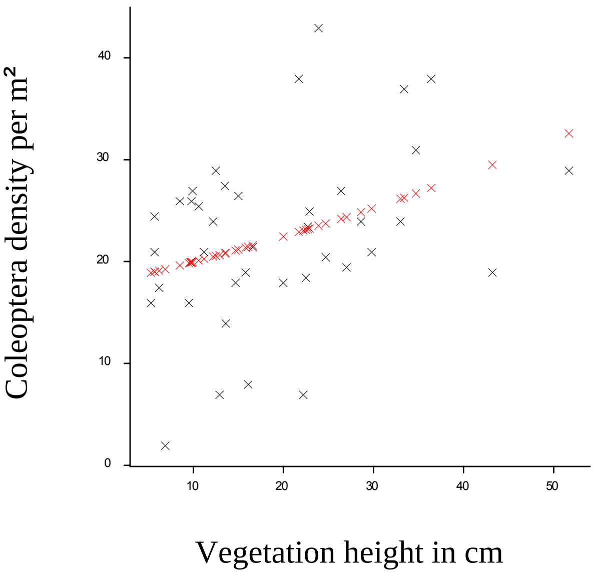

Fig. 6. *Coleoptera density per m² in relation to vegetation height in cm. Coleoptera density is corrected for differences between meadows. Staphylinidae are not included in the Coleoptera. Crosses in red indicate the trend line.*

Other results:

a) Spatial distribution

When possible, the traps within the same meadow had the same distance to the line where the cut and uncut meadow parts bordered onto each other. These distances varied between the meadows from less than one to 13m, on average the distance was 3.9m. Since these distances varied, we were able to test for spatial distribution patterns in relation to this structural change. The Staphylinidae, Diptera, and Symphyta showed significant spatial trends ($p<0.05$). The closer the traps were to the interior of the uncut vegetation, the more likely it was that they hosted more individuals (figure 7&8). The same trend was visible for the wingless Lepidoptera and the bees, but the results were doubtful due to odd data distribution.

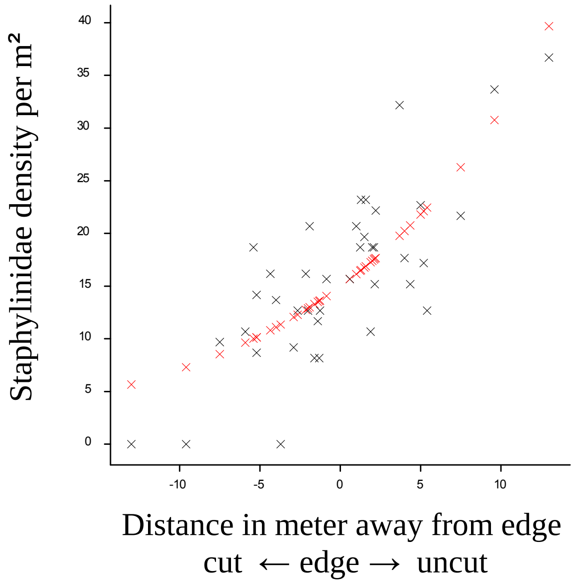

Fig. 7. *Staphylinidae density in relation to distance in meter away from edge where cut and uncut vegetation border on each other. Negative distance for cut part; positive distance for uncut part. Staphylinidae density is corrected for differences between meadows. Crosses in red indicate the trend line.*

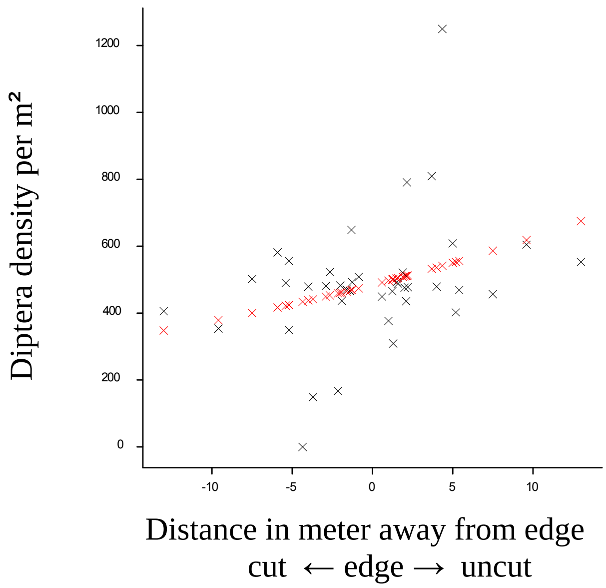

Fig. 8. *Diptera density in relation to distance in meter away from edge where cut and uncut vegetation border on each other. Negative distance for cut part, positive distance for uncut part. Diptera density is corrected for differences between meadows. Crosses in red indicate the trend line.*

b) Flowering intensity

In eight meadow parts, that were not cut the previous growing season, we counted an average of only 7.5 plant species flowering per trap location, whereas we found an average of 9.3 species flowering in the parts that were cut the previous year within the same eight meadows ($p<0.05$,Table 4). Althought the number of flowering plant species yielded no significant difference, we clearly saw that even if a plant species was blooming in one of those eight uncut meadow parts, it was producing far less flowers than in the cut meadow parts within the same meadows (claimed on observation). This is an indication that at least one cut per year stimulates the plants to produce more flowers, which we clearly saw in the other twelve study meadows. In those twelve meadows the farmers were cutting the vegetation twice the previous year, always rotating the uncut meadow parts to an alternating location. This meant that each location within those meadows was cut at least once the previous year. In those meadows we found during our sampling period an average of 10.4 plant species flowering in the uncut vegetation and 10.6 species in the cut vegetation. In addition, visually no difference in flower intensity could be seen in the cut and uncut parts in those twelve meadows.

Discussion:

General trend

Our hypothesis that rotational mowing results in increased individual numbers or diversity of over-wintering arthropods in the taller previously uncut vegetation, could be proven for several groups. Since the twenty sampled meadows came from three distinct areas, which have different climatic and topographic conditions, we assume that our results may indicate a general trend. This trend was also shown by Müller and Mouci (1995) who found that flower strips located in a cereal field had a higher over-wintering abundance of arthropods if the strips were cut previously in May instead later in the season in August. Also meadows that were not cut during one year had an increase of 11 to 14 spider species (Barthel 1997).

Correlation between time after disturbance and abundance

One potential explanation for our results is that the less physical disturbance there is, the more a habitat is favoured by certain animals. This could be especially of importance for less mobile species. The abundance of snails and probably the abundance of the wingless Lepidoptera and the Auchenorrhyncha was positively correlated with the time gone by since their place was cut the last time. The snails and the wingless Lepidoptera are far less mobile compared with other invertebrates and therefore could benefit from less disturbed spots. A fact worth mentioning is that the winged Lepidoptera, on the other hand, were negatively correlated with time gone by since the last disturbance. That meant the winged Lepidoptera were more likely to be found in areas that were cut more recently.

Correlation between vegetation height and abundance

Another potential explanation for our revealed trend is that the vegetation that was cut earlier in the season or not at all had more time to grow until winter and had therefore a higher and denser vegetation that was probably favoured by various arthropods. This positive correlation between vegetation height and arthropod abundance was strongest for the Staphylinidae, the spider diversity on the family level, and probably the Coleoptera, wingless Lepidoptera and Auchenorrhyncha.

Higher and denser vegetation might be attractive for two main reasons. First, ground that is better covered by vegetation does not cool down as much in the winter as ground that is less covered (Bürki & Hausammann 1993). The resistency to cold temperature is highly variable between the arthropod species. Some can endure temperatures well below the freezing point, while others will have high mortalities at these conditions (Bürki & Hausammann 1993). Kirchner (1973) showed that there is a relationship between the cold resistancy of spider species and the over-wintering places they selected. The second reason why taller and denser vegetation may be favoured by certain arthropods is that this environment yields alternative food sources which decline in the adjacent areas once they are harvested (Holt & Barfield 2003, Sears et al. 2004, Thorbek & Bilde 2004). Summarized it can be said that uncut or taller vegetation is beneficial for the survival of certain arthropods during the winter (Desender 1982, D'Hulster & Desender 1984, Sotherton 1984&1985).

Implication for agriculture

Since taller vegetation structure results in increased abundance of certain arthropods, permanent grass strips that are left fallow have been placed within crop fields in England to enhance the survival of predators of agricultural pests (Wratten 1992, MacLeod et al. 2004). In our study the abundance of important agricultural pest predators, such as Staphylinidae, was indeed significantly enhanced in the uncut meadow parts. This is also beneficial for the surrounding areas, since in the spring when the temperatures get warmer and the planted crops start to grow, predators start to move from their over-wintering sites, such as field borders, hedges and uncut meadow parts into the adjacent crops in search for prey (Duelli et al. 1990, Riedl 1990, Thomas et al.1992). Predators can already be present in the crops even before the pests arrive (Frei & Manhart 1992). However, the dispersal distances are limited depending on the mobility of the species. Noetzold (2000) showed that only 25-50% of the predatory Diptera dispersed further than 250m by flying. For other arthropods, the dispersal abilities are shorter. In grassland landscapes, Albrecht (2007) showed that during the growing season the arthropod abundance outside extensively managed meadows, declined to 10% for various arthropods at the following distances away from these extensively managed meadows: 76m for true bugs, 114m for spiders, 139m for grasshoppers, 152m for bees and 177m for ground beetles. It is therefore important to have “island refuges” throughout the agricultural landscape to enable predators and pollinators access in all agricultural areas in order to enhance biological pest control and pollination. Studies by Oestman (2001) indicated that in cereal fields, that were in a landscape with an abundance of field margins, establishment of aphids was lower than in landscapes having fewer field margins. A review by Bianchi et al. (2006) of 24 studies showed that in 74% of the cases the predatory pressure was higher and in 45% of the studies the pest abundance was lower in landscapes that had more non-crop areas. For example, Thies & Tscharnke (1999) found that the presence of old field margins along rape fields was associated with increased predator mortality of the rape pollen beetle, which damages oilseed rape. The need to use insecticides can be greatly reduced or even completely substituted by enhancing the biological pest control, which keeps the agricultural pests at an economically tolerable level (Daily 1997, Oestman et al. 2003, Tscharntke et al. 2005).

Implication for the environment

An increased abundance and species richness of arthropods is beneficial for animals and plants that are dependent for them for food and pollination. Benton et al. (2002) could show that the farmland bird density was significantly related to insect abundance. Albrecht (2007) proved that species richness and abundance of bees were positively correlated with seed production of certain plants.

Management Implications:

In order that the needs of the fauna, flora and human food production are taken account of to a maximum extent, several points have to be considered.

First, tall vegetation structures, which are created by leaving parts of the meadows uncut to provide the fauna a refuge, have to be rotated periodically within the same meadows in order to ensure that the plant species composition and flower intensity does not change. Bosshard et al. (1988) have shown that in the absence of the usual harvest cut, grasses can out-compete herbs. Moreover, our study has shown that herbs get stimulated to produce flowers by cutting them at least once a year.

Second, rotational mowing has to be applied at each harvest cut to ensure that tall vegetation structure is available throughout the entire year. This guarantees that arthropods have always the possibility to seek refuge in taller vegetation, which is vital for various species.

Third, since various arthropods have limited mobility abilities, it is beneficial to leave uncut vegetation at several locations throughout the meadow. This is especially important in larger meadows in which several uncut vegetation spots increases the chance that arthropods throughout the meadows can reach a refuge.

Fourth, areas in meadows in which problem weeds and non-native invasive plants are present should not be chosen to leave the vegetation uncut. The same is true for areas close to certain tree and bush species, which easily seed off or reproduce vegetatively.

Fifth, to reduce the risk that the uncut meadow stripes become heavens for mice and gophers, their various natural enemies should be attracted. By placing poles, which serve as ambushes and putting up nestboxes for example, birds of prey are drawn to these areas.

Acknowledgement:

Without the generous support of a large group of persons, the success of the project would never have been possible. I thank my two advisors Andreas Bosshard and Bernhard Schmid from the University of Zürich who helped me to design, set up and analyse the study, Sabine Rocker from the ETH for the logistics and Jakob Walter from the Fischereiamt Schaffhausen, Ulrich Kloter and Ambros Hänggi from the Natural History Museum of Basel for identifying all the spiders.
In addition I appreciated the support from the following persons who organized for me the study sites or adviced me on the study project: Dieter Rudin from the Landwirtschaftsamt Baselland, Andreas Zehnder from the Landwirtschaftsamt Schaffhausen, Herbert Billing & Martin Bolliger from the Naturschutzamt Schaffhausen, Barbara Stähli & Corina Schiess from the Landwirtschaftlicher Beratungsdienst Lindau and Andreas Müller from the ETH Zürich.
I am also very greatful that sixteen farmer families from the Ergolz, Klettgau and Tösstal valley generously allowed me to conduct the study on their land. This project was kindly funded by the University of Zürich and the Landwirtschaftsamt Baselland.

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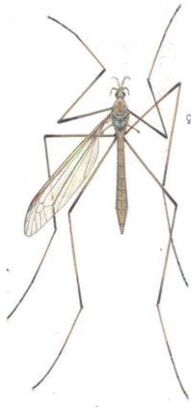
Appendix A. These d*rawings (Chinery 1987, Kerney et al. 1983) represent the invertebrate groups in which the collected invertebrates were sorted into. Flies and midges were both put into the Diptera category.*

Order: Diptera

Engl.: Flies

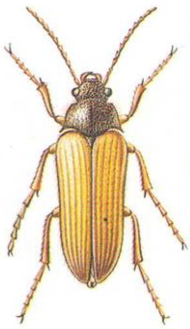
De.: Fliegen



Order: Diptera

Midges

Mücken



Order: Coleoptera

Beetles

Käfer

Family: Staphylinidae

Rove Beetles

Kurzflügel Käfer

Suborder: Apocrita

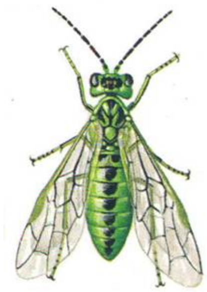
Engl.: Wasps

De.: Wespen

Family: Apidae

Bees

Bienen



Suborder: Symphyta

Sawflies

Pflanzenwespen

Order: Auchenorrhyncha

Leaf & Frog hoppers

Zikaden

Suborder: Hemiptera

Engl.: True Bugs

De.: Wanzen

Order: Saltatoria

Grasshoppers

Heuschrecken

Order: Lepidoptera

Adult Butterflies & Moths winged

Schmetterlinge& Falter

Order: Lepidoptera

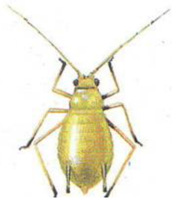
Adult Butterflies & Moths wingless

Sackträger Sackträgermotten

Suborder: Psyllina

Engl.: Jumping Plant Lice

De.: Blattflöhe



Suborder: Aphidina

Aphids

Blattläuse

Family: Formicidae

Ants

Ameisen

Order: Dermaptera

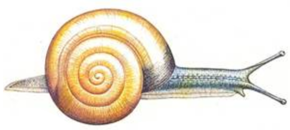
Earwigs

Ohrwürmer

Order: Araneae

Engl.: Spiders

De.: Spinnen



Class: Gastropoda with shells

Snails

Häuschenschnecken

Class: Gastropoda shell-less

Slugs

Nacktschnecken

Appendix B. Raw data of all arthropod groups and covariables from trap and meadow locations. Data in red are estimates.

Line Number	Region	Meadow name	Treatment(uncut=0, cut=1)	Trap type	Formicidae (Ants)	Aphididae (Aphids)	Apiadea (Bees)	Apocrita (Wasps: smaller indiv.)	Apocrita (Wasps: bigger indiv.)	Symphyta (Sawflies)	unid. Hymenopt (Bees & Wasps)	Diptera (Flies & Midgets)	Staphylinidae (Rove Beetles)	other coleoptera	Saltatoria (Grasshoppers)	Lepidoptera (Adults: winged)	Lepidoptera (Adults: wingless)	Larvae & Caterpillars & Maggots
1	Klettgau	Auf Stein	0	Ekl&Pit	2	4	0	5	9	0	0	144	9	31	0	5	0	0
2	Klettgau	Auf Stein	1	Ekl&Pit	1	5	0	28	21	0	0	298	6	26	0	9	0	3
3	Klettgau	Chrummenlanden	0	Ekl&Pit	0	0	0	2	0	0	0	34	9	9	0	0	3	1
4	Klettgau	Chrummenlanden	1	Ekl&Pit	1	0	0	0	0	0	0	41	3	6	0	0	0	0
5	Klettgau	Landstrass	0	Ekl&Pit	1	1	0	8	5	0	0	272	18	27	0	3	0	0
6	Klettgau	Landstrass	1	Ekl&Pit	5	5	0	9	11	0	0	318	6	14	0	2	0	0
7	Klettgau	Rebberg	0	Ekl&Pit	4	4	0	28	11	0	0	286	34	29	0	2	0	3
8	Klettgau	Rebberg	1	Ekl&Pit	5	5	0	13	6	0	8	268	19	12	0	6	0	1
9	Klettgau	Spitzäcker	0	Ekl&Pit	3	4	9	33	18	1	0	508	61	41	0	19	0	8
10	Klettgau	Spitzäcker	1	Ekl&Pit	4	5	0	82	17	1	0	361	19	49	0	6	0	0
11	Klettgau	Tobeläcker	0	Ekl&Pit	7	5	0	23	7	0	0	128	20	25	0	3	0	3
12	Klettgau	Tobeläcker	1	Ekl&Pit	10	6	0	60	16	0	0	132	7	32	0	17	0	2
13	Ergholz	Anwil	0	Ekl&Pit	5	1	0	21	5	2	0	305	12	81	0	0	0	0
14	Ergholz	Anwil	1	Ekl&Pit	0	2	0	42	9	1	0	510	2	40	0	3	0	6
15	Ergholz	Oltingen	0	Ekl&Pit	0	5	0	7	23	1	0	80	13	62	0	2	0	0
16	Ergholz	Oltingen	1	Ekl&Pit	0	7	0	6	6	1	0	167	7	33	1	10	1	0
17	Ergholz	Ormalingen	0	Ekl&Pit	4	5	2	9	11	3	1	856	45	40	0	0	0	1
18	Ergholz	Ormalingen	1	Ekl&Pit	7	4	0	9	3	0	1	196	12	9	0	0	0	0
19	Ergholz	Rothenfluh Bad	0	Ekl&Pit	3	5	0	17	5	0	0	122	11	19	0	1	0	3
20	Ergholz	Rothenfluh Bad	1	Ekl&Pit	2	5	1	8	10	0	0	149	5	26	0	0	0	1
21	Ergholz	Rothenfluh Dorf	0	Ekl&Pit	4	8	0	92	19	1	2	498	12	43	1	3	1	5
22	Ergholz	Rothenfluh Dorf	1	Ekl&Pit	4	7	2	39	14	0	2	414	22	12	0	7	1	0
23	Ergholz	Roth-Orm	0	Ekl&Pit	4	0	0	12	6	0	0	286	17	22	0	1	2	0
24	Ergholz	Roth-Orm	1	Ekl&Pit	7	6	0	2	4	0	0	286	13	20	2	1	0	1
25	Ergholz	Schafmatt	0	Ekl&Pit	6	3	0	8	19	3	0	376	59	14	1	1	0	2
26	Ergholz	Schafmatt	1	Ekl&Pit	1	3	2	6	5	0	0	125	23	4	0	1	0	1
27	Tösstal	Eggwegwald	0	Ekl&Pit	0	0	0	16	6	2	0	507	30	7	0	3	0	7
28	Tösstal	Eggwegwald	1	Ekl&Pit	1	1	0	21	13	2	0	847	15	11	6	4	0	5
29	Tösstal	Fischenthal	0	Ekl&Pit	1	2	0	1	3	0	0	2823	11	6	0	1	0	0
30	Tösstal	Fischenthal	1	Ekl&Pit	3	0	0	2	1	1	0	1282	12	3	0	1	0	6
31	Tösstal	Grossegg	0	Ekl&Pit	0	1	0	7	7	1	0	333	2	6	0	10	3	2
32	Tösstal	Grossegg	1	Ekl&Pit	2	4	0	7	8	1	0	392	2	15	1	8	3	1
33	Tösstal	Nideltobel	0	Ekl&Pit	10	6	0	7	13	0	0	339	6	9	1	15	28	7
34	Tösstal	Nideltobel	1	Ekl&Pit	9	5	0	16	8	0	4	360	12	15	0	34	1	2
35	Tösstal	Ohrüti	0	Ekl&Pit	3	6	0	10	31	1	1	846	22	33	3	19	0	4
36	Tösstal	Ohrüti	1	Ekl&Pit	5	4	0	11	21	0	0	819	14	24	3	5	3	3
37	Tösstal	Steg	0	Ekl&Pit	9	2	3	19	39	1	1	1652	8	10	0	21	0	12
38	Tösstal	Steg	1	Ekl&Pit	8	5	0	13	32	1	0	1029	9	13	0	11	0	11
39	Tösstal	Strahlegg	0	Ekl&Pit	3	3	0	10	8	2	0	517	17	16	0	8	0	8
40	Tösstal	Strahlegg	1	Ekl&Pit	0	2	0	4	6	0	0	258	3	3	0	1	2	2

Line Number	Heteroptera (Bugs: Adults)	Heteroptera (Bugs: juveniles)	Auchenorrhyncha (Frog & Leafhoppers)	Psyllina (Jumping Plant Lice)	Dermaptera (Earwigs)	Araneae (Spiders)	Gastropoda (without shells: Slugs)	Gastropoda (with shells: Snails)	Vegetation height in cm	Distance to vegetation edge in m	Distance between traps in m	Date when last time cut	Numbers of cuts in 2005	Grazed by livestock (no=0, yes=1)	Numbers of flowering plants	Shared flowering plants of cut and uncut parts	Flowering plants found only in cut or uncut part	Altitude in m	Inclination (flat=0, little=1,medium=2,steep=3)
1	2	6	17	0	0	40	2	7	22.9	5.2	10.4	16.6.05	1	0	5	5	0	491	0
2	0	1	7	0	0	42	2	18	9.7	5.2	10.4	29.8.05	2	0	6	5	1	491	0
3	0	0	1	0	4	17	0	3	33	2	4	25.7.04	0	0	7	6	1	440	0
4	0	0	1	0	2	11	9	0	11.2	2	4	24.7.05	1	0	9	6	3	440	0
5	0	0	21	0	0	38	36	20	51.7	7.5	15	25.7.04	0	0	2	2	0	420	0
6	0	3	5	0	0	26	8	5	9.5	7.5	15	24.7.05	1	0	7	2	5	420	0
7	0	2	9	0	0	27	1	5	34.7	1.6	4.7	13.7.05	1	0	10	8	2	552	1
8	1	2	11	0	0	34	6	4	13.6	1.6	4.7	25.8.05	2	0	13	8	5	552	1
9	4	0	38	3	0	43	5	10	22.5	13	26	13.7.05	1	0	10	8	2	470	0
10	12	6	34	1	0	28	0	11	15	13	26	25.8.05	2	0	11	8	3	470	0
11	0	0	506	0	0	35	15	3	43.2	2.2	5.1	21.8.03	0	0	3	3	0	450	0
12	3	0	79	0	1	34	15	1	9.8	2.9	5.1	21.8.05	1	0	8	3	5	450	0
13	1	0	0	0	0	31	3	1	23.9	1	6.9	15.7.05	1	1	9	5	4	581	1
14	1	0	3	0	0	29	1	2	6.9	5.9	6.9	15.9.05	2	1	6	5	1	581	1
15	1	1	13	0	0	22	4	4	33.4	2.1	6.9	4.8.04	0	0	5	3	2	647	2
16	0	0	2	0	0	7	2	6	16.1	2.65	6.9	4.8.05	1	0	5	3	2	647	2
17	1	0	19	2	0	33	0	0	21.7	3.7	7.4	17.6.05	1	0	9	7	2	511	1
18	0	0	5	5	0	16	2	1	12.9	3.7	7.4	1.9.05	2	0	8	7	1	511	1
19	0	0	8	1	0	8	1	5	15.8	1.25	2.5	10.8.05	1	0	10	7	3	555	3
20	0	0	0	0	0	13	5	0	8.5	1.25	2.5	3.10.05	2	0	8	7	1	555	3
21	6	1	7	6	0	7	0	5	36.4	1.9	3.8	15.8.04	0	0	12	11	1	542	2
22	0	0	5	3	0	17	2	1	22.2	1.9	3.8	15.8.05	1	0	14	11	3	542	2
23	0	0	1	2	4	15	0	9	22.7	4	8	28.6.05	1	0	10	9	1	482	2
24	0	0	3	1	0	15	0	1	16.6	4	8	22.9.05	2	0	14	9	5	482	2
25	9	2	8	0	2	22	1	3	13.5	9.6	19.2	27.8.05	1	0	12	10	2	804	1
26	9	0	2	0	0	13	0	4	6.2	9.6	19.2	11.10.05	2	0	11	10	1	804	1
27	0	3	2	2	0	8	2	1	24.7	1.3	2.6	14.7.04	0	1	9	7	2	895	3
28	2	1	0	3	0	2	2	0	5.7	1.3	2.6	14.7.05	1	1	10	7	3	895	3
29	0	0	0	0	0	23	4	0	28.6	4.35	8.7	18.6.05	1	1	16	11	5	763	2
30	0	0	0	1	0	18	3	1	5.7	4.35	8.7	17.8.05	2	1	12	11	1	763	2
31	0	0	13	5	0	19	1	1	20	0.6	2.9	3.9.04	0	0	5	5	0	1066	3
32	0	0	1	4	0	10	1	2	9.9	0.85	2.9	8.8.05	1	0	7	5	2	1066	3
33	3	2	72	2	0	14	8	5	27	5.4	10.8	15.8.04	0	0	16	10	6	728	3
34	2	0	23	6	1	26	3	3	10.6	5.4	10.8	20.8.05	1	0	14	10	4	728	3
35	0	3	11	46	8	16	2	4	26.4	1.5	2.9	27.7.05	1	0	15	10	5	863	3
36	1	0	1	2	17	16	0	9	14.7	1.4	2.9	15.9.05	2	0	14	10	4	863	3
37	0	0	9	11	0	13	6	25	29.8	2.15	4.3	1.6.05	1	0	10	8	2	719	1
38	0	1	10	11	0	29	3	16	12.2	2.15	4.3	6.9.05	2	0	14	8	6	719	1
39	0	1	1	6	0	10	0	2	12.5	5	10.2	1.8.05	1	0	9	6	3	1045	2
40	0	0	0	0	4	12	0	0	5.3	5.2	10.2	20.9.05	3	0	10	6	4	1045	2

Line Number	Exposition(0=N/A,1=North,2=Northeast,3=Ost, 4=Southeast,5=South,6=Southwest, 7=West,8=Northwest)	Coordinates
1	0	680536/285311
2	0	680536/285311
3	0	680069/283461
4	0	680069/283462
5	0	678627/282122
6	0	678627/282122
7	5	681829/285477
8	5	681829/285478
9	0	681744/284560
10	0	681744/284560
11	0	680700/283730
12	0	680700/283731
13	1	637824/255208
14	1	637824/255209
15	8	637827/253759
16	8	637827/253759
17	5	632502/258674
18	5	632502/258674
19	1	636823/257324
20	1	636823/257324
21	4	636064/257318
22	4	636064/257318
23	4	634625/258185
24	4	634625/258185
25	4	638555/252260
26	4	638555/252260
27	1	715145/244108
28	1	715145/244108
29	7	712263/243264
30	7	712263/243264
31	7	716039/243614
32	7	716039/243614
33	3	712131/246845
34	3	712131/246845
35	5	713953/244875
36	5	713953/244875
37	5	713368/245515
38	5	713368/245515
39	7	715420/242133
40	7	715420/242134

Appendix C. Raw data of spider families and their species. Data from meadow "Chrummenlanden" was not included anymore after Araneidae spiders in uncut meadow part hatched from cocoon and plugged up eklektor trap. Note on statistical tests on species abundance: individuals not identified to species level were only included in the test if no other individual of the same family was present in the trap.

					Agelenidae	Araneidae	Araneidae	Clubionidae	Clubionidae	Clubionidae	Dictynidae	Dictynidae
Line number	Region	Meadow name	Treatment (uncut=0, cut=1)	Trap type	Cicurina cicur	Mangora acalypha subad.	Araneidae gen. spec. juv.	Cheiracanthium punctorium	Clubiona neglecta	Clubiona spec.	Argenna subnigra	Dictynidae gen. spec. juv.
1	Klettgau	Auf Stein	0	Ekl&Pit	0	0	0	0	0	0	0	0
2	Klettgau	Auf Stein	1	Ekl&Pit	0	0	0	0	0	0	0	0
3	Klettgau	Chrummenlanden	0	Ekl&Pit	0	0	X	0	0	0	0	5
4	Klettgau	Chrummenlanden	1	Ekl&Pit	0	0	0	0	0	0	0	0
5	Klettgau	Landstrass	0	Ekl&Pit	0	0	0	0	0	0	0	0
6	Klettgau	Landstrass	1	Ekl&Pit	0	0	0	0	0	0	0	0
7	Klettgau	Rebberg	0	Ekl&Pit	0	0	0	1	0	0	0	0
8	Klettgau	Rebberg	1	Ekl&Pit	0	0	0	0	0	0	0	0
9	Klettgau	Spitzäcker	0	Ekl&Pit	0	0	0	0	0	0	0	0
10	Klettgau	Spitzäcker	1	Ekl&Pit	0	0	0	0	0	0	0	0
11	Klettgau	Tobeläcker	0	Ekl&Pit	0	0	0	0	0	0	1	0
12	Klettgau	Tobeläcker	1	Ekl&Pit	0	0	0	0	0	0	0	0
13	Ergolz	Anwil	0	Ekl&Pit	0	0	1	0	0	0	0	0
14	Ergolz	Anwil	1	Ekl&Pit	0	0	0	0	0	0	0	0
15	Ergolz	Oltingen	0	Ekl&Pit	0	0	74	0	0	1	0	0
16	Ergolz	Oltingen	1	Ekl&Pit	0	0	0	0	0	0	0	0
17	Ergolz	Ormalingen	0	Ekl&Pit	0	0	0	0	0	0	0	0
18	Ergolz	Ormalingen	1	Ekl&Pit	0	0	0	0	0	0	0	0
19	Ergolz	Rothenfluh Bad	0	Ekl&Pit	0	0	0	0	0	0	0	0
20	Ergolz	Rothenfluh Bad	1	Ekl&Pit	0	0	0	0	0	0	0	0
21	Ergolz	Rothenfluh Dorf	0	Ekl&Pit	0	0	0	0	2	0	0	0
22	Ergolz	Rothenfluh Dorf	1	Ekl&Pit	0	0	0	0	0	0	0	0
23	Ergolz	Roth-Orm	0	Ekl&Pit	0	0	0	0	1	0	0	0
24	Ergolz	Roth-Orm	1	Ekl&Pit	0	1	0	0	0	0	0	0
25	Ergolz	Schafmatt	0	Ekl&Pit	0	0	0	0	0	0	0	0
26	Ergolz	Schafmatt	1	Ekl&Pit	0	0	0	0	0	0	0	0
27	Tösstal	Eggwegwald	0	Ekl&Pit	0	0	0	0	0	0	0	0
28	Tösstal	Eggwegwald	1	Ekl&Pit	0	0	0	0	0	0	0	0
29	Tösstal	Fischenthal	0	Ekl&Pit	0	0	0	0	0	0	0	0
30	Tösstal	Fischenthal	1	Ekl&Pit	0	0	0	0	0	0	0	0
31	Tösstal	Grossegg	0	Ekl&Pit	0	0	0	0	0	0	0	0
32	Tösstal	Grossegg	1	Ekl&Pit	0	0	0	0	0	0	0	0
33	Tösstal	Nideltobel	0	Ekl&Pit	0	0	0	0	0	0	0	0
34	Tösstal	Nideltobel	1	Ekl&Pit	0	0	0	0	0	0	0	0
35	Tösstal	Ohrüti	0	Ekl&Pit	0	0	0	0	0	0	0	0
36	Tösstal	Ohrüti	1	Ekl&Pit	0	0	0	0	0	0	0	0
37	Tösstal	Steg	0	Ekl&Pit	0	0	0	0	0	0	0	0
38	Tösstal	Steg	1	Ekl&Pit	0	0	0	0	0	0	0	0
39	Tösstal	Strahlegg	0	Ekl&Pit	0	0	0	0	0	0	0	0
40	Tösstal	Strahlegg	1	Ekl&Pit	1	0	0	0	0	0	0	0

Line number	Dysdera erythrina (Dysderidae)	Drassyllus pusillus (Gnaphosidae)	Haplodrassus signifer (Gnaphosidae)	Micaria pulicaria (Gnaphosidae)	Zelotes s. l. sp. juv. (probably Drassyllus pusillus) (Gnaphosidae)	Gnaphosidae gen.spec.juv. (Gnaphosidae)	Hahnia nava (Hahniidae)	Araeoncus humilis (Linyphiidae)	Bathyphantes gracilis (Linyphiidae)	Cnephalocotes obscurus (Linyphiidae)	Ceratinella brevipes (Linyphiidae)	Dicumbium nigrum (Linyphiidae)	Diplastyla concolor (Linyphiidae)	Diplocentria bidentata (Linyphiidae)	Eperigone trilobata (Linyphiidae)
1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1
2	0	2	0	0	0	0	0	6	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4
6	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2
7	1	2	0	0	1	0	0	3	0	1	0	0	0	0	0
8	0	0	0	0	0	0	0	7	0	0	0	0	0	0	1
9	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0
11	0	2	0	0	2	0	0	0	0	0	0	0	0	0	3
12	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
14	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0
15	0	0	0	0	0	0	0	0	0	7	0	1	1	0	0
16	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
17	0	2	0	1	1	0	2	0	0	0	0	0	0	0	0
18	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
23	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0
24	0	1	0	0	1	0	0	2	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	2	1	0	0	1	2	0	0
26	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	1	0	1	0	2	2	0	0	0	0
33	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
39	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
40	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae	Linyphiidae
Line number	Erigone atra	Erigone dentipalpis	Lepthyphantes (Tenuiphantes) tenuis	Meioneta beata	Meioneta rurestris	Microlinyphia pusilla	Panamomops sulcifrons	Pelecopsis parallela	Porrhomma microphthalmum	Porrhomma oblitum	Tisa vagrans	Troxochus nasutus	Walckenaeria alticeps	Walckenaeria antica
1	1	0	0	0	5	0	0	0	2	0	0	0	0	0
2	3	1	0	0	3	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	7	0	0	0	2	0	0	0	0	0	0	0	0	0
6	1	1	0	0	0	0	0	0	0	3	0	0	0	0
7	1	0	0	0	0	0	0	2	0	0	0	0	0	0
8	0	2	0	0	0	0	0	2	0	0	0	0	0	0
9	0	0	1	1	6	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	3	0	0	1	0	0	0	0	0
12	0	2	0	0	6	0	0	0	0	0	0	0	0	0
13	0	0	0	0	1	0	0	0	0	1	0	0	0	0
14	2	6	0	0	0	0	0	0	1	3	1	0	0	0
15	0	0	2	0	0	0	0	1	0	0	0	0	0	1
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	2	0	0	0	0	0	0	0	0	0
18	0	0	0	0	1	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	1	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	4	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	1	0	0	2	0	0	0	0	0	0	0	0	0
25	0	0	0	0	1	0	2	1	0	0	2	0	0	0
26	0	0	0	0	0	0	0	0	0	2	0	0	0	0
27	0	0	1	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	1	0	0	0	0	0	1	0	0	0
29	0	2	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	1	0	0	0	0	0	0	0	0	0	0	2
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	1	0	0
36	0	0	0	0	0	0	0	0	0	0	0	2	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	1	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	1	0	0	0	0	0	0	0	0	0	1	0	0

	Linyphiidae	Linyphiidae	Linyphiidae	Liocranidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae
Line number	Walckenaeria atrotibialis	Walckenaeria nudipalpis	Linyphiidae gen. spec. juv.	Phrurolithus festivus	Alopecosa accentuata	Alopecosa aculeata	Alopecosa cuneata	Alopecosa pulverulenta	Artosa lutetiana	Aulonia albimana	Pardosa lugabris	Pardosa palustris	Pardosa pullata	Trochosa robusta	Trochosa ruricola
1	0	0	3	0	0	0	2	0	0	0	0	10	1	0	0
2	0	0	9	0	0	0	0	0	0	0	0	8	0	0	0
3	0	0	1	0	0	0	1	0	0	0	0	2	0	0	0
4	0	0	0	0	0	0	2	0	0	0	0	1	1	0	0
5	0	0	8	0	0	0	0	0	0	0	0	0	5	0	0
6	0	0	2	0	0	0	0	0	0	0	0	0	3	0	0
7	0	0	1	1	0	0	0	0	1	2	0	6	1	0	0
8	0	0	8	0	0	0	4	0	0	0	0	2	0	0	1
9	0	0	11	0	0	0	3	0	2	0	0	2	1	0	0
10	0	0	10	0	0	0	1	0	0	0	0	2	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
12	0	0	6	0	2	0	0	0	0	0	0	3	0	0	0
13	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0
14	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	3	1	1	0	0	0	13	1	0	0
18	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
20	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0
21	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
22	0	0	2	0	0	0	1	0	2	0	0	0	1	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
25	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
31	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
33	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
34	0	0	0	0	0	1	0	2	0	0	0	0	12	0	0
35	0	0	1	0	0	0	0	5	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	6	0	0	0	0	1	0	0
37	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
38	1	0	0	0	0	0	0	1	4	0	1	0	0	0	0
39	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Lycosidae	Philodromidae	Pisauridae	Salticidae	Salticidae	Salticidae	Salticidae	Salticidae	Tetragnathidae	Theridiidae	Theridiidae
Line number	Trochosa terricola	Arctosa spec. juv.	Pardosa spec. juv.	Trochosa spec. juv.	Lycosidae gen.juv.	Tibellus oblongus	Pisaura mirabilis	Bianor aurocinctus	Euophrys frontalis	Heliophanus flavipes	Heliophanus spec.juv.	Salticidae gen. spec. juv. (probably Heliophanus sp.)	Pachygnatha degeeri	Enoplognatha ovata	Enoplognatha thoracica
1	0	0	14	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	7	0	0	0	0	0	0	0	0	0	1	0	0
3	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0
4	0	0	4	0	0	0	0	0	0	0	0	0	1	0	0
5	0	0	2	0	0	0	0	0	0	0	0	0	5	0	0
6	0	0	1	0	0	0	0	0	0	0	0	0	10	0	0
7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
8	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	1	0	0	1	3	0	0	0	0	0	0	0	0
10	0	0	4	0	0	0	0	0	0	0	0	0	2	0	0
11	0	0	14	0	0	0	1	1	0	0	0	0	1	0	0
12	0	1	8	0	0	0	1	0	0	0	0	0	0	0	0
13	0	0	6	1	0	0	1	0	0	0	0	1	6	0	0
14	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0
15	0	0	1	0	0	0	2	0	0	1	0	0	0	0	0
16	0	0	3	0	0	0	1	0	0	0	0	0	1	0	0
17	0	0	4	1	0	0	0	0	0	0	0	0	1	0	0
18	0	0	3	0	0	0	0	0	0	0	0	0	3	0	0
19	0	0	1	1	0	0	0	0	0	0	0	0	4	0	0
20	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
21	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0
22	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	2	0	0	0	0	0	0	0	0	1	1	0	0
24	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0
25	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
27	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	1	0	1	0	0	0	0	0	0	0	0	0	11	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0
31	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	1	0	0	0	0	0	1	0	0	0	3	0	0
35	0	0	1	1	0	0	0	0	1	2	0	0	4	0	0
36	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0
37	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0
38	0	0	2	2	5	0	0	0	0	0	0	0	9	0	0
39	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0

	Theridiidae	Theridiidae	Theridiidae	Theridiidae	Thomisidae	Thomisidae	Thomisidae	Thomisidae	Thomisidae	Thomisidae	Thomisidae	Thomisidae	Thomisidae
Line number	Paidiscura pallens	Robertus lividus	Robertus neglectus	Theridiidae gen. spec. juv.	Ozyptila claveata	Xysticus acerbus	Xysticus audax	Xysticus bifascius	Xysticus cristatus	Xysticus kempeleni	Xysticus kochi	Ozyptila spec. juv.	Xysticus spec. juv.
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	1	0	1	0	0	0	0	1	0	0
3	0	0	0	0	0	0	0	0	1	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	1	0	0
5	0	0	0	0	0	0	0	0	2	0	0	0	1
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	1
8	0	0	0	0	0	0	1	0	2	0	1	0	0
9	0	0	0	1	0	0	1	0	1	0	3	0	0
10	0	0	0	0	0	0	0	0	1	0	0	0	0
11	0	0	0	1	0	0	0	0	0	0	0	0	1
12	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	1	0	1	0	3
14	0	0	0	0	0	0	0	0	1	0	1	0	1
15	0	0	0	0	0	0	1	0	0	0	0	0	0
16	0	0	0	0	0	0	0	1	0	0	0	0	1
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20	0	0	0	0	0	0	0	2	0	0	0	0	2
21	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	2	0	0	0	0	1
23	0	0	0	0	1	0	1	0	0	0	2	2	1
24	0	0	0	0	0	0	1	0	0	0	0	0	2
25	0	0	0	0	0	0	0	0	1	0	0	0	1
26	0	0	0	0	0	0	0	0	0	0	1	0	1
27	0	0	0	0	0	0	0	0	0	0	0	0	0
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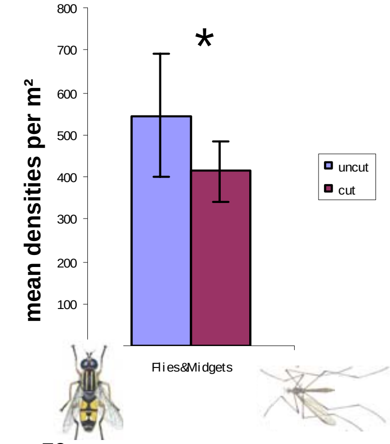
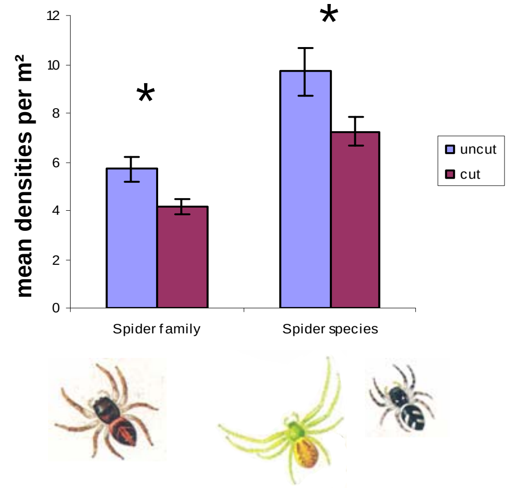
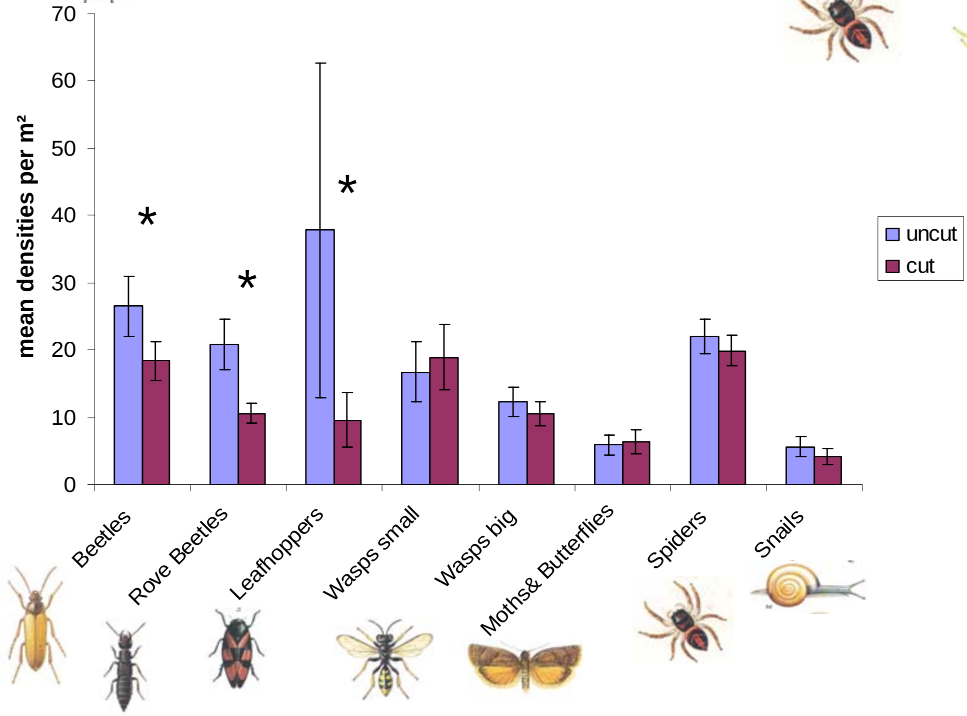
30	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	2	0	0	0	0	0
33	1	0	0	0	0	0	0	0	0	0	0	0	1
34	0	0	0	0	0	0	0	0	2	1	0	0	0
35	0	2	0	0	0	0	1	0	0	0	0	0	3
36	0	0	0	0	0	0	0	0	1	0	0	0	1
37	1	0	1	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	1	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix D. Results of general trend shown graphically (following page).

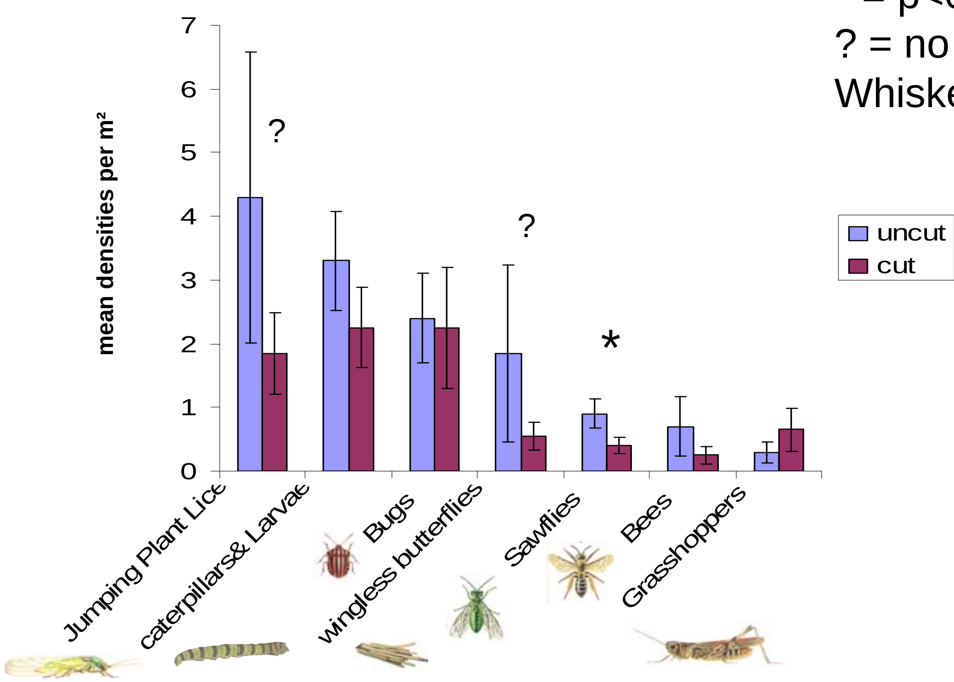
Appendix E. Information leaflet for the farmers who participated in the project (last two pages)





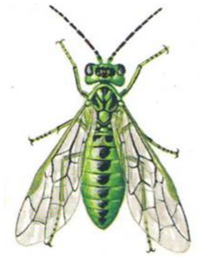


* = p<0.05
? = no statistical test possible
Whiskers indicate + - standard error



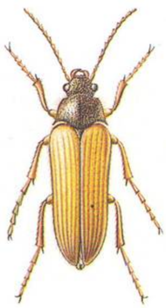
Die Auswirkung der Streifenmahd auf die Überwinterung der Kleinlebewesen

Eine Untersuchung von Andres Overturf, Uni Züri



Warum: Die Streifenmahd wird in verschiedenen Gegenden der Schweiz für die Vernetzung und Verbesserung der Lebensräume der Tiere angewendet. Im Sommer weiss man, dass diese Bewirtschaftungsmethode vorteilhaft für das Kleingetier ist. Während des Winters wusste man aber noch nicht so genau was für eine Bedeutung die Streifenmahd in der Schweiz für die Kleinlebewesen hat.

Was: Die Kleinlebewesen (Insekten und Spinnen) wurden zur Untersuchung ausgewählt, da sie zahlenmässig die Mehrheit der Artenvielfalt ausmachen (60% der Tierarten der Welt sind Insekten oder Spinnen).



Wie: Nach der Schneeschmelze wurde in jeder der 20 untersuchten Wiesen je eine Falle im geschnittenen und ungeschnittenen Wiesenteil aufgestellt. Die Fallen deckten je einen m² ab und wurden wöchentlich, während 10 Wochen, geleert. Die gesammelten Tiere wurden zu Gruppen eingeordnet (z.B. gehörten alle Heugümper in eine Gruppe).

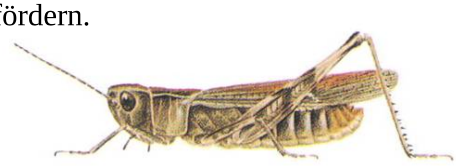
Wo: Die untersuchten Wiesen befanden sich im Ergolztal (Baselland), Klettgau (Schaffhausen) und Tösstal (Zürich).

Ergebnis: Über 24‘000 Insekten und Spinnen wurden gefangen: 14185 im Altgras und 10495 in den geschnittenen Flächen. Das sind im Durchschnitt pro m² 709 Tiere im Altgras und 525 Tiere in den geschnittenen Flächen.

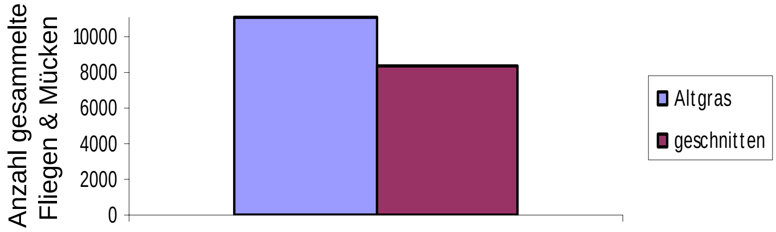
Gewisse Insekten- und Spinnengruppen kamen zahlenmässig in geschnittenen und ungeschnittenen Flächen gleich häufig vor. Andere Gruppen bevorzugten aber deutlich die Altgrasflächen als Überwinterungsorte. Diese waren die Zweiflügler (Fliegen und Mücken), Kurzflügelraubkäfer, sonstige Käfer, Zikaden, und Pflanzenwespen.

Obwohl zahlenmässig gleich viele Spinnenindividuen in den geschnittenen und ungeschnittenen Flächen gefunden wurden, gab es deutlich mehr Spinnenarten im Altgras. Das heisst, dass die Artenvielfalt der Spinnen im Altgras grösser war.

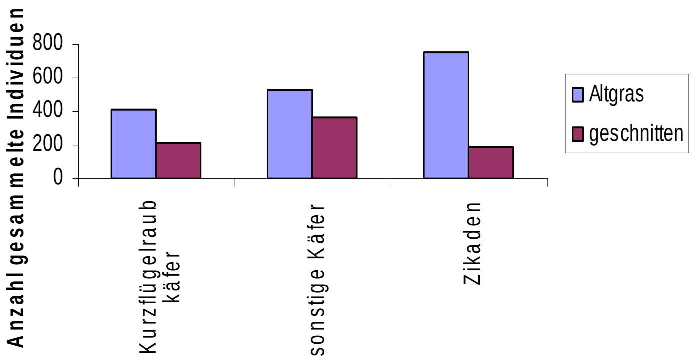
Andere Studien hatten bewiesen, dass je dichter oder höher die Vegetation ist, umso milder ist das Mikroklima am Boden. Im Sommer wird es weniger heiss und im Winter wird es weniger kalt. Da die allermeisten Insekten ihre Temperatur nicht selber regulieren können (“Kaltblüter”), suchen sie Orte auf die ihnen nicht Schaden zufügen können. Dies könnte eine Erklärung sein warum gewisse Kleintiere in unserem Versuch häufiger während des Winters im Altgras zu finden waren. Da man in England das gleiche Phänomen herausgefunden hatte, werden dort permanente Altgrasstreifen, sogenannte “Käferstreifen”, zwischen den Äckern angelegt, um die Nützlinge (vorallem Laufkäfer und Kurzflügelraubkäfer) zu fördern.



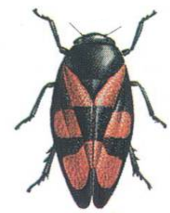
Einige Resultate grafisch dargestellt

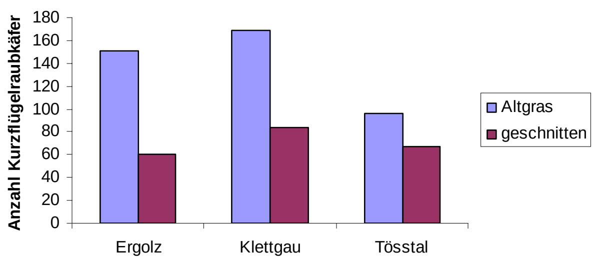


Diese Grafik zeigt die Gesamtzahl der Mücken & Fliegen von allen drei Regionen, separiert nach Altgras und geschnittener Vegetation.



Repräsentation der Anzahl Kurzflügelraubkäfer, sonstige Käfer und Zikaden von allen drei Regionen, separiert nach Altgras und geschnittener Vegetation.

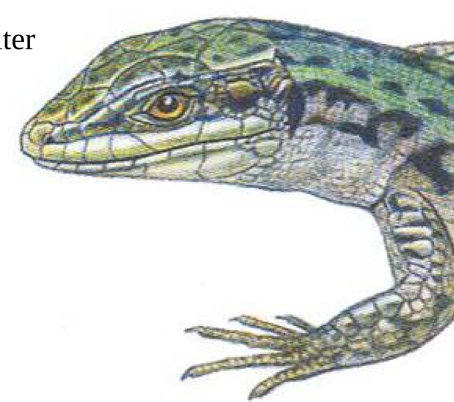




Repräsentation Anzahl Kurzflügelraubkäfer separiert nach Regionen, Altgras und geschnittener Vegetation.

Fazit: Von der Streifenmahd profitieren gewisse Kleintiere während des Winters, da Altgrasflächen ein Refugium vor den rauhen Winterbedingungen bieten. Dies ermöglicht mehr Individuen und Arten das Überleben bis zum nächsten Frühling. Eine erhöhte Zahl von Kleintieren wirkt sich auch positiv auf Zugvögel, Reptilien und Fledermäuse aus, da die Kleintiere ihre Hauptnahrung sind.

Dank: Ich danke den folgenden Bauern für die Mithilfe der Untersuchung:
Ergolztal: Jürg Wirth, Richard Buser, Fritz Bürgin, Daniel Niklaus,
Rolf Schaffner, Daniel Bitterlin, Jürg Gysin
Klettgau: Gabi Ühlinger, Werner Schaad, Hans Kübler, Ernst Walter
Tösstal: Hugo Blaser, Edi Diggelmann, Richard Durussel,
Benjamin Strommer, Peter Oser, Andreas Kurtz,
sowie
die Landwirtschaftsämter der Kantone
Baselland und Schaffhausen



21.2.2007

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