The Effect That Conservation Grazing Has on the Abundance and Diversity of Invertebrates When Compared Against Other Land Management Techniques

Conservation grazing is the practice of using grazing animals to manage areas of land with the aim to maintain and improve the biodiversity of the local population. It has been seen that the grazing in an extensive system can improve the diversity among the flora. This study aimed to investigate the effect that this could have on the composition of the invertebrate population, using carabid beetles as the indicators for the population. The abundance and diversity of the carabids beetles have been compared between 5 different sites which have been managed different ranging from cut for hay, grazed and left unmanaged. With this the other invertebrates sampled were identified to their order and their abundance and diversity was compared. The comparisons showed no significant difference between any of the sites for carabids or the orders of invertebrate. This was not the expected result as is most likely explained by the short sampling period. However further research would be needed to confirm or deny this as well as investigate the implications for land management if this is not the case.

Introduction

This study is designed to investigate the effect of conservation grazing by cattle on the diversity and abundance of invertebrates and carabid beetle species in particular, when compared with other land management techniques in 5 different grassland areas. Carabids were selected as the focus for the study as there is a precedence for their use as bioindicators (Rainio et al. 2003) which will allow for comparisons to made from a large history of other research in the subject, the sampling techniques for the these species is relatively simple and not time intensive.

Conservation grazing is the practice of using non-intensive grazing of livestock such as cattle, sheep or ponies to manage vegetation levels, particularly grasses to maintain or increase the diversity of flora and fauna of the area (Tallowin et al. 2005, Wallis de Vries et al. 2007). This is particularly important for AONBs or SSSI/ASSIs as they quite often contain areas of rough terrain or public rights of way where it may be unsafe to use conventional machinery to manage the vegetation. These areas can also be subject to regulations which prohibit the use of weedkillers or fertilisers to help improve the biodiversity of the area (Moreby et al. 1994).

Breed selection is a key area when considering implementing a conservation grazing scheme. It generally focuses on a traditional hardy breed as they can cope better with this type of grazing as they will be better able to cope with the different forage, as most sites grazed for this type of management are not homogenous grass fields. Ideally they should not require dosing with anthelminthics as this can be passed out in dung and then affect the invertebrate population. Native breeds are often selected as they may have a greater resistance to local parasites and importantly for the purpose of land management, they should graze less selectively than the more common commercial breeds. In this case the grazing has been carried out by the native breeds Irish Moiled and Dexter cattle.

The action of the grazers will increase in floral diversity among the sward, by preferentially grazing out the grass species allowing other species of flora to flourish, which should increase the variety of sward height and important aspect for increasing invertebrate diversity (Kruess & Tscharntke 2002). It has been shown that intensive grazing in grasslands will decrease the diversity of invertebrates yet

the higher sward height of an ungrazed system benefits some species more than others (Kruess & Tscharntke 2002). Therefore a range of different vegetation heights will allow for different levels of cover which will suit a greater range of invertebrates and will increase the survivability of invertebrates which in turn will result in greater numbers of invertebrates. An increase in the abundance of invertebrates will increase the number of species of invertebrates found within the area (Fisher et al. 1943).

An increase in the diversity of flora means a greater range of food sources which could potentially include species that certain herbivorous invertebrates may require for their main food source. This would increase the diversity of food sources for the secondary consumers which could again increase the diversity among this group (Siemann et al. 1998). This increase in diversity and numbers will lead to the system being able to support a larger numbers of predators, such as birds and small mammals, again increasing the diversity of the area.

Differences in the diversity of higher animals like birds and mammals would require a very long ranging study to show any type of causal link between the effect of the grazing and the abundance and diversity of local vertebrates. However the short generation time and high variety of local invertebrate species and well as the ease of sampling, should allow for some conclusions to be drawn. The carabid beetle species will be the focus of this study as they are easily sampled with the use of pitfall traps and contain a large amount of species which could potentially be found.

There are other effects which can be caused by the grazing animals which can potentially increase the abundance and variety of invertebrates. The non-intensive grazing of livestock which are not treated with an anthelminthic should increase the diversity of the invertebrate population not only through the action on the vegetation structure but also by the input of nutrients from their dung, a food source for many species of beetle and fly. It can be more readily used by these species in the absence of any anthelminthics.

The action of poaching by the livestock may also have an effect. Poaching is the name given to the physical effects caused by livestock, mainly larger, heavier cattle walking on a surface ie. trampling grass or breaking up soft ground. This can be a negative effect in some cases where ground is very wet or soft, or there is a high traffic area such as near feed or a water trough and in these cases the flora and ground will be damaged. In the right amount it can be beneficial, they can trample through sward and produce a range of heights amongst the sward, they will also expose areas of ground and could potentially expose food sources for invertebrate species or easier access for burrowing invertebrates.

The areas where the sampling will take place are a part of the Oxford Island nature reserve in Craigavon, an ASSI on the shore of Lough Neagh. There are five sites which are described in detail in the Methods section. The 2 key sites for the purposes of this study are the ‘Hill Field’ a field annually cut for hay and the ‘Upper Closet Meadow’ a field of unimproved grassland regularly grazed by the Irish Moiled and Dexter cattle. The expected result would be that the presence and action of the cattle in the ‘Upper Closet Meadow’ should result in the sampling of that site catching a larger abundance and diversity of invertebrates, in contrast to the ‘Hill Field’ site where the flora is cut to a regular height each year and is expected to not have as high an abundance and diversity as the other sites.

Materials and Methods

Study sites

The areas chosen for sampling are based in the Oxford Island Nature Reserve an ASSI on the shore of Lough Neagh. 5 non-overlapping 'fields' were selected to give a different range of vegetation structure and historical treatment. None of the fields have been treated with fertilizer, slurry or farmhouse manure. The figure below shows a map of the ASSI at Oxford Island with the sample site highlighted (Fig. 1).

Fig 1. Map showing the ASSI land at the Oxford Island Nature Reserve with sampling areas highlighted.

Field 1 ‘Hill Field’ this meadow is annually cut for hay and is not grazed at any time

Field 2 ‘Upper Closet meadow’ is regularly grazed by Irish Moiled and Dexter cattle, classed as unimproved grassland

Field 3 ‘Kinnego meadow’ this meadow is occasionally grazed and is classed as species rich grassland.

Field 4 ‘Annaloiste meadow’ an area of rank grassland which had been ploughed and left not rolled for 30 years and not managed until spring of this year when the Irish Moiled cattle intensively grazed it clearing most of the rank grass.

Field 5 ‘East Shore’ an area of rank grassland close to the lough shore which is not cut or grazed apart from a public pathway which runs through the area.

Beetle sampling

The beetles are sampled using pitfall traps containing a 1:2 solution of monopropylene glycol (antifreeze). The traps were 1L jars filled with 0.5L of solution. The openings of the jars were covered with chicken wire to stop vertebrates from entering the traps and these were covered with a plastic rain cover to prevent traps from flooding. There were 10 traps per ‘field’ arranged in a line transect with 5 paces between each trap and were marked with canes and a GPS.

The traps were placed out for two 4-week periods beginning 28/06/12 and 06/08/12 respectively, with the traps collected and reset after every 2 weeks. In between the two sampling periods a cut of hay was taken from the ‘Hill Field’ but not in the area were the pitfall traps were laid. At the ‘Upper Closet meadow’ the Irish Moiled cattle were allowed back into the sampling area for a limited time to graze but not intensively so.

When the traps were collected the invertebrates from each of the ten traps were combined into a sample and in total there were 4 samples taken from each site they were stored for a short period in the new solution of antifreeze as it was only for a short period until they were identified. The adult carabid beetles were identified to species level whereas all other invertebrates found were identified to order, the larval stages of the invertebrates were disregarded.

Data analysis

The diversity of carabid beetles in each sample will be quantified using Shannon’s diversity index (H’ Log base 10). The resulting indices will be compared using a standard ANOVA. The mean abundance and number of carabid species found per set of traps will also be compared with an ANOVA. These tests will compare the diversity and abundance of carabid beetle species and highlights any significantly different results. The same statistical analysis will be undertaken for the overall abundance of individual invertebrates found. The diversity of orders of invertebrate found will be tested by using the same diversity index and ANOVA combination as the carabid species.

Results

From all the traps 623 individual carabids were collected and identified. 19 different species were discovered with the various *Pterostichus* and *Agonum* species being generally the most abundant.

The first set of traps from the Annaloiste site became spoiled and had begun decomposing before identification and it was not possible to identify them in the condition they were in. Therefore for the purpose of calculating comparative diversity indices I have separated two sets of data, one set disregarding the results from Annaloiste completely and the other set disregarding all of the sites fist set of traps.

Table 1. Total Number of Carabid species found and the mean number found per sample (±SE).

Sample site	Hill Field	Upper Closet	Kinnego	Annaloiste^	East Shore	
Total no. of species	12	13	11	9	13	
Mean no. of species per sample	6.5 ±0.5	5 ±0.32	4.5 ±1.02	5 ±1.22	5.25 ±1.20	NS

Significance for ANOVA (NS=non-significant, *p<0.05, ** p<0.01, ***p<0.001)

^from 3 samples instead of 4 for the other sites

There is not a significant difference between the mean number of species found in each run of traps, p=0.792. However there is difference in the standard error for the different means which suggests a wider range of the number of species found in the traps from the Kinnego, Annaloiste and East Shore sites.

Table 2. Total number of individual carabids found and mean abundance per sample (±SE)

Sample site	Hill Field	Upper Closet	Kinnego	Annaloiste^	East Shore	
Total no. of individual carabids	177	123	57	145	121	
Mean no. of individuals per sample	44.5 ±13.73	30.75 ±16.28	14.25 ±5.19	48.33 ±24.51	30.0 ±12.96	NS

Significance for ANOVA (NS=non-significant, *p<0.05, ** p<0.01, ***p<0.001)

^from 3 samples instead of 4 for the other sites

When looking at the total number of individual carabids found we must ignore the Annaloiste result due to the missing sample, we can see that the number of found in each of the sites is not significantly different. However the samples from Kinnego returned noticeably fewer total indivduals than the others whereas the samples from the Hill Field had more individual carabids than the others. However the difference was not significant with p=0.528.

Table 3. Shannon's diversity indices for carabid species without the results from the Annaloiste site, using all four samples from each of the other sites.

Field	Hill Field	Upper Closet	Kinnego	East Shore	
Shannon's Diversity index (H')	0.979	0.885	0.897	0.876	NS

Significance for ANOVA (NS=non-significant, *p<0.05, ** p<0.01, ***p<0.001)

The diversity indices are all relatively similar with the Hill field being slightly higher but again not significantly so p=0.585.

Table 4. Shannon's diversity indices for carabid species from all of the sites without the results from the first set of samples.

Field	Hill Field	Upper Closet	Kinnego	Annaloiste	East Shore	
H'	0.847	0.749	0.728	0.872	0.765	NS

Significance for ANOVA (NS=non-significant, *p<0.05, ** p<0.01, ***p<0.001)

Again the diversity indices are all relatively similar with the Hill Field and Annaloiste sites giving slightly higher H' values but not significantly so, p=0.874.

Table 5. Carabid species list and count with Annaloiste data omitted.

	Sample Site			
Species	Hill Field	Upper Closet	Kinnego	East Shore
Pterostichus melanarius	23	19	11	27
P. niger	17	30	10	36
P. nigrita	11	6	12	9
Nebria brevicollis	15	10	5	4
Harpalus rufibarbis	41	11	4	6
H. affinis	8	14	0	0
H. rupifes	0	0	1	0
Trechus quadristriatus	18	0	1	0
T. micros	6	0	1	4
T. obtusus	0	0	0	1
Agonum fuligonosum	21	26	3	19
A. assimile	14	1	8	1
A. obscurum	2	1	0	1
Carabus granulatus	1	1	0	0
Abax parallepipedus	0	2	1	0
Notiophilus bigutattus	0	1	0	0
Amara familiaris	0	1	0	2
Bembidion lampros	0	0	0	7
Calathus melanocephalus	0	0	0	4

Table 6. Carabid species list and count from all five sites with first sample set omitted.

Species	Sample Site				
	Hill Field	Upper Closet	Kinnego	Annaloiste	East Shore
Pterostichus melanarius	16	19	11	19	19
P. niger	8	28	10	16	34
P. nigrita	3	5	11	35	1
Nebria brevicollis	15	2	2	12	4
Harpalus rufibarbis	30	4	3	7	5
H. affinis	8	0	0	0	0
H. rupifes	0	0	1	0	0
Trechus micros	6	0	1	0	4
T. obtusus	0	0	0	0	1
Agonum fuligonosum	5	26	0	18	3
A. assimile	0	1	0	25	0
A. obscurum	2	1	0	12	1
Abax parallepipedus	0	2	1	0	0
Notiophilus bigutattus	0	1	0	0	0
Amara familiaris	0	1	0	0	2
Bembidion lampros	0	0	0	1	7

The traps caught 4,227 invertebrates in total from 16 different orders. The majority of invertebrates found belong to the orders Coleoptera, Pulmonata, Aranae and Hymenoptera.

Table 7. Total Number of invertebrate orders found and the mean number found per sample (±SE).

Sample site	Hill Field	Upper Closet	Kinnego	Annaloiste^	East Shore	
Total no. of orders	11	11	13	11	10	
Mean no. of species per sample	7.25±0.25	8 ±0.91	8.5 ±0.50	8±0.58	8.5 ±0.29	NS

Significance for ANOVA (NS=non-significant, *p<0.05, ** p<0.01, ***p<0.001)

^from 3 samples instead of 4 for the other sites

There is not a significant difference between the mean number of species found in each run of traps, p=0.792.

Table 8. Total number of individual invertebrates found and mean abundance per sample (±SE)

Sample site	Hill Field	Upper Closet	Kinnego	Annaloiste^	East Shore	
Total no. of individual invertebrates	797	901	547	457	1525	
Mean no. of individuals per sample	199.25 ±19.20	225.25 ±46.89	136.75 ±40.21	152.33 ±32.77	381.25 ±108.53	NS

Significance for ANOVA (NS=non-significant, *p<0.05, ** p<0.01, ***p<0.001)

^from 3 samples instead of 4 for the other sites

When looking at the total number of individual invertebrates found we must ignore the Annaloiste result due to the missing sample. We can see that the number of invertebrates found in each of the sites is not significantly different p=0.081. However this value is close to significant and the samples from Kinnego returned noticeably fewer total indivduals than the others whereas the samples from the Hill Field had more individual carabids than the others, which was similar when comparing the abundance of the carabids.

Table 9. Shannon's diversity index applied to the orders of invertebrate found, again with the Annaloiste samples removed

Sample site	Hill Field	Upper Closet	Kinnego	East shore	
Shannon's diversity Index (H')	0.652	0.699	0.690	0.749	NS

Significance for ANOVA (NS=non-significant, *p<0.05, ** p<0.01, ***p<0.001)

Table 10. Order diversity index for all sites with first sample set omitted.

Sample site	Hill Field	Upper Closet	Kinnego	Annaloiste	East shore	
(H')	0.631	0.714	0.718	0.702	0.824	NS

Significance for ANOVA (NS=non-significant, *p<0.05, ** p<0.01, ***p<0.001)

Table 7 & 8 shows the Shannon's diversity index applied to the orders of invertebrates found again there is no significant difference in either of the comparisons p=0.774 and 0.588 respectively, however it is possible to see in both cases that the Hill Field is noticeably lower than the others while the East Shore is noticeably higher.

Table 11. Invertebrate Order list and count for all 4 samples sets with the Annaloiste samples removed.

	Sample Site			
Order	Hill Field	Upper Closet	Kinnego	East Shore
Opiliones	1	7	1	59
Pulmonata	207	416	66	703
Aranae	200	138	262	156
Collemba	25	91	10	117
Hymenoptera	52	65	107	198
Diptera	56	61	15	29
Coleoptera	477	379	125	297
Julida	14	11	10	57
Ixodida	3	2	6	0
Megadrilacea	4	5	1	0
Lepidoptera	0	0	2	0
Lithobiomorpha	0	1	0	0
Dermaptera	0	0	0	1
Isopoda	0	0	1	31
Orthoptera	1	0	4	0

Table 12. Invertebrate Order list and count for all 5 samples sites with the first sample set of each of the sites removed.

	Sample Site				
Order	Hill Field	Upper Closet	Kinnego	Annaloiste	East Shore
Opiliones	1	7	1	15	59
Pulmonata	79	201	31	51	336
Aranae	146	82	138	65	122
Collemba	22	80	10	54	76
Hymenoptera	52	27	40	64	126
Diptera	29	52	14	18	22
Coleoptera	316	302	86	291	205
Julida	0	9	5	19	36
Ixodida	3	2	6	1	0
Megadrilacea	1	5	1	0	0
Lepidoptera	0	0	1	0	0
Lithobiomorpha	0	1	0	1	0
Dermaptera	0	0	0	0	1
Isopoda	0	0	0	1	29
Orthoptera	1	0	3	0	0

Discussion

The ANOVA comparisons of the diversity indices for both the carabids and invertebrate orders did not show any significant difference between any of the fields sampled. There are a number of reasons which could cause this.

Both 2011 and 2012 have been wetter than average this could lead to a reduction in diversity among the ground beetles leaving only the more common and robust species in abundance, meaning that a short term sampling study for ground beetles may not reveal any significant differences in levels of diversity. The weather was a problem in particular with the last sample set as the traps needed to be reset after their first few days due to them flooding caused by a period of heavy rain.

It has been suggested that pitfall trapping may not be the most effective method for sampling invertebrates in this type of dense grassland (Thomas and Marshall, 1999). Reliable pitfall catches are dependent on the relationship between the activity and numbers of individual species, which is known as their activity abundance. This refers to the typical range of each individual and theoretically would be a roughly circular area within which their normal movement occurs. In an area a population would have many individuals and their ranges of movement overlapping. When sampling this area with something like a pitfall trap the objective is to have traps inside these areas and as the invertebrates go through their normal movement paths that crossed over the pitfall trap would be captured. Many of these traps through the area should then give a relatively random representative sample.

The dense and varying grass cover in these meadows and the fact that many of the ground beetles do not fly very often, may have resulted in the beetles range and movement in particular being impeded and resulting in an inaccurate sample. If continuing or planning a similar study additional sampling methods such as suction trapping, which can particularly useful for flying insects, could be used in tandem with the pitfall trapping to reduce any potential bias.

As all the areas are based in the Oxford Island nature reserve (see Fig. 1) some of the sample areas may be located too closely to each other to ensure no crossing between the samples. This means that the populations from which the beetles are being sampled from may overlap again resulting in little difference in the measured diversity of those fields as they could be essentially sampling from the same population. To reduce any inaccuracy caused by this the samples should be replicated on similar sites in different areas.

The time constraints of this project only allowed for one 4 week period of sampling in a single year. This leaves the sampling vulnerable to bias from short term issues. As discussed earlier the weather at the time of the study could have an effect. The time of the year and season could have a substantial effect, as the last 2 sample sets contained much fewer organisms, this could understandably have an effect. If the study was continued over the course of a few years in different weather conditions and times of year any bias caused by environmental conditions could be reduced as comparisons could be made between samples taken at the same time of year over the course of a few years.

However there were observable differences in the diversity indices for the carabids. They may not be statistically significant, but the Hill Field and Annaloiste site interestingly resulted in higher diversity

indices which were not expected. The Hill Field is annually cut for hay and the Annaloiste site was a field that had been ploughed almost 30 years ago and remained untouched until this spring when the cattle intensively grazed it in the spring of this year. While the Hill Field is cut for hay annually, it is not a typical hay field that could be seen at a commercial farm for example. It is relatively species rich, yellow rattle has been introduced to parasitise the grass species present, and contains mostly plantain, knapweed, orchid and clover. This along with the regular annual cutting has stopped the grass species from dominating and has led to an uneven sward height which as discussed in the introduction should lead to a higher diversity of invertebrates. As well as this there is no fertiliser spread which would result in a higher invertebrate diversity than a normal hay field (Marini et al. 2008). The Annaloiste site was an area of rank grassland with bracken and thorn bushes before it was grazed and the ground is very uneven this could have resulted in a relatively high diversity due the amount of cover available to protect from predation. The recent input of nutrient from the cattle dung could also account for this relatively high diversity.

The comparisons between total abundance of invertebrates revealed the closest to significant result with the sampling at the 'East Shore' site collecting considerably more invertebrates per sample set than the other sites. This again was not the expected result. This site is an area of rank grass which is on the shore of the lough and has a public pathway on the other side. From Table 11 & 12 we can see that the 'East Shore' had a much larger of number of invertebrates from the orders Pulmonata and Hymenoptera. This is a very sandy area which runs right down to the lough shore which after a few minutes of watching it is possible to observe a lot of ants with potentially a nest in the area, which would explain the large number of Hymenoptera sampled here. There are also a lot of rabbits and birds which use this area and it is possible to see where rabbit grazing has occurred in patches which has provided a range of sward heights and a source of nutrient input to the system. However another aspect of this site is that it is relatively undisturbed while the public pathway is used a lot and its edge is regularly trimmed the area where the sampling is untouched apart from some birds and rabbits. This might link with the Annaloiste result from the carabid sampling as it also was undisturbed until recently when it was grazed intensively which in the short-term may have had a negative effect (Kruess & Tscharntke, 2002).

The 'Upper Closet Meadow' showed no difference from the other sites in regards to diversity or abundance of carabids or the orders of invertebrates. This again was not the expected result; this site is the most regularly grazed in the reserve. It is possible it may be too intensively grazed for the purpose of maintaining the diversity of invertebrates (Wallis de Vries et al. 2007). Another unexpected result was the result for the 'Kinnego' site which had noticeably low abundance of carabids. The site is an area of species- rich grassland which would have been expected to have a high abundance and diversity of invertebrates. This area however was badly affected by the weather as the soil was waterlogged and at one point the traps were flooded by a period of heavy rain. This bad weather might explain why there was low abundance but an average diversity as the beetles may be in abundance but avoiding the wetter areas near where the traps were laid.

Conclusion

This study found no significant difference between either the diversity or abundance of carabid beetles or invertebrates as a whole when comparing these 5 different sites. This does conflict with what was expected and what has been seen in similar studies in different areas. I think what has led

to these different results was the relatively short period of sampling, however it would require further study with similar areas to ascertain the reason for these unusual results. The same study applied to commercial and more extensive systems would also be required. The fact that the results are unexpected does raise the need for further study. The aim for conservation grazing is to improve or maintain diversity. To do this effectively the proper management techniques need to be applied and for this there needs to more research focused on the most effective treatments for different types of land.

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