THE EFFECTS OF ENERGY GRASS PLANTATIONS ON BIODIVERSITY

2nd Annual Report

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Summary

Wildlife monitoring of five field sites growing the perennial rhizomatous grass crops *Miscanthus*, reed canary-grass and switch-grass was carried out (beginning May 2002) to investigate the ecological impact of their plantations on biodiversity. Only five field sites were selected, representing at least one each of the perennial biomass crops grown in the area, due to both limited availability of sites and funding for the work.

This is the second annual report of the effects of energy grass plantations on biodiversity. The main objectives for the period of this report were: (a) completion of wildlife surveys in the 2003 season, and (b) completion of invertebrate identification from the 2003 as well as 2002 season. There is some invertebrate identification still outstanding, and this is planned to be done by the end of March 2004. This report takes account of constructive criticism of the first report.

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. Nevertheless, the programme of biodiversity assessments was continued as for the other biomass crops.

Miscanthus fields were richer in weed vegetation and had greater bare ground patches than reed canary-grass. Percentage weed cover in the *Miscanthus* fields ranged from 48% to 68%, compared to 5% in reed canary-grass fields. Bird use of the biomass crop fields varied depending on bird species. There were substantially more skylarks, meadow pipits and lapwings in the *Miscanthus* (M-2000 or M-2002) than in the reed canary-grass or switch-grass fields, indicating that *Miscanthus* fields were preferred by those bird species at least in early 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 invertebrate and seed foods as well as for cover.

Ground beetles, butterflies and epigeal invertebrates were more abundant and diverse in the most florally diverse habitat of *Miscanthus* fields. The most important invertebrate food taxa in the biomass crop fields included Coleoptera (Curculionidae, Chrysomelidae, Carabidae, Staphylinidae, Elateridae), Hemiptera (Heteroptera and Homoptera), Diptera, and Hymenoptera.

There was no particular crop 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. M-2000 and RCG-2000 had greater small-mammal diversity in 2002 season due to their greater ground cover. In 2003 season, however, fewer small-mammals were caught in M-2000 field possibly because of the mechanical land disturbance during rhizome lifting.

Because perennial rhizomatous grasses require a single planting and related tillage; and because the crops are harvested in March and the land is not disturbed by cultivation every year, these fields were used as over-wintering sites for birds, small-mammals and invertebrates suggesting immediate benefits to biodiversity.

1. Introduction

This is the second annual report of effects of energy grass plantations on biodiversity. The first report, in January 2003, covered year 2002 growing season. Background introduction to the project were described in the first annual report. The main objective of this project was to investigate the ecological impact of biomass grass crops grown in Herefordshire following the "core species" assessment requirement as set out in our contract.

The objectives for the period of this report were:

- Completion of wildlife surveys for the 2003 season
- Completion of invertebrate identification from the 2002 season
- Continued data entry from 2002 and 2003 season
- Continued invertebrate identification from the 2003 season

The previous report noted that the research plans for the 2003 season would include primary monitoring of biodiversity for each of the three biomass crops at five farm sites as follows:

Survey	Number of assessments
Ground flora	once
Ground beetles	twice
Epigeal invertebrates	twice
Birds	15 times
Small-mammals	twice

In addition, secondary survey included butterfly assessments, three times. Crop characteristics such as plant height, plant/stem density, and biomass yield were also assessed.

Laboratory activities included invertebrate identification of samples left from the 2002 season and those collected in the 2003 season. Therefore, this annual report includes not only the data from the 2003 season but also some 2002 data, such as second sampling of ground beetles, and epigeal invertebrate data.

2. Study sites and methods

General study sites and methods are as described in the first year annual report, and are therefore not repeated here. Five farmers' field sites were selected, representing at least one each of the perennial biomass crops grown in the area; more were not included due to constraints on both the availability of sites (i.e. all reed canary-grass and switch grass were used) and funding for the work.

Abbreviations used for the treatment names and crop species (habitats) used, their site location and area of the crop field are given below:

Treatment name, abbreviated	Crop species and year planted	Site location	Total area, ha
M-2002	*Miscanthus* planted in spring 2002	Ox farm, Shobdon	7.0
RCG-2002	reed canary-grass drilled in spring 2002	Ox farm, Shobdon	3.9
SG-2002	switch-grass drilled in spring 2002	Ox farm, Shobdon	3.8
M-2000	*Miscanthus* planted in spring 2000	The Farland's Farm, Lingen	4.1
RCG-2000	reed canary-grass drilled in spring 2000	Norman's farm, Stoke Prior	1.3

In the year 2003, no herbicide was applied to reed canary-grass (RCG-2002) and switch-grass (SG-2002) fields at Shobdon. The *Miscanthus* field at Shobdon (M-2002) was treated once using atrazine (1.4 l ha^{-1}) + glyphosate (1.0 l ha^{-1}) mix on 22nd February 2003. Reed canary-grass field at Stoke-Prior (RCG-2000) was treated with the desiccant herbicide didquat (4 l ha^{-1}) two weeks before harvest, in mid-August 2003. The *Miscanthus* field at Lingen (M-2000) was harvested for its rhizomes on 23rd March 2003, and the field was left to regenerate as a new crop. M-2000 was also treated with atrazine (1.4 l ha^{-1}) + glyphosate (1.0 l ha^{-1}) mix in July of 2003.

Sampling frequency and dates for each monitoring in 2003 season are presented below:

Birds		Every two weeks during breeding season (1 March to Mid- July); and every month for the rest of the time.
Ground beetles		May and July
Arboreal invertebrates		June and July
Small mammals		March and September
Butterflies		June, July and August
% ground cover		June and August

Annual rainfall for the season was 518 mm (courtesy of Corbett Farms Ltd), well below average.

No statistical analysis has been used in this year's report; combined three years data analysis will be used for the final report along with relevant diversity indices.

3. Results

3.1. CROP FIELD CHARACTERSTICS

The *Miscanthus* field at Shobdon (M-2002) was characterized by low crop plant density (between 1 to 2 plants m^{-2}; 18 stems m^{-2}) and almost free of weeds until the end of June. Herbicide application of atrazine (1.4 l ha^{-1}) + glyphosate (1.0 l ha^{-1}) mix on 22nd February 2003 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 1).

In contrast, the *Miscanthus* field at Lingen (M-2000) had a relatively high crop density (16 plants m^{-2}; 86 stems m^{-2}); and covered 80% of the ground before leaf senescence. This was mainly because the rhizomes were cut *in situ* using rotovators to harvest rhizomes for propagation, and subsequently left more rhizomes in the ground. The field was rich mainly in grass weeds and also broad leaved weeds with a total of 10% ground cover by early May and 48% by Mid-September (Table 1).

The reed canary-grass fields at Shobdon (RCG-2002) and at Stoke Prior (RCG-2000) were characterized by tall dense crop fields (100% ground cover), with little weeds (5% ground cover) throughout the season.

The switch-grass field at Shobdon (SG-2002) was characterized as weed infested field, mainly grass and some broad leaved weeds. By mid-September, ground cover of the switch-grass crop was only 27%, compared to 85% by the weeds (Table 1). Switch-grass crops have a very slow initial growth, and as such are the weakest competitor against weeds. Switch-grass crop development and growth early in the growing season was consequently very slow. As a result, the crop was dominated by general grasses followed by reed canary-grass (at 30-60 cm ht), and then by broad-leaved weeds (see section Ground Flora for more detail). By 24th June 2003, switch-grass plants reached only 20 cm in height, and the grass weeds were three times in height and their ground cover was greater than 80%.

The greatest biomass dry matter yield was obtained from two year old reed canary-grass, RCG-2002 (2228 g m^{-2}). This crop was very dense and tall, and past experience has shown that reed canary-grass yield is at its maximum in its second year (John Amos, personal communication). RCG-2000 (1031 g m^{-2}) recorded less than half biomass yield of RCG-2002 probably because of its greater age and limiting soil fertility. Both RCG-2002 and RCG-2000 had the least weed biomass yield of all the crops, with 15 and 13 g m^{-2} respectively.

The crop with the least biomass dry matter yield (506 g m^{-2}) but greatest weed biomass (588 g m^{-2}) was obtained from the switch-grass crop. *Miscanthus* yields were 980 g m^{-2} for the two year old M-2002; and 1328 g m^{-2} for the dug-up four year old *Miscanthus* M-2000. These average yields are despite the presence of 129 and 397 g m^{-2} weed biomass dry matter yield, respectively (Table 1).

Table 1. Crop and weed characteristics at mid-September for *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) fields at Lingen, Shobdon and Stoke Prior in Herefordshire for 2003 growing season.

	M-2002	RCG-2002	SG-2002	M-2000	RCG-2000
Crop plant height, cm	170	214	110	165	150
Number of plants m^{-2}	1	-	-	16	-
Number of stems m^{-2}	18	976	221	86	582
Ground cover by the crop, %	22	100	27	80	100
Ground cover by weeds, %	61	5	85	48	5
Crop biomass DM yield, g m^{-2}	980	2228	506	1328	1031
Weed biomass DM yield, g m^{-2}	129	15	588	397	13

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 crop's active growth stage. However, around 5% of the native reed canary-grass planted in 2000 (RCG-2000) was harbouring green peach aphids (*Myzus persicae*) in mid-August of 2003 shortly before the crop was desiccated to aid harvesting.

3.3. GROUND FLORA

A list of the weed flora in the biomass crop fields and adjacent conventional crop fields, and in the surrounding headlands is presented in Table 2. In terms of weed diversity within the crop fields, the order was switch-grass > *Miscanthus* > reed canary-grass > cereals/break crops.

There was 20% more weed ground cover within the *Miscanthus* field at Shobdon (M-2002) in the summer of 2003 (61%) compared to 2002 (41%). This was mainly due to more weed control measures taken in the first season of the crops growth: glyphosate application before land preparation and two herbicide applications during the growing season. In 2003 season, only one herbicide treatment was applied. Ground cover by the *Miscanthus* crop increased from 5% in the first season to 21% in the second season. The number of weed species within the crop field in 2003 (11 species) was similar to 2002 season (12 species).

Percentage weed cover in the *Miscanthus* field at Lingen (M-2000) decreased from 96% in 2002 to 48% in 2003. Also the number of weed species decreased from 26 in 2002 to only six in 2003. This was probably attributed to the increase in ground cover by the *Miscanthus* crop from 32% in 2002 to 68% in 2003. The crop was planted in 2000 but was harvested for its rhizomes by cutting the rhizomes *in situ* using rotary cultivator (rotovator) in March 2003. The rhizome

pieces were then collected with adapted potato harvester; and the field was left to regenerate after preparing and rolling the land. Although with differing emergence dates, the field was soon full of regenerated *Miscanthus* plants with greater ground cover than in the previous years.

There was 5% weed cover (by two species) in the reed canary-grass field at Shobdon (RCG-2002) in its second year in 2003, compared to 48% (by 19 species) in first season 2002. In contrast, weed cover in the reed canary-grass field at Stoke-Prior was 5% (by four species) in its fourth year in 2003 season, compared to 9% (by nine species) in its third year in 2002.

Due to weed control measure problems and its initial slow growth early in the season, the switch-grass field (SG-2002) scored the highest weed flora with 85% ground cover and 16 species in 2003; compared to 57% weed cover by 17 species in 2002 season. Ground cover by the switch-grass crop itself was 27% this season, compared to 14% in 2002.

With the exception of M-2002, plant species diversity in the field margins was comparable to that within the crop fields in four of the biomass crop habitats in 2002; whereas in 2003, only switch-grass field had comparable number of plant species as field margins.

Dominant plant species within the biomass grass crops differed between habitats. The most dominant plant species in M-2002 crop field were, in decreasing order: couch grass (*Elymus repens*), creeping thistle (*Cirsium arvensis*), oilseed rape (*Brasica napa*), wall speedwell (*Veronica arvensis*), groundsel (*Senecio vulgaris*), annual meadow grass (*Poa annua*), common field speedwell (*Veronica persica*), and cleavers (*Galium aparine*). The most dominant plant species in M-2000 crop field were: couch grass, brown bent (*Agrostis canina*), drooping brome (*Bromus tectorum*), creeping thistle, fumitory (*Fumaria officinalis*) and perennial rye-grass (*Lolium perenne*).

Brown bent, good King Henry goosefoot (*Chenopodium bonus-henricus*) and common hemp nettle (*Galeopsis tetrahit*) dominated within RCG-2002 fields at Shobdon. Whereas, creeping buttercup (*Ranunculus repens*) and Yorkshire fog (*Holcus lanatus*) dominated within RCG-2000 habitat at Stoke-Prior. RCG-2000 also recorded 40% ground cover by bryophytes.

Switch-grass habitat was dominated by tall fescue (*Fescuta arundinacea***)**, couch-grass, brown bent, broad-leaved dock (*Rumex obtusifolius*), fine-leaved sheep's fescue (*Festuca ovina*), creeping buttercup, creeping thistle, greater plantain (*Plantago major*), fathen (*Chenopodium album*), common hemp-nettle, charlock (*Sinapsis arvensis*), and hedge-bindweed (*Calystegia sepium*).

Adjacent arable fields in the 2003 season included winter wheat, winter oilseed rape, spring oats and spring beans; and weed ground cover in each of the crops was between 0 and 1%, which comprised mainly of creeping thistle or common field speedwell.

Table 2. Percentage ground cover for each species of plants within *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) field, their surrounding field margin and adjacent crop (adjac. crop) for the 2003 growing season. Adjacent crop fields were winter wheat for M-2002, winter oilseed rape for RCG-2002 and SG-2002, spring oats for M-2000, and spring field beans for RCG-2002. Names in bold indicate experimental biomass crop species, and arable crop species in adjacent fields.

Common names	Scientific names	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000		
		Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop
DICOTS																
Oilseed rape	***Brasica napa***	4	3	0	0	0	100	0	0	100	0	0	0	0	0	0
Beans	***Phaseolus vulgaris***	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
Nettle, Common	*Urtica dioica*	0	0	0	0	8	0	0	4	0	0	43	0	0	17	0
Thistle, Creeping	*Cirsium arvensis*	7	14	0	0	6	0	2	1	0	4	11	0	0	5	1
Shepherds Purse	*Capsella bursa-pastoris*	1	4	0	0	0	0	0	0	0	0	35	0	0	0	0
Cleaver	*Galium aparene*	2	0	0	0	1	0	0	0	0	0	22	0	0	2	0
Hogweed	*Heracleum sphondylium*	0	3	0	0	2	0	1	16	0	0	4	0	0	1	0
Bindweed, Hedge	*Calystegia sepium*	0	0	0	0	13	0	1	12	0	0	0	0	0	0	0
Dock, Broad Leaved	*Rumex obtusifolius*	0	3	0	0	6	0	3	1	0	0	1	0	0	1	0
Buttercup, Creeping	*Ranunculus repens*	0	0	0	0	0	0	3	0	0	0	2	0	2	7	0
Parsley, Cow	*Anthriscus sylvestris*	0	0	0	0	4	0	0	7	0	0	0	0	0	2	0
Crane's-bill, Cut-leaved	*Geranium dissectum*	1	0	0	0	5	0	0	5	0	0	0	0	0	0	0
Dandelion	*Taraxacum officinale*	0	2	0	0	1	0	0	3	0	0	0	0	0	3	0
Groundsel	*Senecio vulgaris*	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Charlock	*Sinapsis arvensis*	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0
Hemp-Nettle, Common	*Galeopsis tetrahit*	0	0	0	1	1	0	1	3	0	0	0	0	0	0	0
Speedwell, Wall	*Veronica arvensis*	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Speedwell, Common Field	*Veronica persica*	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Sow-Thistle, Prickly	*Sonchus asper*	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Fumatory, Common	*Fumaria officinalis*	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Plantain, Greater	*Plantago major*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0

.....Table 2. Continued

Common names	Scientific names	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000		
		Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop
DICOTS																
Greater Burdock	*Arctium lappa*	0	0	0	0	0	0	0	3	0	0	5	0	0	0	0
Vetch, Bush	*Vicia sepium*	0	2	0	0	0	0	0	0	0	0	0	0	0	5	0
Clover, white	*Trifolium repens*	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Knotgrass	*Polygonum aviculare*	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Horsetail	*Equisetum arvenses*	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Rough Chervil	*Chaerophyllum temulentum*	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Mayweed, Scentless	*Tripleurospermum inodorum*	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Woundwort, Hedge	*Stachys sylvatica*	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Goosefoot, Good King Henry	*Chenopodium bonus-henricus*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Fathen	*Chenopodium album*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Chickweed, Common	*Stellaria media*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Mayweed, Scented (Pineapple Weed)	*Matricaria matricaroides*	0	0	0	0	0	0	0	1	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
Field Pansy	*Viola arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Forget-Me-Not, Field	*Myosotis scorpioides*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Foxglove	*Digitalis purpurea*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Willow Herb, Broad Leaved	*Epilobium montanum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bindweed, Black	*Fallopia convolvulus*	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	0	0
Thistle, Spear	*Cirsium vulgare*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

.....Table 2. Continued

Common names	Scientific names	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000		
		Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop	Within crop	Field margin	Adjac. crop
MONOCOTS																
Reed Canary-Grass	***Phalaris arundinacea***	0	0	0	100	0	0	5	0	0	0	0	0	100	0	0
Couch Grass	*Elymus repens*	34	16	0	0	2	0	17	2	0	17	26	0	0	0	0
Bent, Brown	*Agrostis canina*	0	26	0	2	18	0	16	29	0	14	8	0	0	0	0
Oat-Grass, False or Tall	*Arrhenatherum elatius*	0	23	0	0	60	0	0	20	0	0	0	0	0	2	0
Wheat	***Aesticum sativum***	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0
Oats	***Avena sativa***	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0
Miscanthus	***Miscanthus x giganteus***	21	0	0	0	0	0	0	0	0	68	0	0	0	0	0
Cocksfoot	*Dactylus glomerata*	0	0	0	0	17	0	0	15	0	0	12	0	0	30	0
Bent, Creeping	*Agrostis stolonifera*	0	0	0	0	0	0	0	0	0	0	0	0	1	35	0
Brome, Drooping	*Bromus tectorum*	0	0	0	0	1	0	0	22	0	10	2	0	0	0	0
Tall fescue	*Fescuta arundinacea*	0	3	0	0	0	0	27	0	0	0	0	0	0	0	0
Yorkshire Fog	*Holcus lanatus*	0	0	0	0	4	0	0	6	0	0	0	0	1	19	0
Switch grass	***Panicum virgatum***	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0
Meadow-Grass, Annual	*Poa annua*	2	15	0	0	0	0	0	0	0	0	0	0	1	0	0
Sheep's Fescue, Fine Leaved	*Festuca ovina*	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Rye-Grass, Perennial	*Lolium perenne*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Timothy-Grass, Large Leaved	*Phleum pratense*	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
TREES/SHRUBS																
Bramble (Blackberry)	*Rubus fruticosus*	0	0	0	0	4	0	0	0	0	0	4	0	0	3	0
BRYOPHYTES	*Bryophytes*	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0
Total no of plant species		**12**	**19**	**1**	**3**	**17**	**0**	**17**	**19**	**1**	**7**	**12**	**2**	**5**	**14**	**2**
Total % ground cover		**82**	**132**	**100**	**105**	**150**	**100**	**117**	**157**	**100**	**116**	**175**	**101**	**145**	**132**	**101**
% weed cover (excluding bryophytes)		**61**	**-**	**0**	**5**	**-**	**0**	**85**	**-**	**0**	**48**	**-**	**1**	**5**	**-**	**1**

3.4. GROUND BEETLES

In 2002 season, 84% of the total beetles caught were Carabidae (carabid beetles); 12% were Staphylinidae (rove beetles), and the rest consisted of Silphidae (burying beetles), Scarabaeidae, Chrysomelidae (leaf beetles) and Coccinellidae (lady bird beetles)**.** The majority of the carabid beetles were *Pterostichus* spp. (with 72%), followed by *Harpalus rufipes* (11%) and *Amara* spp. (4%); and this was consistent across all habitats (Table 3 a). The number of catches was greatest for *Miscanthus* fields (120 to 127 beetles); and least for reed canary-grass fields (83 to 86 beetles). It is possible that beetle activity and hence capture rate in pitfall traps could be hindered by the denser reed canary-grass vegetation.

In 2003 season, 83% of the total beetles caught were Carabidae (carabid beetles); 11% were Staphylinidae (rove beetles), and the rest consisted of Silphidae (burying beetles), Curculionidae, Elateridae (Click beetles) and Chrysomelidae (leaf beetles)**.** The majority of the carabid beetles were *Pterostichus* spp. (with 52%), followed by *Amara* spp. (17%) and *Harpalus rufipes* (11%) (Table 3 b). The total number of catches was greatest for SG-2002 (55 individuals), followed by M-2002 (34 individuals). RCG-2002, RCG-2000 and M-2000 recorded similar number of catches: between 19 and 22 individuals.

Table 3. A list of ground beetles and mean number of catches per 10 traps for *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) fields and their surrounding field margins for (a) 2002 growing season and (b) 2003 growing season. Each value is mean of two sampling dates (May and July).

(a) 2002 growing season

Taxonomic group (and species)	M-2002	RCG-2002	SG-2002	M-2000	RCG-2000	Total
Carabidae						
Pterostichus spp.	78	54	72	82	40	326
Harpalus rufipes	8	11	19	10	2	51
Amara spp.	1	0	0	2	14	17
Loricera pilicornis	8	1	1	2	3	15
Trechus spp.	9	1	3	0	0	14
Bembidion spp.	6	0	0	1	2	10
Carabus spp.	0	0	2	3	0	5
Agonum spp.	1	0	0	0	3	4
Clivina fossor	0	0	1	0	2	2
Calathus spp.	1	0	0	1	0	1
Stomis pumicatus	0	0	0	0	0	1
Total carabidae	112	69	99	100	68	447
Staphylinidae	12	10	14	17	14	66
Silphidae	3	8	2	2	2	17
Scarabaeidae	0	0	0	1	0	1
Chrysomelicae	1	0	0	0	0	1
Coccinellidae	1	0	0	0	0	1
Total number of catches	127	86	115	120	83	531

(b) 2003 growing season

Taxonomic group (and species)	M-2002	RCG-2002	SG-2002	M-2000	RCG-2000	Total
Carabidae						
Pterostichus spp.	17	8	22	11	7	65
Amara spp.	8	4	9	0	2	22
Harpalus rufipes	2	3	5	3	2	14
Agonum spp.	2	1	3	0	1	7
Carabus spp	0	1	2	1	2	6
Loricera pilicornis	0	1	2	0	0	3
Clivina fossor	0	0	1	0	1	3
Bembidion spp.	1	0	1	1	0	3
Trechus spp.	1	0	0	0	1	2
Stomis pumicatus	0	1	1	0	0	2
Notiophilus substriatus	0	0	0	1	0	1
Total carabidae	30	17	45	16	17	125
Staphylinidae	2	3	8	2	2	17
Silphidae	1	1	2	0	0	4
Curculionidae	0	1	0	0	1	2
Elateridae	1	1	0	0	1	2
Chrysomelidae	0	0	0	1	0	1
Total number of catches	34	22	55	19	20	150

3.5. BIRDS

A total of 35 species of breeding birds and 24 species of over-wintering birds were recorded in five study sites in 2003 growing season (Table 4 a and b). In 2002 season, the total number was 31 species of breeding birds and 34 species of over-wintering birds. 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 field was greater in *Miscanthus* fields (130 individuals in M-2002 and 30 individuals in M-2000), compared to reed canary-grass (4 or 5 individuals) or switch-grass fields (7 individuals) (Table 4 a). 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 (M-2000 or M-2002).

The most common species using the biomass crop fields during the breeding season include goldfinches (*Carduelis carduelis*), skylarks, stock doves (*Colomba oenas*), lapwings, fieldfares (*Turdus pilaris*), and mistle thrushes (*Turdus viscivorus*). During non-breeding season, the most common species using the biomass crop fields were goldfinches, linnet (*Acanthis cannabina*), meadow pipits (*Anthus pratensis*), skylarks, grey partridge (*Perdix perdix*) and pheasants (*Phasianus colchicus*) (Table 4 b). Wrens (*Troglodytes troglodytes*) and linnets (*Acanthis cannabina*) were also observed to feed within the seed heads of the reed canary-grass in winter.

Skylarks 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 and linnets were using the reed canary-grass seeds as a source of food in winter.

A Kestrel was observed to have been hovering above the switch-grass fields; and also perched on hedge trees at Shobdon and Stoke Prior reed canary-grass field; and buzzards were also observed perching on the trees in the hedges surrounding RCG-2002 and M-2000.

Table 4. A list of bird species and their abundance (mean number of individuals per sighting per field) in each fields of *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) covering the periods between March and November 2003. Each value is mean of 9 sightings in (a) breeding season; and mean of 4 sightings in (b) non-breeding season.

(a) breeding season

Common names	Scientific names	M-2002		RCG-2002		SG-2002		M-2000		RCG-2000		Total
		Crop field	Within hedge	Within crop	Within hedge	Within crop	Within hedge	Within crop	Within hedge	Within crop	Within hedge	
Goldfinch	*Carduelis carduelis*	60	0	0	1	0	1	2	4	0	3	71
Fieldfare	*Turdus pilaris*	10	8	0	0	0	5	0	1	0	28	52
Chaffinch	*Fringilla coelebs*	0	1	0	5	0	5	0	6	1	2	19
Woodpigeon	*Columba palumbus*	6	1	0	3	0	2	2	2	0	2	19
Linnet	*Acanthis cannabina*	4	0	0	2	0	3	5	2	0	3	18
Skylark	*Alauda arvensis*	10	0	2	0	1	0	3	0	0	0	15
Blue Tit	*Parus caeruleus*	0	2	0	3	0	3	0	4	0	3	14
Stock Dove	*Columba oenas*	12	0	0	0	0	0	2	0	0	0	14
Carrion Crow	*Corvus corone*	2	4	0	3	0	2	1	1	0	0	13
Starling	*Sturnus vulgaris*	1	0	0	0	0	0	0	0	0	12	13
Mistle Thrush	*Turdus viscivorus*	0	0	0	1	0	1	10	0	0	0	12
Lapwing	*Vanellus vanellus*	10	0	0	0	0	0	2	0	0	0	12
Blackbird	*Turdus merula*	0	2	0	2	0	1	2	2	1	1	11
Robin	*Erithacus rubecula*	0	2	0	2	0	1	0	2	0	3	9
Wren	*Troglodytes troglodytes*	0	2	0	2	0	2	0	1	2	1	9
Yellowhammer	*Emberiza citrinella*	2	1	0	1	0	1	0	2	0	2	9
Pheasants	*Phasianus colchicus*	0	0	0	1	4	3	0	1	0	0	8
Great Tit	*Parus major*	0	0	0	3	0	2	0	1	0	2	8
Long-tailed Tit	*Aegithalos caudatus*	0	0	0	0	0	8	0	0	0	0	8
Jackdaw	*Corvus monedula*	4	2	0	0	0	0	0	0	0	0	6
Song Thrush	*Turdus philomelos*	0	0	0	1	2	1	0	1	0	1	6
Sedge Warbler	*Acrocephalus schoenobaenus*	0	2	0	0	0	0	0	2	0	2	6
Yellow Wagtail	*Motacilla flava*	3	1	0	0	0	0	0	0	0	2	6
Red-legged partridge	*Alectoris rufa*	3	0	2	0	0	0	0	0	0	0	5
Whitethroat	*Sylvia communis*	0	0	0	2	0	0	1	2	0	0	5

(a) breeding season …… Table 4. Continued

Common names	Scientific names	M-2002		RCG-2002		SG-2002		M-2000		RCG-2000		Total
		Within crop	Within hedge	Within crop	Within hedge	Within crop	Within hedge	Within crop	Within hedge	Within crop	Within hedge	
Chiffchaff	*Phylloscopus collybita*	0	2	0	0	0	1	0	0	0	1	4
Grey Partridge	*Perdix perdix*	2	2	0	0	0	0	0	0	0	0	4
Dunnock	*Prunella modularis*	0	1	0	0	0	0	0	2	0	1	4
Meadow Pipit	*Anthus pratensis*	3	0	0	0	0	0	0	0	0	0	3
Nuthatch	*Sitta europaea*	0	0	0	0	0	3	0	0	0	0	3
Magpie	*Pica pica*	0	2	0	0	0	0	0	0	0	1	3
Blackcap	*Sylvia atricapilla*	0	0	0	1	0	0	0	0	1	0	2
Buzzard	*Buteo buteo*	0	0	0	0	0	0	0	2	0	0	2
Green Finch	*Carduelis chloris*	0	0	0	1	0	1	0	0	0	0	2
Pied/White Wagtail	*Motacilla alba*	0	0	0	0	0	0	1	0	0	0	1
Total no of birds		130	34	4	31	7	45	30	37	5	69	391
Total no of species		15	16	2	17	3	19	11	18	4	18	35

(b) non-breeding season ……Table 4. Continued

Common names	Scientific names	M-2002		RCG-2002		SG-2002		M-2000		RCG-2000		Total
		Within crop	Within hedge	Within crop	Within hedge	Within crop	Within hedge	Within crop	Within hedge	Within crop	Within hedge	
Goldfinch	*Carduelis carduelis*	60	0	0	2	0	0	1	20	0	0	83
Linnet	*Acanthis cannabina*	9	0	5	19	0	0	20	2	6	1	63
Starling	*Sturnus vulgaris*	0	0	0	0	0	0	0	0	0	40	40
Meadow Pipit	*Anthus pratensis*	17	0	0	5	0	0	2	0	0	0	24
Chaffinch	*Fringilla coelebs*	0	0	0	4	0	5	1	5	2	3	19
Skylark	*Alauda arvensis*	16	0	0	0	0	0	3	0	0	0	19
Grey Partridge	*Perdix perdix*	14	0	0	0	0	0	0	0	0	0	14
Pheasants	*Phasianus colchicus*	0	0	3	2	5	2	0	2	0	0	13
Robin	*Erithacus rubecula*	0	0	0	3	0	2	0	2	0	5	12
Blue Tit	*Parus caeruleus*	0	1	0	2	0	2	0	3	0	3	11
Wren	*Troglodytes troglodytes*	0	0	0	2	2	2	0	3	0	3	11
Long-tailed Tit	*Aegithalos caudatus*	0	0	0	0	0	8	0	0	0	0	8
Blackbird	*Turdus merula*	0	0	0	1	0	0	0	1	0	4	6
Woodpigeon	*Columba palumbus*	0	2	0	1	0	2	0	0	0	0	5
Red-legged partridge	*Alectoris rufa*	4	0	0	0	0	0	0	0	0	0	4
Yellowhammer	*Emberiza citrinella*	0	0	0	0	0	0	0	4	0	0	4
Great Tit	*Parus major*	0	0	0	3	0	0	0	0	0	0	3
Buzzard	*Buteo buteo*	0	0	0	1	0	1	0	0	0	0	2
Kestrel	*Falco tinnunculus*	0	0	0	0	0	1	0	0	0	1	2
Pied/White Wagtail	*Motacilla alba*	2	0	0	0	0	0	0	0	0	0	2
Carrion Crow	*Corvus corone*	0	0	0	0	0	1	0	0	0	0	1
House Sparrow	*Passer domesicus*	0	0	0	0	0	0	0	1	0	0	1
Magpie	*Pica pica*	0	0	0	0	0	0	0	0	0	1	1
Yellow Wagtail	*Motacilla flava*	1	0	0	0	0	0	0	0	0	0	1
Total no of birds		123	3	8	44	6	25	27	44	8	60	348
Total no of species		8	2	2	12	2	10	5	10	2	9	24

3.6. SMALL-MAMMALS

In 2003 growing season, a total of six species of small-mammals were caught from five of the biomass crop fields. The most dominant species were wood mouse (*Apodemus sylvaticus*); followed by common shrew (*Sorex araneus*) and field vole (*Microtus agrestis*). Less dominant species included pygmy shrew (*Sorex minutus*) and bank vole (*Clethrionomys glareolus*). Yellow-necked mouse (*Apodemus flavicollis*) was caught only in the field margins of *Miscanthus* crop at Lingen (M-2000) (Table 5). Water shrews, house mice and weasels, which were caught in only one site and in very low numbers in 2002 season, were not caught in 2003 season. The single most dominant small-mammal species in both seasons was wood mouse.

Total number of small-mammals caught was similar in four of the sites (6 to 8 individuals), but was substantially low in M-2000 fields (3 individuals). Small-mammal species diversity was greatest in reed canary-grass (3 to 5 species) and switch-grass fields (3 species); whereas, only wood mice were caught in *Miscanthus* fields.

As in 2002 season, the number of small-mammals caught in field margins was greater than those caught within crop fields consistently across all sites. In 2002 season, a total of 257 individual small-mammals were captured during 1520 trap nights; in 2003 season, the number was only 129.

Table 5. Small-mammals species and their abundance (number of individuals per night per 100 traps) in each field of *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) for 2003 season. Each value is mean of two sampling periods (March and September).

Common names	Scientific names	M-2002		RCG-2002		SG-2002		M-2000		RCG-2000		Total
		Within crop	Field margin	Within crop	Field margin	Within crop	Field margin	Within crop	Field margin	Within crop	Field margin	
Wood mouse	*Apodemus sylvaticus*	6	7	4	4	1	0	2	9	2	4	39
Common shrew	*Sorex araneus*	0	0	1	2	3	4	0	0	1	2	13
Field vole	*Microtus agrestis*	0	0	1	2	1	4	1	0	1	2	12
Pygmy shrew	*Sorex minutus*	0	0	0	2	1	2	0	0	2	0	7
Bank Vole	*Clethrionomys glareolus*	0	0	0	0	0	1	0	0	2	1	4
Yellow-necked mouse	*Apodemus flavicollis*	0	0	0	0	0	0	0	2	0	0	2
Total number of individuals		6	7	6	10	6	11	3	11	8	9	80
Total number of species		1	1	3	4	4	4	2	2	5	4	6

3.7. BUTTERFLIES

A total of 10 butterfly species were recorded in five biomass grass fields and their surrounding field margins in 2003 season (Table 6). Eight species of butterflies were recorded in 2002 season. In the current season, the most common and dominant species within crop fields were small white (*Pieris rapae*), small tortoise shell (*Aglais urticae*) and painted lady (*Cynthia cardui*) with total number of 58, 39 and 15 individuals, respectively, in five fields. Small white was also one of the abundant species in field margins along with meadow brown (*Maniola jurtina*), ringlet (*Aphantopus hyperantus*) and small tortoise shell with 35, 27, 17 and 14 individuals, respectively.

There were more butterflies foraging within field margins than within crop fields in RCG-2002, SG-2002 and M-2000; but number of butterflies foraging within crop fields was three and two times more than those foraging in the field margins in M-2002 and RCG-2000, respectively. The total number of butterflies foraging in crop fields was greatest in *Miscanthus* fields (85 butterflies in M-2002; and 21 in M-2000), followed by switch-grass (17 individuals) and reed canary-grass (12 individuals in RCG-2000 and only 3 individuals in RCG-2002).

In contrast, the total number of butterflies in 2002 season was greatest in newly planted reed canary-grass (RCG-2002), followed by newly planted *Miscanthus* (M-2002) fields.

Table 6. Butterfly species and their abundance (number of individuals per sighting per field) in each field of *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) for 2003 season. Each value is mean of three sightings in June, July and August.

Common names	Scientific names	M-2002		RCG-2002		SG-2002		M-2000		RCG-2000		Total
		Within crop	Field margin	Within crop	Field margin	Within crop	Field margin	Within crop	Field margin	Within crop	Field margin	
Small white	*Pieris rapae*	37	2	2	10	5	4	13	13	2	2	88
Small tortoise shell	*Aglais urticae*	37	6	0	2	1	2	0	4	0	0	52
Meadow brown	*Maniola jurtina*	1	3	1	11	6	6	1	6	1	2	38
Ringlet	*Aphantopus hyperantus*	0	0	0	5	2	10	1	1	3	2	23
Painted lady	*Cynthia cardui*	9	4	0	0	0	0	6	2	0	0	21
Hedge brown	*Maniola tithonus*	0	1	0	3	0	0	0	5	1	0	10
Small skipper	*Thymelicus sylvestris*	0	0	0	0	0	0	0	0	4	1	5
Peacock	*Inachis io*	0	0	0	1	2	0	0	0	0	0	3
Red admiral	*Vanessa atalanta*	0	1	0	0	0	0	0	0	0	0	1
Speckled wood	*Pararge aegeria*	0	0	0	0	0	1	0	0	0	0	1
Total number of individuals		85	17	3	33	17	22	21	30	12	6	242
Total number of species		4	6	2	6	5	5	4	6	5	4	10

3.8. EPIGEAL INVERTEBRATES

Diptera

In the 2002 growing season, over 85% of the Diptera recorded within five biomass crop fields consisted of Bibionidae, Sciaridae, Chironomidae and Chloropidae, with these families accounting for 56%, 8%, 8%, 8% and 5%, respectively. Within the field margins, Bibionidae, Sciaridae, Chironomidae, Chloropidae and Lonchopteridae accounted for 75% of the Diptera; whereas within the hedges, Bibionidae, Sciaridae and Anthomyzidae accounted for 100% of the Diptera recorded. Total number of individuals and species of Diptera was greatest in M-2002 crop fields, followed by SG-2002 and M-2000; and was least in RCG-2002 and RCG-2000 crop fields (Table 7 a).

In the 2003 season, 79% of the Diptera recorded in five biomass crop fields were Phoridae, Anthomyzidae, Sciaridae and Chloropidae accounting for 57%, 13%, 5%, 4% and 3% respectively. In the field margins, 69% of the Diptera consisted of Anthomyzidae, Dolichopodidae, Cecidomyiidae, Chloropidae and Sciaridae accounting for 34%, 11%, 9%, 8% and 7% respectively. Greatest number of Diptera was recorded from M-2002 (106 individuals); the rest of the biomass crop fields recorded less than 20 individuals (Table 7 b).

The single most dominant Dipteran group in 2003 season was the Phoridae with 57%; but in 2002 season, it was the Bibionidae with 56%. In both 2002 and 2003 season, the abundance of Diptera was greatest in *Miscanthus* and switch grass crop fields compared to reed canary-grass fields.

Hymenoptera

In the 2002 season, five of the families of Hymeoptera within the five biomass crop fields and its surroundings belonged to the sub-order Apocrita. The most dominant family within the crop fields was Platygasteridae accounting for 53%, and Pteromalidae accounting for 29%. Cynipidae was the most dominant family within the headlands (with 30%) as well as within the hedges (with 52%). Total counts of Hymenopera (10 individuals) and number of families (3 families) was greatest in M-2002 field (Table 8 a).

In the 2003 season, Hymenoptera families within the crop fields consisted mainly of Pteromalidae and Platygasteridae accounting for 51% and 30% respectively. Both of these families (Pteromalidae and Platygasteridae) were also the most dominant in the headlands accounting for 72% and 10% respectively. In the hedges, 90% of the Hymenoptera consisted of Pteromalidae, Ichneuminidae, Platygasteridae and Braconidae; accounting for 32%, 28%, 15% and 15% respectively. As in the 2002 season, total counts of Hymenoptera (20 individuals) was greatest in M-2002 crop fields in the 2003 season. SG-2002, RCG-2002 and M-2000 crop fields recorded seven individuals or less each; and RCG-2000 recorded none of Hymenoptera (Table 8 b).

The single most dominant family in the 2003 season was the Pteromalidae with 51%, whereas in the 2002 season, it was the Platygasteridae with 53%.

Hemiptera:Heteroptera

In the 2002 season, 92% of the Heteroptera recorded within the five biomass crop fields consisted of Miridae and Anthocoridae accounting for 72% and 20% respectively. Both of these families, Miridae and Anthocoridae, were also the most dominant in the headlands (61% and 26% respectively) and in the hedges (7% and 86% respectively). SG-2002 recorded the greatest Heteroptera abundance with 37 individuals, followed by M-2002, with 18 individuals. M-2000, RCG-2002 and RCG-2000 crop fields recorded less than 16 individuals between them (Table 9 a).

In the 2003 season, all the Heteroptera recorded within the five biomass crop fields consisted of Miridae and Anthocoridae accounting for 54% and 46% respectively. Both of these families, Miridae and Anthocoridae, were also the most dominant in the headlands (87% and 12% respectively) and in the hedges (65% and 35% respectively). This is similar to the results obtained in 2002 season. SG-2002 crop field recorded the greatest Heteroptera abundance with 83 individuals, followed by M-2002 with 49 individuals. M-2000, RCG-2000 and RCG-2002 crop fields recorded three individuals or less each (Table 9 b).

In both 2002 and 2003 season, the two most dominant Heteroptera families in the biomass crop fields were Miridae and Anthocoridae; also in both season, the greatest number of Heteroptera were recorded from SG-2002 crop field.

Hemiptera:Homoptera

In the 2002 season, Homopteran samples were dominated by Aphididae comprising of 99% in five biomass crop fields. Aphididae also was one of the dominant families in the headlands and in the hedges recording 30% and 32% respectively. Other dominant Homoptera families were Cicadellidae (46%) and Cercopidae (23%) in the headlands; and Psyllidae (41%) in the hedges. RCG-2000 recorded the greatest Homoptera (due to entirely Aphididae) of the five biomass crop fields; 25% of the crop field was infested with aphids (Table 10 a).

In the 2003 season, Homopteran samples were dominated by Aphididae and Cicadellida comprising of 77% and 12% respectively in five biomass crop fields. Aphididae also was one of the dominant families of Homoptera in the headlands (with 50%) and in the hedges (with 25%). Other dominant Homoptera families in the headlands were Cercopidae (31%) and Cicadellidae (14%); and in the hedges, Cicadellida (36%), Psyllidae (23%) and Cercopidae (14%). RCG-2002 recorded the greatest Homoptera of the five biomass crop fields, followed by RCG-2000, M-2000, SG-2002 and M-2002 (Table 10 b).

Aphididae was the single most dominant Homopteran family in both 2002 and 2003 season, with 99% and 77% of all Homoptera, respectively.

Coleoptera

In the 2002 season, 100% of the Coleoptera recorded within the five biomass crop fields consisted of Chrysomelidae (76%), Curculinidae (20%), and Coccinellidae (4%). These three families of Coleoptera were also the most dominant in the headlands and in the hedges, comprising of 97% and 92%, respectively. The greatest number of Coleoptera were found in the M-2002 crop fields (60 individuals), followed by M-2000 (46 individuals) and SG-2002 (34 individuals); RCG-2002 recorded 3 individuals (Table 11 a).

In the 2003 season, eighty two percent of the Coleoptera recorded within the five biomass crop fields consisted of Elateridae, Cantharidae, Phalacridae and Curculinidae accounting for 29%, 21%, 21% and 11% respectively. In the headlands, 86% of the Coleoptera consisted of Coccinellidae (33%), Chrysomelidae (20%), Curculinidae (17%), and Phalacridae (16%). In the hedges, 84% of the Coleoptera comprised of Coccinellidae (36%), Cantharidae (21%), Chrysomelidae (14%) and Elateridae (13%). The greatest number of Coleoptera was found in the M-2002 crop field (57 individuals), followed by M-2000 (22 individuals); SG-2002, RCG-2002 and RCG-2000 crop fields recorded 4 individuals each (Table 11 b).

Psocoptera

In 2002 season, 100% of the Psocoptera recorded within the biomass crop fields belonged to the Ectopsocidae. Families of the Psocoptera found in the headlands and hedges, included Ectopsocidae, Lachesillidae and Peripscocidae. Most of the Psocoptera were found in the hedges (Table 12).

Collombolla

No Collombolla were recorded using sweep-netting or beating the stems of the biomass grass crops either in 2002 or 2003 season. Families recorded from the headlands and hedges included Dicrytomidae and Neelidae (Table 12).

Table 7. Mean counts of Diptera (per 10 samples) caught using sweep netting and/or branch/stem beating in *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) crop fields (within crop) and their surrounding field margins in (a) 2002 and (b) 2003 season. Families are arranged in descending order based on total counts of five habitats.

(a) 2002 season

Diptera families	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000			Total
	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	
Bibionidae	22	0	-	11	5	1	22	8	20	6	4	9	6	13	0	127
Sciaridae	2	2	-	0	4	0	0	2	2	3	2	2	4	29	0	52
Chironomidae	4	0	-	2	6	0	0	0	0	1	17	0	2	1	0	33
Chloropidae	0	3	-	0	9	0	0	4	0	8	3	0	1	4	0	32
Lonchopteridae	4	8	-	0	1	0	1	3	0	1	0	0	0	13	0	31
Anthomyzidae	2	0	-	0	0	0	0	0	0	0	1	3	0	10	0	16
Drosophilidae	3	7	-	0	0	0	1	2	0	2	0	0	0	1	0	16
Opomyzidae	4	0	-	0	0	0	0	2	0	0	0	0	0	5	0	11
Agromyzidae	0	6	-	0	0	0	1	0	0	0	0	0	0	0	0	7
Phoridae	1	0	-	0	1	0	0	3	0	0	0	0	0	0	0	5
Cecidomyiidae	1	0	-	0	1	0	0	1	0	0	0	0	0	0	0	3
Syrphidae	0	1	-	0	1	0	0	0	0	0	0	0	0	1	0	3
Calliphoridae	0	0	-	2	0	0	0	0	0	0	0	0	0	0	0	2
Carniidae	1	0	-	0	0	0	0	0	0	0	0	0	0	0	0	1
Dolichopodidae	0	1	-	0	0	0	0	0	0	0	0	0	0	0	0	1
Micropezidae	0	0	-	0	0	0	1	0	0	0	0	0	0	0	0	1
Ptychopteridae	0	0	-	0	0	0	0	1	0	0	0	0	0	0	0	1
Sepsidae	0	0	-	0	0	0	0	0	0	0	0	0	0	1	0	1
Tipulidae	0	0	-	0	0	0	0	0	0	0	0	0	0	1	0	1
Total no of individuals	44	28	-	15	28	1	26	26	22	21	27	14	13	79	0	344
Total no of families	10	7	-	3	8	1	5	9	2	6	5	3	4	11	0	19

(b) 2003 season … Table 7. Continued

Diptera families	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000			Total
	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	
Anthomyzidae	0	10	-	4	3	0	11	78	0	4	5	9	1	19	0	144
Phoridae	87	0	-	1	0	0	0	0	1	0	0	0	0	0	1	90
Dolichopodidae	0	1	-	1	5	0	0	28	9	1	1	5	2	3	0	55
Chloropidae	3	7	-	2	4	1	0	7	0	1	5	2	1	3	5	40
Sciaridae	2	2	-	3	5	1	0	10	0	3	3	5	0	5	3	39
Cecidomyiidae	0	10	-	1	1	0	3	14	1	0	2	0	1	2	1	35
Lauxaniidae	0	2	-	1	6	0	0	8	0	1	1	2	1	3	0	24
Bibionidae	6	0	-	0	1	0	0	10	1	3	0	0	0	0	0	20
Opomyzidae	1	1	-	0	8	0	0	2	0	0	0	0	0	4	0	15
Sepsidae	7	2	-	0	0	0	0	2	0	0	0	0	0	0	0	11
Chironomidae	0	4	-	0	0	0	0	0	1	3	2	0	0	1	0	11
Chamaeyiidae	0	0	-	0	0	0	0	8	0	0	0	0	0	0	0	8
Syrphidae	0	4	-	0	1	0	0	2	0	1	0	0	0	0	0	7
Heleomyzidae	0	0	-	0	0	0	0	6	0	0	0	1	0	0	0	7
Stratiomyidae	0	0	-	0	0	0	0	0	0	0	3	1	0	1	1	6
Tephritidae	0	1	-	1	0	0	0	2	0	0	2	0	0	0	0	5
Drosophilidae	0	5	-	0	0	0	0	0	0	0	0	0	0	0	0	5
Agromyzidae	0	0	-	0	1	0	0	2	0	0	2	0	0	0	0	4
Scatopsicae	0	0	-	0	0	0	0	0	0	0	3	0	0	0	0	3
Calliphoridae	0	1	-	0	0	0	0	2	0	0	0	0	0	0	0	3
Empididae	0	1	-	1	0	1	0	0	1	0	0	0	0	0	0	3
Tabanidae	0	0	-	0	0	0	0	2	1	0	0	0	0	0	0	3
Platystomatidae	0	0	-	0	0	0	0	2	0	0	0	0	0	0	0	2
Acroceridae	0	0	-	0	0	0	0	0	0	1	0	0	0	0	0	1
Tipulidae	0	1	-	0	0	0	0	0	0	0	0	0	0	0	0	1
Culicidae	0	0	-	0	0	1	0	0	0	0	0	0	0	0	0	1
Lonchopteridae	0	0	-	0	1	0	0	0	0	0	0	0	0	0	0	1
Total no of individuals	106	52	-	12	33	3	13	183	14	18	28	23	6	42	11	542
Total no of families	6	15	-	9	11	4	2	17	7	9	11	7	5	9	5	27

Table 8. Mean counts of Hymenoptera (per 10 samples) caught using sweep netting and/or branch/stem beating in *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) crop fields (within crop) and their surrounding field margins in (a) 2002 season and (b) 2003 season. Each value in 2003 season is mean of two sampling dates in May and July. Families are arranged in descending order based on total counts of five habitats.

	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000			Total
Hymenoptera families	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	
(a) 2002 season																
Cynipidae	0	0	-	1	3	1	0	6	0	0	3	0	1	15	13	43
Braconidae	7	7	-	0	4	2	2	2	1	0	3	1	0	0	0	29
Platygasteridae	1	0	-	0	7	1	0	4	2	0	10	0	0	0	0	25
Ichneuminidae	0	1	-	0	0	0	0	6	0	0	2	0	0	7	2	18
Pteromalidae	2	1	-	0	6	0	2	2	0	1	0	3	0	0	1	18
Total no of individuals	10	9	-	1	20	4	4	20	3	1	18	4	1	22	16	133
Total no of families	3	3	-	1	4	3	2	5	2	1	4	2	1	2	3	5
(b) 2003 season																
Pteromalidae	10	28	-	4	14	1	2	133	3	3	5	8	0	28	4	242
Platygasteridae	10	16	-	0	0	0	1	5	4	1	8	2	0	1	1	48
Ichneuminidae	0	8	-	0	1	2	1	8	4	3	3	5	0	0	4	37
Braconidae	0	6	-	0	1	0	3	4	1	0	3	4	0	5	2	27
Cynipidae	0	5	-	0	1	1	1	4	0	0	0	1	0	2	1	16
Tiphiidae	0	0	-	0	0	0	0	2	0	0	1	2	0	0	0	4
Total no of individuals	20	63	-	4	16	3	6	155	12	7	18	22	0	36	12	373
Total no of families	2	5	-	1	4	3	5	6	4	3	5	6	0	4	5	6

Table 9. Mean counts of Hemiptera:Heteroptera (per 10 samples) caught using sweep netting and/or branch/stem beating in *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) crop fields (within crop) and their surrounding field margins in (a) 2002 season and (b) 2003 season. Each value in 2003 season is mean of two sampling dates in May and July. Families are arranged in descending order based on total counts of five habitats.

	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000			Total
Hemiptera: heteroptera families	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	
(a) 2002 season																
Miridae	12	20	-	0	14	1	31	96	6	3	31	0	4	34	0	252
Anthocoridae	3	14	-	4	5	19	5	5	32	2	26	10	0	33	22	180
Nabidae	0	5	-	0	0	0	1	34	0	0	0	0	0	0	1	41
Pentatomidae	3	0	-	0	0	0	0	0	0	0	0	2	0	0	2	7
Berytidae	0	1	-	0	0	0	0	0	2	1	0	0	0	0	0	4
Acanthosomatidae	0	0	-	0	0	0	0	0	0	0	2	0	0	0	0	2
Total no of individuals	18	40	-	4	19	20	37	135	40	6	59	12	4	67	25	486
Total no of families	3	4	-	1	2	2	3	3	3	3	3	2	1	2	3	6
(b) 2003 season																
Miridae	45	240	-	2	54	6	25	157	18	3	168	5	0	57	21	801
Anthocoridae	4	41	-	0	4	4	58	17	8	0	19	12	2	11	2	183
Coreidae	0	0	-	0	0	0	0	0	0	0	7	0	0	0	0	7
Pentatomidae	0	0	-	0	0	0	0	0	0	0	0	1	0	1	0	2
Nabidae	0	0	-	0	1	0	0	0	0	0	0	0	0	0	0	1
Total no of individuals	49	281	-	2	58	10	83	175	26	3	194	18	2	69	24	993
Total no of families	2	2	-	1	2	2	2	2	2	1	3	3	1	3	2	4

Table 10. Mean counts of Hemiptera:Homoptera (per 10 samples) caught using sweep netting and/or branch/stem beating in *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) crop fields (within crop) and their surrounding field margins in (a) 2002 season and (b) 2003 season. Each value in 2003 season is mean of two sampling dates in May and July. Families are arranged in descending order based on total counts of five habitats.

	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000			Total
Hemiptera: homoptera families	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	
(a) 2002 season																
Aphididae	3	41	-	0	6	0	7	1	17	3	4	2	2184	8	1	2277
Cicadellidae	1	3	-	0	26	1	8	5	2	1	22	1	0	35	6	111
Cercopidae	2	0	-	0	7	2	0	6	2	0	12	2	0	21	1	55
Psyllidae	0	0	-	0	1	0	0	0	0	0	0	26	0	0	0	27
Delphacidae	0	0	-	0	0	0	0	1	0	0	0	0	0	0	0	1
Total no of individuals	6	44	-	0	40	3	15	13	21	4	38	31	2184	64	8	2471
Total no of families	3	2	-	0	4	2	2	4	3	2	3	4	1	3	3	5
(b) 2003 season																
Aphididae	6	49	-	108	8	3	0	128	0	7	13	7	0	257	13	598
Cercopidae	0	3	-	2	13	1	3	13	2	1	6	7	0	246	4	300
Cicadellidae	1	10	-	1	29	5	5	47	5	2	22	6	11	6	18	164
Psyllidae	0	2	-	1	5	1	0	14	10	4	17	9	0	13	1	77
Delphacidae	0	0	-	0	1	0	0	9	0	0	0	0	6	0	0	16
Cixiidae	0	0	-	0	0	1	0	2	0	0	0	1	0	0	1	4
Total no of individuals	7	64	-	112	55	10	8	213	17	13	57	29	17	522	37	1158
Total no of families	2	4	-	4	5	5	2	6	3	4	4	5	2	4	5	6

Table 11. Mean counts of Coleoptera (per 10 samples) caught using sweep netting and/or branch/stem beating in *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) crop fields (within crop) and their surrounding field margins in (a) 2002 season and (b) 2003 season. Each value in 2003 season is mean of two sampling dates in May and July. Families are arranged in descending order based on total counts of five habitats.

Coleoptera families	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000			Total
	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	
(a) 2002 season																
Chrysomelidae	54	47	-	0	71	8	24	20	19	29	13	5	0	0	24	292
Coccinellidae	3	8	-	0	12	0	2	36	4	1	1	1	0	3	0	70
Curculinidae	3	2	-	1	1	1	8	10	10	16	8	5	0	12	0	69
Staphylinidae	0	0	-	0	0	0	0	0	3	0	1	0	0	3	0	7
Elateridae	0	0	-	0	2	2	0	0	1	0	0	0	0	0	0	5
Total no of individuals	60	57	-	1	86	11	34	66	37	46	23	11	0	18	24	443
Total no of families	3	3	-	1	4	3	3	3	5	3	4	3	0	3	1	5
(b) 2003 season																
Coccinellidae	0	10	-	1	44	1	1	50	3	1	2	0	0	36	1	148
Curculinidae	9	6	-	0	12	7	0	26	2	0	16	16	1	12	5	111
Chrysomelidae	8	19	-	0	13	3	0	36	2	0	17	6	0	0	1	103
Phalacridae	18	39	-	0	0	0	1	11	1	1	13	1	0	6	0	89
Cantharidae	0	13	-	0	4	6	0	20	8	16	1	1	3	1	3	75
Elateridae	23	6	-	1	1	3	0	2	4	3	3	1	0	1	3	49
Staphylinidae	0	2	-	0	1	1	2	2	1	1	2	1	0	0	0	11
Carabidae	0	0	-	3	1	1	1	0	2	0	2	1	0	0	0	9
Scarabaeidae	0	0	-	0	1	0	0	0	0	0	1	0	0	0	0	1
Cerambycidae	0	0	-	0	0	1	0	0	0	0	0	0	0	0	0	1
Tenebrionidae	0	0	-	0	0	1	0	0	0	0	0	0	0	0	0	1
Total no of individuals	57	95	-	4	73	22	4	147	23	22	54	26	4	56	11	596
Total no of families	4	7	-	3	8	8	4	7	8	5	9	7	2	5	5	11

Table 12. Mean counts of Psocoptera and Collombolla (per 10 samples) caught using sweep netting and/or branch/stem beating in *Miscanthus* (M-2000 and M-2002), reed canary-grass (RCG-2000 and RCG-2002) and switch-grass (SG-2002) crop fields (within crop) and their surrounding field margins in 2002 season. Families are arranged in descending order based on total counts of five habitats.

Taxonomic groups and their families	M-2002			RCG - 2002			SG - 2002			M - 2000			RCG - 2000			Total
	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	Within crop	Head-lands	Hedges	
Psocoptera																
Ectopsocidae	1	0	-	0	0	15	1	0	28	3	1	20	0	0	0	69
Lachesillidae	0	0	-	0	0	2	0	0	0	0	0	1	0	0	0	3
Peripscocidae	0	0	-	0	0	0	0	0	0	0	0	3	0	0	0	3
Total no of individuals	1	0	-	0	0	17	1	0	28	3	1	24	0	0	0	75
Total no of families	1	0	-	0	0	2	1	0	1	1	1	3	0	0	0	3
Collombolla																
Dicyrtomidae	0	0	-	0	2	2	0	1	2	0	0	28	0	5	0	40
Neelidae	0	0	-	0	0	0	0	0	0	0	0	1	0	0	0	1
Total no of individuals	0	0	-	0	2	2	0	1	2	0	0	29	0	5	0	41
Total no of families	0	0	-	0	1	1	0	1	2	0	0	2	0	1	0	2

4. 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. 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 crops supported greater flora and fauna, since they are managed with no fertilizers, no insecticides, no fungicides, and minimal use of herbicides targeting only problem weeds once a year in the establishment years.

Due to weed control measure problems combined with its natural initial slow growth early in the season, the switch-grass field (SG-2002) scored the greatest weed flora ground cover, 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 on *Miscanthus* and reed canary-grass. The *Miscanthus* field at Shobdon (M-2002) was characterized by low crop plant density (18 stems m^{-2}; between 1 to 2 plants m^{-2}) that contributed to 22% ground cover. *Miscanthus* field at Lingen (M-2000) was a relatively high crop density (86 stems m^{-2}; around 16 plants m^{-2}) and covered 80% of the ground.

Miscanthus fields were richer in weed vegetation and had greater bare ground patches than reed canary-grass. Percentage weed cover in the *Miscanthus* fields ranged from 48% to 68%, compared to 5% in reed canary-grass fields. Within the biomass crop fields, some of the weed flora species which are important food sources for granivorous birds were *Cirsium arvensis* (creeping thistle), *Capsella bursa-pastoris* (Shepherds' purse), *Chenopodium album* (fathen), *Chenopodium bonus-henricus* (goosefoot), *Senecio vulgaris* (groundsel), *Sinapsis 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 substantially more skylarks, meadow pipits and lapwings in the *Miscanthus* (M-2000 or M-2002) than in the reed canary-grass or switch-grass habitats, indicating that *Miscanthus* fields were preferred by those bird species largely because the *Miscanthus* canopy takes several seasons to close. Biomass crop fields provide not only nesting habitat for ground-nesting species, such as skylarks and lapwings, but also a winter foraging habitat for the wide range of species which exploit the crop fields for invertebrate and seed foods as well as for cover. 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.

As in 2002 season, the number of skylarks using the *Miscanthus* field at Lingen (M-2000) in 2003 season 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 *Miscanthus* field at Shobdon (M-2002) increased with time, mainly due to the addition of migratory skylarks in early autumn, suggesting that, until large hectarages of *Miscanthus* are planted, the inter-site variation cannot be assessed.

Faunal diversity is generally related with floral diversity; therefore, the greatest number of species tends to be in field margins and the most open biomass crop fields. The sweep-netting and stem/branch beating technique clearly demonstrates this. When comparing the three biomass crop fields, invertebrates 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* field was by far greater than that found within the reed canary-grass field. Number of butterflies in the RCG-2002 declined from first year of its planting to its second 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. The most important invertebrate food taxa in the biomass crop fields were Coleoptera (Curculionidae, Chrysomelidae, Carabidae, Staphylinidae, 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.

No crop-type specificity was observed by the ground beetles despite the differences in the phenology of canopy development of the three biomass crops. The occurrence and abundance of field-inhabiting ground beetles was related with weediness of the crop fields; more carabids were found in densely weeded *Miscanthus* fields than in less weedy reed canary-grass field. This was probably due to 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 foraging in crop fields was greatest in *Miscanthus* fields. As observed during field monitoring, this was related to the number of thistles in the crop field; there were more butterflies in fields with more flowering thistles. The ground flora data also supports this observation; there was 7% ground cover by creeping thistles in M-2002; 4% in M-2000; 2% in SG-2002 and nil in RCG-2002 and RCG-2000. 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 biomass crop fields across all sites. There was no particular crop 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. Vegetation cover provided by biomass crops was probably important to small mammals for protection from predation. M-2000 and RCG-2000 had greater small-mammal diversity in 2002 season due to their greater ground cover. In the 2003 season, however, fewer small-mammals were caught in M-2000 field possibly because of the mechanical land disturbance during rhizome lifting.

In the 2002 season, a total of 257 individual small-mammals were captured during 1520 trap nights, compared to 129 individuals in the 2003 season. The greatest number of small-mammals caught in the 2002 season was in line with an explosion of rodent numbers recorded across

Britain due to earlier spring and later autumn 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.

In conclusion, 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 Coleoptera, Hymenoptera, Diptera, Lepidoptera and Hemiptera species; and provided cover for birds and small-mammals. It should be noted that this 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 include more sites as they become available and to assess biodiversity over longer period until, at least, full canopy cover is achieved by the *Misanthus* crop itself.

5. Plans for next year

The following major tasks are scheduled for the next growing season:

- Complete invertebrate identification from 2003 season, and follow up with data entry and analysis.
- Re-survey all the sites for key fauna and flora, and carry out field assessments for crop characteristics, as in the previous season, as follows:

Survey	Number of assessments
Ground flora	once
Ground beetles	twice
Arboreal invertebrates	twice
Birds	15 times
Small-mammals	twice
Butterflies	three times

- Crop characteristics such as plant height and plant/stem density will also be assessed on a regular basis and when necessary; biomass of weeds and crop will be assessed in September.

7. References

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