Biodiversity of some of the invertebrate taxa occurring in terrestrial habitats in different types of Irish peatlands

By

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Summary

Irish peatlands have, in recent years, been recognised as important both from a national and an international perspective. They are, however, subject to continuing destruction due to afforestation, harvesting (both on a small scale and industrially), reclamation for grassland and damage done by grazing of livestock. Irish peatlands are now included in the Irish Habitats Directive and thus the Irish government is under obligation to protect these rich and biodiverse habitats.

The research undertaken in this study was part of a multi-disciplinary project entitled BOGLAND funded by the EPA. BOGLAND's aim review and synthesise current information on social, economic, environmental and institutional aspects of peatland utilisation and management, research was conducted in areas where knowledge gaps had been identified, and the overall aim was to develop a protocol for the sustainable management of peatlands in Ireland. This project was in the biodiversity workpackage of the BOGLAND project. The specific aim of this project was to investigate the terrestrial invertebrate communities of four peatland types. This was designed to provide baseline data of four terrestrial taxa, mites (Acari), spiders (Araneae) ground beetles (Carabidae) and Enchytraeidae. Particular attention was paid to these taxa because they are known to have significant functional roles in these ecosystems. Sampling of these different peatland types was undertaken in 2006 on the twelve core BOGLAND biodiversity sites and additional sites were sampled in 2007 based on results

obtained in the initial survey. In 2007 only the ground beetles and spiders were sampled and finally in 2009 the Enchytraeidae were sampled on the core BOGLAND sites.

This study shows that there is little specific peatland invertebrate diversity but that the diversity of mites and spiders is high. The diversity of ground beetles and Enchytraeidae were low, although in the case of the ground beetles species such as *Carabus clatratus* and *Carabus nitens* are more abundant on peatland habitats and are deemed as rare species in a European context and thus warrant attention. It was found that disturbance not only changes the species composition of some of these groups but also increases the diversity significantly. However, this habitat fragmentation can lead to loss of some characteristic peatland species. Potential habitat specialists or indicators were identified for some of the taxa studied.

Particular attention was paid to the mites, and the species assemblages on peatlands were shown to differ from those in other Irish habitats but to be broadly similar to the fauna found in similar habitats in the United Kingdom.

Declaration

I hereby declare that I am the sole author of this thesis. I confirm that this work reported here is the original and that the material submitted in this thesis has not already been published in part or in whole for any other degree or qualifications.

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Rachel Wisdom

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1. Introduction

1.1 Peatlands

Peatlands cover approximately 3% of the world's land surface (IPCC - Irish Peatland Conservation Council 1992) and, because of the role of climate in their formation, they occur mainly in the temperate, boreal and sub arctic areas of the Northern hemisphere with approximately seventy percent of the world's peatlands occurring in Russia and Canada. They are found in the Southern hemisphere but to a much lesser extent. It is estimated that ten percent of the British Isles are covered by peatlands and this represents 0.7 % of the world's total (Clymo 1987). Peatlands can be found in tropical and subtropical zones but these peatlands are restricted to sites along the coast and in mountainous areas where the climatic conditions are suitable for peat formation i.e. wet and humid (Doyle and Ó Criodáin 2003). Peatland is a term used to describe peat-covered areas; there is generally a minimum depth requirement for the classification of a site to be a peatland. In Canada the depth is 40cm (National Wetlands Working Group 1997) but the International Mire Conservation group give the figure as 30cm (Joosten and Clarke 2002).

Peat is a biogenic deposit that developed in the Holocene, i.e. within the last 10,000 years (Hammond 1979) and can contain more than ninety percent organic matter. The depth of peat varies greatly; it can be as little as 10cm or up to 10m (Clymo 1987). Under certain conditions organic matter accumulates annually as peat, which over time give deposits which can be of great depth (Doyle and Ó Criodáin 2003). They are an accumulation of waterlogged plant organic matter with a top layer of living plants. The accumulation occurs in areas where the rate of the production of plant matter significantly exceeds the rate of decomposition (Foss 1987). The reduced rates of decomposition are due to the presence of waterlogging. Under such conditions low concentrations of oxygen hinder the growth of primary decomposers, i.e. bacteria and fungi. The formation of peat is therefore dependent on the presence of a high water table and on other factors such as, climate, topography, hydrology, geology and hydrogeology. Differences among these factors give rise to differences in the distribution of peatlands (AGMET - Applied Agricultural Meteorology 1994). As peat accumulates it gives rise to more acid and nutrient poor conditions, this is due to the decrease in the access to cations that were present in the mineral soil. Organic matter has a high cation exchange capacity (CEC), this means that it takes up cations in exchange for hydrogen ions. The result is that mainly cations are adsorbed on the peat particles and thus only a minor part is free in solution (Rydin and Jeglum 2008).

The accumulation of peat is also affected by the chemical and structural composition of the plant material and its ability to decay and therefore some plants accumulate as peat more readily than others. For example, plants with low concentrations of nitrogen in their tissues, typically less than 1% of dry mass, inhibits the decomposition of plant material (Feehan and O'Donovan 1996). The main types of vegetation responsible for peat formation are sedges, grasses, *Sphagnum* and other mosses, and some woody plants (Joosten and Clarke 2002).

There are a number of different types of peatland, which are classified depending on where and how they receive water. Some peatlands depend on precipitation (bogs) whereas others get water from mineral sources (fens). While peatlands are often referred to as mires in other countries (Clymo 1987), the term bog is used to describe peatlands that have a high water table and are poor in nutrients; they are always acidic and dominated by *Sphagnum* mosses (Spitzer and Danks 2006).

1.1.1 Peatlands and global change

The role of peatlands as a carbon sink has been recognised as important in relation to climate change (Fenner, Freeman and Reynolds 2005). They represent a huge reservoir of carbon and contain a greater mass of carbon than all the world's trees (Feehan and O'Donovan 1996). It is estimated that the peatlands in northern latitudes contain approximately 30 percent of the world's store of terrestrial carbon. As climate change becomes a more widely recognised phenomenon there is concern about the stability of peatland soils because destabilisation of these ecosystems, due to global warming, would result in significant losses of carbon to the atmosphere (Ineson *et al.* 1995). Drainage and the destruction of peatlands results in a rapid loss of greenhouse gases, such as methane and carbon dioxide, to the atmosphere (Foss 1996). It is becoming increasingly important to limit the release of these gases if the effects of global warming and the extent of climate change are to be controlled. In a recent article in the *New Scientist* there was concern over the melting of west Siberian peatlands as they have the potential to release billions of tonnes of methane (Pearce 2005). Dissolved organic carbon (DOC) is one of the main losses of carbon from these ecosystems; this is because DOC is important as an energy source for microbial metabolism. The effect of global change on peatlands will be largely abiotic and will have an effect on the depth of groundwater tables and the redox reaction that will thus result (Scott *et al*. 1998). Warming of peatland soils through climate change may increase the biological activity in the soil. The increased biological activity will result in further release of carbon dioxide to the atmosphere and thus "feeding" climate change further (Cole *et al.* 2002). The mean global temperature has increased by 0.6ºC over the last 200 years (IPCC 1996). This is linked to the increase of greenhouse gases in the atmosphere largely due to the combustion of fossil fuels such as oil, peat and coal. The overall concentration of CO_2 has increased by 30%. It has been found that they are closely related to temperature in peat and to the position of the water table (Wilson *et al.* 2006).

Globally peatlands have been exploited for many centuries. Peat was used primarily as a fuel but peatlands have also been used for agriculture and forestry. Other threats include, sheep grazing, erosion, development, damage from tourism, using areas of peatland as landfill and setting up wind farms within a peat system (Renou 2006). Presently interest in Ireland is focusing on the restoration and conservation of remaining peatlands; the peat industry has become increasingly concerned about the damage to peatlands and thus has been an integral part in providing protection for them (Gorham and Rochefort 2003).

1.1.2 Peatlands as a multifunctional resource

The conservation of peatlands is important on a global scale as they are very important in an ecological, educational and historical context and thus are an essential part of our national and natural heritage (Doyle 1990). Apart from their importance as stores of carbon, the necessity to conserve peatlands arises because plants and animals occurring on peatlands have adapted to extreme environments and are thus unique to peatlands (Doyle and Ó Criodáin 2003). It is essential that these characteristic plants and animals be retained for future generations. Peatlands are a vulnerable ecosystem, this has been recognised by the international Ramsar Convention which is an intergovernmental treaty designed to increase activity among different nations and gain international cocoperation in the protection and conservation of all wetlands including peatlands (Spitzer and Danks 2006). They have a different meaning for different people, to a conservationist it may be described as one of the most important ecosystems on the planet, others may see it as carbon store. Due to reduced rates of decomposition in the peatlands they are important sources of historical information and a number of items including bog butter and bog bodies e.g. Tollund man and old Croghan man) have been recovered. The bodies found are approximately 2,300 years old. Peatlands are a reservoir of biodiversity, there are an abundant source of plants and animals, many of which are unique to peatland ecosystems, it is essential that a protocol be designed for the sustainable management of peatlands in order to protect these ecosystems for future generations (Renou 2006). This protocol needs a multi-disciplinary approach, using information that is currently available and then building on this pool of knowledge by active research to produce guidelines for sustainable and wise use of peatlands.

1.2 Ireland and Peatlands

Peatlands occupy 16.2 % of the land surface of the island of Ireland, i.e. 1.34 million hectares, and in the Republic of Ireland, they cover 17.2 % of the total land surface (Hammond 1979; Taylor 1983). This is a higher proportion than in any other European country with the exception of Finland (AGMET 1994). The majority of the bogs in Ireland are blanket bogs, they represent 774,990 hectares, the next most abundant is raised bog with 311,300 hectares and then lastly fen with 92,508 hectares (Foss 1996).

The peatlands of Ireland form an important part of the Irish landscape; they are habitats for a wide range of diverse plants and animals but man has modified much of the peatland ecosystems in Ireland to some degree. Peatland conservation is a high priority in Ireland and a lot of activities have been undertaken by the National Parks and Wildlife Service (NPWS) and the Irish Peatland Conservation

Campaign (IPCC) to protect this natural Irish heritage (AGMET 1994). They originally covered 16% of the Irish landscape but now, due to peat extraction, drainage, forestry and agriculture, only 18% of the original amount is intact (Foss 1996). Because of the huge loss of raised peatland across the continent, the raised bogs in Ireland may be the most important remaining in Europe. It is therefore essential that the remaining raised peatlands be conserved as part of a national and international obligation. Ireland is also a very important country for blanket bog. Ireland has approximately 8% of the world's blanket bog and has the greatest of this amount of habitat in Europe (Foss 1996).

In Ireland peatland is placed into three broad categories, raised bogs; found mainly in the central lowlands of Ireland with some very small areas also occurring in the south-west of the country (NPWS 2008), blanket bogs of the Western seaboard and the upland regions, and fen peats. Raised and blanket bogs are known as ombrogenous mires where their development is promoted by atmospheric precipitation, fen peats are known as topogenous mires the development of this type of peat is under the control of topography and the ground water table (Hammond 1979). Because raised and blanket bogs only receive water from rainfall these peatlands are generally acidic and poor in minerals. Fens receive their water from groundwater sources, which are generally calcium-rich and thus have a neutral or slightly alkaline pH (AGMET 1994).

1.2.1 Peatland types in Ireland

1.2.1.1 Fen Peat

Fen is a peat-forming sub-aquatic soil that is equally likely to be poor or rich in nutrients. There are three types of fen: open water transitional (lake-edge) fens, floodplain fen (callows) and eutrophic valley mires. There are few valley mires in Ireland but the other two types occur in several locations. Fens can occur in upland areas, for example there are stretches of fen present in county Wicklow (Reynolds 1998). Fen peats can be found in river valleys, areas of impeded drainage such as basins or hollows, and can also be located beside lake margins or floodplains. Flushes are similar to fens in that they are fed from leachate. Flushes are not necessarily peat-forming. The main difference between flushes and fens is in the vegetation, which reflect the increased amounts of nutrients in flush. Fens and flushes are categorised depending on where and how they receive their water supply (Fossit 2000). Rich fens are alkaline and are found in areas that have lime-rich soils. Poor fens and flushes on the other hand have a low pH and are not found solely in calcareous areas (Doyle 2003).

Fen peat formed approximately 10,000 years ago, which was at the end of the last glaciation. Much of central Ireland was covered by lakes, which arose due to the melting ice at this time. These lakes had deposits containing lake marl that were overlain by clay and glacial drift, and they received nutrients from mineral-rich groundwater. The edges of these lakes contained vegetation such as reeds and sedges, which died and the remains fell into the water where they were only partially decomposed. This lead to the formation of peat on the bed of the lake. Over time this continuous deposition resulted in the formation of fen peat (Foss 1987). Examples of fens in Ireland are found at Pollardstown Fen and on the south side of the Carlingford Peninsula (Reynolds 1998).

Because of the way a fen receives its water supply and the water source being much less acidic than bog, fens are a more favourable site for the growth of vegetation. The vegetation of a fen is dominated by sedges *Carex* species (sedges) and rushes *Juncus* species (rushes) the most often spotted are, *C. aquatilis* (the water sedge), *C. curta* (white sedge), *C. diandra* (lesser tussock sedge), *C. dioica* (dioecious sedge), *C. echinata* (star sedge), *C. lasiocarpa* (slender sedge), *C. magellanica* (tall bog sedge), *C. nigra* (common sedge) *C. viridula* (long stalked yellow sedge). Rushes are the other most important type of vegetation found on fens, the important rushes are; *Juncus articulatus* (jointed rush), *J. effusus* (soft rush) *J. subnodulosus* (blunt flowered rush). The black bog rush (*Schoenus nigricans*) is also an important rush of certain fen types. Grasses are not important on fens but they do contain a few, such as, *Agrostis stolonifera* (creeping bent) and *Molinia caerulea* (Doyle and Ó'Criodáin 2003).

The nutrients received by fens come from groundwater that circulates and filters through the peat. Fens are alkaline having a pH of 7-8 (Foss 1996). Minerotrophic peatlands are described as having a plentiful supply of water that is rich in minerals, a pH that is close to neutral and a peat depth that is relatively shallow, about 0.3 - 1.8m (Erman and Erman, 1975). Fens that are undisturbed are rare in Ireland, this is especially the case in the midlands, and the greatest threat to these fens is drainage for agricultural development (Hammond 1979).

1.2.1.2 Raised Bog

Raised bogs get their name from their elevated centres. This type of bog occurs across northern Europe and Asia, northern Japan and North America. Raised bogs formed mainly during the post-glacial era in hollows or lakes. Irregular glacial deposits obstructed drainage which then lead to the formation of these peat deposits. A high water table caused flooding; this was particularly common on the Shannon and Erne systems. Over time the water table levels fell and reed swamps developed and thus peat accumulated. Eventually, the peat, and its perched water table, were elevated above the surrounding land so that no mineral water was entering the bog. The vegetation assemblage became composed of species that can survive in low nutrient levels. The main vegetation became *Sphagnum* mosses. The peat continued to grow over many years and this eventually gave rise to the acidic raised bogs. The pH of raised bogs is quite low at around 3.5. This level of acidity is due to the acidifying cation exchange properties of *Sphagnum* mosses.

In active raised bogs the water table is located very close to the soil surface. The acrotelm, which is the top layer of the peat is the only part that is oxygen rich, the remainder, known as the catotelm is anoxic and saturated with water (Moore

1990). Raised bogs contain a basal layer of fen peat, which is overlain by *Sphagnum* peat. Climate had a big part to play in the rate of accumulation of peat. During periods where the climate was drier the peat contained a larger proportion of heather and cotton grass, and less *Sphagnum*. In even drier conditions, pine could invade the bog. The wetter, cooler periods encouraged increased *Sphagnum* growth and forced the retreat of pine, heather and cotton.

Initially the growth of raised bogs was confined to lake basins, but as the climate became wetter they extended laterally. Today, the raised bogs of Ireland are characterised by rainfall of between 800 and 1100 mm per annum (Foss 1987) (Figure 1.1). Paludification and terrestrialisation are involved in the formation of raised bogs. Terrestrialisation occurs due to ecological succession that leads to the eventual development of a bog. Paludification occurs due to lack of drainage and thus the bog spreads over the margins (Feehan 1997).

The depth of a raised bog varies greatly. It can be as little as three metres or as high as twelve metres, the average depth being seven metres. The domed profiles of raised bogs are due to the continuous accumulation of undecayed mosses and other plant remains. The dome of the bog is generally flat and very wet. The margins of this bog type, known as the rand, are drier and as a result have different plant communities. At the edge there is more movement of groundwater, it is here that a belt of marginal fen or lagg may occur (the lagg is the minerotrophic area that starts at the base of the bog) (Davis and Anderson 2001).

In Ireland the total area covered by blanket bog is estimated to be 311,300 hectares. However, due to exploitation these areas are rarely intact today.

The vegetation of a raised bog is dominated by *Sphagnum* moss, dry areas and hummocks which can all be home to species such as; *Calluna vulgaris* (Ling) *Eriophorum vaginatum* (Hare’s tail cottongrass), *Trichophorum caespitosum* (Deergrass), *Erica tetralix* (Cross-leaved heath), (lichens) *Cladonia* spp. (lichens). The wetter areas of raised bogs often have, *Eriophorum angustifolium* (Common cottongrass), *Rhynchospora alba* (white beak sedge), *Narthecium ossifragum*, *Drosera* sp. (sundews) (Fossit 2000).

1.2.1.3 Blanket Bog

Blanket bog is so called because of its appearance, which closely follows the topography of the landscape. Blanket bogs developed after millennia of settlement and are said to be post-Neolithic. The development of blanket bogs is thought to be due to an increasingly wet climate combined with the clearance and felling of woodlands by farmers. Many western bogs developed on soils that were used at some stage by Neolithic farmers as can be clearly seen at Céide Fields, County Mayo.

The distribution of blanket bog is linked with areas that have over 1250mm of precipitation per year (Foss 1987) (Figure 1.1). Blanket bogs rarely form in depressions unlike raised bogs therefore they do not have a layer of fen peat at the bottom. The average depth of a low-level blanket bog is about three metres; mountain blanket bog is approximately 1.5 metres in depth.

The different types of blanket bog that occur in Ireland are blanket bogs that occurs in the uplands and in the lowlands, this is known as Atlantic blanket bog. Sphagnum mosses do not play as major a role as they do in raised bogs (Feehan and O'Donovan 1996). Blanket bogs in the uplands receive a high rate of precipitation while evaporation and temperature decrease with increased altitude. Upland blanket bog is located between 150-300m above sea level in the west of Ireland. Atlantic blanket bog receives high precipitation and low levels of evapotranspiration due to the prevailing westerly airflow. It is the high levels of precipitation that are responsible for this type of peat being referred to as climatic peat. Acidic rock and human interference also contribute to this type of peat formation. It is spread along extensive areas of flat ground below 150m in the west of Ireland, mainly found in Galway and Mayo, with areas also in Kerry, Cork and Donegal (Feehan and O'Donovan 1996).

The main types of vegetation that are found on upland blanket bogs are; *Eriophorum vaginatum* (Hare's tail cottongrass), *Trichophorum cespitosum* (Deergrass), many ericoid species are found also, these include, *Calluna vulgaris* (Ling), *Erica tetralix* (Cross-leaved heath), and *Vaccinium myrtillus* (Bilberry). The vegetation of Atlantic blanket bog differs considerably when compared with upland or mountain blanket bogs, *Schoenus nigricans* (Black Bog-rush), *Molinia caerulea* (Purple Moor-grass), *Pinguicula luistanica* (Pale Butterwort), *Polygala seryllifolia* (Heath Milkwort), *Pedicularis sylvatica* (Lousewort), are all absent in upland blanket bogs (Doyle and Ó Criodáin, 2003). Other species found on lowland blanket bog include; *Drosera* spp. (Sundews), *Pedicularis sylvatica* (Lousewort), *Pinguicula lusitanica* (Pale butterwort), and *Myrica gale* (bog myrtle) (Fossit 2000).

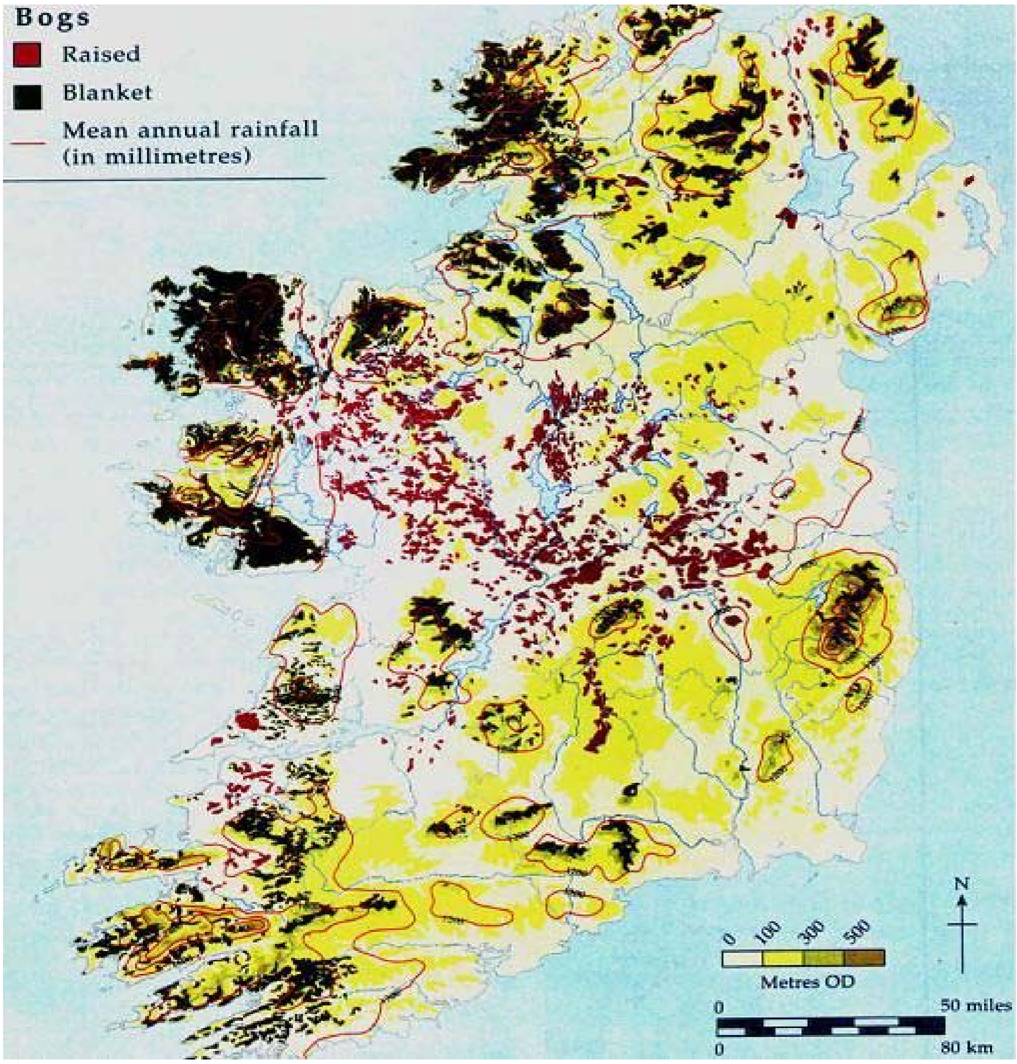


Figure 1.1. Map of Ireland with two different types of peat indicated, blanket and raised and the mean annual rainfall (Taken from Aalen, Whelan and Stout 1997).

1.3 Exploitation of Irish Bogs

Peat has been exploited in Ireland through the ages, where bogs have been damaged by peat extraction (both small and large scale), afforestation and in some cases by land reclamation usually to provide more land for agriculture. For example, peat extraction accounts for approximately 6% of the total primary energy requirement for Ireland. The removal of peat occurs both on a small scale by hand cutting and at a large scale on an industrial level. As a result of this human intervention only 18 percent of the original area of Irish bog remains unspoilt. This figure equates to ninety-two percent of raised bogs and eighty-one percent of blanket bogs that have been lost (Foss 1998).

Peat was first extracted in the 17th century, but this was initially done on a small scale by hand known as turbary extraction. The introduction of large-scale peat extraction in Ireland began in the 1940s, the Irish peat board (Bord na Móna) was established in 1946, this was set up as a semi-state body as a direct result of government policies that were introduced to try and alleviate the difficulties associated with importing fuel supplies into Ireland (Barry 1976; Renou and Farrell 2005). Since the establishment of Bord na Móna twenty-four percent of all raised bogs have been exploited (Cross 1990). The National Parks and Wildlife Service (NPWS) carried out a five-year study of Irish raised bogs which was completed in 1987, this study found that of the original 311,300 hectares of raised peat only 23,000 hectares remained partially intact, yet not one of these raised bog complexes are fully intact.

Small-scale peat extraction was given incentives under the ‘Turf Development Act of 1981’, this provided grants from the government and thus further exploited the bogs (Foss 1996). These grants were still being awarded until 1993. At approximately the same time afforestation of peatlands by private developers and Coillte (a semi-state body) became popular and thus led to further damage of already threatened peatland habitats. Until recently afforestation grants were available both within the European Union (E.U.) and by the Irish government. By 1982, 140,000 of mostly undamaged blanket bog had been afforested and this increased dramatically to 170,000 hectares by 1985 (Feehan and Donavan 1996). It is estimated that 6,300 hectares of raised bog and 211,000 hectares of blanket bog have been afforested (Foss 1996) (see also Table 1.1). Afforestation of peatland sites also occurred from 1741 to 1808 due to incentives given by the Royal Dublin Society, but it was not popular at this time to experiment with the re-planting of peatlands.

Table 1.1 Area in hectares of the main land uses of Irish raised bogs (Cross 1990).

Peatland Use	Area (hectares)	Percentage of raised bogs
Peat developed by Bord na Móna	73,600	24
Developed privately (small-scale extraction etc.)	208,200	67
Afforested	6,300	2
Intact	23,000	7

1.3.1 Conservation of Irish Peatlands

In Ireland the main body concerned with the conservation of peatlands is the IPCC (Irish Peatland Conservation Council) but the Dutch also have a history of involvement in the conservation of Irish bogs through groups such as the Dutch Foundation for the Conservation of Irish Bogs. The need for the conservation is of a growing concern, the reasons for conservation are mainly that these peatlands should be conserved for cultural importance, preservation of important ecological habitats and lastly to protect scientific records from the past that are often found in peatlands.

In 1996, 3,176 hectares of raised bog and 27,279 hectares of blanket bog were purchased for conservation initiatives (Foss 1996). In 1990 Bord na Móna sold 2,018 hectares of raised bog for conservation to the NPWS (National Parks and Wildlife Service). Bord na Móna have employed their own conservation iniatives too, the largest of these taking place in the early 1990s where 100 hectares of cutaway bog at Turraun, County Offaly was converted into a wetland. Coillte have also become actively involved in the conservation of peatland sites, this is funded by the EU and Coillte, these projects are known collectively as the EU Life Projects. The EU projects aim to conserve areas of both raised bog and blanket bog.

Further conservation of Irish peatlands has taken place with the designation of certain areas as Areas of Scientific Interest (ASI), Special Protection Areas (SPA) and Special Areas of Conservation (SAC). These site designations are concerned with the preservation of natural habitats and endangered species.

1.4 Why study peatland invertebrates?

The history and nature of a peatland can be elucidated by studying the invertebrates that occur in them. Because of the extreme conditions in a peatland environment, the invertebrates are very environmentally sensitive and are therefore believed to be useful as bioindicators (Spitzer and Danks 2006). They are extremely diverse and small in size, which has resulted in a paucity of studies of their ecology (Reynolds 1990), especially in Ireland. Raised bogs and blanket bogs are decreasing rapidly worldwide, this means that is imperative to develop a monitoring system that will show changes in the structure of the habitat and the mixed flora and fauna it supports. Raised bogs that are deemed active have been listed as priority habitats in Annex 1 on the EC Habitats directive. There is an urgent need to conserve these threatened habitats. This can only be achieved by assessing the conservation value of peatlands, to determine and therefore ensure preservation of the best examples of the ecosystems (Scott, Oxford and Selden 2006).

Decomposition is very limited in peatlands which is due to a deficit in the detrivore/decomposer group due to the variations in pH and waterlogging. Earthworms, responsible for aerating and the mixing of soils, are essentially absent in undisturbed peatland and Isopoda are also low in numbers. At low pH (approximately 4) enchytraeids take the place of the earthworms and take on the role of aerating and mixing the soil. Acari (mites) and Collembola (springtails) inhabit the top centimetres of the peat soil, but they are unable to occur deeper in deeper soil layers due to a decrease of oxygen as a result of waterlogging (Speight and Blackith 1983). Even in the top few centimetres the food supply of the Collembola may be limited because of the high acidity. Microarthropods such as mites and Collembola account for as much as ninety-five per-cent of the soil mesofauna in some edaphic habitats, therefore they are an important component of the soil food webs because of the way they use organic matter and thus have influence over other decomposers in the soil system (Lachnicht, Schomberg and Tillman 2002).

Peatlands contain a range of habitats for both terrestrial and aquatic invertebrates, these are habitats such as lawn, hummock, hills and bog pools (Spitzer and Danks 2006). The nature of a peatland means that the invertebrates occurring there may not be permanent residents of the peat and some may only be short-term residents. Although this may be the case it is worth noting that their presence can have a significant impact on the nutrient cycling within the ecosystem (Webb, Clarke and Nicholas 1984). The groups of invertebrates found on bogs may not be specific to peatlands (Reynolds 1990). For example many of the aquatic invertebrates are not found solely on peatland habitats (Sheehy Skeffington and O'Connell 1998). Additionally some of the terrestrial fauna found on peatlands may be invaders from surrounding habitats; others are unique to peatland ecosystems and thus can be a means of characterizing a peatland habitat (Batzer and Wissinger 1996).

There is a large body of knowledge on the flora of peatlands in particular vascular plants (Feehan and O'Donovan 1996) but little knowledge exists in the biodiversity of terrestrial fauna. Soil fauna are the most biodiverse aspect of terrestrial ecosystems, they are very important to the functioning of decomposing systems within the soil (Petersen and Luxton 1982). In virgin peatlands the dominant soil fauna are enchytraeids, but as peatlands are altered by human influences such as peat harvesting, different species become more important.

Tipulidae are present in high numbers in drier peat and earthworms are more apparent as the nutrient status of the peat improves. Due to the diversity of invertebrates their study is essential for understanding many ecosystems. In order to comprehend the complex interactions in Bogland ecosystems it is essential that soil dwelling organisms be studied in detail.

Nutrients are not limiting in minerotrophic peatlands and the invertebrate diversity is generally found to be high (Rydin and Jeglum 2008). It appears that the structure of vegetation on fen peats is of greater significance than the type and nature of the organic material underneath (Hájek *et al.* 2006). In ombrotrophic peatlands the main habitats found are aquatic, neuston and terrestrial. Terrestrial habitats on peatlands are only to be considered for this study, but as the water table fluctuates, aquatic and terrestrial habitats replace one another (Blackith 1974). Studies that have been previously conducted on Irish peatlands have found that some fauna are found solely on peatlands but that some may be present often on certain peatland areas. This is because of vegetative associations that certain invertebrates have with some plant species, indicating there are ecological links between plant species and the invertebrates that are found (Blackith 1974). Conducting a detailed study of the invertebrates found on peatlands can give a better knowledge of the role and functions of various fauna in this ecosystem. This in turn could allow us to determine what strategies need to be implemented in order to promote the conservation of the invertebrates on Irish peatlands. It has been suggested that invertebrate monitoring on peatlands may provide information on energy flow and thus may be used to sense impacts of hydrological changes and the impact of atmospheric pollutants (Reynolds 1990). There have been a number of studies on the fauna of peatlands carried out across Europe in particular the U.K. (Macfayden 1952; Springett 1970; Latter and Howson 1978; Cragg 1961, to name but a few) but little research has been carried out in Ireland (Higgins 1984; Good 1985; Blackith 1974; McDonnell, Fahy, and Gormally 2002; Reynolds 1990). Significant differences have been shown to occur in the terrestrial invertebrate assemblages in fens and bogs (eg. Hájek *et al.* 2006). The use of biodiversity indicators in habitat assessment has become increasingly important (Oxbrough *et al.* 2007). Invertebrate biodiversity on peatland enables the determination of species composition and abundance to help the interpretation of the complex ecology and history of these habitats (Spitzer and Danks 2006). The research carried out here can be compared to this body of knowledge to identify any unique relationships within the Irish context.

1.4.1 Mites (Acari)

Acari (mites) are one of the most abundant and diverse group of microarthropods present in terrestrial habitats, including peatland habitats (Belanger 1976). There are several types of mite, including Oribatida (moss mites), Hydracarina (water mites) and some of the Mesostigmata which are associated with the mosses, mainly *Sphagnum*, present in bogs. The population densities of mites can reach several hundred thousand per square metre (Dindal 1990) and it is estimated that there could be more than 100,000 mites per square metre within *Sphagnum* bogs

(Rydin and Jeglum 2006). Adult mites can be differentiated from the number of pairs of legs present, adult mites having four pairs and larval stages only having three. Current research indicates that the principal function of mites in soil is the regulation of organic matter decomposition through the control of the abundance and composition of the microflora. This is achieved firstly by feeding of microphytophagous mites which stimulates new growth and secondly by macrophytophagous mites being responsible for the comminution of organic matter into smaller particles. For these reasons, i.e. due to their role in decomposition of organic soil, and because of their great abundances in peatland soil, mites form an essential part of any study of a terrestrial habitat.

1.4.1.2 Oribatida (Acari: Cryptostigmata)

Oribatida are the most numerous arthropod groups in the organic horizons of the majority of soils. The density of these mites can reach several hundred thousand individuals per square metre (Dindal 1990; Houck 1994). There are presently 7000 described species of oribatid, these species represent approximately 1000 genera in more than 150 families (Balogh and Balogh 1992). Oribatid mites have been recorded since the Devonian period but there are also some genera that were present in the Jurassic period (Krivolutsky and Druk 1986).

The size of oribatid mites varies but most are found in the range of 300-700 µm. The life cycle of oribatids consists of six postembryonic instars, these instars are as follows; an inactive prelarva, and an active larva, protonymph, deutonymph, tritonymph and then finally the adult stage (Siepel 1990). Estimates of the time for development of oribatids in adult form seem to vary from several months to two years in temperate soil (Luxton 1981).

The main function of the Oribatida is in the decomposition of organic matter, the cycling of nutrients and the formation of soil. Each life stage of the Oribatida feed on a wide variety of material such as; living and dead plants, fungi, lichens and also carrion (Behan-Pelletier 1999). Oribatid mites feed by using chelicera and other feeding structures to break up or tear particles (Norton 1990). The faecal matter of oribatids form an important component of the organic horizon in soils (Migge *et al*. 1998).

Three feeding types have been identified among the oribatids; macrophytophages which feed on higher plant material; microphytophages which feed on the microflora found in the soil and panphytophages which feed on both higher plant material and the microflora found in the soil (Behan-Pelletier 1999).

1.4.1.3 Acari: Mesostigmata, Gamasina

Mesostigmata, and particularly Gamasida, are found in many different habitats. They are predominantly predatory mites that live in the soil and soil litter, on the surface of soil or on plants. In soil, Mesostigmata prey on nematodes, Collembola and some insect larvae (Harris and Usher 1976) and some groups are considered to be fungivorous (Krantz and Ainscough 1990). The first life-stage of this mite is a six-legged larval stage, which on the first moult changes into a protonymph then after the second moult a deutonymph and then finally into an adult mite. Development times vary greatly as they are strongly influenced by temperature.

The number of Gamasina that occur in different habitats can be as large as 10,000 individuals/m^2. The size of adult Gamasina typically varies from 0.25-1.55 mm. Gamasina unlike the Oribatids do not alter the soil structure or plant productivity by direct means; however, as they are mainly predatory they have an influence over different populations and thus have an indirect effect on ecosystem function (Koehler 1999).

1.4.2 Ground beetles (Coleoptera: carabidae)

More than eighty percent of the Earth's approximately 1.25 million known species are insects (Knight and Holloway 1990) and ground beetles (Carabidae) are one of the largest and most successful families of beetles. There are approximately 40,000 species world-wide, about 2700 in Europe and 350 in Britain and Ireland (Luff 2007). Speight, Andersonn and Luff (1983) have recorded 198 Irish species of Carabidae.

The species of Carabidae found and Britain and Ireland are for the most part active, terrestrial beetles which collect food on the ground surface and hide in leaves and under stones or rotting wood. The main factor often determining their distribution is the level of moisture in the soil. There are known hygrophilous species such as many *Agonum* and some xerophilous species such as most *Harpalus.*

1.4.2.1 Diet

The majority of carabid species are carnivorous but certain species in the genera *Harpalus* and *Amara* are mainly phytophagous. Carabids feed on a wide variety of arthropods, this includes springtails, mites, flies, molluscs and also earthworms (Coll 1998).

1.4.2.2 Life history

The majority of carabids have one generation per year. In some species the adult population may over-winter and then breed a second time the following year. The eggs of these beetles are laid singly, most often in the soil but also in leaf litter or in rotten wood. Carabids have three larval instars with the life cycle spanning four stages (egg-larva-pupa-adult). Most Carabidae have a short breeding season, this breeding season is usually brought about by suitable temperatures and increased daylight hours (Dindal 1990). The majority of species breed in spring, these are known as 'spring breeders' ('adult hibernators'), the larvae then develops during the summer, the adults develop in autumn and hibernate during the winter. The 'autumn' breeders on the other hand reproduce in summer or autumn with the larvae overwintering and re-emerging as adults the following spring (Golden 2005). Thiele (1977) found that the reproductive patterns of the carabids in temperate zones followed five types: “(i) spring breeders with summer larvae and adult hibernation; (ii) species with winter larvae and reproduction in summer and/or autumn, but with adult dormancy; (iii) species with winter larvae and young adults in spring, which undergo aestivation prior to reproduction; (iv) species with a flexible reproduction period, in which larvae appear to develop equally well in summer as well as winter; (v) species that require more than one season to develop”. However some field studies suggest that carabid lifecycles are not as straightforward as they might seem (Loreau 1985; Den Boer and Den Boer-Daanje 1990). It has been found that adult carabids often hibernate after reproduction and may reproduce again in the following years. This would imply that most adult carabids will hibernate at some stage. Therefore it may be simpler to distinguish species that have summer larvae with those that have winter larvae. The variability of the life cycle has been shown in Ireland on Irish arable fields (Fadl and Purvis 1998). Their research found that what are known as the spring breeders did not exclusively reproduce in spring and that the majority of species reproduced in spring and summer. Climate also plays an important part in the reproduction times of carabids variation in breeding times has been shown by species that occur further north (Niemelä 1989).

Peatlands are well know for their carabid species, very few of these species occur in completely open *Sphagnum*-dominated habitats, but because of the cover and protection provided by small shrubs more than a dozen species may be present. Some of these are habitat generalists and also occur in other habitats such as wooded areas (Rydin and Jeglum 2006). Coleoptera are well recognized as good indicators of habitat type and quality (Luff *et al.* 1989), for this reason beetles, mainly Carabidae, can be used as possible indicator species. The carabids are among the best known insect groups both taxonomically and ecologically (Niemelä 1996). A thorough study of the carabid diversity of Northern Ireland is presented in "the ground beetles of Northern Ireland" (Anderson *et al.* 2000) and this provides a good baseline for any studies in Ireland. These beetles are important polyphagous predators and are well known taxonomically and ecologically. There has also been success in their use as habitat indicators in both forest and agricultural ecosystems (Luff *et al*. 1989)

1.4.3 Spiders (Araneae)

Spiders are predators that are ubiquitous in terrestrial habitats. All spiders are carnivorous. Some construct specialised webs, some hunt their victims, these are known as ground spiders or wandering spiders. They feed on a variety of prey including insects and other arthropods such as spiders and isopods, for this reason they serve important roles in ecosystems (Wise 1993, Foelix 1996). Due to their position in food webs and their relationship with vegetation structure, both of which can be related to changes in habitats, they have been used successfully as indicators of invertebrate diversity (Oxbrough *et al.* 2005) and there has also been some success in the potential use of spiders as general biodiversity indicators

(Oxbrough *et al.* 2007). Many spiders live in habitats that are defined by strict characteristics. The defining characteristics of the spider habitats are defined by physical factors such as temperature, humidity, wind and light intensity, also biological factors play an important role; these factors include, vegetation, the food supply, competitors and enemies.

1.4.3.1 Life history

Whem the spider egg is fertilised, then laid, the egg must be protected this may be done by the use of a silken sac or larger cell. The egg has the potential to start developing within a few hours but can also overwinter. The embryo within the egg sac then develops into a prelarva, this prelarva must moult before it can grow further. It then enters the larval stage of development. The larva must then moult once again and then emerges as a nymph.

There is very little known about Irish spiders. In particular, there is a lack of general information relating to spider distribution and habitat association (Nolan 2002) and accurate knowledge of distribution data is needed. There has been little systematic study of spiders in Ireland and there are only a few comparisons of the species occurring in different specific habitats. The first list of Irish spiders was composed by Workman in 1880; this contained 111 species. Mc Ferran and Ross (1993) list 368 species and van Helsdingen (1996) lists 378 indigenous Irish species, these two lists provided a much needed baseline for those studying spider distributions in Ireland and others have more recently been eager to compile lists of spiders living on individual sites around Ireland. However, more progress needs to be made on Irish spider faunistics.

The studies carried out to date have begun to show some pattern, and a number of species appear to be more widespread in Ireland than in Great Britain, especially some wetland species. However due to the paucity of Irish studies British records have often been used and thus the species information may not be accurate. The greatest problem when dealing with the studies of spiders in Ireland is that it is often difficult to determine whether a species is rare or just under-recorded (Oxbrough *et al.* 2007).

More recent research has been conducted by Oxbrough *et al.* (2005, 2006 and 2007) and Cameron *et al*. (2004) focusing on different habitats found within Ireland, such as peatland, grasslands and forestry. Although some studies have been conducted on peatlands there is still very little known about the species occurring on all the different types, the lack of work on this type of habitat is surprising since peatland represents such a large proportion of Ireland's land area. The vegetation of peatlands has been studied in much greater detail (eg. Foss 1998) but little is still known about their zoology (Higgins 1984). The knowledge gap is not so great in parts of central Europe, which highlights the need to study spiders on peatland habitats. There a large number of spiders living in Irish peatlands and they have a significant functional role (Wise 1993). Reynolds (1990) notes, with regard to peatland habitats in particular, that very little is known about the spatial relationships of spiders and Nolan (2002) state that only recently have any extended studies of spiders been conducted in Ireland and that although raised bogs and fens have been subject to some study there seems to be little work focused on the spiders of blanket bog. In general, Ireland's montane spiders have been studied sporadically (McCormack, Nolan and Regan 2006).

1.4.4 Enchytraeidae

Enchytraeidae are small oligochaetes that vary in size from 2mm to 40mm, they are abundant in soils that contain a large amount of decaying organic matter, they feed on microorganisms, nematodes and plant litter (Wood 1995). They are present in many different types of habitats and form a large percentage of the microfauna of tundra, moorland, peatland and moorlands (Dash and Cragg 1972). Enchytraeids favour soils with a high moisture content, these oligochaetes are absent in dry soils, but if they are present they are not high quality (Healy and Rota 1992). Some enchytraeids may be very small and thus may be confused with soil nematodes, but enchytraeids do not have the buccal stylets and muscular oesophagus used for sucking (Wood 1995).

Enchytraeid worms are most abundant in *Sphagnum* dominated peatlands. It is estimated that enchytraeids make up to 70 per-cent of the faunal biomass of some peatland and that 90 per-cent of the individuals recorded are *Cognettia sphagnetorum* (Springett and Latter 1977).

Enchytraeidae are important for peatland ecosystems as they represent an important part of the decomposer group (Springett, Brittain and Springett 1970). They are responsible for indirectly improving the soil porosity (Amorim *et al.* 2005). Due to their requirement for accumulations of organic matter they are abundant in peatland soils. They generally occur in quite acidic soils and in marine habitats (Healy 1980). Studies conducted at Moor House Nature Reserve in England have found that the Enchytraeidae are found mainly in the top 6 cm of peaty soil (Cragg 1961).

Cognettia sphagnetorum is the dominant enchytraeid on blanket bog according to studies conducted at Moor House by Standen (1973). It is important as a primary decomposer in boreal and temperate peatlands (Laiho *et al.* 2001). This Enchytraeid species has been estimated to make up 75% of the below-ground biomass of blanket peat (Cole, Bardgett and Ineson 2000). *C. sphagnetorum* is thought to have the widest range of all the terrestrial species of enchytraeid that are found in Europe, this is both in an ecological and biogeographical context (Römbke, 1992). *C. sphagnetorum* migrates vertically during the day and then moves upward again in the night, this is thought to be a response to the drying out of the plants on the bog during the day. This enchytraeid reproduces by fragmentation (Standen 1973) and thus there is no drought resistant cocoon stage (Hingley 1993).

Theories exist that enchytraeids take the role of earthworms in that they are responsible for the mixing of organic matter and of the cycling of nutrients in below-ground peatland ecosystem (Didden 1993). Enchytraeids have been found to be important in the alteration of peatland soil systems, this has been shown by studies conducted by Briones *et al.* (1998b). These studies showed that if enchytraeids are abundant they have the ability to improve the leaching of dissolved organic carbon from organic soil by the mobilization of carbon from organic matter with a small ratio of C:N. Enchytraeids have been shown to enhance the release of dissolved organic nitrogen, ammonium, and phosphorus in high organic content soils (Briones *et al.* 1998a). Cole *et al.* (2000) have conducted further studies on the effect enchytraeids have over mineralisation in soils with a high organic content, they found that the enchytraeids influence decomposition and the release of carbon and they can cause increased microbial activity which plays a vital role in the cycling of nutrients in organic soils.

Seventy-one species of enchytraeid are recorded in Ireland (Healy 1976). This number is not for peatlands only but for all the different habitats found in Ireland. The enchytraeid fauna seems to be diverse in Ireland especially in the wetter soils.

1.5 Aims of this project

This project aims to compare some components of the invertebrate fauna of the four main peatland types in Ireland; raised bog, fen, mountain blanket bog, and

Atlantic blanket bog. The taxa studied are mites, spiders, ground beetles (Carabidae) and enchytraeids. Sites were selected around Ireland to represent the different peatland types. Where possible areas of restored peat were compared with areas of intact peat.

An additional study focused on assessing the ground beetle assemblages found on differing sections of peatland. In some cases these sites differed from their original land-use. The different land-uses assessed were habitat disturbance or afforestation with stands of different tree species and year of planting, the fringes of cut-away peat, dry heath, grassland and the non-disturbed area was dry heath and pristine bog.

The final study examined the oribatid mite population from two raised bogs. Within these raised bogs, intact, restored and cutaway habitats were selected, to detect any variations in species composition in addition to the general abundance of the mites.

The overall aim of this study was to gather baseline data on four invertebrate taxa on Irish peatland and thus attempt to detect whether any species collected are unique to peatlands. The results would in turn help design a management protocol for the protection of unique or rare species.

2. Materials and methods

2.1 Study sites

The sampling in this study focused on eleven core sites. The names, locations, bog types and status of these sites are given in Table 1 (see also Table 2.2 and Figure 2.1). These sites were chosen as core sites within the BOGLAND project to provide baseline information on different aspects of peatland biodiversity such as; vegetation, microbial communities, terrestrial invertebrates (this study), aquatic invertebrates and avian fauna. They were chosen as representatives of the four different peatland types to be sampled ie. Raised bog, fen, Atlantic blanket bog and mountain blanket bog. Peatlands can be diverse habitats, therefore sites were chosen in order to be representative of the geographical and physical variation found across Ireland. Where possible, sites were selected that had a long history of academic and management studies. The core sites for the BOGLAND project were selected to try and include near pristine peatland sites that were designated under NATURA 2000 as Special Areas of Conservation (SAC), either included in the same area or nearby there was a degraded peatland ecosystem, but this was not the case for all sites (Renou-Wilson and Bolger 2010).

Within these sites there were areas that were intact or restored or in the case of the site in Kippure all three, intact, restored and cutover (badly damaged). In the first sampling period Carabidae, Araneae and Acarina were examined in eleven sites (Scragh bog was omitted because the habitat was too wet for terrestrial sampling) and the objective was to investigate possible patterns among the different taxa. All sampling of the core sites took place on lawn areas of vegetation. In all cases the samples were taken along a transect line and the samples were taken at two metre intervals.

In 2007 an additional twelve sites were sampled to test for the effect of habitat disturbance on carabid beetle and spiders assemblages. These sites were all located in Co. Offaly. The twelve additional sites were all on raised bogs but they varied in terms of the degree of disturbance and vegetation cover (Table 2.2 and Figure 2.2). These sites included pristine bog, newly exposed cutaway bog, young and old grassland, Sitka spruce and Oak plantations that were planted in 1996, 2000 and 2003. In the latter study only Carabidae and Araneae were sampled.

A further sampling was carried out in October 2009 to look at populations of mites on peatlands with varying degrees of disturbance. This was done by selecting sites that had areas of intact, restored and cutaway peat. The two sites selected were in Co. Offaly, the first site was Mongan Bog (SAC) and the second Lodge Bog; Irish Peatland Conservation Council (IPCC) owned site. In both sites the restored areas were in areas that had been used for small scale peat extraction, i.e. they had been cutover not cutaway. The cutaway area that was sampled was an area that was still being harvested for peat and was devoid of any vegetation, i.e. the site was totally bare.

Table 2.1. Name, region, county, latitude, longitude, bog type and status of the 11 sites sampled in 2006

Name	Region	County	Latitude	Longitude	Bog type	Status	Habitat present *	Site number for mite analysis
Pollardstown	Midlands	Kerry	54°09'N	9°30'W	Fen	NHA SAC	I	17 (I)
Bellacorick flush	West	Mayo	53°11'N	6°50'W	Fen	NHA SAC	I, R	18 (I), 19 (R)
Sharavogue	Midlands	Offaly	53°02'N	7°56'W	Raised bog	NHA SAC	I, R	3 (I), 4 (R)
Clara	Midlands	Offaly	53°19'N	7°38'W	Raised bog	NHA SAC	I, R	1 (I), 2 (R)
Carrowbehy	Midlands	Roscommon	53°47'N	8°49'W	Raised bog	NHA SAC	I, R	4 (I), 5 (R)
Knockmoyle	West	Mayo	54°09'N	9°34'W	Atlantic blanket bog	NHA SAC	I	16 (I)
Owenirragh	West	Mayo	54°16'N	9°37'W	Atlantic blanket bog	LIFE	I, R	14 (I), 15 (R)
Ballygisheen	West	Kerry	51°58'N	9°53'W	Atlantic blanket bog	LIFE NHA SAC	I,D	13 (I), 14 (R)
Fiddandary	Ox mountains	Mayo/Sligo	53°09'N	6°17'W	Mountain blanket	NHA SAC	I,D	6 (I), 7 (R)
Kippure	Wicklow mountains	Wicklow	54°08'N	8°56'W	Mountain blanket	NHA SAC	I,D	8 (I), 9 (R)
Glenlahan	Slieve Bloom	Offaly	53°00'N	8°32'W	Mountain blanket	LIFE NHA SAC	I,D	10 (I), 11 (R)

* I = Intact/pristine habitats; R = Restored habitats

Table 2.2. Peatland types, site name and exact location of sample points in terms of peatland characterisation

Peatland type	Site Name	Terrestrial invertebrates study
Fens	Pollardstown	Reed stands
	Bellacorick Flush	Bog complex
	Scragh	none
Raised bog	Clara	Sub-central; sub marginal; marginal ecotopes
	Sharavogue	Sub-central ecotope (intact); marginal ecotope
	Carrowbehy	Sub central ecotope (intact); and wet heath
Mountain blanket bog	Kippure	Intact bog Restored area Cutover area
	Glenlahan	Intact bog complex Restored bog
	Fiddanderry	Intact bog complex Degraded bog
	Knockmoyle	Intact bog
Atlantic blanket bog	Owenirragh	Intact bog Restored bog
	Ballygisheen	Intact bog Restored bog

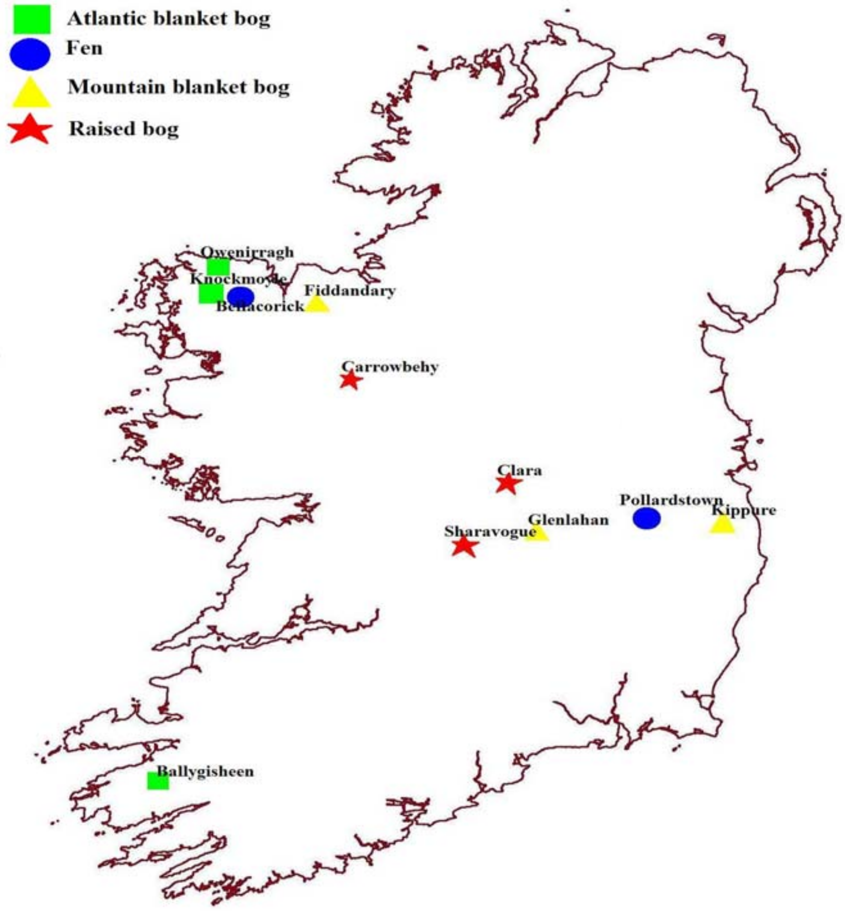


Figure 2.1. Outline map of Ireland with the location of the eleven core BOGLAND sites

Table 2.3. Site name, habitat type and bog type of the site sampled in 2007 for Carabidae and Araneae

Site Name	Habitat Type	Bog Type
Clongawney	Natural wetland recolonisation	Raised
Clongawney	Wooded mineral islands	Raised
Clongawney	Newly exposed bog	Raised
Clongawney	Newly recolonised cutaway	Raised
Boora	Dry heath	Raised
Killaun	Old turbary	Raised
Clongawney	Uncut bog	Raised
Boora	Young grassland	Raised
Boora	Old grassland	Raised
Tumduff	Sitka spruce and Oak plantations planted in 1996 and 2000	Raised
East boora	Sitka spruce and Oak plantations planted in 2003	Raised
Boora	Sitka spruce and Oak plantations planted in 2000	Raised

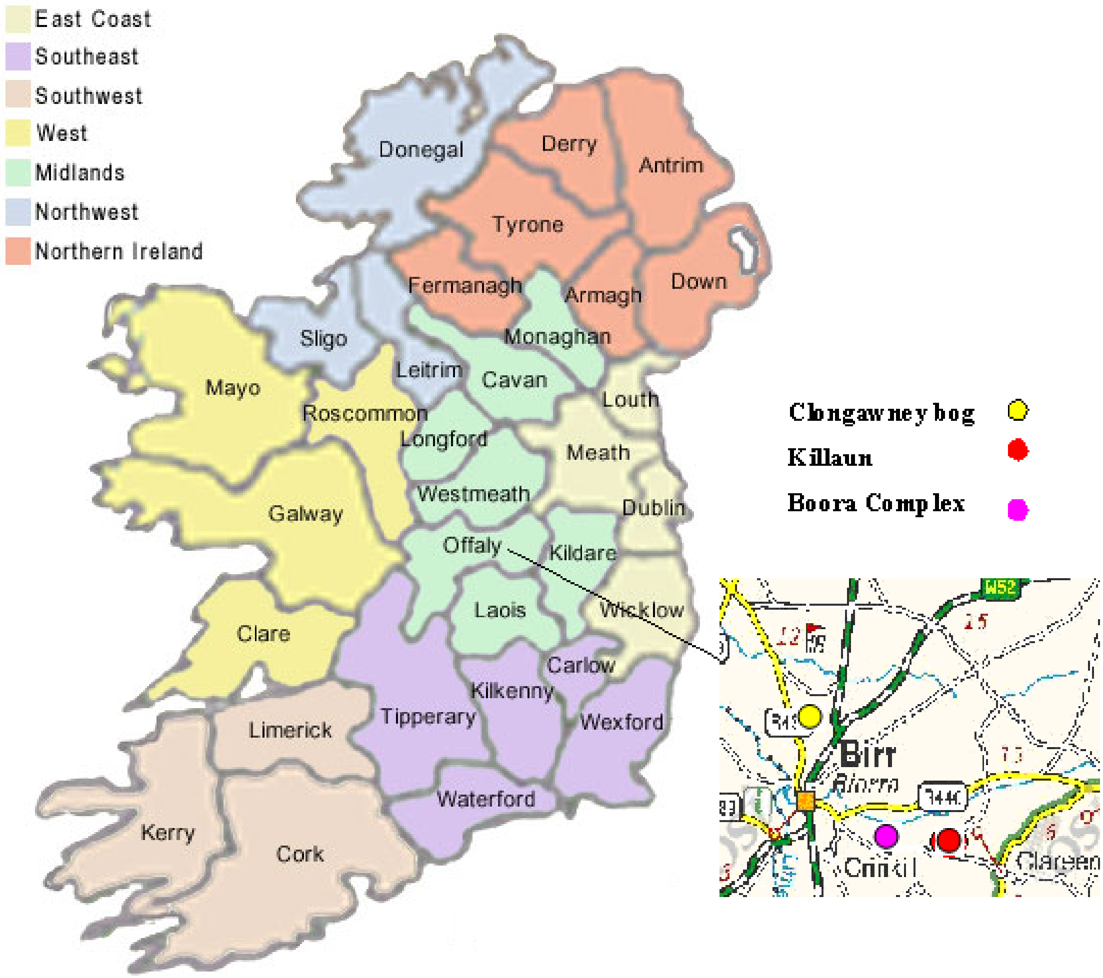


Figure 2.2. The location of the sites sampled in 2007

2.1.1 Vegetation, status and site description

2.1.1.1 Fens

Bellacorick

The Bellacorick site is situated about seven kilometres north-east of Bellacorick, Co. Mayo, on a tributary of the Oweniny River. The site contains a small minerotrophic fen developed on glacial till overlying calcareous sandstone. The entire site is surrounded by drains and an extensive area of mechanically cut peat (see Figures 2.3 and 2.4). Bord na Móna began peat extraction at Bellacorick, County Mayo in 1961. Approximately twenty-five per cent of the area where peat was extracted at this site has now been taken out of production due to overexploitation of peat resources (Farrell and Doyle 2003).

The area sampled for this part of the project was thought to be a fen but on later examination it was found that it was a bog and although there is a flush within the bog complex this was not the area that was sampled. This site is a dry heath, marginal habitat on a bog remnant.

The degraded area that was sampled at the Bellacorick complex is dominated by species of *Calluna*, it contains characteristic wet heath vegetation such as *Molinia* and *Sphagnum.*

Figure 2.3. Aerial view of Bellacorick fen/flush and location of sampling sites indicated by the red circle

Figure 2.4. Bellacorick Fen, County Mayo

Pollardstown Fen

Pollardstown fen is an area of alkaline peatland which obtains its nutrients from calcium rich spring water. Most fens develop further into raised bogs once the peat becomes thick enough to prevent mineral rich groundwater affecting the system. Raised bogs contain acid peat and their only source of nutrients is rainfall. In the case of Pollardstown the succession to raised bog has been prevented by the input of alkaline rich water from a number of important springs. There are layers of calcareous marl in this peat at Pollardstown, this is a result of calcium seeping into the peat from the mineral rich groundwater (Renou-Wilson and Bolger 2010)

Pollardstown Fen is of international importance because this type of fen is now rare in Ireland and Western Europe. In addition, a number of rare plants and animals occur on the fen. The area of the fen is 220 hectares and is situated on the Northern edge of the Curragh, Co. Kildare.

Pollardstown is a National Nature Reserve since 1986. It is also a candidate Special Area of Conservation under the EU Habitats Directive. Three habitats listed on Annex I of the Habitats Directive occur in the area they are:- Alkaline fen, calcareous fen and petrifying springs with toofa formation. Six species which are a priority for conservation and are listed in the directive also occur at the site. The presence of these habitats and species obliges the National Parks and Wildlife Service, the state conservation agency, to afford the fen maximum protection under EU law (IPCC, Irish Peatland Conservation Council).

A canal runs through the centre of the Pollardstown Fen, although this is artificial the rest can be deemed as natural. This area will always remain as a fen because of the calcium rich water that pumps through it. The main vegetation present are *Typha latifolia, Phragmites australis*, although there are not many mosses there is one species that can be found easily, this is *Calliergon Cuspidatum*. There is a small area of *Schoenus nigricans* within this site but this was not the area that was sampled. Toofa habitats can clearly been seen in places where there is a white area on the surface of the soil (see Figures 2.5 and 2.6).

Figure 2.5. Aerial view of Pollardstown fen with the location of the sampling point

Figure 2.6. Pollardstown fen

2.1.1.2 Raised bogs

Sharavogue

Sharavogue Bog is one of the best remaining examples of a raised bog in Ireland. The site not only contains a pristine high bog, but also preserves important relics of the original lagg-zone, (the transitional zone between bog and surrounding landscape which contains species rich fen communities). Such lagg-zones are extremely rare in the Irish and international context because they were lost in virtually every remaining bog site as a result of marginal drainage and peat cutting. For these reasons, Sharavogue Bog is of International conservation importance and it is listed as an SAC under the Habitat's Directive.

Sharavogue bog is located about eight kilometres south of Birr, Co. Offaly, in the Little Brosna Valley. It is situated between the River Little Brosna and a ridge of high ground of Carboniferous limestone. The eastern edge is bordered by a disused railway embankment, the western by the river. The site is underlain by low permeability limestone and limestone till (NPWS (National Parks and Wildlife service)1997).

Although the high bog has suffered some damage from drainage, burning and peat cutting, it is still in moderately good condition. The associated area of fen on the eastern side of the site is intact; its association with the high bog is of considerable conservation significance.

This site is an example of a sub-central ecotype. This type of habitat is characterised by the lack of hummocks and with large areas of lawn that are dominated by *Sphagnum magellanicum*. Wet vegetation is generally uncommon. *Eriophorum* and *Trichophorum caespitosum* are present at this site. The surface of this type of habitat is typically soft and sometimes quaking (see Figures 2.7 and 2.8).

Figure 2.7. An aerial view of Sharavogue bog and the location of the sampling points

Figure 2.8. Sharavogue bog, County Offaly

Clara

Clara Bog is a natural heritage area of great importance. It is one of the last remaining relatively intact raised bogs in Western Europe and provides a unique feature of landscape and geological interest stretching over an area of 460 ha. It lies two kilometres south of the town of Clara and is the largest raised bog remaining east of the Shannon. Attempts by Bord na Móna to exploit it were halted in the 1980s and the bog is now to be carefully preserved. Clara bog is unique for its flora and fauna and for its soak system. The soaks are a series of small lakes which are dotted across the bog. They contain mineral-rich water which comes from beneath and the area around these lakes supports a different type of vegetation to the rest of the bog (see Figures 2.9 and 2.10).

Clara intact habitat

The intact area sampled is intact but not an active bog it is also an example of a sub-central ecotype (at the edge of the active part of the bog).

Clara degraded habitat

The degraded part of Clara contains many areas of dry heath and bare peat with the dominant vegetation being *Calluna*.

Figure 2.9. An aerial view of Clara bog with the location of the two sampling points, the degraded area is nearest the bog margins

Figure 2.10. Clara Bog, County Offaly

Carrowbehy

Carrowbehy, also know as Caher Bog, is a large floodplain bog that developed between low drumlin hills in the headwaters of the River Suck. Carrowbehy Bog is located eight kilometres north-east of Ballyhaunis, Co. Mayo. The main section of this bog is reasonably intact. There are extensive quaking sections throughout the main section of this raised bog. This bog is large and relatively undamaged and species-rich in terms of the plants that are found there There are also well-developed pool and hummock systems. Carrowbehy Bog is an actively growing raised bog and is thus a rare habitat in Europe and is listed by the EU as being of special importance.

The area sampled in Carrowbehy was from an area of wet heath to the east of the high bog, the dominant vegetation here were *Cladonia sp*., *Juncus sp.* and *Calluna sp.* (see Figures 2.11 and 2.12).

Figure 2.11. An aerial view of Carrowbehy bog, with the location of the sampling point indicated by the red circle

Figure 2.12. Carrowbehy Bog, County Roscommon

2.1.1.3 Atlantic Blanket bog

Knockmoyle

Knockmoyle is located north of the Bord na Móna factory at Bellacorick, Co. Mayo. The Oweniny River is to the east of the site. This is a state owned site acquired in 1986. The area of the site is 1,198 hectares (NPWS). It is part of the larger Bellacorick Bog Complex cSAC with extensive pool systems, flushes, shrub and grassland communities.

The whole of this site is intact. There is an algal layer found at the top this is due to burning and grazing at the site. S*choenus. nigricans*, *Eriophorum angustifolium* and *Rhynchospora fusca* are abundant. Hummocks found here are unusual made with different moss fauna and species of heather (see Figures 2.13 and 2.14).

Figure 2.13. Aerial view of Knockmoyle Atlantic blanket bog and the location of the sampling point is indicated by the red circle

Figure 2.14. Knockmoyle, County Mayo

Ballygisheen

Ballygisheen is one of the most extensive areas of intact lowland blanket bog in Co. Kerry. This Atlantic Blanket bog lies within the Killarney National Park, MacGillycuddys Reeks and Caragh River Catchment cSAC. The sampling areas were located within the vicinity of the Coillte restoration site called Dromalonhurt, which lies in the valley below Bealach Oisín, this is approximately 15 kilometres southwest of Killorglin, Co. Kerry. The site is adjacent to the Caragh River (Renou-Wilson and Bolger 2010). This site is dominated by *S. nigricans*, it is much wetter site in comparison to the other Atlantic Blanket bog sites. For this reason there are many pools and large amounts of algae present.

The degraded area sampled at Ballygisheen was an area that had previously been covered with a broadleaf plantation of Birchwood (the Coillte restoration project). The vegetation is rather poor mainly containing brambles and contains little vegetation that would be characteristic of Atlantic blanket bog (see Figures 2.15 and 2.16).

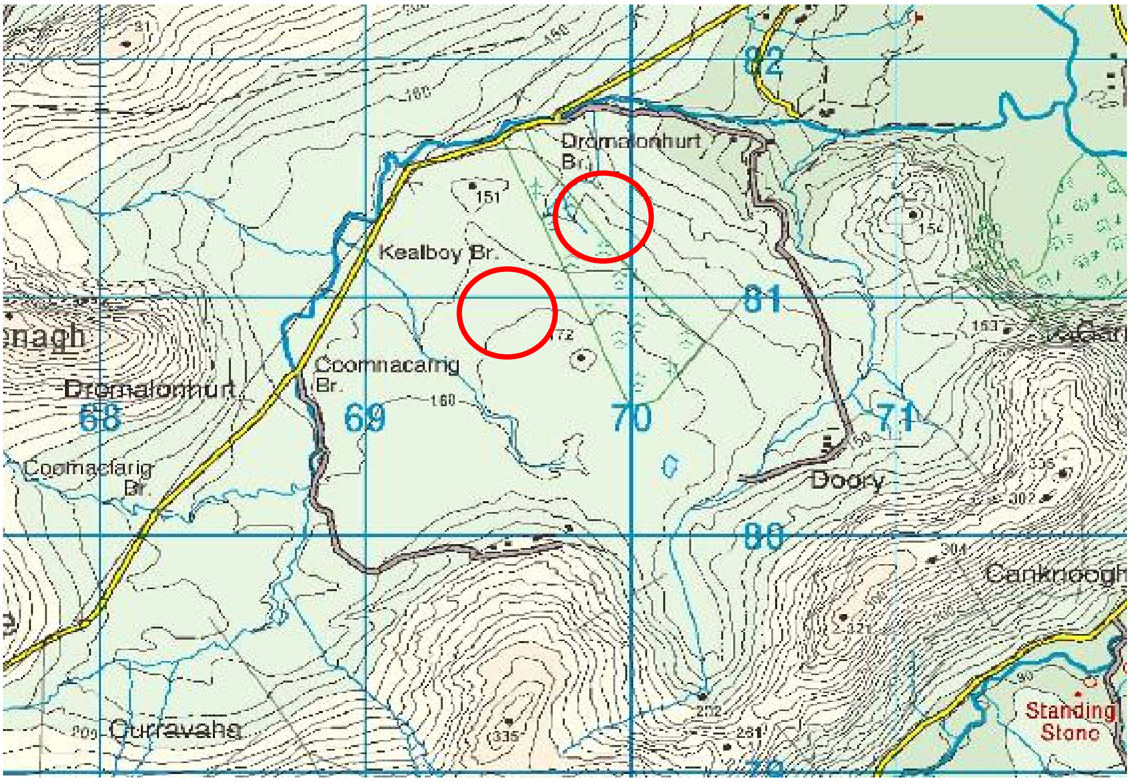


Figure 2.15. Ordnance Survey map of Ballygisheen with the location of the two sampling points indicated by the red circles

Figure 2.16. Ballygisheen, County Kerry

Owenirragh

Owenirragh is an isolated area Atlantic blanket bog which is located six kilometres northeast of Glenamoy, Co. Mayo. It is part of the Coillte blanket bog restoration project and it is fact the largest site within the restoration project. Part of the Bogland site is situated within the Glenamoy Bog Complex cSAC. The vegetation dominating this site is *S. nigricans*. The vegetation in the restored area is mainly *Molinia caerulea* with some *Calluna*, there are also brambles present. This is more like a *Molinia* grassland than an actual bog. A restoration project took place here between 2002 and 2007 (see Figures 2.17 and 2.18).

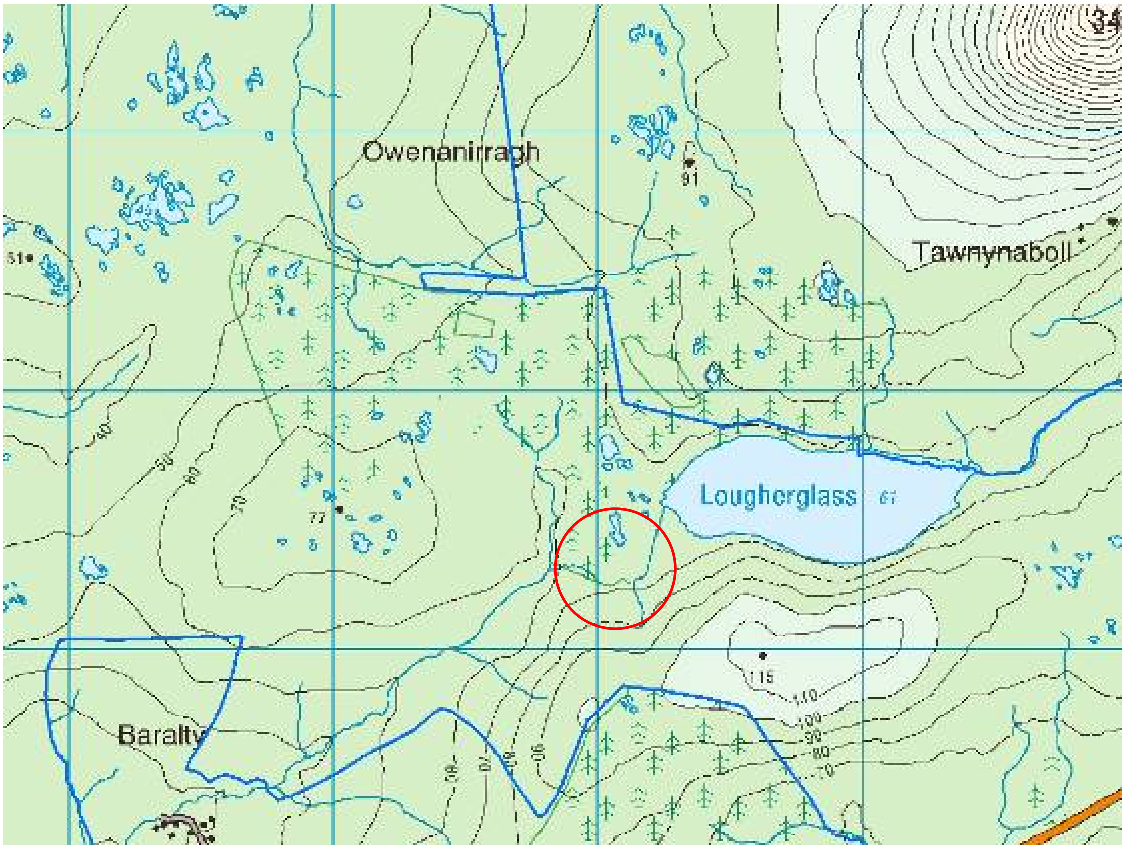


Figure 2.17. Ordnance Survey map of Owenirragh Atlantic blanket bog and the sampling location indicated by the red circle

Figure 2.18. Owenirragh, County Mayo

2.1.1.4 Mountain blanket bog

Fiddandarry

Fiddandarry mountain blanket bog is part of the Ox Mountains Bogs cSAC. This site is located on the Sligo/Mayo border. The Ox Mountains Bogs cSAC contains many mountain blanket bogs situated in the Slieve Gamph, or the Ox Mountain range. Most of the underlying rock is composed of metamorphic schists and gneisses, but igneous intrusions are also found, as at the silica-rich granitic ridge to the east of Easky Lough (Renou-Wilson and Bolger 2010)

The degraded part was mainly an area of bare peat with algae on the top of the peat and the moss *Campylopus introflexus*. Within this area it was a varied habitat due to land use such as grazing. There was also a *Sphagnum* layer incorporated into some of the areas in the degraded system sampled. The samples taken in the intact habitat were taken in an area that was a grassy bog. This is one habitat within a large complex, therefore the variablility in this site is massive. The dominant type of plant found in this area were vascular plants such as *Calluna vulgaris*, *Erica tetralix*, *Scirpus cespitosus* and *Molinia caerulea* (see Figures 2.19 and 2.20).

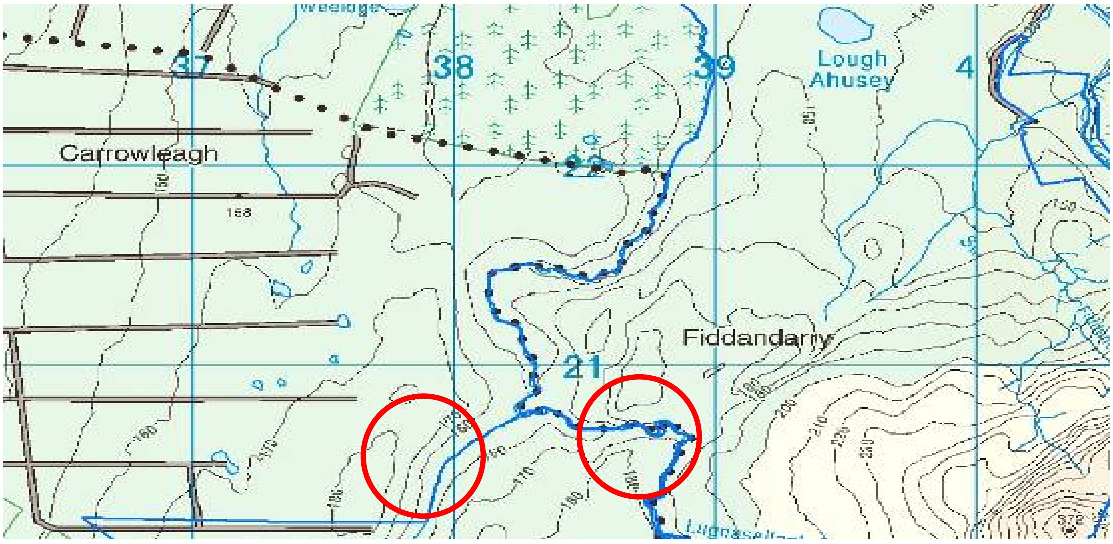


Figure 2.19. Ordnance Survey map showing Fiddandarry and the two sampling locations (indicated by the red circles), the area to the left is the degraded area and the intact area is to the right

Figure 2.20. Fiddandary, County Sligo

Glenlahan

Glenlahan is a mountain blanket bog that is located within the Slieve Bloom mountains in county Laois. A large proportion of the mountains are included within the Slieve Bloom cSAC. The Slieve Bloom Mountains have large areas of forestry. The vegetation found at the sampling points is in both cases (intact and restored areas) dominated by *Calluna vulgaris, Juncus squarrosus* and *Eriophorum vaginatum*. The type of moss found mainly at this site is *Sphagnum capillifolium* (see Figures 2.21 and 2.22).

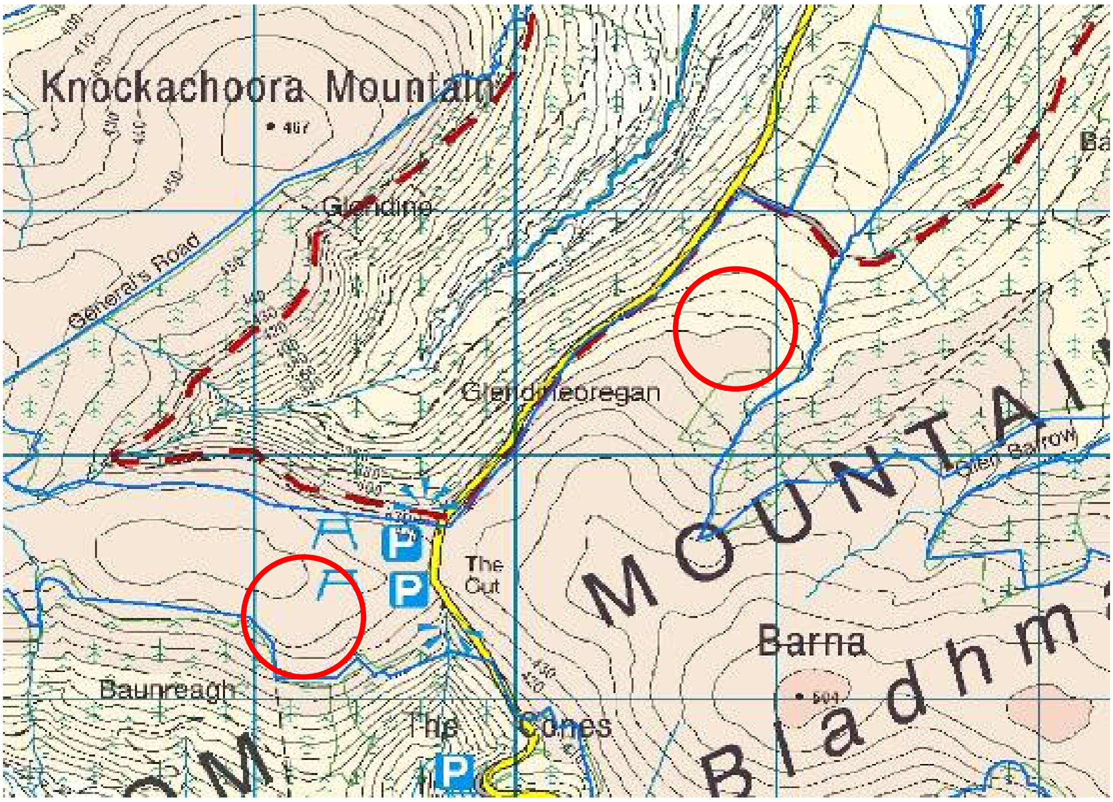


Figure 2.21. Ordnance Survey map of Glenlahan with the sampling location indicated by the red circles

Figure 2.22. Glenlahan, County Laois

Kippure/Liffey Head Bog Complex

Kippure Bog is part of the Wicklow Mountains cSAC. The vegetation is made up of heath and mountain blanket bog, there are also some small wooded areas located beside the rivers. The heath vegetation is found alongside the blanket bog vegetation, both wet and dry heath are present. The heathland vegetation usually consists of *Calluna vulgaris*, *Erica tetralix*, *Eriophorum* spp and *Juncus squarrosus*, in the drier heath species such as *Ulex* spp., *Erica cinerea*, *Vaccinium myrtillus* and *Molinia caerulea*. The blanket bog at the Kippure Bog is dominated by *Trichophorum caespitosum*, *Narthecium ossifragum*, *Eriophrum* spp., *Calluna vulgaris* and different *Sphagnum* species and also in some places *Andromeda polifolia*. The Kippure or Liffey Head Bog Complex is a good representation of blanket bog on the east of Ireland, this is due to the extensive areas of deep peat formation (see Figures 2.23 and 2.24).

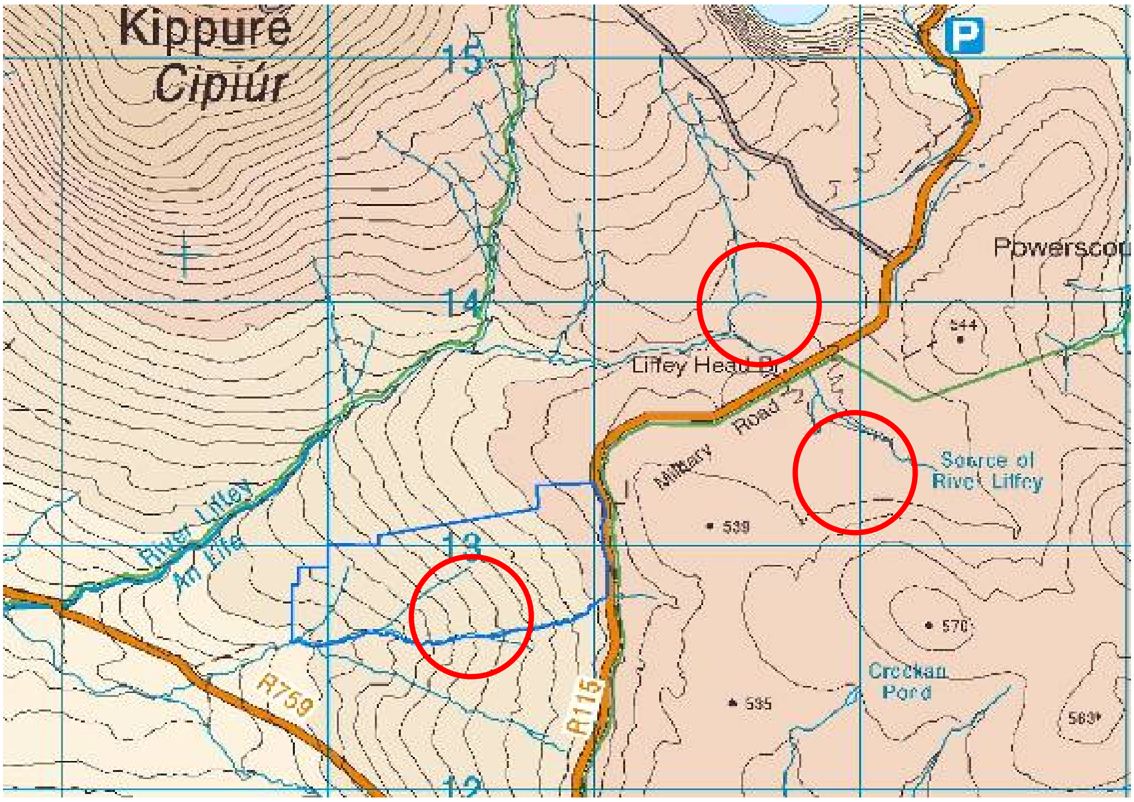


Figure 2.23. Ordnance Survey map of Kippure with the sampling points indicated by the red circles

Figure 2.24. Kippure/Liffey Head bog, County Wicklow

2.1.1.5 Additional sample sites used in 2007 for Carabidae and Araneae

A number of additional sites were selected in 2007 for further study of ground beetles and spiders. Table 2.3 gives a description of the sites that were sampled and their location.

Forestry sites

The sites that were forested were peatlands that had been industrially cutaway. The tree species chosen were Sitka spruce and Oak as these were replicated in all the different cutaway forest sites. These sites were forested by Coillte and used as study sites for the BOGFOR project conducted in UCD. In Boora (1990; this was the year the forestry was planted) the seedlings were planted in uncultivated areas only and the same was the case for the Clongawney site (1989: year of plantation), but in East Boora (2003: Year of plantation) and Tumduff (1996 and 2000: Years of plantations) the trees were planted on cultivated and uncultivated plots.

Other sites

Killaun Bog is located five kilometres east of Birr, Co. Offaly (see Figures 2.25 and 2.26). This site was used in 2007 to take samples on old turbary. Clongawney Bog is also located close to Birr. It was used as a forestry sites but also as a sampling site for natural wetland recolonisation, wooded mineral islands, newly recolonised cutaway, old grassland and uncut bog (see Figures 2.27, 2.28, 2.29, 2.30 and 2.31). Located within the Boora Bog Complex samples were taken on both young and old grassland and also on forested sites (see Figures 2.32 to 2.36).

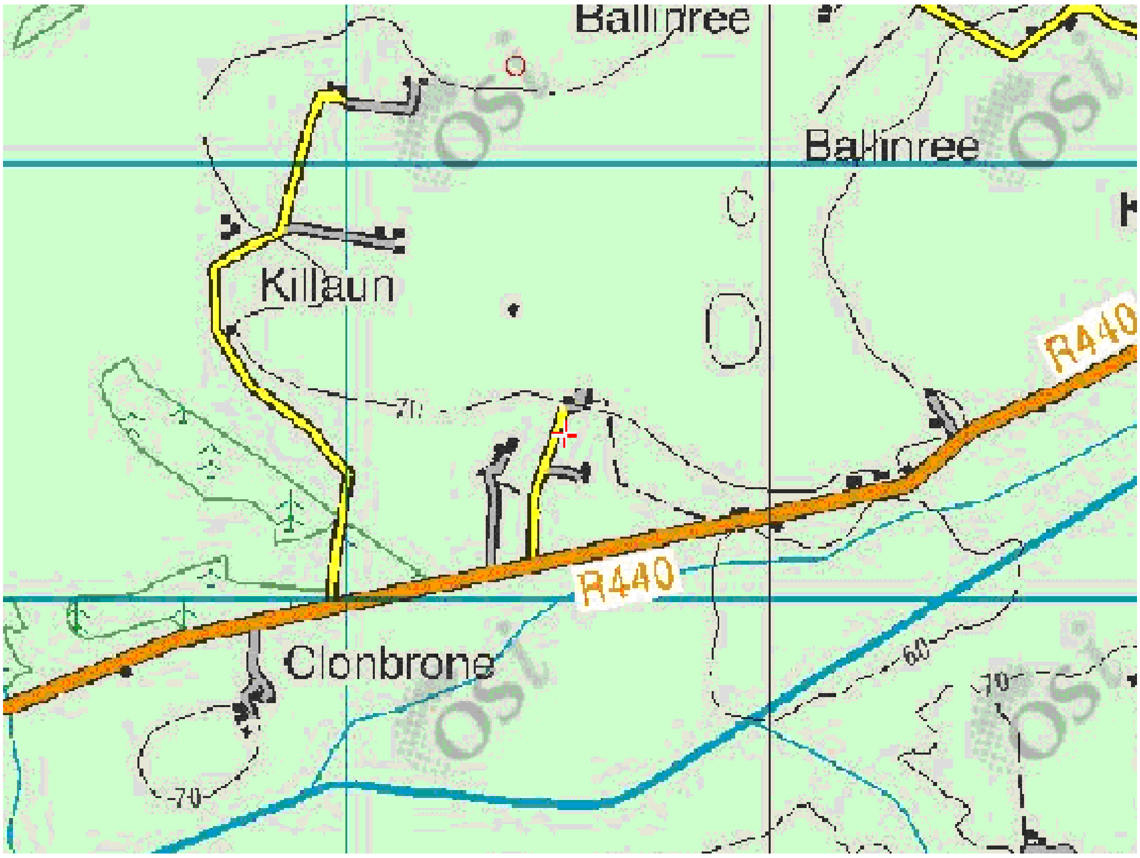


Figure 2.25. Ordnance Survey map showing the location of Killaun Bog, County Offaly

Figure 2.26. Killaun Bog, County Offaly

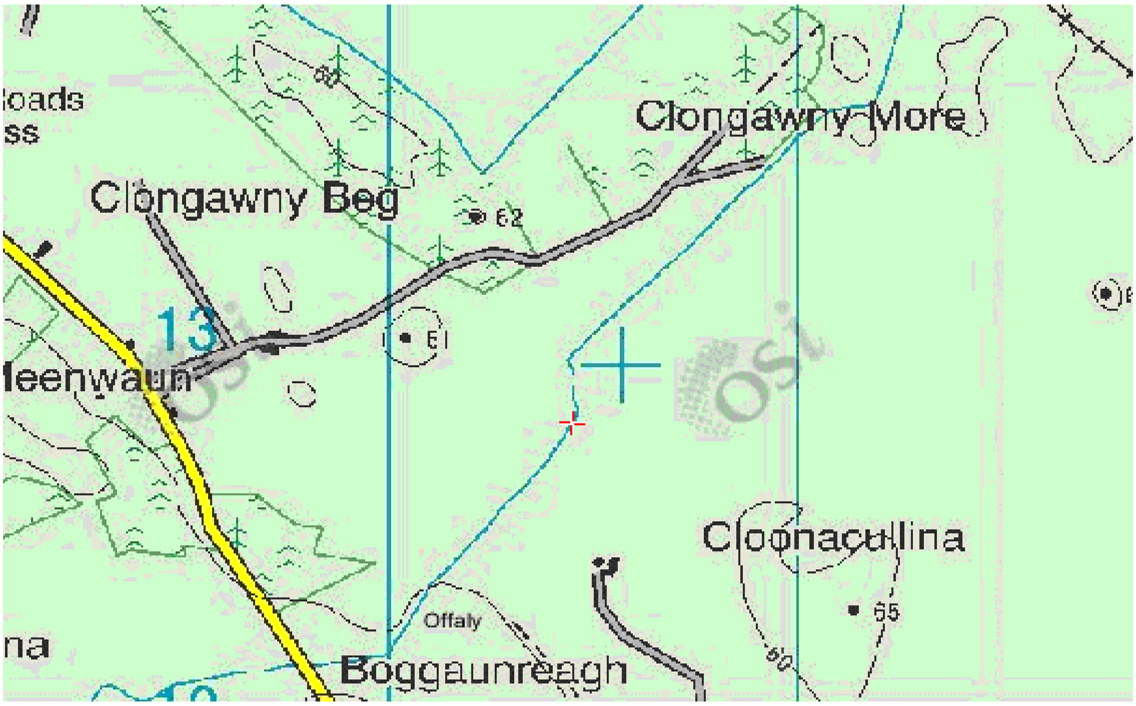


Figure 2.27. Ordnance survey map showing the location of Clongawney Bog, County Offaly

Figure 2.28. Clongawney Bog, County Offaly

Figure 2.29. Mineral Island in Clongawney Bog

Figure 2.30. A cutaway area in Clongawney Bog

Figure 2.31. Old grassland habitat in Clongawney Bog

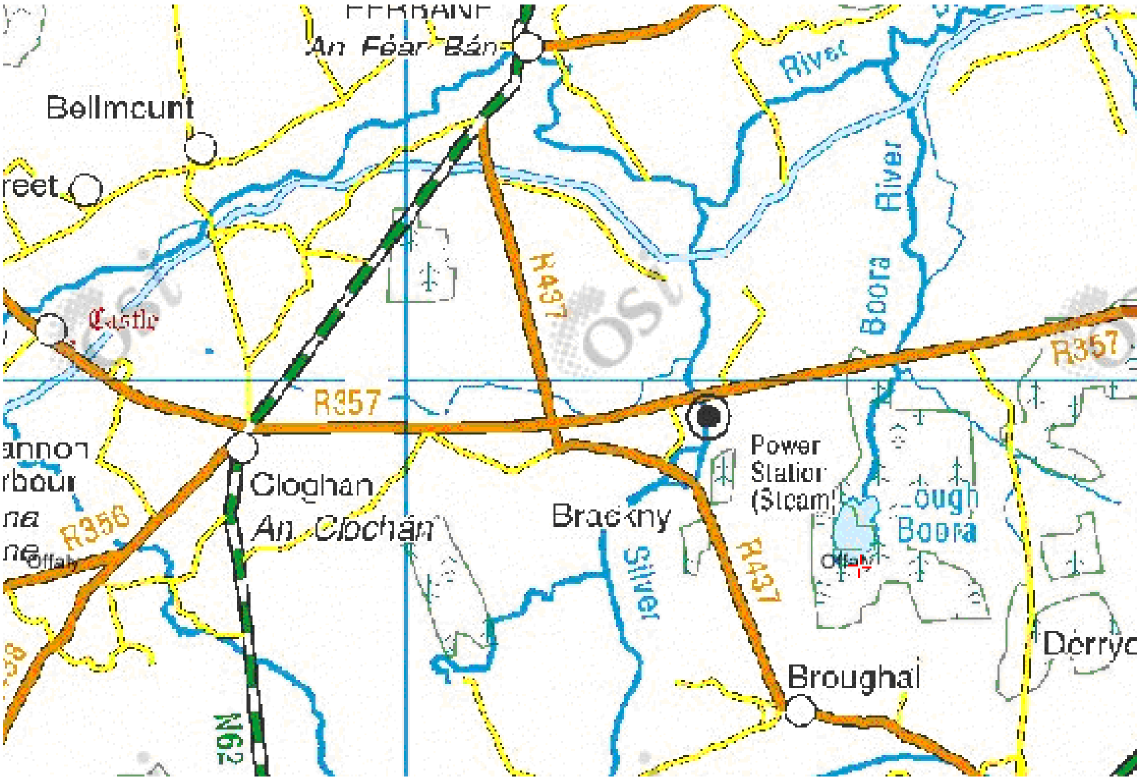


Figure 2.32. Ordnance Survey map showing the location of Lough Boora

Figure 2.33. Sitka spruce plantation in East Boora

Figure 2.34. Sitka spruce at Lough Boora

Figure 2.35. Forestry plantation at Tumduff, planted in1996

Figure 2.36. Forestry plantation at Tumduff, planted in 2000

2.1.1.7 Sites from which mites were sampled in 2009

Mongan Bog and Lodge Bog

Two sites were sampled in 2009, the sites were Mongan Bog and Lodge Bog. These sites were selected because they had intact, restored and cutaway habitats in close proximity. Mongan Bog is candidate special area of conservation (cSAC) and special protection area (SPA), it is located less than two kilometres from the River Shannon and is twelve kilometres south of Athlone. The site is part owned by An Taisce and Bord na Móna (see Figures 2.37 and 2.38). Lodge bog is part of the larger bog complex known as Lullymore and it located in county Kildare (see Figures 2.39 and 2.40). This site is owned by the Irish Peatland Conservation Council (IPCC).

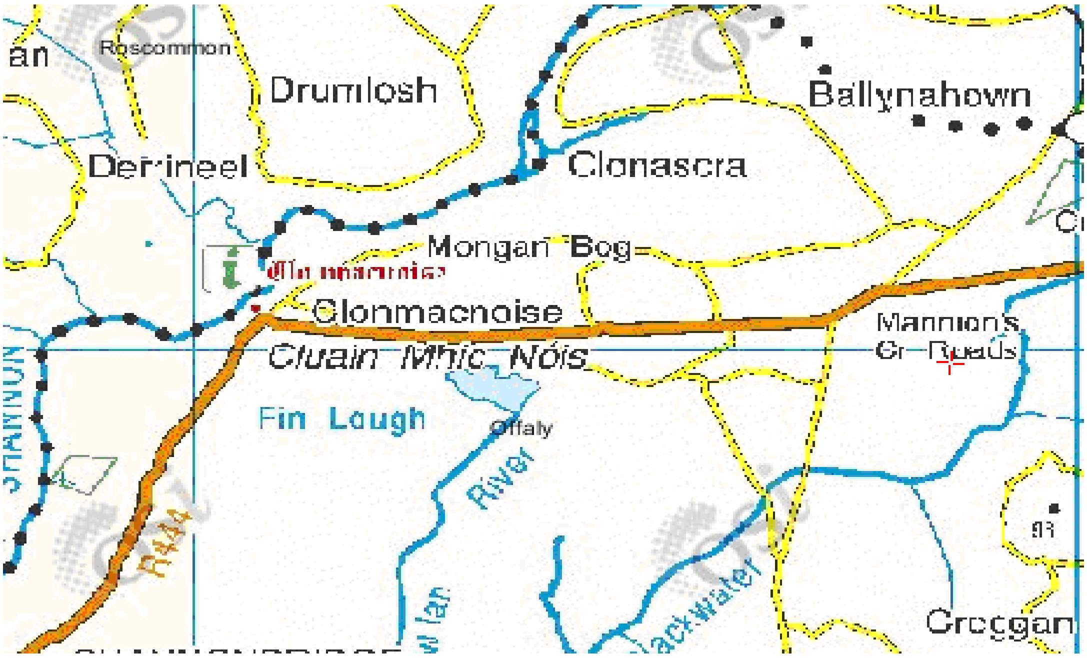


Figure 2.37. Ordnance survey map showing the location of Mongan bog


Figure 2.38. Mongan bog

Figure 2.39. Aerial view of Lodge bog, County Kildare


Figure 2.40. Lodge bog

2.2 Sampling and extraction methods

2.2.1 Sampling methods

Sampling was carried out for spiders and the carabids on the eleven core sites in April and August 2006 but mites were only sampled in April 2006. The carabid and spider fauna were sampled using pitfall traps. The mites were sampled using a soil corer which was 18cm in diameter and 20cm in depth. This size of core was used to allow for adequate sampling of the mites (Edwards 1991). Enchytraeids were sampled in May 2009 using a smaller corer of 6cm diameter and 5cm depth.

2.2.2 Sampling and extraction of mites

Soil cores were taken using a soil corer which was 18cm in diameter and 20cm in depth. Six of these large soil cores were taken at each site in pristine and disturbed habitats if these were present at the site being sampled. The cores were then placed in plastic buckets of a similar size to the cores to prevent squashing or damage which could kill the mites contained within the sample.

Once the soil cores had been transferred to the laboratory they were inverted into a plastic pot with a diameter of 18cm and containing a wire mesh size of $1cm^2$ - the purpose of the mesh was to prevent the soil core from falling into preservation fluid (ethylene glycol) which was contained at the on the bottom of the plastic pot. Approximately 100ml of this preservation fluid was used. The pots containing the cores were then placed in a thermostatically controlled infrared extractor for one week (Kempson *et al.* 1963) (see Figure 2.41). The heat produced by the infrared lamps causes the invertebrates in the soil core to move away from the heat source and into the preservation fluid below. On the first day the temperature in the extractor was set to 30°C, this was increased gradually over the week to final temperature of 70°C. This was done gradually in order to avoid heat shock which would kill the mites being sampled. The apparatus used for the extraction is known as a Kempson bowl extractor. After the samples had been left in the extractor for one week the extracts were sieved using a sieve (diameter of 53 microns). The invertebrates were then placed in specimen tubes with 70% industrial methylated spirits (IMS) for later sorting and identification.

Once the samples were sorted the mites were mounted on slides in lactic acid as a temporary mountant. Lactic acid helps clear the mites and thus structures are easier to see. Once identified the mites were put into permanent mounts using Hoyer's solution. The identification of the oribatid mites was done using Weigmann (2006) and Karg (1993)for the Gamasina.

Figure 2.41. The Kempson bowl extractor in use

2.2.3 Sampling and extraction of enchytraeids

The enchytraeids were sampled using a small corer of 6cm diameter and 5cm depth. Five samples were taken at each site in pristine and disturbed habitats if present. Once the cores were taken they were kept in a refrigerator (between 4ºC and 7ºC) until extraction could take place. Extraction of these worms could not take place all at once because the enchytraeids would die before they could all be identified and thus it was necessary to extract the worms on a daily basis. There is a certain amount of difficulty associated with the sampling and identification of enchytraeids which must be identified live and as therefore, once extracted, they must be identified as soon as possible especially the smaller species as these are likely to die due to heat exposure and over manipulation under the microscope.

Extraction of enchytraeids was carried out using the modified Baerman funnel method or the wet funnel method (O'Connor 1955), using a low heat level. Sudden temperature rise can cause death for enchytraeids (Latter and Howson 1978). This method uses a low level of heat from light bulbs that are present above the soil sample, the soil sample is placed in a sieve and is fully immersed in water (mineral water is best as it does not contain added elements such as chlorine and fluorine), the worms then move down the soil sample away from the heat source. Metal sieves were used initially but the metal elements present were toxic to the worms and thus plastic sieves and funnels were then used. Extraction takes approximately 1-2 hours. Once the worms were extracted they were stored in specimen tubes containing distilled water and refrigerated at 2-5ºC. Identification is best done on live specimens and the use of a microscope with interference contrast optics but the specimens can be preserved using hot Bouin's fluid (Schmelz 2003). Figure 2.42 shows the apparatus used.

The identification of Enchytraeidae was done using Schmelz and Collado (2009) and Chalupsky (1992).

Figure 2.42. Modified Baerman Funnel Apparatus used for the extraction of enchytraeids

2.2.4 Pitfall trapping

The Carabidae and Araneae were sampled by placing six pitfall traps randomly at each site and in both the intact and restored areas where they were available. Pitfall traps are smooth-sided containers that are sunk into the ground. Each trap consisted of a plastic cup 6cm diameter and 8cm deep, containing ethylene glycol (see Figure 2.43). A bulb planter was used to make the holes for the traps and a roof was placed over each trap to prevent them becoming flooded during heavy rainfall. This roof was constructed using a linoleum tile and three large nails to prop it up over the trap. The traps were left open for between four and seven days for the sites sampled in 2006 and in 2007 the traps were left for a period of one month. After collection the pitfall traps were emptied, sieved and sorted and the invertebrates were placed in specimen tubes with 70% IMS for later identification.

Identification of the carabid fauna began as soon as all the pitfall traps had been sorted. The carabid fauna were identified to species level following Luff (2007) and Lindroth (1974). Spider identification was done following Roberts (1993) and Roberts (1995).

Figure 2.43. An example of a pitfall trap and a roof

2.3 Statistical analysis

Analysis of the invertebrate taxa was carried out using multivariate analysis. This was used to detect whether differences occurred in the species assemblages found in the different peatland types and in the peatlands that have varying degrees of disturbance or that have been restored. The forms of analysis used include Detrended Correspondence (DCA) Redundancy Analysis (RDA) and Canonical Correspondence Analysis (CCA) (ter Braak 1986). The specific forms will be indicated as the results are presented.

All the data used in statistical analysis were compiled and stored in Excel 2003. SAS was used to carry out the analysis for a Kruskal – Wallis test for the mite data.

Ordination

Ordination can be used as a means of visualising species and samples in relation to environment variables such as habitat type. Ordination does this by using a broad range of statistical algorithms, this constructs a variable which best describes or is indicative of the species/samples dataset (ter Braak and Prentice 1988). The gradient is then termed the first axis of the ordination. CANOCO has been used here as the ordination program (version 4.5).

Detrended Correspondence Analysis (DCA)

Detrended correspondence analysis is an indirect gradient analysis technique. In indirect gradient analysis environment gradients are not studied directly but are implied in the species composition data (Palmer 1993). Indirect analysis is useful for determining factors relating to community structure. DCA is an average weighting ordination technique which means you can simultaneously include site and species. The data is unconstrained in this method and thus provides and overview of the compositional gradient found in the data (Lepš and Šmilauer 2003) DCA was used in this study as a preliminary investigation of species present in different habitats.

Canonical Correspondence Analysis (CCA)

Canonical correspondence analysis is a direct gradient analysis technique which provides a species-environment relationship by assuming a response model that is common to all species the assumption is that there are underlying environmental variables to which the species respond. CCA focuses on relationships between species and measured environmental variables (ter Braak 1986). Species composition of samples are shown as unimodal models with the environmental variable or variables that are to be investigated. An ordination diagram can then be used where sites and species are represented by points and environmental variables are represented by arrows or vectors. The vectors produced by the environmental variables indicate the direction, rate of change and distribution of the species and the samples along the gradient (ter Braak 1986; Palmer 1993). In this study CCA was used to investigate whether the different peatland types were specific to certain species of invertebrates and whether the varying habitat fragmentation on the peatlands investigated had an affect on species composition.

CCA is used as it provides a more in-depth type of analysis of data than DCA as the statistical significance of the first ordination axis and the other axes can be analysed using Monte Carlo permutation tests. CCA can also give you the option of factoring out environmental variables to reduce variation and these can then be selected as covariables. It is an invaluable method for the interpretation of species in relation to their environmental variables.

Redundancy Analysis (RDA)

Redundancy Analysis (RDA) is a direct gradient analysis technique. RDA is a constrained type of ordination. In constrained ordinations the ordination axes are weighted by the sums of the environmental variables (Lepš and Šmilauer 2003). RDA selects the linear combination of the environmental variables that gives the smallest total residual sum of squares (Jongman *et al.* 1987). RDA is a type of multivariate regression (Palmer *et al.* 2008). The ordination diagram produced when using RDA can be interpreted as a biplot. RDA was use for this study in the same way that CCA was but RDA was used when datasets were not as large and thus the length of the gradients were smaller.

3. Results

3.1 Mites

3.1.1 Survey of the core BOGLAND sites

Seventy species of mite were found among the 5,265 individuals identified. Fifty-three of these were oribatid mites (Cryptostigmata) and seventeen were species of Gamasida (Mesostigmata). The numbers of species found at individual sites varied from nine from the Atlantic Blanket Bog at Ballygisheen to thirty-seven from a raised bog at Sharavogue (Table 3.1). There was no consistent difference in the richness of the fauna in the various peatland types.

Table 3.1. Site name, bog type and number of each mite taxon found in May 2006

Site Name	Bog type	Oribatida	Gamasida
Fiddandary	Mountain blanket	21	1
Kippure	Mountain blanket	14	0
Glenlahan	Mountain blanket	17	1
Sharavogue	Raised bog	37	2
Clara	Raised bog	12	2
Carrowbehy	Raised bog	16	2
Knockmoyle	Atlantic blanket bog	20	6
Owenirragh	Atlantic blanket bog	23	2
Ballygisheen	Atlantic blanket bog	9	0
Pollardstown	Fen	15	6
Bellacorrick	Fen	17	2

Oribatids are the most abundant mites found in peatlands because they are tolerant of the acidic conditions therefore it was not surprising that all of the most abundant species found were oribatids. *Nanhermannia dorsalis* was the most abundant species, 1,487 of this species were collected and it occurred in seventy-two samples. *Platynothrus peltifer* occurred in sixty-three samples and 470 of this species were collected, the next most widespread species (ie. it occurred in many samples) was *Parachipteria punctata*, 326 of which were collected. *Ceratoppia bipilis* was found in 41 samples and 188 individuals were collected. *Chamobates schuetzi* was the second most abundant species after *Nanhermannia dorsalis* and occurred in forty samples, *Hypocthonius rufulus* occurred in forty samples and 254 of this species were collected; *Nothrus silvestris* occurred in 30 samples and 258 specimens were collected; *Carabodes willmanni* occurred in 28 samples with 415 of this species collected; *Banksinoma lanceolata* also occurred in 28 samples and 130 of these mites were collected, only 77 *Opiella nova* were collected but it occurred in twenty-two samples. The genus *Limnozetes* occurred in relatively small numbers, but it is worth noting as it is hygrophilous and is a characteristic genus of moors and bogs (Schatz and Behan-Pelletier 2007; Weigmann 2006). Three species from this genus were recorded. *Limnozetes sphagni*, *Limnozetes amnicus* and *Limnozetes ciliatus*. *Limnozetes sphagni* only occurred in two samples with only fourteen specimens being collected, *Limnozetes amnicus* occurred in eight samples and 25 specimens were recorded, and *Limnozetes ciliatus* was found in seven samples and 20 of this species were recorded.

The most abundant mesostigmatic mite was *Cilliba cassidea*, it was found in 14 samples and 49 specimens were recorded. The next most abundant was *Platyseius italicus*, 22 specimens were recorded but this species was only found in two samples. Fifteen individuals of *Platyseius subglaber* were found in four samples. *Pergamasus robustus* then followed, with eight specimens collected and this species occurring in six samples. The abundance and diversity of mesostigmatic mites was low. Table 3.2 and 3.3 give a species list of the total number of both Cryptostigmata and Mesostigmata mites found in the core BOGLAND sites.

Table 3.2. Species list of the 53 Cryptostigmata mites recorded from peatland habitats that were sampled in 2006

Species and authority
Adoristes ovatus (Koch, 1839)
Adoristes poppei (Oudemans, 1906)
Banksinoma lanceolata (Michael, 1885)
Carabodes labyrinthicus (Michael, 1879)
Carabodes marginatus (Michael, 1884)
Carabodes ornatus Storkan, 1925
Carabodes willmanni Bernini, 1975
Ceratoppia bipilis (Hermann, 1804)
Chamobates cuspidatus (Michael, 1884)
Chamobates schuetzi (Oudemans, 1902)
Eupelops acromios (Hermann, 1804)
Eupelops plicatus (C.L. Koch, 1835)
Euphthiracarus sp.
Fuscozetes fuscipes (Koch, 1844)
Fuscozetes sp.
Heminothrus peltifer (C.L. Koch, 1839)

Table 3.2 cont'd. Species list of the 53 Cryptostigmata mites recorded from peatland habitats that were sampled in 2006

Hydrozetes lacustris (Michael, 1882)
Hydrozetes sp.
Hypocthonus rufulus C.L. Koch 1835
Latilamellobates incisellus (Kramer, 1897)
Lauroppia fallax (Paoli, 1908)
Liacarus sp.
Liebstadia similis (Michael, 1888)
Limnozetes amnicus Behan-Pelletier, 1989
Limnozetes ciliatus (Schrank, 1803)
Limnozetes sp.
Limnozetes sphagni (Michael 1884)
Malaconothrus egregius (Berlese, 1904)
Minunthozetes semirufus (Koch, 1841)
Medioppia subpectinata (Oudeman, 1900)
Melanozetes sp.
Nanhermannia dorsalis (Banks, 1896)
Nothrus silvestris Jacot, 1937
Ololaelap sp.
Opeilla falcata (Paoli, 1908)
Opeilla nova (Oudemans, 1902)
Oribatula tibialis (Nicolaet, 1855)
Parachipteria punctata (Nicolet, 1855)
Peloptulus sp.
Peloptulus montanus Hill 1914
Peloptulus phaeonotus (Koch, 1884)
Pergalumna nervosum (Berlese, 1914)
Phthiracarus affinis (Hull,1914)
Phthiracarus anonymus Grandjean 1933
Phthiracarus clavatus Parry, 1979
Platynothrus peltifer (C.L. Koch 1839)

Table 3.2 cont'd. Species list of the 53 Cryptostigmata mites recorded from peatland habitats that were sampled in 2006

Ramusella elliptica (Berlese, 1908)
Rhysotritia duplicata (Granjean, 1953)
Steganacarus magnus (Nicolet, 1855)
Steganacarus michaeli Bernini and Avanzati, 1987
Suctobelbella subcornigera (Forsslund, 1941)
Tectocepheus minor Berlese 1903
Tectocepheus pilatus Berlese 1895

Table 3.3 Species list of the seventeen Mesostigmata mites recorded from the peatland habitats sampled in May 2006

Species and authority
Cilliba cassidea (Hermann, 1804)
Geholaspis mandibulares (Berlese, 1904)
Leptogamasus sp.
Lysigamasus celticus Bhattachar, 1963
Macrocheles submotus Falconer 1924
Paragamasus robustus (Oudemans, 1902)
Paragamsus similis (Willman, 1953)
Paragamasus sp.
Pergamasus sp.
Pergamasus crassipes (Linne, 1758)
Pergamasus septrionalis Oudemans, 1902
Platyseius italicus (Berlese, 1905)
Platyseius subglaber (Oudemans, 1902)
Veigaia cerva (Kramer, 1876)
Veigaia kochi (Tragardh, 1901)
Veigaia transisalae (Oudemans, 1902)
Zercon zelawaiensis (Sellnick, 1944)

3.1.2 Comparison of assemblages in different peatland types

Ordination analysis was used to illustrate the patterns of variation in the species data and to determine whether these were related to peatland type. The results are presented graphically and, in the ordination plots, the sites, samples and species are ordered based on the similarity or dissimilarity of their distributions, i.e. those that are furthest apart are most dissimilar. All of these analyses were carried out using CANOCO for windows, version 4.53, (ter Braak 2004).

Redundancy analysis (RDA) was used to analyse the data from the first survey because the amount of variation and turnover in species was small (length of gradient of first axis of DCA was 2.91). In order to take into account the fact that some sites had both intact and restored subsites, the statistical comparison of peatland type was carried using peatland condition (intact/restored) as a co-variable (blocking factors).

This analysis showed that the assemblages in raised bog were different (but not significantly so) from those occurring in the other peatland types (Figures 3.1 and 3.2, Table 3.4). These differed particularly from the assemblages occurring in Mountain Blanket Bog.

This analysis shows that there is a separate group of species associated with raised bog habitats that are not found in the other peatland types. However, the difference between raised bog and the three other peatland types was not significant ($P < 0.06$). The species that were found particularly in the raised bog habitat were *Carabodes marginatus, Carabodes ornatus, Carabodes labyrinthicus, Rhysotritia duplicata* and *Phthiracarus clavatus*. Although these species were different from the species found in the three other peatland types, they were rare and their overall abundance on the raised bog was very low. In fact, the species that were found on raised bogs appear characteristic of particular sites rather that a certain peatland habitat.

By contrast, species such as *Phthiracarus affinis*, *Phthiracarus anonymus* and *Medioppia subpectinata,* which were found in Atlantic blanket bogs, were not found in the raised bogs. There was no significant difference between intact and restored areas ($F = 0.877$, $P = 0.25$)

Table 3.4. RDA Statistics for the comparison of mite assemblages in peatlands using automatic selection of environmental variables and restored/intact as the blocking factors. The table at the top, headed marginal effects, lists the individual environmental variables in order of the variance they explain singly (λ1). The table at the bottom, headed conditional effects, shows the environmental variables in order of their inclusion in the model, together with the additional variance each variable explains at the time it was included (λ-A) and the significance of the variable at that time (P-value).

	Marginal Effects			
Variable	Variance N	λ1		
Raised	1	0.14		
MBB	2	0.07		
Fen	4	0.05		
ABB	3	0.02		
	Conditional Effects			
Variable	Variance N	λA	P	F
Raised	1	0.14	0.062	2.81
Fen	4	0.06	0.274	1.22
MBB	2	0.02	0.842	0.33

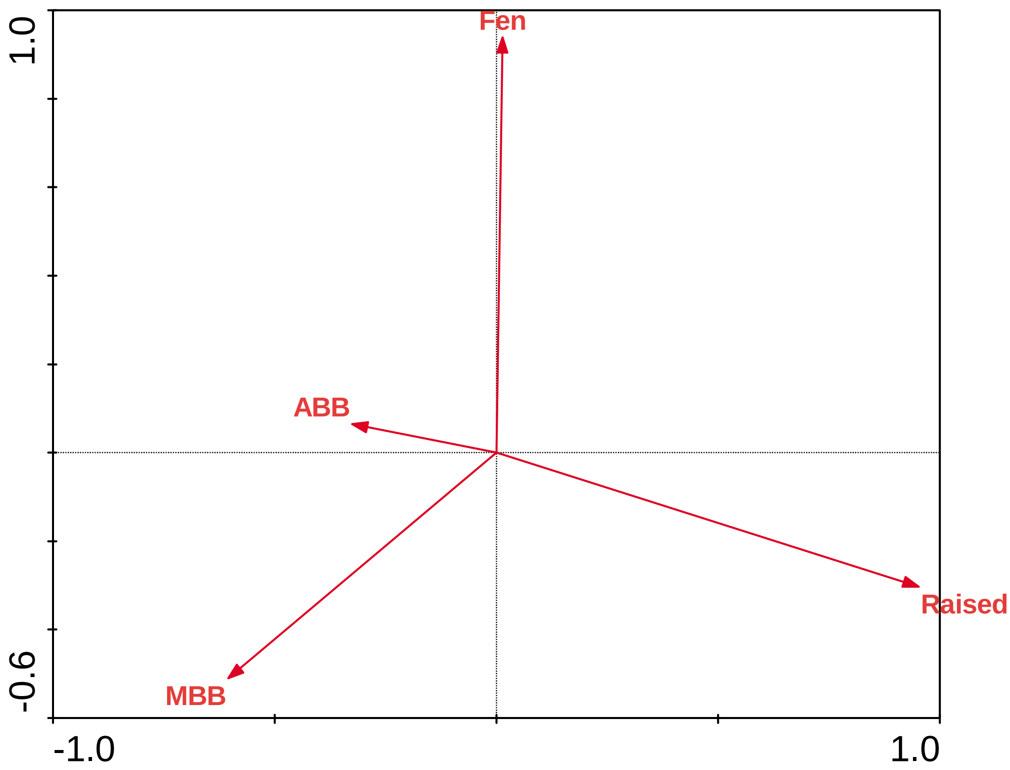


Figure 3.1. RDA analysis of all environmental variables examined in 2006 for all BOGLAND mites with intact/restored as the blocking factor; ABB, Atlantic blanket bog and MBB, mountain blanket bog

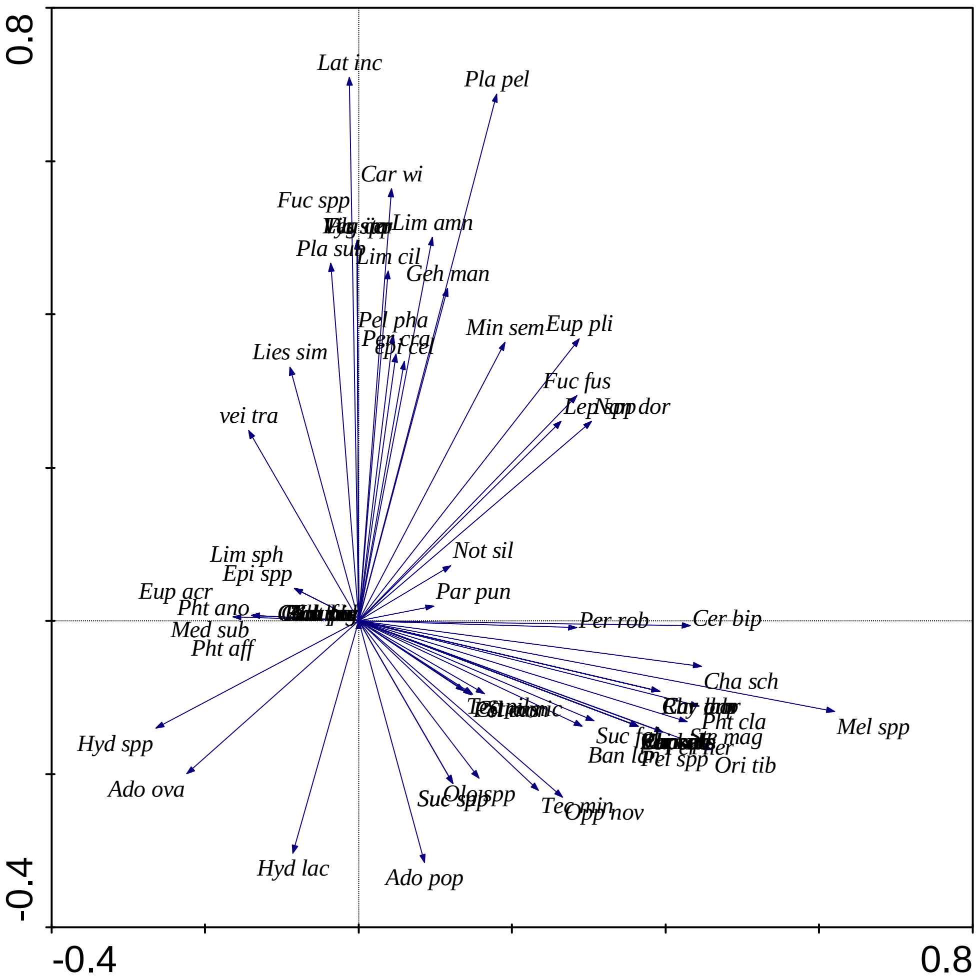


Figure 3.2 RDA of all the mite species found in all peatland habitats sampled in 2006 with intact/restored as the blocking factor (the full names of the abbreviated species are given in appendix 1)

3.1.2.1 Comparison based on Cryptostigmata mites alone

The analysis of the environmental variables produced the same results with the raised bog habitat being different (when $P < 0.06$) (Figure 3.3) from the other three habitats; mountain blanket bog (MBB), Atlantic blanket bog (ABB) and Fen. The oribatid mite data from 2006 were analysed on their own (Figure 3.4) It is clear that the raised bog habitat is somewhat different from the other habitats and this is illustrated by the arrow that indicates the raised bog pointing in the opposite direction to the other habitats (see Table 3.5 for test statistics). Given that all of the species which were particularly associated with raised bog in the previous analysis were oribatids, it is obvious that the same species would be identified here. There was no significant difference between intact and restored sites (F = 0.32, P= 0.75).

Table 3.5. RDA Statistics for the comparison of Cryptostigmata mite assemblages in peatlands using automatic selection of environmental variables and restored/intact as the blocking factors (For further details see legend on Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Raised	1	0.15		
MBB	2	0.07		
ABB	3	0.03		
Fen	4	0.02		
	Conditional Effects			
Variable	Variance N	λA	P	F
Raised	1	0.15	0.060	3.12
MBB	2	0.03	0.636	0.59
ABB	3	0.02	0.750	0.32

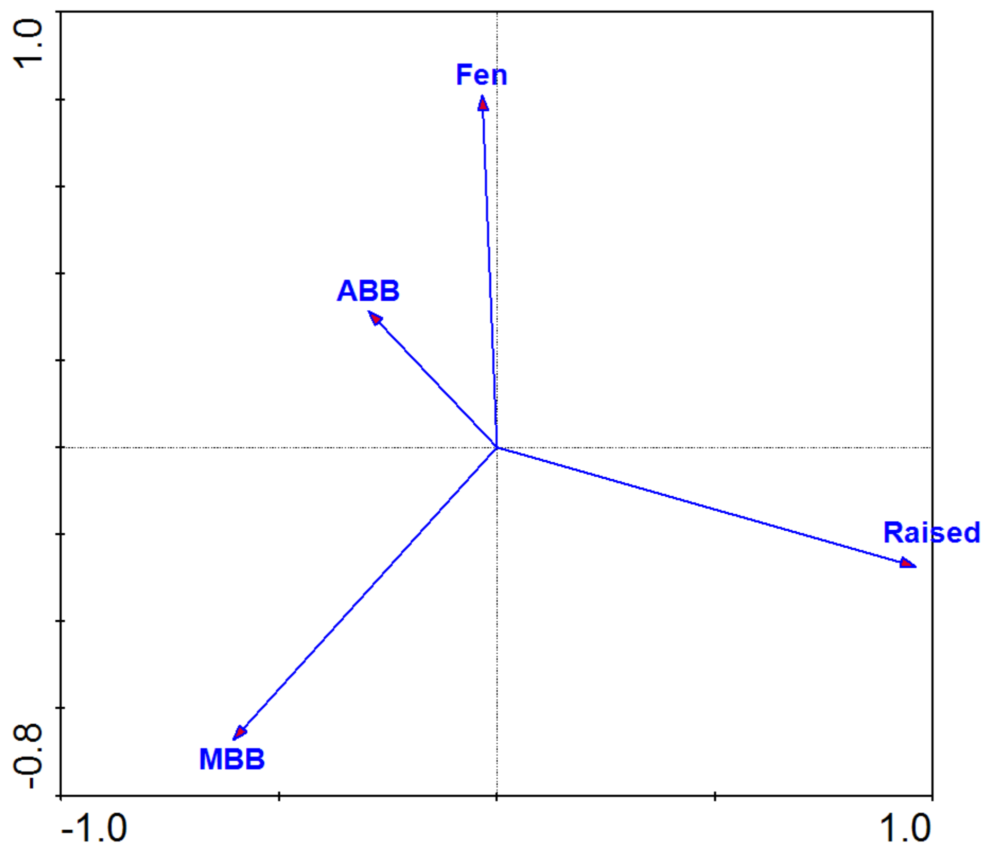


Figure 3.3. RDA of oribatids mites and the environmental variables for the oribatid mite data collected in 2006 with restored/intact as blocking factors (MBB, mountain blanket bog; ABB, Atlantic blanket bog)

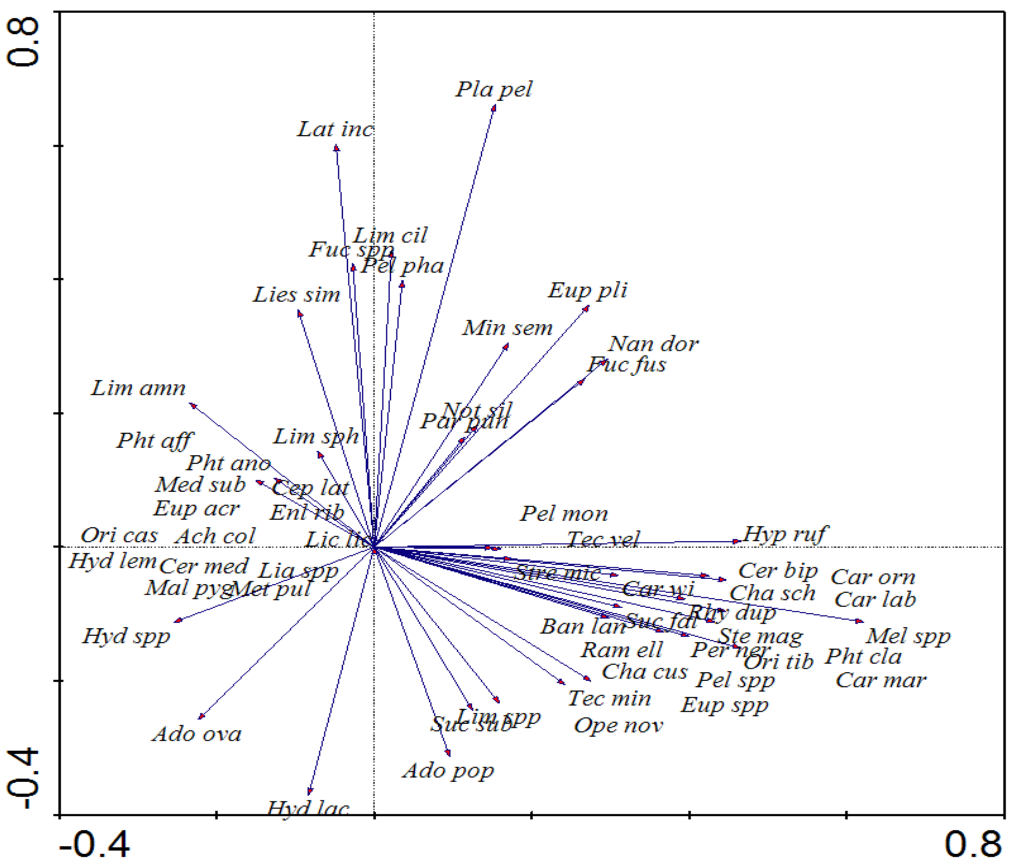


Figure 3.4. RDA ordination plot for the oribatid mite species data from the samples taken in 2006 with restored/intact as the blocking factors (the full names of the abbreviated species are given in appendix 1)

3.1.2.2 Comparison based on Mesostigmata mites alone

In the case of the Mesostigmata, the analysis indicates that the fen sites were the least similar to all of the other sites, this is indicated by the distance that the fen sites are from all the other sites (Figures 3.5, 3.6). Although this difference was not significantly different (Table 3.6), the fens contained one species (*Veigaia cerva*) which did not occur on any other sites. *Geholaspis mandibularis* and *Platysieus subglaber* were most abundant at the fen sites. There was no significant difference between intact and restored areas (F = 3.67, P = 0.1140).

Table 3.6. RDA Statistics for the comparison of Mesostigmata mite assemblages in peatlands using automatic selection of environmental variables and restored/intact as the blocking factors (For further details see legend on Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Fen	4	0.18		
ABB	3	0.05		
MBB	2	0.04		
Raised	1	0.03		
	Conditional Effects			
Variable	Variance N	λA	P	F
Fen	4	0.18	0.148	3.67
MBB	2	0.04	0.376	1.00
Raised	1	0.01	0.956	0.13

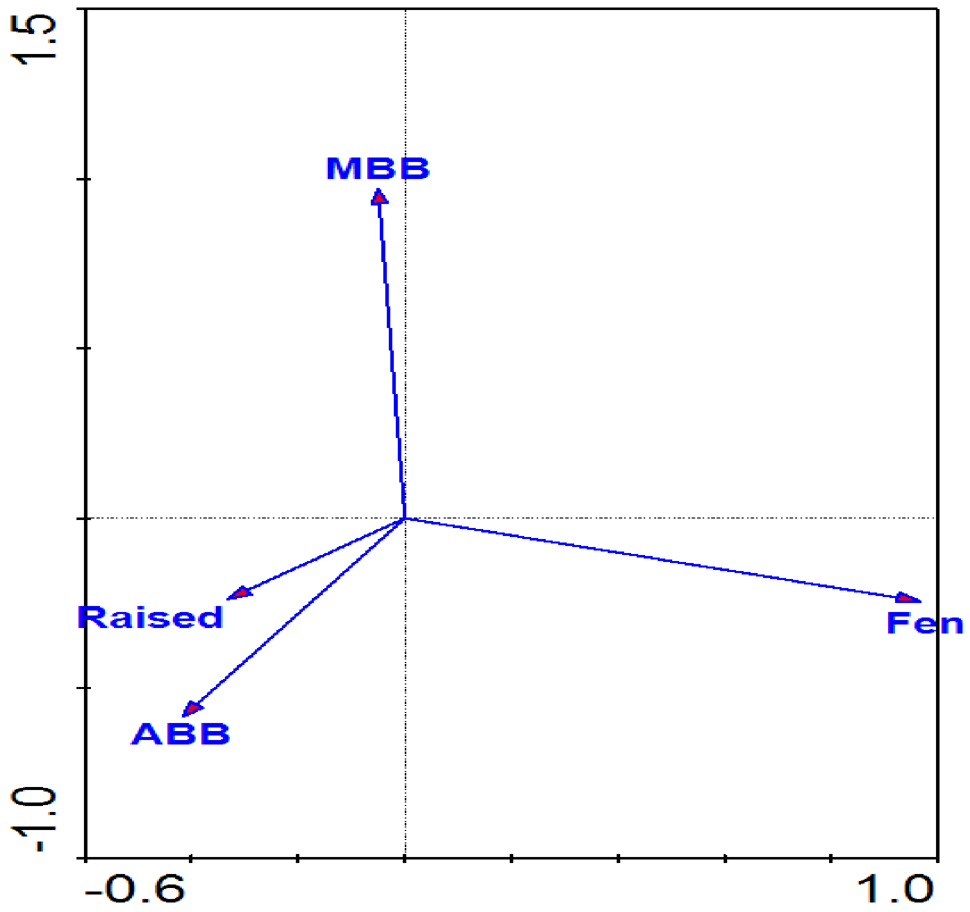


Figure 3.5. An RDA ordination plot of the environmental variables investigated for the Mesostigmata in 2006 with intact/restored as the blocking factors

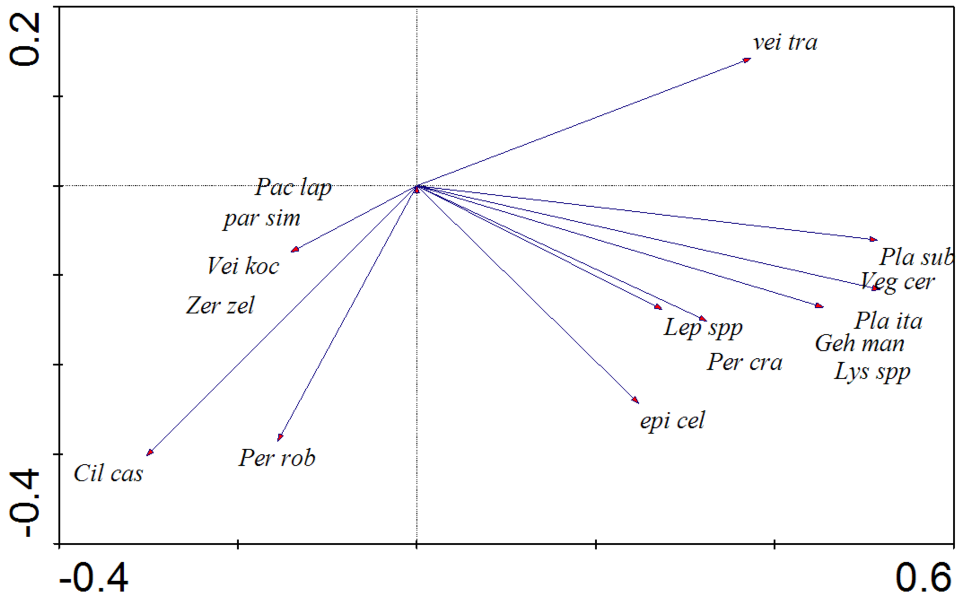


Figure 3.6. RDA ordination plot of the species of Mesostigmata recorded in 2006 with restored/intact as the blocking factors (the full names of the abbreviated species are given in appendix 1)

3.1.3 Analysis of data sets from other sources

The results from the 2006 sampling suggest that, while there is some systematic variation between the mite species occurring in the various peatland types, most species recovered occurred in a range of types. In order (a) to determine whether peatland species vary from those occurring in other Irish habitats and (b) to determine whether those occurring in Irish peatlands are similar to those found elsewhere in similar habitats, analyses were carried out on datasets recovered either from the literature or directly from other projects. The details of these datasets will be given as they are introduced and used.

3.1.3.1 Analysis of the mite data gathered from the CréBeo Project

The CréBeo, project, formally entitled *'Baseline data, response to pressures, functions and conservation of keystone micro- and macro-organisms in Irish soils'* was a large-scale national project funded by the Irish EPA to provide soil biodiversity baseline data for Ireland. In this project the mites from 60 sites were sampled and identified. Samples from forty eight sites were available for analysis here. The sites from which the mites were sampled were divided into a number of habitat types - peatland, pasture, arable land and forestry. The mite identification was conducted at UCD by Dr. Julio Arroyo.

The habitat types that were considered, peat, pasture, arable and forest, all had a significant effect on the abundances of mites (Kruskal-Wallis Test: $H = 11.02$, $p = 0.01$). When Cryptostigmata and Mesostigmata were examined separately, the results were found to be significant, for Cryptostigmata $H = 9.7$, $P = 0.02$ (Figure 3.7a), and for the Mesostigmata $H = 8.2$, $P = 0.04$ (Figure 3.7b). Cryptostigmata were most abundant in the peat and forest habitats with 68.8 and 50.4 individuals per $100cm^3$ of soil (Figure 3.7a). Mesostigmata were most abundant in the forest habitat with 9.7 individuals per $100cm^3$ of soil (Figure 3.7b).

The mean richness of mite taxa was also investigated for the habitat types and was found to be significantly different ($H = 14$, $P = 0.003$) (Figure 3.8a). The mean Cryptostigmata taxon richness was greatest in the forest habitat ($H = 14.1$, $P = 0.0027$). The mean number of Cryptostigmata recorded in each habitat type was similar in peat and pasture and the lowest taxon richness was recorded in the arable habitat. Mean Mesostigmata taxon richness was greatest in the forest habitat ($H = 8$, $P = 0.04$) (Figure 3.8a), with lower numbers of taxa being recorded in all the other habitats (Figure 3.8b). The total number of Mesostigmata taxa recorded was greatest in the forest site (Figure 3.8b).

Ordination analysis of the data from the Crébeo project

In the CréBeo study, the total number of mite species collected across the four habitat types was seventy-six; fifty-five Cryptostigmata (oribatid mites) and twenty-one Mesostigmata. Of the 48 sites examined 5 were peats. Twenty-three oribatid species were recorded from the peat habitats as well as five species of Mesostigmata. When the species lists were compared to the BOGLAND species list it was found that there were only twelve Cryptostigmata species and three Mesostigmata species occurred on both lists.

The most abundant species of mite found across all habitats in CréBeo was *Opiella nova*, a Cryptostigmata mite and it was found in 14 sites and across all the habitats sampled. The next most abundant was *Ramusella clavipectinata* with 84 of this species recovered and with ten occurrences, and it was found in all habitat types, the next was *Nanhermannia dorsalis*, with 73 collected and twelve occurrences, this again occurred in all the habitat types, then *Parachipteria punctata*, with 66 recorded and found in eight samples, this species although found in all the habitats, there were very low numbers of individuals found in the arable habitats in comparison with the abundances found at the other three

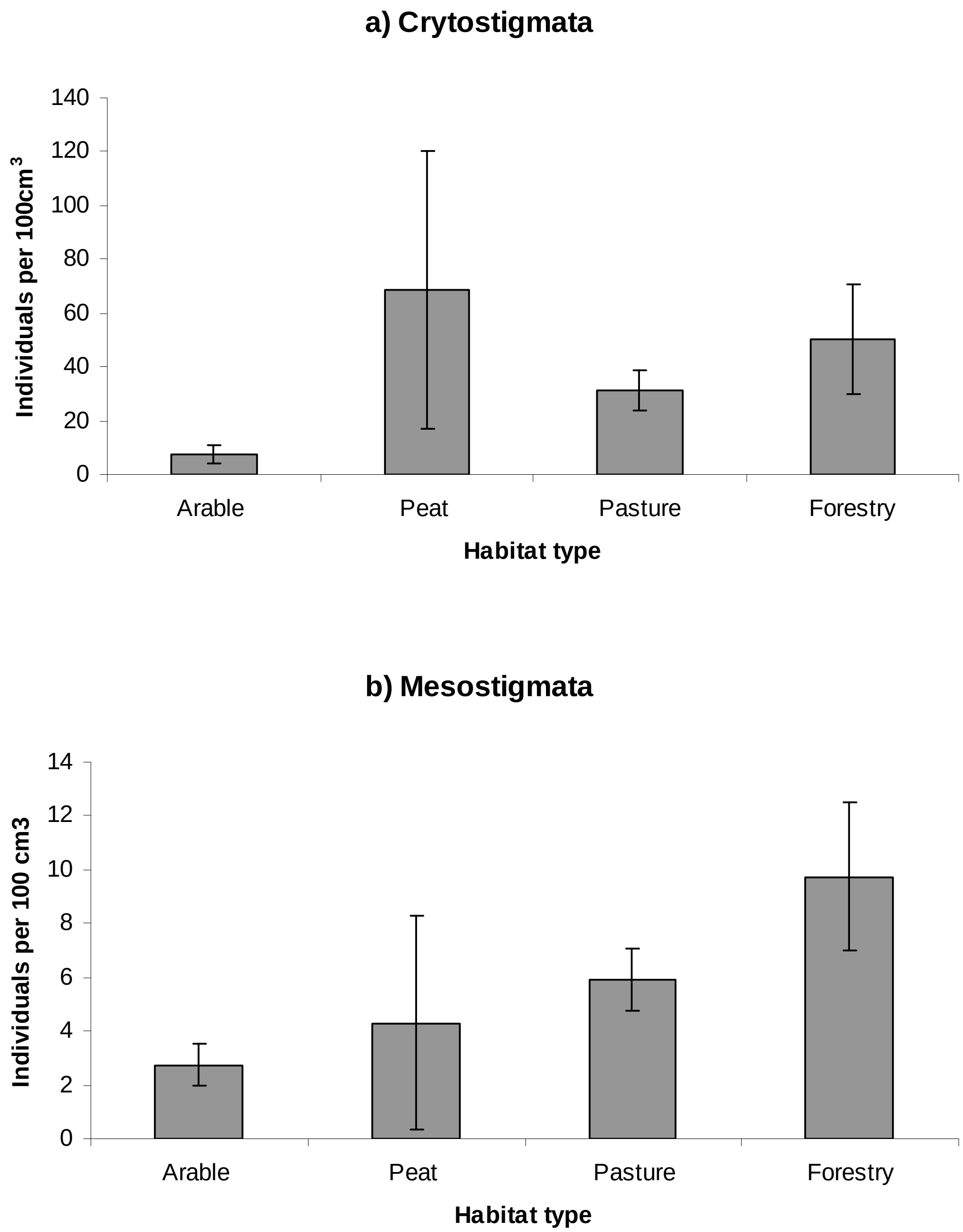
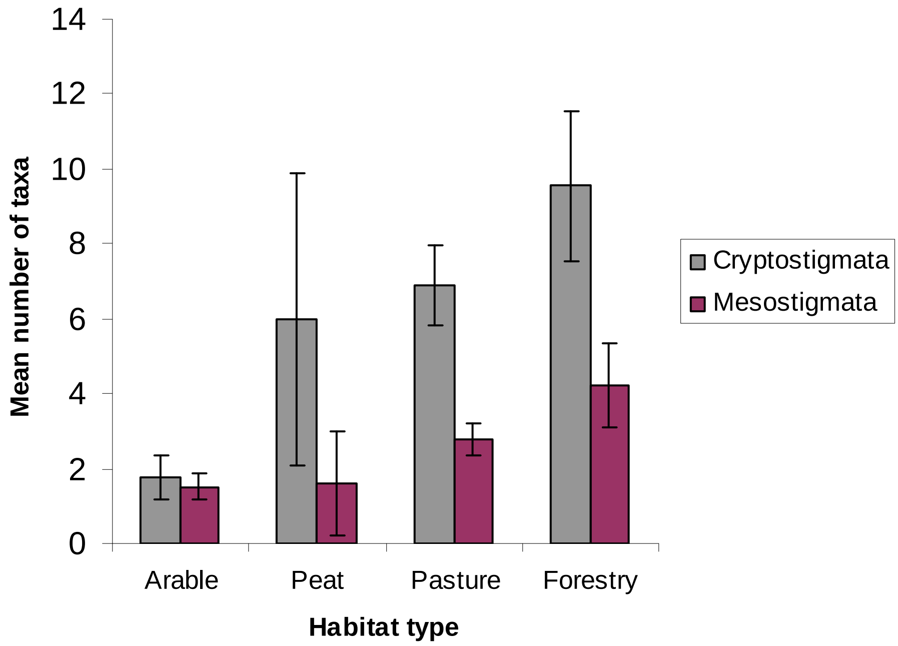


Figure 3.7. a) Cryptostigmata and b) Mesostigmata mite abundance by habitat. Data are means; error bars = 1 s.e.

a)



b)

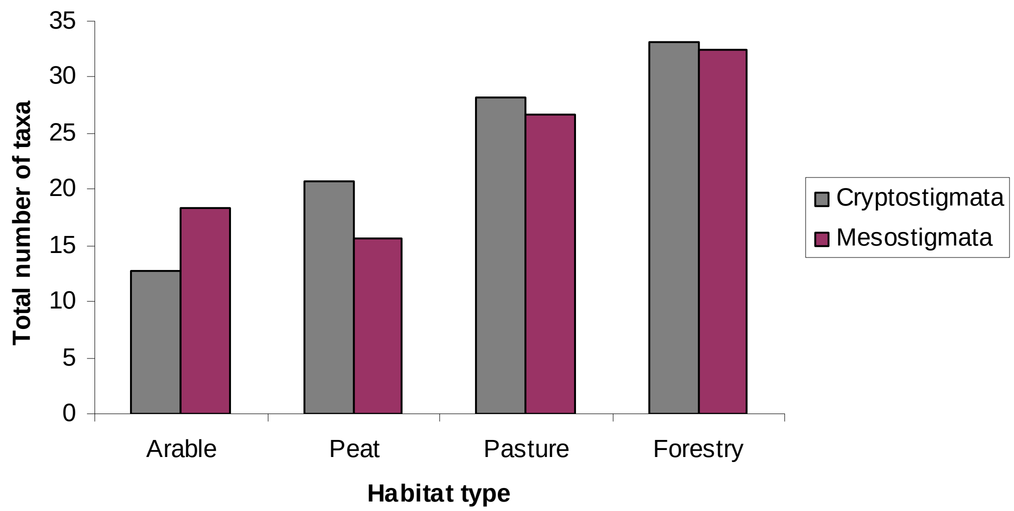


Figure 3.8. Mite diversity by land use class (separated into Cryptostigmata and Mesostigmata). a) mean number of taxa, and b) total number of taxa recorded within each habitat type. Total number of taxa is the sum of taxa recorded within a habitat; other data are means; error bars = 1 s.e.

habitats. The next most abundant, with 52 recorded and thirteen occurrences was *Minunthozetes semirufus*, then *Platynothrus peltifer* which also had 52 recorded, but it is worth nothing that it occurred in 17 samples the highest amount for all species, although it occurred in the most often in the samples it was absent in the arable habitat. *Pantelozetes paolii* was recorded in nine samples and 50 of them were recorded, this species occurred in all habitats. Forty-six *Medioppia subpectinata* were recorded and it was found in thirteen samples and in all habitats.

By contrast to those species mentioned above which occurred in essentially all habitats, there was also a group of relatively common species which did appear to have habitat preferences. Fifty-four individuals of *Phthiracarus affinis* were found in five samples, but it was only recorded in the pasture and peat sites, none of this species was found in arable and forest sites. *Achipteria coleoptrata*, was the next most abundant with 42 collected and this species found in eight sites, but it was found only in the pasture and peat habitat, and in the peat habitat only one individual was found. The next most abundant was *Liebstadia similis* with 34 recorded and seven occurrences, but none of this species occurred at the arable site. Thirty-four *Tectocepheus velatus* were recorded and it was widespread and found in twelve samples but did not occur in the peat samples. These abundances were all for oribatid mites.

The most abundant Mesostigmata mite recorded was *Paragamasus similis* with 17 recorded and it was also the most widespread as it was found in nine samples. The next most abundant species was *Rhodacarus roseus* of which 17 individuals were recorded but with only eight occurrences, the next most abundant species was *Lysigamasus vagabundus* with 15 of this species recorded and found in seven samples. *Veigaia nemorensis*, with 14 recorded and found in six samples, then *Dinychus perforatus* with eleven recorded and seven occurrences, *Uropoda minima* was next with ten and found in five samples, then *Pergamasus crassipes* with nine and six occurrences and *Pergamasus robustus* with seven recorded but also occurring in six samples. The number of species of Mesostigmata was low and the overall abundance was also low in comparison with the oribatids.

Analyses of these data indicate that the assemblages occurring in peatland are significantly different from those occurring in other habitats (Table 3.7, Figure 3.9). The difference appears to be particularly great with the fauna of forests but the eigenvalues for the two first axes are similar (λ_1 = 0.496 and λ_2 = 0.367) indicating similar levels of difference between peatland, forest and pasture assemblages. There is a distinct, and diverse, group of species to the left-hand side of the ordination plot (Figure 3.10) which occur specifically in forest habitats. These include *Quadroppia quadicarinata, Carabodes affinis, Humerobates fungurum, Nothrus silvestris, Ceratozetes peritus, Quadroppia pseudocircumta* which are all woodland species. On the other hand, species such as *Limnozetes amnicus, Sucbelbella acutidens, Inigozetes reticulatus, Pantelozetes paolii,* and

Ramusella clavipectinata appear characteristic of peatlands but having said this, the only species listed here that was found in samples collected in the BOGLAND project was *Limnozetes amnicus*.

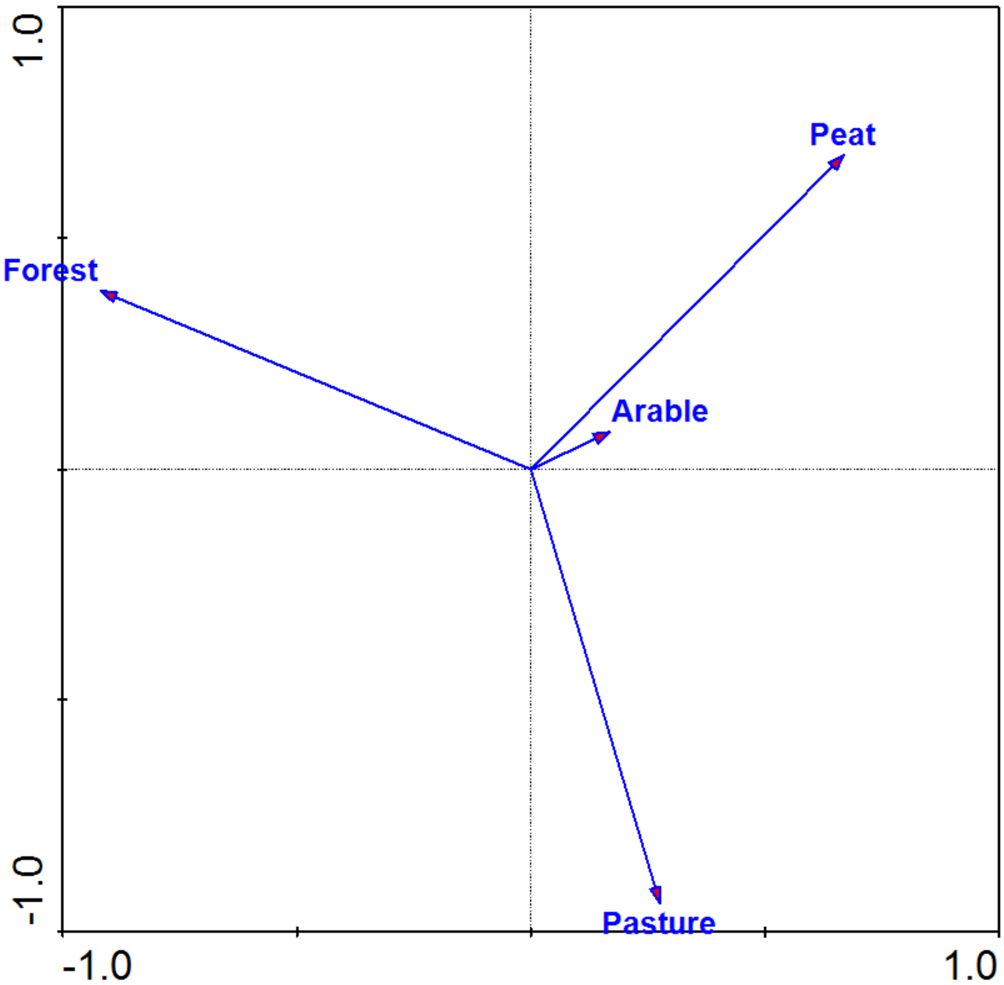


Figure 3.9. CCA ordination plot of the environmental variables tested for the Cryptostigmata and Mesostigmata mites from the CréBeo project

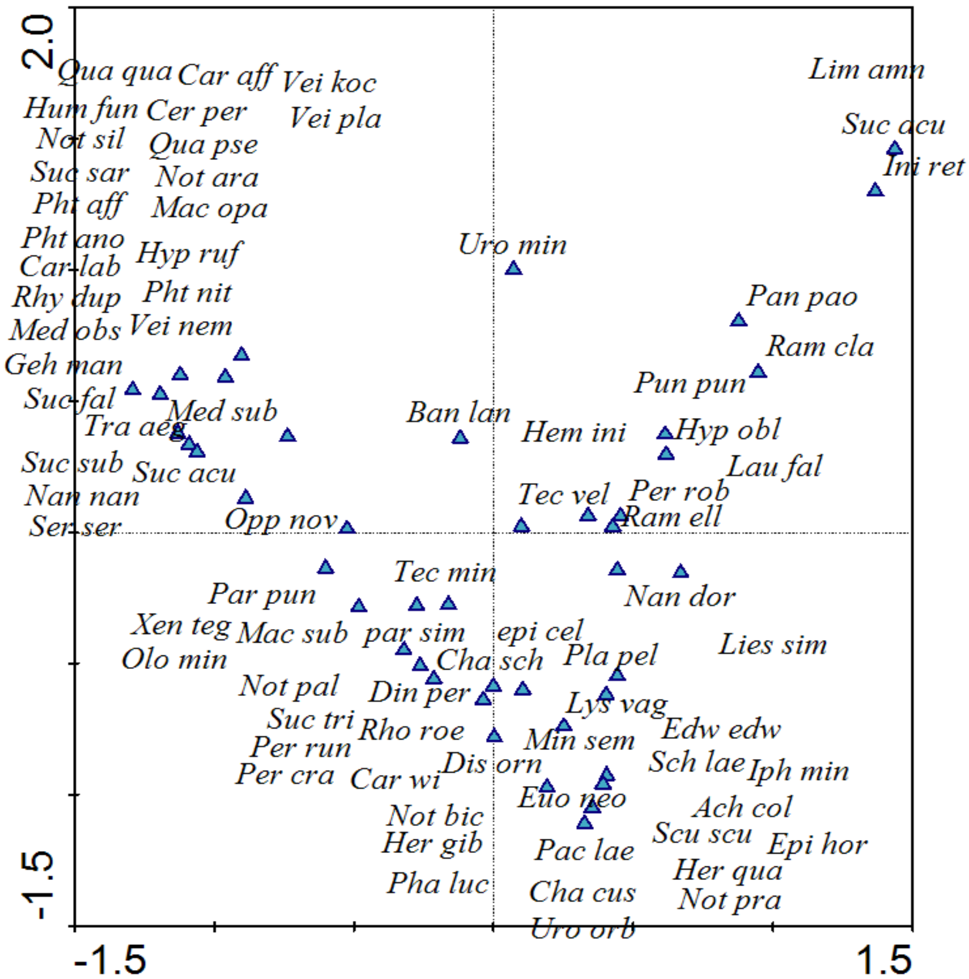


Figure 3.10. CCA ordination plot of the Cryptostigmata and Mesostigmata mites from the CréBeo project (the full names of the abbreviated species are given in appendix 1)

Table 3.7. CCA Statistics for the comparison of mite assemblages in peatlands, forest, pasture and arable using automatic selection of environmental variables. (For further details see legend Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Forest	1	0.48		
Peat	3	0.42		
Pasture	2	0.37		
Arable	4	0.28		
	Conditional Effects			
Variable	Variance N	λ1	P	F
Forest	1	0.48	0.004	2.22
Peat	3	0.37	0.064	1.77
Pasture	2	0.29	0.11	1.36

3.1.3.2 Analysis of the Cryptostigmata mite data from the Crébeo project

Analysis was then undertaken to look at the Cryptostigmata mite species alone. This was done using CCA and again a distinct set of species is found to the left of the graph associated with forests. It is very clear that the oribatid species found in peat, pasture and forestry are very different from each other and are significantly so ($P<0.05$) (Figure 3.11, Table 3.8).

3.1.3.3 *Analysis of the Mesostigmata data from the Crébeo project*

Analysis of the variation of the Mesostigmata among the habitat types showed that the differences were not significant (Table 3.9) but the assemblages in forests tend to be particularly different from those occurring in pasture and arable sites ($P=0.56$) and only two species, *Pergamasus robustus* and *Uropoda minima* were particularly associated with peats (Figure 3.12).

Table 3.8. CCA Statistics for the comparison of Cryptostigmata mite assemblages in peatlands, forest and pasture using automatic selection of environmental variables. (For further details see legend Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Forest	1	0.49		
Peat	3	0.42		
Pasture	2	0.37		
Arable	4	0.28		
	Conditional Effects			
Variable	Variance N	λ1	P	F
Forest	1	0.49	0.002	2.48
Pasture	2	0.38	0.022	1.94
Peat	3	0.27	0.116	1.46

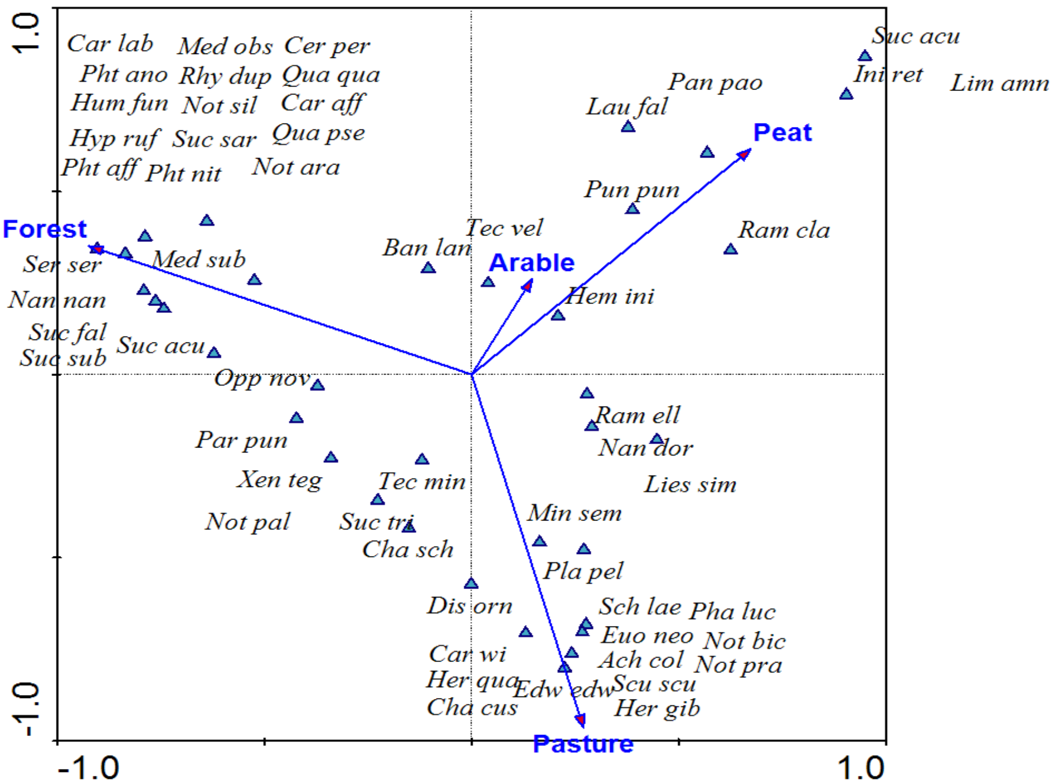


Figure 3.11. CCA ordination plot of the Cryptostigmata mite species found in the CréBeo with the four habitat types (the full names of the abbreviated species are given in appendix 1)

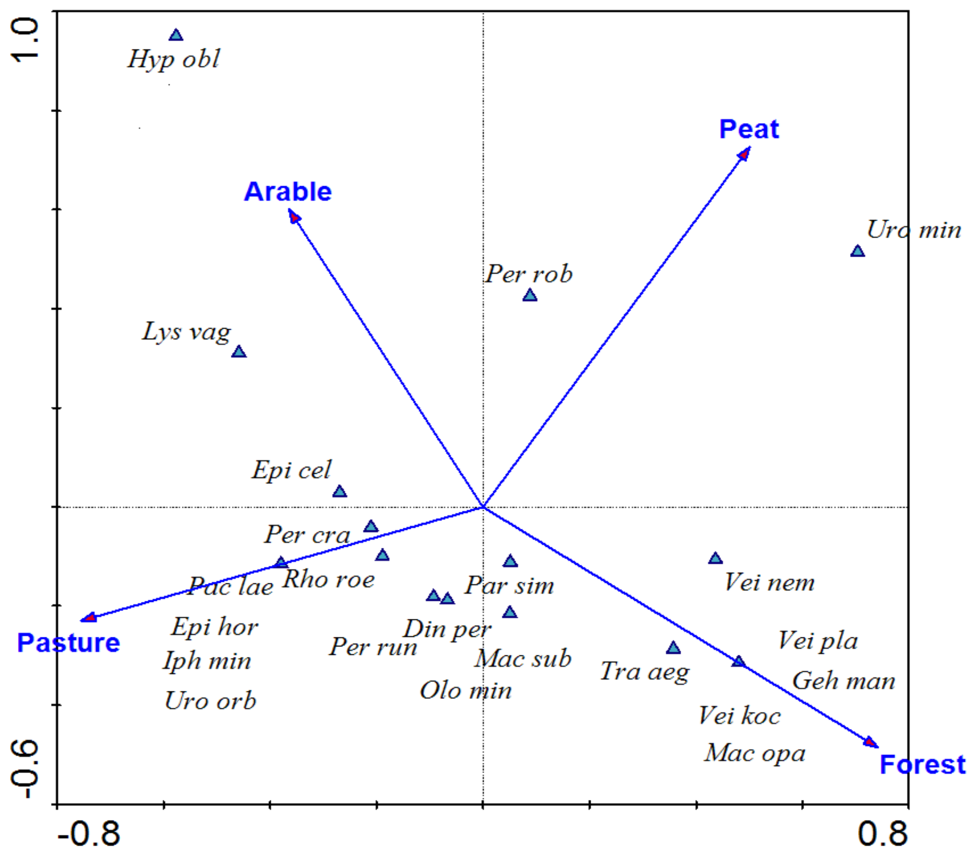


Figure 3.12. CCA ordination plot of the environmental variables and Mesostigmata mites recorded from the CréBeo Project (the full names of the abbreviated species are given in appendix 1)

Table 3.9. CCA Statistics for the comparison of Mesostigmata mite assemblages in peatlands, forest, arable and pasture using automatic selection of environmental variables. (For further details see legend Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Forest	1	0.38		
Pasture	2	0.38		
Peat	3	0.31		
Arable	4	0.27		
	Conditional Effects			
Variable	Variance N	λ1	P	F
Forest	1	0.38	0.056	1.52
Peat	3	0.36	0.15	1.45
Pasture	2	0.23	0.522	0.92

3.1.3.4 Analysis of data from previous studies of Irish mite assemblages and those from BOGLAND Study

A large number of independent studies have been undertaken to assess the mite assemblages living in different habitats in Ireland. The data from these studies were compiled in order to allow another comparison of the mite assemblages in various habitat types in Ireland. The study sites were allocated to one of the following habitat types: pasture, pasture on peat, tillage, sand dunes, forest, bog and saltmarsh. Table 3.10 gives a list of the authors and the habitat from which mites were studied.

When these datasets were combined the species list comprised of 531 species 255 of which were Cryptostigmata and 276 were Mesostigmata. This represents a large proportion of the mites recorded from Ireland and many from the Irish species list which are not included were recorded from non-soil habitats such as those occurring on small mammals and birds. Luxton (1998) lists 160 Cryptostigmata and 234 Mesostigmata in his list of Irish species. Of these 295 are included in this comparison and a further 170 species are added to his list, 106 of these new species records were Cryptostigmata and 64 were Mesostigmata.

An initial Detrended Correspondence Analysis was carried out to examine the broad patterns of variation in the data and this showed that two collections, those collected from the seashore during the Clare Island Survey (Halbert 1915) and from a salt marsh on North Bull Island (Healy 1976) were very distinct from the other assemblages (Figure 3.13). In fact there were 21 species which were found exclusively in one or both of these surveys. For example, the fauna of the saltmarsh habitat included species such as *Hygroribates spoofi* and *Hygroribates bilineatus* which were not found elsewhere. Because of this distinctiveness, these two collections were not included in the later analyses. However, the fauna from other components of the Clare Island Survey were.

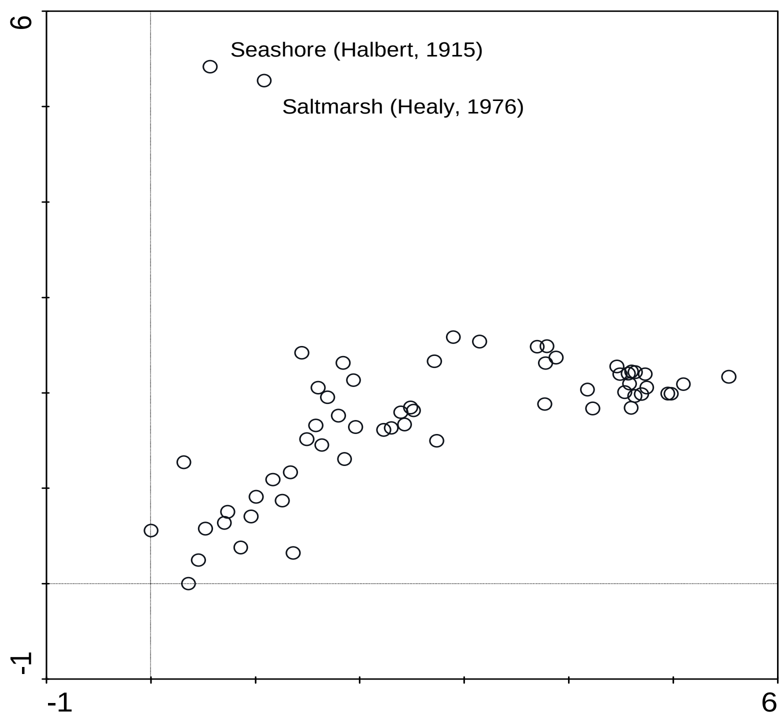


Figure 3.13. DCA ordination plot of previous studies of Irish mites.

CCA was carried out without these collections and the results were very similar to those seen in the analysis of the CréBeo Project. For example, both here and in the analysis of the small data set from the CréBeo project, it is obvious that the fauna of bog/peatland are quite different in terms of species composition to those occurring in other habitats. Bog, pasture, dune and forest were all very different from each other, this is supported by the test statistics given in Table 3.11 and Figure 3.14.

Analysis of the data was done again by separating the Cryptostigmata mites from the Mesostigmata mites. This analysis of the Cryptostigmata species is shown with an ordination plot in Figure 3.16. The relationships of the different habitat types are given in Figure 3.15. When the Crypotstigmata are isolated it shows a very similar distribution to what was given in Figure 3.14 with bog, forestry, dunes and pasture having significantly different species composition (Table 3.11). There are at least 14 Cryptostigmata species associated with the bog habitats (see Box 3.1). The Mesostigmata were then analysed on their own. The results of the analysis of the species is shown in Figure 3.17 and Figure 3.18, in these plots it shows that when For Mesostigmata the assemblages in bog, dunes, forestry and pasture are still significantly different but that dunes are the most significantly different habitat (Figure 3.17 and 3.18, Table 3.13). There seems to be distinctive species associated with forestry, pasture on peat, pasture and dunes (see Box 3.2)

Table 3.10. Author, habitat sampled and sample number used for the comparison on mite fauna from this present study with previous studies

Author	**Habitat**
Arroyo (2007) (Pers. Comm)	Forest
Arroyo (2009) (Pers. comm)	Machair
BOGLAND (present study)	Bog
Bolger (1980)	Pasture
Bolger (Pers. Comm.)	Various habitats on Clare Island
Breslin (1979)	Arable
Curry (1969a)	Old pasture
Halbert (1915)	Various habitats on Clare Island and surrounding areas.
Healy (1976)	Saltmarsh
Heneghan (1994)	Forest
Keeley (1987)	Pasture Forest
Longworth (1973)	Various habitats on reclaimed bog
McCafferty (1978)	Pasture
O'Connell (1994)	Forest
Piotrowska (2009)	Pasture
Purvis (1981)	Various sand dune habitats
Whelan (1976)	Pasture on peat

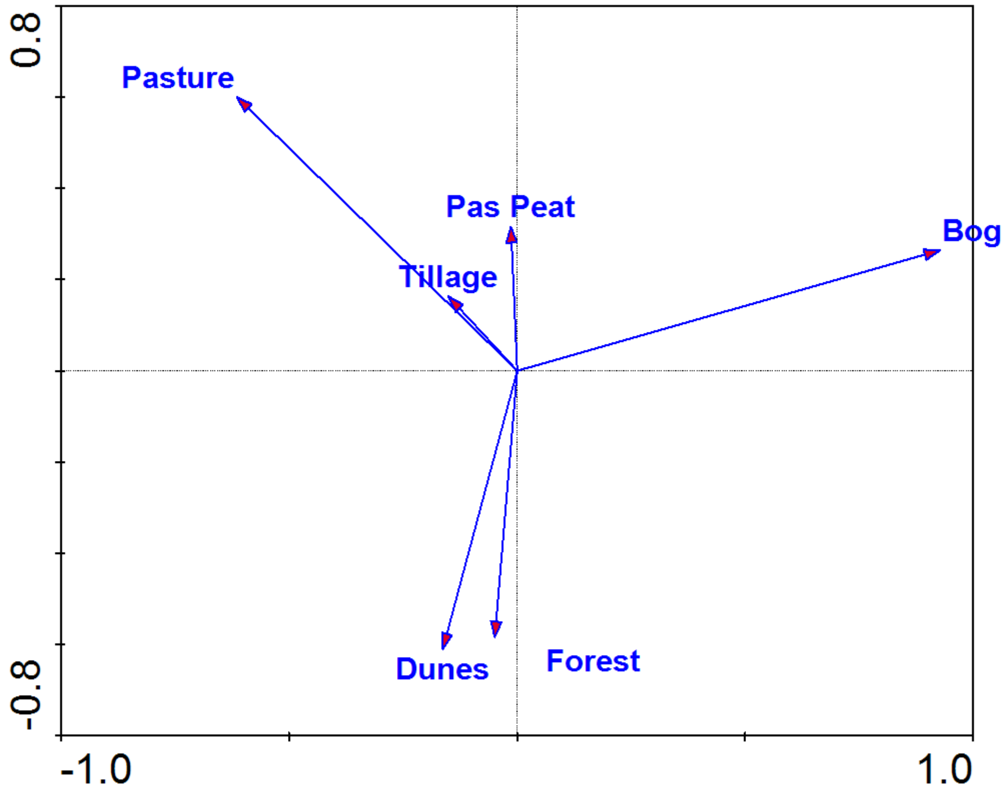


Figure 3.14. CCA ordination plot of the environmental variables investigated for all the Irish mite studies.

Table 3.11. CCA Statistics for the comparison of Cryptostigmata and Mesostigmata mite assemblages in bog, forest, dunes, pasture, pasture on peat and tillage, using automatic selection of environmental variables (For further details see legend Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Bog	3	0.43		
Pasture	1	0.36		
Dunes	7	0.35		
Forest	5	0.35		
Pasture Peat	2	0.25		
Tillage	4	0.16		
	Conditional Effects			
Variable	Variance N	λA	P	F
Bog	3	0.43	0.002	3.02
Forest	5	0.35	0.002	2.55
Dunes	7	0.37	0.002	2.73
Pasture Peat	2	0.25	0.002	1.90
Pasture	1	0.14	0.346	1.13

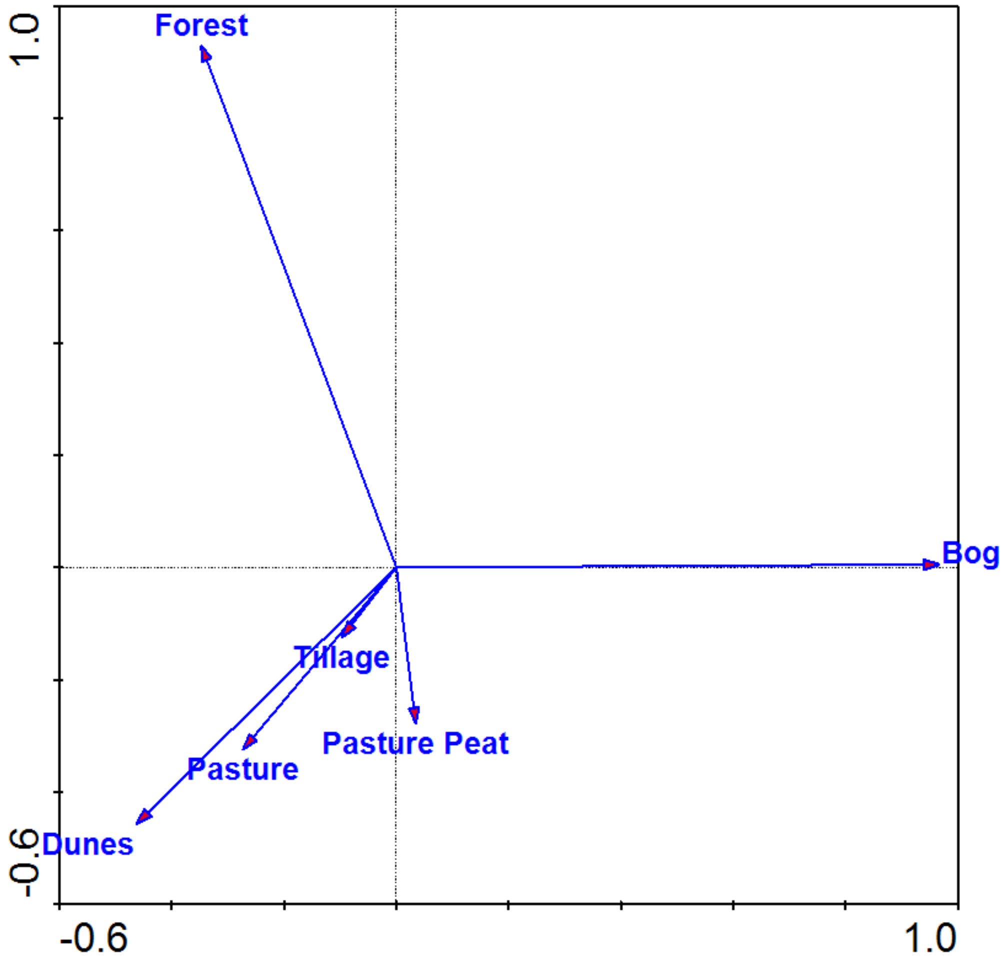


Figure 3.15. CCA ordination plot of the environmental variables investigated for all the Irish studies of Cryptostigmata

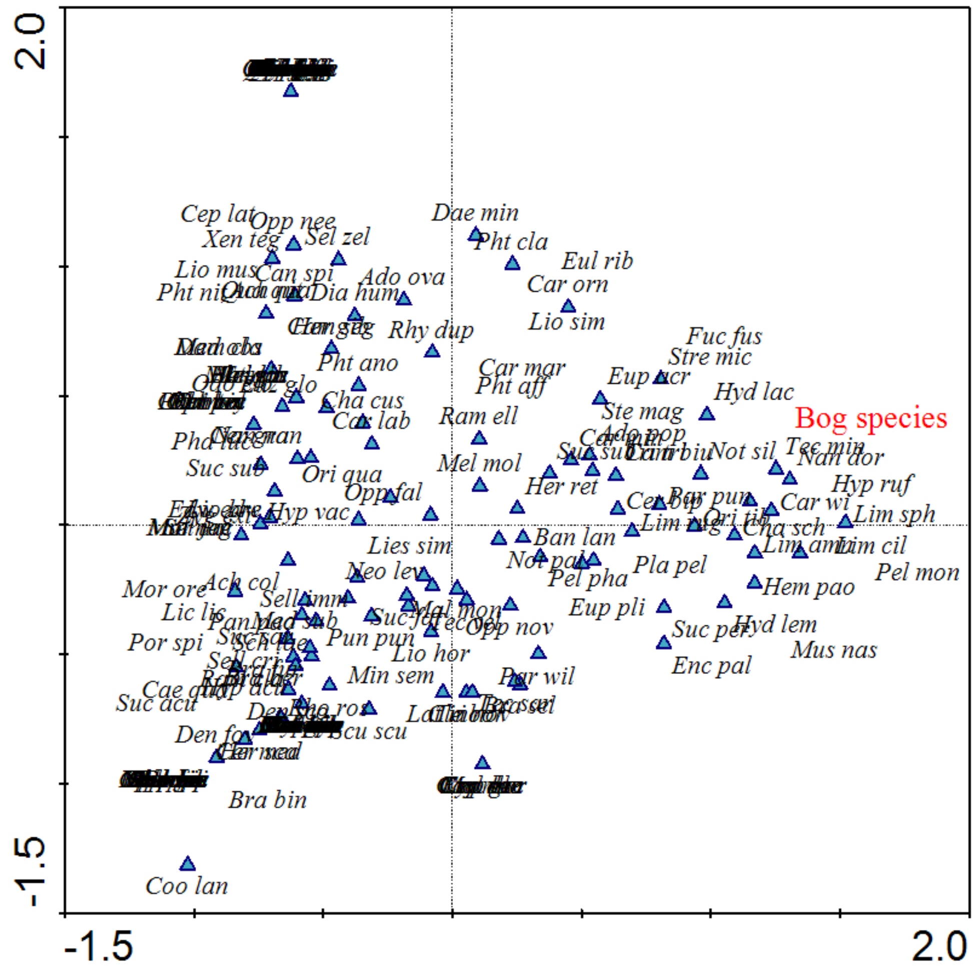


Figure 3.16. CCA ordination plot of the Cryptostigmata found on all Irish studies (see Box 3.1 for a list of the bog species) (the full names of the abbreviated species are given in appendix 1)

Box 3.1

Species associated with bog habitats

Limnozetes sphagni	*Limnozetes ciliatus*
Hypocthonius rufulus	*Carabodes willmanni*
Chamobates schuetzi	*Limnozets amnicus*
Limnozetes rugosus	*Hydrozetes lemnae*
Peloptulus montanus	*Nanhermannia dorsalis*
Hydrozetes lacustris	*Heminothrus paolii*
Platynothrus peltifer	*Parachipteria punctata*

Table 3.12. CCA Statistics for the comparison of Cryptostigmata mite assemblages in bog, forest, dunes, pasture, pasture on peat and tillage, using automatic selection of environmental variables. (For further details see legend Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Bog	3	0.43		
Pasture	1	0.36		
Dunes	7	0.35		
Forest	5	0.35		
Pasture Peat	2	0.25		
Tillage	4	0.16		
	Conditional Effects			
Variable	Variance N	λA	P	F
Bog	3	0.43	0.002	3.02
Forest	5	0.35	0.002	2.55
Dunes	7	0.37	0.002	2.73
Pasture Peat	2	0.25	0.002	1.90
Pasture	1	0.14	0.346	1.13

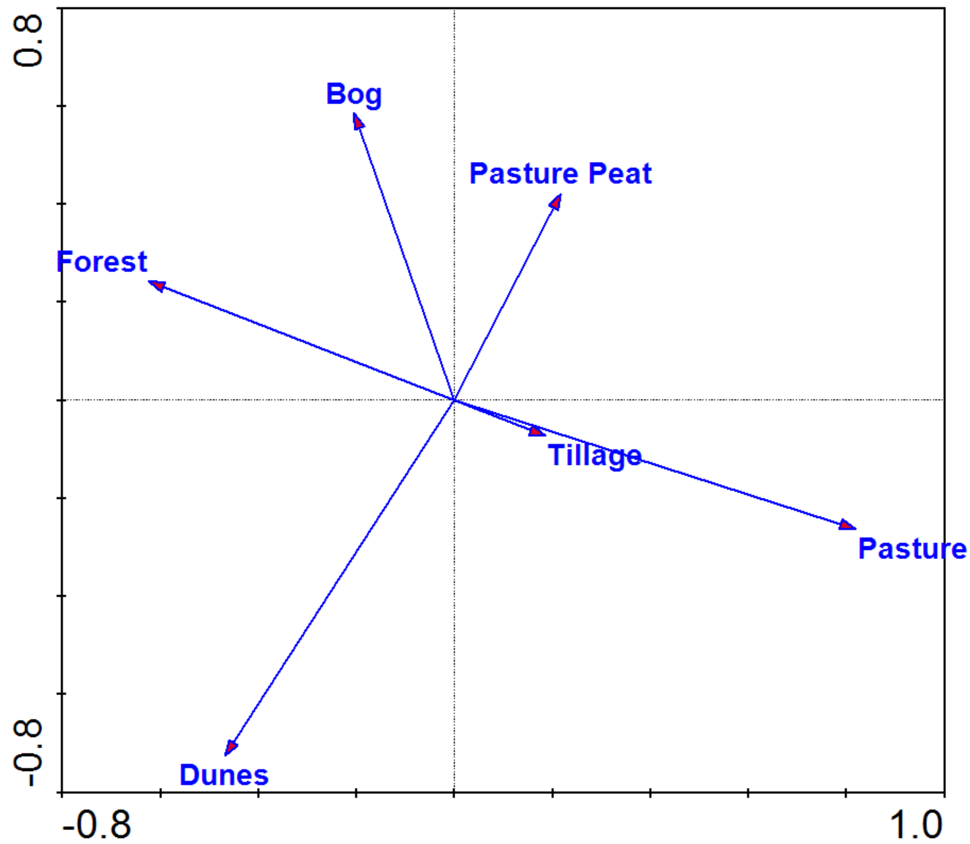


Figure 3.17. CCA ordination plot of the environmental variables investigated for the study of the Mesostigmata in Irish sites

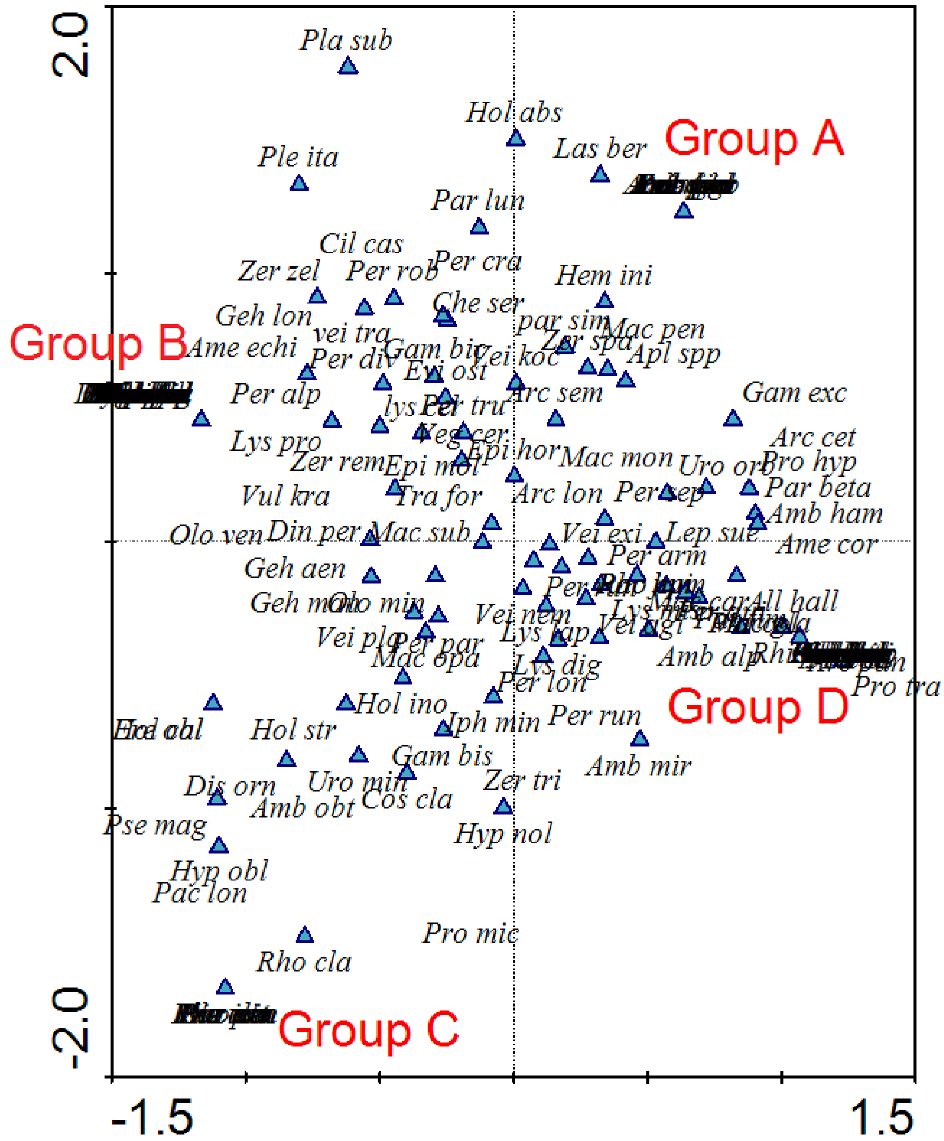


Figure 3.18. CCA ordination plot of all the species of Mesostigmata recorded (see Box 3.2 for species contained in group A, B, C, D) (the full names of the abbreviated species are given in appendix 1)

Box 3.2

Group A species (Pasture on peat)

Pachylaelaps furcifer	*Amblyseius graminis*
Amblyseius graminis	*Ameroseius plumiferus*
Lasioseius confuses	*Leioseius minusculus*
Amblyseius bidens	*Amblyseius umbriticus*
Zercon spatulatus	

Group B species (Forest)

Pachylaelaps magnus	*Trachytes minima*
Pergamasus longicornis	*Epicriopsis rivus*
Blattisocius tarsalis	*Lasioseius ometes*
Proctolaelaps rotunda	*Zerconopsis apodius*
Zerconopsis decemremiger	*Dendrolaelaps cornutus*
Dendrolaelaps euarmatus	*Dendrolaelaps oudemansi*
Dendrolaelaps stammeris	*Dendrolaelaps tenuipilus*
Haemogamasus pontiger	*Holostaspis montana*
Ololaelaps placentula	*Macrocheles terreus*
Pachylaelaps bellicosus	*Pachylaelaps sellnicki*
Eugamasus magnus	*Holoparasitus caesus*
Holoparisitus lawrenci	*Leptogamasus obesus*
Pergamasus schweizen	*Pergamasus wassermani*
Paragamasus integer	*Parasitus evertsi*
Pergamasus noster	*Poecilochirus carabi*

Box 3.2 cont’d.

Amblyseius foramensis	*Amblyseius neobernhardi*
Zercon abaculus	*Zercon colligans*
Trachygamasus oudemansi	*Oplitis philoctena*
Group C species (Dunes)	
Rhodacarus strenzkei	*Macrocheles dentatus*
Dinychus inermis	*Protogamasellus minor*
Laelaspis astronomicus	*Rhodacarus minimus*
Group D species (Pasture)	
Arctoseius pannonicus	*Gamasodes spiniger*
Iphidozercon coroticalis	*Crasycheles holsticus*
Uropoda minima	*Blattisocius dentriticus*
Eulaelaps stabularis	*Cornigamasus lunaris*
Pachyseius femoratus	*Amblysieus cucumeris*
Rhodocarus pallidus	*Dinychus stratus*
Ameroseius furcatus	*Ameroseius imparasetous*
Kleemania plumosus	*Arctoseius magnanalis*
Dendrolaelaps arenarius	*Dendrolaelaps rectus*
Androlaelaps casalis	*Hypoaspis presternatis*
Laelaps agilis	*Pseudoparasitus meridionalis*
Holostaspella ornatus	*Pachylaelaps resinae*
Pachyseius angustiventris	*Eugamasus crassitarsis*
Holoparasitus pollicipatus	*Pergamasus alstoni*
Eugamasus cornutus	*Lysigamasus nasellus*
Box 3.2 cont'd.	
Pachyseius hortensis	*Pergamasus londonensis*

Parasitus consanguineus	*Parasitus hyalinus*
Parasitus insignis	*Pachyseius neglectis*
Parasitus nolli	*Rhodocarellus perspiscuus*
Rhodocarus aequchus	*Rhodacarus agrestis*
Rhodacarus calcarulatus	*Alliphis halleri*
Macrocheles glaber	*Parasitus coleoptratorum*

Table 3.13. CCA Statistics for the comparison of Mesostigmata mite assemblages in bog, forest, dunes, pasture, pasture on peat and tillage, using automatic selection of environmental variables. (For further details see legend Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Pasture	1	0.35		
Dunes	7	0.34		
Forest	5	0.33		
Bog	3	0.28		
Pasture Peat	2	0.28		
Tillage	4	0.15		
	Conditional Effects			
Variable	Variance N	λA	P	F
Pasture	1	0.35	0.002	1.97
Dunes	7	0.32	0.002	1.90
Forest	5	0.33	0.002	1.89
Bog	3	0.23	0.008	1.42
Pasture Peat	2	0.18	0.420	1.02

3.1.3.5 Comparison of data from the BOGLAND, CS2000, Longworth (1973), Crébeo bog sites, Macfadyen (1952) and Whelan (1976)

In order to assess whether the species found in the BOGLAND project were similar to those recorded from peatlands in other Irish and UK studies the mite assemblages were compared with those found in BOGLAND, CréBeo, the UK Countryside Survey 2000 (CS2000) and single site studies of Longworth (1973), Whelan (1976) and Macfadyen (1952) were compared. In the Countryside Survey 2000 of the UK a total 963 sites were sampled for oribatid mites and one-hundred and thirty species were recovered (c.f. Black *et al*. 2003). Thirty eight of these sites were described as peats and fifty-two species were recorded from them. The data from the peatland samples in that study were provided by the Centre for Ecology and Hydrology, United Kingdom. The Longworth (1973) and Whelan (1976) studies were of mites in various managed habitats in Irish peatlands and Macfadyen (1952) was of a study of a *Molinia* fen in England.

DCA was first used to detect any patterns that may be present for the species that were recorded in these peatland studies. This showed that the samples from BOGLAND, CS2000 and CréBeo were quite similar in terms of species composition, but the species found by Macfadyen (1952), Whelan (1976) and Longworth (1973) were different (Figure 3.19). In particular, it was interesting that the CS2000 samples were clustered between the BOGLAND samples and those from the individual site studies and those from CréBeo, which represent a broad range of peatland conditions, were spread throughout the ordination.

When CCA was used it was found that significant differences did exist between the mite assemblages found in the various studies (Figure 3.20, 3.21, Table 3.14). However, the pattern was similar with CréBeo sitting at the centre of the ordination and the other studies separated because of the species that occurred uniquely in them. For example, of the 22 species identified as Group A in Fig 3.21 and Box 3.3 eleven have not been recorded in Ireland and some of the others, e.g. *Ceratozetes gracilis,* are widespread and presumably did not occur in the relatively intact peatlands studied in BOGLAND but would occur in peat soils under other land uses.

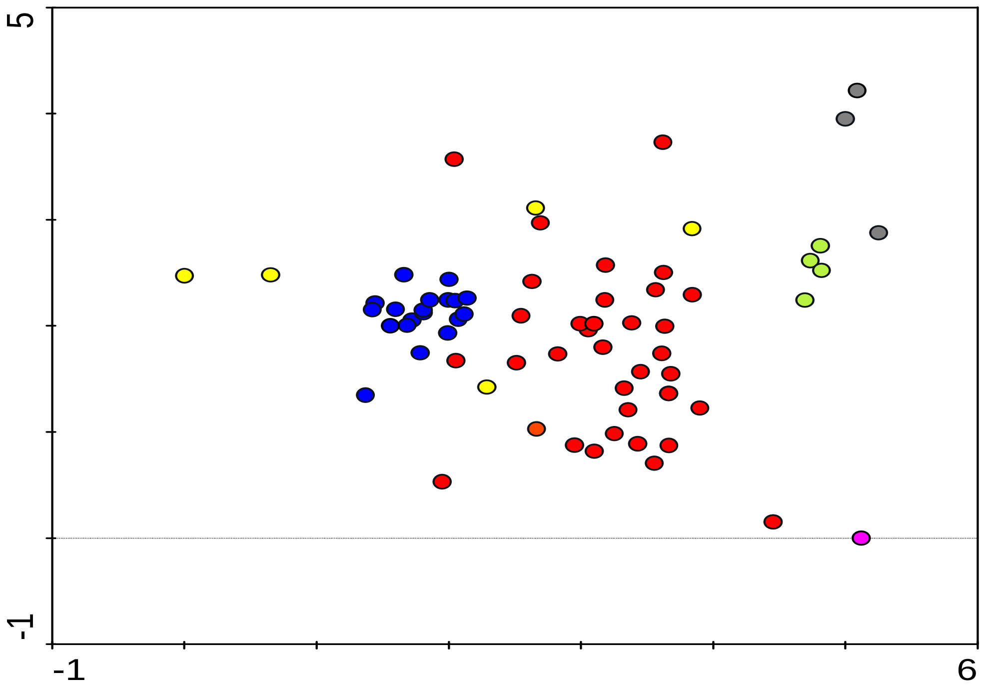


Figure 3.19. DCA of the samples taken for BOGLAND (blue), CréBeo (bog sites) (yellow), CS200 (red), Longworth (1973) (green), Macfadyen (1952) (cerise) and Whelan (1976) (grey).

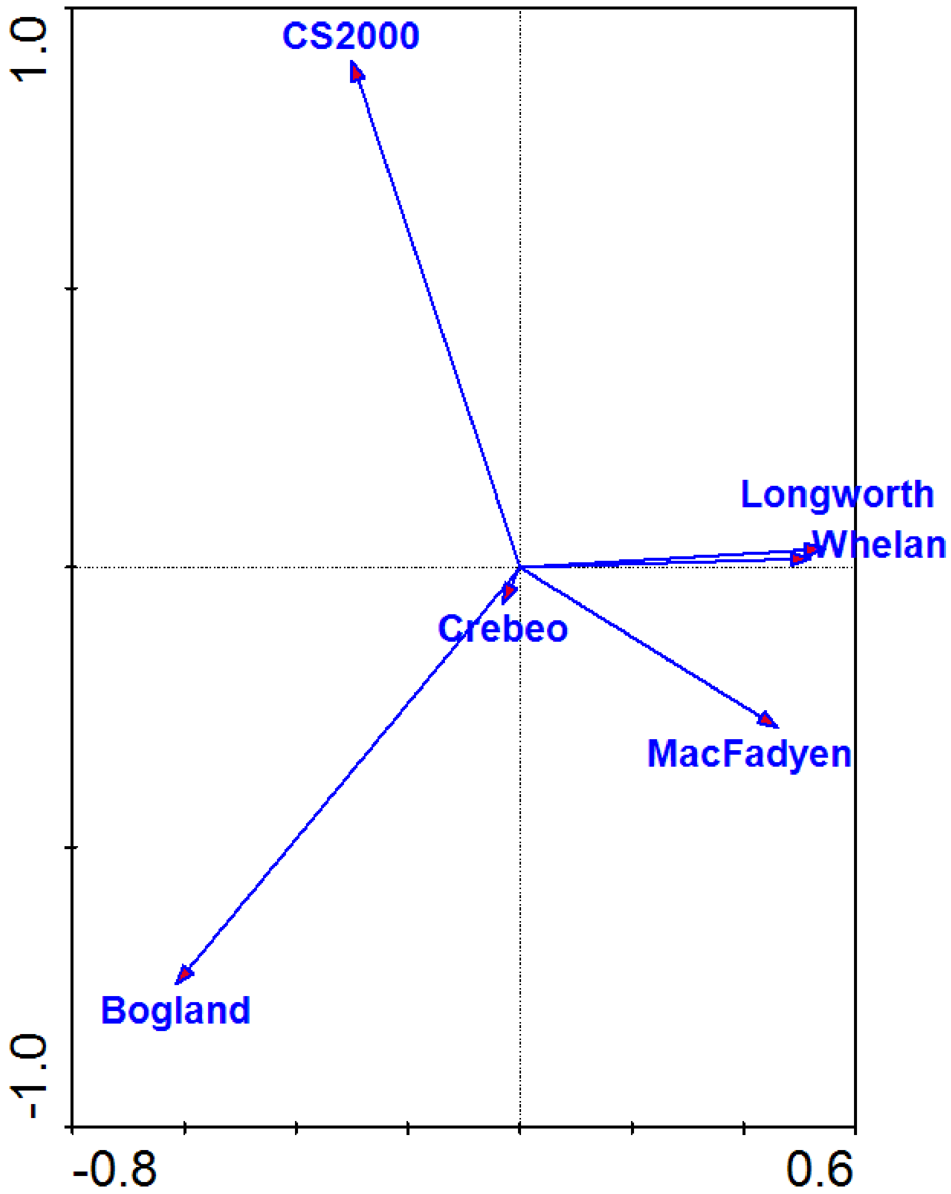


Figure 3.20. CCA of the environmental variables which refer to each study of Cryptostigmata in peat habitats

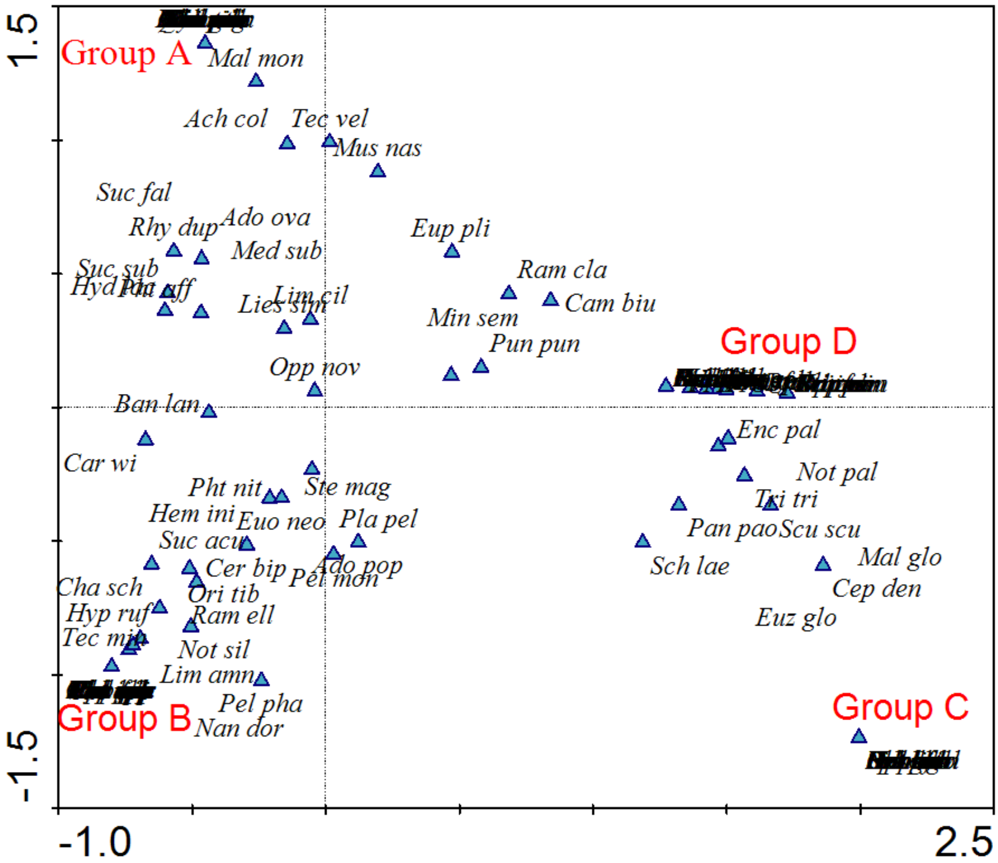


Figure 3.21. CS2000 project, BOGLAND and by Longworth (1973) Whelan (1976), Macfadyen (1952) and Crébeo (see Box 3.3 for the species contained in Group A, B and C) (the full names of the abbreviated species are given in appendix 2)

Table 3.14. CCA Statistics for the comparison of Cryptostimata mite assemblages in peatlands, from the CS200 study, BOGLAND (present study) Longworth (1973),Whelan (1976), Macfadyen (1952) and Crébeo using automatic selection of environmental variables. (For further details see legend Table 3.4)

	Marginal Effects	
Variable	Variance N	λ1
BOGLAND	2	0.59
CS2000	1	0.57
Macfadyen	5	0.56
Longworth	3	0.53
Whelan	4	0.45
CréBeo	6	0.29

	Conditional Effects			
Variable	Variance N	λA	P	F
BOGLAND	2	0.59	0.002	4.43
CS2000	1	0.59	0.002	4.76
Macfadyen	5	0.53	0.002	4.45
Longworth	3	0.41	0.002	3.56
Whelan	4	0.31	0.002	2.74

Box 3.3

Group A Species (CS2000)

Ceratozetes gracilis	*Quadroppia maritalis*
Suctobelba subtrigona	*Suctobelbella similis*
Microppia minus	*Syncthonius crenulatus*
Eulohmannia ribagai	*Trimalaconothrus sculptus*
Disshorhina ornata	*Oribatula saxicola*
Sellnickochthonius cricodes	*Nanhermannia sellnicki*
Liochthonius perfuscrius	*Nanhermannia coronata*
Edwardzetes edwardsi	*Melanozetes stagnatilis*
Nothrus anauniensis	*Liocthonius neglectus*
Chamobates paolii	*Damaeobelba minutissima*
Lauroppia maritima	*Lauroppia translamellata*

Box 3.3 cont'd.

Group B Species (BOGLAND)

Peloptulus phaenotus	*Ramusella elliptica*
Nanhermania dorsalis	*Eupelops plicatus*
Parachipteria punctata	*Phthiracarus murphyi*
Limnozetes amnicus	*Latilamellobates incisellus*
Steganacarus michaeli	*Tectocepheus minor*
Eupelops acromios	*Phthiracarus anonymus*
Chamobates cuspidatus	*Platyseius subglaber*
Limnozetes sphagni	*Carabodes labyrinthicus*
Carabodes ornatus	*Carabodes marginatus*
Fucozetes fuscipes	*Pergalumna nervosum*

Group C species (Macfadyen)

Nanhermannia elegantula	*Berniniella bicarinata*
Ceratozetes mediocris	*Schloeloribates laticeps*
Notapsis coleoptratus	*Oribella berlese*
Humerobates fungurum	*Sphaerozetes orbicularis*
Nothrus bicillatus	*Gustavia microcephala*
Liacarus coracinus	*Belba geniculosa*
Belba pulverulenta	*Oppiella subpectinata*
Phthiracarus ligneous	*Holoderma shreulm*

Group D Species (Longworth/Whelan)

Brachychthonius berlesei	*Parachipteria willmanni*
Suctobelba perforata	*Brachychthonius semiornatus*
Camisia larridi	*Camisia segnis*
Heminothrus longisetosus	*Carabodes minisculus*
Melanozetes mollicomus	*Daemobelba minutisimus*
Enlohmannia ribagai	*Trimalanothrus novus*
Hydrozetes lemnae	*Nothrus praetensis*

Box 3.3 cont'd.	
Oppiella fallax	*Suctobelbela sarakensis*
Limnozetes rugosus	*Brachychthonius sellnicki*
Lauroppia fallax	*Oribatella quadricornuta*
Trichoribates trimaculatus	*Scutovertex sculptus*
Brachychthonius cricoides	*Pantelozetes paolii*
Opeilla ornatus	*Schleroribates laevigatus*
Trichoribates incissellus	*Euzetes globulus*
Malaconothrus globifer	*Cepheus dentatus*
Brachychthonius furcatus	*Parosolozetes perfectus*
Sellnichthonius zelaweiensis	*Trimalaconothrus numerosus*
Eniochthonius minutissimus	*Nanhermannia nana*
Eupelops tardus	

3.1.4 A short study of restored, intact and cutaway bogs in 2009

In 2009, a further thirty-six samples were taken in order to look at the mite assemblages that occurred in restored, intact and industrially cutaway bogs. The sites selected were Mongan Bog in Offaly and Lodge Bog in Kildare.

In total 768 mites were collected and identified from these samples but only eight individuals were recorded from the twelve samples taken from the cutaway sites.

The most abundant species collected was *Nanhermannia dorsalis*, 244 of this species were collected and it occurred in both Lodge Bog intact and restored and also in Mongan bog intact and restored but this species was not found in any of the cutaway samples. The only species that occurred in the cutaway samples was

Limnozetes ciliatus which was the second most abundant species with 125 individuals recorded, it occurred in each of the areas that were sampled, intact restored and cutaway. *Parachipteria punctata* and *Hypocthonius rufulus* were also abundant and were widespread across the intact and restored habitats. *Chamobates schuetzi* and *Platynothrus peltifer* both had forty-nine records and were widespread across the habitats. *Nothrus silvestris* had forty-seven records and it occurred in fifteen of the thirty-six samples. *Carabodes willmanni* was also present in relatively large numbers, forty-four were recorded and from thirteen samples. The rest of the species recovered were found in low numbers and were not as widespread across the intact and restored habitats.

The data were analysed using RDA to determine whether there were differences between the intact, restored or industrially cutaway peatland (Figure 3.22). It was found that the industrially cutaway was statistically different and that the intact and restored site were not significantly different in terms of species composition (Table 3.15). Basically very few mites occurred in the industrial cutaways and all species were more abundant under the other two conditions. Species such as *Carabodes willmanni* and *Hypocthonius rufulus* tended to be more associated with the intact sites while species such as *Parachipteria punctata* were more associated with the restored areas (Figures 3.22, 3.23).

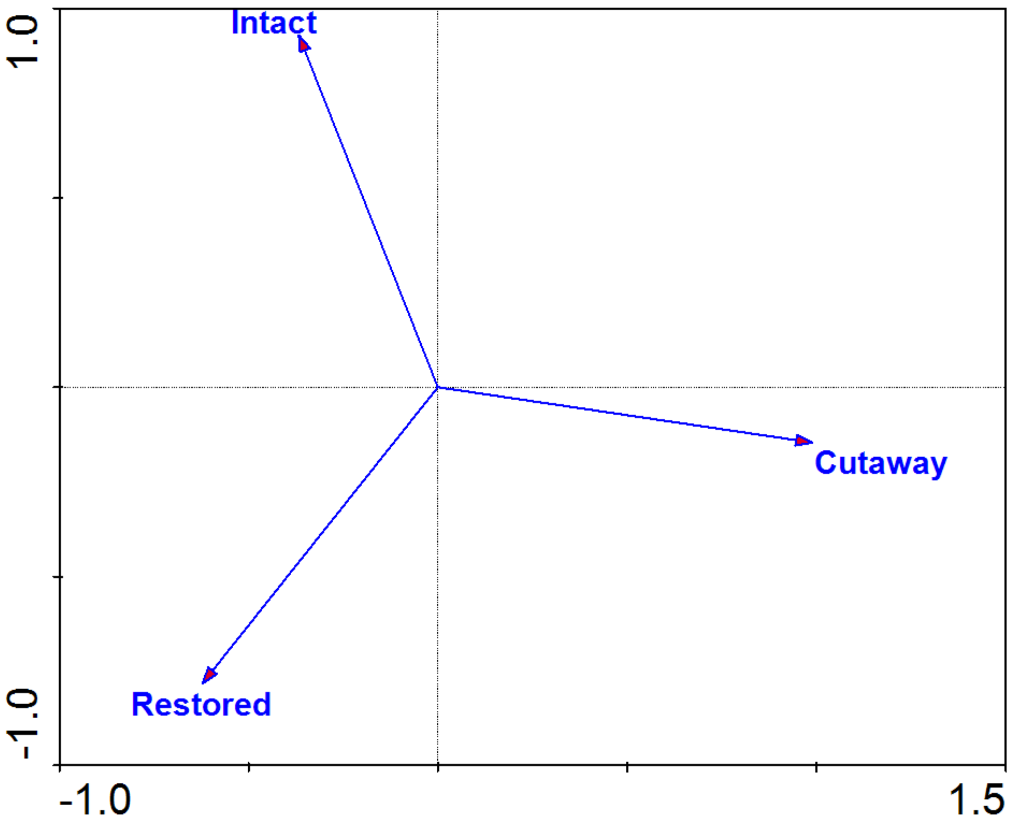


Figure 3.22. RDA of the environmental variables investigated in 2009 based on the condition of the peat that was sampled

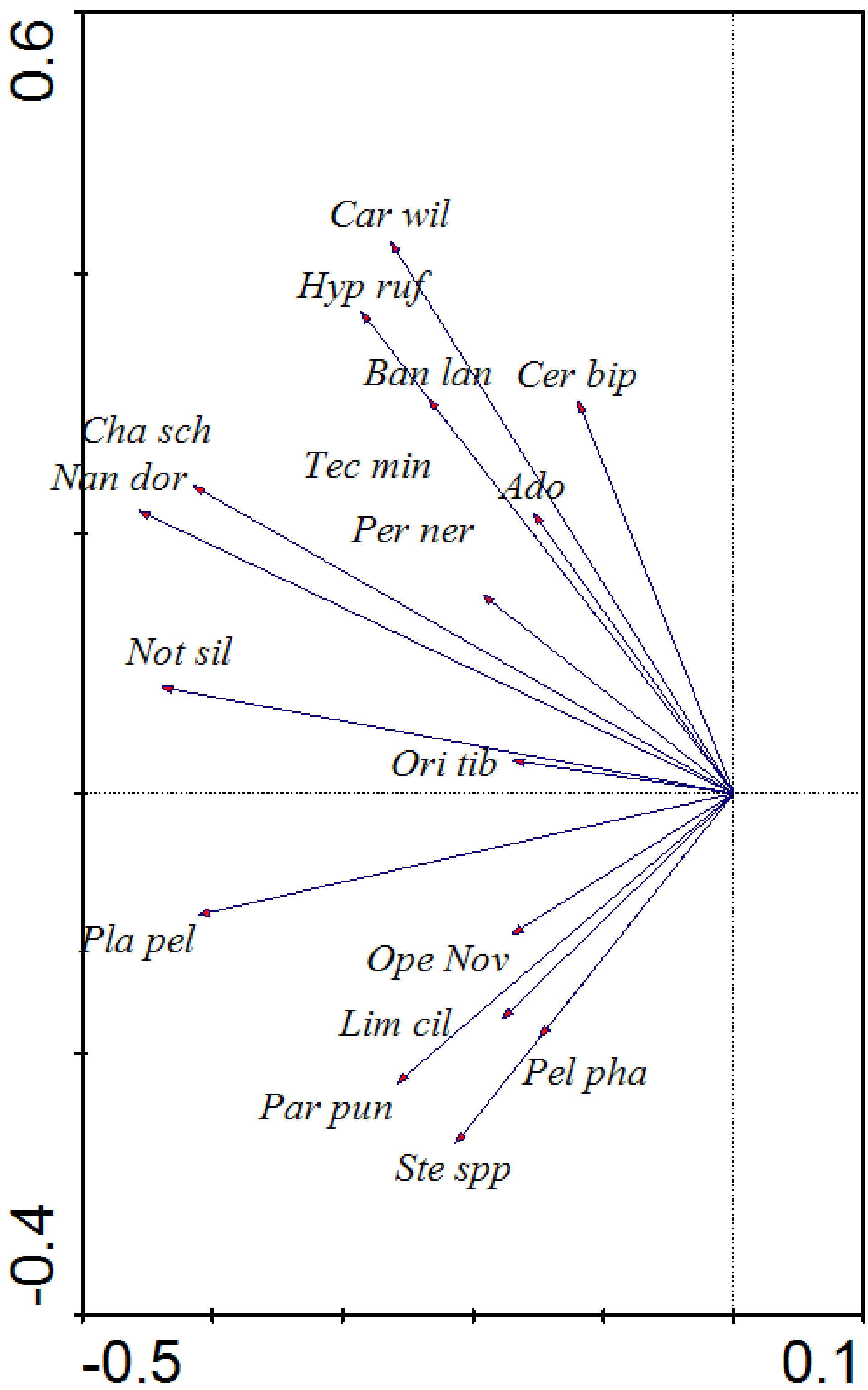


Figure 3.23. RDA of the species of mite recorded in 2009 (the abbreviated list of the species names are given in the appendix 1)

Table 3.15. RDA test statistics for the comparison of mite assemblages in peatlands, of three different condition; intact, restored and industrially cutaway, using automatic selection of environmental variables. (For further details see legend Table 3.4)

	Marginal Effects			
Variable	Variance N	λ1		
Cutaway	3	0.08		
Restored	2	0.06		
Intact	1	0.05		
	Conditional Effects			
Variable	Variance N	λA	P	F
Cutaway	3	0.08	0.004	3.15
Intact	1	0.05	0.098	1.71

3.1.5 Conclusions

The majority of mites found were Cryptostigmata, 53 species of this mite type were found and seventeen were species of Gamasida (Mesostigmata). The sampling of the core BOGLAND sites that took place in 2006 revealed that there was no consistent difference in the richness of the fauna in the various peatland types. *Nanhermannia dorsalis* was the most abundant species found on the core BOGLAND sites. It was found that overall there was no significant difference between the intact and restored areas that were sampled. Raised bogs were the one peatland type that exhibited a somewhat different species composition when analysis was done using the Cryptostigmata, when analysis was done using the Mesostigmata there was no difference between the peat types.

Analysis was carried out using data from other sources. The first dataset used was from the Crébeo project. The most abundant species found in this project was *Opeilla nova*, the most abundant Mesostigmatid mite found was *Paragamasus similis*. When the species lists were compared to the BOGLAND species list it was found that there were only twelve Cryptostigmata species and three Mesostigmata species occurred on both lists.

The next dataset used was very large and it contained data on mite assemblages found in Ireland, this was then used as a comparison with the BOGLAND study. The analysis carried out using this dataset showed similar results to what was found in the Crébeo project. It appears that there are peatlands/bogs are quite different from other habitats in terms of species composition.

The last dataset used for a comparison with the BOGLAND study was CS2000, Longworth (1973), Crébeo bog sites, and Whelan (1976). This dataset was used because they all sampled various types of bog habitat. For this dataset only the Cryptostigmata were considered. It was found that the Irish sites (BOGLAND, Longworth (1973) Crébeo and Whelan (1976) were quite similar in terms of species compostion, but that the species found in the CS2000 study were quite distinct. Further investigation found that all the bog sites tested were in fact significantly different from each other.

The last study undertaken looked at restored, intact and cutaway bogs in 2009 in Ireland. The species richness from these samples was very low. The number of individuals found on the cutaway bogs was almost negligible; those that did occur were all the species *Limnozetes ciliatus*.

3.2 Spiders/araneae

3.2.1 Pitfall trapping for spiders in 2006

The eleven core BOGLAND sites were sampled for spiders in 2006 using pitfall traps. Six traps were set in each sampling area meaning that 114 traps were set in Spring and again in Autumn. In 2006, 426 spiders were recovered representing 51 different species from ten families (Table 3.16). Of these, 292 were collected in Spring and 134 in Autumn. Most of the specimens were identified to species but 167 were immature and thus could only be identified to family level.

Table 3.16. Species identified from eleven core sites, in Spring and Autumn in 2006; including family and abbreviation used in ordination analysis

Family	**Species and Authority**	**Abbreviation**
Lycosidae	*Alopecosa pulverulenta* (Clerck, 1757)	*Alo pulv*
	Pardosa nigriceps (Thorell, 1891)	*Par nigr*
	Pardosa palustris (Linnaeus, 1758)	*Par palu*
	Pardosa prativaga (L. Koch 1870)	*Par prat*
	Pardosa pullata (Clerck, 1757)	*Par pull*
	Pirata hygrophilus (Thorell 1872)	*Pir hygr*
	Pirata latintans (Blackwall, 1841)	*Pir lati*
	Pirata piraticus (Clerck, 1757)	*Pir pira*
	Pirata tenuitarsis (Simon, 1876)	*Pir tenu*
	Pirata uliginosus (Thorell, 1856)	*Pir ulig*
	Trochosa ruricola (De Geer, 1778)	*Tro ruri*
	Trochosa spinipalpis (O.P. Cambridge, 1895)	*Tro spin*
	Trochosa terricola Thorell, 1856	*Tro terr*
Thomisidae	*Oxyptila trux* (Blackwall, 1846)	*Oxy trux*
	Xysticus cristatus (Clerck, 1757)	*Xys cris*
Gnaphosidae	*Drassodes cupreus* (Blackwall, 1834)	*Dra cupr*
	Drassodes lapidosus (Walckenaer, 1802)	*Dra lapi*
Clubionidae	*Clubiona subtilus* Koch, 1867	*Clu subt*
Hahniidae	*Antistea elegans* (Blackwall, 1841)	*Ant eleg*
Liocranidae	*Agroeca proxima* (O.P. Cambridge, 1871)	*Agr prox*
	Scotina celens (Blackwall, 1841)	*Sco cele*
	Scotina gracilipes (Blackwall, 1859)	*Sco grac*
Miturgidae	*Cheiracanthium* (Imm) (Koch 1839)	*Cheiraca*
Tetragnathidae	*Pachygnatha clercki* Sundevall, 1823	*Pac cler*
	Pachygnatha degeeri Sundevall, 1830	*Pac dege*
Theridiidae	*Euryopis flavomaculata* (C.L. Koch, 1836)	*Eur flav*
Linyphiidae	*Agyneta cauta* (O.P. Cambridge, 1902)	*Agy caut*
	Agyneta olivacea (Emerton, 1882)	*Agy oliv*
	Agyneta subtilus (O.P. Cambridge, 1863)	*Agy subt*
	Bathyphantes gracilis (Blackwall, 1841)	*Bat grac*
	Cnephalocotes obscurus (Blackwall, 1834)	*Cne obsc*
	Gonatium rubens (Blackwall, 1833)	*Gon rube*
	Gongylidielum latebricola (O.P. Cambridge, 1871)	*Gong lat*
	Lepthyphantes alacris (Blackwall, 1853)	*Lep alac*
	Lepthyphantes ericaeus (Blackwall, 1853)	*Lep eric*
	Lepthyphantes mengei (Kulczynski, 1887)	*Lep meng*
	Lepthyphantes pallidus (O.P. Cambridge, 1871)	*Lep pall*
	Lepthyphantes tenuis (Blackwall, 1852)	*Lep tenu*
	Micrargus apertus (O.P. Cambridge, 1871)	*Mic aper*
	Oedothorax gibbosus (Blackwall, 1841)	*Oed gibb*

Table 3.16. cont'd. Species identified from eleven core sites, in Spring and Autumn in 2006; including family and abbreviation used in ordination analysis

	Peponocranium ludicrum (O.P. Cambridge, 1861)	*Pep ludi*
	Pocadicnemis pumila (Blackwall, 1841)	*Poc pumi*
	Satilatlas britteni (Kackson, 1913)	*Sat brit*
	Silometopus elegans (O.P. Cambridge, 1872)	*Sil eleg*
	Tapinopa longidens (Wider, 1834)	*Tap long*
	Taranucnus setosus (O.P. Cambridge, 1863)	*Tar seto*
	Trichoncus saxicola (O.P. Cambridge, 1861)	*Tri saxi*
	Trichopterna thorelli (Westring, 1861)	*Trip tho*
	Walckenaeria acuminata Blackwall, 1833	*Wal acum*
	Walckenaeria vigilax (Blackwall, 1952)	*Wal vigi*
	Walckenaeria alticeps (Denis, 1952)	*Wal alti*

In total 11 sites were sampled in Spring and the same 11 were then sampled in Autumn. The most abundant species was *Pardosa pullata*, this species was the most abundant species in both Spring and Autumn. In Spring there were 77 of this species recorded and it occurred in nine of the eleven sites and was found both on intact and restored habitats. It was not found in Spring on two blanket bog sites; Fiddandary and Glenlahan. In Autumn 54 were recorded and it was found at five of the sites, mainly on the intact sites and on only one restored site. It was completely absent in Autumn from Pollardstown Fen, Sharavogue Bog, Clara Bog, Carrowbehy Bog, Fiddandarry and Glenlahan. The next most abundant species found in Spring was *Pardosa nigriceps* with 26 of this species recorded. This species was found in four sites and it was found both on intact and restored habitats and was totally absent from Pollardstown Fen, Bellacorick, Clara Bog, Owenirragh, Knockmoyle, Fiddandary, Kippure and Glenlahan. The second most abundant species recovered in Autumn was *Antistea elegans* with eight specimens recorded and it was found in six sites. This species was found both in intact and restored habitats and was absent from Bellacorick, Clara Bog, Carrowbehy Bog, Knockmoyle and Glenlahan. *Pachygnatha degeeri* was the third most abundant species found in Spring with seven of this species recorded but it was only found in three of the sites and of those three mainly on restored habitats. This species was present on Owenirragh, Pollardstown Fen and Bellacorick. *Trochosa terricola* was third most abundant in Autumn with eight of this species trapped and it occurred in six sites, it occurred equally on both intact and restored sites. This species was absent from Sharavogue Bog, Clara Bog, Knockmoyle, Ballygisheen and Fiddandary. The fourth most abundant species found in Spring was *Drassodes cupreus* and it was found in two sites, and mainly in the intact areas. This species was only present in Sharavogue Bog and Carrowbehy Bog. In Autumn the fourth most abundant species was *Agroeca proxima* and it was only found in two sites, Glenlahan and Sharavogue and both in the restored habitats. The rest of the species recorded were found in very small numbers (>6 per site) and in fewer than three locations.

Seven species of spider were collected exclusively from the fen; *Oedothorax gibbosus*, *Clubiona subtilus*, *Trichopterna thorelli*, *Micrargus apertus*, *Peponocranium ludicrum*, *Pocadicnemis pumila* and *Silometopus elegans*. Eleven species were found only on raised bogs, these were; *Pardosa palustris*, *Pirata latintans*, *Drassodes cupreus*, *Drassodes lapidosus*, *Scotina gracilipes*, *Taranucnus setosus*, *Pirata uliginosus*, *Oxyptila trux*, *Agyneta subtilis*, *Walckenaeria vigilax* and *Walckenaeria alticeps*. Eight species were found exclusively in mountain blanket bogs, these were; *Agyneta olivacea*, *Lepthyohantes alacris*, *Pardosa prativaga*, *Trichoncus saxicola*, *Cnephalocotes obscurus*, *Cheiracanthium sp.* (Immature), *Gonatium rubens* and *Tapinopa longidens*. Five species were only collected from Atlantic blanket bogs, these were; *Scotina celens*, *Satilatlas britteni*, *Bathyphantes gracilis*, *Lepthyphantes ericaeus* and *Pachygnatha clercki*. While this may suggest association between particular spider species and individual habitat types, care must be taken when interpreting these data as only a small number of individuals of many of the species were found and thus the apparent absence from sites could simply reflect the level of sampling. Having said this, only three species were found in all four peatland types, these were; *Antistea elegans*, *Trochosa terricola* and *Pardosa pullata*. There were three species that were found on three of the four peatland types, these were; *Pardosa nigriceps*, *Trochosa spinipalpsis* and *Pirata piraticus*. Immature Lycosidae were found on all four peatland types and Linyphiidae immatures were found on three of the four peatland types.

In order to take into account the repeated sampling of sites on two occasions and the fact that some sites had both intact and restored subsites, the statistical comparison of peatland type was carried out using season and peatland condition (intact/restored) as co-variables (blocking factors). Based on this analysis it was found that the assemblages in mountain blanket bog were significantly different to the other peatland types examined (P=0.032) (Table 3.17 Figure 3.24 and Figure 3.25).

Table 3.17. CCA Statistics for the comparison of spider assemblages in 2006 in different peatland types compared with season and restored/intact as co-variables using automatic selection of environmental variables. The table at the top, headed marginal effects, lists the individual environmental variables in order of the variance they explain singly (λ-1). The table at the bottom, headed conditional effects, shows the environmental variables in order of their inclusion in the model, together with the additional variance each variable explains at the time it was included (λ-A) and the significance of the variable at that time (P-value). P-value the significance level of the effect was obtained with a Monte Carlo permutation test under the null model with 499 random permutations.

	Marginal Effects			
Variable	Variance N	λ1		
Fen	5	0.29		
MBB	6	0.29		
Raised	8	0.28		
ABB	7	0.17		
	Conditional Effects			
Variable	Variance N	λA	P	F
Fen	5	0.29	0.054	1.50
MBB	6	0.28	0.032	1.44
ABB	7	0.21	0.332	1.06

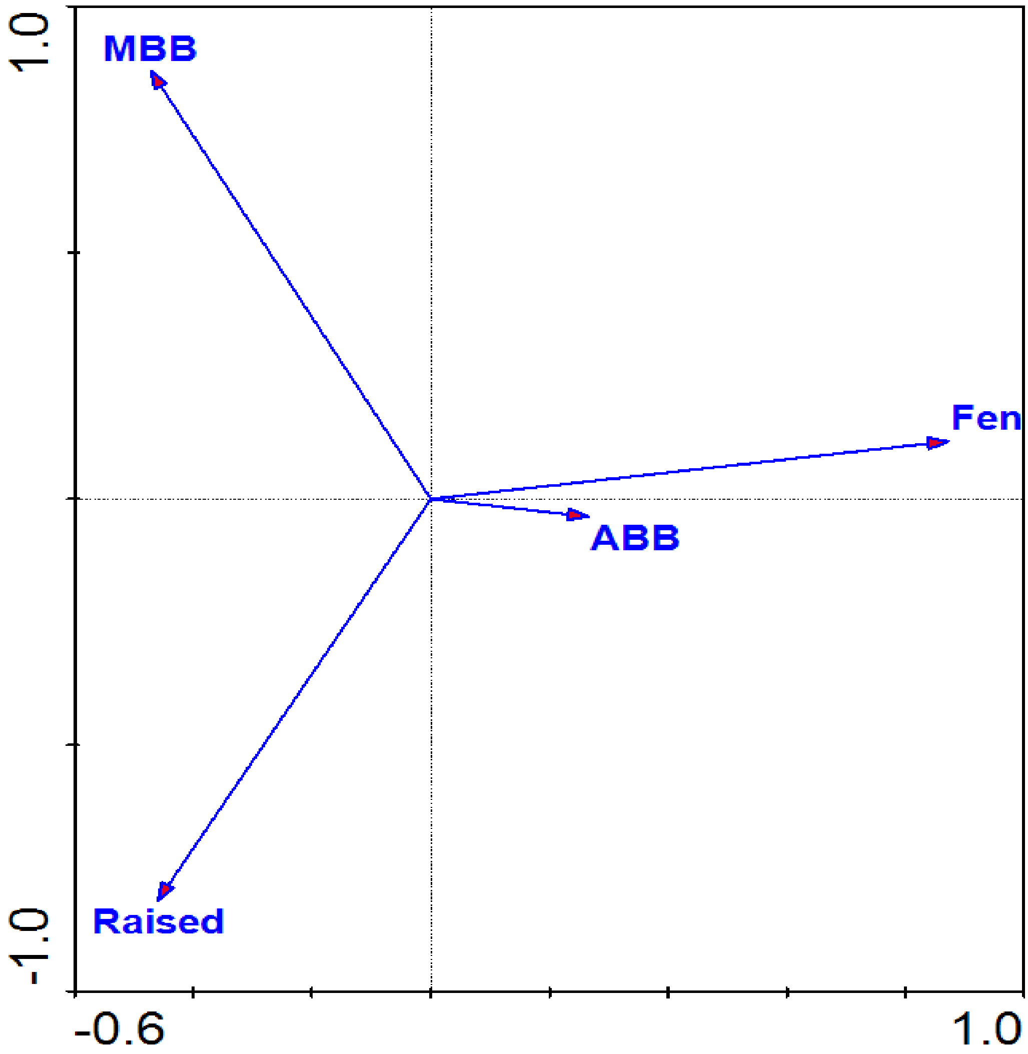


Figure 3.24. CCA ordination plot of the different peatland types compared using season and restored/intact as blocking factors (MBB, mountain blanket bog; ABB, Atlantic blanket bog)

Seasonal effects were analysed using site and condition as blocking factors and it was found that the assemblages in the samples taken in Spring were significantly different from those found in Autumn (CCA, P=0.01). There were a number of species that were associated with particular seasons. Those species associated with Spring were *Lepthyphantes ericalus*, *Pardosa nigrceps*, *Pardosa prativaga*, *Euryopis flavomaculata*, *Drassodes pubescens*, *Bathyphantes gracilis*, *Agyneta subtilis*, *Pachygnatha clercki* and *Satilatles britteni* and some of the species associated with Autumn were *Agroeca proxima*, *Scotina celans*, *Tapinopa longidens*, *Gonatium rubens*, *Antistea elegans* and *Oxyptila trux.* The condition of the peatland (analysed using site and season as blocking factors) did not have a significant effect on the species assemblages.

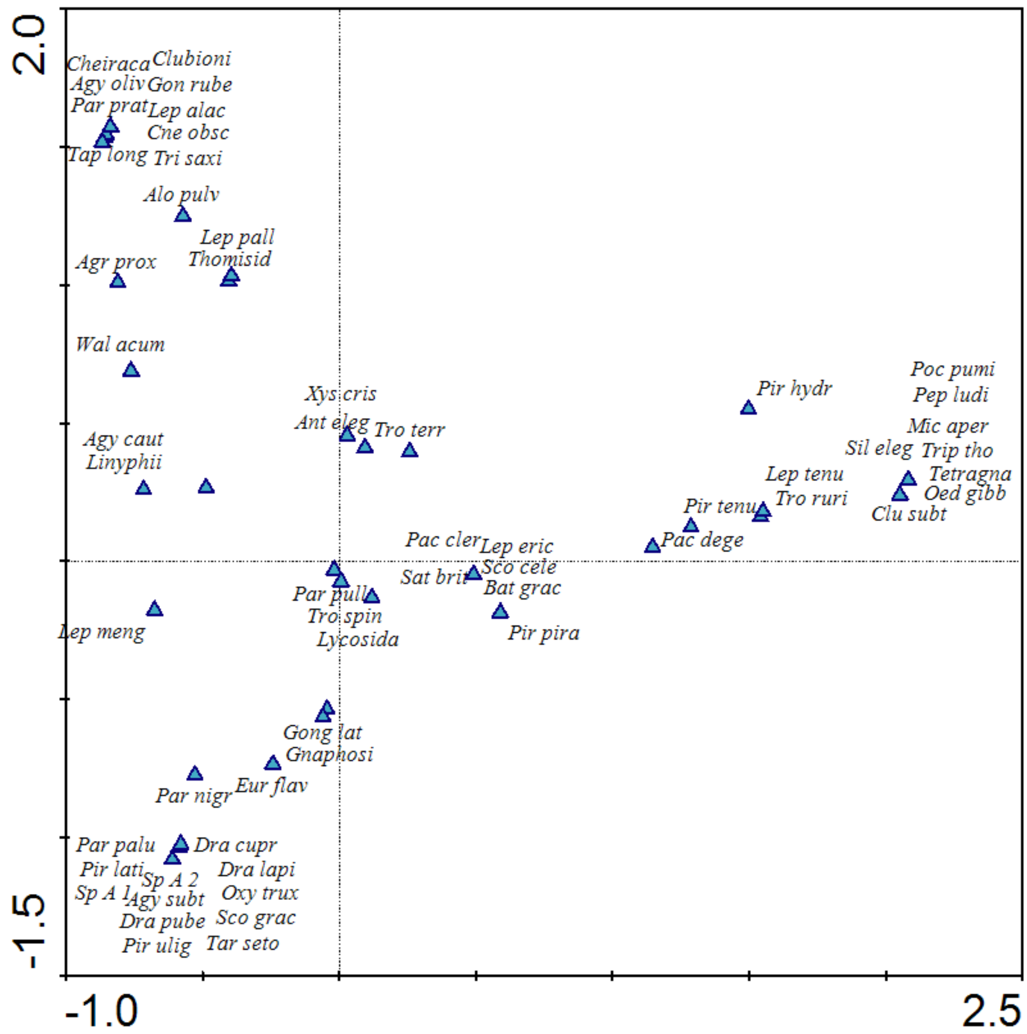


Figure 3.25. CCA ordination plot of spider species found on different peatland types compared with season and restored/intact as blocking factors in 2006 (the list of abbreviated species are given in Table 3.16)

3.2.1.1 Analysis of Spring and Autumn data from 2006 separately

One-hundred and fourteen pitfall traps were set in Spring 2006. These traps captured 292 spiders that were identified whenever possible to species. There was a greater abundance of spiders recorded for Spring, only 134 specimens were found in Autumn. Twenty eight of the species recovered in Spring were not found in Autumn but only nine species recorded in Autumn were not found in Spring. The seasonal difference was significant (P = 0.01). Analysis was done using RDA as the length of the gradient was less than three.

Analysis of Spring samples

The variation between peatland types in terms of community composition found in Spring was investigated using peatland type as the environmental variable and using peatland condition (intact/restored) as a co-variable (blocking factor). Based on this analysis it was found that the assemblages on raised bog (P=0.038) were significantly different to the other peatland types examined (Table 3.18, Figure 3.26). The condition of the peatland (analysed using site) did not have a significant effect on the species assemblages.

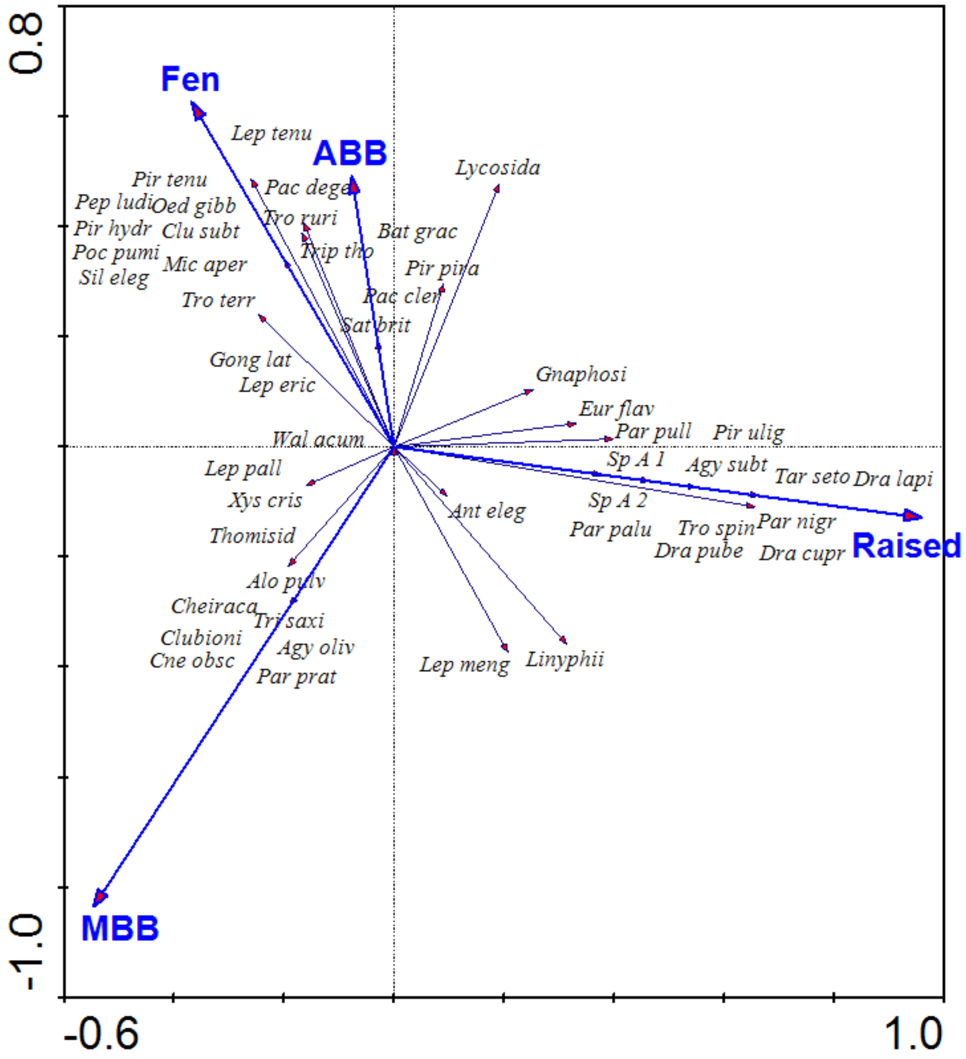


Figure 3.26. RDA ordination plot of the different peatland types compared using restored/intact as blocking factors with the species of spider found in each type in Spring 2006 (MBB, mountain blanket bog; ABB, Atlantic blanket bog) (full names of the abbreviated species are given in Table 3.16)

Table 3.18 CCA Statistics for the comparison of spider assemblages in Spring 2006 in different peatland types compared with season and restored/intact as co-variables using automatic selection of environmental variables (for full details see Table 3.17)

	Marginal Effects			
Variable	Variance N	λ1		
Raised	4	0.15		
MBB	2	0.09		
Fen	1	0.06		
ABB	3	0.03		
	Conditional Effects			
Variable	Variance N	λA	P	F
Raised	4	0.15	0.038	3.03
MBB	2	0.07	0.210	1.42
Fen	1	0.03	0.554	0.62

Analysis of Autumn samples

The species community composition for Autumn 2006 was then considered. RDA was used due to the gradient being less than three. The same analysis was carried out but, in this case, no significant differences were detected between the habitat types (Figure 3.27).

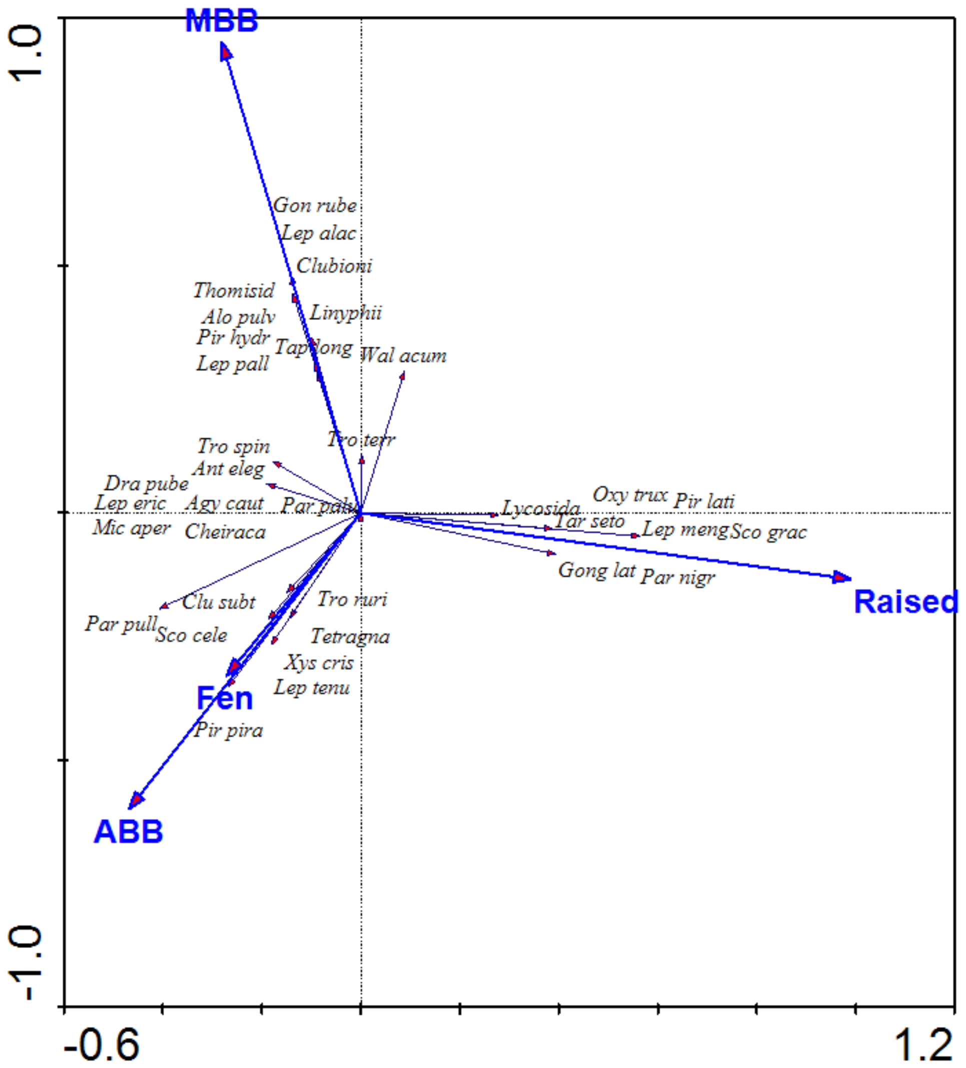


Figure 3.27. RDA ordination plot of the different peatland types compared using restored/intact as blocking factors with the species of spider found in each type in Autumn 2006 (full names of the abbreviated species are given in Table 3.16)

3.2.2 Pitfall trapping for spiders in 2007

Pitfall trapping was again carried out in August and September 2007 to investigate whether different communities would be present in raised bog habitats with varying land uses. The aim of sampling these new sites was to see whether the species composition and diversity of the assemblages found on the core BOGLAND would change when the habitat became a mosaic of different land uses and whether the assemblages associated with each of the land uses varied. These new sites were all on areas of raised bogs that had different land uses, for example areas of broadleaf and coniferous plantation forestry and grassland were sampled. The rationale for the selection of new sites in 2007 was the hypothesis that the new sites would potentially lead to a higher diversity of species but perhaps the species found on the new sites would not be the characteristic species generally found on peatlands. The sites were selected to cover a broad range of land-uses, to detect if there was one land-use that greatly altered species composition or whether changes in land-use on raised bogs did not affect diversity at all. There were 21 new sites in total.

Pitfall traps (126) were set in August 2007 for four weeks, after the four weeks these were emptied and replaced with new traps in September and then left for a further four weeks. The specific land uses sampled were; old grassland, new grassland, old turbary, newly exposed bog, dry heath, wetland recolonisation, uncut bog, mineral islands, a Sitka spruce plantation and an Oak plantation.

Three-hundred and fifty-two individuals and 56 species of spider from 13 families were collected (Table 3.19). The most abundant species found in 2007 was *Xysticus sabulosus*, 34 of this species were recorded but it only occurred in five of the 21 sites, it was present in both the Sitka spruce plantations and the Oak but not only any other land-use other than forestry. The next most abundant spider species was *Lepthyphantes tenuis*, 32 of this species were recorded but it was more widespread than *Xysticus sabulosus* as it occurred in 13 sites. This species was widespread and was found in the Sitka Spruce plantations, Oak plantations, newly exposed bog, old grassland and the mineral island. The next most abundant species was *Pardosa pullata*, again it was quite widespread occurring in ten sites and 32 of this species were recorded. It was found on newly exposed bog, wetland recolonisation, dry heath, old and young grassland and, on Sitka spruce and Oak plantations

Table 3.19. Family, species and authority, abbreviation used for ordination analysis, abundance of species

Family	**Species and authority**	**Abbreviation**	**Abundance**
Linyphiidae	*Agyneta decora* (O. P.Cambridge, 1871)	*Agy dec*	5
	Bathyphantes gracilis (Blackwall, 1841)	*Bat gra*	12
	Cnephalocotes obscurus (Blackwall, 1834)	*Cne obs*	5
	Dicymbium nigrum (Blackwall, 1834)	*Dic nig*	1
	Erigone atra Blackwall, 1833	*Eri atr*	2
	Gonatium rubens (Blackwall 1833)	*Gon rub*	2
	Leptothrix hardyi (Blackwall, 1850)	*Lep har*	9
	Lepthyphantes leprosus (Ohlert, 1865)	*Lep lep*	3
	Lepthyphantes tenuis (Blackwall, 1852)	*Lep ten*	32
	Lepthyphantes mengei Kulczynski, 1887	*Lep men*	21
	Lepthyphantes zimmermanni Bertkau, 1890	*Lep zim*	16
	Lepthyphantes angulatus (O.P.Cambridge, 1881)	*Lep ang*	1
	Lepthyphantes flavipes (Blackwall, 1854)	*Lep flav*	18
	Lepthyphantes alacris (Blackwall, 1853)	*Lep ala*	1
	Lepthyphantes cristatus (Menge, 1866)	*Lap cri*	1
	Microneta viaria (Blackwall, 1841)	*Mic via*	2
	Oedothorax retusus (Westring, 1851)	*Oed ret*	1
	Oedothorax fuscus (Blackwall, 1834)	*Oed fus*	15
	Oedothorax agrestis (Blackwall, 1853)	*Oed agr*	2
	Pocadicnemis pumila (Blackwall, 1841)	*Poc pum*	1

Table 3.19. cont'd Family, species and authority, abbreviation used for ordination analysis, abundance of species

	Savignya frontata Blackwall, 1833	*Sav fro*	1
	Stemonyphantes lineatus (Linnaeus, 1758)	*Ste lin*	2
	Tapinopa longidens (Wider, 1834)	*Tap lon*	6
	Tiso vagans (Blackwall, 1834)	*Tis vag*	2
	Walckenaeria atrotibialis (O. P. Cambridge, 1878)	*Wal atr*	1
	Walckenaeria acuminata Blackwall,1833	*Wal acu*	3
	Walckenaeria nudipalpis (Westring, 1851)	*Wal nud*	5
Lycosidae	*Arctosa perita* (Latreille, 1799)	*Arc per*	2
	Pardosa amentata (Clerck, 1757)	*Par ame*	3
	Pardosa palustris (Linnaeus, 1758)	*Par pal*	1
	Pardosa pullata (Clerck 1758)	*Par pul*	32
	Pardosa agricola (Thorell 1856)	*Par agr*	2
	Pirata hygrophilus Thorell, 1872	*Pir hyg*	10
	Pirata latitans (Blackwall, 1841)	*Pir lat*	9
	Trochosa terricola Thorell, 1856	*Tro ter*	26
	Trochosa robusta (Simon, 1876)	*Tro rob*	3
	Trochosa spinipalpis F. O. P. Cambridge, 1895	*Tro spin*	1
	Xerolycosa nemoralis (Westring, 1861)	*Xer nem*	2
Liocranidae	*Agroeca proxima* (O.P. Cambridge, 1871)	*Agr pro*	5
Clubionidae	*Clubiona compta* Koch C., 1839	*Clu com*	2
Corinnidae	*Phrurolithus festivus* (C. L. Koch, 1835)	*Phr fes*	1
Clubionidae	*Scotina gracilipes* (Blackwall, 1859)	*Sco gra*	9

Table 3.19. cont'd Family, species and authority, abbreviation used for ordination analysis, abundance of species

	Scotina celans (Blackwall, 1841)	*Sco cel*	1
Tetragnathidae	*Pachygnatha degeeri* Sundevall, 1830	*Pac deg*	11
	Pachygnatha clercki Sundevall, 1823	*Pac cle*	3
Thomisidae	*Xysticus sabulosus* (Hahn, 1832)	*Xys sab*	34
	Xysticus cristatus (Clerck, 1757)	*Xys cri*	6
Agelenidae	*Agelena labyrinthica* (Clerck, 1757)	*Age lab*	1
Amaurobiidae	*Coelotes terrestris* (Wider, 1834)	*Coe ter*	1
Gnaphosidae	*Drassodes cupreus* (Blackwall, 1834)	*Dra cup*	2
Theridiidae	*Enoplognatha oelandica* (Thorell, 1875)	*Eno oel*	1
Lycosidae	*Trochosa ruricola* (De Geer, 1778)	*Tro rur*	13
	Arctosa cinerea (Fabricius, 1777)	*Arc cin*	1

3.2.2.1 Ordination analysis of spider data in 2007

The data were examined using the seven land uses as environmental variables and the assemblage at the mineral site was found to be quite different from the other habitats and that intact bog was different from the remainder (Figure 3.29, Table 3.20). *Lepthyphantes alacris*, *Enoplognatha oelandica* and *Lepthyphantes angulatus* were found in the mineral site and not elsewhere and others such as *Agelena labyrinthica* and *Scotina celens* favoured intact bog (Figure 3.28).

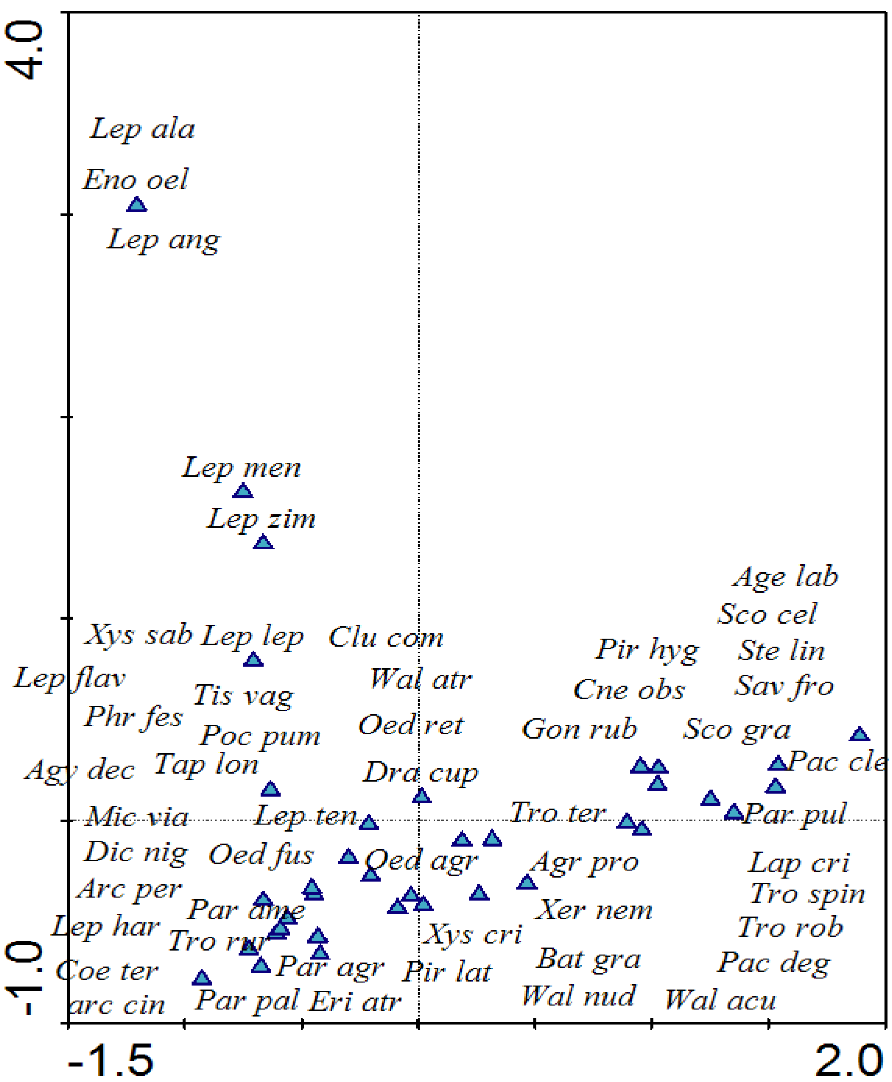


Figure 3.28. CCA ordination plot of the species of spider found in 2007 (full names of the abbreviated species are given in Table 3.19)

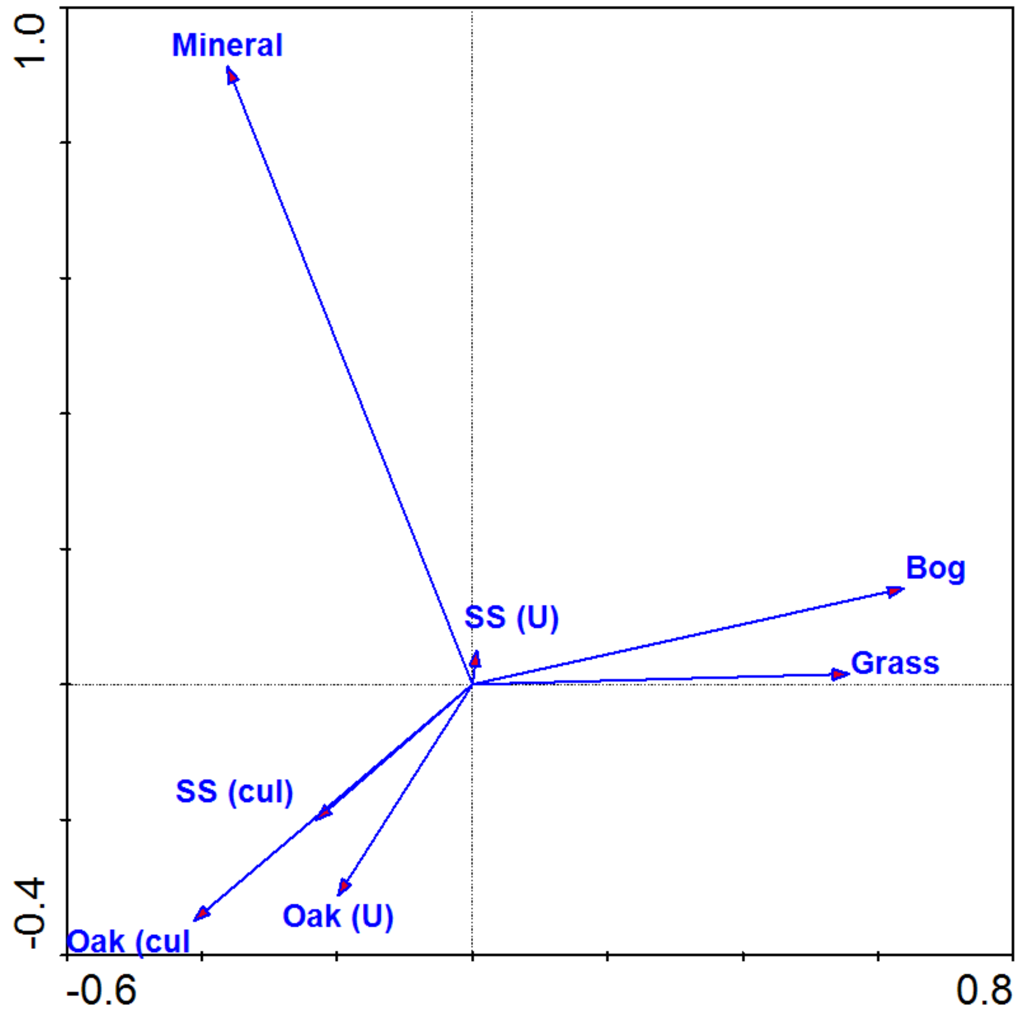


Figure 3.29. CCA ordination plot of the environmental variables investigated in 2007 (SS (U), Sitka Spruce (Uncultivated); SS (cul), Sitka Spruce (cultivated); Oak (U), Oak (Uncultivated); Oak (cultivated)

Table 3.20. CCA Statistics for the comparison of spider assemblages in peatlands with differing land uses in 2006 using automatic selection of environmental variables (for full details see legend on Table 3.17)

	Marginal Effects			
Variable	Variance N	λ1		
Mineral	6	0.46		
Bog	5	0.39		
Grass	7	0.34		
Oak (Uncultivated)	4	0.34		
Oak (cultivated)	3	0.32		
Sitka Spruce (cultivated)	1	0.24		
Sitka Spruce(uncultivated)	2	0.18		
	Conditional Effects			
Variable	Variance N	λA	P	F
Mineral	6	0.46	0.004	1.93
Bog	5	0.38	0.032	1.6
Grass	7	0.37	0.06	1.6
Oak (Uncultivated)	4	0.32	0.064	1.39
Oak (cutivated)	3	0.23	0.452	1.01
Sitka Spruce (cultivated)	1	0.2	0.62	0.88
Sitka Spruce (Uncultivated)	2	0.05	1	0.22

3.2.3 Comparison of pitfall trapping in 2006 with 2007

When the species of spider collected from pitfall traps in 2006 were compared with the species collected in 2007 it was found that they were significantly different ($P= 0.002$). There were 32 species that occurred in 2007 but not in 2006, and 27 species that occurred in 2006 but not in 2007.

3.2.4 Conclusions

The spiders found on mountain blanket bog in 2006 were found to be significantly different to the three other peatland types being investigated. In spring the assemblages in raised bog were significantly different but no significant differences were found in autumn.

The sampling in 2007 showed the bog sites and the mineral islands to be significantly different to the other peat habitats being analysed. When the species assemblages found in 2006 were compared to those of 2007 it was found that they were statistically different.

3.3 Carabidae

3.3.1 Sampling of core BOGLAND sites in 2006

In 2006 a total of 228 pitfall trap were set on the core sites and habitats outlined in the Materials and Methods. One hundred and fourteen of these were set in late Spring (May) and the remaining 114 in Autumn (August). 290 ground beetles were collected in total. 173 of these were collected in Spring and 117 in Autumn.

Table 3.21. Species and authority of the Carabidae caught in 2006 and 2007 and the abbreviation used for ordination

Species and Authority	Abbreviation
Abax parallelepidus (Piller and Mittterpacher, 1783)	*Aba par*
Agonum assimile (Paykull, 1790)	*Ago ass*
Amara lunicollis Schiödte, 1837	*Ama lun*
Bembidion doris (Panzer, 1796)	*Bem dor*
Calathus fuscipes (Goeze, 1777)	*Cal fus*
Calathus micropterus (Duftschmid, 1812)	*Cal mic*
Calathus piceus (Marsham, 1802)	*Cal pic*
Calathus rotundicollis Dejean, 1828	*Cal rot*
Carabus clatratus Linnaeus, 1761	*Car cla*
Carabus glabratus Paykull, 1790	*Car gla*
Carabus granulatus Linnaeus, 1791	*Car gra*
Carabus monilis Fabricus, 1792	*Car mon*
Carabus nemoralis Müller, O.F., 1764	*Car nem*
Carabus violaceus Linneaus, 1758	*Car vio*
Cicindela campestris Linnaeus, 1758	*Cic cam*
Cychrus caraboides (Linnaeus, 1787)	*Cyc car*
Harpalus rufipes (De Geer, 1774)	*Har ruf*
Leistus fulvibaris Dejean, 1826	*Lei ful*
Leistus rufomarginatus (Duftschmid, 1812)	*Lei ruf*
Loricera pilicornis (Fabricius, 1775)	*Lor pil*
Nebria brevicollis (Fabricius, 1792)	*Neb bre*
Notiophilus aquaticus (Linnaeus, 1758)	*Not aqu*
Olisthopus rotundatus (Marsham, 1802)	*Oli rot*
Pterostichus longicollis (Duftschmid, 1812)	*Pte lon*
Pterostichus madidus (Fabricius, 1775)	*Pte mad*
Pterostichus melanarius (Illiger, 1798)	*Pte mel*
Pterostichus niger (Schaller, 1783)	*Pte nig*
Pterostichus versicolor (Sturm, 1824)	*Pte ver*
Synuchus vivalis (Illiger, 1798)	*Syn viv*
Trechus quadristriatus (Schrank, 1781)	*Tre qua*
Trechus secalis (Paykull, 1790)	*Tre sec*

Only eight species of ground beetles were recorded and these were mainly from the genus *Carabus*. The species were *Agonum assimile*, *Carabus clatratus*, *Carabus granulatus*, *Carabus glabratus*, *Carabus monilis*, *Carabus nitens*, *Carabus violaceus* and *Pterostichus melanarius* (Table 3.21).

The eleven core BOGLAND sites were sampled in 2006. The most common species in Spring was *Carabus granulatus*, 61 of this species were collected and it occurred in seven sites and was equally distributed amongst intact and restored sites. It was absent in Spring from Pollardstown Fen, Fiddandarry, Sharavogue Bog and Kippure. The most abundant species in Autumn was *Pterostichus melanarius* with 44 of this species collected and it occurred in seven sites both in intact and restored habitats. This species was absent from Sharavogue Bog, Owenirragh, Knockmoyle and Fiddandarry. In Spring the second most abundant species was *P. melanarius* and it occurred in four sites, both in the intact and restored areas. This species was present in Glenlahan, Fiddandarry, Kippure and Owenirragh. The second most abundant species in Autumn was *Carabus granulatus* and 31 of this species were collected and it occurred in five sites on both intact and restored habitats. This species was present in Bellacorick, Carrowbehy, Clara, Ballygisheen and Glenlahan. The third most abundant species in Spring was *Carabus clatratus*, 31 of this species were recorded, and it occurred at five sites both on intact and disturbed habitats. This species was present on Bellacorick, Owenirragh, Ballygisheen, Fiddandarry and Glenlahan. The third most abundant species in Autumn was also *C. clatratus*, 18 of this species were recorded, and it was found in three sites both on intact and restored habitats. This species was present at Ballygisheen, Fiddandarry and Bellacorick. The rest of the species found were in relatively low numbers.

3.3.1.1 Ordination analysis of data from Spring and Autumn 2006

Two seasons were sampled, Spring and Autumn in 2006. The lengths of the community composition gradients were first determined using Detrended Correspondence Analysis (DCA). The gradient was found to be less than three, therefore RDA (Redundancy Analysis) was used for the analysis of the data from Spring and Autumn.

In order to take into account the repeated sampling of sites on two occasions and that some sites had both intact and restored subsites, the statistical comparison of peatland type was carried out using season and peatland condition (intact/restored) as co-variables (blocking factors). Based on this analysis it was found that the assemblages in the different peat types were not significantly different to the other peatland types examined (Table 3.22, Figure 3.30, 3.31).

Table 3.22. RDA Statistics for the comparison of ground beetle assemblages in 2006 in different peatland types compared with season and restored/intact as co-variables using automatic selection of environmental variables. The table at the top, headed marginal effects, lists the individual environmental variables in order of the variance they explain singly (λ-1). The table at the bottom, headed conditional effects, shows the environmental variables in order of their inclusion in the model, together with the additional variance each variable explains at the time it was included (λ-A) and the significance of the variable at that time (P-value). P-value the significance level of the effect was obtained with a Monte Carlo permutation test under the null model with 499 random permutations.

	Marginal Effects			
Variable	Variance N	λ1		
MBB	2	0.06		
Raised	4	0.04		
Fen	1	0.03		
ABB	3	0.02		
	Conditional Effects			
Variable	Variance N	λA	P	F
MBB	2	0.06	0.088	2.12
Raised	4	0.03	0.240	1.34
Fen	1	0.02	0.644	0.66

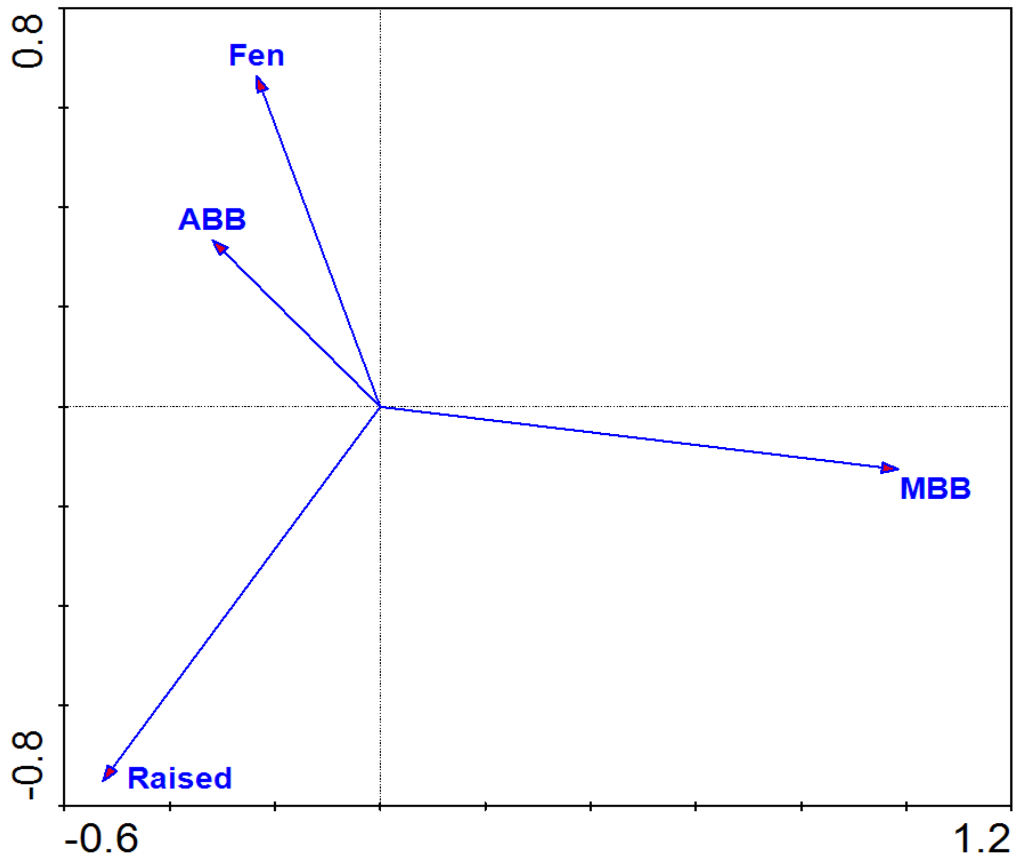


Figure 3.30. RDA ordination plot of ground beetles species found on different peatland types compared with season and restored/intact as blocking factors in 2006 (the list of abbreviated species are given in Table 3.21) (MBB, mountain blanket bog; ABB, Atlantic blanket bog)

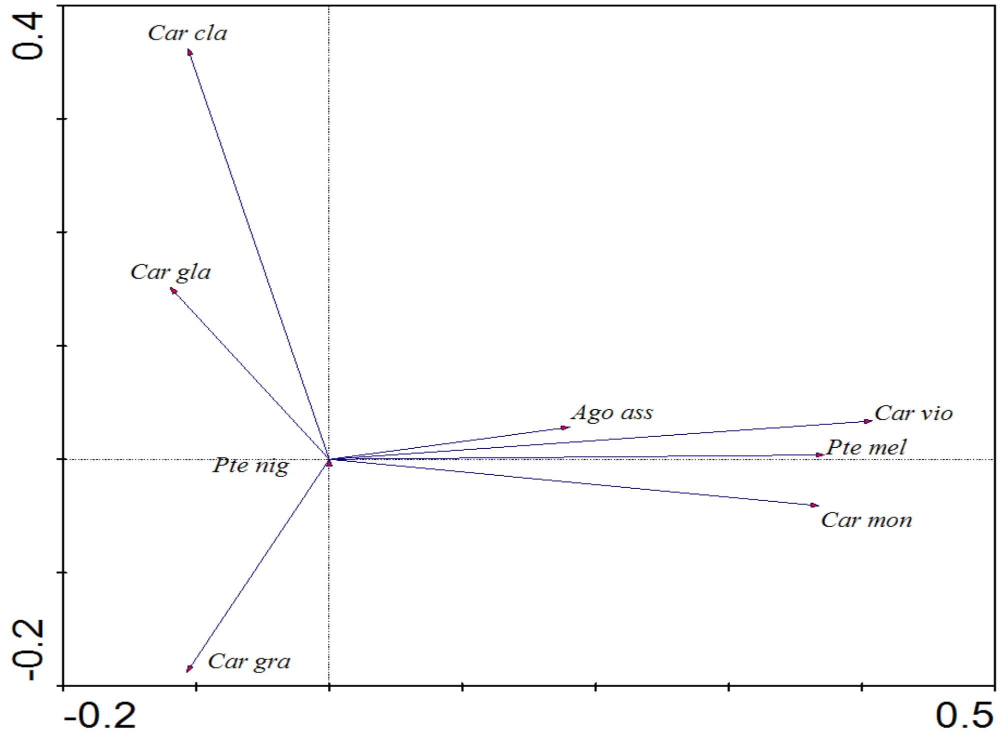


Figure 3.31. RDA analysis of the species of carabid beetles found in Spring and Autumn combined in 2006 using season and restored/intact as blocking factors the full names of the abbreviated species are given in Table 3.21)

Analysis of Spring samples

The variation between peatland types in terms of community composition found in Spring was investigated using peatland type as the environmental variable and using peatland condition (intact/restored) as a co-variable (blocking factor). Based on this analysis it was found that the assemblages were not significantly different (Figure 3.32).

Figure 3.32 illustrates the analysis of the species of ground beetles found in Spring 2006. *Carabus violaceus, Carabus monilis, Agonum assimile* and *Pterostichus melanarius* were closely associated with each other, whereas

Carabus clatratus and *Carabus granulatus* have distinct patterns of distribution. Although the graph of the RDA (Figure 3.32) suggests that the assemblage in the raised bog is very different from the other habitats but when tested statistically, using the Monte Carlo test, there was no significant effect.

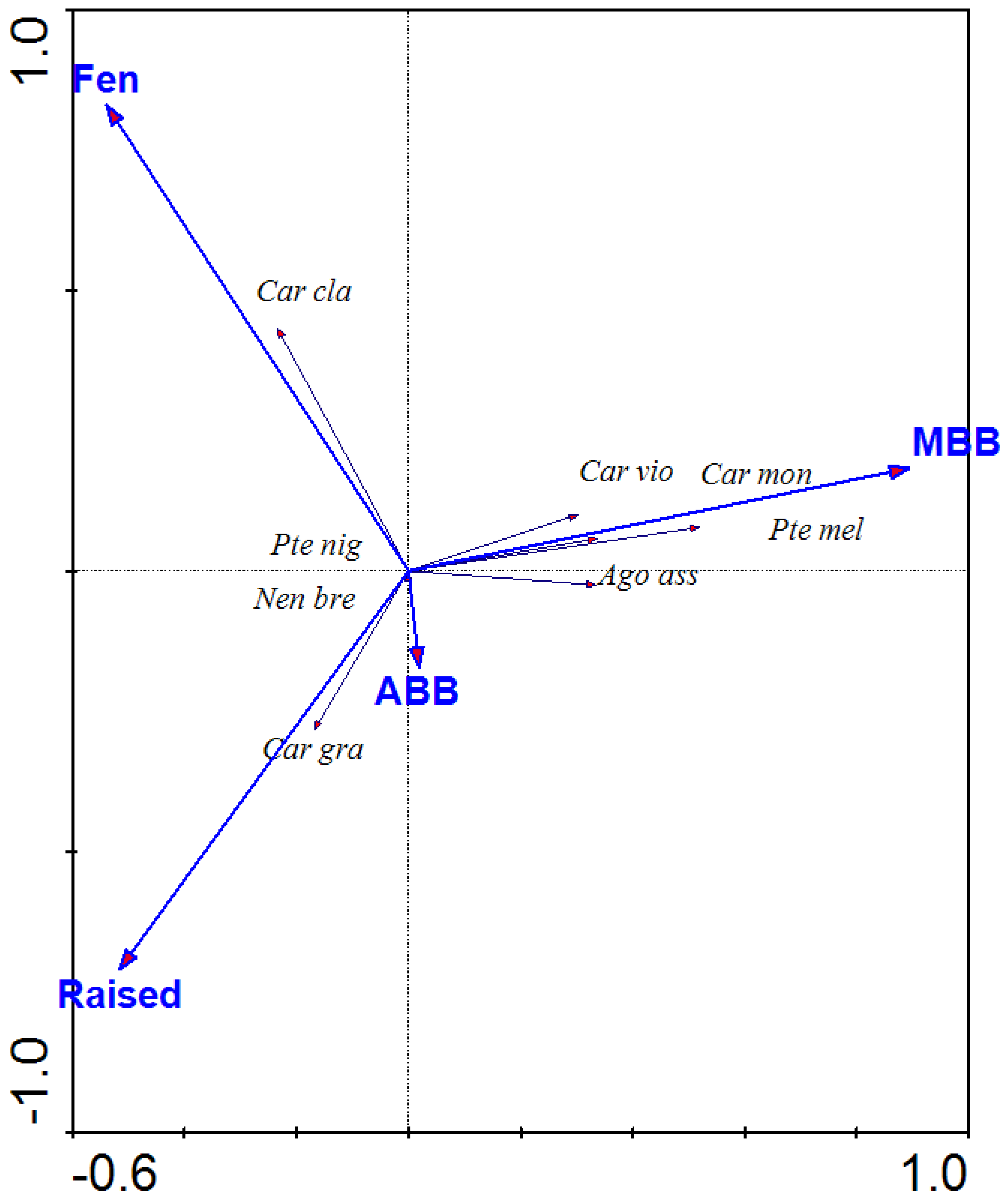


Figure 3.32. RDA ordination plot of the different peatland types compared using restored/intact as blocking factors with the species of ground beetle found in each type in Spring 2006 (full names of the abbreviated species are given in Table 1)(MBB, mountain blanket bog; ABB, Atlantic blanket bog)

Analysis of Autumn samples

The community composition for Autumn 2006 was then considered. RDA was used again due to the gradient being less than three and peatland type was used as the environmental variable and peatland condition (intact/restored) as a co-variable (blocking factor). The same analysis was carried out and again no significant differences were detected between the habitat types (Figure 3.33).

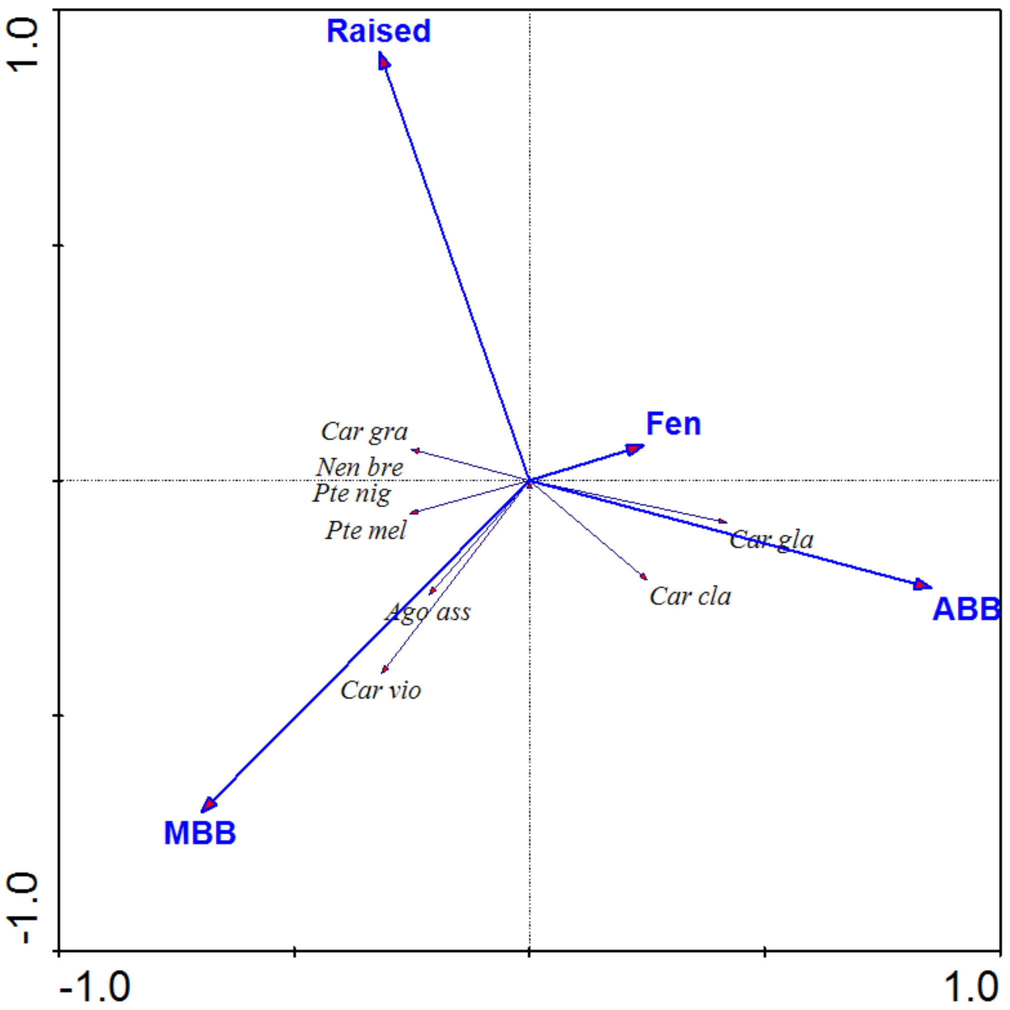


Figure 3.33. RDA ordination plot of the different peatland types compared using restored/intact as blocking factors with the species of ground beetle found in each type in Spring 2006 (MBB, mountain blanket bog; ABB, Atlantic blanket bog)(full names of the abbreviated species are given in Table 3.21)

3.3.2 Analysis of carabid data from 2007

Pitfall trapping was again carried out in August and September 2007 to investigate whether different communities would be present in raised bog habitats with varying land uses. The aim of sampling these new sites was see if the species composition that was found on the core BOGLAND sites would vary greatly from species found on the new selections of raised bog sites. These new sites were all on areas of raised bogs that had different land uses, for example areas of broadleaf and coniferous plantation forestry and grassland were sampled. There were 21 new sites in total.

In 2007 sampling took place in August and September. In total 228 pitfall traps were set. The number set in August was 114 and then the other 114 were set in September. The total number trapped and identified to species in 2007 was 1,434.

In 2007 there were 19 new sites; a description of the sites is given in the Materials and Methods section. Twenty-six species were collected in 2007. The most abundant being *Nebria brevicollis* of which 409 were collected and it occurred in 16 of the 19 sites, it was absent on the dry heath, old turbary at Killaun and on old grassland. The next most abundant species was *Calathus fuscipes*, of which 206 were collected and it occurred in twelve sites, but was absent on newly exposed bog, dry heath, uncut bog, old grassland and on some of the oak and Sitka spruce sites. The next most abundant was *Pterostichus niger*, 203 were collected but it was the most widespread as it occurred in 18 sites and was only absent from one of the mineral island that was sampled at Clongawney. *Pterostichus melanarius* was also abundant with 200 of this species collected and it was also widespread as it was found in 18 of the sites and like *P. niger* it was only absent in one of the mineral islands at Clongawney. *Pterostichus madidus* was next most abundant species and 134 of this species were trapped but it was not as widespread as *P. niger* and *P. melanarius* as it was only found in nine sites, it was mainly present in the mineral island and forestry plantations. The last of the *Pterostichus* genus that was found was *Pterostichus versicolor*, 105 of this species were collected and it was quite widespread occurring in 14 and was absent from the uncut bog, old turbary, one of the mineral islands and some of the forestry sites.

Twenty-six species of ground beetle were identified in the pitfall trapping that took place in 2007, five of these species, *Agonum assimile*, *Carabus granulatus*, *Carabus clatratus*, *Carabus monilis* and *Pterostichus melanarius* were also found in the 2006 samples (see Table 3.21 for the full list of species).

3.3.2.1 Ordination analysis of samples from 2007

The analysis of the land uses clearly show that the grass sites are very different from the other land uses on raised bog (Figure 3.35) and the CCA showed that grass was significantly different P=0.02 from the other habitats all of which are relatively similar to each other (Table 3.23). This difference appears to be primarily related to the presence a high abundance of *Pterostichus madidus* in the grassland sites and that *Carabus clatratus* was only found in the grassland sites and were absent elsewhere (Figure 3.34).

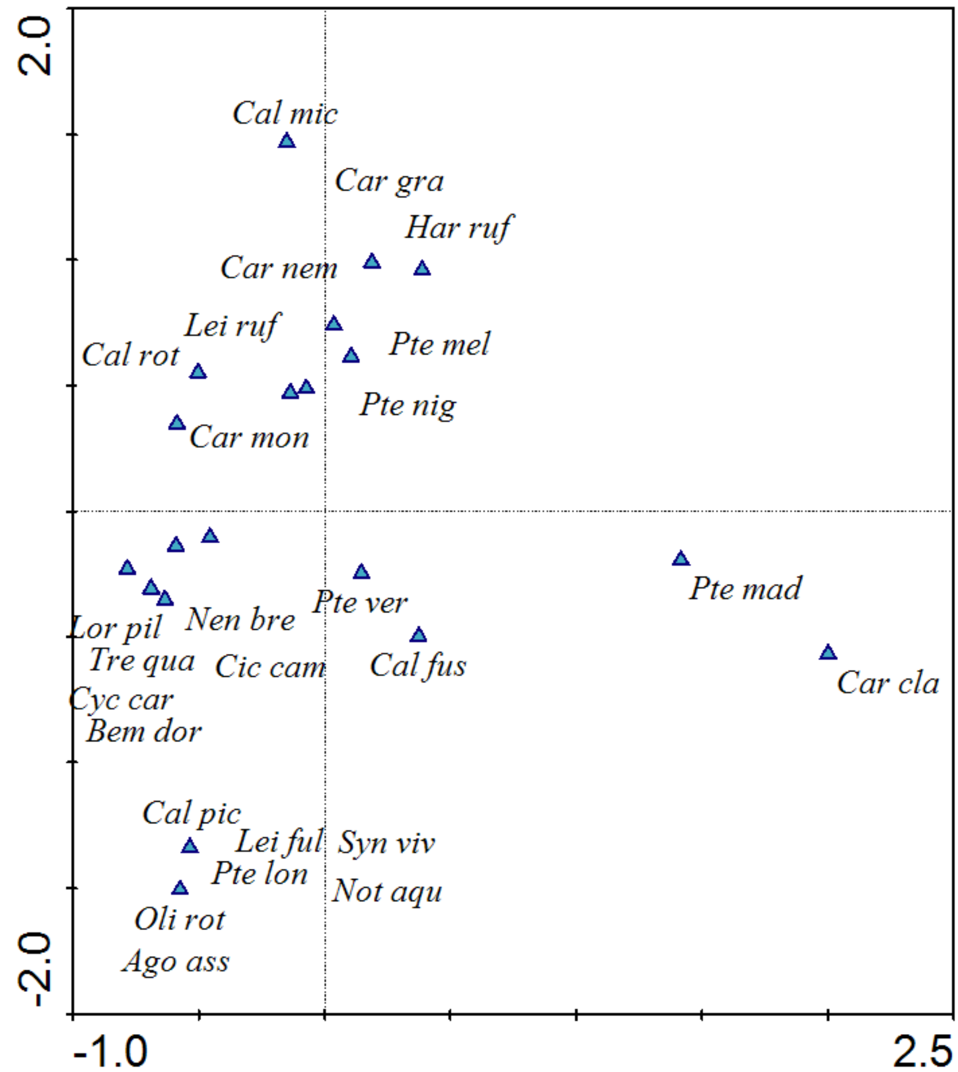


Figure 3.34. CCA ordination plot of the carabid species collected in 2007 from pitfall traps 07 (the full names of the abbreviated species are given in the Table 3.21)

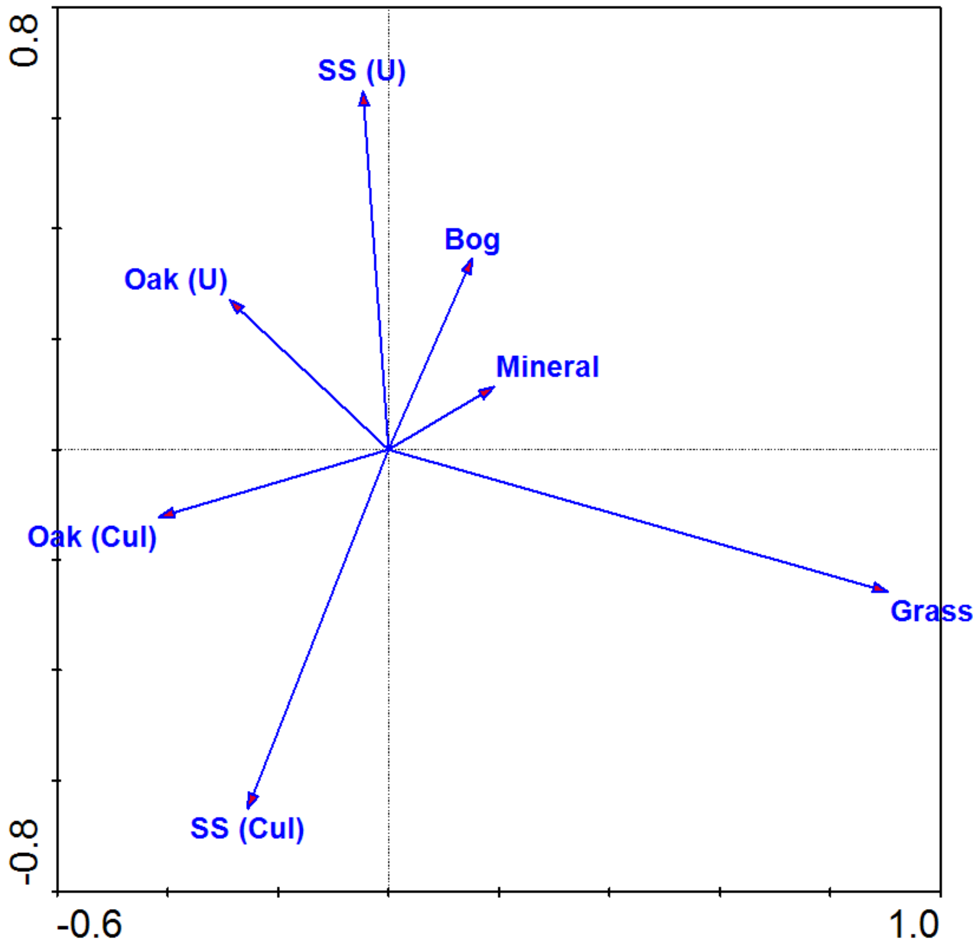


Figure 3.35. CCA ordination plot of the environmental variables examined in 2007; SS (Cul), Sitka Spruce cultivated, SS (U), Sitka Spruce uncultivated, Oak (Cul), Oak cultivated, Oak (U), Oak uncultivated, Bog, mineral islands, Grass

Table 3.23. CCA Statistics for the comparison of carabid beetles assemblages in peatlands with different land uses using automatic selection of environmental variables (for full details see caption in Table 3.22).

	Marginal Effects			
Variable	Variance N	λ1		
Grass	1	0.3		
Sitka Spruce (Cultivated)	2	0.2		
Oak (Cultivated)	3	0.13		
Sitka Spruce (Uncultivated)	4	0.13		
Oak (Uncultivated)	5	0.09		
Bog	6	0.07		
Mineral Islands (Clongawney)		0.02		
	Conditional Effects			
Variable	Variance N	λA	P	F
Grass	1	0.3	0.02	3.71
Sitka Spruce (Cultivated)	2	0.19	0.058	2.43
Oak (Cultivated)	4	0.12	0.186	1.46
Oak (Uncultivated)	5	0.1	0.168	1.3
Sitka Spruce (Uncultivated)	3	0.04	0.886	0.49

3.3.3 Comparison of 2006 carabid beetles assemblages with 2007

The total number of carabid species recorded in 2006 was eight but in 2007 it was 26. This means that there was 18 species found in the 2007 samples not found in 2006.

3.3.4 Conclusions

There was no significant difference between the habitat types or the seasons in the study from 2006 and the diversity of species was low. The ground beetle species that were found on the grass sites within the raised bog in 2007 were significantly different to all the other habitats on peat investigated in 2007. When the species assemblages that were found in 2006 were compared to the species found in 2007 it was found that they were significantly different.

3.4 Enchytraeidae

3.4.1 Sampling of the core BOGLAND sites

Soil cores were taken in order to assess the species of Enchytraeidae present in different peatland types found in Ireland. Eleven sites were sampled but within these sites there was also the possibility of intact, restored or degraded habitats. These samples were taken in May of 2009. In total 1256 enchytraeid worms were collected and identified to species. Twelve species were recorded (Table 3.24).

The most abundant species was *Cognettia sphagnetorum* 890 of which were collected and it occurred in all the eleven sites, the next most abundant species was *Cernosvitoviella ampullax* with 217 of these species collected but it was only found in six of the eleven sites, it was absent in Sharavogue, Pollardstown, Owenirragh, Knockmoyle and Carrowbehy and this species was found on both intact and restored habitats. *Mesenchytraeus sanguineus* was the next most abundant species although the number found was much lower than the previous two species, only 37 were recorded but it was quite widespread as it was found in six sites, but it was absent from Sharavogue, Pollardstown, Clara, Bellacorick and Knockmoyle. This species was found more often on the intact habitats rather than the restored habitats. *Cernosvitoviella atrata* was the next most abundant species with 24 individuals found but it only occurred in five sites, Glenlahan, Kippure, Clara, Pollardstown and Bellacorick. This species was found on both the intact and restored habitats. The abundance of *Marionina filiformis* was similar (23 were collected) to *C. atrata* but it was found in only one sample, this was at the intact site in Bellacorick. All the other species recorded occurred in low numbers. Worth noting are two species which were found exclusively at Pollardstown fen, the species were *Fridericia galba* and *Henlea perpusilla*.

Table 3.24. Species of Enchytraeidae found in 2009 and abbreviation used

Species and authority	Abbreviation used in ordination
Achaeta affinis Nielsen and Christensen, 1959	*Ach aff*
Achaeta sp. 1	*Ach sp1*
Achaeta sp. 2	*Ach sp2*
Achaeta sp. 3	*Ach sp3*
Cernosvitoviella ampullax Klungland and Abrahamsen, 1981	*Cer amp*
Cernosvitoviella atrata (Bretscher, 1903)	*Cer atr*
Cernosvitoviella sp. 1	*Cer sp1*
Cernosvitoviella sp. indet.	*Cer spi*
Cognettia cognettii (Issel, 1905)	*Cog cog*
Cognettia hibernica Healy, 1975	*Cog hib*
Cognettia sphagnetorum (Vejdovský, 1877)	*Cog sph*
Fridericia galba (Hoffmeister, 1843)	*Fri gal*
Henlea perpusilla Friend, 1911	*Hen per*
Marionina clavata Nielsen and Christensen, 1961	*Mar cla*
Marionina argentea (Michael, 1889)	*Mar arg*
Marionina filiformis Nielsen and Christensen, 1959	*Mar fil*
Enchytronia sp. 1	*Enc sp1*
Mesenchytraeus sanguineus Nielsen and Christensen, 1959	*Mes san*

3.4.1.1 Ordination analysis of enchytraeids from the core BOGLAND sites

Redundancy analysis (RDA) was used to analyse the data from the first survey because the amount of turnover in species was small (the length of the gradient of the first axis in DCA was less than three). While the ordination diagram suggests that there are certain species associated with different habitats (Figures 3.36 and 3.37) the results of the Monte Carlo test show that the contribution of the environmental variables (peatland types) to the variation in assemblage structure was not significant (Table 3.25).

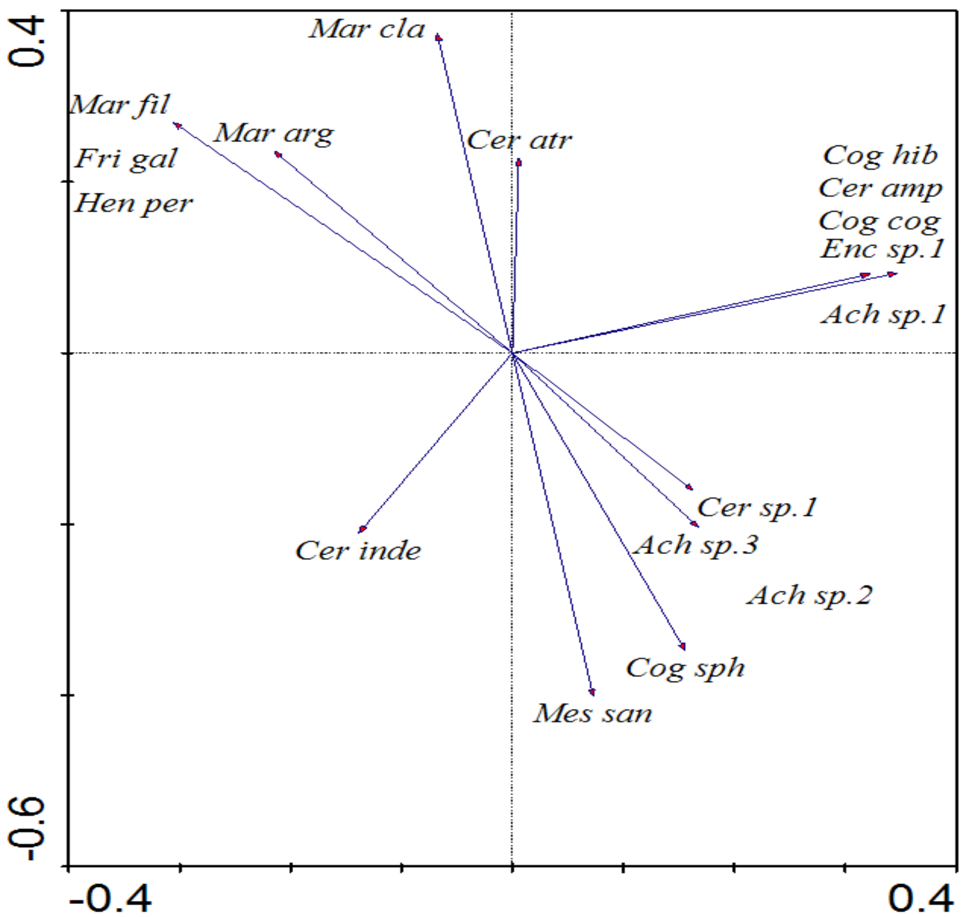


Figure 3.36. RDA ordination plot of the species of enchytraeid found on the core BOGLAND sites in 2009 (the full names of the abbreviated species are given in Table 3.24)

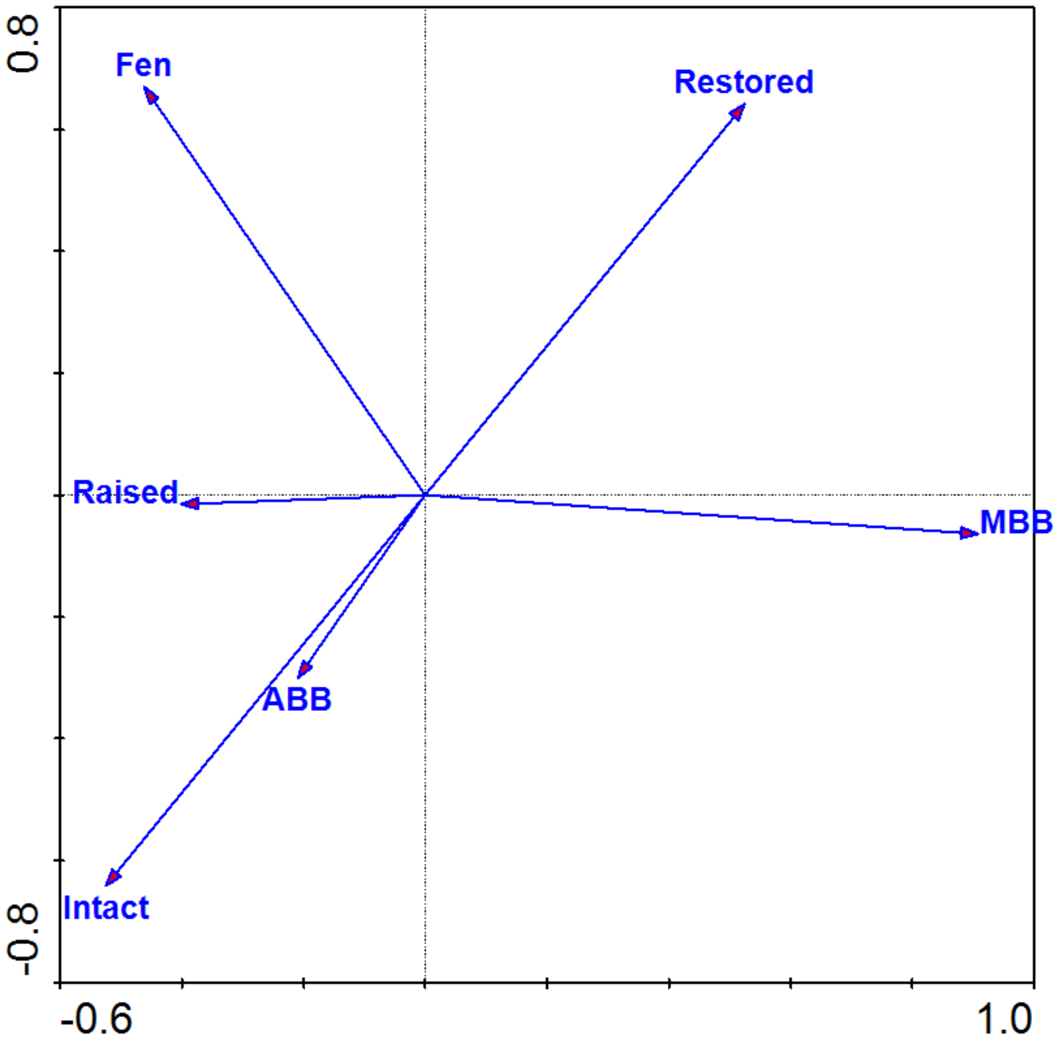


Figure 3.37. RDA ordination plot of the environmental variables investigated in 2009, MBB; mountain blanket bog, ABB; Atlantic blanket bog

Table 3.25. RDA Statistics for the comparison of enchytraeid assemblages in peatlands using automatic selection of environmental variables. The table at the top, headed marginal effects, lists the individual environmental variables in order of the variance they explain singly (λ1). The table at the bottom, headed conditional effects, shows the environmental variables in order of their inclusion in the model, together with the additional variance each variable explains at the time it was included (λA) and the significance of the variable at that time (P-value).

	Marginal Effects			
Variable	Variance N	λ1		
MBB	3	0.07		
Intact	5	0.04		
Restored	6	0.04		
Fen	1	0.04		
Raised	2	0.01		
ABB	4	0.01		
	Conditional Effects			
Variable	Variance N	λA	P	F
MBB	3	0.07	0.154	1.59
Intact	5	0.03	0.598	0.74
Fen	1	0.03	0.408	0.66
Raised	2	0.01	0.948	0.07
ABB	4	0	0.99	0.02

3.4.2 Analysis of enchytraeid data from a previous study (Healy 1976)

Analysis of an existing dataset on the species of enchytraeid found in different peatland habitats within Ireland was undertaken to gain a more complete view of the species of enchytraeids occurring in peatland sites and to use the older data as a valuable comparison. Healy (1976) sampled a wide range of habitats, these included, bogs, flush areas, acid grasslands, neutral grasslands, marshes, fens, aquatic areas, coniferous woodlands, deciduous woodlands, sand dunes, salt marshes, sea cliffs, brackish water and intertidal sand. The analysis undertaken here concentrates on the fen and bog sites that were studied among this wide range of study sites. Enchytraeids were collected from four raised bog sites, 13 blanket bogs and eleven fens in Ireland. Thirty-one species of enchytraeid were collected in this study (Table 3.26).

Table 3.26 Species of enchytraeid collected in peatlands by Healy (1976) and the abbreviation used for ordination analysis

Species and authority	**Abbreviation used in ordination**
Achaeta aberrans Nielsen & Christensen, 1961	*Ach abe*
Achaeta affinis Nielsen and Christensen, 1959	*Ach aff*
Achaeta bohemica (Vejdovsky, 1879)	*Ach boh*
Buccholzia fallax Michaelsen, 1887	*Buc fal*
Cernosvitoviella atrata (Bretscher, 1903)	*Cer atr*
Cernosvitoviella goodhui Healy, 1975	*Cer goo*
Cernosvitoviella sphaerotheca Healy, 1975	*Cer spa*
Cognettia cognettii (Issel, 1905)	*Cog co*
Cognettia glandulosa (Michaelsen, 1828)	*Cog gla*
Cognettia hibernica Healy, 1975	*Cog hib*
Cognettia sphagnetorum (Vejdovsky, 1877)	*Cog spa*
Enchytraeus buchholzi Vejdovský, 1879	*Enc buc*
Enchytraeus minutus Nielsen and Christensen, 1961	*Enc min*
Enchytronia parva Nielsen and Christensen, 1959	*Enc par*
Fridericia bulboides Nielsen and Christensen, 1959	*Fri bul*
Fridericia bulbosa (Rosa, 1887)	*Fri bul*
Fridericia galba (Hoffmeister, 1843)	*Fri gal*
Fridericia hegemon (Vejdovsky, 1878)	*Fri heg*
Fridericia paroniana Issel, 1904	*Fri par*
Fridericia perrieri (Vejdovsky, 1877)	*Fri per*
Fridericia polychaeta Bretscher, 1900	*Fri pol*
Fridericia sylvatica Healy, 1979	*Fri syl*
Henlea nasuta Eisen, 1978	*Hen nas*
Henlea perpusilla Friend, 1911	*Hen per*
Marionina argentea (Michael, 1889)	*Mar arg*
Marionina clavata Nielsen and Christensen, 1961	*Mar cla*
Marionina communis Nielsen and Christensen, 1959	*Mar com*
Marionina filiformis Nielsen and Christensen, 1959	*Mar fil*
Marionina riparia Bretscher, 1899	*Mar rip*
Mesenchytraeus armatus Levinsen, 1884	*Mes arm*
Mesenchytraeus sanguineus Nielsen and Christensen, 1959	*Mes san*

3.4.2.1 Ordination analysis if enchytraeid data from Healy (1976)

The community composition was investigated using RDA because the length of the gradient was less than 3 (Figure 3.38). The assemblages in fen were found to be significantly different to the others (P = 0.02) (Table 3.27, Figure 3.39.). Some of the species exclusively found on the fen habitats were *Marionina argentea*, *Enchytraeus buchholzi*, *Henlea perpusilla*, *Henlea nasuta*, *Mesenchytraeus armatus*, *Fridericia galba* and *Achaeta bohemica*.

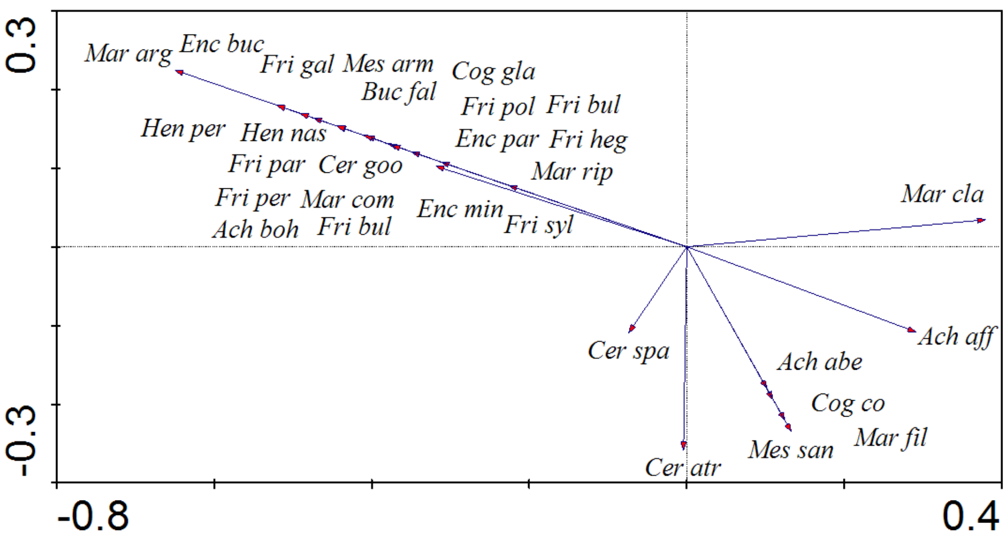


Figure 3.38. RDA ordination plot of the species of enchytraeids found by Healy in 1976 and their community composition (the names of the abbreviated species are given in Table 3.26)

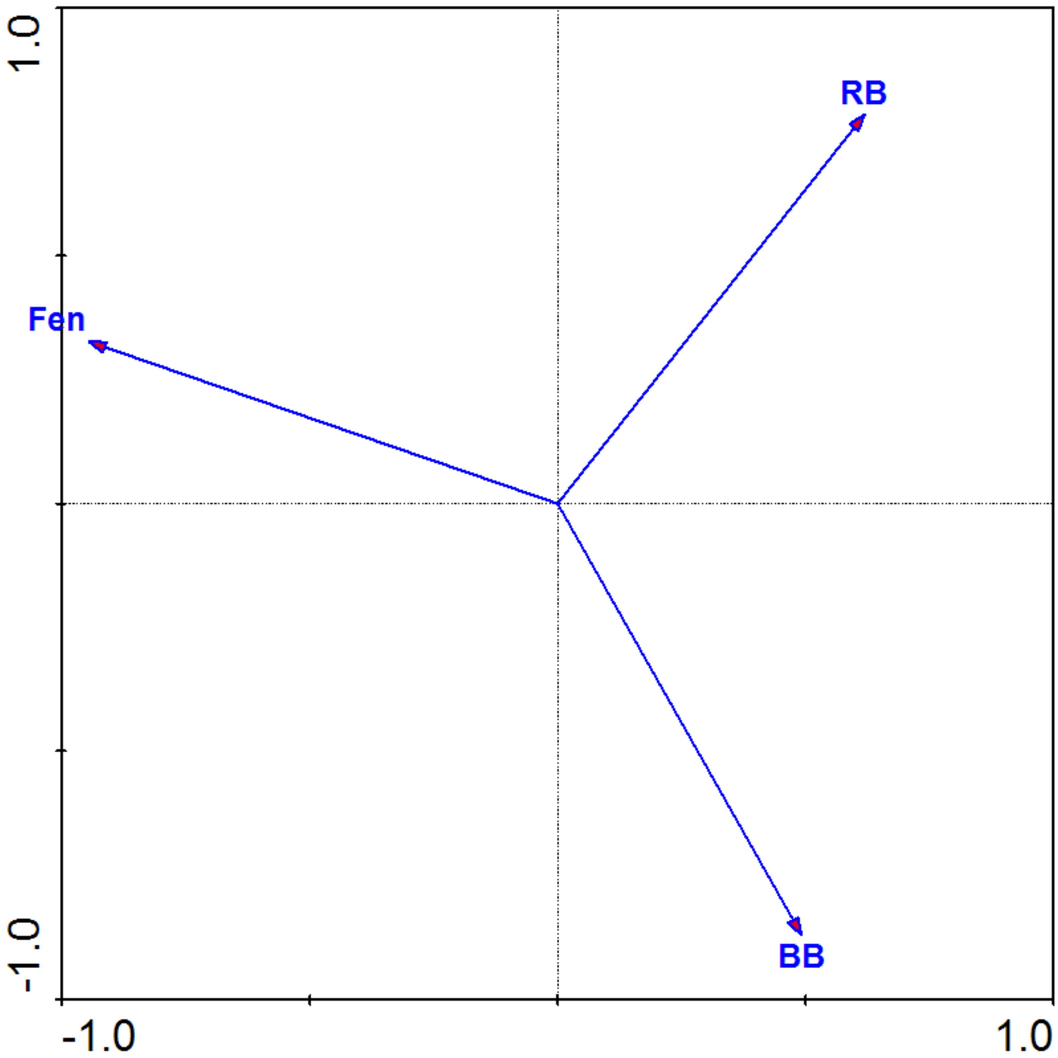


Figure 3.39. RDA of the environmental variables which were the three peatland types; RB, raised, BB, blanket bog and fen, investigated by Healy 1976

Table 3.27. RDA Statistics for the comparison of enchytraeid assemblages in three peatland types using automatic selection of environmental variables (Data used from Healy 1976) (For further details see caption on Table 3.25)

	Marginal Effects			
Variable	Variance N	λ1		
Fen	3	0.13		
Raised Bog	2	0.06		
Blanket Bog	1	0.04		
	Conditional Effects			
Variable	Variance N	λA	P	F
Fen	3	0.13	0.02	3.79
BB	1	0.02	0.34	0.69

3.4.3 Conclusions

The analysis of the species assemblages for the enchytraeids showed no significant difference between peatland types or between intact or restored areas of sites. The most abundant enchytraeid was *Cognettia sphagnetorum* and it was found in all sites except Pollardstown Fen.

The analysis of the data from Healy (1976) shows a distinct difference in the species of enchytraeid that were found in fens in comparison to two other bog types, blanket bog and raised bog.

4. Discussion

Peatlands are an important resource for many reasons and one of the important aspects of peatlands is that they have a wide diversity of species and life forms. Irish peatlands have played an important part in the culture and history of the life of Irish people for centuries and have had many functions over the years apart from just the use of the peat as fuel. The heterogeneity of habitats and diversity of species found in peatlands makes these habitats a rich and unique source of life. Ireland still accounts for 50% of the raised bog in Europe and it also has a large proportion of the blanket bog. These habitats are disappearing rapidly due to a wide variety of land uses and thus it is vital to conserve them as they are not only important in an Irish context but also internationally.

The aim of this project was to investigate the biodiversity of four taxa, mites, spiders, ground beetles (Carabidae) and enchytraeids, in the four main peatland types in Ireland; raised bog, fen, mountain blanket bog, and Atlantic blanket bog. This was to compile data on the types of species found in peatlands, in order to attempt to characterise the invertebrate peatland fauna and to identify potential components that are specific to peatlands. This is the first project on Irish peatlands that has aimed to study such a large number of taxa and over a number of peatland types across Ireland.

The species diversity of the Irish peatlands investigated in the core BOGLAND sites varied between the taxa studied. Mites were the most diverse group studied, with a total of 70 species collected. The majority of the species found on the peatlands were quite common and could be found in other habitats across Ireland and thus for the majority of species collected they would be found not only on peatland habitats but on a wide range of Irish habitats. Yet, there were some species that were potential indicator species, as they are found more frequently in peatland habitats than any other habitat type. One species of Cryptostigmata mite found was a new record for Ireland.

Spiders were undoubtedly the next most diverse taxonomic group studied in this project, with 58 species collected in total. A number of rare species were collected both in intact and disturbed sites and a number of new county records were discovered in disturbed habitats. The assemblages of spiders found on mountain blanket bog were significantly different from those found on the three other peatland types. The spiders collected in the intact BOGLAND core sites were significantly different from those found on the fragmented disturbed peatlands thus indicating that habitat fragmentation has the ability to alter the spider assemblage and to introduce species that may not have been previously found at that particular peatland site.

The diversity of ground beetles was very low with only eight species collected from intact sites. However, the species collected were mainly characteristic peatland species which are present on peatlands in greater numbers than on any other Irish habitat type. One species in particular, *Carabus clatratus,* is a well known peatland species and the status of this in a European context is rare due to habitat loss due to peatland destruction. This was observed then the peatland was disturbed and a habitat mosaic created, the number of species present increased, presumably due to the augmentation of the habitat types.

The diversity of Enchytraeidae was also low, with only twelve species collected. The most abundant species found was *Cognettia sphagnetorum* which is a typical peatland species. The lowest species richness and lowest abundance was found on one of the fen sites. This was expected and the species found at this site were not found in the other peatland sites.

4.1 Cryptostigmata and Mesostigmata fauna of peatlands

The aim of sampling the mite fauna of Irish peatlands was to classify the assemblages that were found in terms of peat type and to determine whether some species occurred only in peat habitats or whether they were common in other habitats such as grassland or forestry. The samples taken from the core BOGLAND sites yielded a broad range of Cryptostigmata species but few Mesostigmata. This was expected as the large amount of organic matter found in peatlands is more favourable as a habitat for Cryptostigmata because they contribute to the decay of organic matter (Behan-Pelletier 1999) and they also constitute the main part of acarine populations in the soil (Luxton 1996). The majority of species collected from the core BOGLAND sites were relatively common and can be found in other habitats with high levels of soil organic matter such as in coniferous forestry and moss. This is in general agreement with what has been reported in the literature which suggests that most oribatid species are not found solely on peatlands and most of the species present are also found in other wet habitats (Behan-Pelletier and Bissett 1994). According to Willmann (1931) and Karg (1993) there are a number of species found in BOGLAND that are common in peat but perhaps are not found solely on peat habitats. These species include; *Peloptulus montanus*, *Peloptulus phaenotus, Tectocepheus velatus*, *Carabodes labyrinthicus*, *Carabodes marginatus*, *Carabodes minisculus*, *Adoristies poppei*, *Fuscozetes fuscipes* and *Minunthozetes semirufus.*

The oribatid communities varied between peatland types but the genus *Limnozetes*, of which three species were found in BOGLAND (*Limnozetes amnicus*, *Limnozetes ciliatus* and *Limnozetes sphagni*), is found frequently in peats (Markkula 1986a) and is thus a potential indicator of peatlands. Interestingly the species *Hydrozetes lacustris* consistently occurs in association with species of *Limnozetes* (Willmann 1931). One species, *Limnozetes amnicus* (Behan-Pelletier), recovered from Ballygisheen, Co. Kerry was a new record for Ireland (confirmed by Valerie Behan-Pelletier in 2008). Additionally a possible species new to science was found at Pollardstown Fen. This appears to be a member of the Galumnidae but the charateristics are different from any species that has been recorded previously. These discoveries show that mites have not been studied extensively at these sites in the past.

The hypocthoniid *Hypochthonius rufulus* is found widely on different peatlands and also occurred widely in the BOGLAND study. Studies in northeastern North America have found that species from the genus *Nanhermannia* to be the most common species of oribatid mites in peatland habitats whereas the Oppiidae and Suctobelbidae are usually very low in numbers even though they are amongst the most numerous species in other habitats (Arroyo and Bolger 2008; Behan-Pelletier and Bissett 1994). *Nanhermannia dorsalis* was present in large numbers in nearly all of the samples in this present study, and only one species of Suctobelbidae (*Suctobelbella falcata*) and one species of Oppiidae (*Opeilla nova*) were collected.

When comparing the Cryptostigmata found in the other peatland studies (UK Countryside Survey 2000, Longworth 1973, Crébeo, Macfadyen 1952 and Whelan 1976) to the habitat preferences given by Willmann (1931) and Karg (1993) there were no additional species found, other than those found in BOGLAND that seem to be exclusively peatland species. The species that were found on the non-Irish bog sites i.e. Macfadyen (1952) and CS2000 were used to find whether the differences found between them and the Irish bog sites could be attributed to species that are absent in Ireland.

A number of species were found to only occur on the CS2000 sites but not on the Irish bog sites and furthermore there was a number of species that are not present or recorded in Ireland according the Luxton's species list (1998). These species include *Lauroppia translamellata, Nanhermannia coronata*, *Nanhermannia* *sellnicki, Nothrus anauniensis, Quadroppia maritalis, Suctobelbella similis* and *Synchthonius crenulatus.*

One species known to occur in Ireland, which occurred only in the CS2000 samples was *Oribatula saxicola.* A number of species from Macfadyen (1952) are also not recorded in Ireland, the species were; *Schleroribates laticeps*, *Humerobates rostrolamellatus*, *Nothrus bicillatus*, *Gustavia microcephulus*, *Phthiracarus ligneus* and *Holderma shreulm.* Additionally there were a number of species present in Macfadyen's study that were not found in the other bog sites although these species are recorded for Ireland, these were; *Nanhermannia elegantula*, *Berniniella bicarinata*, *Ceratozetes mediocris*, *Liacarus coracinus*. The additional species found in the non-Irish sites may be the main reason why there is a large amount of variation between the Irish and UK sites.

Very few Mesostigmata species, only 17 in total, were collected. The species found were not remarkable or species that are solely found in peat habitats because, as already mentioned, it is the Cryptostigmata that favour these habitats with large amounts of organic matter.

The peatland habitat that appeared to be most different from the three other peatland types was the raised bog. This may be partly due to the low numbers of some the species that were collected from these sites. For example; *Rhysotritia duplicata* and *Carabodes marginatus* were not found on any other peatland type except the raised bogs.

In order to determine the extent of the similarity/dissimilarity of the species occurring in peatlands with those occurring in other Irish habitats, analysis was undertaken using previous records occurring in the literature or other studies carried out by the research group at UCD. The habitats varied, there were; grasslands, peatlands, machairs and forestry. The studies used for comparison are outlined in 3.1.3.2 in the Results section. The aim of using the additional data was to determine whether the species found in the BOGLAND study were unique to the peatlands being studied in BOGLAND or whether they were similar to other species that had been recorded previously. It was clear that the assemblages found in the BOGLAND study were quite distinct from those found in other habitats. The other peatland sites included in the study, most notably those studies by Longworth (1973) and in the Countryside Survey 2000 (Black *et al*. 2003). Species such as *Adoristes poppei*, *Ceratoppia bipilis*, *Chamobates schuetzi* and *Oppiella nova* appeared common to those sites

The level of diversity in the BOGLAND core sites was greater than many other Irish habitats when compared to all the other Irish studies. The only other habitat with a greater diversity was found to be forestry.

The CréBeo dataset was analysed on its own. The aim of this analysis was to determine whether there would be habitat differences between a number of different land-use types; forestry, arable, peat and pasture. Most importantly it was used to determine whether the assemblages found in the bog sites were different from the other land-use types. The forestry sites were found to be the most different from the other habitats in terms of species composition, this was undoubtedly due to the greater taxon richness found in the forestry sites. They also contained many species that were not found elsewhere, for example species such as *Geholaspis mandibularis* and *Ceratozetes peritus* were only found in the forestry sites and not in any of the other habitats.

The overall species list compiled from all the Irish mite species data for Cryptostigmata and Mesostigmata was compared with the Irish species list provided by Luxton (1998). This comparison found a number of species records could be added to the list, both in the Cryptostigmata and the Mesostigmata. There was an additional 106 Cryptostigmata and 64 Mesostigmata added to Luxton's list from 1998 (see appendix 1 for the full list of species). The fact that a great number of mite species were added to the original list compiled by Luxton (1998) implies that our knowledge of the soil fauna of Irish habitats has not been explored widely enough, and although the list provided by this present study has aimed to provide a thorough list there is still the potential that some species, present in Ireland, have not been recorded due to lack of scientific investigations. A number of habitats used to compile the updated mites species list were not considered in Luxton's species list, this included habitats such as Machairs, saltmarshes, a range of habitats on peatlands, managed grassland and forestry in addition to data from the Clare Island survey. This updated list is a significant contribution to ensuring that the mite records for Ireland are as complete as possible.

The selection of new sites sampled in 2009 aimed to look at the species diversity of raised bogs that were either intact, restored or cutaway. The restored sites were sites that had undergone either small scale extraction, i.e. peat was extracted and on a very small scale (industrial peat extraction machinery was not used), or, in the case of Lodge Bog, the sites were drained. The species found in both the intact and restored sites were similar to the species found in the core BOGLAND sites in 2006 and no additional species were added to the list. This was as expected since the peatland type and status were comparable to the raised bogs that had already been sampled from the core sites.

The samples taken from the cutaway peatlands in both Mongan Bog and Lodge Bog yielded extremely low abundances of mites and the only species that was found was from the genus *Limnozetes*, which although, as already described, this genus is widespread in peatlands, it was alarming that this was the only species found and in such small numbers, indicating the use of industrial extraction had decimated populations of mites. This shows that mechanical harvesting is detrimental to mite populations, whether or not populations of mites have the ability to recover from such a loss of diversity is unknown and would be invaluable information in a future study.

The mites were sampled in Spring 2006, only one season was sampled due to the large numbers of mites that were collected which was partly due to the large core size and thus there was large volumes of soil for mite extraction. It would be interesting if other seasons were studied for comparison to detect any variations between the species present at different times of the year. It would also be productive if there was a focus on the vegetation growing on the soil and to detect any influence vegetation type may have over the species of mite collected. It would be interesting the look at the mite populations present on the peatland habitat mosaics sampled for spiders and ground beetles in 2007 to investigate whether the alteration of the original peatland landscape modifies the species community composition as it did in the case of the spiders and ground beetles. It is possible that with more extensive studies that new records or even new species may be collected. This would involve more intensive sampling studies conducted over a longer time period, yet due to the lack of habitat specific species, it is unlikely that more species would be found.

Further study is necessary to sample mite populations on cutaway bogs and then compare the species to a section of the bog that has been restored under a strict management protocol. This study would need to be conducted over a number of years to detect if mite populations regenerate after a certain time, or revert back to similar levels in terms of species before peatland extraction began.

A large body of data for the Cryptostigmata and Mesostigmata found in peatlands in Ireland has been gathered and therefore providing a baseline for any further mites studies that are conducted on Irish peatland and thus provides an invaluable comparison. The overall species diversity for the mites found in core BOGLAND sites was similar to listed species of some studies eg. Longworth (1973) and Black *et al.* (2003). The additional species added to the list compiled by Luxton (1998) provides an even larger list of the species of Cryptostigmata and Mesostigmata found in Ireland and is an important tool when determining whether a species has been recorded before in Ireland. The taxonomic skills that are required for mite identification are great, and accurate identification to species level requires much patience and time. The new Irish record of *Limnozetes amnicus* and the potential of the new species from the Galumnidae are interesting finds and suggest a potential for further new discoveries if sampling of mites continues on these peatland habitats. Seventy-one species of Oribatida are listed in Canadian peatlands (Behan-Pelletier and Bissett 1994) only eleven species were found were common within the BOGLAND study, although there were a number of families and genera that were common to both, only the species differed, this is more than likely due to species variation caused by sampling in countries that are great distances apart. The Canadian study shows that the oribatid diversity of peatlands is great and this is what was found with the BOGLAND study.

4.2 Spider assemblages on Irish peatlands

Due to variations in the environmental conditions between different peat types it has been suggested that there would be differences in the species associated with them. Nolan (2002) suggested that particular characteristics of mountain blanket bog such as high altitude, high degree of exposure, low pH, low nutrient value of vegetation, high degree of precipitation and saturated substrate would probably serve to influence the diversity and abundance of spiders, and that these conditions would be different to those on other peatland types. Hence variation of species assemblages would occur, especially with regard to mountain blanket bog and fen. Therefore the results that were obtained for spiders in 2006 were as expected.

Past literature has shown, in general, there is a different distribution of species for different peatland types. An example of this is where van Helsdingen (1997) found 59 species on Pollardstown fen, but only eleven of these species corresponded with species found on mountain blanket bog by Nolan (2002). Nolan (2002) also notes that although far more work needs to be done on spiders on different peatland habitats, before respective faunas can be compared properly, it appears that there are distinct differences between raised bog, fen and mountain blanket bog. Oxbrough *et al.* (2006) have found that fens and Atlantic blanket bog support a distinct spider fauna from other peatland types and it has been suggested that wet flushes on both types may be important indicators of biodiversity in peatlands. The species of spider found in 2006 and 2007 were compared to habitat data given in Roberts (1993 and 1995). Each species was assessed to see whether it was a species described as being found solely on peat habitats and, while a number of species are described as being found in peat habitats and heaths, in most cases they are also found in other habitat types such as forest. The peatland species found were *Leptothrix hardyi*, *Bathyphantes gracilis*, *Xerolycosa nemoralis*, *Scotina gracilipes*, *Pachygnatha clercki* and *Euryopis flavomaculata.*

Two species collected in 2006 were thought to be new records for Ireland; the species were *Micrargus apertus* and *Walckenaeria alticeps* (both Linyphiidae).

These were collected in Bellacorick, Co. Mayo and Sharavogue, Co. Offaly. Unfortunately although these are rare species they were not new records.

Other rare species were collected in 2006. Rare species are defined here as species that have been recorded as occurring in less than five counties in Ireland (Cawley 2001). Assessing whether a species is rare was done with the use of journal publications such as Cawley (2001; 2009), van Helsdingen (1996) and and “invertebrate Ireland” as a source for information on records. Three rare species of Lycosids were found, the first was *Pardosa prativaga*, this species has been only recorded in four counties in Ireland; Antrim, Down, Clare and Offaly. This species was found at the Kippure site in Co. Wicklow and thus it is a new county record. *Pirata latitans* has only been recorded in three Irish counties, these counties are, Carlow, Waterford and Offaly, this species was found in Offaly in the 2006 samples. *Pirata tenuitarsis* has been recorded in only one Irish county, which is Kildare. In 2006 it was found in Pollardstown Fen in Co. Kildare and also in Ballygisheen, Co. Kerry (which is a new county record). A member of the Clubionidae- *Clubiona subtilus*, has been recorded in four Irish counties; Kildare, Wicklow, Cork and Wexford. In this study in 2006 it was found at Pollardstown fen, Co. Kildare.

There were two species of Linyphiidae that were deemed to be rare. The first was *Agyneta cauta*, which has been recorded in four Irish counties; Antrim, Clare, Offaly and Donegal. In the samples taken in 2006 it was found in Glenlahan, Co. Laois, Carrowbehy Co. Roscommon and Kippure, Co. Wicklow. These are three new county records. The second rare species from the Linyphiidae was *Trichoncus saxicola*. This species has only been recorded in one Irish county; Dublin. In this study it was found in Kippure, Co. Wicklow in the 2006 samples. Nolan (2002) has found, that when assessing the spider populations on mountain blanket bog, there seems to be a distinct mountain assemblage.

Spiders collected in 2007 were compared to information on rare species (Cawley 2001 and Van Helsdingen 1996) and some additional rare species *Leptothrix hardyi* which is only recorded in Antrim, Dublin and Wicklow, but was found here on Oak and Sitka Spruce plantations in Offaly and thus is a potential new county record; *Lepthyphantes angulatus* which was recorded in Fermanagh, but in this case it was found in the mineral island at Clongawney Bog Co. Offaly, therefore this is a possible new county record; *Walckenaeria atrotibialis* was recorded in Antrim, Carlow, Down and Roscommon but here it was found in a Sitka Spruce plantation in Offaly. Therefore this is another potential new county record. *Pirata latitans* and *Agyneta cauta* which are rare species in Ireland were found both in the 2006 and 2007 samples.

The spider fauna was assessed on the new sample sites on forestry and other land use changes on peatlands these changes can cause major alterations in the abiotic and biotic aspects of an ecosystem. Oxbrough *et al.* (2006) indicated that peatlands are very sensitive to afforestation and that if you are conserving biodiversity loss, peatlands are unsuitable for afforestation. Distinct species have been found in Ireland on various habitats (Cameron, Johnston and McAdam 2004).

The species of spider collected in 2006 were compared with the species found on the additional sampling sites used in 2007. When they were compared it was found that they had 24 species in common, and that thirty-four species were found solely in 2006 and thirty-two species were found solely in 2007. The species composition for the two years was significantly different. This is interesting as it indicates that when peatland habitats are altered by changing their land use the species composition changes and the species that are found may be more typical of forest and grassland areas rather than true bog. The species found on the mineral islands, the true bogs sites and the grassland site in 2007 were significantly different to each other indicating the management and changes in the land-use within bogs may have an effect on the species composition.

There were a large number of species represented by only one individual. For example of the seven species only recorded from fens, five of them were represented by only one specimen. An illustration of this problem is that *Pardosa uliginosus* has been recorded in several types of peatland in Ireland, however, in this survey it was found in only one peatland type (raised bog) and only one individual of this species was caught. When there is a large number of species which are represented by a single individual (which occurs regularly in studies such as these) it is not easy to value such species as the sampling is limited and a solution to this problem is to perhaps use more that one method of trapping and to have an extended sampling period.

Pitfall traps only measure spider activity and some species are more active than others (Oxbrough *et al.* 2005). Lycosids are most frequently caught in studies using pitfall traps due to their high activity on the ground. This means that species that are less active on the ground are less likely to be caught and therefore may not be represented in a survey. Also the vegetation structure around a pitfall trap can have a negative effect on the capture rate of invertebrates and, where the vegetation varies among the sample points, the interpretation of absolute abundance data is problematic (Melbourne 1999). To conclude this point the findings in this study can only be related to active ground dwelling spiders.

Further study could take these issues into account as well as concentrating on the differences in each peatland type with regard to structural variations (microhabitats) as structural characteristics of the vegetation are thought to be important factors for habitat selection in spiders (Gajdoš and Toft 2000). New species records of Irish spider fauna are uncovered quite often in Ireland (eg. Fahy and Gormally 2003; Cawley 2001 and Nolan 2009) this is mainly due to lack of study. Thus with further sampling of peatland sites there is the potential to find new records that otherwise will have been overlooked. The potential of using spiders as indicators of peat bogs has been investigated in England by Scott, Oxford and Selden (2006) and a similar type of study would be beneficial in Ireland as spiders can be used to signal habitat changes.

Although fens showed that they had low species abundance, they had several species not collected from other peatland types and other studies have shown that a number of rare species occur on them (Helsdingen 1997). In fact, irrespective of any species abundance, each peatland type appeared to support a number of species only found on that type. Establishing that these species represent specific peatland type fauna is made difficult by a lack of records. While some of the species discussed may have a limited distribution to specific peatland types, others may be more common than this survey and other records indicate.

4.3 Ground beetle assemblages on Irish peatlands

The number of species found in the core BOGLAND sites was low and only eight species (*Carabus granulatus, Carabus clatratus, Carabus violaceus, Carabus glabratus, Carabus nitens, Agonum assimile and Pterostichus melanarius*) were found in total. This was surprising, for example, comparisons made with the data gathered in the PhD study by M. Coll (1998) showed the species found were quite different. This analysis suggested that the differences between the BOGLAND study and that of M. Coll (1998) can be attributed to the fact that M. Coll's (1998) sampling occurred in areas of peatland under some sort of management; for example, forestry. Forestry has the potential to alter abiotic factors such as pH but also vegetation and soil fauna (Coll and Bolger 2007). It is possible that disturbed or managed peatlands may have a greater diversity of carabid species. The peatland habitats dealt with in the core BOGLAND sampling protocol were largely intact areas and hence it is proposed that this is the reason for such great variation in the species that were caught.

The data from the pitfall traps in 2006 was further compared with information contained in *The Ground Beetles of Northern Ireland* (Anderson, McFerran, & Cameron 2000) and the online information provided for use in conjunction with the book (www.habitas.org.uk). The information gathered from these two resources is presented in Table 4.1. It appears that although very few carabid species were gathered in 2006 that this is a true reflection of what may be found in an intact peatland habitat and low species diversity in peatlands has also been noted in McDonnell, Fahy and Gormally (2002). The idea that additional species would be added to peatland habitas if they are disturbed was investigated in the second year of sampling where heavily degraded, managed or drained sites were sampled. A number of sites were chosen for this analysis in order for intensive sampling of the carabid fauna to take place. Pitfall traps were left for approximately four weeks, collected and then new pitfall traps were set, this was done over a two month period. The spider fauna were also collected and identified to provide a comparison with the species found in 2006.

There was not a clear distinction between the species found in the different habitats in the new sites in 2007 and although the habitats had been altered from their original or undisturbed peatland state to a different land use, it was apparent that many of the characteristic peatland species were present such as; *Cicindela campestris*, *Carabus granulatus* and *Carabus nemoralis*, yet the numbers found were less than would be found on semi-intact or pristine peatlands and there was a greater abundance of species that would be indicative of habitat mosaics such as some species from the genus *Pterostichus.* The only habitat type that seemed to exhibit signs of being slightly different in terms of the carabid species found was the young grassland. It is thought that bare peat sites are more likely to support ground beetle communities associated with adjacent habitats rather the species associated with bare peat (Blake *et al.* 2003).

Table 4.1. Species of ground beetle recorded on Irish peatlands recorded in Mc Ferran and Cameron (2002) and their associated habitat and county record

Species	Habitat	County record
Carabus glabratus	Lives among heather and litter on well-vegetated upland peat, particularly on raised bogs.	Wicklow and Kerry
Carabus arvensis	In Atlantic heaths down to sea level on western coasts.	No southern record
Carabus problematicus	A woodland species but very local at lower altitudes and found mainly in overgrown montane dwarf shrub heaths.	In Mayo, Kerry, Wicklow.
Carabus clatratus	Occupies a wide range of habitats in areas of high rainfall but principally in peaty marshes, wet hay meadows and boggy lakeshores.	Found along the west coast, Kerry and Wicklow
Carabus granulatus	Easily the commonest *Carabus* in Ireland. Ubiquitous in wet fields, river margins, fens, lakeshores, and upland peat.	Found in the midlands, Wicklow, Galway, Kerry and the west coast
Carabus nitens	It is diurnal and often found running on heather moorland in the uplands. Prefers the inteface between wet and drier areas.	Recorded in Northern Ireland.
Nebris brevicollis	Occurs in most habitats but particularly under stones in woodland and dense heather moorland.	Very common throughout Ireland.

Nebria salina	Mainly under stones on mountain summits, or in dry open sites in peatlands, occasionally on the coast.	Found in Wicklow, Kerry, Galway and Mayo.
Dyschirius globosus	Bare peat and mud.	Found in the midlands, Cork, Kerry, Wexford, Mayo, Galway and Dublin.
Patrobus assimilis	Northern and upland on dry gravelly or peaty soils particularly on high peatlands.	Few records in the south, Kerry, Mayo and Wicklow.
Trechus obtusus	Very common in a variety of habitats from gardens to montane peatlands and hill summits.	Records for Mayo, Galway, Kildare, Kilkenny, Cork and Wicklow.
Bembidion doris	Locally abundant in fens and bogs.	Some records in Galway, the midlands and Kerry.
Bembidion mannerheimi	Black ground beetle common in moist places near freshwater and on upland peat.	Records for Dublin, Mayo, Kerry, Waterford, Wexford, Cork and the midlands.
Abax parallelepipedus	Lives under stones, loose bark, leaf litter etc, in woodland, heaths and montane peatlands.	Quite common in southern Ireland.
Agonum fuliginosum	Very common in wetlands and upland peat	Found in the midlands, Galway, Kerry, Wicklow and Mayo.

A rare species of ground beetle, *Carabus clatratus,* was collected. *Carabus clatratus* is widespread across the Palearctic, the distribution of this large ground beetle extends to Korea, Manchuria and Japan. Although local and rare *C. clatratus* has been recorded in Sweden, Norway, Finland and Russia. It has also been recorded in Denmark, Estonia, Latvia, the British Isles, Holland, south-east France, northern Italy, Greece and Bavaria. It can be found as far east as

Arkhangelsk and Causasus in Russia, Kirgizia and western Turkestan and also Siberia. In Scotland it is locally distributed in the Lowlands and Highlands (Fowler 1887).

C. clatratus occurs widely in Ireland and has been recorded in a total of 30 localities in the 15 out of the 32 Irish counties (Johnson and Halbert 1902). The earliest noted record of *C. clatratus* is that of Patterson (1838) where he found this ground beetle on Birkie bog, which is thought to be in south Co. Antrim or north Co. Down. The next record is from Walker (1880) who found *C. clatratus* from Teelin Bay, Co. Donegal. Walker also recorded this beetle from Dinish Island in Co. Galway and Westport, Co. Mayo. Cuthbert (1896) found *C. clatratus* on the Great Sugar Loaf in Co. Wicklow, he remarks that the species does not occur in the east of Ireland. Even at this time it seems that the species was rare, with only eight sites known.

The distribution of *C. clatratus* in Ireland is described as being confined mainly to the north and the west. This study found that the distribution was mainly the same as the majority of this species were found in counties Mayo and Kerry, but a small amount of this species were also found on the Laois/Offaly boarder in the Slieve Bloom mountains at the Glenlahan site. Outside the Fermanagh area there are post 1960 records only for counties Down (Day 1987), Galway (R. Smith), west Mayo (M.C.D. Speight) and north Kerry (P. Kirby) (in Van Helsdingen 1996).

In the north of Ireland it was widespread according to Johnson and Halbert (1902) but it is now found only locally and restricted to the valley of the River Erne, Co. Fermanagh and areas of higher ground to the south of this. It is thought to be extinct in counties Derry, Tyrone and Antrim and in Edenderry Marsh in county Down. *C. clatratus* has been recorded in wet places such as bogs but this species is not restricted to peatlands as it has been found in lakeshore pastures and hay meadows in some areas of Co. Fermanagh where the soil type wet Calp dominates (McFerran., Cameron and Anderson 1995). *C. clatratus* is quite often found on blanket bog at the margins of water bodies for example stream and bog pools. This species is missing in pure sand, gravel and loam, whereas abundance of vegetation is preferable and should extend into water (Lindroth 1992). In the BOGLAND study this species was found both on Atlantic blanket bog and mountain blanket bog.

Although peatland habitats are not essential for *C. clatratus* it seems that a very wet ground condition is essential (Anderson, Mcferran and Cameron 2000). This species has the ability to become amphibious and usually does this to search for prey. Water snails, small crustaceans, insect and amphibian larvae, leeches and small fish are caught. It can stay submerged for more than 17 minutes and air is stored beneath the elytra at the tip of the abdomen (Thiele 1977).

C. clatratus breeds mainly in the spring/summer, with summer larvae and over-wintering adults. *C. clatratus* can occur in areas modified by man but the main threat nationally to this species seems to be the loss of peatland habitats through drainage and afforestation. *C. clatratus* has been lost on areas of peatlands where afforestation has occurred, this is thought to be due to the lowering of the water table and thus the loss of the specialised habitat required by this ground beetle (Cameron 1994), but it may be possible that this species can survive on wet cultivated land in western Ireland, despite a general decline due to the destruction of many peatland habitats. It seems that there is the possibility that *C. clatratus* is present on a peatland may not be dependent on the site being pristine, some studies have found that this ground beetle is the first species to re-colonize industrially harvested blanket bogs. This would suggest that the species is somewhat tolerant of degraded habitats (Heery 2002). But, having said this, the total loss of their specific habitat rather than just its degradation will result in the extinction of local populations and will endanger other populations as the remaining suitable habitat becomes more fragmented (Woodcock *et al.* 2004).

C. clatratus was found during the sampling in both 2006 and in 2007. The number of individuals collected on the core BOGLAND sites was 46, but only two of this species were collected in the degraded sites sampled in 2007. This species was found at Owenirragh, Co. Mayo and Ballygisheen, Co. Kerry which are Atlantic blanket bogs and Fiddandary, Co. Sligo and Glenlahan, Co. Laois which are both mountain blanket bogs. This is an interesting result as it shows *C. clatratus* occurs far more infrequently in peatlands that have been altered for varying land uses, therefore indicating, that if peatland habitats are altered greatly from their original composition in terms of vegetation cover or organic matter content due to drainage, that rare ground beetles such as *C. clatratus* may suffer an enormous loss in abundance and may eventually be wiped out from peatland habitats. This also indicates that if one species is affected by changes in the compositional structure of a peatland it may mean that other species could be threatened by changes in the habitat structure.

The same issues arose in the study of the ground beetle populations as did with the spiders, i.e. low numbers of individuals, although the species recorded in 2006 had only one species that was only found once: *Carabus nitens.* It was found at Clara raised bog. The problem of single specimens was more of a problem in 2007. *Loricera pilicornis* and *Bembidion doris* were examples of species where only one specimen was recorded. Carabids cannot necessarily be used as a proxy for all invertebrates, but studies into their populations can illustrate the complex issues associated with invertebrate conservation (Telfer and Eversham 1996).

Any future work on the study on ground beetles populations should include more intensive sampling of the different peatland types studied here and to investigate further how seasonality effects the species that are trapped. It would also be interesting to focus on microhabitats within peatlands. Additionally it would be useful if further work carried out on the rare peatland species such as *C. clatratus* and *C. nitens* was approached in order to enhance the necessity of minimal disturbance of peatland habitats to protect characteristic peatland species.

There is a need to investigate site wetness and vegetation development in relation to the study of ground beetles as demonstrated by Gardner (1991) and Anderson *et al.* (1995). Studies into the identification of indicator ground beetle species such as those conducted by Eyre (2004) and Luff (1989 and 2007) would be a possible avenue for further study. It has been suggested that ombrotrophic bogs should remain unmanaged, but conserved, in order to maintain ground beetle assemblages (Holmes *et al.* 1993).

New sites were selected in 2007 and this yielded more species but although some of the species found were characteristic peatland species the abundances of these species were low. The results obtained in 2007 show that reclaimed peatland habitats are drastically modified, this may be due to changes in soil moisture, greater depth of aerobic soil, less complex vegetation and increased plant productivity (Curry, Boyle and Farrell 1989). Further studies need to be conducted to test for seasonal difference and it would be further beneficial if more intensive sampling took place over a longer period of time. Afforestation appears to introduce higher ground beetle diversity, but it does not favour the rarer species (Butterfield *et al.* 1995).

4.4 Enchytraeidae assemblages on Irish peatlands

Eighty-one species of terrestrial Enchytraeidae are recorded for Ireland, the fauna is diverse especially in wet soil (Healy 1980). Healy (1978) noted that Ireland has a somewhat rich enchytraeid fauna when compared to other European countries, this may be attributed to the moist, mild climate and to the intensity of sampling that has be undertaken in the past. The data collected here show the species composition is quite similar among peatland types but the species found in fens seem to be somewhat different. This may be due to differeces in terms of vegetation and the lack of organic matter within the fen, as it is a minerotrophic habitat.

Although twelve species of enchytraeid were recorded from the sampling of the core sites, this is a relatively low number when compared with Healy (1976). A possible reason for this was the need for more extensive sampling to take place and this perhaps would have given a more representative view of the species present on the BOGLAND sites. In Healy (1980) six species are listed as being frequent in wet soil. Of these six, *Cognettia sphagnetorum*, *Mesenchytraeus sanguineus* were both found in the BOGLAND samples. The pH and water level significance vary with species but they can be used as a good indication of what species to expect in certain habitats (Healy 1980, and Standen and Latter 1977). Enchytraeids are unable to colonise aquatic habitats as they cannot survive without oxygen (Healy 1987).

The amount of work done on the Enchytraeidae in Ireland is very small and much of the work was conducted by Healy (1976). More recent studies have been conducted in other countries looking at whether enchytraeids enhance mineralisation of upland soils (Cole, Bardgett and Briones 2000) and the release of dissolved organic carbon of peatlands (Cole *et al.* 2002). The focus of studies relating to enchytraeids in recent years seem less to do with the taxonomy of the species but more to do with using known species as indicators to investigate environmental stresses in soils eg. Römbke and Knacker (2004), and Didden and Römbke (2001).

In order to improve the list of species that were collected in 2009 it would be necessary to conduct more extensive sampling in terms of the numbers of cores taken and to do this over an extended period of time in order to collect the full spectrum of enchytraeid species present in Irish bogs listed by Healy (1976) and detect the presence of any potential new species. Enchytraeid identification remains problematic despite much revision of the taxonomy (Chalupský 1991) and there is further need for elaboration since there is much confusion about much of the genera (Didden 1993).

4.5 Overall comments and conclusions

The results of this study indicate that there is little peatland specific invertebrate biodiversity. This means that many of the invertebrate species found on Irish peatlands can be found in other habitats such as grassland and forestry. The extreme environment found in peatland, low pH, poor nutrients and limited oxygen would lead one to conclude that invertebrate species found on them would somehow be unique or tyrphobiont (unique to bogs) but this is not the case (Reynolds 1990). However, it is possible that some of the invertebrate species found in peatlands, although not unique to this habitat, may be more abundant in peat habitats than in any other habitat type. Therefore, although Irish peatlands contain few tyrphobionts, there are some species that are characteristic of peatland but not confined to them (tyrphophiles) (Spitzer and Danks 2006). These can also be characterised as generalists (Danks and Rosenberg 1987). A proposed reason for the lack of diversity of invertebrates is that the vegetation in the surrounding areas is not diverse and this leads to low invertebrate diversity (Webb, Clarke and Nicholas 1984). The vegetational cover seems particularly important to the spider assemblages that are collected (Downie, Butterfield and Coulson 1995).

The similarity of mite species found specifically on peatlands with coniferous forestry is perhaps related to the high levels of organic matter that is present. It has been shown that mite communities represent more typically species found in coniferous forestry when a peatland is drained and that overall diversity of species increases (Laiho *et al.* 2001). It appears that there are few species of mites that are restricted to peatlands. The only genera noted as a potential indicator are *Limnozetes* and *Hydrozetes* because these favour waterlogged conditions with high soil acidity. Overall peatland habitats for mites are characterised by few species but a high number of individuals are present (Behan-Pelletier and Bissett 1994).

The spider fauna was diverse but again the species found were not restricted to peatland habitats. There has been some research done into the potential use of ground-dwelling spiders on peatlands as ecological indicators for conservation on peat habitats. Scott, Selden and Oxford (2006) identified a number of bog associated species that could potentially be used as indicator species but whether there is the potential to apply this protocol to Irish peatlands is unknown as it is a matter for further study. New species records from peatlands in Ireland are being uncovered quite frequently, one new record is from as recent as 2009. The species record was *Walckenaeria alticeps* (Nolan 2009). This indicates that there is still the potential that many species have been overlooked and further investigation may yield new records or perhaps even new species.

Raised bogs in particular tend to be low in species diversity in terms of ground beetles (Anderson 1996) but these habitats are important for some ground beetle populations. The two ground beetle species of note from peatland habitats in Ireland are *Carabus clatratus* and *Carabus nitens* and Ireland has important European populations. *C. nitens* in particular is described as being one of the most endangered ground beetles in Central Europe and habitat fragmentation has an adverse affect on populations (Assmann and Janssen 1999; McFerran 1996). Irish peatlands are also home to other members of the *Carabus* genus such as *C. glabratus* and *C. problematicus* and thus Irish peatlands provide important habitats for populations of these species.

The low species diversity of Enchytraeidae was as expected because of the highly acidic conditions as many species of enchytraeid, in particular members of the genus *Fridericia,* are unable to tolerate high soil acidity. Having said this, the abundance of *Cognettia sphagnetorum* in peatland habitats is greater than in any other habitats and has been used to look at the effects of carbon dynamics in organic soils. Furthermore it has been proposed that this species enhances processes of decomposition (Briones, Ineson and Poskitt 1998) and mineralisation in peat soils (Cole, Bardgett and Ineson 2000).

High species diversity is often considered an important factor when sites are proposed for conservation but this idea is not appropriate for the management of peatlands, as peatlands show a low diversity for many invertebrate groups (Webb, Clarke and Nicholas 1984). This makes the issue if conservation of peatland for invertebrates far more complex.

Despite the limitations of this study which have been pointed out above, it provides a major advance in out knowledge of the terrestrial fauna of peatlands, and of Ireland in general. This study had gathered some baseline data on the biodiversity of some Irish peatlands in terms of the invertebrate diversity that they contain. This baseline information can be used to design a protocol for future management of peatlands in terms of conservation of rare species and to provide important information for future invertebrate studies on peatlands in Ireland.

Bogs contain small numbers of characteristic invertebrates belonging to many different families, including some species that are not found or are rare on other habitats in addition some species that are more abundant in peatlands than elsewhere; this represents the heterogeneity of peatland habitats (Spitzer and Danks 2006). It is not clear whether restoration policies have the ability to return peat habitats to their original state in terms of invertebrate composition but it is essential that heterogeneity within peat habitats are conserved, due to species having different yet specific demands for their optimum conditions.

Peatlands, not only in an Irish context, but also in European and global contexts are an important habitat for biodiversity. Due to the use of industrial machinery over the 50 years for turf extraction the damage to peatlands has been detrimental. Without the proper management of peatlands to prevent further degradation and restore damaged or degraded habitats there is the potential for loss of species to occur. This idea has only become realised in recent years and thus efforts are now being made to protect peatland habitats across the world. The key element to prevent habitat loss in any ecosystem is sustainability and is applicable for peatlands too.

The implementation of a national policy to promote the sustainable use of peatlands would the first step in the protection of Irish peatlands. It is necessary to do this as a conservation and restoration policy for peatland habitats will provide a notable contribution to Ireland's obligations that need to be met under the Convention on Biological Diversity (CBD) and also another policy under the European Union (EU), to prevent the further loss of biodiversity by 2010. Protection of Irish peatlands is an issue that must be addressed but the difficulty arises when finance, expertise and knowledge are lacking. There is the potential for partnerships to be undertaken with other countries to protect these habitats and promote sustainability. Globally peatlands are a habitat/ecosystem that must be conserved to our best ability for future generations (Renou-Wilson and Bolger 2010). Fragmentation coupled with habitat loss are the forerunners in species decline globally (Heliölä, Koivula and Niemelä 2001).

Ireland's peatlands are culturally and scientifically important. They form a large constituent of Irish wetlands. The need for the conservation of these wetlands will ensure that these sites are protected for future scientific research. The conservation of peatland has only become topical in recent years, since approximately 1976.

Much of the peatland in Ireland have been damaged to a varying degree. Of the original 1,177,670 hectares of peatland in the Republic of Ireland, an estimated 184,000 hectares of blanket bog; 18,424 hectares of raised bog; and approximately 20,000 hectares of fen are at present included within the Special Areas of Conservation (SAC) and statutory Natural Heritage Areas (NHA). There has been a significant decline in the amount of active raised bogs in recent years (Douglas and Ryan 2006).

Intact active raised bog is a rare and threatened habitat in Ireland. The area of this type of bog has decreased in area by over 35% in the last ten years. The main threats to these habitats are continued peat-cutting, drainage, forestry and burning. The conservation of these habitats within Ireland is deemed to be poor, although there has been progress in the conservation of Irish peatlands through policies implemented by government agencies, non-governmental organisations and Bord na Móna.

How is it possible to protect peatlands in Ireland in the future? There is a need to designate further areas as SACs and NHAs. Once these practices have been put in place management plans need to be produced to ensure that peatlands are adequately protected and if restoration is necessary it should be done in the most suitable way for the peatland habitat in question and to try and restore that habitat to the best possible condition. This can only be done through further study of peatland habitats and studies into the sustainability and functioning of peat habitats. Education is needed to protect these habitats for future generations. It is essential for people to understand that peatlands are part of their heritage, and they should not be destroyed. If peatlands are not conserved in Ireland to an even greater extent than they are at present, there will undoubtedly be a loss of a rich and biodiverse landscape.

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6. Appendices

Appendix 1. Cohort, Family, genus and species of mite, abbreviation used in ordination, presence in Luxton (1998), BOGLAND and additional species added from past studies on mites in Ireland

Name	Abbrev.	Luxton	This study	Species added
Suborder ANTENNOPHORINA				
Family ANTENNOPHORIDAE Berlese, 1892				
Genus *Antennophorus* Haller, 1887				
uhlmanni Haller, 1887		*		
Family CELAENOPSIDAE Berlese, 1892				
Genus *Celaenopsis* Berlese, 1886				
badius (C. L. Koch, 1839)		*		
Suborder GAMASINA				
Family AMEROSEIlDAE Evans, 1963				
Genus *Ameroseius* Berlese, 1903				
corbiculus (Sowerby, 1806)	*Ame cor*	*		
echinopsis (Fan and Chen, 1996)	*Ame echi*			*
furcatus Karg, 1971	*Ame fur*			*
imparsetosus Westerboer, 1963	*Ame imp*			*
plumigerus (Oudemans, 1930)	*Ame plu*			*
Genus *Epicriopsis* Berlese, 1916				
horridus (Kramer, 1876)	*Epi hor*	*		
rivus Karg, 1971	*Epi riv*			*
Genus *Kleemannia* Oudemans, 1930				
gracilis (Halbert, 1923)		*		
plumigera (Oudemans, 1930)		*		
plumosus (Oudemans, 1902)	*Kle plu*	*		
Family ASCIDAE Voigts et Oudemans, 1905				

Genus *Antennoseius* Berlese, 1916				
unidentified species		*		
Genus *Arctoseius* Thor, 1930				
butleri (Hughes, 1948)		*		
cetratus (Sellnick, 1940)	*Arc cet*	*		
longispinosus (Hirschmann, 1963)	*Arc lon*			*
magnanalis Evans, 1958	*Arc mag*	*		
pannonicus Willmann, 1949	*Arc pan*	*		
Venustulus (Berlese, 1917)		*		
semicissus(Berlese, 1892)	*Arc sem*			*
Genus *Asca* von Heyden, 1826				
bicornis (Canestrini et Fanzago, 1887)		*		
Genus *Blattisocius* Keegan, 1944				
amboinensis (Oudemans, 1925)		*		
dentriticus (Berlese, 1918)	*Bla den*	*		
keegani Fox, 1947		*		
mali (Oudemans, 1929)		*		
tarsalis (Berlese, 1918)	*Bla tar*	*		
Genus *Cheiroseius* Berlese, 1916		*		
borealis (Berlese, 1904)	*Cle bor*	*		
curtipes (Halbert, 1923)		*		
laelaptoides (Berlese, 1887)		*		
necorniger (Oudemans, 1903)	*Che nec*			*
serratus (Halbert, 1915)	*Che ser*	*		
Genus *Gamasellodes* Athias-Henriot, 1961				
bicolor (Berlese, 1908)	*Gam bic*	*		
Genus *Iphidozercon* Berlese, 1903				
corticalis Evans, 1958	*Iph cor*	*		
minutus (Halbert, 1915)	*Iph min*	*		
Genus *Lasioseius* Berlese, 1916		*		
berlesei (Oudemans, 1938)	*Las ber*	*		

confusus Evans, 1958	*Las con*			*
muricatus (C. L. Koch, 1839)		*		
ometes (Oudemans, 1903)	*Las ome*	*		
penicilliger Berlese, 1916		*		
Genus *Leioseius* Berlese, 1916				
minusculus Berlese, 1905	*Lei min*			*
salinus (Halbert, 1920)	*Lei sal*	*		
Genus *Melichares* Hering, 1838		*		
unidentified species				
Genus *Neojordellsia* Evans, 1957				
levis (Oudemans et Voigts, 1904)	*Neo lev*	*		
Genus *Platyseius* Berlese, 1916				
italicus (Berlese, 1905)	*Ple ita*	*		
major (Halbert, 1923)		*		
subglaber (Oudemans, 1903)	*Pla sub*	*		
Genus *Proctolaelaps* Berlese, 1923				
pygmaeus (Muller, 1860)	*Pro hyp*	*		
rotundus Hirschmann, 1963	*Pro rot*			*
Genus *Protogamasellus* Karg, 1962				
hibernicus Evans, 1982		*		
mica (Athias-Henriot, 1961)	*Pro mic*	*		
Protogamasellus minor	*Pro min*			*
singularis (Karg, 1962)		*		
Genus *Zerconopsis* Hull**,** 1918				
apodius Karg, 1969	*Zer apo*			*
Decemremiger Evans and Hyatt, 1960	*Zer dec*			*
remiger (Kramer, 1876)	*Zer rem*	*		
Genus *Zercoseius* Berlese, 1916				
spathuliger (Leonardi, 1899)	*Zer spa*	*		
Family DERMANYSSIDAE Kolenati, 1859				
Genus *Dermanyssus* de Geer, 1778				

Subgenus *Dermanyssus* de Geer, 1778				
gallinae (de Geer, 1778)		*		
Family D1GAMASELLlDAE Evans, 1957				
Genus *Dendrolaelaps* Halbert, 1915				
arenarius Karg, 1962	*Den are*			*
armatus (Hirschmann, 1960)				*
cornuutulus Hirschmann, 1960	*Den cor*			*
cornutus (Kramer, 1886)		*		
euarmatus (Hirschmann, 1960)	*Den eur*	*		
foveolatus (Leitner, 1949)	*Den fov*	*		
oudemansi Halbert, 1915	*Den oud*	*		
rectus Karg, 1962	*Den rec*			*
stammeri Hirschmann, 1960	*Den sta*			*
tenuipilus Hirschmann, 1960	*Den ten*			*
Genus *Dendroseius* Karg, 1965				
scotarius (Sheals, 1958)	*Den sco*	*		
Genus *Digamasellus* Berlese, 1905				
halophilus (Willmann, 1951)	*Dig hal*			*
inermis (Halbert, 1920)		*		
Genus *Punctodendrolaelaps* Hirschmann et Wisniewski, 1982				
strenzkei (Hirschmann, 1960)		*		
Family EPICRIIDAE Berlese, 1885				
Genus *Epicrius* Canestrini et Fanzago, 1887				
mollis (Kramer, 1876)	*Epi mol*	*		
Family EVIPHIDIDAE Berlese, 1913				
Genus *Alliphis* Halbert, 1923				
halleri (G. et R. Canestrini, 1881)	*All hall*	*		
Genus *Crassicheles* Karg, 1963				
holsaticus (Willmann, 1937)	*Cra hol*	*		
Genus *Eviphis* Berlese, 1903				
ostrinus (C. L. Koch, 1836)	*Evi ost*	*		

Genus *Thinoseius* Halbert, 1920				
fucicola (Halbert, 1920)		*		
Family HALARACHNIDAE Oudemans,1906				
Halarachne Allnan, 1847		*		
halichoeri Allnan, 1847		*		
Family HALOLAELAPIDAE Karg, 1965				
Genus *Halolaelaps* Berlese et Trouessart, 1889				
celticus Halbert, 1915	*Hal cel*	*		
marinus (Brady, 1875)	*Hal mar*	*		
Genus *Leitneria* Evans, 1957				
granulata (Halbert, 1923)		*		
Family LAELAPIDAE Berlese, 1892				
Genus *Androlaelaps* Berlese, 1903				
casalis (Berlese, 1887)	*And cos*	*		
Genus *Cosmolaelaps* Berlese, 1903				
claviger (Berlese, 1883)	*Cos cla*	*		
vacua (Michael, 1891)	*Hyp vac*	*		
Genus *Eulaelaps* Berlese, 1903				
stabularis (C. L. Koch, 1836)	*Eul sta*	*		
Genus *Haemogamasus* Berlese, 1889				
arvicolarum (Berlese, 1920)		*		
pontiger (Berlese, 1904)	*Hae pon*	*		
Genus *Holostaspis* Kolenati, 1858				
montana (Berlese, 1904)	*Hae mon*	*		
Genus *Hypoaspis* Canestrini, 1884				
Subgenus *Alloparasitus* Berlese, 1920				
acuta (Michael, 1891)		*		
oblongus (Halbert, 1915)	*Hyp obl*	*		
praesternalis Willmann, 1949	*Hyp pre*			*
sardous (Berlese, 1911)		*		
Subgenus *Gaeolaelaps* Tragardh, 1952				

aculeifer (Canestrini, 1884)		*		
lubrica (Voigts et Oudemans, 1904)	*Hyp acu*	*		
nolli Karg, 1962	*Hyp nol*	*		
Genus *Laelaps* C. L. Koch, 1836				
agilis C. L. Koch, 1836	*Lae agi*	*		
Genus *Laelaspis* Bedese, 1903				
astronomica (C. L. Koch, 1839)	*Lar ast*	*		
Genus *Myonysslls* Tiraboschi, 1904				
decumani Tkaboschi, 1904		*		
Genus *Ololaelaps* Berlese, 1904				
placentula (Berlese, 1887)	*Olo pla*	*		
veneta (Berlese, 1903)	*Olo ven*	*		
Genus *Pseudoparasitus* Oudemans, 1902				
meridionalis (G. et R. Canestrini, 1882)	*Pse mer*	*		
ovatulus (Halbert, 1915)	*Pse ova*	*		
Family MACROCHELIDAE Vitzthum, 1930				
Genus *Geholaspis* Berlese, 1918				
Subgenus *Geholaspis* Berlese, 1918				
aeneus Krauss, 1970	*Geh aen*	*		
longispinosus (Kramer, 1876)	*Geh lon*	*		
Subgenus *Longicheles* Valle, 1953				
mandibularis (Berlese, 1904)	*Geh man*	*		
Genus *Glyptholaspis* Filipponi et Pegazzano, 1960				
americana (Berlese, 1888)		*		
Genus *Holostaspella* Berlese, 1903				
ornata (Berlese, 1904)	*Hol orn*	*		
subornata Bregetova et Koroleva, 1960		*		
Genus *Macrocheles* Latreille, 1829				
carinatus (C. L. Koch, 1839)	*Mac car*	*		
decoloratus (c. L. Koch, 1839)		*		
dentatus (Evans et Browning, 1956)	*Mac den*	*		

glaber (Miiller, 1860)	*Mac gla*	*		
matrius (HnIl, 1925)		*		
montanus (Wilhnann, 1951)	*Mac mon*	*		
opacus (C. L. Koch, 1839)	*Mac opa*	*		
penicilliger (Berlese, 1904)	*Mac pen*	*		
scutatus (Berlese, 1904)	*Mac scu*			*
subbadius (Berlese, 1904)		*		
submotus Falconer, 1923	*Mac sub*	*		
tardus (C. L. Koch, 1841)		*		
terreus (Canestrini et Fanzago, 1877)	*Mac ter*	*		
Family MACRONYSSlDAE Oudemans, 1936				
Genus *Steatonyssus* Kolenati, 1858				
peliblepharus Kolenati, 1858		*		
Pamily PACHYLAELAPlDAE Berlese, 1913				
Genus *Pachylaelaps* Berlese, 1886				
bellicosus Berlese, 1920	*Pac bel*			*
furcifer Oudemans, 1903	*Pac fuc*			*
*jurassicus*Schweizer, 1961	*Pac jur*			*
littoralis Halbert, 1915	*Pac lit*	*		
longisetis Halbert, 1915	*Pac lon*	*		
magnus (Halbert, 1915)	*Pac mag*	*		
resinae Karg, 1971	*Bac res*			*
Sellnicki Hirschmann and Krauss,1965	*Pac sel*			*
Genus *Pachyseius* Berlese, 1910				
angustiventris Willmann, 1935	*Pac ang*	*		
humeralis Berlese, 1910	*Pac hum*	*		
Family PARASITlDAE Oudemans, 1901				
Genus *Amblygamasus* Berlese, 1904				
hamatus (C.L. Koch, 1835)	*Amb ham*			*

mirabilis (Willmann, 1951)	*Amb mir*	*		
Genus *Cornigamasus* Evans et Till, 1979				
lunaris (Berlese, 1882)		*		
Genus *Eugamasus* Berlese, 1892				
berlesei Willmanni, 1935		*		
cavernicola Trägårdh, 1912		*		
cornutus (G. and R. Can 1882)				*
crassitarsis (Halbert, 1923)	*Eug cra*	*		
magnus (Kramer, 1876)	*Eug mag*	*		
Genus *Gamasodes* Oudemans, 1939				
bispinosus (Halbert, 1915)	*Gam bis*	*		
fimbriatus Karg, 1971		*		
spiniger (Trägårdh, 1910)	*Gam spi*	*		
Genus *Holoparasitus* Oudemans, 1936				
absolini (Willmann, 1940)	*Hol abs*			*
caesus Micherdzinski, 1969	*hol cae*			*
calcaratus (C. L. Koch, 1839)	*Hol cal*	*		
inornatus (Berlese, 1906)	*Hol ino*	*		
lawrencei Hyatt, 1987	*Hol law*	*		
pollicipatus Berl. 1903	*Hol pol*	*		
stramenti Karg, 1971	*Hol str*			
Genus *Leptogamasus* Trägardh, 1936				
alstoni (Bhattacharyya, 1963)	*Per als*			*
obesus (Holzmann, 1969)	*Lep obe*			*
parvulus (Berlese, 1903)		*		
suecicus Trägardh, 1936		*		
Genus *Lysigamasus* Karg, 1971				
armatus (Halbert, 1915)	*Per arm*	*		
celticus (Bhattacharyya, 1963)	*lys cel*	*		
cornutus (Kramer, 1886)	*Eug cor*	*		
digitulus (Karg, 1963)	*Lys dig*	*		

femoratus (Bhattacharyya, 1963)	*Pac fem*	*		
lapponicus (Tragardh, 1910)	*Lys lap*	*		
misellus (Berlese, 1903)	*Lys mis*	*		
nasellus Karg, 1968	*Lys nas*			*
parrunciger (Bhattacharyya, 1963)	*Per par*	*		
processiferus (Halbert, 1915)	*Lys pro*	*		
runcatellus (Berlese, 1903)	*Per run*	*		
runciger (Berlese, 1904)	*Per run*	*		
schweizeri Bhattachar, 1963	*Per sch*			*
truncus (Schweizer, 1961)	*Per tru*	*		
wasmanni (Oudemans, 1902)	*Per was*			*
Pergamasus hortensis Bhattacharyya, 1963	*Pac hor*	*		
Genus *Paragamasus* Hull, 1918				
alpestris (Berlese, 1904)	*Per alp*	*		
diversus (Halbert, 1915)	*Per div*	*		
integer(Bhattacharyya, 1963)	*Par int*			*
robustus (Oudemans, 1902)	*Per rob*	*		
rothamstedensis (Bhattachar, 1963)	*Par rot*			*
londonensis Bhattacharyya, 1963	*Per lon*			*
similis (Willmann, 1953)	*par sim*		*	*
Genus *Parasitellus* Willmann, 1939				
ignotus (Vitzthum, 1930)		*		
talparum (Oudemans, 1913)		*		
Genus *Parasitus* Latreille, 1795				
americanus (Berlese, 1906)		*		
beta Oudemans et Voigts, 1904	*Par beta*	*		
coleoptratorum (Linnaeus, 1758)	*Par col*	*		
consanguineus Oudemalls et Voigts, 1904	*Par con*	*		
evertsi Oudemans, 1902	*Par eve*	*		
fimetorum (Berlese, 1904)	*Par fim*	*		
hyalinus (Willmann, 1949)	*Par lya*	*		

insignis (Holzmann, 1969)	*Par ins*			*
kempersi Oudemans, 1902	*Par kemp*	*		
loricatus (Wankel, 1861)		*		
lunulatus (Muller, 1859)	*Par lun*			*
neglectus (Berlese, 1903)	*Pac neg*	*		
nolli (Karg, 1965)	*Par nol*			*
Genus *Pergamasus* Berlese, 1904				
alpinus (Berlese, 1903)		*		
crassipes (Linnaeus, 1758)	*Per cra*	*		
longicornis (Berlese, 1906)	*Per lon*	*		
norvegicus (Berlese, 1905)	*Per nos*	*		
noster (Berlese, 1903)	*Per nos*			*
quisquiliarum (G and R. Can. 1882)	*Per qui*			*
septentrionalis (Oudemans, 1902)	*Per sep*	*		
suecicus (Trägardh, 1936)	*Lep sue*			*
Genus *Poecilochirus* G. et R. Canestrini, 1882				
carabi G. et R. Canestrini, 1882	*Poe car*	*		
davydovae Hyatt, 1980		*		
subterraneus (Muller, 1860)				
Genus *Porrhostaspis* Milller, 1859				
lunulata Müller, 1859		*		
Genus *Trachygamasus* Berlese, 1904				
ambulacralis (Willmann, 1949)		*		
gracilis (Karg, 1965)	*Tra gra*	*		
oudemansi Hirschmann & Zirngiebl Nicol, 1969				*
Genus *Vulgarogamasus* Tichomirov, 1969				
burchanensis (Oudemans, 1903)		*		
immanis (Berlese, 1904)		*		
kraepelini (Berlese, 1905)	*Vul kra*	*		
oudemansi (Berlese, 1904)		*		

trouessarti (Berlese, 1892)		*		
Family PHYTOSEIIDAE Berlese, 1916				
Genus *Amblydromella* Muma, 1961				
foenilis (Oudemans, 1930)		*		
rhenana (Oudemans, 1905)		*		
rhenanoides (Athias-Henriot, 1960)		*		
richteri (Karg, 1970)		*		
Genus *Amblyseius* Berlese, 1904				
alpinus Schweizer, 1922				*
Bidens Karg, 1970	*Amb bid*			*
deleoni Muma et Denmark, 1970		*		
foramenis Karg, 1970	*Amb for*	*		
graminis Chant, 1956	*Amb gra*			*
obtusus (C.L. Koch, 1839)	*Amb obt*			*
subspecies *hibernicus* Momen, 1987		*		
neobernhardi Athias-Henriot , 1966	*Amb neo*			*
umbraticus (Chant, 1956)	*Amb umb*	*		
Genus *Anthoseius* de Leon, 1959				
intermedius Momen, 1987		*		
Genus *Euseius* Wainstein, 1962				
finlandicus (Oudemans, 1915)		*		
Genus *Neoseiulus* Hughes, 1948				
barkeri Hughes, 1948		*		
cucumeris (Oudemans, 1930)	*Amb cuc*	*		
Genus *Phytoseius* Canestrini & Fanzago 1902				
spoofi (Oudemans, 1915)		*		
Genus *Seiulus* Berlese, 1887				
bidentatus Momen, 1987		*		
Genus *Typhloctonus* Muma, 1961				
tiliarum (Oudemans, 1930)		*		

Genus *Typhlodromips* de Leon, 1965				
bryophilus (Karg, 1970)		*		
Genus Typhlodromus Scheuten, 1857				
pyri Scheuten, 1857		*		
tiliae Oudemans, 1929	*Typ til*	*		
Typhlodomus rhaetius	*Tyo rhe*			*
Family RHODACARIDAE Oudemans, 1902				
Genus *Cyrtolaelaps* BerIese, 1887				
mucronatus (G.et .R. Canestrini, 1881)	*Cry muc*	*		
Genus *Hydrogamasus* BerIese, 1892				
giardi (BerIese et Trouessart, 1889)		*		
littoralis (G. et R. Canestrini, 1881)		*		
Genus *Minirhodacarellus* Shcherbak, 1980				
minimus (Karg, 1961)	*Rho min*	*		
Genus *Rhodacarellus* Willmann, 1935				
epigynialis Sheals, 1956	*Rho epi*	*		
perspicuus Halaśkova, 1958	*Rho per*			*
silesiacus Willmann, 1936	*Rhi sil*	*		
Genus *Rhodacarus* Oudemans, 1902				
aequalis Karg 1971	*Rho aeq*			*
*agrestis*Karg, 1971	*Rho agr*			*
calcarulatus Berlese, 1921	*Rho cal*			*
clavulatus Athias-Henriot, 1961	*Rho cla*	*		
coronatus Berlese, 1921	*Rho cor*			*
pallidus Hull, 1917	*Rho pal*	*		
reconditus Athias-Henriot, 1931				*
roseus Oudemans, 1902	*Rho ros*	*		
strenzkei Willmann, 1957	*Rho str*	*		
Family SPINTURNICIDAE Oudemans, 1901				
Genus *Paraperiglischrus* Rudnick, 1960				
rhinolophinus (C. L. Koch, 1841)		*		

Genus *Spinturnix* von Heyden, 1826				
plecotinus (C. L. Koch, 1836)		*		
Family VEIGAIIDAE Oudemans, 1939				
Genus Cyrthydrolaelaps Berlese, 1905				
hirtus Berlese, 1905	*Cyr hir*	*		
incisus Evans, 1955		*		
Genus *Gamasolaelaps* Berlese, 1904				
excisus (L. Koch, 1879)	*Gam exc*	*		
Genus *Veigaia* Oudemans, 1905				
agilis (Berlese, 1916)	*Vei agi*	*		
cerva (Kramer, 1876)	*Veg cer*	*		
exigua (Berlese, 1916)	*Vei exi*	*		
kochi (Trägårdh, 1901)	*Vei koc*	*		
nemorensis (C. L. Koch, 1839)	*Vei nem*	*		
planicola (Berlese, 1892)	*Vei pla*	*		
transisalae (Oudemans, 1901)	*vei tra*	*		
Family ZERCONIDAE Canestrini, 1891				
Genus *Prozercon* Sellnick, 1943				
fimbriatus (C. L. Koch, 1839)		*		
traegardhi (Halbert, 1923)	*Pro tra*	*		
Genus *Seiodes* Berlese, 1887				
Genus *Zercon* C. L. Koch, 1836				
abaculus (C.L. Koch, 1839)	*Zer aba*			*
colligans Berlese, 1920	*Zer col*			*
spatulatus (C.L. Koch, 1839)	*Zer spa*			*
perforatulus Berlese, 1903		*		
triangularis C. L. Koch, 1836	*Zer tri*	*		
zelawaiensis Sellnick, 1944	*Zer zel*	*		
Suborder SEJINA				
Family SEJlDAE Berlese, 1913				

Genus *Sejus* C. L. Koch, 1836					
togatus C. L. Koch, 1836			*		
Suborder UROPODINA					
Family POLYASPIDIDAE Berlese, 1917					
Genus *Polyaspinus* Berlese, 1916			*		
cylindricus Berlese, 1916 [			*		
Genus *Polyaspis* Berlese, 1881	*Pol sp*		*		
unidentified species			*		
Genus *Trachytes* Michael, 1894					
minima Trägårdh, 1910	*Tra min*		*		
oudemansi Hirschmann & Zirngiebl-Nicol, 1969	*Tra oud*				*
pauperior (Berlese, 1914)			*		
pyriformis (Kramer, 1876)			*		
Genus *Uroseius* Berlese, 1888					
Subgenus *Apionoseius* Berlese, 1904					
turki Hirschmann, 1979			*		
Subgenus *Uroseius* Berlese, 1888					
acuminatus (C. L. Koch, 1847)			*		
Family PROTODINYCHIDAE Evans, 1957					
Genus Protodinychus Evans, 1957					
unidentified species			*		
Family THINOZERCONIDAE Halbert, 1915					
Genus *Thinozercon* Halbert, 1915					
michaeli Halbert, 1915	*Thi mic*		*		
Family TRACHYUROPODIDAE Berlese, 1917					
Genus *Oplitis* Berlese, 1884					
philoctena (Trouessart, 1902)	*Opi phi*		*		
Genus *Traehyuropoda* Berlese, 1888					
celtica Halbert, 1907			*		
coccinea (Michael, 1891)			*		
formicaria (Lubbock, 1881)	*Tra for*		*		

sinuata (Berlese, 1904)		*		
troguloides (Canestrini et Fanzago, 1877)		*		
Family 'I'REMATURIDAE Berlese, 1917				
Genus Trematuridae Berlese, 1916				
campomolendina (Berlese, 1887)	*Tre cam*	*		
jacksonia (Hughes, 1948)		*		
obscura (C. L. Koch, 1836)		*		
orbicularis (C. L. Koch, 1839)		*		
punctatissima (Halbert, 1915)	*Tre pun*	*		
Family UROPODIDAE Berlese, 1900				
Genus *Discourella* Berlese, 1910				
cordieri (Berlese, 1916)		*		
Genus *Uropoda* Latreille, 1806				
Subgenus *Cilliba* von Heyden, 1826				
cassidea (Hermann, 1804)	*Cil cas*	*		
Subgenus *Phaulodinychus* BerIese, 1903				
littoralis (Trouessart, 1902)		*		
orchestiidarium (Barrois, 1887)	*Phau orc*	*		
pulcherrima (Be rIese, 1903)		*		
repletus (BerIese, 1903)	*Pha rep*	*		
Subgenus *Uropoda* Latreille, 1806				
halberti Hirschmann, 1993	*Uro hal*	*		
minima Kramer, 1882	*Uro min*			
orbicularis (Muller, 1776)	*Uro orb*			
Family URODINYCHIDAE Berlese, 1917				
Genus *Dinychus* Kramer, 1882				
carinatus Berlese, 1903		*		
inermis (C. L. Koch, 1841)	*Din ine*	*		
stratus Sellnick, 1945	*Din str*			*
peforatus Kramer, 1882	*Din per*	*		
Genus *Uroobovella* BerIese, 1905				

euris (F. et S. Turk, 1952)		*		
marginata (C. L. Koch, 1839)		*		
notabilis Berlese, 1903		*		
Genus Fuscuropoda				
Appendiculata	*Fus app*	*		
Genus Olodiscus				
Minima	*Olo min*	*		
Cohort PALAEOSOMATA				
Superfamily PALAEACAROIDEA Grandjean, 1932				
Family ADELPHACARIDAE Grandjean, 1954				
Genus *Aphelacarus* Grandjean, 1932				
unidentified species	*Apl spp*	*		
Cohort ENARTHRONOTA				
Superfamily BRACHYCHTHONIOIDEA Thor, 1934				
Family BRACHYCHTHONIIDAE Thor, 1934				
Genus *Brachychthonius* Berlese, 1910				
berlesei Willmann, 1928	*Bra ber*	*		
bimaculatus Willmann, 1936	*Bra bin*	*		
hirtus Moritz, 1976	*Bra hir*			*
Genus *Eobrachythonius* Jacot, 1936				
oudemansi Van der Hammen, 1952		*		
Genus *Liochthonius* van der Hammen, 1959				
alpestris (Forsslund, 1958)	*Lio alp*			*
brevis (Michael, 1888)	*Lio bre*			
evansi (Forsslund, 1958)	*Lio eva*			*
horridus (Sellnick, 1928)	*Lio hor*	*		
hystricinus (Forsslund, 1942)	*Lio hys*	*		
laetepictus (Berlese)	*Lio lae*			*
lapponicus (Trägårdh, 1910)	*Lio lapp*	*		

leptaleus Moritz, 1976	*Lio lep*	*		
muscorum Forsslund, 1964	*Lio mus*	*		
perfusorius Motitz, 1976	*Lio per*			*
sellnicki (Thor, 1930)	*Bra sel*	*		
simplex (Forsslund, 1942)	*Lio sim*	*		
mixochthonius Niedbala, 1972				*
pilososetosus (Forsslund, 1942)				*
Genus *Neoliochthonius* Lee, 1982				
globuliferus (Strenzke, 1951)	*Neo glo*			*
piluliferus (Forsslund, 1942)		*		
Genus *Sellnickochthonius* Krlvolutsky, 1964				
cricoides (Weis-Fogh, 1948)	*Sell cri*	*		
furcatus (Weis-Fogh, 1948)	*Bra fur*	*		
honestus (Moritz, 1976)	*Bra hon*			*
hungaricus (J. Balogh, 1943)		*		
immaculatus (Forsslund, 1942)	*Sell imm*	*		
jacoti (Evans, 1952)	*Sel jac*	*		
oesziae (Balogh and Mahunka, 1979)	*Sell oes*			*
rostratus (Jacot, 1936)	*Sel ros*	*		
suecicus (Forsslund, 1942)	*Sel sue*	*		
zelawaiensis (Sellnick, 1928)	*Sel zel*	*		
Genus *Synchthonius* van der Hammen, 1952				
elegans Forsslund, 1957	*Syn ele*			*
Superfamily HYPOCHTHONIOIDEA Berlese, 1910				
Family Eniochthoniidae Grandjean, 1947				*
Genus Grandjean, 1933				*
Eniochthonius minutissimus (Berlese, 1903)	*Enc pal*			*
Family HYPOCHTHONIIDAE Berlese, 1910				
Genus *Hypochthonius* C. L. Koch, 1835				
luteus Oudemans, 1917	*Hyp lut*	*		
rufulus C. L. Koch, 1835	*Hyp ruf*	*		

Superfamily PROTOPLOPHOROIDEA Ewing, 1917				
Family COSMOCHTHONIIDAE Grandjean, 1947				
Genus *Cosmochthonius* Berlese, 1910				
lanatus (Michael, 1885)	*Coo lan*	*		
Cohort MIXONOMAT A				
Superfamily EUPHTHIRACAROIDEA Jacot, 1930				
Family EUPHTHIRACARIDAE Jacot, 1930				
Genus *Euphthiracarus* Ewing, 1917				*
cribrarius (Berlese, 1904)	*Eup cri*			*
Genus *Rhysotritia* Markel et Meyer, 1959				
duplicata (Grandjean, 1953)	*Rhy dup*	*		
Superfamily PERLOHMANNIOIDEA Grandjean, 1954				
Family PERLOHMANNIIDAE Grandjean, 1954				
Genus *Perlohmannia* Berlese, 1916				
insignis (Berlese, 1904)		*		
Superfamily PHTHIRACAROIDEA Perty, 1841				
Family PHTHIRACARIDAE Perty, 1841				
Genus *Atropacarus* Ewing, 1917				
striculus (C. L. Koch, 1835)	*Ste str*	*		
Genus *Hoplophorella* Berlese, 1923				
unidentified species		*		
Genus *Phthiracarus* Perty, 1841				
affinis (Hull, 1914)	*Pht aff*	*		
anonymus Grandjean, 1933	*Pht ano*	*		
bryobius Jacot, 1930	*Pht bry*			*
clavatus Parry, 1979	*Pht cla*	*		
compressus Jacot, 1930	*Pht com*			*
dasypus van der Hammen, L. (1959)	*Pht das*			
globosus (C.L. Koch, 1841)	*Pht glo*			*
laevigatus (C.L. Koch, 1844)	*Pht lae*			*
Longulus (C.L.Koch,1841)	*Pht lon*			*

membranifer Parry, 1979	*Pht mem*	*		
montanus Pérez-Iñigo, 1969	*Pht mon*			*
rectisetosus Parry, 1979	*Pht rec*			*
Genus *Steganacarus* Ewing, 1917				
magnus (Nicolet, 1855)	*Ste mag*	*		
michaeli Bernini and Avanzati 1987	*Stre mic*			*
nitens Nicolet, 1855	*Pht nit*			*
wandae Niedbala, 1981	*Ste wa*			
Cohort DESMONOMATA				
Superfamily CROTONlOIDEA Thorell, 1876				
Family CAMlSIlDAE Oudemans, 1900				
Genus *Camisia* von Heyden, 1826				
biurus (C. L. Koch, 1839)	*Cam biu*	*		
*solhoey*i Colloff, 1993				
horrida (Hermann, 1804)	*Cam hor*	*		
invenusta (Michael, 1888)		*		
segnis (Hermann, 1804)	*Cam seg*	*		
spinifer (C. L. Koch, 1835)	*Can spi*	*		
Genus *Platynothrus* Berlese, 1913				
peltifer (C. L. Koch, 1839)	*Pla pel*	*		
Genus *Heminothrus* Berlese, 1913				*
longisetosus Willmann, 1925	*Hem lon*			*
Family MALACONOTHRIDAE Berlese, 1916				
Genus *Malaconothrus* Berlese, 1904				
globiger Trägardh, 1910	*Mal glo*	*		
monodactylus (Michael, 1888)	*Mal mon*	*		
processus van der Hammen, 1952		*		
punctulatus van der Hammen, 1952	*Mal pun*	*		
purvisi Luxton, 1987		*		
pygmaeus Aoki, 1969	*Mal pyg*			*
Genus *Trimalaconothrus* Berlese, 1916				

glaber (Michael, 1888)	*Tri gla*	*		
maior (Berlese, 1910)	*Tri nov*	*		
tardus (Michael, 1888)	*Tri tar*			
Family Mucronothridae kunst, 1972				*
Genus *Mucronothrus*Trägårdh, 1931				*
nasalis (Willmann, 1929)	*Mus nas*			*
Family NOTHRIDAE Berlese, 1896				
Genus *Nothrus* C. L. Koch, 1835				
anuaniensis Canestrini and Fanzago, 1876	*Not ana*			*
biliatus Koch, 1841*, sp. Inq nr*	*Not bic*			*
palustris C. L. Koch, 1839	*Not pal*	*		
pratensis Sellnick, 1928	*Not pra*			*
silvestris Nicolet, 1855	*Not sil*	*		
Superfamily HERMANNIOIDEA Sellnick, 1928				
Family HERMANNIIDAE Sellnick, 1928				
Gcnus *Hermannia* Nicolet, 1855				
convexa (C. L. Koch, 1839)	*Her con*	*		
gibba (C. L. Koch, 1839)	*Her gib*	*		
pulchella Willmann, 1952		*		
reticulata Thorell, 1871	*Her ret*	*		
scabra (L. Koch, 1879)	*Her sca*	*		
Superfamily NANHERMANNIOIDEA Sellnick, 1928				
Family NANHERMANNIIDAE Sellnick, 1928				
Genus *Nanhermannia* Berlese, 1913				
dorsalis (Michael, 1885)	*Nan dor*			*
eoronata Berlese, 1913		*		
elegantula Berlese, 1913	*Nan ele*	*		
nana (Nicolet, 1855)	*Nan nan*	*		
Cohort BRACHYPYLINA				
Superfamily AMEROBELBOIDEA Grandjean, 1954				
Family CTENOBELBIDAE Grandjean, 1965				

Genus *Ctenobelba* J. Balogh, 1943				
obsoleta (C. L. Koch, 1841)		*		
pectinigera (Berlese, 1908)	*Erm pec*			*
Superfamily AMERONOTHROIDEA Willmann, 1931				
Family AMERONOTHRIDAE Willmann, 1931				
Genus *Ameronothrus* Berlese, 1896				
lineatus (Thorell, 1871)	*Ame lin*	*		
maculatus (Michael, 1882)		*		
nigrofemoratus (L.Koch, 1879)	*Hyg nog*			*
schneidereri (Oudemans, 1903)	*Ame bil*			*
Genus *Hygroribates* Jacot, 1934				
bilineatus (Michael, 1888)	*Hyg bil*	*		
marinus (Banks, 1896)		*		
spoofi Oudemans, 1899	*Hyg spo*			*
Family CYMBAEREMAEIDAE Sellnick, 1928				
Genus *Cymbaeremaeus* Berlese, 1896				*
cymba (Nicolet, 1855)	*Cym cym*			*
Genus *Scapheremaeus* Berlese, 1910 *				
palustris Sellnick, 1924		*		
Family MICREREMIDAE Grandjean, 1954				
Genus *Micreremus* Berlese, 1908				
brevipes (Michael, 1888)	*Mic bre*	*		
Superfamily CARABODOIDEA C. L. Koch, 1837				
Family CARABODIDAE C. L. Koch, 1837				
Genus *Carabodes* C. L. Koch, 1835				
affinis Berlese, 1913	*Car aff*	*		
areolatus Berlese, 1916	*Car are*			*
coriaceus C.L. Koch, 1835	*Car cor*	*		
femoralis (Nicolet, 1855)	*Car fem*			*
labyrinthicus (Michael, 1879)	*Car lab*	*		
marginatus (Michael, 1884)	*Car mar*	*		

ornatus Storkan, 1925	*Car orn*			*
Reticulatus Berlese, 1916	*Car ret*			*
schatzi Bernini, 1976	*Car min*			*
willmanni Bernini, 1975	*Car wi*	*		
Genus *Odontocepheus* Berlese, 1913				
elongatus (Michael, 1879)	*Odo elo*	*		
Superfamily Oripodidea Jacot, 1925				
Family Scheloribatidae Jacot, 1935				
Genus *Schleroribates* Berlese, 1908				
rigisetosus Willmann, 1951	*Sch rig*			*
Family TECTOCEPHEIDAE Grandjean, 1954				
Genus *Tectocepheus* Berlese, 1896				
minor Berlese, 1903	*Tec min*		*	
velatus alatus Berlese, 1913	*Tec ala*			*
velatus sarekensis Trägårdh, 1910	*Tec sar*			*
velatus (Michael, 1880)	*Tec vel*	*		
Superfamily CEPHEOIDEA Berlese, 1896				
Family CEPHEIDAE Berlese, 1896				
Genus *Cepheus* C. L. Koch, 1835				
dentatus(Michael, 1888)	*Cep den*			*
latus C. L. Koch, 1835	*Cep lat*	*		
Genus *Conoppia* Berlese, 1908				
palmicinctum (Michael, 1880)		*		
Genus *Tritegeus* Berlese, 1913				
bisulcatus Grandjean, 1953	*Tri bis*	*		
Genus *Ommatocepheus* Berlese, 1913				
ocellatus (Michael, 1882)	*Omm oce*			*
Superfamily DAMAEOIDEA Berlese, 1896				
Family DAMAEIDAE Berlese, 1896				
Belba von Heyden, 1826				*

corynopus (Hermann, 1804)	*Bel cor*			*
Genus *Damaebelba* Sellnick, 1928				
minutissima (Sellnick, 1920)	*Dae min*			*
Genus *Damaeus* C. L. Koch, 1835				
Subgenus *Adamaeus* Norton, 1977				
maximus Mihelcic, 1957	*Dam max*			*
onustus (C. L. Koch, 1841)		*		
Subgenus *Paradamaeus* Bulanova-Zachvatkina, 1957				
clavipes (Hermann, 1804)	*Dam cla*	*		
Genus Spatiodamaeus				
verticillipes (Nicolet, 1855)	*Spa ver*	*		
Genus *Epidamaeus* Bulanova-Zachvatkina, 1957				
setiger (Kulczynski, 1902)	*Dam set*			*
tatricus (Kulczynski, 1902)	*Epi tat*			*
unidentified species		*		
Genus *Metabelba* Grandjean, 1936				
papillipes (Nicolet, 1855)	*Met pap*	*		
pulverosa Strenzke, 1953	*Met pul*			*
Genus *Porobelba* Bulanova, Zachvatkina, 1960				*
spinosa (Sellnick, 1920)	*Por spi*			*
Superfamily EREMAEOIDEA Sellnick, 1928				
Family EREMAEIDAE Sellnick, 1928				
Genus *Eremaeus* C. L. Koch, 1835				
oblongus C. L. Koch, 1835	*Ere obl*	*		
Superfamily GUSTAVIOIDEA Oudemans, 1900				
Family CERATOPPIIDAE Kunst, 1971				
Genus *Ceratoppia* Berlese, 1908				
bipilis (Hermann, 1804)	*Cer bip*	*		
quadridentata (Haller, 1882)	*Cae qua*	*		
Family LIACARIDAE Sellnick, 1928				

Genus *Adoristes* Hull, 1916				
ovatus (C. L. Koch, 1839)	*Ado ova*	*		
poppei (Oudemans, 1906)	*Ado pop*	*		
Genus *Cultroribula* Berlese, 1908				
bicultrata (Berlese, 1905)	*Cul bic*			*
Genus *Liacarus* Michael, 1898				
badghysi Krivolutsky, 1966	*Lia bad*			*
brevilamellatis Michelcic	*Lia bre*			*
coracinus (C. L. Koch, 1839)	*Lia cor*	*		
niten (Gervais, 1844)	*Lia nit*			*
xylariae (Schrank, 1803)	*Lia xyl*	*		
Genus *Xenillus* Robineau-Desvoidy, 1839				
tegeocranus (Hermann, 1804)	*Xen teg*	*		
Superfamily HERMANNIELLOIDEA Grandjean, 1934				
Family HERMANNIELLIDAE Grandjean, 1934				
Genus *Hermanniella* Berlese, 1908				
picea (C. L. Koch, 1839)		*		
Superfamily HYDROZETOIDEA Grandjean, 1954				
Family HYDROZETIDAE Grandjean, 1954				
Genus *Hydrozetes* BerIese, 1902				
lacustris (Michael, 1882)	*Hyd lac*	*		
lemnae (Coggi, 1899)	*Hyd lem*			
Family LIMNOZETIDAE Grandjean, 1954				
Genus *Limnozetes* Hull, 1916				
amnicus (Behan-Pelletier, 1989)	*Lim amn*			*
ciliatus (Schrank, 1803)	*Lim cil*	*		
rugosus (Sellnick, 1923)	*Lim rug*	*		
sphagni (Michael, 1880)	*Lim sph*			*
Superfamily LIODOIDEA Grandjean, 1954				
Family LIODIDAE Grandjean, 1954				
Genus *Neoliodes* Berlese, 1888				

theleproctus (Hennann, 1804)		*			
Genus *Poroliodes* Grandjean, 1934					
farinosus (C. L. Koch, 1839)	*Po far*	*			
Genus *Platyliodes* Berlese, 1917					*
longisetosus Sitnikova, 1975	*Pla lon*				*
Superfamily OPPIOIDEA Grandjean, 1951					
Family CALEREMAEIDAE Grandjean, 1965					
Genus *Caleremaeus* Berlese, 1910					
monilipes (Michael, 1882)	*Cal mon*	*			
Family OPPIIDAE Grandjean, 1951					
Genus *Beminiella* J. Balogh, 1983					
bicarinata (paoli, 1,908)	*Ber bic*	*			
serratirostris (Golosova, 1970)	*Opp ser*	*			
Dissorhina Hull, 1916					
ornata (Oudemans, 1900)	*Dis orn*	*			
Genus *Medioppia* Subias et Minguez, 1985					
neglecta Perez-Inigo,1969	*Mul neg*				*
obsoleta (paoli, 1908)	*Med obs*	*			
Genus *Microppia* J. Balogh, 1983					
minus (Paoli, 1908)	*Mic min*	*			
minutissima (Sellnick, 1950)	*Opp min*	*			
minutus Evans	*Lau min*				*
Genus *Moritzoppia* Subias et Rodriguez, 1987					
oreia Colloff et Seyd, 1991	*Mor ore*	*			
Genus *Multioppia* Hammer, 1961					
excisa Moritz, 1971	*Mul exc*	*			
laniseta Moritz, 1966					*
Genus Neotrichoppia (Confinoppia)					
variabilis Iturrondobeita and Subias, 1981	*Con var*	*			
Genus *Oppia* C. L. Koch, 1835					
nitens C. L. Koch, 1835		*			

Genus *Oppiella* Jacot, 1937				
fallax (Paoli, 1908)	*Opp fal*			*
subpectinata (Oudemans, 1900)	*Med sub*			*
Opeilla (Mortizoppia) keilbachi (Moritz, 1969)	*Mor kei*			*
neerlandica (Oudemans, 1900)	*Opp nee*			*
nova (Oudemans, 1902)	*Opp nov*	*		
obscura (Mahunka and Manhunka-Papp, 2000)	*Lau ten*			*
Opeilla (Rhinoppia) subpectinata (Oudemans, 1900)	*Opp sub*		*	*
Opeilla (Rhinoppia) unicarinata(Paoli, 1908)	*Mor uni*			*
Genus *Quadroppia* Jacot, 1939				
monstruosa Hammer, 1979	*Qua mon*			*
pseudocircumita Minguez, Riz and Subias, 1985	*Qua pse*			*
quadricarinata (Michael, 1885)	*Qua qua*	*		
Genus *Ramusella* Hammer, 1962				
clavipectinata (Michael, 1885)	*Ram cla*	*		
elliptica (Berlese, 1908)	*Ram ell*			*
Genus *Serratoppia* Subias et Minguez, 1985				
duffyi (Evans, 1954)		*		
serrata (Mihelcic, 1956)	*Ser ser*			*
Genus *Subiasella* J. Balogh, 1983		*		
lamellata (Halbert, 1923)				
Family SUCTOBELBIDAE Grandjean, 1954				
Genus *Suctobelba* Paoli, 1908				
arcana Moritz, 1970	*Suc arc*			*
trigona (Michael, 1888)	*Suc tri*	*		
Genus *Suctobelbella* Jacot, 1937				
acutidens (Forsslund, 1941)	*Suc acu*	*		
falcata (Forsslund, 1941)	*Suc fal*	*		
?nasalis (Forsslund, 1941)		*		
perforata (Strenzke, 1950)	*Suc per*			*
sarekensis (Forsslund, 1941)	*Suc sar*	*		

subcornigera (Forsslund, 1941)	*Suc sub*	*		
Subtrigona (Oudemans, 1916)	*Suc sub*			*
Family THYRISOMIDAE Grandjean. 1954				
Genus *Banksinoma* Oudemans, 1930				
lanceolata (Michael, 1885)	*Ban lan*	*		
Genus *Pantelozetes* Grandjean, 1953				
multidentata (Evans, 1954)		*		
paolii (Oudemans, 1913)	*Pan pao*	*		
Cohort PORONOTA				
Superfamily CERATOZETOIDEA Jacot, 1925				
Family CERATOZETIDAE Jacot, 1925				
Genus *Ceratozetes* Berlese, 1908				
cuspidatus Jacot, 1939	*Cer cus*			*
gracilis (Michael, 1884)	*Cer gra*	*		
peritus Grandjean, 1951	*Cer per*			*
mediocris Berlese, 1908	*Cer med*	*		
Genus *Diapterobates* Grandjean, 1936				
humeralis (Hennann, 1804)	*Dia hum*	*		
Genus *Edwardzetes* Berlese, 1914				
edwardsi (Nicolet, 1855)	*Edw edw*	*		
Genus *Fuscozetes* Sellnick, 1928				
fuscipes (C. L. Koch, 1844)	*Fuc fus*	*		
Genus *Humerobates* Sellnick, 1928				
rostrolamellatus Grandjean, 1936	*Hum fun*	*		
Genus *Latilamellobates* Shaldybina, 1971				
incisellus (Kramer, 1897)	*Lat inc*	*		
Genus *Melanozetes* Hull, 1916				
meridianus Sellnick, 1928	*Mel mer*			*
mollicomus (C. L. Koch, 1839)	*Mel mol*	*		
stagnatilis (Hull, 1914)	*Mel sta*	*		
Genus *Sphaerozetes* Berlese, 1885				

orbicularis (C. L. Koch, 1835)	*Sph orb*	*		
piriformis (Nicolet, 1855)	*Sph pir*	*		
Genus *Trichoribates* Berlese, 1910				
novus (Sellnick, 1928)		*		
trimaculatus (C. L. Koch, 1835)	*Tri tri*	*		
Family CHAMOBATIDAE Grandjean, 1954				
Genus *Chamobates* Hull, 1916				
borealis (Tragardh, 1902)	*Cha inc*			*
caucasicus Shaldybina, 1969	*Cha cau*			*
cuspidatus (Michael, 1884)	*Cha cus*	*		
pusillus (Berlese, 1895)	*Cha pus*	*		
schuetzi (Oudemans, 1902)	*Cha sch*	*		
subglobulus (Oudemans, 1900)	*Cha sub*	*		
Family EUZETIDAE Grandjean, 1954				
Genus *Euzetes* Berlese, 1908				
globulus (Nicolet, 1855)	*Euz glo*			*
nuens (Johnston, 1853)		*		
Family MYCOBATIDAE Grandjean, 1954				
Genus *Minunthozetes* Hull, 1916				
semirufus (C. L. Koch, 1841)	*Min sem*	*		
tarmani Feider,Vasiliu and Calugar, 1971	*Mun ta*			*
Genus *Mycobates* Hull, 1916				
parmeliae (Michael, 1884)		*		
sarekensis (Triigardh, 1910)		*		
Genus *Punctoribates* Berlese, 1908				
punctum (C. L. Koch, 1839)	*Pun pun*	*		
quadrivertex (Halbert, 1920)	*Pun qua*	*		
Superfamily GALUMNOIDEA Jacot, 1925				
Family GALUMNIDAE Jacot, 1925				
Genus *Acrogalumna* Grandjean, 1956				
longipluma (Berlese, 1904)	*Per lon*	*		

Genus *Pergalumna* Grandjean, 1936					
capillaris Aoki, 1961	*Per cap*	*			
nervosa (Berlese, 1914)	*Per ner*	*			
Superfamily LICNEREMAEOIDEA Grandjean, 1931					
Family PASSALOZETIDAE Grandjean, 1954					
Family Licneremaeidae Grandjean, 1931					*
Genus *Licneremaeus* Paoli, 1908					*
Licnophorus (Michael, 1882)	*Lic lic*				*
Genus *Passalozetes* Grandjean, 1932					
perforatus (Berlese, 1910)	*Par per*	*			
Family SCUTOVERTICIDAE Grandjean, 1954					
Genus *Scutovertex* Michael, 1879					
minutus (C. L. Koch, 1835)	*Scu min*	*			
sculptus Michael, 1879	*Scu scu*	*			
Superfamily ORIBATELLOIDEA Jacot, 1925					
Family ACHIPTERIIDAE Thor, 1929					
Genus *Achipteria* Berlese, 1885					
coleoptrata (Linnaeus, 1758)	*Ach col*	*			
italicus Oudemans, 1927	*Ach ita*				*
Genus *Parachipteria* van der Hammen, 1952					
nicoleti (Berlese, 1883)		*			
nitens (Nicolet, 1855)	*Ach nit*				*
petiti Travé, 1960	*Par pet*				*
?punctata (Nicolet, 1855)	*Par pun*	*			
Genus *Pseudachipteria* Trave, 1960					
magna (Sellnick, 1928)	*Pse mag*	*			
willmanni van der Hammen, 1952	*Par wil*				*
Family ORIBATELLIDAE Jacot, 1925					
Genus *Ophidiotrichus* Grandjean, 1953					
tectus (Michael, 1884)	*Oph tec*				*
Genus *Oribatella* Banks, 1895					

berlesei (Michael, 1898)	*Ori ber*			*
calcarata (C. L. Koch, 1835)	*Ori cal*	*		
quadricornuta (Michael, 1880)	*Ori qua*	*		
superbula Berlese, 1904	*Ori sup*	*		
Superfamily ORlPODOIDEA Jacot, 1925				
Family HAPLOZETIDAE Grandjean, 1936				
Genus *Haplozetes* Willmann, 1935				
vindobonensis (Willmann, 1935)	*Ind vin*			*
Genus *Joelia* Oudemans, 1906				
fiorii (Coggi, 1898)	*Joe fior*			*
Genus *Xylobates* Jacot, 1929				
capucinus (Berlese, 1908)				
Family ORIBATULIDAE Thor, 1929				
Genus *Liebstadia* Oudemans, 1906				
humerata Sellnick, 1928	*Lie hum*			*
similis (Michael, 1888)	*Lies sim*	*		
Genus *Oribatula* Berlese, 1895				
saxicola Halbert, 1920		*		
tibialis (Nicolet, 1855)	*Ori tib*			*
venusta (Berlese, 1908)	*Ori ven*	*		
Genus *Phauloppia* Berlese, 1908				
lucorum (C. L. Koch, 1841)	*Pha luc*	*		
rauschenensis (Sellnick, 1908)	*Pha rau*	*		
Genus *Zygoribatula* Berlese, 1916				
exilis (Nicolet, 1855)	*Zyg exi*	*		
Family SCHELORIBATIDAE Grandjean, 1954				
Genus *Dometorina* Grandjean, 1951				
plantivaga (Berlese, 1895)		*		
Genus *Hemileius* Berlese, 1916				
initialis (Berlese, 1908)	*Hem ini*	*		
Genus *Scheloribates* Berlese, 1908				

laevigatus (C. L. Koch, 1835)	*Sch lae*	*		
pallidulus (C. L. Koch, 1841)	*Sch lat*	*		
Superfamily PHENOPELOPOIDEA Petrunkovitch, 1955				
Family PHENOPELOPIDAE Petrunkovitch, 1955				
Genus *Eupelops* Ewing, 1917				
acromios (Hermann, 1804)	*Eup acr*	*		
bilobus (Sellnick, 1928)	*Pel bil*	*		
major (Hull, 1914)	*Eup maj*			*
hirtus (Berlese, 1916)	*Eup hir*			*
nepotulus (Berlese, 1917)	*Euo neo*	*		
plicatus (C. L. Koch, 1835)	*Eup pli*	*		
tardus (C. L. Koch, 1835)	*Eup tar*	*		
torulosus(C.L Koch, 1839)	*Eup tor*			*
Genus *Peloptulus* Berlese, 1908				
Peloptulus gibbus	*Pel gib*	*		
montanus Hull, 1914	*Pel mon*	*		
phaeonotus (C. L. Koch, 1844)	*Pel pha*			*
Cohort Holonota Balogh, 1972				*
Family Eulohmanniidae Grandjean, 1931				*
Genus *Eulohmannia*				*
ribagai (Berlese, 1910)	*Eul rib*			*

Appendix 2. Cryptostimata mites species and the abbreviation used for ordination from CS200 and Macfadyen (1952)

Species	**Abbreviation used in ordination**
Nothrus anauniensis	*Not ana*
Acrogalumna alongipluma	*Acr alo*
Chamobates paolii	*Cha pao*
Damaeobelba minutissima	*Dam min*
Eupelops hirtus	*Eup hir*
Hermanniella granulata	*Her gra*
Lauroppia maritima	*Lau mar*
Lauroppia translamellata	*Lau tra*
Liocthonius neglectus	*Lio neg*
Melanozetes stagnatilis	*Mel sta*
Moritzoppia keilbachi	*Mor kei*
Moritzoppia oreia	*Mor ore*
Nanhermannia coronata	*Nan cor*
Nanhermannia sellnicki	*Nan sel*
Nothrus anauniensis	*Not ara*
Oribatula saxicola	*Ori sax*
Parachipteria petiti	*Par pet*
Peloptulus gibbus	*Pel gib*
Poroliodes farinosus	*Po far*
Quadroppia maritalis	*Qua mar*
Suctobelbella similis	*Suc sim*
Syncthonius crenulatus	*Syn cre*
Trimalaconothrus sculptus	*Tri scu*
Nanhermannia elegantula	*Nan ele*
Berniniella bicarinata	*Ber bic*

Ceratozetes mediocris	*Cer med*
Schloeloribates laticeps	*Sch lat*
Notapsis coleoptratus	*Not col*
Oribella berlese	*Ori ber*
Humerobates fungurum	*Hum fun*
Sphaerozetes orbicularis	*Sph orb*
Nothrus bicillatus	*Not bic*
Gustavia microcephala	*Gus mic*
Liacarus coracinus	*Lio cor*
Belba geniculosa	*Bel gen*
Belba pulverulenta	*Bel pul*
Oppiella subpectinata	*Opp sub*
Phthiracarus ligneous	*Pht lig*
Holoderma shreulm	*Hol shr*