A report on the suitability of different habitat types for Grey Partridge, *Perdix perdix*, chicks.

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Irish Grey Partridge Conservation Trust

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1. Introduction

1.1 History

Grey partridges (*Perdix perdix*) were considered common in Europe in the early part of the 20th century but have since undergone dramatic declines across the whole of Europe, in fact, some countries no longer support viable populations. Due to the relatively recent decline of *P. Perdix*, historic data sets with large sample sizes exist and can be used to validate any models constructed (such as Agent-based models (ABMs) and pattern-oriented modelling (POMs)) which aid conservation efforts (Topping *et al*., 2010).

There are several accepted causes for the decline in Grey Partridge populations including loss of suitable nest sites, use and intensification of agricultural practices, climate, increased predation, reduced availability of invertebrate chick food, changes in landscape structure and 'agricultural intensification' which has been described as a catalyst for the degeneration of environmental conditions for the grey partridge. Mechanisms responsible for decline vary between populations may be combinations of more than one state that it is unclear whether and to what extent ecological enhancement measures may restore abandoned areas for eventual re-colonisation (Buner *et al*., 2005).

In general, populations of *P. perdix* continue to decline on a European scale despite the fact that this highly vulnerable species has been deemed a flagship species, this leads to the assumption that conservation measures in many cases are not satisfactory (Buner *et al*., 2005).

It is documented that *P. pendrix* requires unmanaged or extensively managed sites with a predominately herbaceous cover such as idle fields, boundaries of managed land or hedgerows. Agriculture intensification is linked to the reduction and removal of such habitats which has resulted in the decline of *P. pendrix* and thus indicating the importance of these habitats. Since the latter half of the 1950s, in the Czech Republic, agricultural land has begun to encroach on areas of open countryside resulting in the loss of suitable partridge habitat. This has lead to a decrease in Partridge populations reaching a decline of 95% by the end of the 1980s. Grazed wastelands in the Czech Republic were the preferred nesting habitats for the grey partridge during the 1960s. these wastelands however have now become rare because of urbanisation, agricultural intensification but also many have been left un-grazed, becoming overgrown and thus unsuitable habitats for the grey partridge (Šálek *et al*., 2004).

In Great Britain, there has been a decline of 90% in the grey partridge population resulting in these birds being placed on the Red list of Bird Conservation Concern in the UK. The Grey Partridge is one of the species in the Farmland Bird Indicator used in the UK, this assesses the status and progress of the species and endeavours to reverse the decline of farmland birds by 2020. The grey partridge is one species included in the farmland bird indicator as part of the European wild bird indicators produced by Pan-European Common Bird Monitoring Scheme (Šálek *et al*., 2004).
There has been 40 years of research regarding the factors responsible for the decline in Grey Partridge numbers and as a result of this there is good knowledge regarding land management measures necessary to increase numbers at the farm level thus reversing their decline (Šálek *et al*., 2004).

The Irish Grey Partridge Conservation Trust is a registered charity which was established to support the conservation of the Irish Grey Partridge as part of Irelands Natural Biodiversity (Irish Grey Partridge Conservation Trust, 2005).

1.2 Objectives of the Trust

With respect to the Grey Partridge, The Irish Grey Partridge Conservation Trust aims to "promote the conservation, preservation, care, protection and where desirable the restocking of native game birds and in particular the Grey partridge on the island of Ireland". The Trust also aims to promote the preservation and conservation and enhance the environment in Ireland, with particular focus to establish a viable population of Irish Grey Partridge on the island of Ireland. They aim to translocate or restock former native species of wildlife with particular focus on the Irish Grey Partridge. An important objective of the trust is to "encourage the promotion of education, learning and public awareness with particular emphasis on the Irish Grey Partridge and native Irish game birds in general". "The establishment of conservation programmes and initiatives for the reintroduction, establishment and/or restocking of very rare or extinct species of flora, fauna, wildlife and game birds on the Island of Ireland" is also a main objective. Finally, the trust focuses on the acquisition and management of nature reserves and habitats and the re-establishment of old habitats, environmental important or sensitive areas and/or lands available for scientific research or educational needs for the future of Ireland's wildlife, and in particular, the Irish Grey Partridge (Irish Grey Partridge Conservation Trust, 2005).

1.3 Status from 1900 to present.

Nationally The Irish Grey partridge suffered a high level of decline which was attributed to poaching. This decline was considered so serious that by the early 1930s wild birds were imported and released and legislation prohibiting their shooting was introduced. As a result of this, increase in numbers was noticed from 1933 and the birds had even colonised areas in the west of Ireland where they were previously unknown. This increase was not noticed nationally and most counties still held sparsely distributed populations (Irish Grey Partridge Conservation Trust, 2005).

National bird surveys carried out by Birdwatch Ireland (formally the Irish Wildbird Conservancy) and the British Trust for Ornithology, found there to be a dramatic decrease in the distribution of partridges since the late 1960's. a survey carried out between 1988 and 1991 found partridges to be breeding in 3.5% of the 1,010 10km squares surveyed nationwide. This is a dramatic decrease from the findings of the survey carried out between 1968 and 1972 where partridges were found to be breeding in 25.2% of the same survey sites (Irish Grey Partridge Conservation Trust, 2005).

In 1991 a survey was carried out through regional gun clubs by the National Association of Regional Game Councils (NARGC) to determine where Partridges occurred in Ireland. As a result of this, three main populations were identified. These consisted of one population in Co. Wexford which was found to be a mixed stock containing both wild and released birds and two populations in the midlands (Boora, Co. Offaly and Lullymore, Co. Kildare) which were found to consist of completely wild stock. Today, the cutaway bogland at Boora Co. Offaly contains the only population of wild grey partridges remaining in Ireland (Irish Grey Partridge Conservation Trust, 2005).

1.4 Habitats

According to Topping *et al.,* (2010) an unavoidable dilemma in the conservation of threatened species is that their ecologies are generally poorly understood. However, in an effort to avoid a scenario where this lack of knowledge becomes a confounding factor, the Grey Partridge Conservation Trust have created a range of varied habitats. The conservation area has been divided into different habitat areas. This has allowed extensive experimentation with the composition and location of different habitat types. There are no physical barriers between many of the habitats and those present are designed to exclude farm animals and allow the grey partridges to range freely. Some habitats are managed relatively intensively while others can be described as semi- natural. However, the movements of the partridges between the different habitats are monitored by staff and in this way it can be deduced which habitats are most suitable for the different life stages of the grey partridge.

Agri- environmental schemes (AES) in many EU Member States have addressed declines in farmland bird populations (Ewald *et al.*,2010). These schemes have shown that the creation of certain habitats within agricultural systems can positively influence grey partridge survival and productivity. For example, beetle banks have been shown to have consistently positive effects (Ewald *et al.*,2010). The success of previously proven habitat types has been integrated with experimental habitat creation in the Lough Boora Parklands. The conservation area largely resembles the ideal habitat of the grey partridge, which according to Salek *et al*., 2004, comprises of open, low intensity, mixed farmland comprising small fields bounded by hedges and grassy habitats. Valuable habitat types also include unmanaged or extensively managed sites with a predominantly herbaceous cover such as idle fields, boundaries of managed land. However, cereal crops are also cultivated in the conservation area, as it has been shown that *Perdix perdix* occurs commonly within the highly intensive cereal ecosystems of Western Europe (Salek *et al.,* 2004).

Field boundaries with grassy strips and isle sites are recognised as a significant component of breeding habitat of the grey partridge, *Perdix perdix*, in Europe (Salek *et al.,* 2004). In fact the persisting high densities of wild grey partridges in Prague, the Czech Republic has been attributed in part to the existence of unmanaged wasteland and herbaceous patches between urbanised areas and surrounding agricultural land (Salek *et al.,* 2004).

Different habitat types must be managed in different was to ensure the most productive ecosystem for the partridges. For example, some grass mixes may act as refuges for both birds and insects, at least provisionally. However, as the vegetation ages, these habitats may become less productive. Wastelands overgrown by dense shrubs and high trees are usually unsuitable for grey partridges (Salek *et al.,* 2004). In contrast, hedge rows and beetle banks must be concealed by dead grasses in order to provide sufficient cover for grey partridges from the high predator densities which occur in these areas (Salek *et al.,* 2004).

The use of set-aside aims to improve farmland habitat and alleviate predation and therefore, to maintain or restore partridge populations. These set- aside areas have been used extensively in France, and have been planted with maize or kale based mixtures. Maize-based mixtures are thought to provide protection from predators such as raptors. This is particularly important in mid- summer when most crops have been harvested, until late winter. Kale- based cover mixtures are thought to provide invertebrate food for chicks during the breeding season (Bro *et al.*, 2004). Linear features such as set- aside strips and hedges increase the amount of edge habitat available by splitting large fields (Bro *et al.,* 2004).

1.5 Food Preference

Knowledge of the dietary preferences and requirements of a species is important to any conservation effort as it may be used to design appropriate habitats that maximise food supplies and improve survival (Moreby *et al.*, 2006). Invertebrates are essential for the survival of partridge chicks. The abundance and diversity of these invertebrates is, in turn, influenced by the vegetation of the habitat.

The survival of chicks increases with the abundance of their preferred insect prey. One study has shown chick survival rates increasing with numbers of plant bugs. The number of plant bugs available was also shown to be positively correlated to weather conditions (Panek, 1992).

According to Potts(1970), the proportion of aphids in the cereal arthropod fauna has increased since the introduction of herbicides in the 1950s. However, partridge chicks will only select a small proportion of aphids in their diet, and chick growth rate is significantly lower when chicks are fed with a high proportion of aphids. Therefore, high aphid densities associated with cereal crops cannot substitute for a diverse insect fauna as food for partridge chicks (Borg & Toft, 2000). Since the 1950s, an increase in the use of herbicides has led to a concurrent decrease in arthropod and invertebrate abundances in cereal ecosystems. This in turn has directly affected the survival rate of grey partridge chicks, which are highly dependent on arthropod food for the first 2-3 weeks of their lives (Borg & Toft, 2000). Although faecal analysis has shown that aphids comprise a considerable proportion of wild partridge chicks diets, they have also been shown to be a low value food source to both arthropod insectivores and partridge chicks. Partridge chicks fed on aphid rich diet were shown to have slower growth rates than self- selecting chicks. This may affect chick survival as small chicks are particularly at risk from hypothermia. Chicks fed on high proportions of aphids were also seen to have poor flight feather development rates which may make them more vulnerable to predation (Borg & Toft, 2000). A recent study concluded that changes in overall density and composition of cereal arthropods since the introduction of intensive pesticide use in the 1950s may have given partridge chicks less opportunity to select preferred food items, making them more dependent on whatever insect food could be found, which will now often be aphids (Borg & Toft, 2000).

1.6 Weather

The survival of grey partridge chicks is intrinsically linked with weather conditions, especially during the first few weeks. Weather affects chick survival both directly by influencing chick activity and indirectly by affecting food supplies (Green, 1984). In fact, a study carried out by Panek in 1992 found a direct positive correlation between chick survival rates and mean temperatures. Chick survival was also seen to decrease with increasing numbers of rainy days in June (Panek, 1992). Small chicks must be brooded periodically by their parents in order to maintain a stable body temperature (Panek, 1992). In fact, the extent of the impact of weather conditions on chick survival can be seen from a study carried out on the population dynamics of grey partridges in England. In this study, weather conditions were identified as the most important factor in determining year to year population density changes (Panek, 1992).

1.7 Aims

The aims of this study are:

- To assess insect abundance within each of the different habitat types.
- To assess invertebrate species richness within each of the different habitat types.
- To interpret the obtained data to assess which habitats support invertebrate fauna which is most valuable nutritionally to grey partridge chicks.

2. Materials and Methods

Different habitat types were identified within the conservation area. The dominant vegetation type and composition of a particular site was used to classify the habitat as verge, brood rearing, nesting, beetle bank, semi- natural, border or crop. The natural boundaries of the habitat types were used and as a result the sizes of the sites varied. The GPS co-ordinates of the boundaries of each site were recorded. These co-ordinates were then entered into the GIS programme, Arc View. In this way, the habitat composition of the conservation area was mapped. In total, 52 sites were identified. The experimental design was based on a study carried out by Diane Armitage in 2008 and 2009. Insect sampling was carried out within each of these sites. Sampling was only carried out on warm, still days between 10am and 6pm during June and July, 2010.

Sweep nets sampling was carried out. 30 paces were taken through the identified site, a sweep accompanying each pace, in this way the area sampled was consistent between sites. An electric pooter was then used to take the invertebrates from the sweep net. The Invertebrates were then placed in 70% alcohol in labelled jars. The samples were later sorted and identified using microscopy, with the abundance of each insect order present being recorded. In this way, both invertebrate abundance and species richness were identified for each site.

Dietrick vacuum (D-Vac) sampling was also carried out at each site to identify the invertebrate fauna present in the soil. The D- Vac which was kindly supplied by the National University of Ireland Galway. The D-vac was supplied by GS Electric (model number CPM-023) and had a 12 V/18A battery. The diameter was 80mm and mesh size was circa 250µm. A sub-sample was obtained by turning the D-vac on and putting the end of the cone in direct contact with the soil for 10 seconds. Each sub- sample was taken 5 paces apart in a straight line. Each sample was comprised of 5 sub- samples. The invertebrates were removed from the D-vac cone using an electric pooter. The sample was then placed in a labelled container containing 70% alcohol. Each sample was later sorted and identified using microscopy. Both invertebrate abundance and species richness were recorded for each site.

3. **Results**

52 sites were sampled during this study using both sweep netting and D-vac sample methods. After analysis, each sample was grouped in relation to the type of habitat the site contained. The categories for habitat type used were: road-side verge, brood rearing/nesting, beetle bank, semi-natural, border and crop. Insect abundances and species richness were then used to find statistically significant differences between the different habitat types. The data obtained by the two different sampling methods were analysed separately and comparisons were made with a previous report completed by Armitage in 2010. Statistical analysis was carried out using the package R 2.10.

3.1 Sweep Data

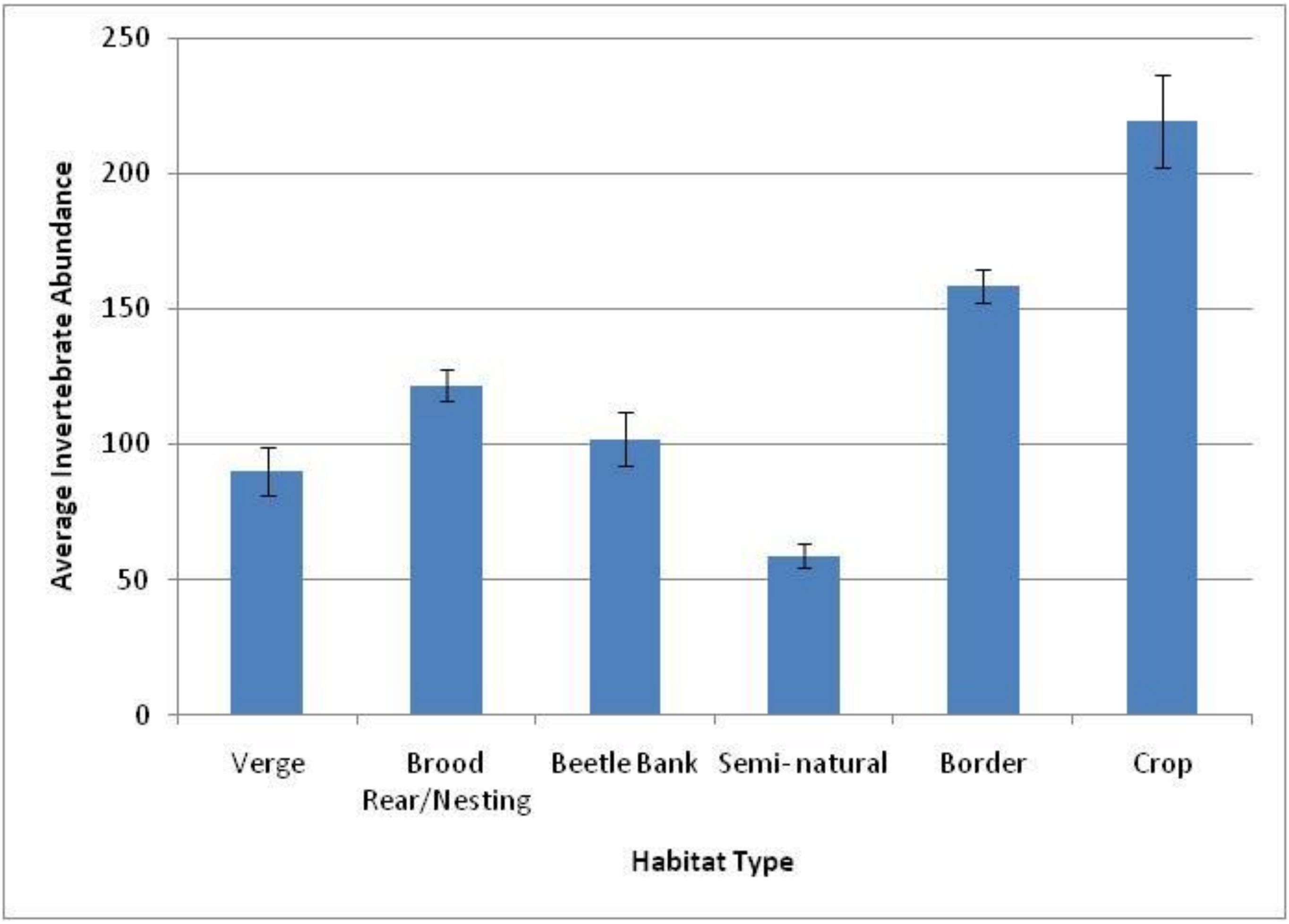

Figure 1. The average invertebrate abundance (±SE) in each habitat type determined from sweep net samples.

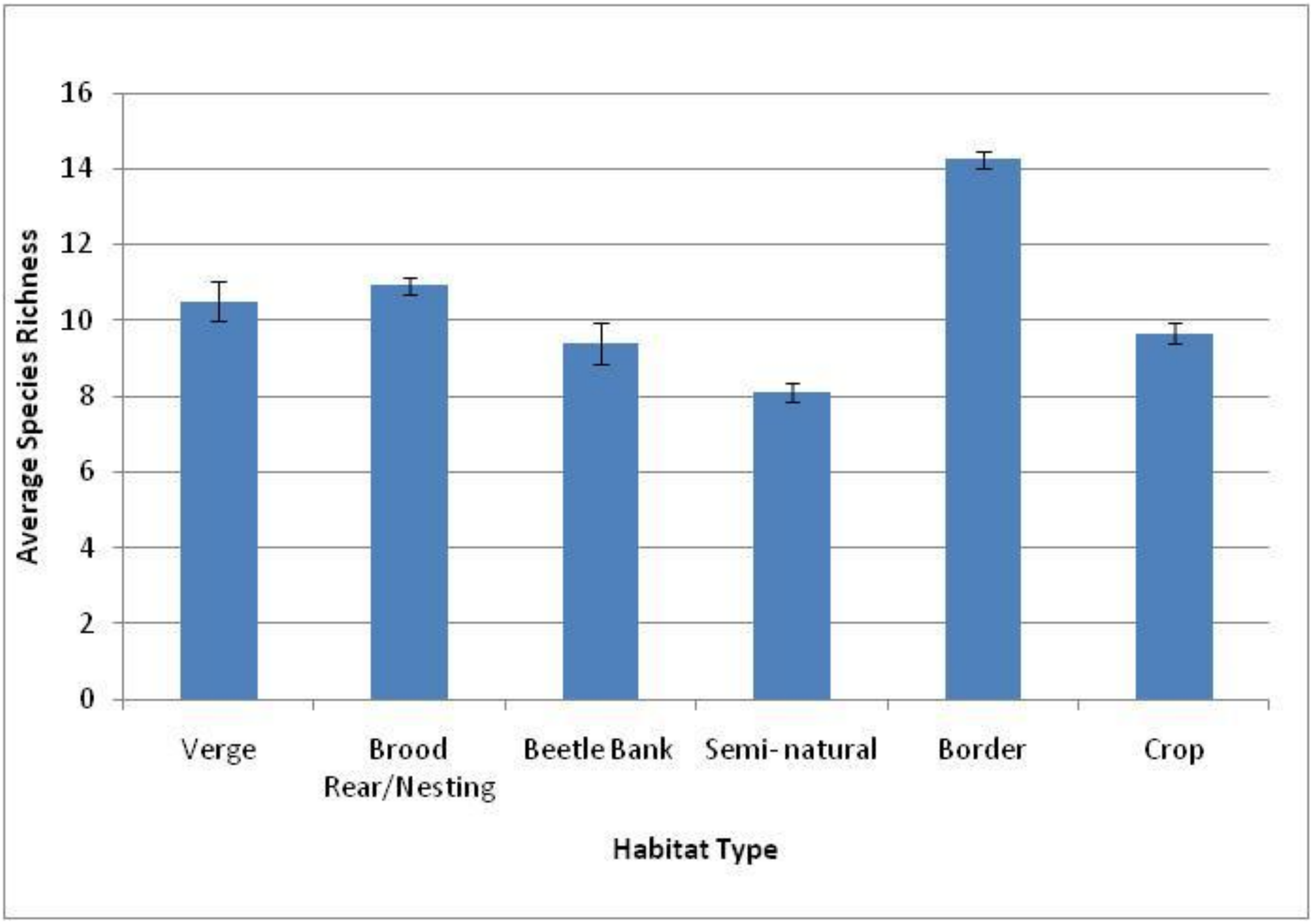

Figure 2. The average invertebrate species richness (±SE) in each habitat type determined from sweep net samples.

As seen in Fig.1. the highest average insect abundance was found amongst the crops (219.56±17.17). These were large areas of trittikale and wheat which were often fringed by a mix of brood rearing grasses such as kale, chicory and reed canary grass. These fringes were recorded as borders, and it can be seen that these borders had the second highest average insect abundance (158.5±6.36). As seen in Fig.2., in terms of species richness, these borders were the most diverse habitats with the highest average species richness of 14.25 (±0.27). This was greater than the average species richness for the crops (9.67±0.27), and may suggest that although the crops support the highest numbers of insects, that the borders may be the more preferable habitats in terms of insect diversity. Semi- natural habitats were shown to have both the lowest average invertebrate abundance (58.89±4.7) and the lowest average species richness (8.11±0.23) of all the habitat types.

As seen in Fig.1., marked differences are evident between the average insect abundances for the different habitat types. However, an Analysis of Variance was carried out in R 2.10, and it was found that significant differences in insect abundances only occurred between the semi-natural and border habitats (P<0.05), and the semi-natural and crop habitats (P<0.01).

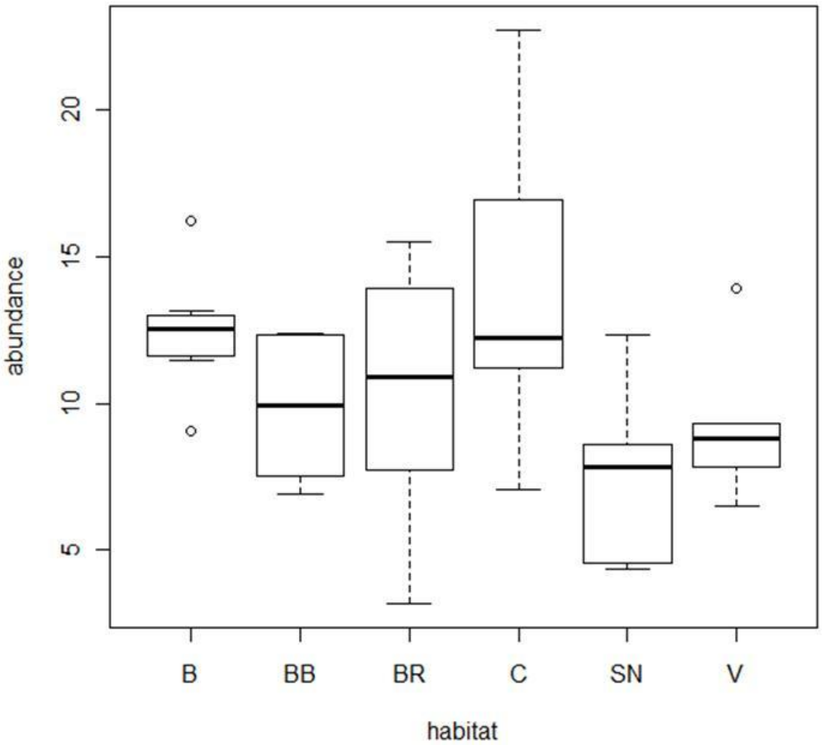

Figure 3. A boxplot illustrating invertebrate abundances in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge (V).

A similar analysis was carried out to determine if significant differences occurred between the species richness of the different habitat types. It was found that significant differences in species richness occurred between the beetle-banks and the border habitats (P<0.05), the crops and the border habitats (P<0.01), and the semi-natural and border habitats (P<0.001).

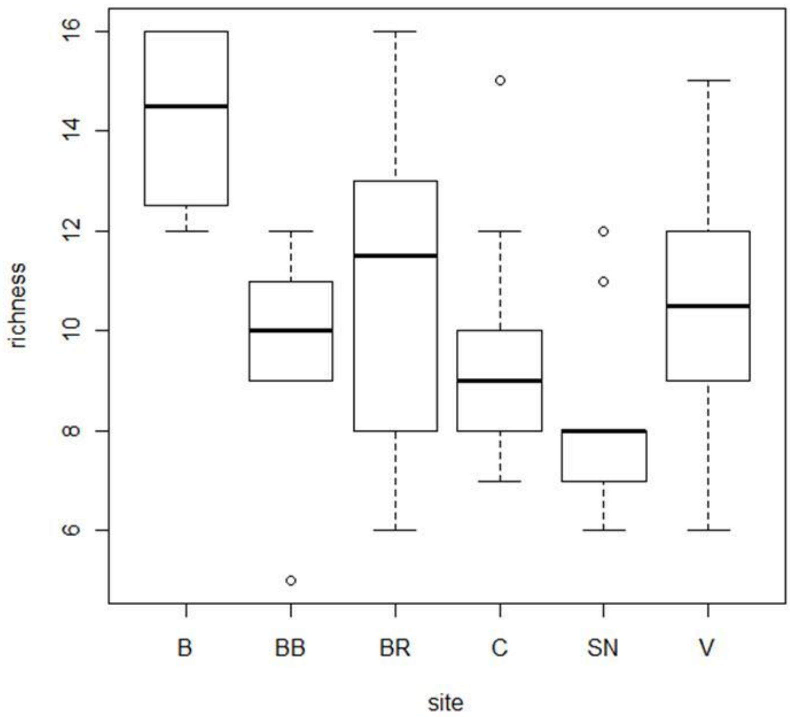

Figure 4. A boxplot illustrating invertebrate species richness in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge (V).

3.2 Dietrick- vacuum Data

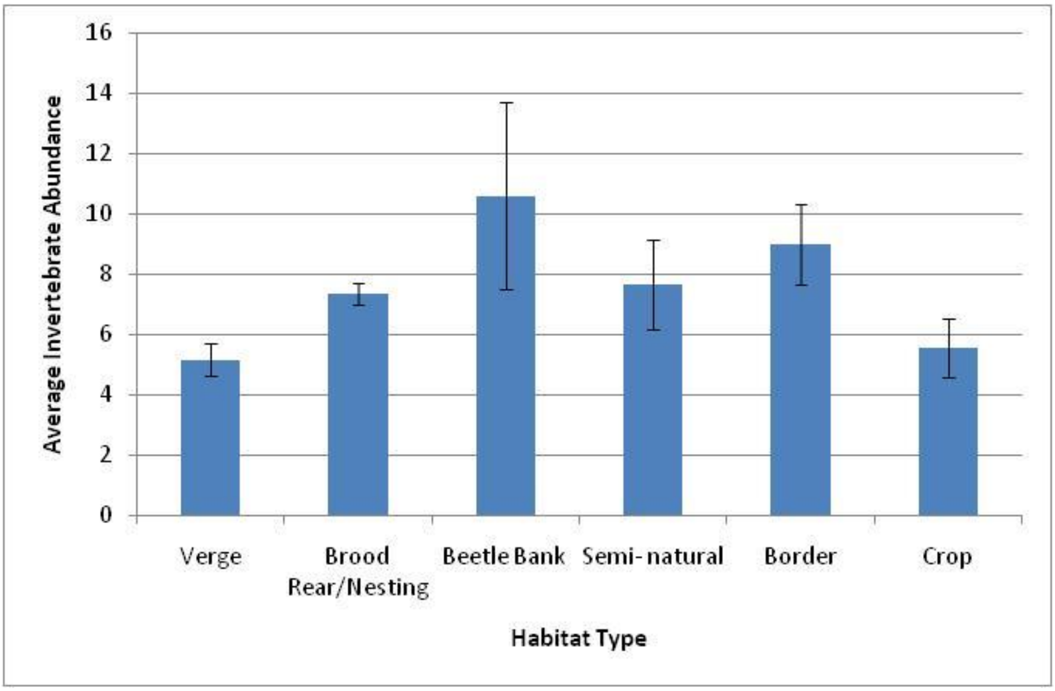

Figure 5. The average invertebrate abundance (±SE) in each habitat type determined from D-vac sampling.

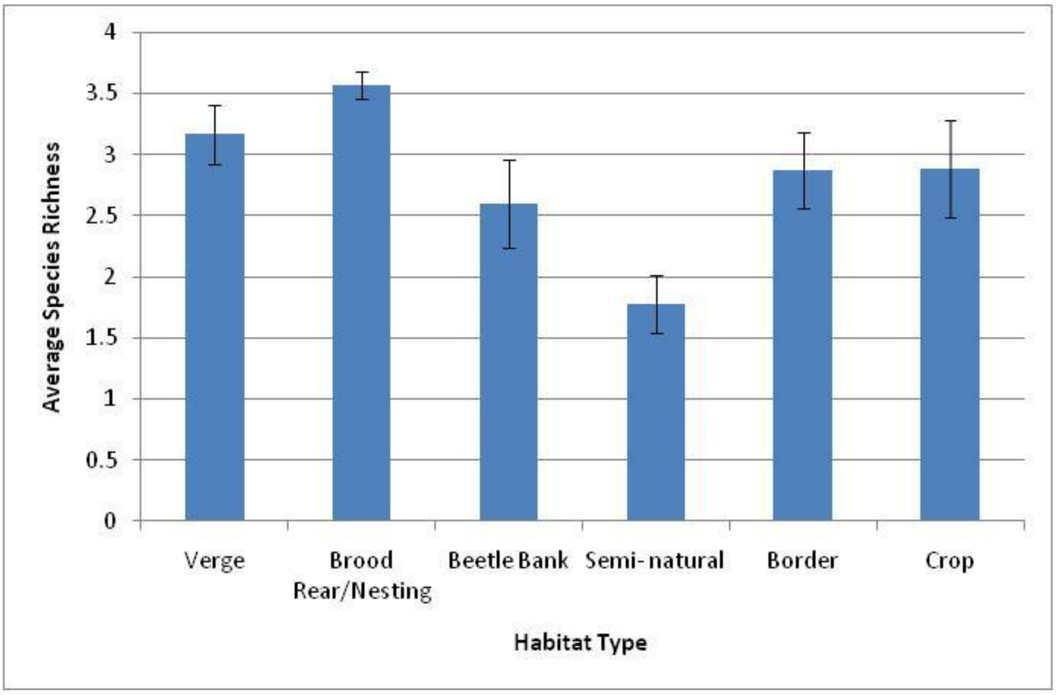

Figure 6. The average invertebrate species richness (±SE) in each habitat type determined from Dietrick Vacuum sampling.

As seen in figures 5 and 6, the number of insects sampled from the soil using the D-vac was considerably lower than the numbers of insects sampled by sweep netting. Therefore, these results will be analysed separately. It can be seen from Fig.5., that the highest average invertebrate abundance of 10.6 was found in the beetle banks, however, the standard error for this habitat were very high. Therefore, a larger sample size is needed to ensure that this trend is not being driven by one or more unusually large sub-samples. A concurrent trend is seen between border habitat for both the sweep and the D-vac data, as for both sampling methods the border areas represent the best habitat in terms of insect abundance. The brood rearing/ nesting habitat supported the highest insect diversity of any habitat by D-vac sampling at 3.57 (±0.11). As seen for the sweep data, the semi-natural habitat supported the lowest species richness (1.78±0.23) by D-vac sampling.

Kruskal Wallis analysis was used to determine whether significant differences occurred between the different habitat types each. The difference between insect abundances sampled in each habitat type was not significant (χ^2=5.43, df=5,p>0.05) (Fig.7). It was also found that no significant differences occurred in species richness between the different habitat types (χ^2=5.13,df=5,p>0.05) (Fig.8).

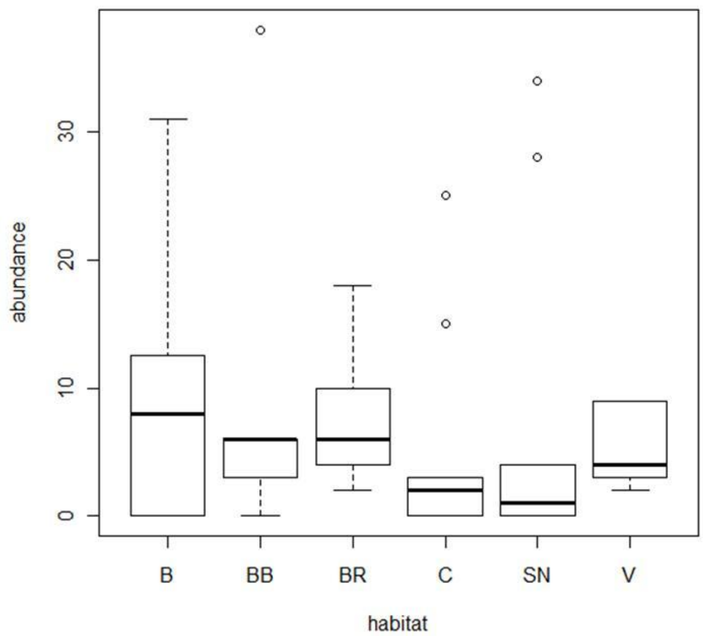

Figure 7. A boxplot illustrating invertebrate abundances in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge. (V).

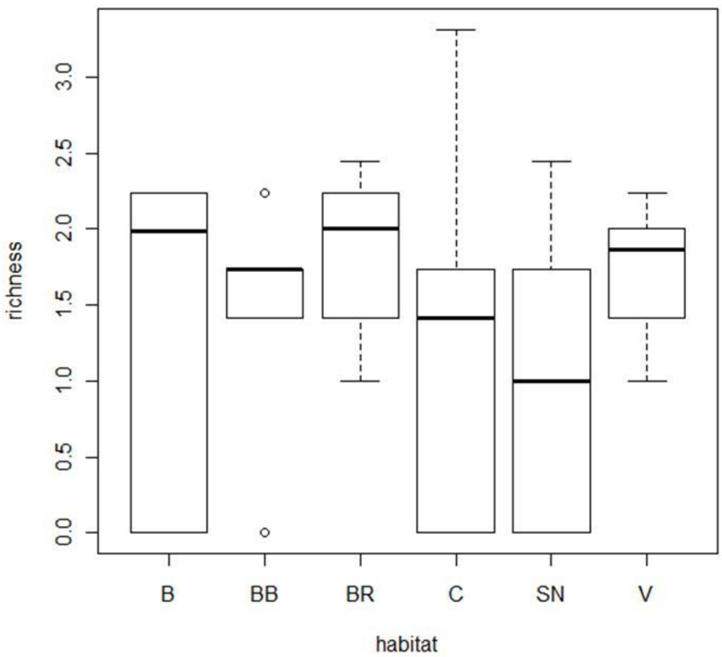

Figure 8. A boxplot illustrating invertebrate species richness in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge (V).

3.3 Taxa Analysis

Kruskal Wallis analysis was carried out on the data obtained by sweep sampling to determine whether the numbers of each insect order differed in respect to habitat type. The following results were found:

Table 1. The results of Kruskal Wallis analysis on the differences in invertebrate abundances between habitats. Both significant (S) and non-significant (NS) differences in order abundances between different habitat types were obtained.

Order	Significance	X^2	p	df
Lepidoptera (Moths)	NS	4.3385	0.5018	5
Carabidae (Beetles)	NS	6.914	0.2271	5
Hymenoptera- Symphyta (Sawfly)	NS	9.1807	0.1021	5
Homoptera (Hoppers)	NS	9.7555	0.08247	5
Araneae (Spider)	NS	7.1401	0.2104	5
Curculionidae (Weevil)	S	18.0797	0.002848	5
Heteroptera (Plant bug)	S	11.4349	0.04358	5
Aphididae (Aphid)	S	28.1541	3.40E-05	5
Staphilynidae (Rove beetle)	S	33.0037	3.76E-06	5
Diptera (Flies)	S	12.1976	0.03218	5

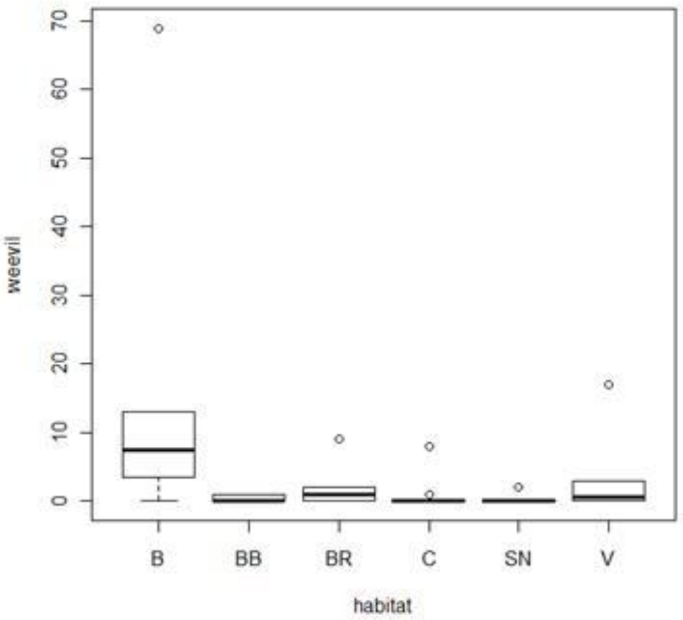

Figure 9. A boxplot illustrating weevil abundance in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge (V).

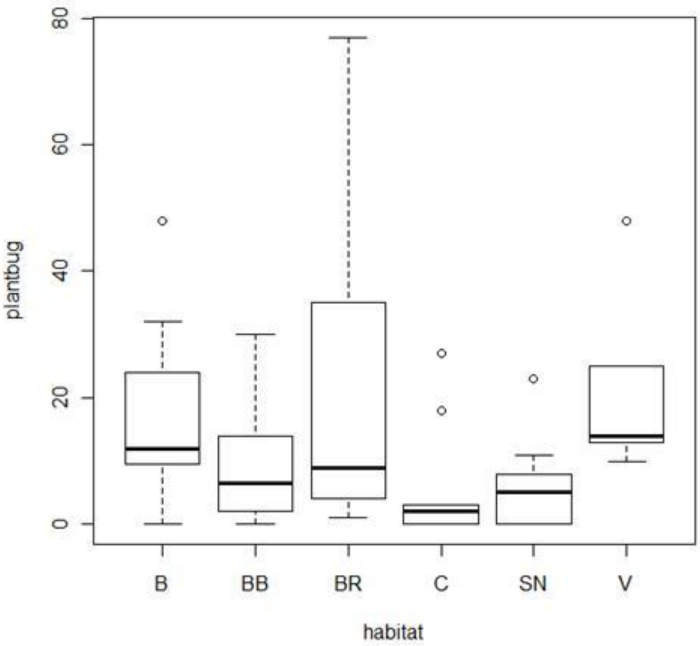

Figure 10. A boxplot illustrating plant bug abundance in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge (V).

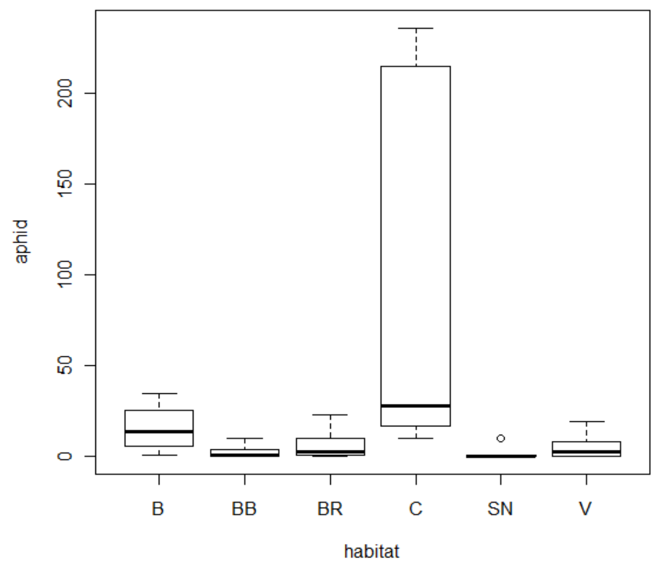

Figure 11. A boxplot illustrating aphid abundance in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge (V).

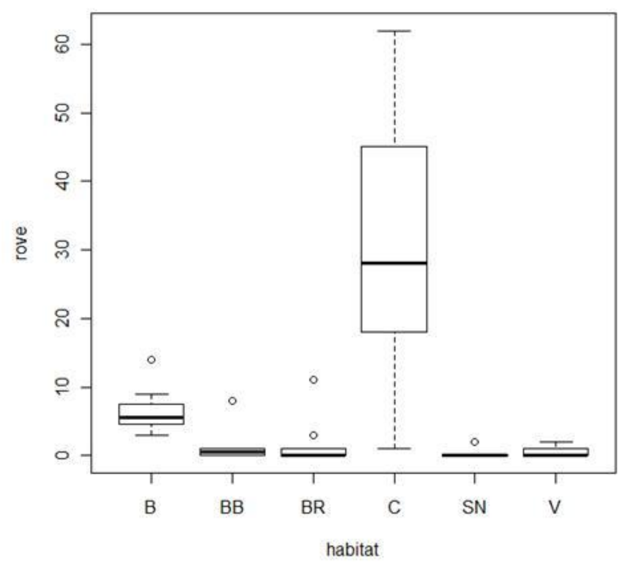

Figure 12. A boxplot illustrating rove beetle abundance in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge (V).

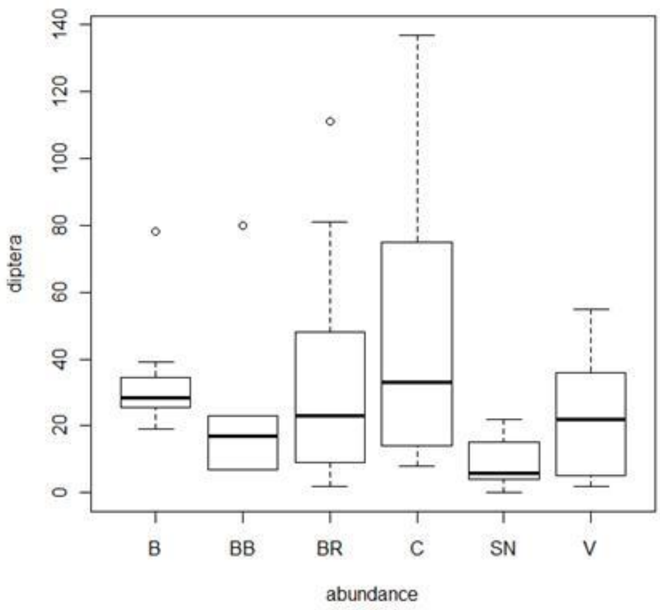

Figure 13. A boxplot illustrating diptera abundance in relation to the different habitat types for the sweep data. The habitats are border (B), beetle bank (BB), brood rearing (BR), crops (C), semi-natural (SN), and verge (V).

It can be seen from Table 1., that the number of weevils present in the different habitat types differed significantly. This is also shown in Fig.9., where it is shown that the number of weevils within the border habitats was significantly higher than in the other habitat types. Plantbug abundances also differed significantly across habitats and were significantly higher in the border, brood rearing and verge habitats than the other habitat types. This is shown in Fig.10. As seen in Figures 11 and 12, a dramatic trend was observed among aphid and rove beetle abundances, with the crops supporting significantly higher abundances than all other habitat types. The abundances of dipteral species also differed significantly between the different habitat types. As seen in Fig. 13, the borders, brood rearing areas and the crops supported the highest numbers of diptera.

3.4 Chick Food Index

The Chick food Index (CFI) was calculated using the formulae defined by Potts and Aebischer, (1991);

Chick food index = $0.141x_1 + 0.120x_2 + 0.083x_3 + 0.006x_4 + 0.0004\, x_5$

Where: x_1 = density of ground beetles (Carabidae)

x_2 = density of caterpillars (Lepidoptera) and sawfly larvae (Symphyta)

x_3 = density of leaf beetles (Chrysomelidae) and weevils (Curculionidae)

x_4 = density of plant bugs (Heteroptera) and leaf hoppers (Cicadellidae)

x_5 = density of aphids (Aphididae)

A CFI of >0.7 is the minimum necessary for an adequate diet for grey partridge chicks (Armitage, 2010).

Table 2. The Chick Food Index (CFI) results for each habitat sampled considering the Sweep samples alone. To be considered adequate for the diet of grey partridge chicks, the CFI must be above 0.7 (Armitage, 2010). Any habitat which contain a CFI below 0.7 do not contain an adequate CFI as defined by (Potts and Aebischer, 1991).

Habitat	**CFI**	**Adequate**
Verge (n=6)	0.7676	Yes
Brood Rearing/Nesting (n=14)	1.4709	Yes
Beetle Bank (n=5)	0.7503	Yes
Semi-Natural (n=9)	0.9473	Yes
Border (n=8)	3.3667	Yes
Crop (n=9)	0.6343	No

Table 3. The Chick Food Index (CFI) results for each habitat sampled considering the D-Vac samples alone. To be considered adequate for the diet of grey partridge chicks, the CFI must be above 0.7 (Armitage, 2010). Any habitat which contain a CFI below 0.7 do not contain an adequate CFI as defined by (Potts and Aebischer, 1991).

Habitat	**CFI**	**Adequate**
Verge (n=6)	0.009	No
Brood Rearing/Nesting (n=14)	0.0333	No
Beetle Bank (n=5)	0.0114	No
Semi-Natural (n=9)	0.0260	No
Border (n=8)	0.0023	No
Crop (n=9)	0.0283	No

Table 4. The Chick Food Index (CFI) results for each habitat sampled considering the Sweep and D-Vac samples together. To be considered adequate for the diet of grey partridge chicks, the CFI must be above 0.7 (Armitage, 2010.). Any habitat which contain a CFI below 0.7 do not contain an adequate CFI as defined by (Potts and Aebischer, 1991).

Habitat	**CFI**	**Adequate**
Verge (n=6)	0.7766	Yes
Brood Rearing/Nesting (n=14)	1.5042	Yes
Beetle Bank (n=5)	0.7617	Yes
Semi-Natural (n=9)	0.9733	Yes
Border (n=8)	3.369	Yes
Crop (n=9)	0.6626	No

Table 5. Chick Food Index (CFI) for each of the sample areas, the “Marl Square” and the “New Area” considering the Sweep and D-Vac methods alone and pooled.

Square	**CFI**	**New Area**	**CFI**
Sweep	1.2166	Sweep	1.5840
D-Vac	0.0226	D-Vac	0.0174
D-Vac + Sweep	1.2391	D-Vac + Sweep	1.6014

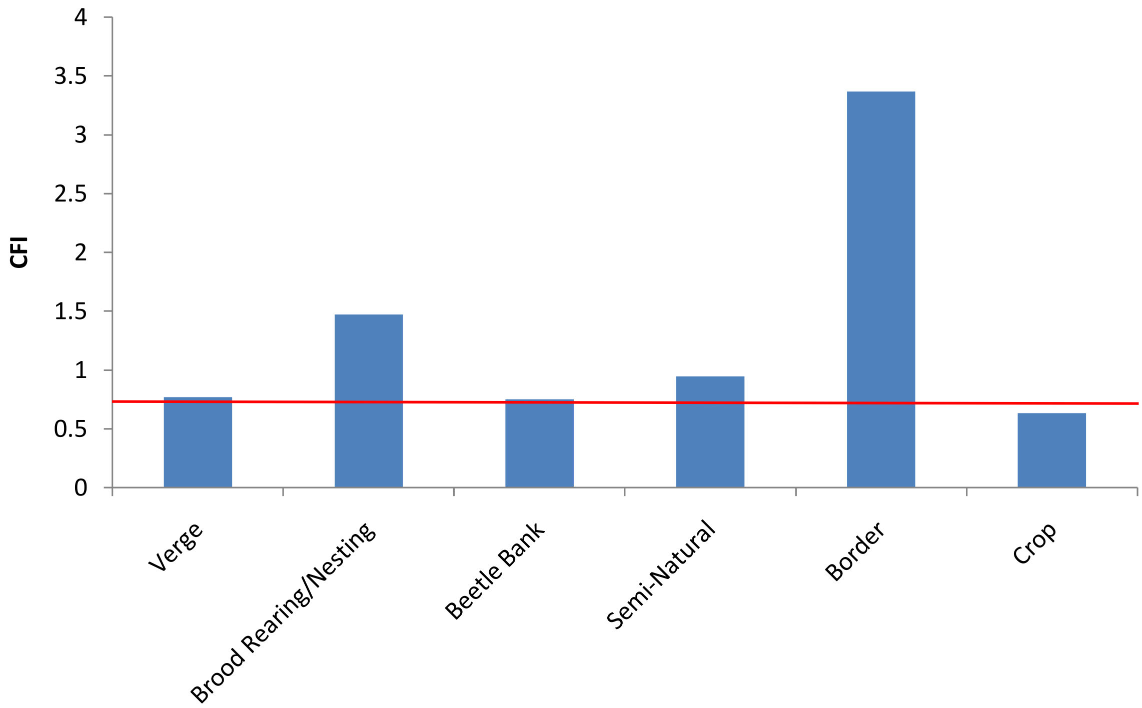

Figure 14. The Chick Food Index (CFI) results for each habitat sampled considering the Sweep samples alone. The horizontal axis contains the various habitats sampled. The red line represents minimum CFI necessary for an adequate diet for grey partridge chicks (0.7). Any sites which contain a CFI below the line do not contain an adequate CFI as defined by (Potts and Aebischer, 1991).

It is clear from Figure 14. and Table 2. which contain only the Sweep net samples, that the Border habitat has a much higher CFI (3.3667) than any of the other habitats sampled. The Brood Rearing/Nesting habitat is ranked second to this with a CFI of 1.4709 which is comfortably above the minimum CFI necessary for adequate diet for grey partridge chicks (0.7) as does the Semi-Natural habitat (CFI of 0.9473). The Verge and the beetle bank CFI are above the minimum necessary for adequate diet for grey partridge chicks, however just slightly (0.7676 and 0.7503 respectively). The Crop habitat (0.6343) lies below the minimum necessary CFI.

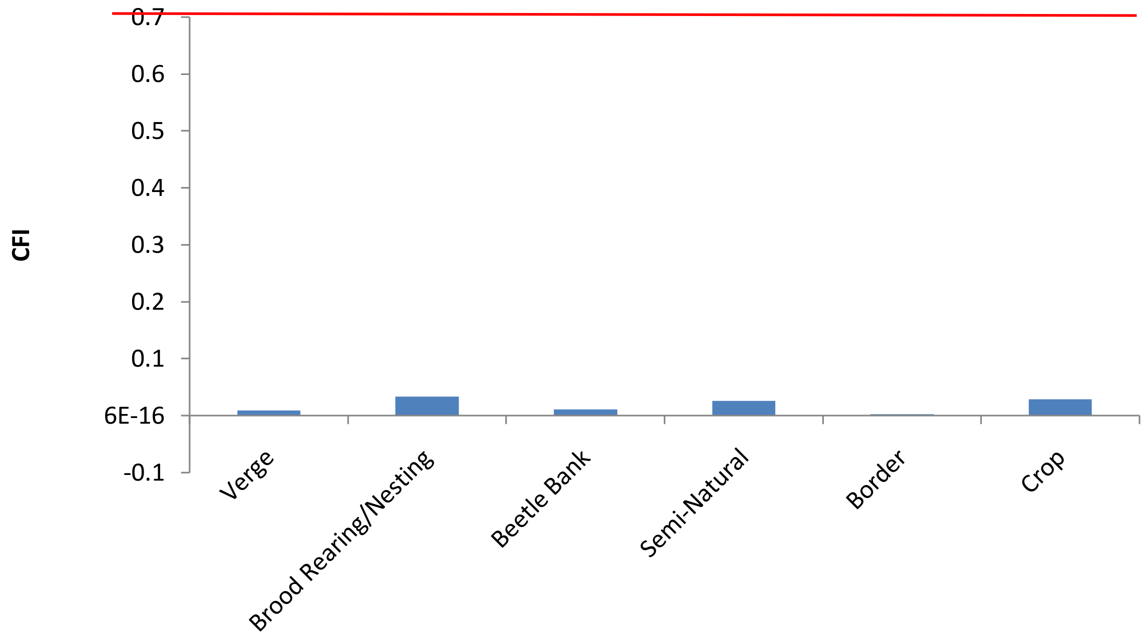

Figure 15. The Chick Food Index (CFI) results for each habitat sampled considering the D-Vac samples alone. The horizontal axis contains the various habitats sampled. The red line represents minimum CFI necessary for an adequate diet for grey partridge chicks (0.7). Any sites which contain a CFI below the line do not contain an adequate CFI as defined by (Potts and Aebischer, 1991).

Evidently the CFI results obtained from the D-vac samples alone are well below the minimum necessary for adequate diet for grey partridge chicks (Figure 15; Table 3). The border habitat has the lowest CFI (0.0023) of each of the habitats sampled; this is in contrast to the findings using the sweep net samples alone.

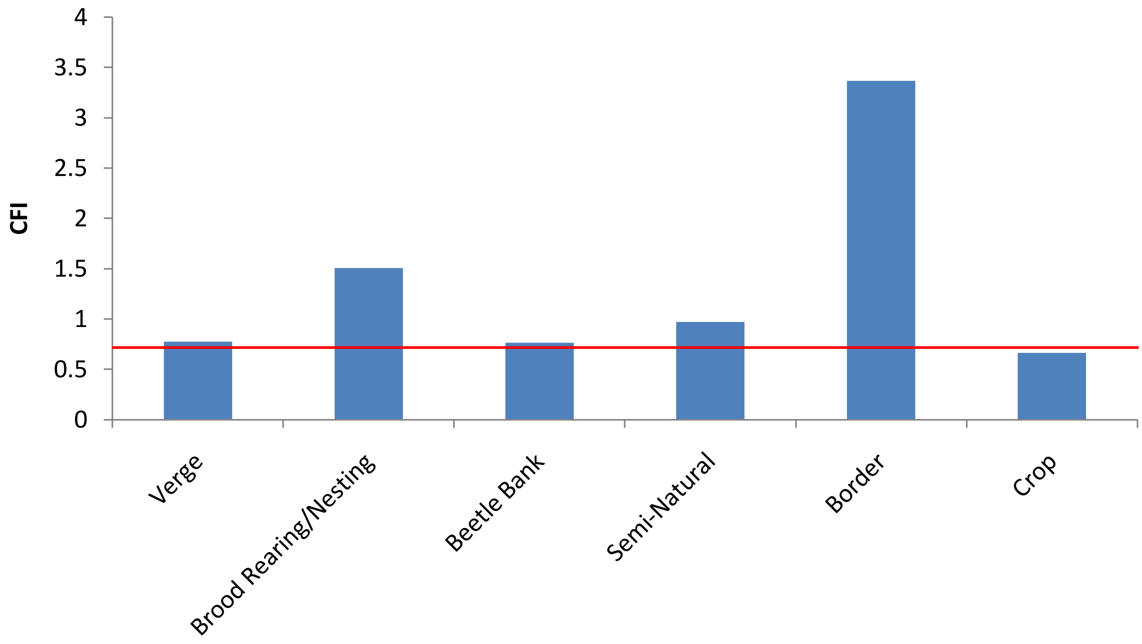

Figure 16. The Chick Food Index (CFI) results for each habitat sampled considering the D-Vac and Sweep samples together. The horizontal axis contains the various habitats sampled. The red line represents minimum CFI necessary for an adequate diet for grey partridge chicks (0.7). Any sites which contain a CFI below the line do not contain an adequate CFI as defined by (Potts and Aebischer, 1991).

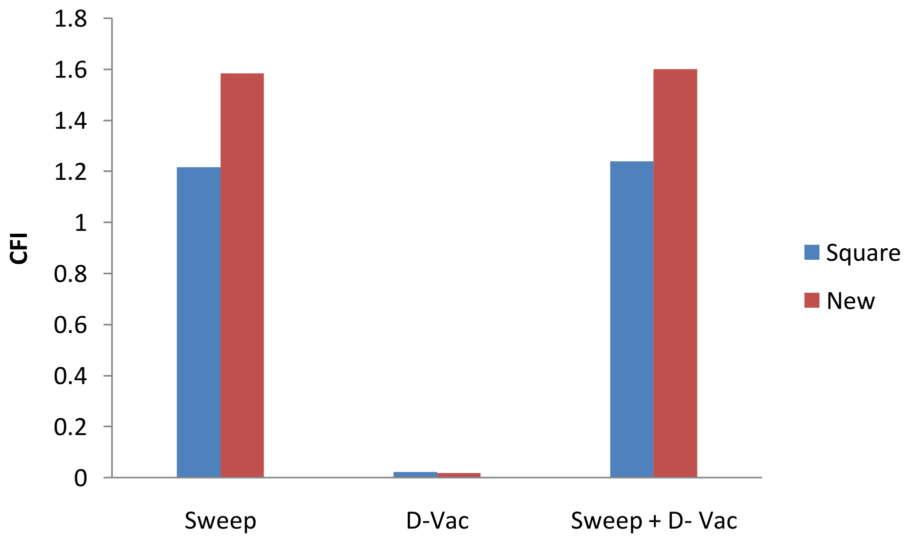

Figure 17. Chick Food Index (CFI) for each of the sample areas, the "Marl Square" and the "New Area" considering the Sweep and D-Vac methods alone and pooled.

Due to the low CFI values obtained from the D-vac samples, the pooled results (D-V and Sweep) show the same pattern as the sweep samples alone (Figures 14, 16, Tables 2, 4).

Figure 17 and Table 5 illustrate that the Chick Food Index (CFI) was higher in the "New Area" than was found in the "Marl Square" considering the Sweep method alone and the pooled methods including the Sweep and D-Vac. The "Marl Square" had a higher CFI than the "New Area" when the D-Vac sampling Method was used.

4. Discussion

Weather

June 2010 was described by Met Eireann as another dry month continuing a spell of relatively dry weather everywhere, as shown in Fig.18. Monthly rainfall totals were very low making it the driest June since 1941 at Malin Head (www-2). Mean monthly air temperatures were between one and two degrees higher than normal and it was the warmest June for 40 years at Mullingar Airport (www-2).

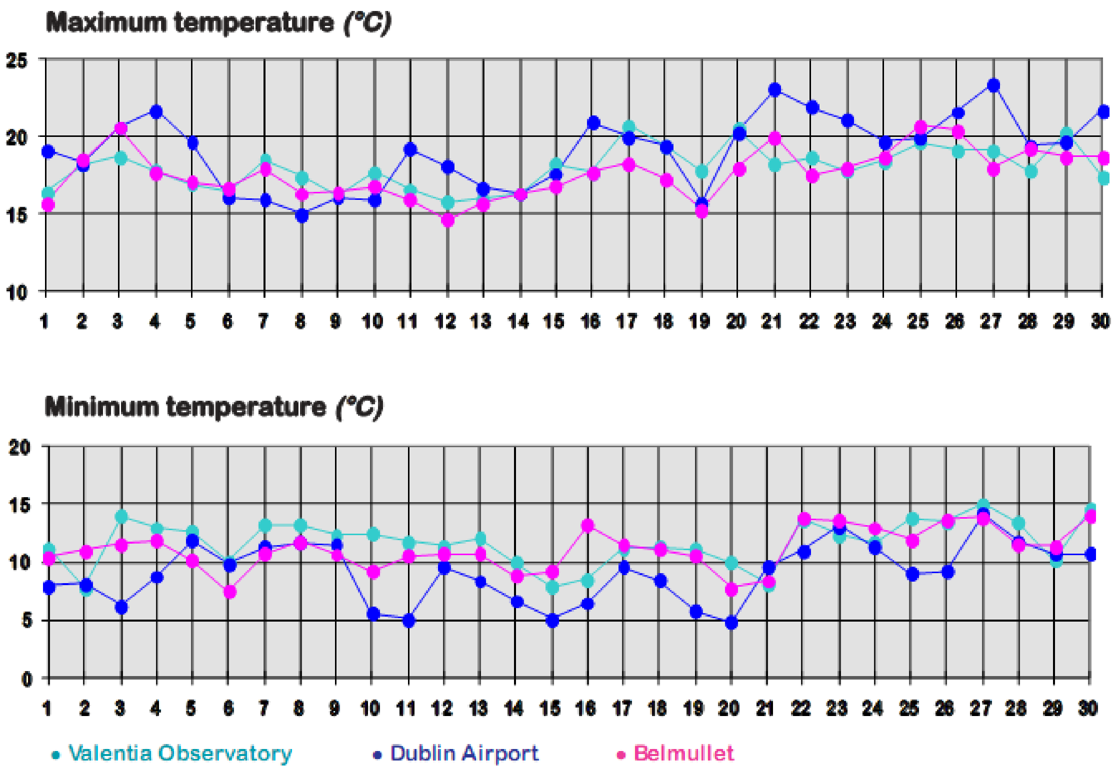

Figure 18. The maximum and minimum air temperature recorded for June 2010 at Valentia Observatory, Dublin Airport and Belmullet (www-2).

The invertebrate sampling was carried out during June and therefore, the results must be discussed with respect to these unusually good weather conditions. Insect activity is directly related to air temperature and it is very likely that dry weather promotes invertebrate abundance. This contrasts the conditions that the previous report by Armitage (2010) encountered. In June 2008, the rainfall recorded was at least 50% higher than normal, making it the wettest the wettest summer ever recorded (June, July and August are used as the summer months by Met Eireann and records for Birr go back 55 years) (Armitage, 2010).

Food Preference

There is a well proven link between invertebrate abundance and grey partridge chick survival (Potts & Aebischer, 1991). As partridge chicks are so reliant on an insect diet during their early lives, it seems reasonable to assume that chick survival should be influenced both by invertebrate abundance and invertebrate species richness. In fact, studies have shown that newly hatched chicks are particularly vulnerable to chilling, and that resistance to chilling is correlated with weight and not with age (Southwood & Cross, 2002). The high protein content of insects is essential to maintain a vigorous growth rate, and the availability of insects is, therefore, integral to the survival of partridge chicks. A paper produced in 1967 outlined the key mortality in a partridge population to be that of the young chicks (Blank *et al.*, 1967). As insect availability is directly correlated with vegetation type, it is integral to the success of the project that a prescription is identified which provides ample insect availability for growing partridge chicks. This prescription could then be applied to surrounding farmlands, allowing the dispersal of the species throughout the study area, and ideally throughout Ireland.

A knowledge of the invertebrate diet of the chicks of many farmland bird species as it can help in their habitat management and conservation including the selection and design of appropriate habitats that maximise food supplies and improve survival. A study carried out by Moreby et al (2006) found that with no movement of invertebrate prey, chicks food choice was influenced mainly by size and colour. When colour of similar sized prey was considered, it was discovered that the chicks showed a preference for green/yellow over black/brown and red was least selected. When moving invertebrate prey was considered, colour and size had the greatest effect on choice. This study also found that in natural habitats, the chicks showed a preference for larger colours and it was noticed that immobile green/yellow prey items may be more difficult to see if cryptically coloured. Further to this, another important factor to note is that some desirable prey items may be located high on the vegetation and thus physically unavailable, restricting food choice to smaller, less preferred food items.

However, this situation describes the ideal habitat where both insect abundance and diversity is high. This situation is in fact, very rare and it much more likely that if partridges extend their range into surrounding farmlands, that they will be exposed to a much reduced prey availability. A partridge chick may need to consume all available prey species, in arable cereal crops (Moreby *et al.*, 2006). This situation may be intensified by the use of pesticides.

According to Moreby *et al.*, 2006, generally chicks' diets from modern intensively managed arable land are diverse, showing an opportunistic foraging strategy.

Habitat

On analysis of the sweep net data, it was seen that different habitats supported significantly different abundances of the insect orders. This suggests that habitat alteration and management makes a significant impact on the invertebrate community of the conservation area, and therefore, it is a key process affecting the breeding success and survival of partridge populations. The planning and maintenance of the habitats within the conservation area is vital to the continuation of the Irish partridge population. It can be seen that the most successful habitat type in relation to chick survival was the border areas. These are mixed grass borders containing vegetation such as chicory, reed canary grass and kale. The border strips surround crops such as wheat and triticale. These borders are approximately 3 metres wide and support the highest number of invertebrate species of any habitat type. The border areas also contained the second highest invertebrate abundance of all the areas. It can be seen from the results of the Chick Food Index that neither abundance nor species richness alone can be used to identify a suitable habitat for grey partridge chicks. Although the crops contained the highest abundance of insects, the diversity within these crops was very low, with aphids and diptera dominating the invertebrate community. Although the crop environment may contribute to the diversity and abundance of the surrounding borders, the crops alone are not conducive to the survival of grey partridge chicks.

Chick Food Index

The Chick Food Index (Potts and Aebischer, 1991) calculated here considers only a subset of the insects found in the habitats sampled.

The CFI obtained from each habitat were above the minimum necessary for an adequate diet for grey partridge chicks (0.7) in all areas apart from the Crop. The highest CFI was recorded in the Border habitat where a score of 3.369 was recorded. This was followed by the Brood Rearing/Nesting habitat (1.5042). The Beetle Bank and Verges showed a low CFI (0.7617 and 0.7766), this result is perhaps of concern as the score lies close to the minimum necessary for an adequate diet for grey partridge chicks and perhaps, given a more unfavourable summer for insect survival, the CFI may drop below adequacy levels. This is further good reason for annual assessment. An interesting finding is that the Semi-Natural habitat has a relatively high CFI (0.9733) indicating that little land management may result in adequate numbers of the appropriate insects for the grey partridge chicks' diet.

A Chick Food Index (CFI) comparison between the New area and the Marl Square considering the D-Vac method of sampling showed the CFI to be higher in the Square than the New Area though this difference was low (0.0052). However when the sweep method of sampling and the Sweep and D-Vac methods combined were considered, the New area showed a higher CFI than was found in the Marl Square (0.3674 and 0.3623 respectively).

The Armitage report (2010) found insect abundance to be higher in the Square but the CFI was not considered. However, CFI in this report was considered to be of higher importance.

5. Conclusion

In response to our initial aims;

- The insects were found to be most abundant in the Crop and least abundant in the Semi-natural.
- Species richness was found to be highest in the border and lowest in Semi-natural habitats.
- The highest Chick Food Index was found within the Borders, all apart from one habitat (Crop) sampled contained a CFI above the minimum necessary for an adequate diet for grey partridge chicks, though these varied in magnitude amongst habitats.

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