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# THE EFFECTS OF ENERGY GRASS PLANTATIONS ON BIODIVERSITY

A preliminary study

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**FINAL REPORT**

# THE EFFECTS OF ENERGY GRASS PLANTATIONS ON BIODIVERSITY

**Project Number: CFP 374/22**

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## Executive summary

### Objectives

Wildlife monitoring of five field sites growing the perennial rhizomatous grass crops Miscanthus, reed canary-grass and switch-grass was carried out in 2002, 2003 and 2004 to investigate the ecological impact of these plantations on biodiversity where possible using existing standard protocols.

### Background

Unlike reed canary-grass, both switch-grass and Miscanthus are not native to Britain. Miscanthus species originate from Asia, and switch-grass species from North America. Biomass crops have the potential to make a major contribution to future energy demands in the UK, and thus fulfil part of the government's commitment towards the Kyoto Climate Change Agreement. However, before any introduced perennial biomass grass crop is grown in Britain to a commercial scale of production, it is paramount that environmental impacts are carefully considered in determining its potential to become a major resource for sustainable bio-energy. Currently, biomass grass crops are grown on existing agricultural lands, and are not replacing land-uses of high ecological value, such as natural forests, semi-natural grasslands or high value agricultural crops. Over 100 ha of land within Herefordshire were planted with Miscanthus (*Miscanthus x giganteus*), switch-grass (*Panicum virgatum*) and reed canary-grass (*Phalaris arundinacea*) in 2002. The area has now expanded to over 300 ha consisting of predominantly Miscanthus (95% of the area) and to a lesser extent reed canary-grass (5%).

### Summary of the work

The study was carried out in 2002, 2003 and 2004 at five commercial farms within Herefordshire: one on Farland's farm at Lingen, three on Ox farm at Shobdon and one on Norman's farm at Stoke Prior. These were two Miscanthus, two reed canary-grass and one switch-grass sites. Miscanthus site 1 (7 ha) at Shobdon was planted in 2002 and rhizomes were lifted in 2004, so the maximum age of the crop stand during the study period was 2 years. Miscanthus site 2 (4.1 ha) at Lingen was planted in 2000 and rhizomes were lifted in 2003, so the maximum age of the crop stand was 3 years. Reed canary-grass site 1 (3.9 ha) at Shobdon was planted in 2002 and the maximum age of the crop stand was 3 years. Reed canary-grass site 2 (1.3 ha) at Stoke Prior had a maximum age of 4 year crop stand - it was planted in 2000 and the crop was dug up in 2003 for economic reasons, and thus was replaced by a site at Lingen which was planted in 2003. Switch-grass field at Shobdon (3.8 ha) had a maximum of 2 year old crop stand: it was planted in 2002, and was dug up in 2004.

Selection of sites (and their total numbers) was dependent upon the availability of sites, the quality of the crop stands and funding for the work: for example, all reed canary-

grass and switch-grass sites were chosen, and Miscanthus sites were chosen in two out of four possible farms. When the project began it was expected that the crops would remain for at least the duration of the study, but the value of the rhizomes was such that they were lifted before crop maturity, a factor over which we had no control.

Since it is not possible to monitor all species and their abundance, indicators were chosen to represent a wide-ranging group of organisms. The remit for this project was to monitor major groups for which widely accepted protocols already existed. Indicators of biodiversity chosen in this study were based on ADAS's review of methodologies for future ecological monitoring in energy crops. These focused mainly on 'core groups' and 'priority additional groups' which are considered to be an indicative of overall biodiversity in the energy grass plantations. All of the 'core groups' (i.e. ground flora, ground beetles, arboreal insects, breeding birds and small-mammals) were assessed, but from the 'priority additional groups' only butterflies, bumble bees and hoverflies were monitored.

Quadrat work was used to record ground flora (% ground cover) within and around the periphery of each crop. Ground beetles were sampled by pitfall trapping; arboreal invertebrates by sweep netting, beating and using yellow sticky traps and small-mammals by live trapping using Longworth traps. The Common Birds Census technique was used to monitor populations of birds but with an extended season of operation. The Centre for Ecology and Hydrology's Butterflies Monitoring Scheme methodology was used to record butterflies, and this methodology was also adopted to record bumble bees and hoverflies.

Of the three biomass crops, switch-grass, the model species for biomass energy production in America, did not grow as vigorously as expected and was infested with grass and broad leaved weeds. Due to poor overall performance, it was ploughed over at the beginning of its third season. Thus, much of this report focuses on Miscanthus and reed canary-grass crops.

It is evident that both Miscanthus and switch-grass do not represent a typical mature or well established crop stands, but they do represent the current experience of commercial farms in the UK for establishment years. If the crop is widely planted and grown, as in this case, mainly for rhizomes, then the results from these early years may come to reflect the biodiversity status of a considerable proportion of the national crop at any one time. The reed canary-grass, however, does represent a well established and mature crop stands. In terms of crop stands, the reed canary-grass in its second or third season is on a par with the adjacent arable crops or a well established crops stands of Miscanthus with 100% canopy cover (e.g. more than five year old crops). The results of the current work do provide a valuable first baseline biodiversity data from commercial biomass grass farms in the UK including a wide-ranging group of organisms (from invertebrates to birds and small-mammals) that could be utilised for further research work.

As the study is a survey rather than an experimental study, differences in terms of the actual biomass crop species can only be looked at on a broad scale using herbicide management information supplied by farmers, agronomic practices of growing the crops

such as plant density and row width, age of the crop stands, and quality and size of the surrounding non-crop habitats such as field margins and hedges. These are the factors that were found to have most influence on the biodiversity of the perennial biomass grass crops in the current study.

The results of this study have shown that all biomass grass crops and arable fields were subject to flushes of weeds to a varying extent, and differences between the crop habitats were readily apparent and clearly visible both in the establishment year as well in the following year/s. On average, in terms of richer diversity in weed vegetation, the order was: Miscanthus > reed canary-grass > wheat. In terms of frequency of herbicide application to control non-crop plants, wheat fields received the greatest herbicide application followed by Miscanthus, and then reed canary-grass. Miscanthus fields were richer in weed vegetation than reed canary-grass or arable fields. This was attributed to the crop's initial slow growth and development early in the season (characteristic of $C_4$ plants), coupled with the agronomic practice of planting the crop in wide rows and at very low plant density leaving plenty of space for weeds to flourish with little competition for soil nutrient and light resources, as observed during the establishment years (year one to three).

Percentage weed cover in the two/three year old Miscanthus fields ranged from 48% to 96% compared to 1% to 5% in the two/three years old reed canary-grass fields and 1% to 7% in the arable fields. This indicates that weed cover in the well established reed canary-grass and adjacent arable fields was similar despite differences in herbicide application. Complete weed control was achieved in the established reed canary-grass as a result of rapid canopy cover early in the spring with no herbicide application; whereas in the wheat fields, this was achieved by the use of pre- and post-emergence application of herbicides. Therefore, the greater weed diversity in the reed canary-grass fields compared to the arable crops is mainly due to the weediness of the reed canary-grass fields in the first year of planting. Indeed, comparison between different biomass crops or between biomass crops and arable crops could be made easier if well established and matures stands of all the biomass crops were used in the study. This was not possible in the current study due to limited availability of sites since an interest in the commercial growing of the biomass crops has only recently begun.

Bird use of the biomass crop fields varied depending on species. There were considerably more open-ground bird species such as skylarks, meadow pipits and lapwings within Miscanthus than within reed canary-grass fields, indicating that Miscanthus fields were preferred by those bird species at least in the first years after planting. Biomass crop fields provide not only nesting habitat for ground-nesting species but also a winter foraging habitat for the wide range of species which exploit the crop fields for invertebrates and seeds as well as for cover. With the exception of the open-ground birds, most of the bird species were found more abundantly within the hedges than in crop fields indicating the importance of retaining field structure when planting biomass crops.

Ground beetles, butterflies, bumble bees, hoverflies and arboreal invertebrates were more abundant and diverse in the most floristically diverse habitat of Miscanthus fields.

The most important invertebrate taxa in the biomass crop fields included Coleoptera (Curculionidae, Chrysomelidae, Carabidae, Staphylinidae and Elateridae), Hemiptera (Heteroptera and Homoptera), Diptera and Hymenoptera.

There was no particular crop-type preference by the small-mammal species, but rather a preference for good ground cover and little land disturbance, which was provided by all of biomass crop fields. Field margins and boundaries had higher small-mammal abundance than biomass crop fields, probably because most of the small-mammal species are border habitat specialists occurring mainly close to woodland, hedges, boundaries and in unploughed headlands.

## Conclusions

Because perennial rhizomatous grasses require a single planting and related tillage; and because the crops are harvested up to March and the land is not disturbed by cultivation every year, these fields were used as over-wintering sites for birds, also by small-mammals and invertebrates suggesting immediate benefits to biodiversity. These results clearly demonstrate that perennial biomass grasses grown as an energy source have a positive effect on biodiversity and can benefit native wildlife. These preliminary conclusions are based on five farm sites and where the oldest Miscanthus crop was only three years old. Further monitoring is, therefore, recommended to assess biodiversity well after full canopy cover is achieved by the Miscanthus crop itself. Both Miscanthus and switch-grass crop stands were young and not well established, and consequently their fields were weedier than the well established reed canary-grass or arable crop fields.

Miscanthus does not reach maximum canopy cover well until year three or over. We do not know how the relationship between crop architecture and wildlife changes as the crop ages and the canopy starts to close earlier in successive years coupled with increasing storage/root systems. Based on the experience from the current well established and mature stands of reed canary-grass, we could extrapolated that the biodiversity of Miscanthus crop fields is most likely to decrease as the crop achieves its maximum crop productivity both in its above-ground and below-ground biomass in older crop canopies. Nevertheless, how older Miscanthus crop stands that are managed under low-input agrochemical management systems will compare with arable crops can only be answered after a wide-scale long-term monitoring and this we would consider to be important future work.

## 1. Introduction

Under the Kyoto Climate Change Agreement, the UK government has agreed to reduce greenhouse gas emissions by 12.5% by 2010, relative to 1990 levels (DTI, 1999). To achieve its obligations, the government is working towards a target of generating 10% of electricity from renewable sources, such as biomass crops, by 2010. One of the key benefits of biomass grass crop plantations is that the energy used up in growing them (during planting, agro-chemical spraying, harvesting, drying the crop etc.) is much less than that released when they are burnt. In addition, biomass crops are environmentally beneficial and are good examples of sustainable agriculture. Over the whole cycle they are at least carbon neutral (McLaughlin and Walsh, 1998); and studies have identified real potential benefits to biodiversity (Eppel-Hotz and Marzini, 1998) and the potential to develop integrated pest management strategies (Borjesson, 1999). Moreover, growing biomass crops, as an energy source is environmentally less destructive than felling trees; and contains less nitrogen than arable crops and so release less $N0_x$ to the atmosphere (Maryan, 1997).

This project deals mainly with the effect of growing perennial biomass grasses on biodiversity. Before any perennial biomass grass crop is grown in Britain to a commercial scale of production, it is paramount that environmental impacts are carefully considered in determining its potential to become a major resource for sustainable bio-energy. Currently, biomass grass crops are grown on existing agricultural lands, and are not replacing land-uses of high ecological value, such as natural forests, semi-natural grasslands or high value agricultural crops. Over 100 ha of land within Herefordshire were planted with Miscanthus (*Miscanthus giganteus*), switch-grass (*Panicum virgatum*) and reed canary-grass (*Phalaris arundinacea*) when the research work began in 2002, and it is these sites which are the subject of this biodiversity project. The area has now expanded to over 300 ha consisting of predominantly Miscanthus (95% of the area) and to a lesser extent reed canary-grass (5%).

The three biomass grass species grown are rhizomatous perennials. Unlike reed canary-grass, both switch-grass and Miscanthus are not native to Britain. Miscanthus species originate from Asia, and switch-grass species from North America. Due to technical difficulties and financial implications of removing an introduced species once it is established, control is more feasible if 'problem' species can be identified at an early stage of establishment e.g. if they have a negative effect on biodiversity. Therefore, every proposed species introduction should be subject to rigorous ecological assessment if possible prior to introduction or at least before full-scale commercial production.

It is hypothesised that replacing ex-arable land with native or introduced new species of perennial biomass grass crops will affect the biodiversity. Agricultural land makes up a big proportion of Britain's countryside; therefore, maximizing its value to wildlife is essential if viable populations of many native elements of the flora and fauna are to be maintained. The main objective of this project was to investigate the ecological impact of introduced biomass grass crops grown in Herefordshire. In order to determine how

biomass grasses on ex-arable land affect key flora and fauna (both on an annual basis and as the crops develop over the period of study), baseline and ongoing studies were conducted on a range of organisms: vegetation, ground beetles, arboreal invertebrates, birds and small-mammals. The remit of the project was to study core groups of organisms using standard existing protocols and this determined how the study was undertaken and which organisms were included.

## 2. Study sites and methods

### 2.1. STUDY SITES

The study was carried out for three years (2002, 2003 and 2004) at five commercial farms within Herefordshire: one on Farland's farm at Lingen, three on Ox farm at Shobdon and one on Norman's farm at Stoke Prior. These were two Miscanthus fields, two reed canary-grass fields, and one switch-grass field. All sites consisted of mixed farmland, with fields bound by hedges or tree lines. All the sites were located adjacent to a hedge on all aspects, except for the Miscanthus site 1 at Shobdon, where there were no hedges on aspects north and east, and the hedges on aspects south and west were at least 15 m away from the field. Adjacent land-use consisted of a combination of arable crops, set-aside, silage and pasture grazed by cattle, sheep and horses. A full history of the land under study including soil type, soil pH, slope, aspect, exposure, date of planting and nitrogen:phosphate:potassium (N:P:K) prior to planting is presented in Table 1.

*Site selection*

Selection of sites (and their total numbers) was dependent upon the availability of sites, the quality of the crop stands and funding for the work: for example, all reed canary-grass and switch-grass sites were chosen, and Miscanthus sites were chosen in two out of four farms. Based on these factors, five farm sites were selected representing each of the perennial biomass grass crops grown in the area. There was no scope for choice of sites as they were very limited in number, and those sites selected were mainly because (a) they were available and (b) had a better crop stand quality than those not selected. We also had no control over the management of the crops and if or when they were lifted.

### 2.2. DESCRIPTION OF CROP SPECIES

*Miscanthus*

Miscanthus (M) is a perennial $C_4$ rhizomatous grass, which is planted as rhizomes in the spring and harvested in winter every year with a potential yield up to 20 t dry biomass $ha^{-1}$ (Schwarz and Greef, 1996; Bullard, 2000). Miscanthus can grow as high as 3 m in the UK, and its lifetime is at least 15 years. It spreads naturally by means of rhizomes. The rhizomes can be split and the pieces re-planted to produce new plants. Miscanthus produces new shoots annually, which emerge during April. The leaves start to dry during autumn, as the nutrients are translocated back to the rhizomes by the end of the growing season (Mutoh and Nakamura, 1978). Fertilizer requirements of the crop are very low due to good nutrient-use efficiency of the crop and autumn leaf fall as well as the plant's ability to re-cycle nutrients into the rhizomes at the end of the growing season (DEFRA, 2001). Weed control in the critical establishment year of the crop is important; however, once the crop is well established from the second or third year

onwards, weed growth can be adequately suppressed by the leaf litter layer produced on the soil surface and by the closure of the crop's canopy (Bullard, 2000).

*Switch-grass*

Switch-grass (SG) is also a perennial rhizomatous $C_4$ plant that originated from North America. The crop is established from seeds in the late spring and harvested in winter every year. The crop's life cycle extends up to eight years. In its establishment year, its growth is very slow and weed control is essential for its development (Christian *et al.*, 1999). Its nitrogen requirement is low (Christian *et al.*, 1999).

*Reed canary-grass*

Reed canary-grass (RCG) is a cold tolerant perennial rhizomatous $C_3$ plant grass with high yield potential of up to 14 t biomass $ha^{-1}$ (Schwarz and Greef, 1996). It is native to Britain, and usually found along rivers, streams and marshy lands. It can grow as high as 2 m. It established from seeds in the spring and harvested in winter every year. The life cycle of the crop is about five years, but can achieve its full yield potential by the second year, which is much earlier than Miscanthus or switch-grass. Its growth is very fast even during the establishment year, and weed control using herbicides is kept to a minimum. The crop, however, suffers from a range of native pests and diseases as well as lodging (Christian *et al.*, 1999). The nitrogen demand of the crop is very low.

## 2.3. CROP MANAGEMENT

Crop management strategies across the sites followed normal farm practice as imposed by the routine management of each farm, and was out of our control.

Before planting, all sites were sprayed with glyphosate to control perennial weeds. In the spring, a firm fine seedbed was prepared by ploughing, cultivating and rolling before drilling or planting.

Planting of Miscanthus rhizomes was carried out using an adapted semi-automatic potato planter. RCG and SG seeds were drilled using pneumatic precision drill. All the three crop species were harvested using mower conditioner, and were later baled.

All the biomass grasses were managed with low-input agricultural practice. None of the sites were applied with chemical fertilisers or insecticides; and herbicide application was confined to the critical establishment phase, and was kept to a minimum if applied in the $2^{nd}$ or $3^{rd}$ season. Details of herbicides applied for each crop habitat are given in Table 2.

Table 1. Details of study sites including site location, total crop area, soil type, soil pH, slope, aspect, exposure, annual rainfall (RF), date of planting and N:P:K prior to planting.

| | Miscanthus site 1 | Miscanthus Site 2 | Reed canary-grass, site 1 | Reed canary-grass, site 2 | Switch-grass Site 1 |
|---|---|---|---|---|---|
| Grid reference | SO 394 598<br>Lat $52^0$ 13.9' N<br>Long $2^0$ 53.2' W | SO 353 686<br>Lat $52^0$ 18.4' N<br>Long $2^0$ 57' W | SO 412 612<br>Lat $52^0$ 14.6' N<br>Long $2^0$ 51.9' W | SO 524 558<br>Lat $52^0$ 11.8' N<br>Long $2^0$ 42' W | SO 412 613<br>Lat $52^0$ 14.6' N<br>Long $2^0$ 51.9' W |
| Altitude | 93 m | 305 m | 93 m | 119 m | 93 m |
| Site location | Ox farm, Shobdon | The Farland's Farm, Lingen | Ox farm, Shobdon | Norman's farm, Stoke Prior | Ox farm, Shobdon |
| Total area, ha | 7.0 | 4.1 | 3.9 | 1.3 | 3.8 |
| Soil type | Silty loam | Clay loam | Black peat, with Clay loam in places | Clay loam | Black peat, with Clay loam in places |
| Soil pH | - | 6.8 | 7.9 | 6.6 | 7.9 |
| Slope | 0% | 3% | 0% | 1% | 0% |
| Aspect | No aspect | South | No aspect | East | No aspect |
| Exposure | Not exposed | Exposed | Not exposed | Not exposed | Not exposed |
| Annual RF*: | | | | | |
| Year 2000 | 973 mm | | 973 mm | | 973 mm |
| Year 2001 | 766 mm | | 766 mm | | 766 mm |
| Year 2002 | 878 mm | | 878 mm | | 878 mm |
| Year 2003 | 518 mm | | 518 mm | | 518 mm |
| Year 2004 | 785 mm | | 785 mm | | 785 mm |
| Planting date** | 24 April 2002 | 30 March 2000 | 17 June 2002 | April 2000 | 17 June 2002 |
| N:P:K prior to planting | 5:2:2 normal:normal: normal (adequate levels) | - | -:0.6:1.5 -:60:30 kg/ha high:v low:low levels | - | -:0.6:1.5 -:60:30 kg/ha high:v low:low levels |

*Annual rainfall from Ox House rain gauge, Shobdon (courtesy of the Corbett family).

** Both Miscanthus sites were harvested for their rhizomes (site 1 in April 2004; and site 2 in April 2003) and left to re-generate naturally. Reed canary-grass site 2 at Stoke prior was ploughed up in September 2003, and replaced by another reed canary-grass field at Lingen (which was planted in the Spring of 2003) by a similar sized area, very close to the Miscanthus site 2.

Table 2. A list of herbicides applied before and after planting for each of the biomass grass crop fields.

| Crop habitat | Before planting | After planting | | | | |
|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2002 | 2003 | 2004 |
| Miscanthus site 1 | Glyphosate @ 2.5 kg/ha | - | - | Mecoprop-P (1.4 l/ha) + Fluroxypr (1 l/ha) mix on 25/7/02 | Atrazine (1.4 l/ha) + glyphosate (1.0 l/ha) mix on 22/2/03 | None |
| Miscanthus site 2 | Glyphosate | Fluroxypyr and Metsulfuron-methyl mix - post emergence | Glyphosate (3 l/ha) on 1/04/01 Metsulfuron-methyl (30 g/ha) and Mecoprop-P (1.5 l/ha) mix on 3/7/01 | Glyphosate (4 l/ha) on 22/3/02 Metsulfuron-methyl (30 g/ha) and Fluroxypr (0.8l/ha) mix on 26/6/02 | Atrazine (1.4 l/ha) in March 2003 | None |
| Reed canary-grass Site 1 | Glyphosate @ 2.5 kg/ha | - | - | MCPA (2 l/ha) + Fluroxypr (1 l/ha) mix on 29/7/02 | None | None |
| Reed canary-grass Site 2* | Glyphosate | Fluroxypr (1 l/ha) - post emergence | None | None | Didquat (4 l/ha) in mid-August 2003 | - |
| Switch-grass | Glyphosate@ 2.5 kg/ha | - | - | MCPA (2 l/ha) + Fluroxypr (1 l/ha) mix on 29/7/02 | None | - |

* The reed canary-grass field that replaced reed canary-grass site 2, was not applied with any pesticides in its first as well as its second year.

## 2.4. MONITORING

Since it is not possible to monitor all species and their abundance, and as required by the remit of the project, indicators were chosen to represent a wide-ranging group of organisms. Indicators of biodiversity chosen in this study were based on ADAS's review of methodologies for future ecological monitoring in energy crops (Britt, 2001). These focused mainly on 'core groups' and 'priority additional groups' which are considered to be an indicative of overall biodiversity in the energy grass plantations. All of the 'core groups' (i.e. ground flora, ground beetles, arboreal insects, breeding birds and small-mammals) were assessed, but from the 'priority additional groups' only butterflies, bumble bees and hoverflies were monitored. These were chosen due to their roles in pollinating plants as well as their sensitivity to nectar and pollen resources available (Goulson & Wright, 1998; Champion *et al.*, 2003; Pywell *et al.*, 2004). Bumble bees and hoverflies were monitored in the third year to make up for the lost work in switch-grass site in that year.

In order to allow comparison with previous studies and to establish a protocol for future work, standard evaluation techniques were used wherever possible during monitoring as required by our contract.

Primary surveys included all the 'core groups':

- Quadrats to record ground flora (% ground cover) within and around the periphery of each crop
- Evaluation of beetle population and canopy invertebrates
- Breeding bird surveys based on the British Trust for Ornithology Common Bird Census and regular point counts throughout the year
- Small-mammal surveys using line transects of Longworth traps using Mammal Society protocol

Secondary surveys of the study included some of the 'priority additional groups':

- butterfly counts in 2002, 2003 and 2004 (CEH Butterfly Survey protocol); and
- bumble bees and hoverflies in 2004

These surveys were carried out for each crop type and, as controls, within each type of surrounding land-use, such as headlands and hedgerows.

Crop characteristics such as plant height and plant/stem density were also assessed when necessary; and biomass of weeds and crop measured at the end of September.

*Ground flora*

Percentage cover of each plant species was estimated once in July each year using 50 cm x 50 cm quadrats at 20 random points:

- within the crop
- in the field margins and
- in adjacent arable crop fields

Plants were identified to species level apart from bryophytes, which were recorded as a single group. Botanical nomenclature followed Rose (1981) and Hubbard (1984).

*Ground beetles*

Sampling for ground beetles was performed using pitfall traps arranged in transects consisting of five traps each. There were eight transects per site; six of these were within the cropped areas and two in the field margins - giving a total 40 traps in each site. Based on stratified random sampling, two transects within the crop areas were allocated to begin at the crop edge, two transects to begin at 20 m from the crop edge, and two transects to begin at the centre of the crop field. Two transects (of 5 traps each) were also located within the field margins and boundaries, representing both the headlands and hedges as appropriate. The distance between two transects within one side of a field (and in the field margins) was 1 m enabling access to both transects in one pass in order to minimize damage to the dense reed canary-grass crops.

The pitfall traps were made from 7 cm diameter plastic vending machine cups, which were inserted into the ground with their top flush with the soil surface. The traps were sheltered from rain and entry of animals by pot saucers, which were raised about 1.5 cm off the ground over the traps using support sticks. Each trap was part filled with dilute methanol (50%) as a preservative. Traps were left for one week and the contents preserved in alcohol for later identification. Pitfall trapping was carried twice in each year; in July and September in 2002 and in May and July in 2003 and 2004. Ground beetles were identified using the key in Lindroth (1974) and Forsythe (1987); and supported by using picture plates in Harde (2000).

*Bird surveys*

The Common Birds Census technique was used to monitor populations of birds during breeding season, and used as indicative of species present in the crops. Fortnightly visits from March to July were made to each site; and monthly visits were also made from August to February to monitor over-wintering birds. Surveys were made between 8.00 to 13.00 GMT, but were not carried out in windy or in wet weather conditions. On each visit to the farm site, a route around all field boundaries was walked recording all the birds seen or heard within the field or boundary. An additional route within the cropped area was also made in order to disturb and monitor open land birds such as skylarks, meadow pipits and grey partridges. Survey routes were varied between visits to control for diurnal variation in birds activity. Birds flying over the site, which did not take-off from or land in a particular field or boundary, were excluded in this study. Relative abundance of birds was assessed from each visit; and were standardised to unit area (hectare) to account for the differences in the field sizes. Avian nomenclature followed Gibbons *et al.* (1993); and a pocket guide by Saunders (1976) was used when identifying birds in the fields.

*Small-mammals*

Following the practical guide by Gurnell and Flowerdew (1994), live trapping of small-mammals was carried our using Longworth traps filled with hay and baited with cereal grains. This was done twice per year, in the spring and in September. There were six transects within a crop field, two transects each on three sides of a field; and a further two transects were set up in the field margins (giving a total of eight transects). Based on stratified random sampling, two transects within the crop fields were allocated to begin at the crop edge, two transects to begin at 20 m from the crop edge, and two transects to begin at the centre of the crop field. The distance between two transects within one side of a field (and in the field margins) was 1 m enabling access to both transects in one pass in order to minimize damage to the dense reed canary-grass crops. In each transect, six Longworth traps were placed 2.5 m apart. A total of 48 traps were set up per site. Traps were left in place for 5 consecutive days and were checked once a day. Using fur clipping, relative abundance was estimated by mark/recapture techniques. Relative abundance data were standardised to number of individuals per night per 100 traps.

*Butterfly monitoring*

The 'butterfly transect' method, based on the Centre for Ecology and Hydrology's Butterflies Monitoring Scheme (BMS) methodology (Pollard & Yates, 1993), was used to record butterflies in each site. This method involved the establishment of two fixed line transects across each site within the cropped areas, and a single fixed line transect in the field margins. Walks at a slow steady pace were carried out along each transect and the number of individuals of each butterfly species counted in each transect. Counts of individual butterfly species for each transect at each site were summed for the recording period separately for cropped areas and field margins. The total number of butterflies and the number of species (species richness) were also calculated. All counts were standardised to 100 m in order to take account of differences in the length of transects. To ensure consistency between sites, surveys were carried out on the same day for all the sites on a bright, sunny and calm day between 10:00 and 16:00 British Summer Time. Three visits were made in 2003 (June, July and August) and four visits in 2004 (May, June, July and August); one visit was made in 2002, in August. Nomenclature for butterflies followed Asher *et al.* (2001)

*Bumble bee and hoverfly monitoring*

Based on the line-transect method developed for the UK BMS (Pollard & Yates 1993) and adapted as a standard method for bee surveys, a standard walk through three transects within the crop fields and another line transect within the field margins was undertaken, in July and August of 2004 to record bumble bees (Roy *et al.,* 2003) and hoverflies (Sutherland *et al.,* 2001) abundance. All bumble bees and hoverflies approximately 1 m on each side of each transect were recorded.

Hoverflies were recorded to species level in the field, but where identification to species or genus in the field was not possible the insect was caught and preserved in 70% methanol for later identification. Hoverflies were identified using a guide by Stubbs and Falk (1983) and Gilbert (1986). Nomenclature also followed the same relevant guides.

Counts were made for groups of bumble-bee (*Bombus*) species based on the following colour type according to Prys-Jones and Corbet (1991): black and red tail (*B. lapidarius*); brown/ginger (*B. pascuorum*); one or two yellow bands with red tail (*B. pratorum*); two yellow bands with white or buff tail (*B. terrestris/B. lucorum*); three yellow bands with white tail (*B. hortorum*). In all cases, only actively foraging individuals or nest-searching queens were counted.

*Arboreal invertebrates*

Sweep netting was used in the field margins and cropped areas where the crops were suitably low in early growth. There were six sweepings per sample at 10 randomly selected points (i.e. 10 samples) giving a total of 60 sweep nettings per field. The speed and spatial extent of sweeping was kept as constant as possible. When the crops were tall, a beating technique was used and individual stems shaken or beaten over a tray. These were repeated 10 times randomly within the crop as well as within the field margins.

Moreover, visual inspection of each crop species at each site was carried out to determine the prevalence of leaf miners, and by splitting the stems for stem borers.

In 2002, sticky yellow traps (10 cm x 24 cm) were also used along a transect at 10 m intervals into the crop to detect insect movement within the crop. Three transects were set up in three different sides of a field. Traps were vertically positioned so that the 10 cm side of each trap was parallel to the ground, and below the crop canopy but above the weeds. In 2003 and 2004, three malaise traps per field were used to survey invertebrates. One malaise trap was positioned in the field margins; and two traps within the cropped areas - 20 m from the crop edge and 60 m from the crop edge. Additional sticky yellow traps were also positioned by the side of each malaise traps. The number of individuals per family was counted on each sticky and malaise trap. Only data from sweep netting and beating are presented in this report.

Arboreal sampling was carried out twice in 2003 and 2004 during May, June or July; and once in 2002, in August. Chinery (1993) and Oldroyd (1970) was used in the identification and nomenclature of arboreal invertebrates.

*Diversity indices*

The diversity of plant, carabid, bird, small-mammal and butterfly communities was described by the species richness (*S,* number of species) and the Shannon-Wiener index of diversity (*H´*):

$H' = -\sum p_i \ln(p_i)$, where $p_i = n_i/N$.

For animals and count based data, $n_i$ is the number of individuals of species $i$, and $N$ is the total number of individuals in the sample; for plants, $p_i$ is equivalent to the relative percentage cover value of the species expressed as a proportion (Waite, 2000). The diversity index H´ is sensitive to rare species abundance, and reflects population heterogeneity in diverse communities (Krebs, 1999).

*Statistical analysis*

All data were summarised per replicate (there were two replications for each of Miscanthus and reed canary-grass, but data from switch-grass were excluded from the analysis for reasons explained in the results section), and analysis of variance (ANOVA) following randomised block design was carried out using SAS software after testing for normal distribution, i.e. skewness and kurtosis (Snedecor and Cochran, 1980). This was used to validate the use of ANOVA and also to assess if data transformation was necessary or not.

Differences between the crop species (Miscanthus and reed canary-grass) effects for samples recorded from two land-uses (cropped area or field margins) in three years (2002, 2003 and 2004) were tested using ANOVA, with a term for the 'crop species x land-use x year' interaction. There was no first-order or second-order interaction between factors, unless and otherwise stated in the results section.

For ground flora data, ANOVA on 'percentage ground cover' and 'diversity of plant species' was performed as '2 crop species x 3 land-use x 3 year' factorial design with two replications. Data on birds, butterflies and arboreal invertebrates, i.e. 'total number of individuals' and/or 'diversity of species', were also analysed similarly as '2 crop species x 2 land-use x 3 year' factorial design with two replications.

For ground beetles and small-mammals, ANOVA on 'total number of individuals' and 'diversity of species' was carried out as '2 crop species x 2 land-use x 2 sampling dates x 3 year' factorial design with two replications. ANOVA was carried out as '2 crop species x 2 land-use x 2 sampling date' factorial design with two replications for 'total number of individuals' of bumble bees and hoverflies.

## 3. Results

### 3.1. CROP FIELD CHARACTERISTICS

Pictures of Miscanthus, reed canary-grass and switch-grass fields from the study sites are given in Appendix 1 (a, b, c, d, e, f, g & h).

*Miscanthus site 1*

The Miscanthus field at Shobdon (M site 1) was characterized by low crop plant density (2 plants $m^{-2}$ consisting of 5 to 18 stems $m^{-2}$) with 5 to 22% ground cover by the crop and 41 to 69% cover by weeds (Table 3). Crop plants were generally small, with plant height ranging from 53 to 170 cm; and above-ground biomass dry matter yield of between 152 to 980 g $m^{-2}$. Weed biomass ranged from 129 to 379 g $m^{-2}$.

In 2002, the site was sprayed late in the season with Mecoprop-P (1.4 l/ha) + Fluroxypr (1 l/ha) mix on 25$^{th}$ of July to control cleavers. In 2003, however, herbicide application of atrazine (1.4 l $ha^{-1}$) + glyphosate (1.0 l $ha^{-1}$) mix on 22$^{nd}$ February effectively killed existing grass weeds and also suppressed emergence of broad leaved weeds. Broad leaved weeds (such as thistles) and grass weeds started growing noticeably from July onwards (see section Ground Flora for details on types of weeds). By mid-September, weed ground cover was 61% compared to 22% by the Miscanthus crop itself (Table 3). In 2004, the crop was harvested for its rhizomes in April; and left to re-generate. This mechanical soil disturbance followed by no herbicide application resulted in 69% weed cover, mainly couch grass (*Elymus repens*) and thistles.

*Miscanthus site 2*

In contrast, the Miscanthus field at Lingen (M site 2) had a relatively high crop density (4 to 16 plants $m^{-2}$; 27 to 86 stems $m^{-2}$); and covered 32 to 80% of the ground before leaf senescence. Weed cover ranging between 48 to 96% (Table 3). Crop plants were more robust compared to Miscanthus site 1: with plant height ranging from 165 to 225 cm; and above-ground biomass dry matter yield of between 969 to 1914 g $m^{-2}$. The crop was already a three year old stand when this project began; but was harvested for its rhizomes in 2003 and left to re-generate naturally. The substantial increase in the number of plants and stems per unit area in 2003 compared to 2002 was mainly because the rhizomes were cut *in situ* using rotovators to harvest rhizomes for propagation, and subsequently left more rhizomes in the ground.

Despite two herbicide applications in 2002 and one in 2003 (see Table 2), the field was consistently rich predominantly in grass weeds but also broad leaved weeds. There was no herbicide application in 2004. Weed biomass yield was greatest for this site, ranging from 397 to 794 g $m^{-2}$.

*Reed canary-grass sites 1 and 2*

Both reed canary-grass sites were characterized by tall dense crop fields (100% ground cover), with few weeds throughout the season (Table 3). The current experience has shown that reed canary-grass can achieve its optimum yield by the second year of its cycle; and had the least weed biomass yield of the three biomass crops.

*Switch-grass*

The switch-grass field at Shobdon (SG) was characterized as a weed infested field, mainly grass and some broad leaved weeds. In 2002, ground cover of the crop was 14% compared to 57% for the weeds. Also in 2003, ground cover of the switch-grass crop was 27%, compared to 85% by the weeds (Table 3).

Switch-grass crop growth and development early in the growing season was very slow, and was a weak competitor against weeds. As a result, the crop was dominated by general grass and broad-leaved weeds (see section Ground Flora for more detail). For example in 2003, by the end of June, switch-grass plants reached only 20 cm in height whilst the grass weeds were three times taller and covered 80% of the ground. Switch-grass biomass dry matter yield was 262 g $m^{-2}$ in 2002 and 506 g $m^{-2}$ in 2003, compared to weed biomass yield of 394 and 588 g $m^{-2}$ respectively.

Due to its poor growth and weed infestation problems, the switch-grass field was ploughed up and planted with Miscanthus in the spring of 2004. For this reason, data from the switch-grass site are not included in the rest of the results and discussion section of this report, but are included in the appendix tables.

*Field margins*

Field margins comprised of naturally regenerated grass and broad leaved plants (see section Ground Flora section for details) with ground cover ranging from 103 to 175% (mean, 120%). The size of the field margins varied within the same site as well as between sites: some were of 1 m width and some were of 3 m or 6 m width conservation headlands. Four of the study sites had at least one side of their farm a field margin of 3 m or 6 m wide conservation headland.

Table 3. Crop and weed characteristics at the end of September for five of the biomass crop sites in (a) 2002, (b) 2003 and (c) 2004.
M = Miscanthus; RCG = Reed canary-grass; SG = Switch-grass; DM = dry matter

(a) 2002

| | M site 1 | M site 2 | RCG site 1 | RCG site 2 | SG |
|---|---|---|---|---|---|
| Crop plant height, cm | 53 | 200 | 60 | 150 | 15 |
| Number of plants $m^{-2}$ | 2 | 4 | - | - | - |
| Number of stems $m^{-2}$ | 5 | 27 | 905 | 627 | 197 |
| Ground cover by the crop, % | 5 | 32 | 100 | 100 | 14 |
| Ground cover by weeds, % | 41 | 96 | 48 | 9 | 57 |
| Crop biomass DM yield, g $m^{-2}$ | 152 | 969 | 939 | 1036 | 262 |
| Weed biomass DM yield, g $m^{-2}$ | 160 | 794 | 144 | 23 | 394 |

(b) 2003

| | M site 1 | M site 2 | RCG site 1 | RCG site 2 | SG |
|---|---|---|---|---|---|
| Crop plant height, cm | 170 | 165 | 214 | 150 | 110 |
| Number of plants $m^{-2}$ | 2 | 16 | - | - | - |
| Number of stems $m^{-2}$ | 18 | 86 | 976 | 582 | 221 |
| Ground cover by the crop, % | 22 | 68 | 100 | 100 | 27 |
| Ground cover by weeds, % | 61 | 48 | 5 | 5 | 85 |
| Crop biomass DM yield, g $m^{-2}$ | 980 | 1328 | 2228 | 1031 | 506 |
| Weed biomass DM yield, g $m^{-2}$ | 129 | 397 | 15 | 13 | 588 |

(c) 2004

| | M site 1 | M site 2 | RCG site 1 | RCG site 2 | SG |
|---|---|---|---|---|---|
| Crop plant height, cm | 97 | 225 | 215 | 205 | - |
| Number of plants $m^{-2}$ | 2 | 9 | - | - | - |
| Number of stems $m^{-2}$ | 10 | 64 | 488 | 652 | - |
| Ground cover by the crop, % | 6 | 63 | 100 | 100 | - |
| Ground cover by weeds, % | 69 | 77 | 1 | 5 | - |
| Crop biomass DM yield, g $m^{-2}$ | 189 | 1914 | 1540 | 1107 | - |
| Weed biomass DM yield, g $m^{-2}$ | 379 | 582 | 6 | 9 | - |

## 3.2. PESTS AND PLANT DISEASES

Visual inspection of the plants on a monthly basis for leaf eaters and splitting of stems showed that there was no major threat of pests (leaf miners or stem borers) and diseases affecting the Miscanthus, reed canary-grass or switch-grass during the crops' active growth stage.

However, the native reed canary-grass planted in 2000 at Stoke Prior (RCG site 2) was infested by green peach aphids (*Myzus persicae*), in early September 2002 and mid-August 2003. Around 15 to 20% of the crop was affected by the middle of October 2002; but only 5% of the crop in 2003 shortly before the crop was desiccated to aid harvesting. The was no effect of the aphids on the biomass yield of the crop since the infestation started well after crop maturity, and when the crop's leaves were beginning to dry out and senesce. There was no sign of any barley yellow dwarf virus (BYDV) disease as a result of the aphid presence within the crop plants.

A powdery mildew (*Erysiphe* spp.) was also observed on an oak tree and couch-grass within the reed canary-grass fields at Shobdon (RCG site 1) in early September 2002. However, weekly check of the reed canary-grass has confirmed that the fungal disease was not transferred to the main crop. The couch-grass contracted powdery mildew just before dying off towards the end of its annual season.

## 3.3. GROUND FLORA

A list of the weed flora in the biomass crop fields, surrounding field margin and adjacent arable crop fields is presented in Appendix 2. Forty eight species of plants were recorded from the field margins; 25 weed species recorded from the perennial biomass grass crop fields; and 9 species from arable crop fields. In terms of greater weed cover and diversity of weed species within the crop fields, the order was Miscanthus > reed canary-grass > cereals/break crops (Tables 4 &5; Appendix 2). The corresponding $H'$ diversity index values were 1.57, 0.53 and 0.07 respectively (Table 5).

Dominant plant species, especially the broad leaved weeds, within the biomass grass crops differed between crop fields. The most dominant plant species in Miscanthus crop fields were, in decreasing order of percentage ground cover: couch grass (*Elymus repens*), annual meadow grass (*Poa annua*), drooping brome (*Bromus tectorum*), cleavers (*Galium aparine*), field pansy (*Viola arvensis*), creeping thistle (*Cirsium arvense*), common fumatory (*Fumaria officinalis*), black bindweed (*Fallopia convolvulus*), groundsel (*Senecio vulgaris*), speedwells (*Veronica* spp.) and brown bent (*Agrostis canina*). Whereas, the most dominant plant species in reed canary-grass crop fields were: common hemp nettle (*Galeopsis tetrahit*), hedge bindweed (*Calystegia sepium*), charlock (*Sinapis arvensis* ), many-seeded goosefoot (*Chenopodium polyspermum*), good King Henry goosefoot (*Chenopodium bonus-henricus*), creeping buttercup (*Ranunculus repens*), couch grass (*Elymus repens*), Yorkshire fog (*Holcus lanatus*) and brown bent (*Agrostis canina*). The occurrence of broad leaved weeds in reed canary-grass field was restricted to the establishment year; thereafter, the few

weeds that existed included grass weeds such as annual meadow grass and brown bent. In the first year of planting, reed canary-grass site 1 recorded a 48% weed cover, but this declined to 5% in year two and 1% in year three, and was comparable to that of arable crops in the surrounding areas.

Dominant plants in the field margins were false oat-grass (*Arrhenatherum elatius*), brown bent, cocksfoot (*Dactylus glomerata*), couch grass, drooping brome, creeping bent *(Agrostis stolonifera)*, Yorkshire fog, stinging nettles (*Urtica dioica)*, hogweed *(Heracleum sphondylium)*, creeping thistles, hedge bindweed, cleavers and rough chervil *(Chaerophyllum temulentum*).

Adjacent arable crop fields included mainly winter wheat and to a lesser extent winter oilseed rape, spring oats, spring barley and spring beans. Weed ground cover in each of the arable crops was between 0.7 and 1.6%, which comprised mainly of annual meadow grass, brown bent, creeping thistle, field pansy and common field speedwell (*Veronica persica).*

There was no significant difference in weed cover and number of weed species in years 2002, 2003 and 2004; therefore, only the means of the three years data are presented in Tables 4 & 5. Miscanthus did not achieve its maximum crop canopy within the study period; while reed canary grass consistently achieved its maximum ground cover right from the establishment year. Moreover, both Miscanthus fields were subjected to mechanical soil disturbance during rhizome lifting, and there was no continuity in the age of the crop stand as their life cycle was interrupted. Weed cover was three times more ($P = 0.008$), number of weed species 31% more ($P = 0.002$) and $H'$ diversity index 2.5 times more ($P = 0.019$) within Miscanthus fields than reed canary-grass or arable crop fields (Tables 4 & 5). Mean ground flora cover ($P = 0.0001$), mean number of species ($P = 0.0001$) and mean $H'$ diversity index ($P = 0.0001$) was significantly more within field margin than within cropped area of Miscanthus or reed canary-grass or adjacent arable fields (Tables 4 & 5).

Table 4. Percentage weed cover in Miscanthus and reed canary-grass fields, surrounding field margins and adjacent arable crop fields. Each value is the mean of three years; and values in parenthesis are $\sqrt{x+1}$ transformed data.
LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | |
|---|---|---|
| Land-use | Miscanthus | Reed canary-grass |
| Biomass cropped areas | 71.1 (8.4) | 21.2 (4.2) |
| Field margins | 138.9 (11.8) | 137.5 (11.7) |
| Adjacent arable cropped areas | 1.6 (1.5) | 0.7 (1.3) |
| LSD ($P$ = 0.05, d.f. 17) | (1.68) | |

Table 5. Diversity of weed species in Miscanthus and reed canary-grass fields, surrounding field margins and adjacent arable crop fields.
Diversity indices: $S$ = number of species; $H'$ = Shannon-Wiener index of diversity.
Each value is the mean of three years.
LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | | |
|---|---|---|---|---|
| Land-use | Miscanthus | | Reed canary-grass | |
| | *S* | *[H′]* | *S* | *[ H′]* |
| Biomass cropped areas | 14.0 | [1.37] | 7.7 | [0.53] |
| Field margins | 20.1 | [2.85] | 15.3 | [2.36] |
| Adjacent arable cropped areas | 2.3 | [0.07] | 1.7 | [0.04] |
| LSD ($P$ = 0.05, d.f. 17) | 4.79 | [0.385] | | |

## 3.4. GROUND BEETLES

On average, more than 83% of the total beetles caught using pitfall traps were Carabidae (carabid beetles); more than 10% were Staphylinidae (rove beetles), and the rest consisted of Silphidae (burying beetles), Curculionidae, Elateridae (Click beetles) and Chrysomelidae (leaf beetles), Scarabaeidae, Coccinellidae (lady bird beetles) and Cantharidae. The majority of the carabid beetles were *Pterostichus* spp. (with 63%), followed by *Amara* spp. (11%) and *Harpalus rufipes* (11%) (Appendix 3). The total number of catches was, on average, greater for the Miscanthus fields (61 individuals) than the reed canary-grass fields (50 individuals). It is possible that beetle activity and hence capture rate in pitfall traps could be hindered by the denser reed canary-grass vegetation.

Carabids were 28% more abundant ($P = 0.008$) within the Miscanthus fields compared to the reed canary-grass (Table 6). Carabid abundance also varied significantly ($P = 0.003$) between years: there were more than twice or four times more carabids in 2002 than in 2004 or 2003 respectively (Table 6). The number of individual carabid beetles caught was not influenced by the proximity of field margins or the distance from the edge of the crop. Similar numbers of beetles were caught in the middle of the biomass crop fields, at 20 m from the edge and at the edge of the crop fields.

No significant difference was observed in the mean number of carabid species collected in the Miscanthus or reed canary-grass fields. However, Miscanthus fields scored significantly more ($P = 0.02$) $H'$ diversity index than the reed canary-grass fields (Table 7). Diversity indices were significantly greater ($P = 0.001$ for number of species, and $P = 0.03$ for $H'$ index of diversity) in the cropped areas of the biomass crops than in the field margins.

Table 6. Mean number of carabids (per 10 traps) caught within Miscanthus and reed canary-grass fields, and surrounding field margins. Each value is the mean of two sampling dates.
Values in parenthesis are $\sqrt{x+1}$ transformed data.
LSD = least significant difference; and d.f. = degrees of freedom

| Year | Cropped areas | | Field Margins | | Mean |
|---|---|---|---|---|---|
| | Miscanthus | Reed canary-grass | Miscanthus | Reed canary-grass | |
| 2002 | 103.1 (10.2) | 84.2 (9.2) | 114.3 (10.7) | 19.3 (4.5) | 80.2 (8.7) |
| 2003 | 23.0 (4.9) | 26.6 (5.3) | 23.5 (4.9) | 7.0 (2.8) | 20.0 (4.5) |
| 2004 | 38.1 (6.3) | 19.4 (4.5) | 55.3 (7.5) | 9.8 (3.3) | 30.7 (5.4) |
| Mean | 54.7 (7.1) | 43.4 (6.3) | 64.4 (7.7) | 12.0 (3.5) | |

LSD ($P$ = 0.05, d.f. 35) for comparing land use means = 1.69; year means = 2.08; and any individual values = 4.16

Table 7. Diversity of carabids in Miscanthus and reed canary-grass fields, surrounding field margins and adjacent arable crop fields.
Diversity indices: $S$ = number of species; $H'$ = Shannon-Wiener index of diversity.
Each value is the mean of two sampling dates.
LSD = least significant difference; and d.f. = degrees of freedom

| Land-use | Crop species | | | | Mean | |
|---|---|---|---|---|---|---|
| | Miscanthus | | Reed canary-grass | | | |
| | *S* | *[H′]* | *S* | *[H′]* | *S* | *[H′]* |
| Biomass cropped areas | 6.6 | [1.18] | 6.3 | [0.92] | 6.5 | [1.05] |
| Field margins | 3.4 | [0.94] | 3.4 | [0.77] | 3.4 | [0.85] |
| Mean | 5.0 | [1.06] | 4.9 | [0.84] | | |

LSD ($P$ = 0.05, d.f. 35) for comparing crop species means = 1.27 [0.249]; land-use means = 1.27 [0.176]; and any individual values = 2.54 [0.176]

## 3.5. BIRDS

A total of 37 species of birds during the breeding season and 35 species of over-wintering birds were recorded in the study sites (Appendix 4). Most of the bird species were found more abundantly within the hedges than in crop fields, with the exception of skylarks (*Alauda arvensis*), lapwings (*Vanellus vanellus*) and meadow pipits (*Anthus pratensis*). Bird use of the crop fields was greater in the Miscanthus fields compared to the reed canary-grass. This was due to not only the presence of diverse weeds within the crop fields but also the presence of bare ground patches. Skylarks, meadow pipits and lapwings were found only or predominantly within the Miscanthus fields.

The most common species using the biomass crop fields during the breeding season include goldfinches (*Carduelis carduelis*), skylarks, stock doves (*Colomba oenas*) and lapwings. During non-breeding season, the most common species using the biomass crop fields were linnets (*Acanthis cannabina*), meadow pipits (*Anthus pratensis*), skylarks, grey partridges (*Perdix perdix*) and pheasants (*Phasianus colchicus*) (Appendix 4).

Skylarks, grey partridges and lapwings were using the Miscanthus fields for breeding. Grey partridges and pheasants were using the biomass crop fields for breeding as well as for cover during the winter. Wrens (*Troglodytes troglodytes*) and linnets (*Acanthis cannabina*) were also observed to forage the seed heads of the reed canary-grass in winter.

*Total number of birds and species diversity*

The effect of crop species or land-use on total number of birds was not significant but there was a significant ($P$ = 0.005) crop species x land-use interaction (Table 8). The number of birds in the cropped areas of Miscanthus was 71% more than those in the surrounding field margins; whereas, the number of birds in the cropped areas of reed canary-grass was nine times less than those in the surrounding field margins. The greater number of birds in the cropped areas of Miscanthus was mainly due to the greater number of open ground birds (such as skylark, meadow pipit, lapwing, and crows) and farmland seed eaters (such as chaffinch, goldfinch and linnet). The number of birds using the Miscanthus fields was four times more than those using reed canary-grass fields; whereas the number of birds using the field margin around the Miscanthus was three times less than those using field margins around reed canary-grass fields. The number of birds using the field margins around the Miscanthus was less than that of reed canary-grass's field margins mainly because one of the Miscanthus fields (site 1) had no hedgerow on two sides, and the two sides with hedgerows were at least 15 m away.

Land-use significantly affected the diversity of bird species recorded: there was twice as much number of species ($P$ = 0.0002) and 1.8 times more $H'$ diversity index ($P$ = 0.001) in the field margins than in the cropped areas (Table 9). The main effect of crop species on diversity of birds was not significant (with $P$ = 0.072 for number of species and $P$ = 0.052 for $H'$ diversity index); but there was a significant crop species x land-use

interaction for both number of species ($P$ = 0.007) and $H'$ diversity index ($P$ = 0.017) (Table 9). Miscanthus cropped areas had a significantly greater diversity of birds (S and $H'$) than reed canary-grass cropped areas; whereas the diversity of birds was similar in the field margins surrounding the Miscanthus and the reed canary-grass fields. The diversity of birds was greater in the field margins compared to the cropped areas of both Miscanthus and reed canary-grass fields.

Table 8. Mean number of birds (sightings per visit per ha, during breeding season) in Miscanthus and reed canary-grass fields, and surrounding field margins.
Each value is the mean of nine sightings and three years; and values in parenthesis are $\sqrt{x+1}$ transformed data.
LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 9.6 (3.2) | 2.2 (1.8) | 5.9 (2.8) |
| Field margins | 5.6 (1.7) | 20.9 (4.4) | 13.2 (3.1) |
| Mean | 7.6 (2.5) | 11.6 (3.4) | |

LSD ($P$ = 0.05, d.f. 11) for comparing crop species means = 1.06; land-use means = 1.06; and any individual values = 1.49

Table 9. Diversity of birds (during breeding season) in Miscanthus and reed canary-grass fields, and surrounding field margins.
Diversity indices: $S$ = number of species; $H'$ = Shannon-Wiener index of diversity.
Each value is the mean of nine sightings and three years. LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | | | Mean | |
|---|---|---|---|---|---|---|
| Land-use | Miscanthus | | Reed canary-grass | | | |
| | $S$ | $[H']$ | $S$ | $[H']$ | $S$ | $[H']$ |
| Biomass cropped areas | 10.3 | [1.81] | 3.0 | [0.96] | 6.7 | [1.38] |
| Field margins | 13.3 | [2.38] | 15.2 | [2.49] | 14.3 | [2.43] |
| Mean | 11.8 | [2.09] | 9.1 | [1.72] | | |

LSD ($P$ = 0.05, d.f. 11) for comparing crop species means = 3.03 [0.375]; land-use means = 3.03 [0.375]; and any individual values = 4.29 [0.530]

## 3.6. SMALL-MAMMALS

Six species of small-mammals were caught from the biomass crop fields (Appendix 5). The most dominant species were wood mice (*Apodemus sylvaticus*); followed by field voles (*Microtus agrestis*). Less dominant species included yellow-necked mice (*Apodemus flavicollis*), common shrews (*Sorex araneus*), pygmy shrews (*Sorex minutus*) and bank voles (*Clethrionomys glareolus*). Yellow-necked mice were predominantly found in the field margins. The single most dominant small-mammal species occurring consistently both in cropped areas and in the field margins at all sites every year was wood mouse.

Small-mammal abundance did not differ between sampling periods or between crop species; but varied significantly between years ($P = 0.0001$) and between land-use, i.e. cropped areas and field margins ($P = 0.0012$) (Table 10). There were 62% more small-mammals in the field margins compared to the cropped areas of biomass crops. The number of small-mammals caught in 2002 was more than twice as much as in 2003 or 2004.

The diversity of small-mammal species (S and $H'$) was similar between sampling dates or between years; but field margins tended to have slightly more diversity than the cropped areas of the biomass crops (Table 11).

Table 10. Total number of small-mammals caught (per night per 100 traps) in Miscanthus and reed canary-grass fields, and surrounding field margins. Each value is the mean of two sampling dates (April and September); and values in parenthesis are $\sqrt{x+1}$ transformed data. LSD = least significant difference; and d.f. = degrees of freedom

| | Land-use | | Mean |
|---|---|---|---|
| Year | Cropped areas | Field margins | |
| 2002 | 11.3 (3.5) | 21.2 (4.6) | 16.3 (4.0) |
| 2003 | 7.4 (2.9) | 7.8 (2.9) | 7.6 (2.9) |
| 2004 | 5.1 (2.5) | 9.3 (3.2) | 7.2 (2.8) |
| Mean | 7.9 (2.9) | 12.8 (3.6) | |

LSD ($P$ = 0.05, d.f. 35) for comparing land-use means = 0.36; year means = 0.44; and any individual values = 0.87

Table 11. Diversity of small-mammal species in Miscanthus and reed canary-grass fields, and surrounding field margins.
Diversity indices: $S$ = number of species; $H'$ = Shannon-Wiener index of diversity. Each value is the mean of two sampling dates (April and September). LSD = least significant difference; and d.f. = degrees of freedom

| | Land-use | | | | Mean | |
|---|---|---|---|---|---|---|
| Year | Cropped areas | | Field margins | | | |
| | *S* | *[H′]* | *S* | *[H′]* | *S* | *[H′]* |
| 2002 | 2.8 | [0.74] | 3.6 | [0.76] | 3.2 | [0.75] |
| 2003 | 2.3 | [0.70] | 2.9 | [0.71] | 2.6 | [0.70] |
| 2004 | 2.1 | [0.67] | 3.1 | [0.77] | 2.6 | [0.72] |
| Mean | 2.4 | [0.70] | 3.2 | [0.73] | | |

LSD ($P$ = 0.05, d.f. 35) for comparing land-use means = 0.87 [0.171]; year means = 1.06 [0.209]; and any individual values = 2.13 [0.418]

## 3.7. BUTTERFLIES

A total of 15 butterfly species were recorded in the biomass grass fields and surrounding field margins during the study period (Appendix 6). The most common and dominant species within Miscanthus crop fields were small white (*Pieris rapae*) and small tortoise shell (*Aglais urticae*); within reed canary-grass fields, they were small white, meadow brown (*Maniola jurtina*) and large skipper (*Ochlodes venatus*). Small white, meadow brown, hedge brown/gate keeper (*Pyronia tithonus*) and small tortoise shell (*Aglais urticae*) were the most abundant species in the field margins. Less common butterfly species included: red admiral (*Vanessa atalanta*), peacock (*Inachis io*), green-veined white (*Pieris napi*), comma (*Polygonia c-album*), painted lady (*Cynthia cardui*), ringlet (*Aphantopus hyperantus*), speckled wood (*Pararge aegeria*), small copper (*Lycaena phlaeas*) and orange tip (*Anthocharis cardamines*).

Butterfly abundance was two-folds more ($P = 0.021$) in Miscanthus than in reed canary-grass fields (Table 12). Butterfly abundance also differed significantly ($P = 0.004$) between land-use: there were three times more butterflies in the field margins than in the biomass cropped area (Table 12). Butterfly abundance did not differ between years.

The diversity of butterfly species (S and $H'$) was not significantly different between crop species, between land-use or between years (Table 13); although there was a tendency for slightly more diversity of species within the Miscanthus than within the reed canary-grass fields, and also a slightly more diversity in the field margins than in the cropped areas.

Table 12. Butterfly abundance (number of individuals per sighting per 100m section) in Miscanthus and reed canary-grass fields, and surrounding field margins.
Each value is the mean of three years; and values in parenthesis are $\sqrt{x+1}$ transformed data.
LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 5.5 (2.5) | 2.3 (1.8) | 3.9 (2.2) |
| Field margins | 17.1 (4.1) | 8.3 (2.9) | 12.7 (3.5) |
| Mean | 11.3 (3.3) | 5.3 (2.3) | |

LSD ($P$ = 0.05, d.f. 11) for comparing crop species means = 0.82; land-use means = 0.82; and any individual values = 1.16

Table 13. Diversity of butterfly species in Miscanthus and reed canary-grass fields, and surrounding field margins.
Diversity indices: $S$ = number of species; $H'$ = Shannon-Wiener index of diversity.
Each value is the mean of three years.
LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | | | Mean | |
|---|---|---|---|---|---|---|
| Land-use | Miscanthus | | Reed canary-grass | | | |
| | *S* | *[H′]* | *S* | *[H′]* | *S* | *[H′]* |
| Biomass cropped areas | 4.3 | [1.07] | 3.5 | [0.97] | 3.9 | [1.02] |
| Field margins | 6.1 | [1.31] | 5.0 | [1.18] | 5.6 | [1.24] |
| Mean | 5.3 | [1.19] | 4.3 | [1.07] | | |

LSD ($P$ = 0.05, d.f. 11) for comparing crop species means = 2.08 [0.510]; land-use means = 2.08 [0.510]; and any individual values = 2.95 [0.719]

## 3.8. BUMBLE BEES

Four species of bumble bees were recorded from all sites of the biomass crop fields and surrounding field margins (Appendix 7). Cropped areas as well as field margins of Miscanthus were dominated by the white/buff tailed bumble bees (*Bombus lucorum/terrestris*) and red tailed bumble bee (*Bombus lapidarius*). Field margins of reed canary-grass fields were dominated by common carder bee (*Bombus pascuorum*) and white/buff tailed bumble bees. The least common species recorded was the early bumble bee (*Bombus pratorum*).

No bumble bees were recorded from reed canary-grass cropped area, while Miscanthus recorded more than 10 individuals per 100 m transect of cropped areas (Table 14). The field margins recorded on average five times more bumble bee abundance than the cropped areas. Moreover, the field margins surrounding Miscanthus recorded similar abundance as that surrounding the reed canary-grass. Bumble bees were surveyed only in year 2004, and ANOVA was not carried out due to the small number of samples.

The number of bumble bee species observed in the cropped areas (4.0 species) was similar to that in the field margins surrounding Miscanthus (3.8 species) or reed canary-grass (3.8 species).

Table 14. Bumble bee abundance (number of individuals per sighting per 100m section) in Miscanthus and reed canary-grass fields, and surrounding field margins.
Each value is the mean of two sampling dates.

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 10.2 | 0.0 | 5.1 |
| Field margins | 26.7 | 26.1 | 26.4 |
| Mean | 18.4 | 13.1 | |

## 3.9. HOVERFLIES

A total of 10 species of hoverflies were recorded from all biomass crop sites (Appendix 8). The most dominant and commonly occurring hoverfly species in both sites of the cropped area of Miscanthus were long hoverfly (*Sphaerophora scripta*) and dwarf dronefly (*Eristalis arbustorum*). Field margins of Miscanthus fields were dominated by long hoverfly and lunar hoverfly (*Eupeodes luniger*); and field margins of reed canary-grass fields were dominated by marmalade hoverfly (*Episyrphus balteatus*) and long hoverfly. Less dominant species recorded were chequered hoverfly (*Melanostoma scalare*), large lunar hoverfly (*Scaeva* spp.), lesser banded hoverfly (*Syrphus vitripennis*), black-tailed hoverfly (*Epistrophe elegans*), gold-belled hoverfly (*Xylota segnis*), and dark hoverfly (*Pipiza noctiluca*).

No hoverflies were recorded from reed canary-grass cropped areas, while 48 individuals were recorded per 100 m transect of Miscanthus cropped areas (Table 15). The Miscanthus cropped areas recorded 65% more hoverfly abundance that the surrounding field margins. The field margins surrounding the Miscanthus recorded similar abundance as that surrounding the reed canary-grass. Hoverflies were surveyed only in year 2004, and ANOVA was not carried out due to the small number of samples.

The number of hoverfly species observed in cropped areas (8.3 species) was similar to that in the field margins of Miscanthus (8.3 species) or reed canary-grass (8.5 species).

Table 15. Hoverfly abundance (number of individuals per sighting per 100m section) in Miscanthus and reed canary-grass fields, and surrounding field margins.
Each value is the mean of two sampling dates.

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 80.0 | 0.0 | 40.0 |
| Field margins | 48.2 | 49.4 | 48.8 |
| Mean | 64.1 | 24.7 | |

## 3.10. ARBOREAL INVERTEBRATES

### Diptera

On average, over 81% of the Diptera recorded within four of the biomass cropped areas consisted of Bibionidae, Phoridae, Sciaridae, Anthomyzidae, Chironomidae and Chloropidae, with these families accounting for 34%, 25%, 7%, 6%, 6% and 4%, respectively. Within the field margins, over 71% of the Diptera consisted of Sciaridae, Anthomyzidae, Chloropidae, Chironomidae, Bibionidae and Lonchopteridae, accounting for 16%, 15%, 12%, 11%, 9% and 7% respectively (Appendix 9). Less dominant families of Diptera within cropped areas as well as within field margins included: Dolichopodidae, Drosophilidae, Opomyzidae, Sepsidae, Cecidomyiidae, Lauxaniidae, Acroceridae, Micropezidae, Calliphoridae, Agromyzidae, Carniidae, Empididae, Tephritidae, Syrphidae, Stratiomyidae, Tipulidae, Scatopsicae and Empididae (Appendix 9).

The interaction between land-use and crop species was significant ($P$ = 0.042) for dipeteran abundance (Table 16). The Miscanthus cropped areas recorded 2.7 times more dipteran abundance than the reed canary-grass cropped areas, but the field margins around Miscanthus recorded 22% less than the field margins around reed canary-grass. The field margins around Miscanthus recorded only 11% more dipteran abundance than the Miscanthus cropped areas, but the field margins around reed canary-grass recorded 3.9 times more than the reed canary-grass cropped areas (Table 16).

Number of dipteran families was greater in the field margins (16 families around Miscanthus and 14 families around reed canary-grass) than in the cropped areas (13 families within Miscanthus and 9 families within reed canary-grass).

Table 16. Dipteran abundance (number of individuals per 10 samples) in Miscanthus and reed canary-grass fields, and surrounding field margins. Each value is the mean of three years. LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 44.0 | 16.2 | 30.1 |
| Field margins | 48.7 | 62.7 | 55.7 |
| Mean | 46.4 | 39.5 | |

LSD ($P$ = 0.05, d.f. 11) for comparing crop species means = 24.99; land-use means = 24.99; and any individual values = 24.98

**Hymenoptera**

Six of the families of Hymeoptera recorded within the biomass crop fields and its surroundings belonged to the sub-order Apocrita. The most dominant family within the crop fields was Pteromalidae accounting for 38%, and Braconidae accounting for 34%. Pteromalidae and Platygasteridae were the most dominant family within the field margins (with 35% and 23%). Other families recorded within the cropped areas and the field margins were Cynipidae, Ichneuminidae and Tiphiidae (Appendix 10).

The interaction between land-use and crop species was significant ($P$ = 0.0002) for hymenopteran abundance (Table 17). The Miscanthus cropped areas recorded 2.1 times more hymenopteran individuals than the reed canary-grass cropped areas, but the field margins around Miscanthus recorded 4% more than the field margins around reed canary-grass. The field margins around Miscanthus recorded 5.2 times more hymenopteran abundance than the Miscanthus cropped areas, but the field margins around reed canary-grass recorded 10.6 times more than the reed canary-grass cropped areas (Table 17).

Number of hymenopteran families was greater in the field margins (6 families around Miscanthus and 5 families around reed canary-grass) than in the cropped areas (4 families within Miscanthus and 3 families within reed canary-grass).

Table 17. Hymenopteran abundance (number of individuals per 10 samples) in Miscanthus and reed canary-grass fields, and surrounding field margins.
Each value is the mean of three years. LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 6.4 | 3.0 | 4.7 |
| Field margins | 33.0 | 31.8 | 32.4 |
| Mean | 19.7 | 17.4 | |

LSD ($P$ = 0.05, d.f. 11) for comparing crop species means = 10.21; land-use means = 10.21; and any individual values = 14.44

**Hemiptera:Heteroptera**

Over 95% of the heteropterans recorded within the cropped areas consisted of Miridae and Anthocoridae accounting for 79% and 16% respectively. Both of these families, Miridae and Anthocoridae, were also the most dominant in the field margins (75% and 22% respectively). Other heteropteran families caught in both the cropped areas and the field margins were Pentatomidae, Berytidae, Acanthosomatidae, Coreidae and Nabidae (Appendix 11).

The effect of crop species and land-use on heteropteran abundance was significant ($P < 0.04$); so was the interaction ($P = 0.0001$) between crop species and land-use (Table 18). The Miscanthus cropped areas recorded 5.2 times more heteropteran individuals than the reed canary-grass cropped areas, but the field margins around Miscanthus recorded only 76% more than the field margins around reed canary-grass. The field margins around Miscanthus recorded only 6.5 times more heteropteran abundance than the Miscanthus cropped areas, but the field margins around reed canary-grass recorded 19 times more than the reed canary-grass cropped areas (Table 18).

Number of heteropteran families was greater in the field margins (4 families around Miscanthus and 3 families around reed canary-grass) than in the cropped areas (3 families within Miscanthus and 2 families within reed canary-grass).

Table 18. Heteropteran abundance (number of individuals per 10 samples) in Miscanthus and reed canary-grass fields, and surrounding field margins. Each value is the mean of three years. LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 23.2 | 4.5 | 13.9 |
| Field margins | 150.5 | 85.6 | 118.1 |
| Mean | 86.9 | 45.1 | |

LSD ($P = 0.05$, d.f. 11) for comparing crop species means = 32.27; land-use means = 32.27; and any individual values = 45.62

**Hemiptera:Homoptera**

Within the cropped areas, homopteran samples were dominated by Aphididae comprising of 97% in four of the biomass crop fields. Aphididae was also one of the dominant families within the field margins recording 49%; along with Cicadellidae (25%) and Cicadellida (21%). Less dominant homopteran families included the Delphacidae, Psyllidae and Cercopidae (Appendix 12).

Neither the main effect of crop species and land-use nor the interaction between them was significant on homopteran abundance. However, the reed canary-grass cropped areas tended to record more homopteran numbers (390 individuals) mainly due to aphid infestation in one of the sites (Table 19, Appendix 12).

Number of homopteran families was similar in the Miscanthus cropped areas and their field margins (4 families); and was slightly more in the field margins of reed canary-grass (5 families) than within its cropped areas (4 families).

Table 19. Homopteran abundance (number of individuals per 10 samples) in Miscanthus and reed canary-grass fields, and surrounding field margins. Each value is the mean of three years. Values in parenthesis are 'log +1' transformed data. LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 11.8 (1.1) | 390.4 (2.6) | 201.1 (2.3) |
| Field margins | 68.6 (1.8) | 188.0 (2.3) | 128.3 (2.1) |
| Mean | 40.2 (1.6) | 289.2 (2.5) | |

LSD ($P$ = 0.05, d.f. 11) for comparing crop species means = 1.21; land-use means = 1.21; and any individual values = 1.71

## Coleoptera

Within the cropped areas, 84% of the arboreal coleopterans recorded consisted of Chrysomelidae (57%), Cantharidae (20%), and Coccinellidae (7%). Within the field margins, 91% of the Coleoptera consisted of Chrysomelidae (47%), Coccinellidae (20%), Curculinidae (14%) and Phalacridae (10%). Less dominant families both within cropped areas and field margins comprised of Elateridae, Staphylinidae, Scarabaeidae and Carabidae (Appendix 13).

The interaction between land-use and crop species was significant ($P$ = 0.0032) for arboreal coleopteran abundance (Table 20). The Miscanthus cropped areas recorded 14 times more number of coleopteran individuals than the reed canary-grass cropped areas, but the field margins around Miscanthus recorded 9% less than the field margins around reed canary-grass. The field margins around Miscanthus recorded only 64% more coleopteran abundance than the Miscanthus cropped areas, but the field margins around reed canary-grass recorded 25 times more than the reed canary-grass cropped areas (Table 20).

Number of coleopteran families was greater in the field margins (7 families around Miscanthus and 8 families around reed canary-grass) than in the cropped areas (6 families within Miscanthus and 4 families within reed canary-grass).

Table 20. Coleopteran abundance (number of individuals per 10 samples) in Miscanthus and reed canary-grass fields, and surrounding field margins. Each value is the mean of three years. LSD = least significant difference; and d.f. = degrees of freedom

| | Crop species | | Mean |
|---|---|---|---|
| Land-use | Miscanthus | Reed canary-grass | |
| Biomass cropped areas | 45.0 | 3.2 | 24.1 |
| Field margins | 73.6 | 81.2 | 77.4 |
| Mean | 59.3 | 42.2 | |

LSD ($P$ = 0.05, d.f. 11) for comparing crop species means = 32.96; land-use means = 32.96; and any individual values = 46.59

## Psocoptera

Within the cropped areas, 100% of the Psocoptera recorded belonged to the Ectopsocidae. Families of the Psocoptera found in the field margins included Ectopsocidae (38%), Lachesillidae (35%) and Psocidae (29%) (Appendix 14).

**Neuroptera**

Families of Neuroptera found in the cropped areas belonged to Hemerobiiddae (34%), Osmylidae (33%) and Sisyridae (33%). In the field margins, Chrysopidae (85%) and Dilaridae (15%) (Appendix 14).

**Collombolla**

Within the cropped areas, 100% of the Collombolla recorded belonged to the Dicrytomidae. Families of the Collombolla found in the field margins included Dicrytomidae (96%) and Sminthuridae (6%) (Appendix 14).

**Thysanoptera**

Families of Thysanoptera found in the cropped areas belonged to Phlaeothripidae (82%) and Thripidae (18%); and within the field margins both Phlaeothripidae and Thripidae contributed 83% and 17% respectively (Appendix 15).

**Orthoptera**

No Orthoptera were recorded using sweep-netting or beating the stems of the biomass grass crops. Families recorded from the field margins included Dicyrtomidae (96%) and Sminthuridae (4%) (Appendix 15).

**Dermaptera**

No Dermaptera were recorded within the cropped areas of the biomass grass crops. A single family belonging to Forficulidae (100%) was recorded from the field margins (Appendix 15).

## 3. Discussion

It is thought that the decline over the last few decades in arable weeds and their associated invertebrates is due to changes in agricultural practices, such as an increase in winter sown cereals, increased frequency of tillage, a reduction in under-sown grass, changes in crop rotations, farm specialisation leading to a loss of mixed farms, and increased mechanization (Moreby and Southway, 1999). The most widespread effects, however, on both the arable flora and fauna, are mainly due to pesticides (Aebischer, 1991). Most winter cereals receive about seven different types of pesticide each year, i.e. two to three herbicides, three fungicides and an insecticide. Low input perennial grass biomass crop fields supported greater flora and fauna, since they were managed with no fertilizers, no insecticides, no fungicides, and minimal use of herbicides targeting only problem weeds once a year in the establishment year and in the second or third year. Likewise, Eppel-Hotz and Marzini (1998) reported a greater ecological value in four year old Miscanthus fields compared to cornfields in Germany. In general, however, there is little substantive literature on the value to biodiversity of the crops we have studied here.

Due to weed control problems combined with its natural initial slow growth early in the season, the switch-grass field scored the greatest weed flora ground cover in its second season, with 85%. Weed biomass and cover in the switch-grass field was substantially greater than the biomass and cover by the switch-grass crop itself. For this reason, the discussion section focuses primarily on Miscanthus and reed canary-grass crops. The Miscanthus field at Shobdon (M site 1) was characterized by low crop plant density (between 5 to 18 stems $m^{-2}$) that contributed to 5% to 22% ground cover. Miscanthus field at Lingen (M site 2) was a relatively high crop density (27 to 86 stems $m^{-2}$) and covered between 32 to 68% of the ground. In contrast, reed canary-grass fields at all sites consisted of tall dense crop (2 m high at physiological maturity stage) covering 100% of the ground with no weeds and no bare ground, except in the establishment year. Similarly, all the arable crops assessed for ground flora were characterised by dense crop stands of 100% ground cover with little weed ground cover.

It is evident that both Miscanthus and switch-grass do not represent a typical mature or well established crop stands, but they do represent the current experience of commercial farms in the UK for establishment years. Our Herefordshire experience suggests that it is possible that, at any one time, a large proportion of the national crop of Miscanthus would be in an early years establishment state if grown to supply the rhizome market therefore our results could have more general applicability than if all crops were grown to maximum biomass yield. The reed canary-grass, however, does represent a well established and mature crop stands. In terms of crop stands, the reed canary-grass in its second or third season is on a par with the adjacent arable crops or a well established crops stands of Miscanthus with 100% canopy cover (e.g. more than five year old crops). The results of the current work do provide a valuable first baseline biodiversity data from commercial biomass grass farms in the UK including a wide-ranging group of organisms (from invertebrates to birds and small-mammals) that could be utilised for further research works.

As the study is a survey rather than an experimental study, differences in terms of the actual biomass crop species can only be looked at on a broad scale using herbicide management information supplied by farmers, agronomic practices of growing the crops such as plant density and row width, age of the crop stands, and quality and size of the surrounding non-crop habitats such as field margins and hedges. These are the factors that were found to influence the biodiversity of the perennial biomass grass crops in the current study.

The results of this study have shown that Miscanthus, reed canary-grass and switch-grass fields were subject to flushes of weeds to a varying extent, and differences between the crop habitats were readily apparent and clearly visible both in the establishment year as well in the following year/s. On average, in terms of richer diversity in weed vegetation, the order was: Miscanthus > reed canary-grass > wheat. In terms of frequency of herbicide application to control non-crop plants, wheat fields received the greatest herbicides followed by Miscanthus, and then reed canary-grass. Miscanthus fields were richer in weed vegetation than reed canary-grass or arable fields. This was attributed to the crop's initial slow growth and development early in the season (characteristic of $C_4$ plants), coupled with the agronomic practice of planting the crop in wide rows and at very low plant density leaving plenty of space for weeds to flourish with little competition for soil nutrient and light resources, as observed during the establishment years (year one to three).

Miscanthus fields were not only richer in weed vegetation but also had greater bare ground patches than reed canary-grass. Percentage weed cover in the two/three year old Miscanthus fields ranged from 48% to 96% compared to 1% to 5% in the two/three year old reed canary-grass fields and 1% to 7% in the arable fields. This indicates that weed cover in the well established reed canary-grass and adjacent arable fields was similar despite differences in herbicide application. Complete weed control was achieved in the established reed canary-grass as a result of rapid canopy cover early in the spring with no herbicide application; whereas in the wheat fields, this was achieved by the use of pre- and post-emergence application of herbicides. Therefore, the greater weed diversity (based on weed cover and number of species) in the reed canary-grass fields compared to the arable crops is mainly due to the weediness of the reed canary-grass fields in the first year of planting. Indeed, comparison between different biomass crops or between biomass crops and arable crops could be made easier if well established and matures stands of all the biomass crops were used in the study. This was not possible in the current study due to limited availability of sites since an interest in the commercial growing of the biomass crops has begun only recently.

Within the biomass crop fields, some of the weed flora species which are potentially important food sources for granivorous birds were: *Cirsium arvense* (creeping thistle), *Capsella bursa-pastoris* (Shepherds' purse), *Chenopodium album* (fathen), *Chenopodium bonus-henricus* (goosefoot), *Senecio vulgaris* (groundsel), *Sinapis arvensis* (charlock), *Polygonum aviculare* (knotgrass), *Stellara media* (chickweed), *Veronica persica* (common field speedwell), *Veronica arvensis* (wall speedwell), *Viola arvensis* (field pansy), *Ranunculus repens* (creeping buttercup) and *Poa annua* (annual

meadow grass). In addition, although the potential value of wild grass seeds as food for birds in the absence of cereal grains is not reported in the literature, wrens and linnets were observed to use the reed canary-grass seed heads in winter for food or forage.

Bird use of the biomass crop fields varied depending on species. There were considerably more skylarks, meadow pipits and lapwings in the Miscanthus than in the reed canary-grass fields, indicating that Miscanthus fields were preferred by those bird species largely because the Miscanthus canopy takes several seasons to close. Miscanthus fields provide not only nesting habitat for ground-nesting species, such as skylarks, grey partridges and lapwings, but also a winter foraging habitat for the wide range of species which exploit the crop fields for invertebrates and seeds as well as for cover. The value of the reed canary-grass fields as a foraging area for seed eating birds in winter was very high, with flocks of linnets and individual wrens observed to forage the seed heads. With the exception of skylarks, lapwings and meadow pipits, most of the bird species were found more abundantly within the hedges than in crop fields indicating the importance of retaining field structure when planting biomass crops.

Vegetation density is reported to be a key factor influencing foraging efficiency and habitat preferences in some ground-feeding birds (Henderson *et al.*, 2000). The number of skylarks using the cropped area of Miscanthus site 2 at Lingen declined with time from late spring to early autumn, as the ease of foraging and ground access declined with an increase in crop height and density of the crop itself. Whereas the number of skylarks in the cropped area of Miscanthus site 1 at Shobdon increased with time, mainly due to the addition of flocks of skylarks in early autumn, suggesting that, until large hectarages of Miscanthus are planted and left undisturbed for several years, the inter-site variation cannot be assessed. Miscanthus site 1 was in its establishment year in two out of the three seasons studied; first in the year it was planted (2002) and second in the year after it was harvested for its rhizomes (2004).

Faunal diversity is generally related to floral diversity (Thomas & Marshal, 1999); therefore, the greatest number of invertebrate families tended to be in the field margins and the most open biomass crop fields. When comparing the two biomass crop fields, the number of invertebrate families belonging to Diptera, Hymenoptera, Heteroptera and arboreal Coleoptera were more abundant and diverse in the most florally diverse habitat of Miscanthus fields. Miscanthus crop itself supported very small invertebrate numbers compared to the native reed canary-grass; but the number of invertebrates found in the weed vegetation within the Miscanthus fields was by far greater than that found within the reed canary-grass fields. More homopterans were found in reed canary-grass fields due to aphid infestation of the reed canary-grass crop, particularly in one of the sites. Number of butterflies in the reed canary-grass site 1 at Shobdon declined from first year of its planting to its second and third year, which was related to the total loss of the weed flora in the field. Indeed the invertebrate fauna might be expected to continue to decline as the crop gets denser and the canopy closes.

Invertebrates are particularly important food sources for birds during the breeding season, especially for independent young (Wilson *et al.*, 1999). The most important invertebrate food taxa in the biomass crop fields were Coleoptera (Curculionidae,

Chrysomelidae, Carabidae, Staphylinidae and Elateridae), Hemiptera (Heteroptera and Homoptera), Diptera, Hymenoptera and Arachnida (especially Araneae). Accessibility of invertebrates to birds, however, may be reduced in the tall, dense swards structures characteristic of reed canary-grass crops and mature, well established Miscanthus crops.

No crop-type specificity was observed by the ground beetles despite the differences in phenology and canopy development of the two biomass crops. The occurrence and abundance of field-inhabiting ground beetles was related to the weediness of the crop fields; more carabids were found in the more weedy Miscanthus fields than in the less weedy reed canary-grass field. This was probably due to a better micro-environmental conditions in the weed layer for reproduction and larval survival as well as from the seed diet provided there for the seed eating adult beetles (such as *Amara* spp. and *Harpalus* spp.) as well as herbivorous invertebrate for predators.

Some of the carabids caught in the biomass crop fields were true predators belonging to the genera *Agonum*, *Bembidion* (partly), *Calathus*, *Carabus*, *Notiophilus* and *Pterostichus* (partly). Predominant plant eaters were mainly species of the genera *Amara* and *Harpalus.* According to Kromp (1999), *Pterostichus melanarius, Harpalus rufipes, Calathus fuscipes*, *Amara plebeja,* some *Notiophilus* spp. and some *Bembidion* spp. also feed on aphids by foraging on the ground.

The total number of butterflies, bumble bees and hoverflies foraging in crop fields was greatest in Miscanthus fields. As observed during field monitoring, this was mainly related to the number of thistles and also other flowering plants such as charlock in the crop field; there were more butterflies, bumble bees and hoverflies in fields with more flowering plants. Data from percentage ground cover by flora also supports this observation. For example, there were between 4% to 7% ground cover by creeping thistles in Miscanthus cropped areas, compared to nil in reed canary-grass cropped areas. Consequently, numbers observed were related more to adult food (nectar) plants than to plants used for breeding e.g. grasses and nettles. Larval searches may have given differing results.

Field margins had consistently higher small-mammal abundance than cropped areas of biomass crops across all sites. This may be due to, in part, the fact that most of the small-mammal species were border habitat specialists occurring mainly close to woodland, hedges and boundaries. They experience only minimal disturbance from farm operations such as land cultivation, agro-chemical spraying and harvesting. Uncultivated border habitats such as hedges provide extensive and undisturbed cover for breeding and protection from predators (Chapman and Ribic, 2002).

There was no particular crop-type preference by the small-mammal species, but rather a preference for good ground cover and little land disturbance, which was provided by both of the biomass crop fields. Reed canary-grass was by its nature a dense crop; and although the crop density for Miscanthus was lower, its weed vegetation cover was generally high (see section 3, Ground flora). Perennial biomass grass crops provide cover from predators at a time when arable fields such as winter wheat become unstable and provide little cover during winter and particularly after harvesting.

More than twice as many small-mammals were captured in 2002 compared with 2003 or 2004. The greatest number of small-mammals caught in 2002 was in line with an explosion of rodent numbers recorded across Britain due to earlier spring and later autumn breeding associated with mild temperatures. According to the National Geographic News website posted on 3rd of June 2003, two billion field voles were born in Britain in 2002, compared to the usual figure of 700 million.

Potentially, arable plants in the field margins and those within the cropped areas of the biomass crops can be used as hosts and food for beneficial insects. Weeds influence the diversity and abundance of plant eating insects and associated natural enemies in crop systems. Certain weeds, such as Umbelliferae, Leguminosae and Compositae, play an important role by harbouring and supporting beneficial arthropods that aid in suppressing pest population (Altieri, 1999). Field margins surrounding Miscanthus and reed canary-grass crop fields recorded high diversity of plant species, provided a habitat for invertebrates and a food resource for small-mammals and birds. The majority of the bird species and small-mammals were found within the field margin. However, some pests detrimental to agricultural crops can also migrate into the crop fields and cause crop damage. No major pests were reported in the current study, apart from aphid infestation in one of the reed canary-grass sites after the crop's physiological maturity.

Miscanthus does not reach maximum canopy cover well until year three or over; thus continued monitoring of its biodiversity is necessary in order to give a complete assessment of its value to wildlife to the farmed landscape. We do not know how the relationship between crop architecture and wildlife changes as the crop ages and the canopy starts to close earlier in successive years coupled with increasing storage/root systems. Based on the experience from the current well established and mature stands of reed canary-grass, we could extrapolated that the biodiversity of Miscanthus crop fields is most likely to decrease as the crop achieves its maximum crop productivity both in its above-ground and below-ground biomass in older crop canopies. Nevertheless, how older Miscanthus crop stands that are managed under low-input agrochemical management systems will compare with arable crops can only be answered after a wide-scale long-term monitoring.

## 5. **Conclusions**

Our findings relate entirely to young crops. This may well be representative of large areas of the national crop if large areas are cultivated for rhizomes. Conversely it illustrates the need to establish long term monitoring sites in Miscanthus crops which are being grown to full maturity, in order to assess the biodiversity implications of older crops and this we would see as a research priority.

The findings from the current project indicate that, with appropriate management strategies, perennial biomass grass crop plantations can provide substantially improved habitat for many forms of native wildlife, due to the low intensity of the agricultural management system and the untreated headlands. Since no fertilisers were applied to biomass grass crop plantations, they may also indirectly improve the biodiversity in streams through reduced nutrient leaching.

Biomass grass fields, which are rich in arable weeds, provide shelter and/or access to food for beetles, butterflies, bumble bees, hoverflies, birds and small-mammals due to the low chemical input to the crops. These sorts of wildlife may be important food sources for predatory mammals and birds such as the barn owl (*Tyto alba*). This study emphasises the value of headlands and hedgerows in maintaining biodiversity which may provide one of the main advantages of this crop to wildlife.

Because perennial rhizomatous grasses require a single initial planting and related tillage; and because the crops are harvested in March and the land is not disturbed by cultivation every year, the fields were used as over-wintering sites for birds, small-mammals and invertebrates suggesting immediate benefits to biodiversity. Even though the weed flora is directly important for providing phytophagous insects used as food by birds, it is the total effect of having increased weeds, i.e. micro-climate, prey, refuges, cover etc. which are important for many groups of wildlife. Weed cover in the Miscanthus fields increased the general invertebrate diversity of many orders, such as the arboreal Coleoptera, Hymenoptera, Diptera, Lepidoptera and Hemiptera; and provided cover for birds and small-mammals. It should be noted that these preliminary conclusions are based on (a) five farm sites and (b) the oldest Miscanthus crop was two years old. Further monitoring is, therefore, recommended to assess biodiversity over longer period until, at least, full canopy cover is achieved by the Miscanthus crop itself.

The switch-grass crop was lost to this study through an inadequate understanding of its husbandry. It is clear that considerable work needs to be undertaken on the requirements of this crop if it is to become a viable energy crop in the UK. Until then work on its effects on biodiversity will not be possible.

Several external constraints were imposed upon this study, one was that we should only study core groups using standard methodologies and the second was that we had no control over our study crops such that when it was economically advantageous to harvest rhizomes of Miscanthus after two or three years our study sites were lost.

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**Appendix 1 (a, b, c, d, e, f, g & h).** Pictures of Miscanthus, reed canary-grass and switch-grass fields.

(a) Miscanthus site 2 at Lingen – a one year old crop stand after rhizome lifting (12th August 2003)

(b) Miscanthus site 2 at Lingen – a two year old crop stand after rhizome lifting (11th October 2004).

(c) Miscanthus site 1 at Shobdon – a two year old crop stand after planting (12th August 2003)

(d) Reed canary-grass site 1 at Shobdon – a one year old crop stand.

(e) Reed canary-grass site 1 at Shobdon – a two year old crop stand (12th August 2003).

(f) Reed canary-grass site 1 at Shobdon – a three year old crop stand (11th October 2004).

(g) Reed canary-grass site 2 at Stoke Prior – a four year old crop stand (12th August 2003).

(h) Switch-grass site at Shobdon – two year old crop stand (not clearly visible) dominated by grass weeds (12th August 2003)

**Appendix 2.** Percentage ground cover for each species of plants within Miscanthus, reed canary-grass and switch-grass fields, their surrounding field margin and adjacent crop (adjac. crop) for (a) 2002, (b) 2003 and (c) 2004. Adjacent crop fields were mostly winter wheat, but also included winter oilseed rape, spring oats, spring barley and spring field beans. Names in bold indicate experimental biomass crop species, and arable crop species in adjacent fields. Species are arranged in descending order based on total counts of the three biomass crop fields.

**(a) 2002**

| Common names | Scientific names | Miscanthus | | | Reed canary-grass | | | Switch-grass | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop |
| DICOTS | | | | | | | | | | |
| Cleavers | *Galium aparine* | 8.6 | 12.4 | 2.3 | 0.0 | 4.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| Bindweed, Hedge | *Calystegia sepium* | 0.0 | 0.0 | 0.0 | 3.7 | 8.1 | 0.0 | 2.5 | 12.8 | 0.0 |
| Nettle, Common (Stinging) | *Urtica dioica* | 0.0 | 7.8 | 0.0 | 0.0 | 9.8 | 0.0 | 0.0 | 7.0 | 0.0 |
| Hogweed | *Heracleum sphondylium* | 0.1 | 0.5 | 0.0 | 0.0 | 3.7 | 0.0 | 0.0 | 16.5 | 0.0 |
| Thistle, Creeping | *Cirsium arvense* | 3.5 | 9.3 | 0.0 | 0.0 | 2.4 | 0.3 | 0.0 | 2.0 | 0.0 |
| Goosefoot, Many Seeded | *Chenopodium polyspermum* | 0.0 | 0.0 | 0.0 | 3.6 | 0.0 | 0.0 | 11.0 | 0.0 | 0.0 |
| Rough Chervil | *Chaerophyllum temulentum* | 0.0 | 12.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Charlock | *Sinapis arvensis* | 0.6 | 1.8 | 0.0 | 3.6 | 0.0 | 0.0 | 6.1 | 0.0 | 0.0 |
| Horsetail | *Equisetum arvense* | 0.0 | 0.1 | 0.0 | 0.0 | 9.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Field Pansy | *Viola arvensis* | 7.2 | 0.6 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Buttercup, Creeping | *Ranunculus repens* | 0.0 | 1.0 | 0.0 | 0.4 | 4.3 | 0.0 | 0.0 | 2.0 | 0.0 |
| Dandelion | *Taraxacum officinale* | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.1 | 0.0 |
| Hemp-Nettle, Common | *Galeopsis tetrahit* | 0.0 | 0.0 | 0.0 | 4.9 | 0.0 | 0.0 | 2.3 | 0.0 | 0.0 |
| Redshank | *Polygonum persicaria* | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | 5.1 | 0.0 | 0.0 |
| Lesser Burdock | *Arctium minus* | 0.0 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Willow Herb, Broad Leaved | *Epilobium montanum* | 0.3 | 3.2 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fumatory, Common | *Fumaria officinalis* | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bindweed, Black | *Fallopia convolvulus* | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Good King Henry | *Chenopodium bonus-henricus* | 0.0 | 0.0 | 0.0 | 2.7 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| Sow-Thistle, Prickly | *Sonchus asper* | 0.0 | 0.2 | 0.0 | 0.7 | 0.0 | 0.0 | 1.7 | 0.0 | 0.0 |
| Fathen | *Chenopodium album* | 0.4 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 |
| Groundsel | *Senecio vulgaris* | 1.7 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Potato | *Solanum tuberosum* | 0.0 | 0.0 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Forget-Me-Not, Field | *Myosotis scorpioides* | 0.0 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**(a) 2002 ….. Appendix 2. continued**

| Common names | Scientific names | Miscanthus | | | Reed canary-grass | | | Switch-grass | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop |
| DICOTS | | | | | | | | | | |
| Thistle, Spear | *Cirsium vulgare* | 0.0 | 1.7 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Woundwort, Hedge | *Stachys sylvatica* | 0.0 | 0.5 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Speedwell, Wall | *Veronica arvensis* | 0.3 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Dock, Curled | *Rumex obtusifolius* | 0.0 | 1.6 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Parsley, Cow | *Anthriscus sylvestris* | 0.0 | 1.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Speedwell, Common Field | *Veronica persica* | 0.1 | 0.0 | 0.5 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mayweed, Scentless | *Tripleurospermum inodorum* | 0.0 | 0.3 | 0.1 | 0.2 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Speedwell, Green Field | *Veronica agrestis* | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Foxglove | *Digitalis purpurea* | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Vetch, Tufted | *Vicia cracca* | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sow-Thistle, Smooth | *Sonchus oleraceus* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 |
| Vetch, Bush | *Vicia sepium* | 0.0 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mayweed, Scented | *Matricaria recutita* | 0.0 | 0.5 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Plantain, Ribwort | *Plantago lanceolata* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 |
| Speedwell, Grey Field | *Veronica polita* | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Willow Herb, Great | *Epilobium hisutum* | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Shepherds Purse | *Capsella bursa-pastoris* | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| Mustard, Hedge | *Sisymbrium officinale* | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| Chickweed, Common | *Stellaria media* | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Hawksbeard, Rough | *Crepis biennis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| Clover, white | *Trifolium repens* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Speedwell, Ivy-Leaved | *Veronica hederifolia* | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Plantain, Greater | *Plantago major* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sow-Thistle, Perennial | *Sonchus arvensis* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**(a) 2002 ….. Appendix 2. continued**

| Common names | Scientific names | Miscanthus | | | Reed canary-grass | | | Switch-grass | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop |
| MONOCOTS | | | | | | | | | | |
| **Wheat** | ***Aesticum sativum*** | 0.1 | 0.0 | 100.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 100.0 |
| **Reed Canary-grass** | ***Phalaris arundinacea*** | 0.0 | 0.0 | 0.0 | 80.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Oat-Grass, False or Tall | *Arrhenatherum elatius* | 0.0 | 10.8 | 0.0 | 0.0 | 37.0 | 0.0 | 0.0 | 25.3 | 0.0 |
| Couch Grass | *Elymus repens* | 23.1 | 4.9 | 0.0 | 1.3 | 1.5 | 0.0 | 21.7 | 4.8 | 0.0 |
| Meadow-Grass, Annual | *Poa annua* | 8.6 | 1.8 | 0.2 | 0.6 | 2.3 | 0.1 | 0.3 | 0.0 | 40.0 |
| Bent, Creeping | *Agrostis stolonifera* | 0.0 | 4.8 | 0.0 | 0.0 | 3.9 | 0.0 | 0.0 | 21.5 | 3.1 |
| Yorkshire Fog | *Holcus lanatus* | 0.0 | 1.5 | 0.1 | 1.2 | 9.6 | 0.0 | 0.0 | 8.5 | 0.0 |
| **Miscanthus** | *Miscanthus **giganteus*** | 18.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Switch grass** | ***Panicum virgatum*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.4 | 0.0 | 0.0 |
| Soft-Grass, Creeping | *Holcus mollis* | 0.0 | 1.0 | 0.0 | 0.0 | 5.4 | 0.0 | 0.0 | 7.0 | 0.0 |
| Cocksfoot | *Dactylus glomerata* | 0.0 | 3.0 | 0.0 | 0.0 | 3.5 | 0.0 | 0.0 | 2.0 | 0.0 |
| Brome, Drooping | *Bromus tectorum* | 4.4 | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Brome, Barren | *Bromus sterilis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.3 | 5.0 |
| Brome, Upright | *Bromus erectus* | 0.0 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rye-Grass, Perennial | *Lolium perenne* | 0.0 | 2.9 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.8 | 0.0 |
| Brome, Soft | *Bromus mollis* | 0.0 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sheep's, Fine Leaved | *Festuca tenuifolia* | 0.0 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Timothy-Grass, Large Leaved | *Phleum pratense* | 0.0 | 0.5 | 0.0 | 0.0 | 2.5 | 0.0 | 0.0 | 0.5 | 0.0 |
| Bent, Common Or Black Top | *Agrostis tenuis* | 0.0 | 0.3 | 0.0 | 0.0 | 2.3 | 0.0 | 0.0 | 1.0 | 0.0 |
| Wild Oat, Spring | *Avena fatua* | 1.2 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bent, Brown | *Agrostis canina* | 0.6 | 2.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rush, Toad | *Juncus bufonius* | 0.0 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Vernal-Grass, Sweet | *Anthoxanthum odoratum* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 |

**(a) 2002 …….. Appendix 2. continued**

| Common names | Scientific names | Miscanthus | | | Reed canary-grass | | | Switch-grass | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop |
| ***Trees/shrubs*** | | | | | | | | | | |
| Bramble (Blackberry) | *Rubus fruticosus* | 0.0 | 0.1 | 0.0 | 0.0 | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Elm, Common | *Ulmus procera* | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| ***Bryophytes*** | | | | | | | | | | |
| Bryophytes | | 0.2 | 0.8 | 0.0 | 7.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total number of species | | 23 | 48 | 9 | 25 | 26 | 6 | 18 | 16 | 4 |
| Total %ground cover | | 87.1 | 121.1 | 105.8 | 115.7 | 120.6 | 100.9 | 70.6 | 118.9 | 148.1 |
| % crop cover | | 18.6 | - | 100 | 80.7 | - | 100 | 14 | - | 100 |
| % weed cover only | | 68.5 | - | 5.8 | 35.0 | - | 0.9 | 56.6 | - | 48.1 |

**(b) 2003**

| Common names | Scientific names | Miscanthus | | | Reed canary-grass | | | Switch-grass | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop |
| DICOTS | | | | | | | | | | |
| **Oilseed rape** | ***Brasica napa*** | 2.0 | 1.5 | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 100.0 |
| **Beans** | ***Phaseolus vulgaris*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 |
| Nettle, Common | *Urtica dioica* | 0.0 | 21.5 | 0.0 | 0.0 | 12.0 | 0.0 | 0.0 | 4.3 | 0.0 |
| Thistle, Creeping | *Cirsium arvense* | 5.4 | 12.3 | 0.0 | 0.0 | 5.5 | 0.5 | 2.3 | 1.0 | 0.0 |
| Shepherds Purse | *Capsella bursa-pastoris* | 0.4 | 19.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cleavers | *Galium aparine* | 0.9 | 11.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Hogweed | *Heracleum sphondylium* | 0.0 | 3.5 | 0.0 | 0.0 | 1.3 | 0.0 | 0.6 | 16.0 | 0.0 |
| Bindweed, Hedge | *Calystegia sepium* | 0.0 | 0.0 | 0.0 | 0.0 | 6.5 | 0.0 | 1.0 | 11.8 | 0.0 |
| Dock, Broad Leaved | *Rumex obtusifolius* | 0.0 | 1.5 | 0.0 | 0.0 | 3.3 | 0.0 | 3.5 | 1.0 | 0.0 |
| Buttercup, Creeping | *Ranunculus repens* | 0.0 | 1.0 | 0.0 | 0.9 | 3.3 | 0.0 | 2.8 | 0.0 | 0.0 |
| Parsley, Cow | *Anthriscus sylvestris* | 0.0 | 0.0 | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 7.0 | 0.0 |
| Crane's-bill, Cut-leaved | *Geranium dissectum* | 0.3 | 0.0 | 0.0 | 0.0 | 2.3 | 0.0 | 0.3 | 5.0 | 0.0 |
| Dandelion | *Taraxacum officinale* | 0.0 | 0.9 | 0.0 | 0.1 | 1.5 | 0.0 | 0.1 | 3.0 | 0.0 |
| Groundsel | *Senecio vulgaris* | 1.6 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Charlock | *Sinapis arvensis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 5.5 | 0.0 |
| Hemp-Nettle, Common | *Galeopsis tetrahit* | 0.0 | 0.0 | 0.0 | 0.5 | 0.3 | 0.0 | 1.2 | 3.0 | 0.0 |
| Speedwell, Wall | *Veronica arvensis* | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Speedwell, Common Field | *Veronica persica* | 1.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sow-Thistle, Prickly | *Sonchus asper* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.8 | 0.0 | 0.0 |
| Fumatory, Common | *Fumaria officinalis* | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Plantain, Greater | *Plantago major* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 |

**(b) 2003 …….. Appendix 2. continued**

| Common names | Scientific names | Miscanthus | | | Reed canary-grass | | | Switch-grass | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop |
| DICOTS | | | | | | | | | | |
| Lesser Burdock | *Arctium minus* | 0.0 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 0.0 |
| Vetch, Bush | *Vicia sepium* | 0.0 | 0.8 | 0.0 | 0.0 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Clover, white | *Trifolium repens* | 0.0 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Knotgrass | *Polygonum aviculare* | 0.0 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Horsetail | *Equisetum arvense* | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rough Chervil | *Chaerophyllum temulentum* | 0.0 | 0.0 | 0.0 | 0.1 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mayweed, Scentless | *Tripleurospermum inodorum* | 0.1 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Woundwort, Hedge | *Stachys sylvatica* | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Good King Henry | *Chenopodium bonus-henricus* | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fathen | *Chenopodium album* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 |
| Chickweed, Common | *Stellaria media* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 |
| Mayweed, Scented | *Matricaria recutita* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 |
| Sow-Thistle, Perennial | *Sonchus arvensis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 |
| Field Pansy | *Viola arvensis* | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Forget-Me-Not, Field | *Myosotis scorpioides* | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Foxglove | *Digitalis purpurea* | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Willow Herb, Broad Leaved | *Epilobium montanum* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| Bindweed, Black | *Fallopia convolvulus* | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Wild carrot | *Daucus carota* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 |
| Thistle, Spear | *Cirsium vulgare* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |

**(b) 2003 ….. Appendix 2. continued**

| Common names | Scientific names | Miscanthus | | | Reed canary-grass | | | Switch-grass | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop | Cropped area | Field margin | Adjac. crop |
| MONOCOTS | | | | | | | | | | |
| **Reed Canary-Grass** | ***Phalaris arundinacea*** | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 5.4 | 0.0 | 0.0 |
| Couch Grass | *Elymus repens* | 25.7 | 21.0 | 0.0 | 0.1 | 1.0 | 0.0 | 17.1 | 2.0 | 0.0 |
| Bent, Brown | *Agrostis canina* | 6.8 | 16.9 | 0.0 | 0.9 | 9.1 | 0.0 | 16.1 | 28.8 | 0.0 |
| Oat-Grass, False or Tall | *Arrhenatherum elatius* | 0.0 | 11.5 | 0.0 | 0.0 | 30.9 | 0.0 | 0.0 | 20.3 | 0.0 |
| **Wheat** | ***Aesticum sativum*** | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Oats** | ***Avena sativa*** | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Miscanthus** | *Miscanthus* ***giganteus*** | 44.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cocksfoot | *Dactylus glomerata* | 0.0 | 5.8 | 0.0 | 0.0 | 23.0 | 0.0 | 0.0 | 15.0 | 0.0 |
| Bent, Creeping | *Agrostis stolonifera* | 0.0 | 0.0 | 0.0 | 0.3 | 17.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Brome, Drooping | *Bromus tectorum* | 4.9 | 1.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 21.5 | 0.0 |
| Tall fescue | *Festuca arundinacea* | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 27.3 | 0.0 | 0.0 |
| Yorkshire Fog | *Holcus lanatus* | 0.0 | 0.0 | 0.0 | 0.6 | 11.0 | 0.0 | 0.0 | 6.0 | 0.0 |
| **Switch grass** | ***Panicum virgatum*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 26.6 | 0.0 | 0.0 |
| Meadow-Grass, Annual | *Poa annua* | 1.4 | 7.3 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sheep's Fescue, Fine Leaved | *Festuca tenuifolia* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.1 | 0.0 | 0.0 |
| Rye-Grass, Perennial | *Lolium perenne* | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| Timothy-Grass, Large Leaved | *Phleum pratense* | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | |
| Bryophytes | *Bryophytes* | 0.0 | 0.0 | 0.0 | 20.0 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 |
| Bramble (Blackberry) | *Rubus fruticosus* | 0.0 | 2.0 | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | | | | |
| Total no of plant species | | 18 | 27 | 4 | 13 | 22 | 3 | 16 | 19 | 1 |
| Total % ground cover | | 99 | 154 | 101 | 125 | 141 | 101 | 117 | 157 | 100 |
| % cover by the crop | | 45 | - | 100 | 100 | - | 100 | 85 | - | 0 |
| % weed cover (excluding bryophytes) | | 55 | - | 1 | 5 | - | 1 | 31 | - | 100 |

**(C) 2004**

| Common names | Scientific names | Miscanthus | | | Reed canary grass | | |
|---|---|---|---|---|---|---|---|
| | | Within crop | Field margin | Adjac. crop | Within crop | Field margin | Adjac. crop |
| DICOTS | | | | | | | |
| Thistle, Creeping | *Cirsium arvensis* | 6.6 | 13.9 | 0.0 | 0.0 | 8.3 | 0.0 |
| Nettle, Common | *Urtica dioica* | 0.1 | 11.0 | 0.0 | 0.0 | 12.8 | 0.0 |
| Bindweed, Hedge | *Calystegia sepium* | 0.0 | 0.0 | 0.0 | 0.0 | 18.1 | 0.0 |
| Cleavers | *Galium aparine* | 1.7 | 4.6 | 0.0 | 0.0 | 1.0 | 0.0 |
| Hogweed | *Heracleum sphondylium* | 0.0 | 2.3 | 0.0 | 0.0 | 5.0 | 0.0 |
| Rough Chervil | *Chaerophyllum temulentum* | 0.0 | 7.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mayweed, Scented | *Matricaria recutita* | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lesser Burdock | *Arctium minus* | 0.0 | 0.0 | 0.0 | 0.0 | 3.3 | 0.0 |
| Dock, Broad Leaved | *Rumex obtusifolius* | 0.0 | 0.3 | 0.0 | 0.0 | 2.5 | 0.0 |
| Thistle, Spear | *Cirsium vulgare* | 0.6 | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 |
| Shepherds Purse | *Capsella bursa-pastoris* | 0.1 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Field Pansy | *Viola arvensis* | 2.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| Groundsel | *Senecio vulgaris* | 0.5 | 1.0 | 0.0 | 0.0 | 1.0 | 0.0 |
| Woundwort, Hedge | *Stachys sylvatica* | 0.0 | 1.0 | 0.0 | 0.0 | 1.0 | 0.0 |
| Forget-Me-Not, Field | *Myosotis scorpioides* | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bindweed, Black | *Fallopia convolvulus* | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bird's foot-trefoil, common | *Lotus Corniculatus* | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mayweed, Scentless | *Tripleurospermum inodorum* | 0.9 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Parsley, Cow | *Anthriscus sylvestris* | 0.0 | 0.3 | 0.0 | 0.0 | 0.5 | 0.0 |
| Speedwell, Common Field | *Veronica persica* | 0.3 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 |
| Oilseed rape | *Brasica napa* | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fumatory, Common | *Fumaria officinalis* | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Horsetail | *Equisetum arvense* | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fathen | *Chenopodium album* | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mustard, Hedge | *Sisymbrium officinale* | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Hemp-Nettle, Common | *Galeopsis tetrahit* | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sow-Thistle, Smooth | *Sonchus oleraceus* | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Chickweed, Common | *Stellaria media* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |

**(C) 2004….. Appendix 2. continued**

| Common names | Scientific names | Miscanthus | | | Reed canary grass | | |
|---|---|---|---|---|---|---|---|
| | | Within crop | Field margin | Adjac. crop | Within crop | Field margin | Adjac. crop |
| MONOCOTS | | | | | | | |
| **Wheat** | ***Aesticum sativum*** | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 100.0 |
| **Reed Canary-Grass** | ***Phalaris arundinacea*** | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| Couch Grass | *Elymus repens* | 38.8 | 38.8 | 0.0 | 0.0 | 7.3 | 0.0 |
| Oat-Grass, False or Tall | *Arrhenatherum elatius* | 0.0 | 12.3 | 0.0 | 0.0 | 38.5 | 0.0 |
| **Miscanthus** | *Miscanthus **giganteus*** | 34.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bent, Brown | *Agrostis canina* | 17.9 | 9.3 | 0.1 | 1.5 | 5.3 | 0.1 |
| Yorkshire Fog | *Holcus lanatus* | 0.0 | 3.3 | 0.0 | 0.1 | 23.0 | 0.0 |
| Cocksfoot | *Dactylus glomerata* | 0.0 | 6.5 | 0.0 | 0.6 | 17.8 | 0.0 |
| Brome, Drooping | *Bromus tectorum* | 6.0 | 6.5 | 0.0 | 0.1 | 2.5 | 0.0 |
| Brome, Meadow | *Bromus commutatus* | 0.0 | 7.8 | 0.0 | 0.1 | 1.8 | 0.0 |
| Annual meadow-Grass | *Poa annua* | 1.2 | 1.0 | 0.2 | 0.6 | 0.0 | 0.1 |
| Wild Oat, Common | *Avena fatua* | 0.1 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| SHRUBS | | | | | | | |
| Bramble (Blackberry) | *Rubus fruticosus* | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total no of plant species | | 21 | 25 | 5 | 8 | 18 | 5 |
| Total % ground cover | | 108 | 117 | 101 | 103 | 112 | 101 |
| % cover by the crop | | 35 | - | 100 | 100 | - | 100 |
| % weed cover | | 73 | - | 1 | 3 | - | 1 |

**Appendix 3.** A list of ground beetles and mean number of catches per 10 traps for Miscanthus, reed canary-grass, and switch-grass fields and their surrounding field margins for (a) 2002, (b) 2003 and (c) 2004.
Each value is mean of two sampling dates (May and July) and three distances from the crop edge (crop edge, 20m from crop edge, and centre of the crop field). Species and families are arranged in descending order based on total counts of the three biomass crop fields.

**(a) 2002**

| Taxonomic group (and species) | Miscanthus | | Reed canary-grass | | Switch-grass | |
|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin |
| Carabidae | | | | | | |
| *Pterostichus* spp. | 75.5 | 93.0 | 57.2 | 17.0 | 88.3 | 22.0 |
| *Harpalus* spp. | 8.8 | 9.8 | 8.8 | 1.0 | 24.2 | 3.0 |
| *Amara* spp. | 1.3 | 1.5 | 9.3 | 0.3 | 0.0 | 0.0 |
| *Trechus* spp. | 4.8 | 4.3 | 0.9 | 0.0 | 3.2 | 1.5 |
| *Loricera pilicornis* | 5.8 | 2.3 | 2.7 | 0.3 | 0.8 | 1.5 |
| *Bembidion* spp. | 4.1 | 1.5 | 1.6 | 0.3 | 0.0 | 0.5 |
| *Carabus* spp. | 1.1 | 1.8 | 0.2 | 0.0 | 1.7 | 4.5 |
| *Agonum* spp. | 0.4 | 0.0 | 1.9 | 0.0 | 0.3 | 0.0 |
| *Clivina fossor* | 0.1 | 0.0 | 1.1 | 0.3 | 0.7 | 0.0 |
| *Calathus* spp. | 0.6 | 0.3 | 0.0 | 0.0 | 0.3 | 0.0 |
| *Stomis pumicatus* | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 1.0 |
| *Olisthopus rotundatus* | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.0 |
| *Cychrus caraboides* | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.5 |
| *Notiophilus substriatus* | 0.1 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| *Asaphidion flavipes* | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| *Patrobus atrorufus* | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| Total carabidae | 103.0 | 114.3 | 84.0 | 19.0 | 120.2 | 34.5 |
| | | | | | | |
| Staphylinidae | 6.9 | 6.0 | 3.1 | 3.5 | 7.0 | 4.0 |
| Siliphidae | 2.5 | 2.3 | 3.6 | 10.5 | 2.8 | 0.5 |
| Elateridae | 0.0 | 0.0 | 1.6 | 2.0 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Curculionidae | 0.0 | 0.0 | 0.4 | 3.0 | 0.0 | 0.0 |
| Scarabaeidae | 0.3 | 1.3 | 0.0 | 0.0 | 0.0 | 1.0 |
| Chrysomelidae | 0.8 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Coccinellidae | 0.3 | 0.3 | 0.1 | 0.0 | 0.0 | 0.5 |
| Cantharidae | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| Catopidae | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total number of catches | 114.0 | 124.0 | 92.9 | 38.0 | 130.0 | 40.5 |

**(b) 2003**

| Taxonomic group (and species) | Miscanthus | | Reed canary-grass | | Switch-grass | |
|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin |
| Carabidae | | | | | | |
| *Pterostichus* spp. | 16.8 | 11.0 | 11.3 | 3.3 | 42.2 | 2.5 |
| *Amara* spp. | 0.3 | 7.3 | 4.8 | 0.8 | 16.5 | 0.5 |
| *Harpalus* spp. | 2.7 | 1.8 | 3.5 | 1.0 | 9.5 | 0.0 |
| *Agonum* spp. | 0.3 | 1.8 | 1.6 | 0.0 | 5.7 | 0.0 |
| *Carabus* spp. | 0.0 | 0.5 | 2.3 | 0.5 | 4.5 | 0.0 |
| *Loricera pilicornis* | 0.2 | 0.0 | 1.1 | 0.3 | 2.8 | 0.5 |
| *Clivina fossor* | 0.2 | 0.0 | 1.4 | 0.3 | 2.0 | 0.0 |
| *Bembidion* spp. | 1.3 | 0.5 | 0.3 | 0.0 | 1.2 | 0.0 |
| *Trechus* spp. | 1.0 | 0.0 | 0.2 | 0.3 | 0.3 | 0.0 |
| *Stomis pumicatus* | 0.0 | 0.0 | 0.2 | 0.8 | 0.7 | 0.5 |
| *Notiophilus substriatus* | 0.3 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Asaphidion flavipes* | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 |
| Total carabidae | 23.0 | 23.5 | 26.6 | 7.0 | 85.5 | 4.0 |
| Staphylinidae | 2.5 | 1.3 | 2.4 | 3.0 | 6.2 | 10.0 |
| Siliphidae | 0.2 | 0.8 | 0.7 | 0.3 | 2.2 | 1.5 |
| Elateridae | 0.1 | 0.5 | 0.0 | 1.0 | 0.3 | 0.0 |
| Curculionidae | 0.2 | 0.3 | 0.0 | 1.8 | 0.0 | 0.0 |
| Coccinellidae | 0.1 | 0.3 | 0.0 | 0.0 | 0.3 | 0.0 |
| Chrysomelidae | 0.3 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 |
| Cantharidae | 0.1 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 |
| Total number of catches | 26.3 | 26.8 | 29.8 | 13.0 | 94.7 | 15.5 |

| Taxonomic group (and species) | Miscanthus | | Reed canary-grass | | Switch-grass | |
|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin |
| Carabidae | | | | | | |
| *Pterostichus* spp. | 29.4 | 35.8 | 8.4 | 4.0 | - | - |
| *Harpalus* spp. | 2.0 | 6.0 | 2.2 | 1.5 | - | - |
| *Amara* spp. | 0.6 | 9.0 | 2.2 | 1.3 | - | - |
| *Trechus* spp. | 3.4 | 0.0 | 0.2 | 0.5 | - | - |
| *Agonum* spp. | 0.3 | 2.5 | 1.8 | 0.0 | - | - |
| *Clivina fossor* | 0.3 | 0.0 | 1.6 | 0.3 | - | - |
| *Loricera pilicornis* | 0.3 | 0.0 | 1.4 | 0.5 | - | - |
| *Carabus* spp. | 0.0 | 0.0 | 1.3 | 1.0 | - | - |
| *Bembidion* spp. | 0.9 | 0.5 | 0.3 | 0.0 | - | - |
| *Calathus* spp. | 0.6 | 0.5 | 0.0 | 0.0 | - | - |
| *Notiophilus substriatus* | 0.3 | 1.0 | 0.0 | 0.0 | - | - |
| *Stomis pumicatus* | 0.0 | 0.0 | 0.1 | 0.8 | - | - |
| Total carabidae | 38.1 | 55.3 | 19.4 | 9.8 | - | - |
| Staphylinidae | 1.6 | 1.0 | 2.6 | 3.3 | - | - |
| Siliphidae | 2.4 | 1.5 | 1.1 | 0.3 | - | - |
| Curculionidae | 0.3 | 0.5 | 0.0 | 2.3 | - | - |
| Elateridae | 0.2 | 0.0 | 0.2 | 1.0 | - | - |
| Chrysomelidae | 0.3 | 0.5 | 0.1 | 0.0 | - | - |
| Coccinellidae | 0.2 | 0.3 | 0.0 | 0.0 | - | - |
| Cantharidae | 0.2 | 0.0 | 0.0 | 0.0 | - | - |
| Total number of catches | 43.3 | 59.0 | 23.3 | 16.5 | - | - |

**Appendix 4.** A list of bird species and their abundance (mean number of individuals per sighting per ha) in each fields of Miscanthus, reed canary-grass and switch-grass for (a) 2002, (b) 2003 and (c) 2004 breeding and non-breeding season. Each value is mean of 9 sightings during breeding season; and mean of 4 sightings in non-breeding season. Species are arranged in descending order based on total counts of the three biomass crop fields.

**(a) 2002 breeding season**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Blue Tit | *Parus caeruleus* | 0.0 | 0.2 | 0.8 | 2.7 | 0.0 | 1.1 | 4.8 |
| Carrion Crow | *Corvus corone* | 0.1 | 0.0 | 0.8 | 0.3 | 0.9 | 2.6 | 4.7 |
| Jackdaw | *Corvus monedula* | 0.0 | 0.0 | 0.0 | 0.3 | 1.8 | 2.4 | 4.5 |
| Rook | *Corvus frugilegus* | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 2.6 | 3.9 |
| Chaffinch | *Fringilla coelebs* | 0.6 | 0.7 | 0.3 | 1.3 | 0.4 | 0.5 | 3.8 |
| Lapwing | *Vanellus vanellus* | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.6 |
| Linnet | *Acanthis cannabina* | 0.3 | 0.7 | 0.0 | 1.5 | 0.0 | 0.5 | 3.0 |
| Yellowhammer | *Emberiza citrinella* | 0.5 | 0.4 | 0.0 | 1.3 | 0.0 | 0.3 | 2.5 |
| Woodpigeon | *Columba palumbus* | 0.0 | 0.1 | 0.4 | 1.3 | 0.0 | 0.5 | 2.4 |
| Blackbird | *Turdus merula* | 0.6 | 0.2 | 0.0 | 0.9 | 0.0 | 0.5 | 2.2 |
| Great Tit | *Parus major* | 0.1 | 0.1 | 0.0 | 1.7 | 0.0 | 0.3 | 2.2 |
| Wren | *Troglodytes troglodytes* | 0.1 | 0.1 | 0.0 | 1.2 | 0.0 | 0.7 | 2.1 |
| Skylark | *Alauda arvensis* | 1.6 | 0.0 | 0.2 | 0.0 | 0.3 | 0.0 | 2.0 |
| Goldfinch | *Carduelis carduelis* | 0.1 | 0.2 | 0.0 | 0.3 | 0.5 | 0.0 | 1.1 |
| Stock Dove | *Columba oenas* | 0.1 | 0.0 | 0.0 | 0.7 | 0.0 | 0.3 | 1.1 |
| Chiffchaff | *Phylloscopus collybita* | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.5 | 1.0 |
| House Sparrow | *Passer domesicus* | 0.1 | 0.1 | 0.0 | 0.8 | 0.0 | 0.0 | 1.0 |
| Robin | *Erithacus rubecula* | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.3 | 0.7 |
| Dunnock | *Prunella modularis* | 0.0 | 0.2 | 0.0 | 0.5 | 0.0 | 0.0 | 0.7 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Magpie | *Pica pica* | 0.0 | 0.1 | 0.0 | 0.4 | 0.0 | 0.0 | 0.5 |
| Pheasants | *Phasianus colchicus* | 0.1 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.5 |
| Buzzard | *Buteo buteo* | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.3 | 0.5 |
| Song Thrush | *Turdus philomelos* | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.3 | 0.4 |
| Mistle Thrush | *Turdus viscivorus* | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.4 |
| Pied/White Wagtail | *Motacilla alba* | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.3 |
| Whitethroat | *Sylvia communis* | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.3 |
| Nuthatch | *Sitta europaea* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 |
| Lesser Whitethroat | *Sylvia curruca* | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| Sedge Warbler | *Acrocephalus schoenobaenus* | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| Fieldfare | *Turdus pilaris* | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Yellow Wagtail | *Motacilla flava* | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| | | | | | | | | |
| Total no of birds | | 8.5 | 4.9 | 3.3 | 18.2 | 5.3 | 13.9 | 54.0 |
| Total no of species | | 16 | 19 | 8 | 19 | 6 | 17 | 31 |

**(a) 2002 non-breeding season**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Fieldfare | *Turdus pilaris* | 0.0 | 1.3 | 0.0 | 12.1 | 0.0 | 0.0 | 13.3 |
| Meadow Pipit | *Anthus pratensis* | 4.3 | 0.1 | 0.8 | 2.1 | 1.1 | 2.5 | 10.9 |
| Chaffinch | *Fringilla coelebs* | 0.7 | 1.2 | 0.0 | 3.7 | 0.0 | 1.3 | 6.9 |
| Long-tailed Tit | *Aegithalos caudatus* | 0.0 | 0.0 | 0.0 | 2.7 | 0.0 | 3.3 | 6.0 |
| Starling | *Sturnus vulgaris* | 0.0 | 0.0 | 0.0 | 5.4 | 0.0 | 0.0 | 5.4 |
| Skylark | *Alauda arvensis* | 4.7 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 5.2 |
| Linnet | *Acanthis cannabina* | 0.0 | 0.3 | 1.4 | 2.5 | 0.0 | 0.9 | 5.1 |
| Blue Tit | *Parus caeruleus* | 0.8 | 0.7 | 0.0 | 2.6 | 0.0 | 0.7 | 4.8 |
| Lapwing | *Vanellus vanellus* | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 |
| Carrion Crow | *Corvus corone* | 1.3 | 0.1 | 0.0 | 1.3 | 0.4 | 0.7 | 3.7 |
| Pheasants | *Phasianus colchicus* | 0.8 | 0.2 | 0.1 | 0.4 | 0.5 | 1.3 | 3.4 |
| Wren | *Troglodytes troglodytes* | 0.0 | 0.3 | 1.0 | 1.1 | 0.0 | 0.9 | 3.3 |
| Blackbird | *Turdus merula* | 0.3 | 0.4 | 0.4 | 1.5 | 0.0 | 0.7 | 3.2 |
| Robin | *Erithacus rubecula* | 0.4 | 0.6 | 0.0 | 0.9 | 0.0 | 1.2 | 3.0 |
| Great Tit | *Parus major* | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 2.4 | 2.8 |
| Grey Partridge | *Perdix perdix* | 0.3 | 0.3 | 0.1 | 1.8 | 0.0 | 0.0 | 2.5 |
| Goldfinch | *Carduelis carduelis* | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 1.8 | 2.3 |
| Woodpigeon | *Columba palumbus* | 0.3 | 0.2 | 0.0 | 0.8 | 0.0 | 0.8 | 2.0 |
| Yellowhammer | *Emberiza citrinella* | 0.0 | 0.3 | 0.0 | 0.7 | 0.0 | 0.5 | 1.5 |
| Jackdaw | *Corvus monedula* | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | 1.2 |
| Whitethroat | *Sylvia communis* | 0.0 | 0.4 | 0.0 | 0.8 | 0.0 | 0.0 | 1.1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Mistle Thrush | *Turdus viscivorus* | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 | 0.3 | 0.9 |
| Buzzard | *Buteo buteo* | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.3 | 0.8 |
| Yellow Wagtail | *Motacilla flava* | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 |
| Blackcap | *Sylvia atricapilla* | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.6 |
| Chiffchaff | *Phylloscopus collybita* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 |
| Rook | *Corvus frugilegus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 |
| Dunnock | *Prunella modularis* | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| House Sparrow | *Passer domesicus* | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Red-legged partridge | *Alectoris rufa* | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.4 |
| Sedge Warbler | *Acrocephalus schoenobaenus* | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.4 |
| Pied/White Wagtail | *Motacilla alba* | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 |
| Greenfinch | *Carduelis chloris* | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| Kestrel | *Falco tinnunculus* | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| | | | | | | | | |
| Total no of birds | | 18.2 | 9.3 | 4.6 | 45.7 | 2.5 | 20.7 | 178.8 |
| Total no of species | | 14 | 22 | 8 | 22 | 4 | 19 | 34 |

**(b) 2003 breeding season**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Fieldfare | *Turdus pilaris* | 0.7 | 0.7 | 0.0 | 10.8 | 0.0 | 1.2 | 13.4 |
| Goldfinch | *Carduelis carduelis* | 4.6 | 0.5 | 0.0 | 1.1 | 0.0 | 0.3 | 6.4 |
| Starling | *Sturnus vulgaris* | 0.1 | 0.0 | 0.0 | 4.6 | 0.0 | 0.0 | 4.7 |
| Chaffinch | *Fringilla coelebs* | 0.0 | 0.7 | 0.4 | 1.3 | 0.0 | 1.3 | 3.8 |
| Linnet | *Acanthis cannabina* | 0.8 | 0.3 | 0.0 | 1.2 | 0.0 | 0.8 | 3.1 |
| Blue Tit | *Parus caeruleus* | 0.0 | 0.6 | 0.0 | 1.4 | 0.0 | 0.9 | 2.9 |
| Woodpigeon | *Columba palumbus* | 0.7 | 0.3 | 0.0 | 1.2 | 0.0 | 0.5 | 2.7 |
| Wren | *Troglodytes troglodytes* | 0.0 | 0.2 | 0.8 | 0.7 | 0.0 | 0.5 | 2.2 |
| Long-tailed Tit | *Aegithalos caudatus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 2.1 |
| Blackbird | *Turdus merula* | 0.2 | 0.4 | 0.4 | 0.7 | 0.0 | 0.3 | 1.9 |
| Robin | *Erithacus rubecula* | 0.0 | 0.3 | 0.0 | 1.2 | 0.0 | 0.3 | 1.9 |
| Pheasants | *Phasianus colchicus* | 0.0 | 0.1 | 0.0 | 0.1 | 0.9 | 0.7 | 1.9 |
| Great Tit | *Parus major* | 0.0 | 0.1 | 0.0 | 1.2 | 0.0 | 0.5 | 1.8 |
| Mistle Thrush | *Turdus viscivorus* | 1.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 1.6 |
| Carrion Crow | *Corvus corone* | 0.3 | 0.4 | 0.0 | 0.3 | 0.0 | 0.6 | 1.6 |
| Yellowhammer | *Emberiza citrinella* | 0.1 | 0.3 | 0.0 | 0.8 | 0.0 | 0.3 | 1.5 |
| Skylark | *Alauda arvensis* | 1.0 | 0.0 | 0.2 | 0.0 | 0.3 | 0.0 | 1.5 |
| Song Thrush | *Turdus philomelos* | 0.0 | 0.1 | 0.0 | 0.5 | 0.5 | 0.3 | 1.4 |
| Sedge Warbler | *Acrocephalus schoenobaenus* | 0.0 | 0.3 | 0.0 | 0.8 | 0.0 | 0.0 | 1.1 |
| Stock Dove | *Columba oenas* | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 |
| Yellow Wagtail | *Motacilla flava* | 0.2 | 0.1 | 0.0 | 0.8 | 0.0 | 0.0 | 1.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lapwing | *Vanellus vanellus* | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 |
| Chiffchaff | *Phylloscopus collybita* | 0.0 | 0.1 | 0.0 | 0.4 | 0.0 | 0.3 | 0.8 |
| Nuthatch | *Sitta europaea* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.7 |
| Dunnock | *Prunella modularis* | 0.0 | 0.3 | 0.0 | 0.4 | 0.0 | 0.0 | 0.7 |
| Whitethroat | *Sylvia communis* | 0.1 | 0.2 | 0.0 | 0.2 | 0.0 | 0.0 | 0.6 |
| Blackcap | *Sylvia atricapilla* | 0.0 | 0.0 | 0.4 | 0.1 | 0.0 | 0.0 | 0.5 |
| Magpie | *Pica pica* | 0.0 | 0.1 | 0.0 | 0.4 | 0.0 | 0.0 | 0.5 |
| Red-legged partridge | *Alectoris rufa* | 0.2 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.4 |
| Jackdaw | *Corvus monedula* | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| Greenfinch | *Carduelis chloris* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.4 |
| Grey Partridge | *Perdix perdix* | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| Buzzard | *Buteo buteo* | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| Meadow Pipit | *Anthus pratensis* | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| Pied/White Wagtail | *Motacilla alba* | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| | | | | | | | | |
| Total no of birds | | 13.0 | 6.9 | 2.4 | 30.4 | 1.7 | 11.9 | 119.1 |
| Total no of species | | 19 | 23 | 6 | 24 | 3 | 19 | 35 |

**(b) 2003 non-breeding season**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Starling | *Sturnus vulgaris* | 0.0 | 0.0 | 0.0 | 15.4 | 0.0 | 0.0 | 15.4 |
| Linnet | *Acanthis cannabina* | 3.1 | 0.4 | 3.2 | 2.9 | 0.0 | 0.0 | 9.5 |
| Goldfinch | *Carduelis carduelis* | 4.4 | 2.4 | 0.0 | 0.3 | 0.0 | 0.0 | 7.1 |
| Chaffinch | *Fringilla coelebs* | 0.1 | 0.7 | 0.8 | 1.6 | 0.0 | 1.3 | 4.5 |
| Robin | *Erithacus rubecula* | 0.0 | 0.2 | 0.0 | 2.2 | 0.0 | 0.5 | 2.9 |
| Pheasants | *Phasianus colchicus* | 0.1 | 0.2 | 0.5 | 0.3 | 1.2 | 0.5 | 2.9 |
| Wren | *Troglodytes troglodytes* | 0.0 | 0.3 | 0.0 | 1.3 | 0.4 | 0.5 | 2.5 |
| Blue Tit | *Parus caeruleus* | 0.0 | 0.4 | 0.0 | 1.3 | 0.0 | 0.5 | 2.2 |
| Long-tailed Tit | *Aegithalos caudatus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 2.0 |
| Meadow Pipit | *Anthus pratensis* | 1.5 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 2.0 |
| Skylark | *Alauda arvensis* | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 |
| Blackbird | *Turdus merula* | 0.0 | 0.2 | 0.0 | 1.5 | 0.0 | 0.0 | 1.6 |
| Grey Partridge | *Perdix perdix* | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| Woodpigeon | *Columba palumbus* | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.4 | 0.7 |
| Kestrel | *Falco tinnunculus* | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.3 | 0.6 |
| Yellowhammer | *Emberiza citrinella* | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Buzzard | *Buteo buteo* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.4 |
| Great Tit | *Parus major* | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.4 |
| Magpie | *Pica pica* | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.4 |
| Red-legged partridge | *Alectoris rufa* | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| Carrion Crow | *Corvus corone* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Pied/White Wagtail | *Motacilla alba* | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Stock Dove | *Columba oenas* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| Dunnock | *Prunella modularis* | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| House Sparrow | *Passer domesicus* | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Yellow Wagtail | *Motacilla flava* | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| | | | | | | | | |
| Total no of birds | | 12.5 | 5.8 | 4.4 | 28.7 | 1.6 | 6.6 | 59.6 |
| Total no of species | | 10 | 12 | 3 | 16 | 2 | 10 | 26 |

**(C) 2004 breeding season**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Goldfinch | *Carduelis carduelis* | 0.7 | 0.5 | 0.0 | 2.3 | - | - | 3.5 |
| Linnet | *Acanthis cannabina* | 0.8 | 0.7 | 0.5 | 1.4 | - | - | 3.4 |
| Lapwing | *Vanellus vanellus* | 2.7 | 0.0 | 0.0 | 0.0 | - | - | 2.7 |
| Chaffinch | *Fringilla coelebs* | 0.3 | 0.7 | 0.0 | 1.2 | - | - | 2.2 |
| Blue Tit | *Parus caeruleus* | 0.0 | 0.3 | 0.0 | 1.5 | - | - | 1.8 |
| Robin | *Erithacus rubecula* | 0.0 | 0.3 | 0.0 | 1.3 | - | - | 1.6 |
| Blackbird | *Turdus merula* | 0.1 | 0.4 | 0.0 | 0.9 | - | - | 1.4 |
| Wren | *Troglodytes troglodytes* | 0.0 | 0.3 | 0.0 | 1.1 | - | - | 1.3 |
| Pheasants | *Phasianus colchicus* | 0.7 | 0.3 | 0.1 | 0.1 | - | - | 1.3 |
| Yellow Wagtail | *Motacilla flava* | 0.2 | 0.0 | 0.0 | 1.0 | - | - | 1.2 |
| Yellowhammer | *Emberiza citrinella* | 0.0 | 0.3 | 0.0 | 0.8 | - | - | 1.1 |
| Skylark | *Alauda arvensis* | 0.8 | 0.0 | 0.3 | 0.0 | - | - | 1.1 |
| Woodpigeon | *Columba palumbus* | 0.1 | 0.1 | 0.0 | 0.8 | - | - | 1.0 |
| Magpie | *Pica pica* | 0.0 | 0.0 | 0.0 | 0.5 | - | - | 0.5 |
| Whitethroat | *Sylvia communis* | 0.0 | 0.2 | 0.0 | 0.2 | - | - | 0.4 |
| Meadow Pipit | *Anthus pratensis* | 0.4 | 0.0 | 0.0 | 0.0 | - | - | 0.4 |
| Dunnock | *Prunella modularis* | 0.0 | 0.2 | 0.0 | 0.3 | - | - | 0.4 |
| Stock Dove | *Columba oenas* | 0.1 | 0.1 | 0.0 | 0.0 | - | - | 0.3 |
| Great Tit | *Parus major* | 0.0 | 0.0 | 0.0 | 0.3 | - | - | 0.3 |
| Long-tailed Tit | *Aegithalos caudatus* | 0.0 | 0.0 | 0.0 | 0.3 | - | - | 0.3 |
| Grey Partridge | *Perdix perdix* | 0.2 | 0.0 | 0.0 | 0.0 | - | - | 0.2 |
| Carrion Crow | *Corvus corone* | 0.2 | 0.0 | 0.0 | 0.0 | - | - | 0.2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sedge Warbler | *Acrocephalus schoenobaenus* | 0.0 | 0.2 | 0.0 | 0.0 | - | - | 0.2 |
| Chiffchaff | *Phylloscopus collybita* | 0.0 | 0.1 | 0.0 | 0.0 | - | - | 0.1 |
| Greenfinch | *Carduelis chloris* | 0.0 | 0.0 | 0.0 | 0.1 | - | - | 0.1 |
| Song Thrush | *Turdus philomelos* | 0.0 | 0.0 | 0.0 | 0.1 | - | - | 0.1 |
| Jackdaw | *Corvus monedula* | 0.0 | 0.1 | 0.0 | 0.0 | - | - | 0.1 |
| Pied/White Wagtail | *Motacilla alba* | 0.1 | 0.0 | 0.0 | 0.0 | - | - | 0.1 |
| | | | | | | | | |
| Total no of birds | | 6.7 | 4.4 | 1.0 | 11.8 | - | - | 23.9 |
| Total no of species | | 14 | 16 | 3 | 18 | - | - | 28 |

**Appendix 5.** Small-mammals species and their abundance (number of individuals per night per 100 traps) in each field of Miscanthus, reed canary-grass and switch-grass for (a) 2002, (b) 2003 and (c) 2004.
Each value is mean of two sampling periods (March and September). Species are arranged in descending order based on total counts of the three biomass crop fields.

**(a) 2002**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Wood mouse | *Apodemus sylvaticus* | 13.2 | 6.8 | 4.9 | 3.6 | 4.9 | 2.1 | 35.4 |
| Field vole | *Microtus agrestis* | 0.3 | 8.3 | 2.1 | 5.2 | 0.0 | 10.4 | 26.4 |
| Yellow-necked mouse | *Apodemus flavicollis* | 0.0 | 7.3 | 0.5 | 1.0 | 0.0 | 0.0 | 8.9 |
| Bank Vole | *Clethrionomys glareolus* | 0.3 | 0.0 | 1.0 | 3.6 | 0.0 | 0.0 | 5.0 |
| Pygmy shrew | *Sorex minutus* | 0.3 | 1.0 | 1.0 | 0.5 | 0.0 | 3.1 | 6.1 |
| Common shrew | *Sorex araneus* | 0.2 | 0.0 | 1.9 | 1.0 | 0.0 | 0.0 | 2.6 |
| Total number of small mammals | | 14.4 | 23.4 | 11.5 | 15.1 | 4.9 | 15.6 | 84.9 |
| Total number of species | | 5 | 4 | 6 | 6 | 1 | 3 | 6 |

**(b) 2003**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Wood mouse | *Apodemus sylvaticus* | 4.2 | 8.3 | 2.8 | 4.2 | 1.0 | 0.0 | 20.5 |
| Common shrew | *Sorex araneus* | 0.0 | 0.0 | 1.2 | 2.1 | 2.8 | 4.2 | 10.2 |
| Field vole | *Microtus agrestis* | 0.2 | 0.0 | 1.2 | 2.1 | 0.3 | 4.2 | 8.0 |
| Pygmy shrew | *Sorex minutus* | 0.0 | 0.0 | 0.9 | 1.0 | 1.0 | 2.1 | 5.0 |
| Bank Vole | *Clethrionomys glareolus* | 0.0 | 0.0 | 0.9 | 0.5 | 0.0 | 1.0 | 2.4 |
| Yellow-necked mouse | *Apodemus flavicollis* | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| Total number of individuals | | 4.3 | 9.4 | 6.9 | 9.9 | 5.2 | 11.4 | 47.1 |
| Total number of species | | 2 | 2 | 5 | 5 | 4 | 4 | 6 |

**(c) 2004**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Wood mouse | *Apodemus sylvaticus* | 4.2 | 7.3 | 2.4 | 4.7 | - | - | 18.5 |
| Field vole | *Microtus agrestis* | 0.0 | 1.0 | 0.0 | 0.0 | - | - | 1.0 |
| Common shrew | *Sorex araneus* | 0.0 | 0.0 | 0.7 | 0.5 | - | - | 1.2 |
| Pygmy shrew | *Sorex minutus* | 0.3 | 0.5 | 1.2 | 2.1 | - | - | 4.2 |
| Bank Vole | *Clethrionomys glareolus* | 0.2 | 0.0 | 0.7 | 1.6 | - | - | 2.4 |
| Yellow-necked mouse | *Apodemus flavicollis* | 0.0 | 0.0 | 0.9 | 0.5 | - | - | 1.4 |
| Total number of individuals | | 4.0 | 9.0 | 6.0 | 11.0 | - | - | 28.8 |
| Total number of species | | 3 | 3 | 5 | 5 | - | - | 6 |

**Appendix 6.** Butterfly species and their abundance (number of individuals per sighting per 100m section) in each field of Miscanthus, reed canary-grass and switch-grass fields for (a) 2002, (b) 2003, and (c) 2004. Each value is mean of three sightings (in 2003) or four sightings (in 2004) between May to August. Species are arranged in descending order based on total counts of the three biomass crop fields.

**(a) 2002**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Small white | *Pieris rapae* | 3.4 | 8.5 | 2.7 | 5.2 | 4.6 | 8.4 | 32.8 |
| Hedge brown (Gatekeeper) | *Pyronia tithonus* | 0.6 | 2.1 | 0.5 | 3.0 | 0.0 | 1.8 | 8.0 |
| Meadow brown | *Maniola jurtina* | 0.2 | 0.9 | 0.7 | 0.0 | 0.2 | 1.2 | 3.3 |
| Small tortoise shell | *Aglais urticae* | 1.6 | 0.6 | 0.0 | 0.0 | 0.2 | 0.0 | 2.4 |
| Green viened white | *Pieris napi* | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 1.2 | 1.8 |
| Peacock | *Inachis io* | 0.2 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 |
| Red admiral | *Vanessa atalanta* | 0.4 | 0.0 | 0.2 | 0.0 | 0.4 | 0.0 | 1.0 |
| Large skipper | *Ochlodes venatus* | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.3 |
| Total number of individuals | | 6.3 | 13.1 | 4.4 | 8.8 | 5.5 | 12.6 | 50.6 |
| Total number of species | | 6 | 5 | 5 | 3 | 4 | 4 | 8 |

**(b) 2003**

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Small white | *Pieris rapae* | 3.1 | 4.4 | 0.4 | 3.5 | 1.2 | 2.2 | 14.7 |
| Meadow brown | *Maniola jurtina* | 0.2 | 2.4 | 0.3 | 3.7 | 1.4 | 3.6 | 11.5 |
| Ringlet | *Aphantopus hyperantus* | 0.1 | 0.2 | 0.3 | 2.2 | 0.4 | 5.8 | 9.1 |
| Small tortoise shell | *Aglais urticae* | 1.9 | 2.6 | 0.0 | 0.7 | 0.3 | 1.0 | 6.5 |
| Hedge brown (Gatekeeper) | *Pyronia tithonus* | 0.0 | 1.8 | 0.2 | 1.0 | 0.0 | 0.0 | 2.9 |
| Painted lady | *Cynthia cardui* | 1.0 | 1.5 | 0.0 | 0.0 | 0.1 | 0.0 | 2.6 |
| Peacock | *Inachis io* | 0.0 | 0.1 | 0.0 | 0.3 | 0.4 | 0.2 | 1.0 |
| Large skipper | *Ochlodes venatus* | 0.0 | 0.0 | 0.6 | 0.4 | 0.0 | 0.0 | 1.0 |
| Speckled wood | *Pararge aegeria* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.4 | 0.5 |
| Red admiral | *Vanessa atalanta* | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| Small copper | *Lycaena phlaeas* | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Comma | *Polygonia c-album* | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| Total number of individuals | | 6.3 | 13.2 | 1.9 | 11.8 | 3.8 | 13.2 | 50.2 |
| Total number of species | | 5 | 9 | 5 | 9 | 6 | 6 | 12 |

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Hedge brown (Gatekeeper) | *Pyronia tithonus* | 0.3 | 8.5 | 0.0 | 1.3 | _ | _ | 10.1 |
| Small white | *Pieris rapae* | 2.5 | 3.2 | 0.1 | 1.3 | _ | _ | 7.1 |
| Meadow brown | *Maniola jurtina* | 0.4 | 3.7 | 0.2 | 0.9 | _ | _ | 5.2 |
| Green viened white | *Pieris napi* | 0.4 | 3.5 | 0.4 | 0.3 | _ | _ | 4.6 |
| Small tortoise shell | *Aglais urticae* | 0.1 | 2.0 | 0.0 | 0.3 | _ | _ | 2.4 |
| Ringlet | *Aphantopus hyperantus* | 0.1 | 1.4 | 0.0 | 0.2 | _ | _ | 1.7 |
| Peacock | *Inachis io* | 0.0 | 1.3 | 0.0 | 0.0 | _ | _ | 1.3 |
| Painted lady | *Cynthia cardui* | 0.0 | 0.3 | 0.0 | 0.0 | _ | _ | 0.4 |
| Speckled wood | *Pararge aegeria* | 0.0 | 0.3 | 0.0 | 0.0 | _ | _ | 0.4 |
| Large skipper | *Ochlodes venatus* | 0.0 | 0.2 | 0.0 | 0.1 | _ | _ | 0.3 |
| Orange tip | *Anthocharis cardamines* | 0.0 | 0.3 | 0.0 | 0.0 | _ | _ | 0.3 |
| Total number of individuals | | 3.8 | 24.8 | 0.7 | 4.5 | _ | _ | 33.8 |
| Total number of species | | 6 | 11 | 3 | 7 | _ | _ | 11 |

**Appendix 7.** Bumble bee species and their abundance (number of individuals per sighting per 100 m section) in Miscanthus and reed canary-grass fields for 2004. Each value is mean of two sightings (July and August). Species are arranged in descending order based on total counts of the three biomass crop fields.

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Total |
|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | |
| White/buff-tailed bumble bee | *Bombus lucorum/terrestris* | 5.0 | 10.4 | 0.0 | 5.7 | 21.0 |
| Red tailed bumble bee | *Bombus lapidarius* | 2.7 | 13.4 | 0.0 | 4.6 | 20.7 |
| Common carder bee | *Bombus pascuorum* | 1.1 | 1.7 | 0.0 | 12.1 | 14.9 |
| Early bumble bees | *Bombus pratorum* | 1.4 | 1.1 | 0.0 | 3.8 | 6.3 |
| Total number of individuals | | 10.2 | 26.6 | 0.0 | 26.1 | 62.9 |
| Total number of species | | 4 | 4 | 0 | 4 | 4 |

**Appendix 8.** Hoverfly species and their abundance (number of individuals per sighting per 100 m section) in Miscanthus and reed canary-grass fields for 2004. Each value is mean of two sightings (July and August). Species are arranged in descending order based on total counts of the three biomass crop fields.

| Common names | Scientific names | Miscanthus | | Reed canary-grass | | Total |
|---|---|---|---|---|---|---|
| | | Cropped area | Field margin | Cropped area | Field margin | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Long hoverfly | *Sphaerophoria scripta* | 34.9 | 12.1 | 0.0 | 11.9 | 58.9 |
| Dwarf dronefly | *Eristalis arbustorum* | 13.8 | 6.5 | 0.0 | 5.9 | 26.1 |
| Lunar hoverfly | *Eupeodes luniger* | 9.2 | 10.2 | 0.0 | 4.0 | 23.4 |
| Chequered hoverfly | *Melanostoma scalare* | 7.3 | 8.4 | 0.0 | 5.7 | 21.4 |
| Marmalade hoverfly | *Episyrphus balteatus* | 0.7 | 6.7 | 0.0 | 13.5 | 20.9 |
| Large lunar hoverfly | *Scaeva* spp. | 9.4 | 1.2 | 0.0 | 1.1 | 11.7 |
| Lesser banded hoverfly | *Syrphus vitripennis* | 2.0 | 0.4 | 0.0 | 2.6 | 5.1 |
| Black-tailed hoverfly | *Epistrophe eligans* | 1.8 | 1.6 | 0.0 | 1.5 | 4.8 |
| Gold-belled hoverfly | *Xylota segnis* | 0.7 | 0.6 | 0.0 | 2.0 | 3.3 |
| Dark hoverfly | *Pipiza noctiluca* | 0.3 | 0.4 | 0.0 | 1.2 | 1.9 |
| Total number of individuals | | 80.0 | 48.1 | 0.0 | 49.3 | 49.0 |
| Total number of species | | 10 | 10 | 0 | 10 | |

**Appendix 9.** Mean counts of Diptera (per 10 samples) in Miscanthus, reed canary-grass and switch-grass crop fields and their field margins in (a) 2002, (b) 2003 and (c) 2004. Families are arranged in descending order based on total counts of the three crops.

**(a) 2002**

| Diptera families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Bibionidae | 14.0 | 2.0 | 8.5 | 9.0 | 22.0 | 8.0 | 63.5 |
| Sciaridae | 2.5 | 2.0 | 2.0 | 16.5 | 0.0 | 2.0 | 25.0 |
| Chloropidae | 4.0 | 3.0 | 0.5 | 6.5 | 0.0 | 4.0 | 18.0 |
| Lonchopteridae | 2.5 | 4.0 | 0.0 | 7.0 | 1.0 | 3.0 | 17.5 |
| Chironomidae | 2.5 | 8.5 | 2.0 | 3.5 | 0.0 | 0.0 | 16.5 |
| Drosophilidae | 2.5 | 3.5 | 0.0 | 0.5 | 1.0 | 2.0 | 9.5 |
| Anthomyzidae | 1.0 | 0.5 | 0.0 | 5.0 | 0.0 | 0.0 | 6.5 |
| Opomyzidae | 2.0 | 0.0 | 0.0 | 2.5 | 0.0 | 2.0 | 6.5 |
| Agromyzidae | 0.0 | 3.0 | 0.0 | 0.0 | 1.0 | 0.0 | 4.0 |
| Phoridae | 0.5 | 0.0 | 0.0 | 0.5 | 0.0 | 3.0 | 4.0 |
| Cecidomyiidae | 0.5 | 0.0 | 0.0 | 0.5 | 0.0 | 1.0 | 2.0 |
| Syrphidae | 0.0 | 0.5 | 0.0 | 1.0 | 0.0 | 0.0 | 1.5 |
| Calliphoridae | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| Micropezidae | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 1.0 |
| Ptychopteridae | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| Carniidae | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Dolichopodidae | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Sepsidae | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |
| Tipulidae | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |
| Total no of individuals | 32.5 | 27.5 | 14.0 | 53.5 | 26.0 | 26.0 | 179.5 |
| Total no of families | 11 | 11 | 5 | 13 | 5 | 9 | 19 |

**(b) 2003**

| Diptera families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Anthomyzidae | 2.0 | 7.5 | 2.5 | 11.0 | 11.0 | 78.0 | 112.0 |
| Phoridae | 43.5 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 44.0 |
| Dolichopodidae | 0.5 | 1.0 | 1.5 | 4.0 | 0.0 | 28.0 | 35.0 |
| Cecidomyiidae | 0.0 | 6.0 | 1.0 | 1.5 | 3.0 | 14.0 | 25.5 |
| Sciaridae | 2.5 | 2.5 | 1.5 | 5.0 | 0.0 | 10.0 | 21.5 |
| Chloropidae | 2.0 | 6.0 | 1.5 | 3.5 | 0.0 | 7.0 | 20.0 |
| Lauxaniidae | 0.5 | 1.5 | 1.0 | 4.5 | 0.0 | 8.0 | 15.5 |
| Bibionidae | 4.5 | 0.0 | 0.0 | 0.5 | 0.0 | 10.0 | 15.0 |
| Opomyzidae | 0.5 | 0.5 | 0.0 | 6.0 | 0.0 | 2.0 | 9.0 |
| Chamaeyiidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.0 | 8.0 |
| Sepsidae | 3.5 | 1.0 | 0.0 | 0.0 | 0.0 | 2.0 | 6.5 |
| Heleomyzidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 | 6.0 |
| Chironomidae | 1.5 | 3.0 | 0.0 | 0.5 | 0.0 | 0.0 | 5.0 |
| Syrphidae | 0.5 | 2.0 | 0.0 | 0.5 | 0.0 | 2.0 | 5.0 |
| Tephritidae | 0.0 | 1.5 | 0.5 | 0.0 | 0.0 | 2.0 | 4.0 |
| Agromyzidae | 0.0 | 1.0 | 0.0 | 0.5 | 0.0 | 2.0 | 3.5 |
| Drosophilidae | 0.0 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 |
| Calliphoridae | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 2.0 | 2.5 |
| Stratiomyidae | 0.0 | 1.5 | 0.0 | 0.5 | 0.0 | 0.0 | 2.0 |
| Tabanidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 2.0 |
| Platystomatidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 2.0 |
| Scatopsicae | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
| Empididae | 0.0 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 1.0 |
| Acroceridae | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Tipulidae | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Lonchopteridae | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total no of individuals | 62.0 | 40.5 | 10.5 | 38.5 | 14.0 | 185.0 | 350.5 |
| Total no of families | 12 | 18 | 9 | 13 | 2 | 17 | 26 |

**(c) 2004**

| Diptera families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| Bibionidae | 13.8 | 4.2 | 12.5 | 13.0 | - | - | 43.4 |
| Sciaridae | 4.8 | 6.3 | 0.5 | 22.6 | - | - | 34.2 |
| Anthomyzidae | 4.8 | 10.1 | 1.0 | 15.1 | - | - | 31.0 |
| Chironomidae | 2.8 | 15.0 | 1.8 | 6.9 | - | - | 26.4 |
| Chloropidae | 2.5 | 9.4 | 1.0 | 13.1 | - | - | 26.0 |
| Lonchopteridae | 1.0 | 4.5 | 1.5 | 9.0 | - | - | 16.0 |
| Dolichopodidae | 1.8 | 2.8 | 0.5 | 4.0 | - | - | 9.1 |
| Drosophilidae | 1.0 | 5.0 | 1.0 | 0.6 | - | - | 7.6 |
| Cecidomyiidae | 0.5 | 2.8 | 1.0 | 2.5 | - | - | 6.8 |
| Agromyzidae | 0.5 | 4.8 | 0.0 | 0.3 | - | - | 5.5 |
| Opomyzidae | 0.0 | 1.0 | 1.5 | 2.5 | - | - | 5.0 |
| Lauxaniidae | 0.5 | 2.3 | 0.5 | 1.3 | - | - | 4.6 |
| Syrphidae | 0.0 | 1.0 | 0.0 | 2.1 | - | - | 3.1 |
| Tephritidae | 0.5 | 2.3 | 0.0 | 0.0 | - | - | 2.8 |
| Stratiomyidae | 0.0 | 2.1 | 0.0 | 0.5 | - | - | 2.6 |
| Phoridae | 0.8 | 0.0 | 0.5 | 1.3 | - | - | 2.5 |
| Sepsidae | 0.0 | 1.5 | 0.0 | 0.6 | - | - | 2.1 |
| Tipulidae | 0.0 | 1.0 | 0.0 | 0.6 | - | - | 1.6 |
| Empididae | 0.5 | 1.0 | 0.0 | 0.0 | - | - | 1.5 |
| Calliphoridae | 0.0 | 1.0 | 0.3 | 0.0 | - | - | 1.3 |
| Acroceridae | 1.0 | 0.0 | 0.0 | 0.0 | - | - | 1.0 |
| Micropezidae | 1.0 | 0.0 | 0.0 | 0.0 | - | - | 1.0 |
| Carniidae | 0.0 | 0.0 | 0.5 | 0.0 | - | - | 0.5 |
| Total no of individuals | 37.5 | 78.0 | 24.0 | 96.0 | - | - | 235.5 |
| Total no of species | 16 | 19 | 14 | 17 | - | - | 23 |

**Appendix 10.** Mean counts of Hymenoptera (per 10 samples) in Miscanthus, reed canary-grass and switch-grass crop fields and their field margins in (a) 2002, (b) 2003 and (c) 2004. Families are arranged in descending order based on total counts of the three crops.

| Hymenoptera families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| **(a) 2002** | | | | | | | |
| Cynipidae | 0.0 | 1.5 | 1.0 | 9.0 | 0.0 | 6.0 | 17.5 |
| Braconidae | 3.5 | 5.0 | 0.0 | 2.0 | 2.0 | 2.0 | 14.5 |
| Platygasteridae | 0.5 | 5.0 | 0.0 | 3.5 | 0.0 | 4.0 | 13.0 |
| Ichneuminidae | 0.0 | 1.5 | 0.0 | 3.5 | 0.0 | 6.0 | 11.0 |
| Pteromalidae | 1.5 | 0.5 | 0.0 | 3.0 | 2.0 | 2.0 | 9.0 |
| Total no of individuals | 5.5 | 13.5 | 1.0 | 21.0 | 4.0 | 20.0 | 65.0 |
| Total no of families | 3 | 5 | 1 | 5 | 2 | 5 | 5 |
| **(b) 2003** | | | | | | | |
| Pteromalidae | 3.0 | 16.5 | 1.5 | 21.0 | 10.0 | 133.0 | 185.0 |
| Platygasteridae | 0.5 | 12.0 | 0.5 | 0.5 | 10.0 | 5.0 | 28.5 |
| Ichneuminidae | 0.5 | 5.5 | 1.5 | 0.5 | 0.0 | 8.0 | 16.0 |
| Braconidae | 1.5 | 4.5 | 0.0 | 3.0 | 0.0 | 4.0 | 13.0 |
| Cynipidae | 0.5 | 2.5 | 0.0 | 1.5 | 0.0 | 4.0 | 8.5 |
| Tiphiidae | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 2.0 | 2.5 |
| Total no of individuals | 6.0 | 41.5 | 3.5 | 26.5 | 20.0 | 156.0 | 253.5 |
| Total no of families | 5 | 6 | 3 | 5 | 2 | 6 | 6 |
| **(c) 2004** | | | | | | | |
| Pteromalidae | 3.8 | 7.3 | 0.5 | 19.3 | - | - | 30.8 |
| Platygasteridae | 0.5 | 15.8 | 0.8 | 8.0 | - | - | 25.1 |
| Braconidae | 1.5 | 10.5 | 3.0 | 4.5 | - | - | 19.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cynipidae | 1.5 | 4.3 | 0.3 | 12.0 | - | - | 18.1 |
| Ichneuminidae | 0.5 | 5.2 | 0.0 | 4.0 | - | - | 9.7 |
| Tiphiidae | 0.0 | 0.8 | 0.0 | 0.0 | - | - | 0.8 |
| | | | | | | | |
| Total no of individuals | 7.8 | 43.9 | 4.5 | 47.8 | - | - | 103.9 |
| Total no of species | 5 | 6 | 4 | 5 | - | - | 6 |

**Appendix 11.** Mean counts of Hemiptera:Heteroptera (per 10 samples) in Miscanthus, reed canary-grass and switch-grass crop fields and their field margins in (a) 2002, (b) 2003 and (c) 2004. Families are arranged in descending order based on total counts of the three crops.

| Hemiptera:Heteroptera families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| **(a) 2002** | | | | | | | |
| Miridae | 7.5 | 25.5 | 2.0 | 24.0 | 31.0 | 96.0 | 186.0 |
| Anthocoridae | 2.5 | 20.0 | 2.0 | 19.0 | 5.0 | 5.0 | 53.5 |
| Nabidae | 0.0 | 2.5 | 0.0 | 0.0 | 1.0 | 34.0 | 37.5 |
| Pentatomidae | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
| Berytidae | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| Acanthosomatidae | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| Total no of individuals | 12.0 | 49.5 | 4.0 | 43.0 | 37.0 | 135.0 | 280.5 |
| Total no of families | 4 | 5 | 2 | 2 | 3 | 3 | 6 |
| **(b) 2003** | | | | | | | |
| Miridae | 24.0 | 204.0 | 1.0 | 55.5 | 25.0 | 157.0 | 466.5 |
| Anthocoridae | 2.0 | 30.0 | 1.0 | 7.5 | 58.0 | 17.0 | 115.5 |
| Coreidae | 0.0 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 3.5 |
| Pentatomidae | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |
| Nabidae | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |
| Total no of individuals | 26.0 | 237.5 | 2.0 | 64.0 | 83.0 | 174.0 | 586.5 |
| Total no of families | 2 | 3 | 2 | 4 | 2 | 2 | 5 |
| **(c) 2004** | | | | | | | |
| Miridae | 27.8 | 114.8 | 3.5 | 58.8 | - | - | 204.8 |
| Anthocoridae | 2.8 | 43.1 | 3.0 | 26.6 | - | - | 75.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nabidae | 0.0 | 3.0 | 0.0 | 0.3 | - | - | 3.3 |
| Acanthosomatidae | 0.0 | 2.5 | 0.0 | 0.0 | - | - | 2.5 |
| Berytidae | 1.0 | 1.0 | 0.0 | 0.0 | - | - | 2.0 |
| Pentatomidae | 0.0 | 0.0 | 1.0 | 0.0 | - | - | 1.0 |
| | | | | | | | |
| Total no of individuals | 31.5 | 164.4 | 7.5 | 85.6 | - | - | 289.0 |
| Total no of species | 3 | 5 | 3 | 3 | - | - | 6 |

**Appendix 12.** Mean counts of Hemiptera:Homoptera (per 10 samples) in Miscanthus, reed canary-grass and switch-grass crop fields and their field margins in (a) 2002, (b) 2003 and (c) 2004. Families are arranged in descending order based on total counts of the three crops.

| Hemiptera:Homoptera families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| **(a) 2002** | | | | | | | |
| Aphididae | 3.0 | 22.5 | 1092.0 | 7.0 | 7.0 | 1.0 | 1132.5 |
| Cicadellidae | 1.0 | 12.5 | 0.0 | 30.5 | 8.0 | 5.0 | 57.0 |
| Cercopidae | 1.0 | 6.0 | 0.0 | 14.0 | 0.0 | 6.0 | 27.0 |
| Delphacidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| Psyllidae | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |
| Total no of individuals | 5.0 | 41.0 | 1092.0 | 52.0 | 15.0 | 13.0 | 1218.0 |
| Total no of families | 3 | 3 | 1 | 4 | 2 | 4 | 5 |
| **(b) 2003** | | | | | | | |
| Aphididae | 6.5 | 31.0 | 54.0 | 132.5 | 0.0 | 128.0 | 352.0 |
| Cercopidae | 0.5 | 4.5 | 1.0 | 129.5 | 3.0 | 13.0 | 151.5 |
| Cicadellidae | 1.5 | 16.0 | 6.0 | 17.5 | 5.0 | 47.0 | 93.0 |
| Psyllidae | 2.0 | 9.5 | 0.5 | 9.0 | 0.0 | 14.0 | 35.0 |
| Delphacidae | 0.0 | 0.0 | 3.0 | 0.5 | 0.0 | 9.0 | 12.5 |
| Cixiidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 2.0 |
| Total no of individuals | 10.5 | 61.0 | 64.5 | 289.0 | 8.0 | 213.0 | 646.0 |
| Total no of families | 4 | 4 | 5 | 5 | 2 | 6 | 6 |
| **(c) 2004** | | | | | | | |
| Aphididae | 8.3 | 49.8 | 11.3 | 134.9 | - | - | 204.1 |
| Cicadellidae | 5.3 | 27.2 | 2.5 | 58.8 | - | - | 93.7 |
| Cercopidae | 1.5 | 16.2 | 0.8 | 20.1 | - | - | 38.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Psyllidae | 2.3 | 10.7 | 0.3 | 9.0 | - | - | 22.2 |
| Delphacidae | 2.5 | 0.0 | 0.0 | 0.3 | - | - | 2.8 |
| Total no of individuals | 19.8 | 103.8 | 14.8 | 223.0 | - | - | 361.3 |
| Total no of species | 4 | 4 | 5 | 5 | - | - | 5 |

**Appendix 13.** Mean counts of arboreal Coleoptera (per 10 samples) in Miscanthus, reed canary-grass and switch-grass crop fields and their field margins in (a) 2002, (b) 2003 and (c) 2004. Families are arranged in descending order based on total counts of the three crops.

| Coleoptera families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| **(a) 2002** | | | | | | | |
| Chrysomelidae | 41.5 | 30.0 | 0.0 | 35.5 | 24.0 | 20.0 | 151.0 |
| Coccinellidae | 2.0 | 4.5 | 0.0 | 7.5 | 2.0 | 36.0 | 52.0 |
| Curculinidae | 9.5 | 5.0 | 0.5 | 6.5 | 8.0 | 10.0 | 39.5 |
| Staphylinidae | 0.0 | 0.5 | 0.0 | 1.5 | 0.0 | 0.0 | 2.0 |
| Elateridae | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 1.0 |
| Total no of individuals | 53.0 | 40.0 | 0.5 | 52.0 | 34.0 | 66.0 | 245.5 |
| Total no of families | 3 | 4 | 1 | 5 | 3 | 3 | 5 |
| **(b) 2003** | | | | | | | |
| Coccinellidae | 0.5 | 6.0 | 0.5 | 40.0 | 1.0 | 50.0 | 98.0 |
| Chrysomelidae | 4.0 | 18.0 | 0.0 | 6.5 | 0.0 | 36.0 | 64.5 |
| Curculinidae | 4.5 | 11.0 | 0.5 | 12.0 | 0.0 | 26.0 | 54.0 |
| Phalacridae | 9.5 | 26.0 | 0.0 | 3.0 | 1.0 | 11.0 | 50.5 |
| Cantharidae | 8.0 | 7.0 | 1.5 | 2.5 | 0.0 | 20.0 | 39.0 |
| Elateridae | 13.0 | 4.5 | 0.5 | 1.0 | 0.0 | 2.0 | 21.0 |
| Staphylinidae | 0.5 | 2.0 | 0.0 | 0.5 | 2.0 | 2.0 | 7.0 |
| Carabidae | 0.0 | 1.0 | 1.5 | 0.5 | 1.0 | 0.0 | 4.0 |
| Scarabaeidae | 0.0 | 0.5 | 0.0 | 0.5 | 0.0 | 0.0 | 1.0 |
| Total no of individuals | 40.0 | 76.0 | 4.5 | 66.5 | 5.0 | 147.0 | 339.0 |
| Total no of families | 7 | 9 | 5 | 9 | 4 | 7 | 9 |
| **(c) 2004** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Chrysomelidae | 24.5 | 44.9 | 1.5 | 81.0 | - | - | 151.9 |
| Coccinellidae | 2.0 | 9.3 | 1.3 | 26.5 | - | - | 39.1 |
| Curculinidae | 1.5 | 17.6 | 0.5 | 11.0 | - | - | 30.6 |
| Cantharidae | 9.0 | 8.3 | 1.0 | 2.0 | - | - | 20.3 |
| Phalacridae | 0.5 | 17.6 | 0.0 | 0.5 | - | - | 18.6 |
| Elateridae | 2.0 | 3.2 | 0.3 | 2.0 | - | - | 7.4 |
| Staphylinidae | 2.0 | 3.2 | 0.0 | 1.5 | - | - | 6.7 |
| Scarabaeidae | 0.0 | 0.8 | 0.0 | 0.3 | - | - | 1.1 |
| Carabidae | 0.5 | 0.0 | 0.0 | 0.3 | - | - | 0.8 |
| | | | | | | | |
| Total no of individuals | 42.0 | 104.9 | 4.5 | 125.0 | - | - | 276.4 |
| Total no of species | 8 | 8 | 5 | 9 | - | - | 9 |

**Appendix 14.** Mean counts of Psocoptera, Neuroptera and Collombolla (per 10 samples) in Miscanthus, reed canary-grass and switch-grass crop fields and their field margins in (a) 2002, (b) 2003 and (c) 2004. Families are arranged in descending order based on total counts of the three crops.

| Families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| **(a) 2002** | | | | | | | |
| Psocoptera | | | | | | | |
| Ectopsocidae | 2.0 | 0.5 | 0.0 | 0.0 | 1.0 | 0.0 | 3.5 |
| Neuroptera | | | | | | | |
| Hemerobiiddae | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.5 |
| Osmylidae | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Collombolla | | | | | | | |
| Dicyrtomidae | 0.0 | 0.0 | 0.0 | 3.5 | 0.0 | 1.0 | 4.5 |
| **(b) 2003** | | | | | | | |
| Psocoptera | | | | | | | |
| Stenopsocidae | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
| Lachesillidae | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 1.0 |
| Neuroptera | | | | | | | |
| Chrysopidae | 0.0 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 |
| Sisyridae | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Dilaridae | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |
| Collombolla | | | | | | | |
| Dicyrtomidae | 0.5 | 6.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.5 |
| Sminthuridae | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **(c) 2004** | | | | | | | |
| Psocoptera | | | | | | | |
| Ectopsocidae | 1.0 | 1.7 | 0.5 | 0.0 | - | - | 3.2 |
| Lachesillidae | 0.0 | 0.0 | 0.0 | 1.0 | - | - | 1.0 |
| | | | | | | | |
| Neuroptera | | | | | | | |
| Chrysopidae | 0.0 | 0.8 | 0.0 | 0.0 | - | - | 0.8 |
| Hemerobiiddae | 0.0 | 0.0 | 0.5 | 0.0 | - | - | 0.5 |
| Osmylidae | 0.5 | 0.0 | 0.0 | 0.0 | - | - | 0.5 |
| Sisyridae | 0.5 | 0.0 | 0.0 | 0.0 | - | - | 0.5 |
| Dilaridae | 0.0 | 0.0 | 0.0 | 0.3 | - | - | 0.3 |
| | | | | | | | |
| Collombolla | | | | | | | |
| Dicyrtomidae | 0.5 | 0.0 | 0.0 | 3.8 | - | - | 4.3 |

**Appendix 15.** Mean counts of Thysanoptera, Orthoptera and Dermaptera (per 10 samples) in Miscanthus, reed canary-grass and switch-grass crop fields and their field margins in (a) 2002, (b) 2003 and (c) 2004. Families are arranged in descending order based on total counts of the three crops.

| Families | Miscanthus | | Reed canary-grass | | Switch-grass | | Total |
|---|---|---|---|---|---|---|---|
| | Cropped area | Field margin | Cropped area | Field margin | Cropped area | Field margin | |
| **(a) 2002** | | | | | | | |
| Thysanoptera | | | | | | | |
| Thripidae | 1.0 | 0.0 | 0.0 | 0.5 | 1.0 | 0.0 | 2.5 |
| Orthoptera | | | | | | | |
| Acrididae | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| **(b) 2003** | | | | | | | |
| Thysanoptera | | | | | | | |
| Phlaeothripidae | 3.5 | 6.0 | 0.0 | 0.0 | 0.0 | 2.0 | 11.5 |
| Dermaptera | | | | | | | |
| Forficulidae | 0.0 | 0.5 | 0.0 | 1.5 | 0.0 | 0.0 | 2.0 |
| **(c) 2004** | | | | | | | |
| Thysanoptera | | | | | | | |
| Phlaeothripidae | 4.5 | 2.5 | 0.0 | 0.0 | - | - | 7.0 |
| Thripidae | 0.8 | 0.0 | 0.0 | 1.3 | - | - | 2.0 |
| Orthoptera | | | | | | | |
| Acrididae | 0.0 | 3.7 | 0.0 | 0.0 | - | - | 3.7 |
| Dermaptera | | | | | | | |
| Forficulidae | 0.0 | 1.0 | 0.0 | 0.0 | - | - | 1.0 |