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Buffer zones for biodiversity of plants and arthropods: is there a compromise on width?

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Rev vi marken let
Det er gammel ret
fuglen og den fattige
skal også være mæt
(Mads Henriksen 1868)

Preface

The present report "Buffer zones for biodiversity of plants and arthropods: is there a compromise on width?" on buffer zones along hedges represents a follow-up on a review publication from the Danish Ministry of Environment (Sigsgaard ***et al.*** 2007). That review addressed the potential use of various types of buffer zones to improve biodiversity and natural pest regulation in arable fields. The review publication established a need for research on the necessary dimensions of buffer zones, if such zones should become an operational and efficient tool to conserve biodiversity under pressure from intensive modern agriculture.

On this background, the Ministry of Environment made a call for research proposals among which the present project was financed. The project focuses on identifying a buffer zone width, which can both ensure a significant biodiversity increase and also be agriculturally feasible. The project has used plants, insects and spiders to measure biodiversity effects of different widths of buffer zones in spring barley.

The project has involved the following institutions and persons:

- Department of Agriculture and Ecology, University of Copenhagen (zoological expertise): Peter Esbjerg (Project leader), Lene Sigsgaard, Rasmus Nimgaard and Søren Navntoft.
- Department of Biology, University of Copenhagen (botanical expertise): Louise C. Andresen, Ib Johnsen, Niels Bruun, Jill Nothlev and Andreas Kelager.
- Department of Genetics and Biotechnology, University of Aarhus (statistical expertise): Kristian Kristensen.

The project group enjoyed current guiding discussions with an expert group:

- Jørn Kirkegaard (coordinator) and Lise Samsøe-Petersen, Environmental Protection Agency, Danish Ministry of Environment.
- Hans-Werner Griepentrog, Jannie Maj Olsen and Jacob Weiner, Dept. of Agriculture and Ecology, Univ. of Copenhagen.
- Lisa Munk, Dept. of Plant Biology and Biotechnology, Univ. of Copenhagen.
- Søren Marcus Pedersen and Jens Erik Ørum, Dept. of Food and Resource Economics, Univ. of Copenhagen.
- Lise Nistrup Jørgensen, Dept. of Integrated Pest Management, Univ. of Aarhus.
- Hanne Lindhard Pedersen, Dept. of Horticulture, Univ. of Aarhus.
- Poul Henning Petersen, Danish Agricultural Advisory Service.
- Niels Lindemark, Danish Crop Protection Association.
- Marc Trapman, BioFruitAdvices.

We thank the whole group for the collaboration.

The project was hosted by Gjorslev Estate. We owe the owner Peter Tesdorph sincere thanks for this possibility. The project layout and the treatments were managed in a most careful and competent way. For this we are very grateful to the Estate Manager Anders Bak Hansen and his most skilled Machine Operator Frank Holm. Without the skills and support from Peter Tesdorph and his staff this fairly complicated large scale project design could not have been carried out.

Summary

This report presents the results of a one-season field investigation of plant and arthropod biodiversity, as affected by the width of hedge-bordering buffer zones, maintained without application of fertilizers and pesticides. A review on buffer zones in arable fields (Sigsgaard et al. 2007) pointed at the effect of buffer width on biodiversity in and along agricultural fields as a question calling for attention. The Danish Ministry of Environment made a call for research projects; among other subjects on this aspect of buffer zones. The present project, which incorporated buffer zones of 4, 6, 12 and 24 m and a 0-m control was accepted, and started 2008. It included co-workers from University of Copenhagen (Department of Agriculture and Ecology and Department of Biology) and University of Aarhus (Department of Genetics and Biotechnology).

The aim of the project was to identify a buffer width which would significantly increase biodiversity in the field and in the hedge and which would also be agriculturally acceptable. For this, the effects of buffer zones of different widths were compared in order to investigate whether there is a compromise on width with respect to the increase in biodiversity and the agricultural feasibility. The buffer zones were placed along hedges in four large fields with spring sown barley at Gjorslev Estate on Eastern Zealand. In these zones, the hedge plant composition (woody species and dominant herbs) and their flowering was registered. This was followed by further plant species and plant density counts in the field. The plants' flowering and generative stage were also noted. Insects and spiders were recorded by four methods three times during the season: beating tray sampling in hedges, transect counts of flying insects, sweep net sampling and pitfall trapping in the hedge-bottom and field areas.

Plants were identified mainly to species, and this was also the case for a considerable quantity of insects (e.g. butterflies, bumblebees, ground and leaf beetles, weevils and true bugs) while others were identified to genus, family or other well defined groups (e.g. small parasitic wasps). The plant and arthropod data were analysed in relation to buffer zone width and distance to the hedge. In addition, the effects of plant abundance and diversity were analysed for some arthropod taxa.

Both buffer zone width and distance to the hedge influenced plants and arthropods significantly. The abundance of wild plants in the field increased significantly and was more than doubled with a 6 m buffer zone compared to sprayed and fertilized field – an effect which to some degree continued with increased buffer width. Also the biodiversity of wild plants was increased with the establishment of buffer zones. 6 m of buffer was the minimum width required in order to significantly increase the plant biodiversity compared to plots without buffer area. There was a tendency towards increased biodiversity of wild plants at a further increased buffer width.

While the buffers only delivered limited protection of the hedge fauna, the buffer zone effects on the arthropod fauna within the hedge bottom (the vegetation beneath the hedge and out to the crop) and in the field were

marked both in terms of increased abundance and in terms of increased biodiversity. For the arthropod abundance within the hedge bottom, a buffer width of 24 m delivered the most general increases, although in several cases a narrower buffer also resulted in higher abundances within the hedge bottom.

In the field (outside the hedge bottom) a significantly higher arthropod abundance was generally obtained with a 6 m or wider buffer zone. In addition, a generally and very markedly higher biomass of important bird chick-food items was found within the buffer zones at all distances from the field edge.

The biodiversity of arthropods within the hedge bottom increased consistently with a buffer zone width of minimum 6 m. This result was very clear and for the majority of the analysed taxa, a further increase in buffer width did not result in significantly higher biodiversity. This was further underpinned by the analysis of the marginal gain of biodiversity at increased buffer width, where it was found that the vast majority of the biodiversity increase within hedge and field was obtained already with a 6 m wide buffer zone.

Buffer zones had no effect on the flowering within the hedge bottom. The flowering percentages of wild plants in the field, however, was markedly higher within the buffer zones compared to treated field, and the importance of flowering was underlined by the significant positive correlations between flowering and activity of both butterflies and bumblebees.

An important spin off from this project is that butterflies seem to fulfil the role as a practical indicator for improvement of biodiversity. They responded positively to flowering, and positive correlations were found between biodiversity of butterflies and wild plants and between butterflies and other important arthropod taxa.

It is concluded, that irrespective of the slightly further increases of plant diversity and diversity of some arthropods at buffer zones widths of 12 m and 24 m, a 6 m buffer zone may be seen as a width providing a relatively high proportion of the biodiversity found at broader buffer zones in this one-year study. A 6 m wide buffer zone will also deliver a considerable amount of food resources for higher animals such as birds and small mammals.

For farmers, a 6 m buffer zone along hedges will primarily occupy a part of the field with some yield depression due to hedge competition. Furthermore, such a zone will increase the supply of food for game birds and hence open for an extra income.

For decision makers, the potential of a 6 m wide buffer zone along hedges, as a mean to counteract the negative effects of intensive modern farming on terrestrial biodiversity, should be both acceptable and somewhat attractive. 6 m buffer zones ought to open for subsidised regulation of biodiversity. In addition, monitoring of biodiversity effects should be possible using diversity of butterflies as indicator.

For an assessment of the full potential of buffer zones, future studies should include the performance of buffer zones present in field margins for more than one year. For such more permanent buffer zones, it will be important to include studies on vegetation management, and how vegetation management may further increase biodiversity of plants, insects and spiders, while avoiding that the buffer zones become a source of perennial weeds. It is also highly relevant to consider potential buffer zone effects on landscape connectivity by studying the effect of buffer area and the corridor effect for improved dispersal of flora and fauna by arranging coherent buffer zones over larger areas.

Sammenfatning

Rapporten beskriver resultaterne af en ét-årig undersøgelse af biodiversitetseffekten af forskellige bufferzone-bredder langs levende hegn i kornmarker. Bufferzoner er markstriber, som ikke er sprøjtet og gødet til gavn for vilde planter og dyr. En review-undersøgelse af bufferzoner i marker (Sigsgaard et al. 2007) afslørede et stærkt behov for at undersøge effekten af bufferbredde på biodiversiten i og nær landbrugsarealer. Dette spørgsmål var blandt de prioriterede i et udbud fra Miljøministeriet. Nærværende projekt blev accepteret og startede i 2008 med belysning af bufferbredder på 4, 6, 12 og 24 m. Projektet har involveret medarbejdere fra Københavns Universitet (Institut for Jordbrug og Økologi samt Biologisk Institut) og Aarhus Universitet (Institut for Genetik og Bioteknologi).

Projektet havde til formål at finde en bufferzone-bredde, som giver væsentlige forbedringer af biodiversiteten af vilde planter, insekter og edderkopper og som samtidig er landbrugsmæssigt acceptabel. De fire anvendte bufferbredder plus en 0-m kontrol blev placeret langs hegn i fire meget store vårbygmarker på Gjorslev Gods på Østsjælland. Hegnenes sammensætning af både vedplanter og urter samt urternes blomstring i fodposen blev opgjort, og i markarealerne blev opgjort plantearter, plantetætheder, blomstringsfrekvenser og generativ udvikling. Insekter og edderkopper blev opgjort via nedbankning fra hegn, ketcher-prøver, tælling af flyvende insekter i standardbaner og fangst i faldgruber.

Planter blev artsbestemt, og det samme gjaldt en stor del af insekterne (som f.eks. dagsommerfugle, humlebier, løbe-, blad- og snudebiller og tæger) mens andre kun blev identificeret til slægt, familie eller underorden (f. eks. små snyltehvepse). Planteforekomsternes sammenhæng med bufferbredde, afstand til hegn og flere andre faktorer blev analyseret statistisk. Forekomsterne af leddyr blev analyseret i forhold til det samme sæt faktorer samt i nogle tilfælde i forhold til planteforekomsterne.

Både bufferbredden og afstanden til hegn havde væsentlig indflydelse på planter og leddyr. Forekomsten af vilde planter i marken steg signifikant og blev mere end fordoblet med en 6 m bred bufferzone – en effekt der i nogen grad fortsatte med yderligere forøgelse af bufferbredden. Også biodiversiteten af vilde planter blev forøget med etablering af bufferzoner. En signifikant effekt på biodiversiteten krævede en bufferbredde på minimum 6 m sammenlignet med mark uden bufferzoner. En yderligere forøgelse af bufferbredden medførte en tendens til øget plantediversitet.

Mens effekten af bufferzonerne kun i behersket omfang kunne spores hos leddyrene på hegnenes vedagtige planter, var buffervirkningerne på leddyr i hegnenes fodpose (vegetationen under hegnet og ud til afgrøden) og i marken markante i form af øget antal og øget biodiversitet. For leddyrforekomsterne i hegnenes fodpose var en 24 m bufferzone den bredde, der gav den mest generelle antalsmæssige fremgang for de undersøgte grupper, men i flere tilfælde gav en smallere bufferbredde også antalsmæssig fremgang i hegnenes fodpose.

I marken (uden for hegnenes fodpose) var 6 m den smalleste bufferbredde, der gav en væsentlig og generel antals- eller aktivitetsmæssig fremgang på markfladen, men generelt steg mængden af leddyr med bufferbredden. Også biomassen af særlig egnet fugleføde steg generelt og særdeles markant i bufferzonerne i alle afstande fra hegn.

Biodiversiteten af leddyr i hegnenes fodpose blev markant forbedret med en 6 m bred bufferzone. Dette resultat var meget klart, og yderligere forøgelse af bufferbredden til 12 eller 24 m gav for flertallet af artsgrupperne ikke målbar biodiversitetsmæssig fremgang. At også den samlede biodiversitetsmæssige hovedgevinst af leddyr for hegn og mark set under et blev opnået allerede ved en 6 m bred bufferzone blev specielt tydeligt, når biodiversiteten målt i forhold til det samlede undersøgte areal (fra hegnet og ud i marken) blev analyseret.

Bufferzonerne havde ingen effekt på blomstringen i hegnenes fodpose. De vilde planters blomstring var derimod markant højere i bufferzonerne end i behandlet mark, og betydningen af denne blomstring blev understreget af de positive korrelationer mellem blomstringen og aktiviteten af både humlebier og sommerfugle.

Dagsommerfuglene synes at kunne fungere som indikator for biodiversitet. De responderede positivt på blomstring, og der var en positiv korrelation mellem biodiversiteten af dagsommerfugle og biodiversiteten af vilde plantearter, tæger og biller, som alle var vigtige målgrupper.

Det konkluderes, at uanset muligheden for et vist niveau af yderligere forbedringer af plante- og leddyrdiversitet ved bufferbredder på 12 og 24 m, er forbedringerne, der opnås ved en 6 m bufferbredde, biodiversitetsmæssigt attraktive, og 6 m kan ses som en bredde, der giver en relativ høj mætning mht. biodiversitet. En 6 m bred bufferzone vil også bidrage med et betydeligt ekstra fødegrundlag for højerestående dyr som fugle og mindre pattedyr.

For landbrugere burde 6 m subsidierede bufferzoner langs hegn udgøre et acceptabelt og i nogen grad attraktivt tiltag. Således vil en 6 m bred bufferzone langs hegn falde på et areal, hvoraf en væsentlig del er udbyttebegrænset af konkurrencen fra hegnet. Hertil kommer, at bufferzonens positive effekt på mængden af føde til kyllinger af agerhøne og fasan vil medføre muligheder for øgede jagtindtægter.

For de politiske beslutningstager kunne anlæg af bufferzoner udgøre en interessant mulighed for at opnå en subsidieret modregulering af landbrugets negative biodiversitetseffekter. Tilmed kan biodiversitetsgevinsten ret overkommeligt effektmoniteres ud fra forekomsten af dagsommerfugle.

Hvis bufferzoners fulde potentiale skal udnyttes, vil det være vigtigt at finde frem til det areal af 6 m bufferzoner, der kræves for at opnå en markant positiv effekt på biodiversiteten på landskabsniveau. Også effekten af tid, og hvordan den videre håndtering/ pleje af vegetationen i bufferzoner bedst fremmer biodiversiteten og beskytter landbruget mod uønsket ukrudt, bør undersøges. Bufferzoner vil typisk ligge i mere end et enkelt år, og biodiversiteten må herved forventes yderligere øget.

Det vil også være vigtigt at overveje og belyse, hvilke korridor-muligheder der vil være for at opnå en forbedret og ønskelig spredning af arter, hvis sammenhægende bufferzoner placeres hensigtsmæssigt over lidt større landskaber.

1 Introduction

1.1 Background

In the discussion of the fate of biodiversity in the modern landscape the role of intensified agricultural production and particularly the use of chemical inputs attract much attention. Through analysis of data over 30 years in the UK, Benton et al. (2002) found that the decline in bird populations are correlated with declining insect populations, caused by agricultural intensification. Also in Denmark the improvements of crop yield and quality are at the expense of biodiversity in the arable fields (Andreasen et al. 1996; Kudsk & Streibig 2003; eds. Esbjerg & Petersen 2002, Navntoft et al. 2003), and the use of insecticides has in 1998 (Grell 1998) been suggested as a major factor behind the decline of Danish breeding birds. The British Game Conservancy Trust financed experiments with unsprayed field margins in order to increase the numbers of birds of game. Important effects were demonstrated on bird food insects for the field living birdlife such as Grey Partridge and Pheasant but also butterflies benefitted from non-treated 6 m field margins (Potts 1986, Sotherton 1987, Sotherton et al. 1989). A parallel Danish investigation of effects on flora and insects of 6 m non-sprayed field margins along hedgerows found improvements for both plants and insects (Hald et al., 1988). Later Esbjerg & Petersen, eds. (2002) demonstrated increases of wild flora species, flowering plants, insect and bird abundances at half and particularly quarter dosages of herbicides and insecticides. With conversion to organic farming a further increase in flowering plants and higher presence of butterflies was found, and the concomitant increase of weed seeds and arthropods was followed by a doubling of Skylarks in the organic fields (Navntoft et al. 2003).

The above findings, and the suggestions of Marshall (1989) and Wilson & Aebisher (1995), that hedgerows are important for the wild flora abundance, make hedges and field margins along them an interesting study area for biodiversity improvements. Many studies have looked into different aspects of field margins and others have looked into the potential use of flower strips and beetle banks, mostly with improvement of pest regulation by predators and parasitoids as the focus area.

Despite many demonstrations of predation (e.g. Collins et al. 2002, Collins et al. 2003) the demonstration of direct benefits to farmers at field level have failed except in a very few cases (e.g. Östman et al. 2003).

In contrast to this, the indications of biodiversity improvements are many but the approaches are mostly agriculturally focussed and very mixed in terms of both methodologies and terminologies. This was underlined by a review of buffer zone approaches mainly in Europe (Sigsgaard et al. 2007). Most remarkable was the fact that most buffer zone dimensions seemed to be selected somewhat arbitrarily.

At the administrative level, non-treated field margins is one of the targets of agricultural subsidies in several EU-countries. However, the width of the margin requested varies between countries (Sigsgaard et al. 2007). In this light, and on background of the general concern about biodiversity in farm landscapes, it is interesting that nobody has yet asked if it is possible to find a margin width, which will on one hand ensure a high saving/ improvement of biodiversity, and on the other hand will be tolerable for practical agriculture. Sigsgaard et al. (2007) among others point at the need to further investigate the influence of width and area of buffer zones.

In the current study, we investigated the biodiversity effect of non-fertilized and pesticide free buffer zones bordering hedgerows in order to fulfil the below aims.

1.2 Aims and hypotheses

The project takes some initial methodological steps towards a more systematic analysis of the importance of pesticide and fertilizer free buffer zones along hedgerows, here defined as field margins with one or more rows of woody plants, for improved biodiversity in agricultural landscapes. The project focuses on the impact of a simple set of different buffer widths (4, 6, 12 and 24 m).

AIM AND HYPOTHESES
The aim of the investigation was to identify a buffer zone width which would deliver a significant improvement of biodiversity (measured as species richness and a biodiversity index) from which an additional increase in width would only lead to marginally higher biodiversity. This aim was based on the two hypotheses below, which should be regarded as interconnected:

1) The biodiversity of plants and arthropods in a buffer zone along a hedgerow will increase with increasing width of the buffer zone, until a substantial saturation level is reached. Further increase of the width will only yield a relatively limited further increase of biodiversity.

2) It will be possible to identify an agriculturally practicable buffer zone width along hedgerows which will benefit flora and fauna so much, that the abundance and biodiversity will increase significantly.

Furthermore, an important part of this project was to identify organisms which may serve as suitable bioindicators for biodiversity improvements caused by buffer zones in arable fields.

2 Methods

In order to investigate the influence of buffer zone widths on biodiversity, we have tried to reduce the often challenging variation caused by using different farms over several years. Therefore, the whole experiment took place within one season at one large estate, Gjorslev Gods, on eastern Zealand. Gjorslev provided study facilities in four large spring barley fields with basically the same type of hedge composition with a herbaceous hedge bottom along the eastern side of the fields. The hedgerows had the same geographical orientation (north-south hedges). The size of the fields permitted the establishment of the necessary plot sizes within each field. The fertilization and spraying within the experimental plots was handled solely by the Farm Manager and one very experienced machine operator.

The biological work consisted of the following main parts:

1) Characterisation of the hedgerows (dimensions, composition of woody species and their flowering frequency)
2) Recording of all plant species in the fields and along the hedges, and in addition assessment of plant densities and flowering density.
3) Transect counting of selected insects such as butterflies and bumblebees.
4) Pitfall trapping of epigaeic beetles and spiders with focus on beneficials (natural enemies of pests).
5) Sweep net sampling of insects on plants designed to permit estimates of abundance, biodiversity and bird prey.
6) Beating tray samples of insects from hedges designed for obtaining abundance and biodiversity estimates.

Table 2. 1. Schematic summery of sampling times of wild flora and arthropods in hedge, hedge-bottom and field. Vegetation recording: 1) hedge dimensions, 2) hedge woody species composition, 3) hedge woody species flowering intensity, 4) coverage of hedge-bottom herbs 5) coverage of flowering and generative hedge-bottom herbs, field assessment of 6) number of Herbs and 7) number of flowering and generative Herbs. Arthropod recordings: 8) Pitfall trapping of epigaeic arthropods, 9) sweep net sampling of herbaceous dwelling arthropods, 10) transect counts of butterflies and bees and 11) arthropods sampled from woody hedge components.

Biotope	May, Period 1	June, Period 2	July, Period 3
Hedgerow	1, 2, 3, 11	3, 11	3, 11
Hedge-bottom	4, 8, 9	4, 5, 8, 9	4, 5, 8, 9
Field	6, 8, 9, 10	6, 7, 8, 9, 10	6, 7, 8, 9, 10

In Table 2.1 the sampling schedule of all data samplings is presented. Further details on the different methodologies are given in the subsequent sections of this chapter.

2.1 Study site and experimental design

The study was carried out as a single year field study at Gjorslev Estate in 2008.

2.1.1 Gjorslev Estate

Gjorslev Estate (Gjorslev vej 20, Holtug, 4660 Store Heddinge, Denmark, coordinates (wgs84): 55°21'14.34"N, 12°22'51.93"E) covers 1.668 ha of which 753 ha is forest. Gjorslev was asked to host the trial because of its large field sizes with well established homogeneous hedgerows. Large fields with long uniform hedgerows were needed in order to establish the required experimental design (section 2.1.2). An aerial view of a part of Gjorslev is presented in Fig. 2.1.

Fig. 2.1. Areal view of the four experimental fields At Gjorslev Estate: Møllemark (MM), Enghaven (EH), Anders mark (AM) and Skovmark (SM). The positions of the experimental parts of the hedgerows are indicated with red lines. The area is characterised by Large Fields in a relatively Heterogenous landscape with forest, lakes, running water and sea shore. As an indication of scale, the experimental area in Møllemark (MM) is 543 m long.

2.1.2 Experimental design

Four fields were included in the experiment (Fig. 2.1). In Fig. 2.2 an outline of an experimental field is presented. Data were collected on the western side of the eastern hedgerows in all fields. Along each hedge there were five treatments consisting of areas treated with neither fertilizer nor pesticides in 2008 – called buffer zones. The widths of the zones were 0, 4, 6, 12 or 24 m and they were arranged in chronological order for easier and more reliable management (Fig. 2.2).

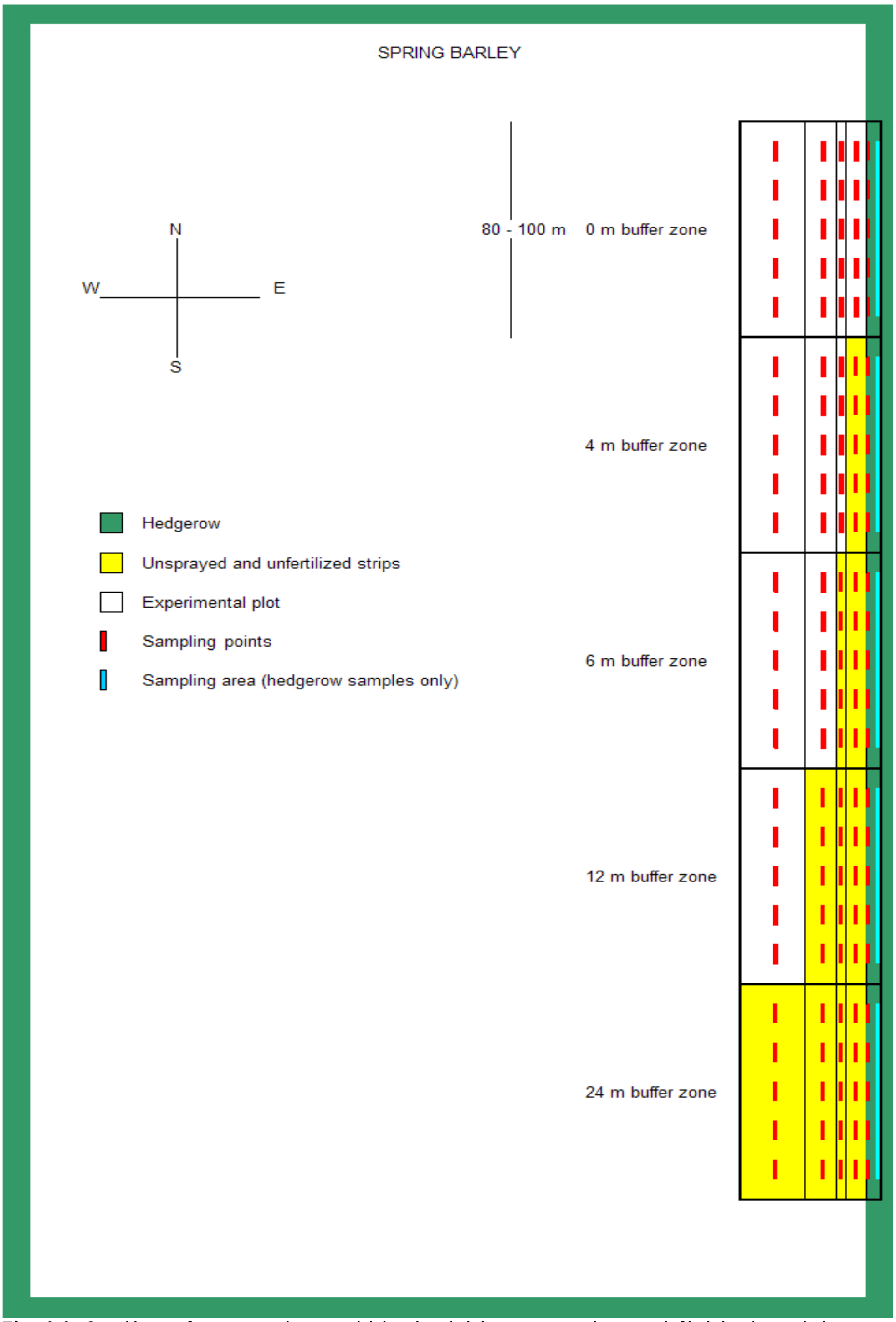


Fig. 2.2. Outline of an experimental block within an experimental field. The trial included four such areas. There were five experimental plots within each block, each being 80 – 108.5 m long depending on the length of the hedgerow used in each field. The plot arrangement within a field was not randomized but was arranged at descending width of the buffer zone. However, within each field it was randomized whether the widest buffer zone of a field should be placed north or south. Five rows of sampling points perpendicular to the field edge were established for each experiment and were between 12.5 and 19.6 m apart depending on the plot length. The first and last sampling row within each plot was placed 15 m from the plot edge to lower interference from neighbour plots or ordinary field. Plant and arthropod sampling along each sampling row was carried out in the hedge bottom (ref. distance 0) and then 2, 5, 9 and 18 m within the field from the field edge (red squares). This sampling grid contained in total 25 sampling points per plot (5 × 25 = 125 pr. field). Additionally plant and arthropod recordings were carried out within the hedgerow.

The various buffer zones (treatments) are referred to as buffer 0 (0 m buffer), buffer 4 (4 m buffer) etc. ***It is important to emphasize that when the term "buffer 0 – 24" is used, it is the entire experimental plot area (in some cases at a specific distance from hedge) that is referred to and not only the width of the buffer strips (see Fig. 2.2). Hence, the size of the sampled area was always the same and it is only the ratio between treated and non-treated areas that varies.***

The experiments were always surrounded by a section of ordinary field or headland. In both SM and MM the almost full length of the fields were included in the experiment and only guarded by 24 m of headland in both ends, as the field and the neighbour area on the western side of the hedgerow was fairly homogenous. In EH only the Northern end of the field was used, as the southern end was relatively low and often flooded during spring. This field was therefore guarded by 24 m of headland towards North and by approximate 200 m of field in the southern part. The experimental block in AM was placed along the middle of the hedgerow, thereby avoiding bordering up to a forest in the Northern part and a low waterlogged area in the Southern end. The experimental area AM was therefore bordered by 214 m toward North and 157 m toward South.

In SM and MM parts of the hedgerows had no trees or shrubs but herbs or grasses only. In SM this part was located in buffer 12 and comprised 30 m bordering to buffer 6. In MM buffer 24, 14 m were without woody plants. For more information on the hedgerows see section 3.1.1.

After randomization, the widest (24 m) buffer zone was placed at the northern end of the hedge in SM, MM and AM and at the southern end in EH. The plots in SM were 104.5 m long, 108.5 m in MM and 80 m in both EH and AM.

2.1.3 Pesticide and fertilizer applications

The four fields were treated identically with respect to the cultivation procedures, including fertilizing, sowing and pesticide application. The crop (spring barley cv. Henley) was sown relatively late in April due to wet soils. Right before sowing, liquid ammonia fertilizer was placed very accurate (injected) within the treated areas of the experimental plots. Later ammonium sulphate was applied (by rotary spreader) to the treated areas (for more information on fertilizer applications see Appendix A). Three weeks after sowing, a mixture of herbicides and fungicides was applied using low-drift (yellow) nozzles along with manganese sulphate. Eight weeks after sowing a mixture of fungicides and insecticides was applied (see Appendix A). Three weeks later, another insecticide treatment was carried out. The crop was harvested mid August (For more information on the pesticides and other field treatments see Appendix A). The pesticide dosages were normal according to the Danish Agricultural Advisory Service and close to the mean of 2008 (Miljøstyrelsen 2009).

2.2 Weather

The weather in spring (March, April and May) 2008 can be summarised as sunny and warm (dmi.dk/dmi/vejret_i_danmark_-_foraar_2008). The mean temperature in Denmark was 7.9°C which is 1.7°C above the average of the period 1961-90 but 1.1°C lower than the same period in 2007. The mean precipitation in Denmark in spring 2008 was 131 mm which was 3 mm below the average of 1961-90. Denmark had 663 h of sunshine in spring 2008, which is the sunniest spring since the recording started in 1920.

The summer (June, July and August) in 2008 was sunny, wet and mild (dmi.dk/dmi/vejret_i_danmark_-_sommer_2008). The mean temperature in DK was 16.4°C which is 1.2°C above the average of 1961-90. The last half of July was very warm with several days above 25°C. The mean precipitation was 240 mm which was 52 mm or 28% above the mean of 1961-90, although by far the highest amount of rain fell in August. Denmark had 721 h of sunshine in summer 2008, which is 130 h or 22% above the mean of 1961-90.

We measured the weather at Gjorslev using a local weather station (Hardi Klimaspyd) placed in the centre of the experimental field SM (Skovmark). These local weather data can be found in Appendix G.

2.3 Yield

The average barley yield in the experimental fields in 2008 was 72 hkg ha^{-1} (79 hkg in SM, 72 hkg in MM, 76 hkg in EH and 59 hkg in AM). Yield losses within the buffer strips was not measured, however, according to the farm manager the yield in the buffer zones was assessed to be less than half the yield in the ordinary field (A.B. Hansen pers. comm.).

2.4 Vegetation recording

2.4.1 Hedgerow

Plant species composition of the hedgerows was assessed for all woody species and dominant herbs with 1 m resolution. The woody species were assessed once at May 7th and the dominant herbs were assessed at three runs commencing May 7th, June 19th and July 17th. The dimensions of the hedge were measured once at May 7th with total height, height of bank and total width. Flowering intensity was determined for the dominant flowering woody species: May 7th to 12th for hawthorn (***Crataegus spp.***) and June 19th for rose (***Rosa spp.***). Inflorescences (Crataegus) and number of flowers (Crataegus and Rosa) were counted on three 50 cm long branches in each plot. The value of the plants as pollen and nectar sources was recorded according to The Danish Beekeepers´ Association (Svendsen 1994).

2.4.2 Hedge bottom and field

In two sampling runs, 27 May - 12 June and 6 – 16 July respectively, vegetation was registered after the experimental fields had been sprayed with herbicides. At the distances 0, 2, 5, 9 and 18 m from the field edge (Fig. 2.2), 10 vegetation frames (Fig. 2.3) were used for density counts and for plant species (when possible) or genus recording according to Frederiksen et al**.** (2006). The frames were 40 × 50 cm^2, and divided into 20 sub-quadrants. Within the hedge bottom, density counts were not possible, and instead percent ground cover of each species/genus was recorded. At the second sampling run, flowering and generative stages of the plants were registered. The frames were always placed adjacent to one pit-fall (Fig. 2.3). Furthermore, 40 m from the hedge, 12 vegetation frames were sampled for additional information.

At the first sampling run, the number of spring barley plants was counted in all vegetation frames in four of the 20 sub-frames. The growth stage of spring barley was assessed according to the BBCH scale (Tottman & Broad 1987). Furthermore, the height and percentage cover of spring barley was registered, in treated and non-treated areas.

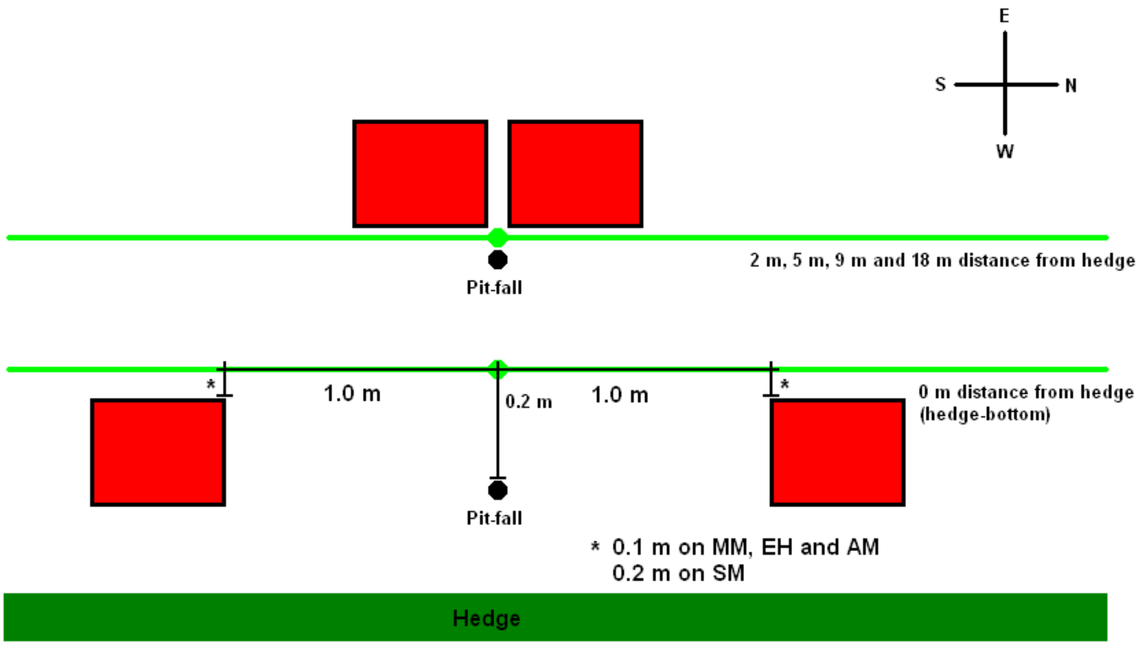


Fig. 2.3. The frames for wild flora registration (red squares). The frames in the hedge bottom and field were placed pair-wise with one pitfall for catching ground dwelling arthropods. A sampling point is indicated with a green spot. The sampling grid within a plot consisted of 25 sampling points (Fig. 2.2).Within the hedge bottom further spacing of the vegetation frames was needed because of the risk of flora damage when working with the pitfalls. Abbreviations for the four experimental fields: MM = Møllemark, EH = Enghaven, AM = Andersmark, SM = Skovmark.

2.5 Arthropod recording

Arthropod sampling was carried out in each of three sampling periods in 2008: Period 1 was after herbicide and fungicide application (May – early June). Period 2 was after the first insecticide and fungicide application (June – early July). Period 3 was after the second insecticide application (July).

2.5.1 Hedgerow

Arthropods were sampled on the woody plants of the hedgerows using a beating tray sampling technique. The sampling was carried out in May (28 May 2008), June (18 and 20 June 2008) and July (14 and 15 July 2008). Samples were collected in the five buffer zones per field along the west side of the hedges of the four experimental fields.

A beating sample was the sum of beating 1branch of 10 individual trees of the same species. Each branch received three firm beats. Arthropods were collected in plastic bags attached to the opening of the tray funnel. Samples were labelled with date, locality, buffer zone width, woody plant species and sample number.

The total number of samples per treatment was between 9 and 11 in order to accommodate that at least two samples were collected from each of the selected woody species present within a treatment (the average number of trees per combination of sampling time, field and buffer width was 9.6). In Andersmark, which was dominated by rose, it was not possible to obtain two samples pr treatment from the only other available species, hawthorn. The total number of samples was 576.

The faunal composition and total number of arthropods depends on the woody plant species. To obtain a correct picture of changes over time, and to be able to compare data from different treatments and fields, arthropods were only collected from the most common woody species available for sampling (it must be possible to reach and beat branches) in the four fields. In three of the fields, the woody species sampled were blackthorn (***Prunus spinosa***), elderberry (***Sambucus nigra***) hazel (***Corylus avellana)*** and hawthorn (***Crataegus*** spp**.**). However, the hedgerow of the fourth field, Andersmark, was strongly dominated by roses (***Rosa*** spp.), with a few hawthorn interspersed, and only these two species were sampled in this hedgerow. Though present, it was not possible to sample from roses in the other three fields, as the roses in these fields were growing inside the hedgerow, and were not accessible for sampling.

Samples were kept in cooling boxes in the field. Cooling boxes maintained samples near 12°C, hereby reducing deterioration as well as arthropod activity, hence the risk of predation in the samples. In the laboratory samples were kept at -20°C until sorting and identification to order, family, genus or species under the stereomicroscope (see Table C.1 in Appendix C). All arthropods were named according to Fauna Europaea 2009 (http://www.faunaeur.org/index.php).

For important bird food items, the fresh weight was determined as a quantitative measure of the amount of bird food. For details on arthropod prey included as bird food see section 2.5.2.2.

For each sample, the woody species was recorded and the number of arthropod species was counted. The number of species was summed over the samples in each plot and Shannon’s indexes were averaged over the trees in each plot. Shannon’s biodiversity index was calculated for each combination of sampling time, field and buffer width (see section 2.6).

2.5.2 Hedge bottom and field

Three different sampling methods were used in order to cover arthropod populations of flying (avian), herbaceous dwelling and ground dwelling (epigaeic) species.

2.5.2.1 Transect counts of butterflies and bees

Standardized transect counts of Lepidoptera (butterflies) and Apidae (bees) were carried out following a method by Pollard (1977) and Pollard & Yates (1993) in order to estimate the activity of these insects in relation to buffer zone width.

Insect counts during systematic walks along the fields (transects) were carried out 2, 5, 9 and 18 m from the field edge. The 2 m distance census area was 4 m wide. It covered the hedgerow and 4 m into the field. In the relatively narrow 4–6 m strip (see Fig. 2.2) the census area was only 2 m wide. At the 9 and 18 m distances the census area was 4 m wide. In all cases the census area in front of the observer was 5 m long. The order of field visits, the starting points of the transect walks (North or South) and the order of the starting distance from the field edges were all randomised. Care was taken not to count an individual more than once, however, in doubtful cases or if an individual came from behind of the observer, it was always counted as a new individual. If the identity of an individual was uncertain, it was caught with a butterfly net and identified to species.

The observer spent 5 – 15 minutes walking through each census area of a plot. The time spent for each plot within a field was kept approximately uniform and was always registered.

Transect counts were preformed during three periods with three or four replicates in each of the four fields. Period 1: 27 May to 4 June. Period 2: 25 June to 11 July. Period 3: 24 – 31 of July. In total 40 transect counts were carried out. The earliest transect count began at 10.37 and the latest transect count ended at 18.14 (Greenwich Mean Time + 2 h). Wind speed (m/s at 24 m from the hedgerow), sunshine (on a scale from 0 – 4 with 0 representing full sun and 4 completely clouded) and temperature (ºC) were all registered. The wind speed never exceeded 6.5 m/s and the temperature was always above 17 °C during transect counts. If rain set in, the counting was abandoned and a new attempt was made the next day. During each period, one set of transect walks were completed in each of the four fields before starting the next sampling round. Each round lasted no more than three days.

2.5.2.2 Sweep net sampling of arthropods in the herbaceous vegetation

Herbaceous-dwelling arthropods like butterfly larvae and leaf beetles were sampled using standard sweep nets (diam. 27 cm). One sample (10 standard sweeps) was taken at each of the 25 sampling points per plot (see Fig. 2.2) on three occasions. The first sampling occasion was 2-3 June, 12-13 days after herbicide and fungicide applications. The second sampling round was carried out 24-26 June, 7-9 days after the first insecticide and fungicide application. The third and last sampling occasion was 15-16 July, 13-14 days after the second insecticide application. In total 1500 sweep net samples were collected.

The catch from each sample was put in a plastic bag, labelled and placed in a cooling box until it was frozen at -20ºC later the same day. In the laboratory all arthropods were counted and identified at least to order. The majority of, taxonomic units were identified to species (see Table D.20 in Appendix D). All arthropods were named according to Fauna Europaea 2009 (http://www.faunaeur.org/index.php).

Chick-food items

In order to identify buffer zone effects on the availability of arthropod food for higher trophic levels, arthropods being important as chick-food (see Wratten & Powell 1991, Sotherton & Moreby 1992, Petersen & Navntoft 2003) from the sweep net samples were grouped and weighed per sample (g fresh biomass after de-frosting): Araneae, Opiliones, Coleoptera (except Coccinellidae and Cantharidae), Hemiptera, Lepidoptera (larvae only), Tenthredinidae (larvae only), Syrphidae (larvae and pupae only), Orthoptera and Neuroptera.

2.5.2.3 *Pitfall trapping of epigaeic arthropods*

Carabidae (ground beetles), Staphylinidae (rove beetles), Araneae (spiders) and other epigaeic arthropods were sampled with pitfall traps (plastic cups, diameter 82 mm, depth 70 mm, with snap-on lids) buried flush with the soil surface. The traps were partly filled with 200 ml of trapping and preservation fluid (a mixture of 1:1 ethylene glycol and tap water, with one drop of non-perfumed detergent per 10 l). In total 25 traps were used per plot (see Figs. 2.2 and 2.3). Three sampling rounds were carried out. The first set of traps were started 28 May (six days after herbicide application, see Appendix A for pesticide details). The second set of traps was started 18 June (one day after the first insecticide application) and the third set of traps was started 11 July (nine days after the second insecticide application). The first sampling round lasted 48 h and the second and third 72 h before the traps were collected, labelled and stored at 5°C until further processing. In total 1500 pitfall samples were collected. In the laboratory arthropods belonging to Araneae (spiders), Carabidae (ground beetles), Staphylinidae (rove beetles) and a few other taxa were counted and identified at minimum to family but preferably to species (see Table D.24 in Appendix D)

2.6 Data analysis

In addition to the actual recorded number of individuals, two measures were calculated in order to access the biodiversity: The number species (species diversity) and Shannon´s biodiversity index, H (Magurran 2004). Shannon´s H was calculated as:

$$H = \sum_{i=1}^{a} \left\{ -\frac{n_i}{N} \log\left(\frac{n_i}{N}\right) \right\}$$

where

a is the number of species

n_i is the number of individual of species i

N is the total number of individuals

Both measures were calculated and analysed for selected groups of plants and arthropods.

In order to estimate and test the effects of buffer width, distances from hedge and in some cases sampling time, the data were analysed statistically. The applied statistical methods and models depended to a large extent on the type of data, so that linear mixed models were used for data that could be assumed to be normally distributed such as weights, Shannon´s biodiversity index and log-transformed number of species, while counts and relative counts that could be assumed to be Poisson distributed and binomial distributed, respectively, were analysed using generalised linear mixed models. The random effects included in the models reflect that each field could be regarded as a complete block (replicate) in the same experiment – an experiment that is regarded as a split-block design. The actual applied models are explained, shown in a mathematical form and listed in Appendix F. In the following, the models are described very briefly with reference to the detailed description in Appendix F. The theory of linear mixed models and generalised linear mixed models may be found in books such as McCulloch and Searle (2001) and West et al. (2007). All statistical analyses were performed using the procedures MIXED, GLIMMIX and NLMIXED of SAS (SAS, 2008). Some of the results were visualised using the graphical procedures of SAS (SAS 2009a and SAS 2009b).

2.6.1 Flora analyses

The number of counted plants at each sampling period was analysed using generalised linear mixed models. The analyses were carried out for the different sampling period and groups (all, type and family) of plant species. The fixed effects in the model depended on the source of the data: field or hedge. For data from the hedge the model included the fixed effect of field and buffer width (Model 6 of Appendix F). For data from the field the model included the fixed effect of field and buffer width, distance to hedge and the interaction between buffer width and distance (Model 8 of Appendix F). The data from the field were also analysed in models, where the effect of buffer width and distance to hedge were treated as continuous variable using a second degree model (Model 12 of Appendix F). This model was then subsequently reduced by removing non-significant effects in order to get a model as simple as possible. The percentage of flowering plants at the second sampling run were analysed using a generalised linear mixed model including the effect of field and buffer width, distance to hedge and the interaction between buffer width and distance (Model 9 of Appendix F). The percent flowering plants in hedge-bottom at the second sampling run was calculated from the sum over coverage of all plants and flowering plants for each combination of field and buffer width. The log-transformed values were analysed in a linear model including the effect of field and buffer width as fixed effects (Model 13 of Appendix F).

Shannon´s index and the number of species (after log-transformation) were analysed in different models. Initially the data were analysed in a linear mixed model. The effect of location (control recordings in “the middle” of the field versus plots close to the hedge) together with the following three effects: [1)] distance to hedge, [2)] width of buffer zone and [3)] the interaction between distance to hedge and width of buffer zone. The model also included the effect of sampling period and interactions with sampling period (Model 14 of Appendix F).

In order to evaluate the distance at which Shannon's index was reduced to half its value at the hedge, the difference between its value in the hedge and its value in “the middle” of the field was also modelled using the logistic function. Two versions of the models were used: [1)] where it was assumed that decrease per unit (log distance) were the same for all buffer zones and [2)] where it was assumed that decrease per unit (log distance) depended on the buffer zone (Model 5 of Appendix F).

2.6.2 Arthropod analyses

2.6.2.1 Hedgerow

The different groups of arthropods in the beating tray samples at each sampling period were analysed in a generalised linear mixed model including the fixed effect of field, buffer width and tree species (Model 7 of Appendix F) whereas the weights of bird feed at each sampling time were analysed using a linear mixed model including field, buffer width and tree species as fixed effects (Model 4 of Appendix F).

2.6.2.2 Hedge bottom and field

Transect counts of butterflies and bees

The number of individuals for different groups of arthropods were analysed separately for each sampling period using a generalised linear mixed model that included the fixed effect of field and buffer width distance to hedge and the interaction between buffer width and distance. In order to adjust for time spent in the transect, day and time of sampling and the other conditions for activity (e.g. temperature) the logarithm of the time spent in the transect was includes as an offset variable, the actual day was included as a fixed effect while the linear and quadratic effects of the following variables were included as covariates (fixed continuous effects): time of day (hours before or after noon), amount of sun (on a scale from 0 to 4 with 0 being full sun (no clouds) and 4 being fully overcast) and temperature (°C). This model was then reduced step by step by removing non significant covariates. The full model is Model 10 of Appendix F.

Shannon´s index (see section 2.6) and number of species (after log-transformation) for selected groups of arthropods were analysed using a linear mixed model including the fixed effects of buffer width, distance to hedge, sampling period and all 2- and 3-way interactions between these (Model 2 of Appendix F).

Sweep net sampling of herbaceous dwelling arthropods

The data were aggregated over replicates before analyses in order to decrease the number observations with zero target arthropods. Different groups of arthropods at different sampling periods were analysed using a generalised linear mixed model that included the fixed effect of field, buffer width, distance to hedge and the interaction between buffer width and distance (Model 8a in Appendix F).

The weight of bird feed at each sampling period were analysed in a linear mixed model including the fixed effects of field, buffer width, distance to hedge and the interaction between buffer width and distance (Model 3 of Appendix F).

Shannon´s index and number of species (after log-transformation) for selected groups of arthropods were analysed using a linear mixed model including the fixed effects of field, buffer width, distance to hedge, sampling period and all 2- and 3-way interactions between buffer width, distance to hedge and sampling period (Model 2 of Appendix F)

Pitfall trapping of epigaeic arthropods

The data were aggregated over replicates before analyses in order to decrease the number observations with zero target arthropods. Different groups of arthropods sampled were analysed separately at each sampling time using a generalised linear mixed model that included the fixed effect of field, buffer width, distance to hedge and the interaction between buffer width and distance (Model 8a of Appendix F).

Shannon´s index and number of species (after log-transformation) for selected groups of plants were analysed using a linear mixed model including the fixed effects of field, buffer width, distance to hedge, sampling period and all 2- and 3-way interactions between buffer width, distance to hedge and sampling period (Model 2 of Appendix F)

2.6.3 Combined flora and arthropod analyses

2.6.3.1 Activity of Lepidoptera (butterflies) and Bombus in relation to flower and host plant abundance

In order to evaluate the effect of plants on the occurrence of selected groups of arthropods, avian species from transect data were analysed in a second model. This second model included the same fixed effects as the model for transect data (Model 10 of Appendix F) together with linear and quadratic effects of the following variables: number of host plants (or coverage of host plants)and number of flowers for selected or all plant species (Model 11 of Appendix F). The full model was reduced step by step by removing non significant variables.

2.6.3.2 Analyses on the marginal gain of biodiversity when increasing buffer width

For wild plants and selected arthropods groups (Heteroptera, herbivorous coleopterans, Carabidae and Lepidoptera), the total number of species in each of the distances ranges 0, 0-2 m, 0-5 m, 0-9 m and 0-18 m was summarised for each combination of field and buffer width. Woody species in the hedge rows were not included in the plant analyses. Lepidoptera (butterflies) were not analysed for distance 0 m, as this distance was included in distance 2 m during data recording.

The number of species from each of those distance ranges were analysed in a linear mixed model (after log-transformation) including the effect of field and buffer width (Model 13 of Appendix F). These analyses were carried out on the July data comprising hedge bottom and field area (sampling run 2 for plants and sampling period 3 for arthropods) where the experimental plot had received the full fertilizer and pesticide effects.

The data for all buffer widths were also analysed in a non-linear model (Model 15 of Appendix F) to estimate the species – area relationship (SPAR). Arthropod data from the woody species in the hedgerows were included in the modelling, however, the distances in the hedgerow (hedge bottom versus hedge row) were analysed as one distance (dist. 0) in this model to make them fit into the assumed species – area relationship. The area for each distance was counted as the unit 1. Data were summarized across all sampling times in order to reveal buffer effects on biodiversity comprising the entire season.

2.6.3.3 Lepidoptera (butterflies) as bioindicator for biodiversity gains of buffer zones

The data for selected group of arthropods were analysed in a generalised linear model in order to examine the possible correlation between arthropod species diversity and species diversity between arthropods and dicotyledons. In order to avoid that the possible correlation was introduced by the difference between treated and untreated plots, the model include the effect of treatment as fixed factor as well as possible significant effect of field. The model also allowed the correlation to depend on whether the plots were treated or untreated (for more details see Model 16 in Appendix F).

3 Results

3.1 Flora

3.1.1 Hedge

The hedgerows (Appendix B, Table B.3.) of the four fields, did not differ significantly with respect to species composition for woody plants (***P***=0.9457, one-way ANOVA) or for dominant herbs (***P***=0.7365; ***P***=0.9010 and ***P***=0.7532 respectively for each sampling run). However, despite the lack of statistical difference, the hedge in AM differed from the other three hedgerows by being dominated by roses (***Rosa*** spp.) (see Table B.3 in appendix B).

3.1.2 Hedge bottom and field

All plant species present in the field and the hedge-bottom are presented in Appendix B, Tables B.1 and B.2 with the abundance given for each combination of distance and buffer zone width. Results of the statistical analysis on weed densities in the field are presented in Table 3.1. The densities of all recorded weeds in the field are presented in Fig. 3.1. The figure shows no change in number of weed plants with distance from the hedge, with a buffer width 0 m. At buffer 24, however, the number of weed plants increased with proximity to the hedge. Increasing buffer width resulted in higher number of weeds with distance from the hedgerow.

Table 3.1. Schematic summary of the statistical analyses on abundance of the wild flora in the field at the second sampling run in July. Monocots are all individuals of the monocotyledonous species , Dicots are all individuals of dicotyledonous species.

Order	Family	Run[2]	Test results $F_{(ndf,ddf)}^{P1}$			
			Field[3]	Distance[4]	Buffer[5]	Buffer × Distance[6]
Monocots	All	2	$21.31_{(3,14)}^{***}$	$5.52_{(4,11)}^{*}$	$5.05_{(4,12)}^{*}$	$1.99_{(16,52)}^{*}$
	Poaceae	2	$21.31_{(3,14)}^{***}$	$5.52_{(4,11)}^{*}$	$5.05_{(4,12)}^{*}$	$1.99_{(16,52)}^{*}$
Dicots	All	2	$13.36_{(3,12)}^{***}$	$6.77_{(4,11)}^{**}$	$8.08_{(4,16)}^{***}$	$5.16_{(16,43)}^{***}$
	Apiaceae	2	$51.15_{(3,16)}^{***}$	$4.49_{(4,7)}^{*}$	$0.76_{(4,8)}^{NS}$	$6.85_{(16,52)}^{***}$
	Asteraceae	2	$4.57_{(3,11)}^{*}$	$15.54_{(4,15)}^{***}$	$3.08_{(4,55)}^{*}$	$2.63_{(16,47)}^{**}$
	Brassicaceae	2	$2.83_{(3.20)}^{NS}$	$2.45_{(4,13)}^{NS}$	$3.49_{(4,16)}^{*}$	$3.90_{(16,51)}^{***}$
	Chenopodiaceae	2	$20.66_{(3,9)}^{***}$	$3.26_{(4,7)}^{NS}$	$7.20_{(4,11)}^{**}$	$4.99_{(16,55)}^{***}$
	Lamiaceae	2	$3.83_{(3,16)}^{*}$	$7.93_{(4,13)}^{**}$	$2.88_{(4,26)}^{*}$	$1.55_{(16,51)}^{NS}$
	Scrophulariaceae	2	$0.67_{(3,14)}^{NS}$	$3.07_{(4,11)}^{NS}$	$0.86_{(4,19)}^{NS}$	$3.63_{(16,47)}^{***}$
	Violaceae	2	$9.94_{(3,16)}^{***}$	$0.91_{(4,11)}^{NS}$	$2.06_{(4,11)}^{NS}$	$3.33_{(16,45)}^{***}$
All	All	2	$30.14_{(3,13)}^{***}$	$9.86_{(4,14)}^{***}$	$14.48_{(4,62)}^{***}$	$3.61_{(16,62)}^{***}$

[1] ^{NS} not significant, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, F is the F-value, ndf and ddf is the numerator and denominator degree of freedom used for testing the significance.
[2] The second sampling round was carried out from 24 June.
[3] Effect of field (four fields were included in the experiment).
[4] Effect of distance from field edge (sampling was carried out 2, 5, 9 and 18 m from the field edge).
[5] Effect of buffer width (0, 4, 6, 12 and 24 m).
[6] Effect of the combination of distance and buffer width.

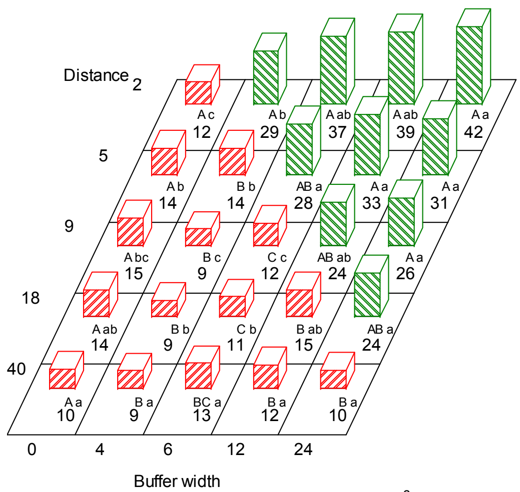


Fig. 3.1. Estimated total weed numbers (plant no. per m^2) at the second sampling run (July)at the distances 2 ,5 ,9 ,18 and 40 m to the hedgerow at the buffer widths 0, 4, 6, 12 and 24 m. Within each buffer width, figures with the same capital letter are not significantly different (P=0.05). Within each distance, figures with the same lower case letter are not significantly different (P=0.05). Red bars (hatched from lower left to upper right) are numbers in areas treated with fertilizer and pesticides. Green bars (hatched from upper left to lower right) are non-treated area (buffer zone).

Monocotyledonous weeds (monocots)

For monocots (non-sensitive to the applied herbicide), there were significant effects of field, buffer zone and distance, as well as the interaction between buffer zone and distance (Table 3.1 and Fig. 3.2). There was a tendency towards more monocot weeds with increasing buffer width. The number of monocots seemed to decrease with distance from hedge. However the effect seemed to depend on the buffer width, and was only significant for some combinations of buffer width and distance – probably because of the low number of monocots and the dicot-selective herbicides used in the experimental period.

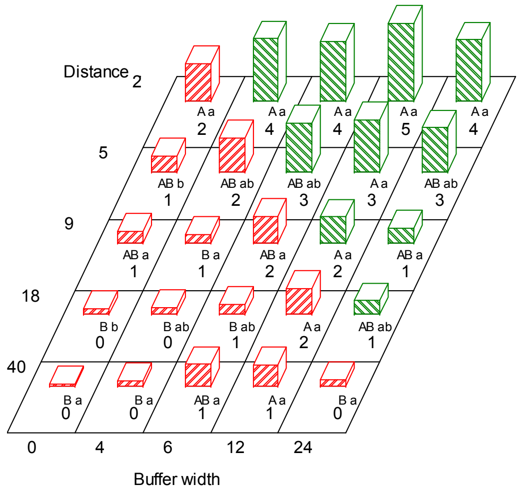


Fig. 3.2. Number of monocotyledoneous weed plants (no. per m^2) at the second sampling run (late June-July)at the distances 2 ,5 ,9 ,18 and 40 m to the hedgerow at the buffer widths 0, 4, 6, 12 and 24 . Within each buffer width, figures with the same capital letter are not significantly different (P=0.05). Within each distance, figures with the same lower case letter are not significantly different (P=0.05). Red bars (hatched from lower left to upper right) are numbers in areas treated with fertilizer and pesticides. Green bars (hatched from upper left to lower right) are non-treated area (buffer zone).

Dicotyledonous weeds (dicots)

For dicots there were significant effects of field, distance, buffer zone and the interaction between distance and buffer zone (Table 3.1). The total number of dicots at the second sampling run seemed mainly to depend on whether the area was treated or not (Fig. 3.3). Buffer 4 was the narrowest buffer width to deliver significantly higher densities of dicots compared to treated field. Beyond distance 5 m the effect of buffer width was less clear but still revealing a tendency towards more dicots with increasing buffer width (Fig. 3.3).

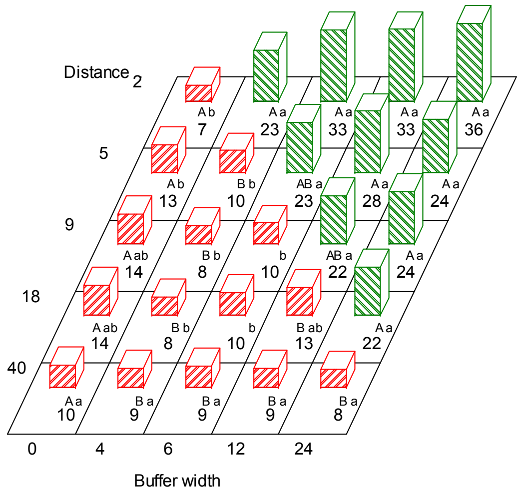
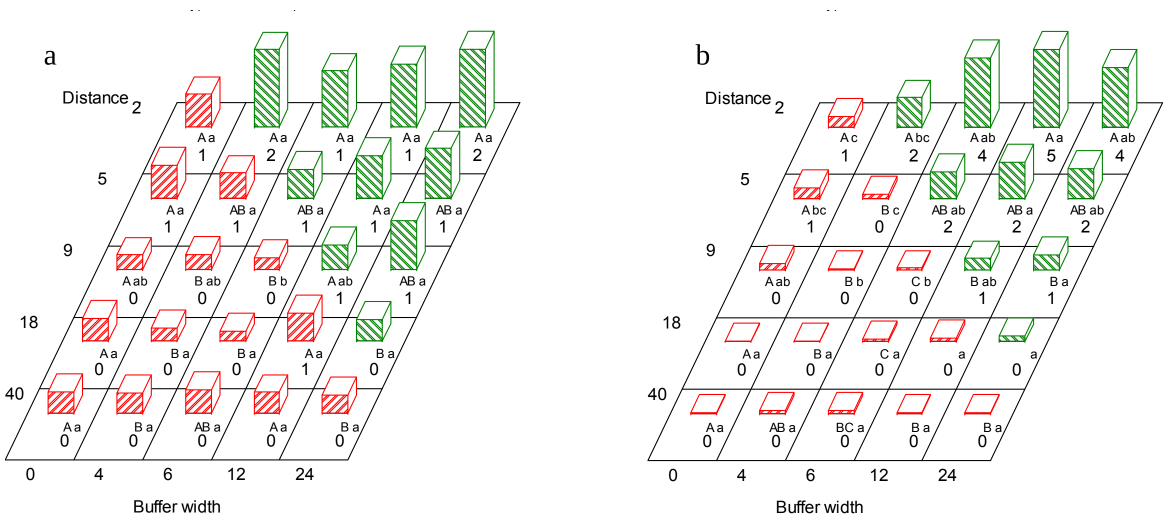


Fig. 3.3. Number of dicotyledoneous weeds (no. per m^2) at the second sampling run (late June-July) at the distances 2, 5, 9, 18 and 40 m to the hedgerow at all the buffer widths: 0, 4, 6, 12 and 24 m. Within each buffer width, figures with the same capital letter are not significantly different (P=0.05). Within each distance, figures with the same lower case letter are not significantly different (P=0.05). Red bars (hatched from lower left to upper right) are numbers in areas treated with fertilizer and pesticides. Green bars (hatched from upper left to lower right) are non-treated area (buffer zone).

Weeds according to family

For all families, except ***Lamiaceae***, a significant interaction between distance and buffer zone width (Table 3.1) was found. The effects of buffer width, distance from hedge and the interaction between those are visualised in Fig. 3. 4. For ***Apiaceae*** and ***Poaceae,*** the interaction seemed partly to be caused by an apparent missing effect of buffer widths for some distances. For ***Asteraceae***, ***Chenopodiaceae*** and ***Scrophulariaceae*** the interaction was probably partly caused by very few weeds in some plots, and partly from the difference between treated and untreated areas. For ***Brasicaceae,*** the interaction seemed to be caused mainly by a difference between treated and untreated areas. For ***Lamiaceae,*** there was much higher number of weeds at distance 2 m than at the other distances. For ***Violaceae,*** a low number of weeds were found for buffer 0 at 2 m from the hedge. Otherwise the number of weeds seems to be relatively homogeneous over the area, but with a tendency to higher numbers in untreated areas than in treated areas.



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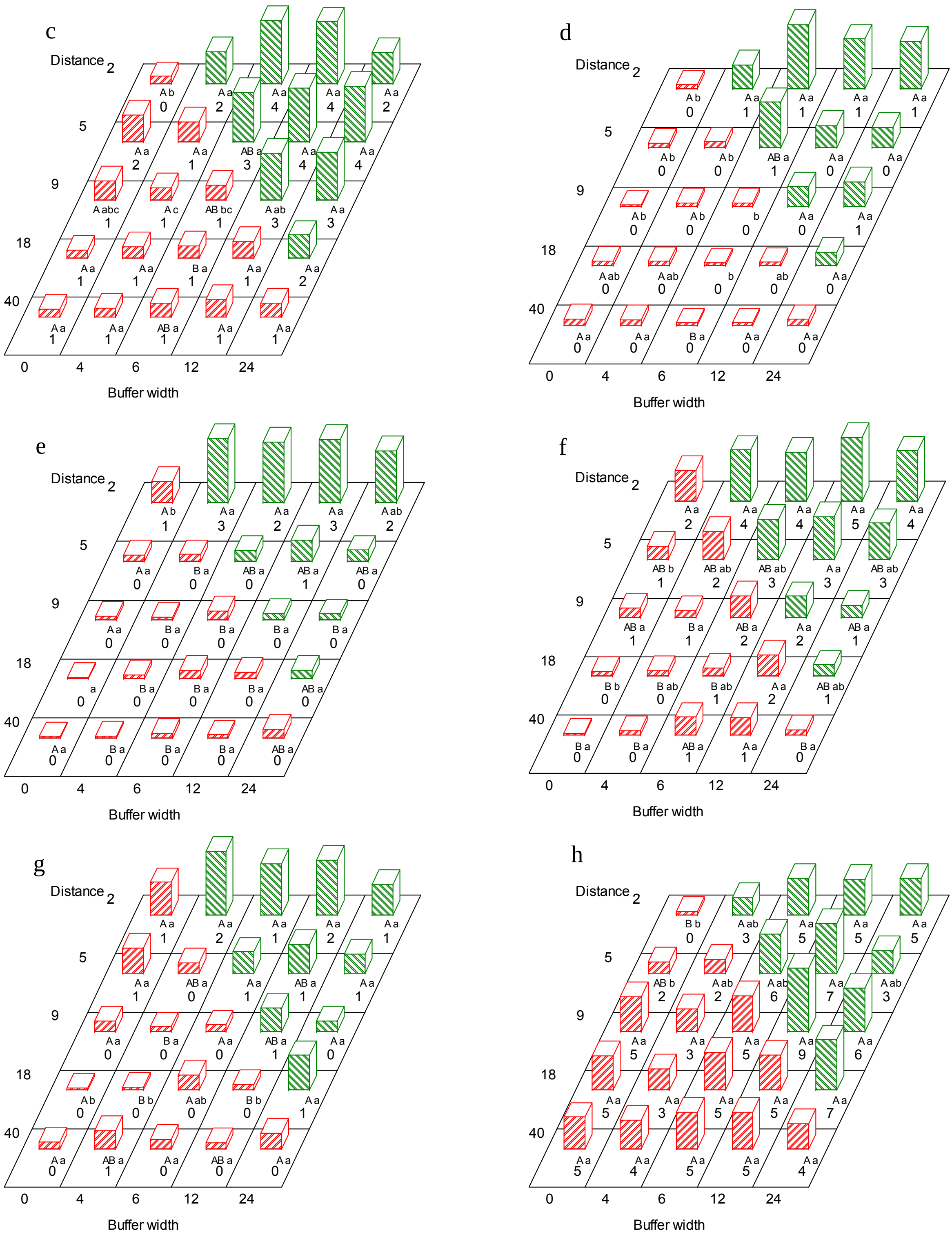


Fig. 3.4. Number of weedplants (no. per m^2) for each of the families: *Apiaceae* (a), *Asteraceae* (b), *Brassicaceae* (c), *Chenopodiaceae* (d), *Lamiaceae* (e), *Poaceae* (f), *Scrophulariaceae* (g) and *Violaceae* (h) at the second sampling run (late June-July)at the distances 2, 5,9, 18 and 40 m to the hedgerow at the buffer widths 0, 4, 6, 12 and 24 m. Within each buffer width, figures with the same capital letter are not significantly different (P=0.05). Within each distance, figures with the same lower case letter are not significantly different (P=0.05). Red bars (hatched from lower left to upper right) are numbers in areas treated with fertilizer and pesticides. Green bars (hatched from upper left to lower right) are non-treated area (buffer zone).

The crop

The spring barley crop responded significantly to management with fertilization and pesticides. The crop cover, the crop height and the growth stage was smaller in the buffer zone than in the conventional field. The same number of crop plants had established in treated and non-treated areas (data not shown) (Table 3.2).

Table 3.2. Spring barley cover, height and growth stage (BBCH) at first (from 27 May) and second sampling run (from 6 July). Significant effects (one-way ANOVA) of management) are indicated as follows: † for P< 0.1; * for P<0.05; ** for P< 0.01 and *** for P< 0.001.

	Treatment	Cover (%)	Height (cm)	BBCH
First run	+	94 ***	36 †	22.5 *
First run	-	26	27	19
Second run	+	80 **	72 *	77
Second run	-	53	62	77

3.1.3 Buffer zone effects on floral biodiversity

Species richness and Shannon´s H in hedge bottom and field

In the analyses on plant densities above, it was not possible to include data from the hedge bottom because the data were sampled as percent ground cover, and data sampled in the field were a density per. m^2. However, as the number of species were recorded both in hedge bottom and field, it was possible to combine the data within the biodiversity analyses.

For both Shannon’s H and number of weed species there were significant effects of both buffer width, distance to hedge, sampling time and interaction between these. The mid-field references at 40 m (all treated with pesticides and fertilizer) had a lower value than the mean of the other plots, as could be expected.

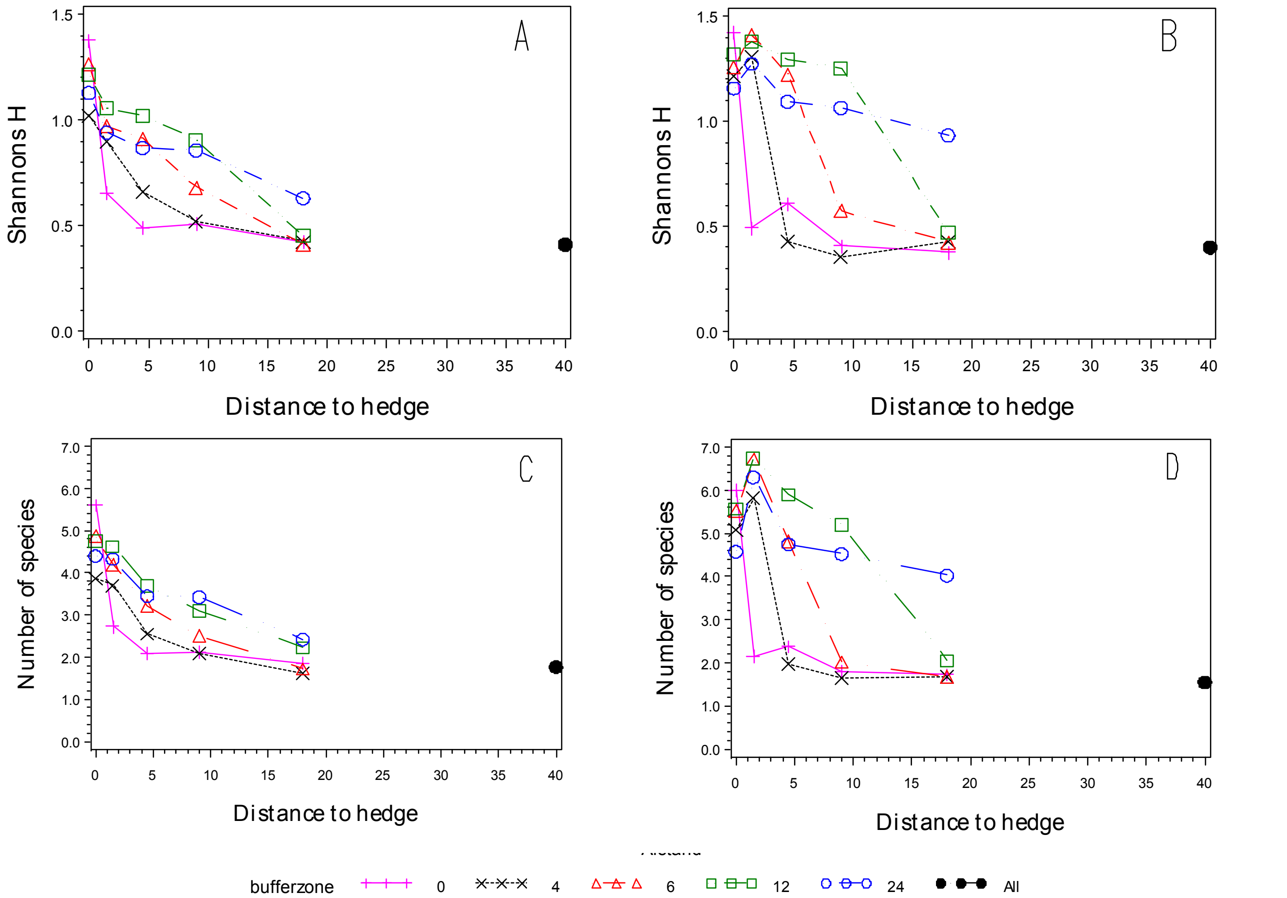


Fig. 3.5. number of weed species per sample and the biodiversity index (Shannon's H) plotted against distance to hedge for each buffer width. A: Shannon's H at sampling run 1 (27 May – 12 June), B: Shannon's H at sampling run 2 (6 – 16 july), C: Number of weed species at run 1left and D: Number of weed species at run 2.

The number of weeds at sampling run 2 for buffer 4, 6 and 12 showed a rather steep decrease with increasing distance from the buffer zone margins and outwards, while buffer 24, with no records just outside the zone margin, showed a less steep decrease with distance – more equal to the general tendency at sampling run 1 (Fig. 3.5). For both sampling runs the biodiversity were generally larger for untreated than treated plots. Buffer 0 showed a steep decrease in plant numbers immediately outside its margins at both sample runs. The data used in the Fig. 3.5 are shown in Table 3.3. This table can also be used for pairwise comparisons of differences between buffer widths and distances.

Table 3.3. Estimated values of Shannon H and number of weed species for combinations of distance to hedge, buffer width and time.

Distance, m	Buffer width, m	Shannon H		No of wild plant species	
		Run 1	Run 2	Run 1	Run 2
0	0	1.38	1.42	5.60	6.00
	4	1.02	1.22	3.88	5.08
	6	1.26	1.26	4.88	5.53
	12	1.21	1.32	4.75	5.58
	24	1.13	1.16	4.40	4.58
2	0	0.66	0.49	2.73	2.15
	4	0.90	1.31	3.70	5.83
	6	0.97	1.41	4.20	6.73
	12	1.06	1.38	4.63	6.75
	24	0.94	1.27	4.33	6.30
5	0	0.49	0.61	2.10	2.38
	4	0.66	0.43	2.55	1.98
	6	0.91	1.23	3.23	4.83
	12	1.02	1.30	3.70	5.90
	24	0.87	1.09	3.45	4.75
9	0	0.51	0.41	2.13	1.80
	4	0.52	0.35	2.10	1.65
	6	0.68	0.57	2.50	2.03
	12	0.91	1.25	3.10	5.20
	24	0.86	1.07	3.43	4.53
18	0	0.42	0.38	1.85	1.73
	4	0.42	0.43	1.63	1.68
	6	0.41	0.42	1.73	1.68
	12	0.45	0.47	2.23	2.05
	24	0.63	0.93	2.43	4.03
40	All	0.41	0.40	1.78	1.55
LSD[a]	Horizontal	0.25		0.84	
LSD[b]	Other	0.38		1.38	

a) If the difference between the two sampling runs for the same plot (combination of buffer and distance) are larger than the LSD-value, then the parameter has changed significantly (at the 5% level) from run 1 to run 2.
b) If the difference between any pair of plots at the same sampling run are larger than the LSD-value then the variable are significantly different (at the 5% level) for those two plots. This LSD-value can similarly be used to compare a plot at run 1 with another plot at run 2.

Shannon´s biodiversity index modelled by a logistic function

In order to be able to interpolate the biodiversity index (Shannon´s H) to other distances than the measured, and to estimate the distance at which the biodiversity was reduced to half its value at the hedge, empirical models based on the logistic model was developed (see section 2.6.1 and Model 5 in Appendix F). For each sampling run, a full model with two parameters for each buffer zone (a parameter describing the distance at which the index is halved and the slope for each buffer zone) and a simplified model (with a common slope for all buffer zone) was estimated. The estimates of the parameters for both models and both sampling runs are shown in Table 3.4. The full model did not explain the data more sufficient than the simplified model (se the row AIC of Table 3.4) and therefore the simplified model, with a common slope (Model 5 of Appendix F) were applied for producing Fig. 3.6.

The biodiversity (Shannon´s H) at the hedge and in the middle of field was almost identical at both sampling runs (about 1.2 and 0.4, respectively) and the value in the field were for both sampling runs reduced to about one third of its value at the hedge. At sampling run 2, the effect of the different buffer width had an effect that reached further out into the field (almost 5 times further, the parameter β_0) than at sampling run 1, and this seemed to be the most pronounced difference between the two sampling runs. The distances at which the biodiversity index was halved increased with buffer width but did not vary significantly from sampling run 1 to sampling run 2, although there seemed to be a steeper increase with buffer zones at sampling run 2 than at sampling run 1. For both buffer 12 and 24 at sampling run 1, the biodiversity index was halved at about 11 m from the hedge, whereas 13 m and 19 m, respectively, were needed to halve the number of species at buffer 12 and 24 sampling run 2. Part of this difference (although not significant) may have been caused by the larger number of species (mainly/partly because the plants had developed and more plants could be identified to species) at sampling run 2 than at sampling run 1.

Table 3.4. Estimated parameters of the logistic model (both Model 1 and 2 presented) for Shannon´s biodiversity index at each sampling run (time) separately. At the bottom, the halving distances d_b in m, (and its 95% confidence intervals) at which Shannon´s index has decreased by half of its value form the value of the hedge bottom for each bufferzone width. StdE = Standard Error of estimate.

Time	Sampling run 1				Sampling run 2			
Model	1 (Full model)		2 (Simplified model)		1 (Full model)		2 (Simplified model)	
Parameter[a]	Estimate	StdE	Estimate	StdE	Estimate	StdE	Estimate	StdE
β_0	2.02	1.50	2.05	2.24	9.96	13.09	3.46	5.33
β_4			1.41	1.02			10.15	129.5
β_6			2.24	1.86			5.22	2.07
β_{12}			4.98	5.75			7.45	4.20
β_{24}			0.75	0.60			0.55	0.51
γ_{field}	0.46	0.12	0.45	0.11	0.43	0.06	0.41	0.06
γ_{hedge}	1.12	0.09	1.13	0.07	1.27	0.04	1.32	0.05
δ_0	0.17	0.45	0.15	0.42	0.15	0.38	-0.32	0.99
δ_4	1.13	0.52	1.00	0.52	1.03	0.80	0.72	3.96
δ_6	1.91	0.39	1.89	0.35	2.04	0.23	1.87	0.14
δ_{12}	2.38	0.31	2.37	0.21	2.59	0.34	2.49	0.18
δ_{24}	2.39	0.46	2.35	0.73	2.93	0.08	3.48	1.29
σ_A^2	0.011	0.011	0.010	0.008	0.006	0.006	0.008	0.006
σ_D^2	0.065	0.010	0.063	0.009	0.049	0.007	0.045	0.007
AIC	38.7		43.1		10.1		10.2	
d_0	1.2 a (0.4-3.4)		1.2 a (0.4-3.1)		1.2 a (0.5-2.9)		0.7 a (0.1-7.6)	
d_4	3.1 ab (0.9-10.5)		2.7 ac (0.8-9.2)		2.8 abc (0.4-18.7)		2.0 ab (0.0-24000)	
d_6	6.7 ab (2.7-16.9)		6.6 ac (2.9-15.3)		7.7 bd (4.4-13.3)		6.5 b (4.6-9.1)	
d_{12}	10.8 b (5.2-22.3)		10.7 bc (6.5-17.5)		13.4 cd (6.0-29.9)		12.1 b (7.9-18.5)	
d_{24}	10.9 b (3.7-32.7)		10.4 ab (1.9-58.0)		18.8 c (15.6-22.6)		32.6 b (1.5-695)	

[a] The parameters with Greek letters are parameters of the statistical model (Model 5 of Appendix F): β_0-β_{24} are the coefficients for the exponential effects. γ_{field} and γ_{hedge} are the estimated biodiversity (Shannon´s H) in the field and hedge, respectively. δ_0-δ_{24} are the constant effects of each buffer width. AIC is a measure for comparing model 1 and model 2 (a small value is best) (Akaike, 1974). The d_0-d_{24} are estimates (with confidence limits) of the distance at which the biodiversity index (Shanons H) has been reduced to half it value at the hedge bottom. Halving distances followed by the same letter are not significant different ($P \geq 0.05$).

At sampling run 1, a buffer width of 12 m was necessary in order to obtain a significantly higher halving distance compared to buffer 0 (Table 3.4). However, at sampling run 2 (were the wild flora had developed and more plants could be identified to species), a buffer width of 6 m was sufficient to get a significantly higher halving distance compared to buffer 0 (Table 3.4). To get a significantly higher halving distance compared to buffer 6 at sampling run 2, a buffer width of 24 m was needed (Table 3.4).

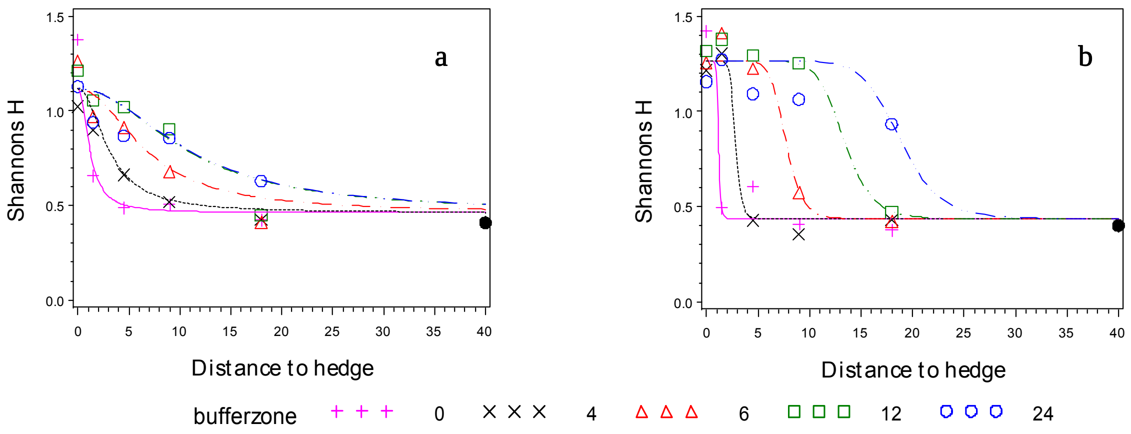


Fig. 3.6. Modelled biodiversity index (Shannon H) against distance to hedge for each buffer width **a:** Sampling run 1 **b:** sampling run 2. The fitted curves are based on the logistic model presented in Table 3.4 with common slope for all buffer zones (Model 1) using observations at distance 0-18 m and the mid-field references at 40 m.

3.1.4 Flowering in hedge-bottom and field

The percentages of flowering plants in the hedge bottom are presented in Table 3.5. There was no significant effect of buffer zones on the flowering percentages within the hedge bottom, but for the monocots (grasses) there seemed to be a tendency towards increased flowering at the widest buffer zones (12 and 24 m) compared to the more narrow buffers (0 – 6 m).

Table 3.5. Percent flowering plants in the hedge bottom in July (sampling run 2).

Test taxa	Buffer 0	Buffer 4	Buffer 6	Buffer 12	Buffer 24
All wild plants	8 a[1]	11 a	11 a	12 a	11 a
Dicots	15 a	20 a	23 a	17 a	24 a
Monocots	4 a	5 a	3 a	13 a	13 a

[1] Estimates within each row followed by the same letter are not significantly different ($P \geq 0.05$).

The flowering percentages of all plants in the field and the dicots in the field were significantly related to buffer width, distance to hedge and the interaction (Table 3.6). The dicots in the field area showed also a significant effect of field (Table 3.6).

Table 3.6. Schematic summary of the statistical effects on flowering percentages.

Test taxa	Test results $F_{(ndf,ddf)}^{P1}$			
	Field	Buffer	Distance	Buffer × Distance
All wild plants	$5.29_{(3,3)}^{NS}$	$30.87_{(4,31)}^{***}$	$13.63_{(3,33)}^{***}$	$9.54_{(12,28)}^{***}$
Dicots	$19.51_{(3,3)}^{*}$	$27.32_{(4,25)}^{***}$	$17.07_{(3,35)}^{***}$	$10.41_{(12,25)}^{***}$

[1] ^{NS} not significant, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, F is the F-value, ndf and ddf is the numerator and denominator degree of freedom used for testing the significance.

Within the field, the wild plants were flowering vividly in the buffer zones but not in the treated (fertilized and sprayed) field (Fig. 3.7).

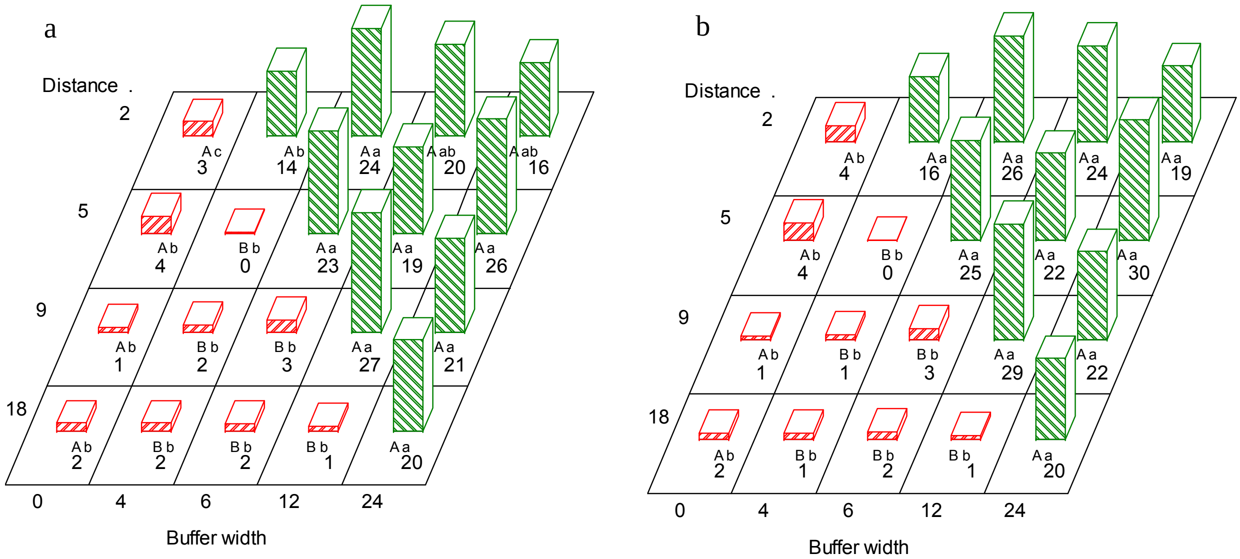


Fig. 3.7. Flowering percentages for all plants (a) and dicotyledoneous species (b), for each combination of buffer width (m) and distance (m) from hedge. Within each buffer width, figures with the same capital letter are not significantly different (P≥0.05). Within each distance, figures with the same lower case letter are not significantly different (P≥0.05). Red bars (hatched from lower left to upper right) are percentages in areas treated with fertilizer and pesticides. Green bars (hatched from upper left to lower right) are non-treated area (buffer zone).

3.2 Arthropods

3.2.1 Hedgerow

In hedgerow woody species, a total of 29,577 arthropods were sampled in beating trays. Only orders and families in which significant effects of buffer zone width were found are treated below. Arthropods sampled in hedgerow trees are presented in Appendix C, with sums of numbers collected in each buffer zone.

Araneae

Across hedgerow woody species, there were neither significant trends for the number of spider individuals versus buffer width nor the number of spider families versus buffer width.

Shannon´s H was significantly higher for buffer 0 when compared with all other buffers in period 1(t= 2.2, df=42, ***P***=0.04 Fig. 3.8).

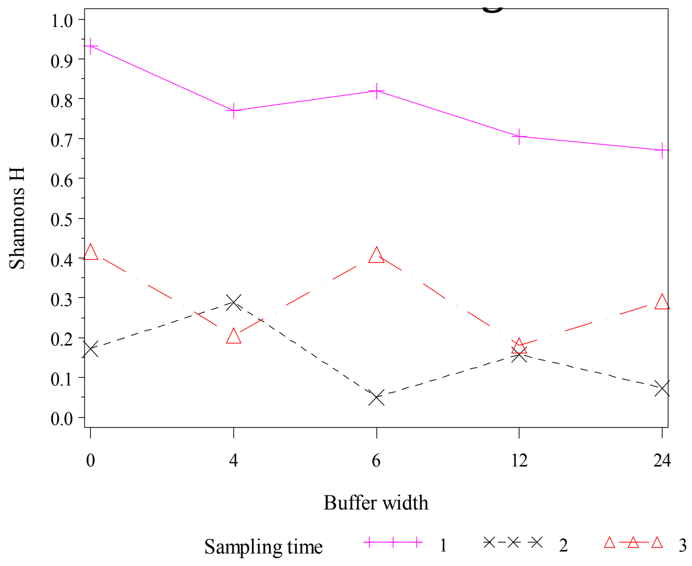


Fig. 3.8. Shannon´s H for Araneae in hedgerow trees in buffer widths 0, 4, 6, 12 and 24 m. For period 1, Araneae diversity was highest in buffer 0 (no buffer zone). In periods 2 and 3, after pesticide had been used, there were no significant differences.

In hawthorn, numbers of the family Araneidae were significantly affected by buffer width in period 3 (July) ((F=3.5, df=34, ***P***=0.02). Tukeys test for pairwise comparison showed that there were significantly more spiders in buffer 24 than in buffer 12 (t=2.00, P=0.03). For other buffer widths, there is no clear trend indicating higher numbers or diversity with increasing buffer width (estimates for numbers in buffers 0, 4, 6, 12 and 24 were: 0.7, 0.1, 0.7, 0.2 and 1.1).

Hemiptera

There was no overall significant effect of buffer width on Hemiptera numbers or on Hemiptera species diversity in hedgerow trees, though for period 2, a trend towards more Hemiptera with wider buffers is seen(Fig. 3.9).

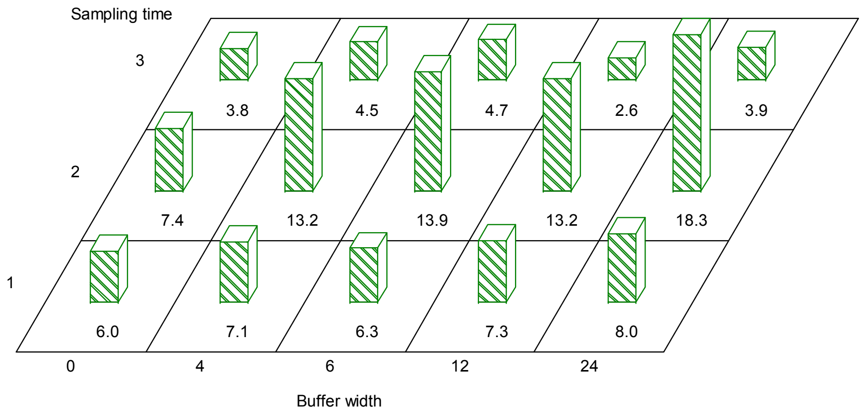


Fig. 3.9. Average Hemipteran numbers caught per sample in hedgerow trees in buffer widths 0, 4, 6, 12 and 24 m. A comparison of buffer 0 against all other buffers, showed that in period 2 there were significantly fewer Hemiptera in buffer 0. A pairwise comparison of Hemiptera numbers showed significantly more Hemiptera in buffer 24 than in buffer 0.

A comparison of buffer 0 against all other buffers, showed that in period 2 there were significantly fewer Hemiptera in buffer 0 (t=-2.52, df=17.3, ***P***=0.02) than in buffers 4, 6, 12 or 24 m. A pairwise comparison of Hemiptera numbers in hedgerow woody species protected by different buffer widths, showed significantly more Hemiptera behind a 24 m buffer than behind a 0 m buffer (t=-2.67, df=14.2, ***P***=0.02).

In blackthorn Hemiptera numbers were significantly affected by buffer at time 2 (P < 0.04) (estimates for buffers 0, 4, 6, 12 and 24: 10.2, 22.6, 16.6, 16.4 and 9.1). In hawthorn Hemiptera numbers were significantly higher in buffer 4 than 0 at time 2 (***P***=0.05)(estimates for buffers 0, 4, 6, 12 and 24: 14.3, 29.5, 32.7, 24.2 and 27.2).

Across tree species, buffer width significantly affected the number of aphids found within the hedgerows in period 1(May) and period 2 (June) (F=2.73, df=12, ***P***=0.03 and F=4.84, df=11, ***P***=0.02, respectively) (Fig. 3.10), with more aphids found where the buffer was wider. A pairwise comparison using Tukeys test showed significantly more aphids on hedgerow trees behind a buffer of 24 m than one of 0 m in Period 2 (estimate -1.2, df=12, ***P***=0.004).

Hedgerow living aphids are mostly specialists on specific tree species. For example hazel is the only host of ***Corylobium avellana*** and ***Myzocallis coryli***. Some winged specimens of ***Rhopalosiphum avenae*** were also found in the hedgerows. The trend of increasing numbers with increasing buffer width was also observed for the winged ***R. avenae*** (See Appendix C).

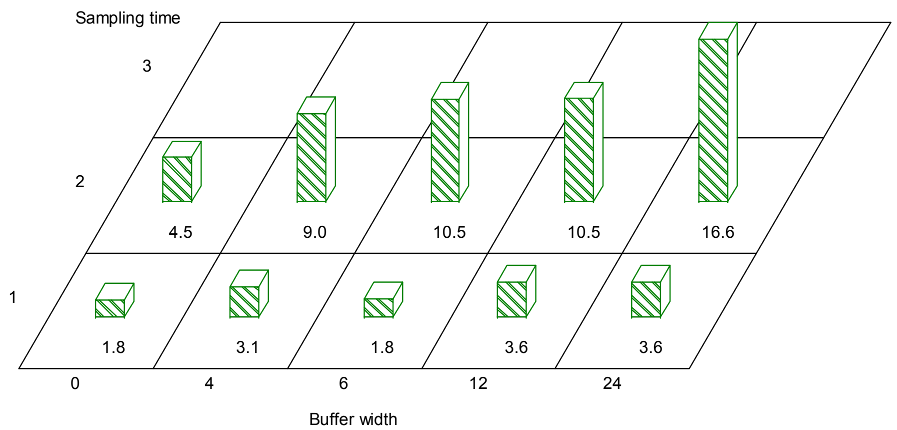


Fig. 3.10. Average aphid numbers caught per sample in hedgerow trees in buffer widths 0, 4, 6, 12 and 24 m. Both for period 1 in May (sampling time 1) and for period 2 in June (sampling time 2) there was a significant effect of buffer width on the number of aphids caught. For Period 3 (sampling time 3) there were too few aphids for a statistical analysis. The majority were tree living aphids, but a few *Rhopalosiphum avenae* were also caught.

The Heteroptera species number in buffer 0 versus all other buffer widths was 60% lower across sampling dates, with estimated species numbers of 0.4 at buffer 0 m, 0.7 at buffers 4, 6 and 12 and 0.8 at buffer 24, but the difference was not significant (df=42, ***P***=0.14).

In blackthorn the numbers of Heteroptera were significantly affected by buffer width × period (F=3.86, df=31, ***P***=0.01) (estimates for buffers 0, 4, 6, 12, 24 in period 1: 0.7, 0.6, 0.3, 0.6, 0.6 and in period 2: 0.3, 0.7, 0.7, 1.0, 0.9 and in period 3: 3.4, 2.3, 2.7, 0.7 and 3.0), likewise a highly significant effect of buffer width × period was found on the Shannon´s H for Heteroptera species diversity in blackthorn (F=8.08, df=13, ***P***=0.0006).

A trend of higher number of Miridae, the most important family in the Heteroptera, with increasing buffer width was seen on roses in period 3 (estimates: 1.1, 1.7, 2.1, 2.3 and 4.4 respectively). However, since roses were only sampled in one field, AM (Andersmark), data cannot be statistically analysed.

Coleoptera

Overall, the order of Coleoptera was not significantly affected by buffer width either in numbers of individuals, species or diversity (Fig. 3.11).

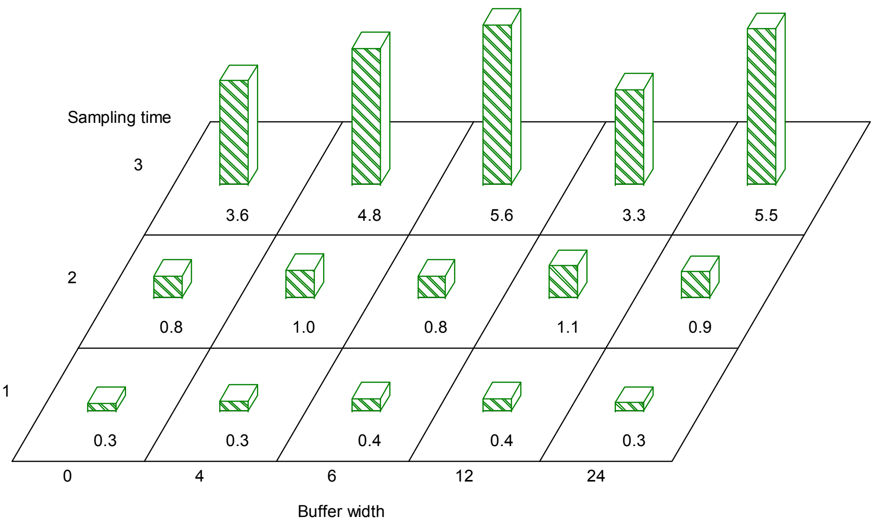
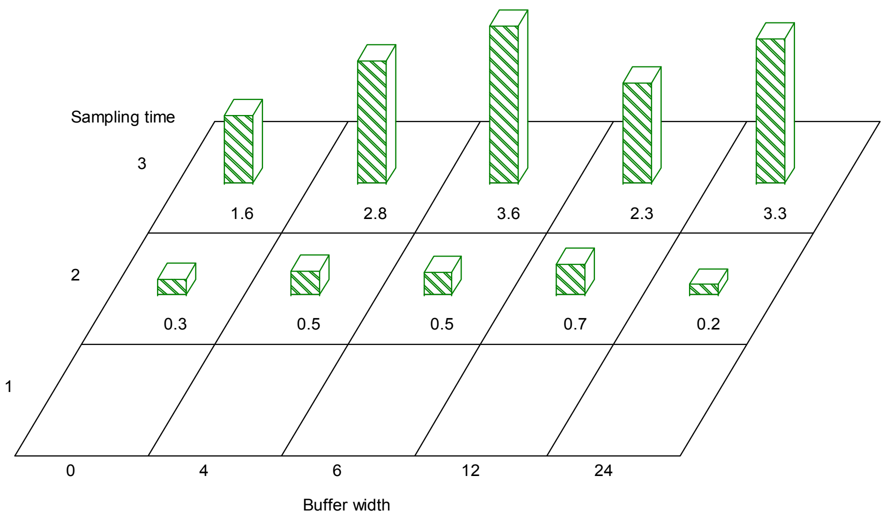


Fig. 3.11. Average Coleoptera numbers caught per sample in hedgerow trees in buffer widths 0, 4, 6, 12 and 24 m. Both for period 1 in May (sampling time 1) and for period 2 in June (sampling time 2) there was a significant effect of buffer width on the number of aphids caught. For Period 3 (sampling time 3) there were too few aphids for a statistical analysis.

However, a comparison of buffer width 0 m against all other buffer widths, found that in period 2 there were significantly fewer Coleoptera in hedgerow treatments without any buffer than with a buffer zone (t=-2.54, df=180, ***P***=0.01). A pairwise comparison of Coleoptera numbers in hedgerow trees protected by different buffer widths, showed a significant difference between 0 m and 12 and 24 m (t=-2.28, ***P***=0.02 and t=-2.54 , ***P***=0.01, respectively, both df =180)

On the family level the effect of buffer width at period 3 was significant for Nitidulidae (F=.74, df=12, ***P***=0.001) and Curculionidae (F=.33, df=12, ***P***=0.049). There were significantly more Nitidulidae in buffers 6 m and 24 m than in buffer 0 m (Tukeys test for pairwise comparisons) (df=13, ***P***=0.001 and df=13, ***P***=0.006) (Fig. 3.12a). For Curculionidae there was no clear trend towards more individuals at increased buffer width (Fig. 3.12b). Curculionid diversity (Shannon´s H) at time 3 was less at buffer 0 than at other buffers (4, 6, 12 and 24 m), though not significantly so (df=45, ***P***=0.07).

a.



b.

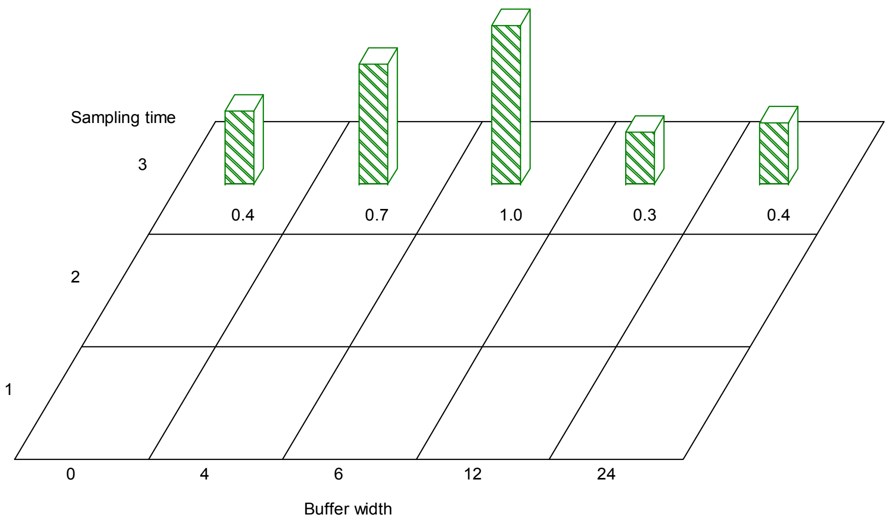


Fig. 3.12. Average numbers of a) Nitulidae and b) Curculionidae caught per sample in hedgerow trees in buffer widths 0, 4, 6, 12 and 24 m. In period 3 (July) there was a significant effect of buffer width on the number of Nitidulidae and Curculionidae caught. For Period 1 too few Nitidulidae were caught for a statistical analysis. Curculionid numbers could only be analysed for period 3.

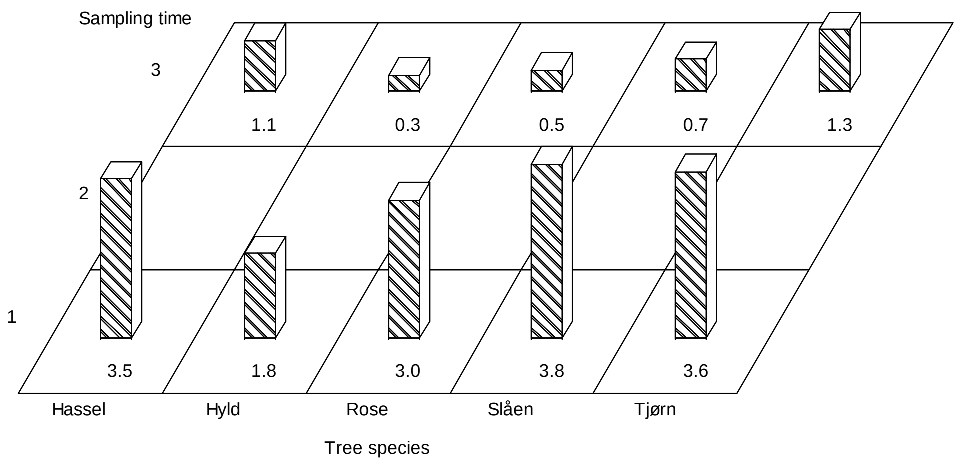
On blackthorn there was a significant effect of buffer on Coccinellid numbers (F=3.56, df=15, ***P***=0.03). In July 30 % more coccinellids were found in hedges with a buffer zone than without (buffer 0 compared to all treatments) (df=40.5, t=-2.07, ***P***=0.04).

Chick-food

There were no significant effects of buffer width on the amount of chick- food available within the hedges.

The effect of woody species on arthropod abundance

There were significant differences among the numbers of individuals in the arthropod taxa found in the five species of hedgerow woody plants. For the arthropods which showed significant responses to buffer width at either order, suborder or family levels, differences in their number or diversity among woody species are listed below.



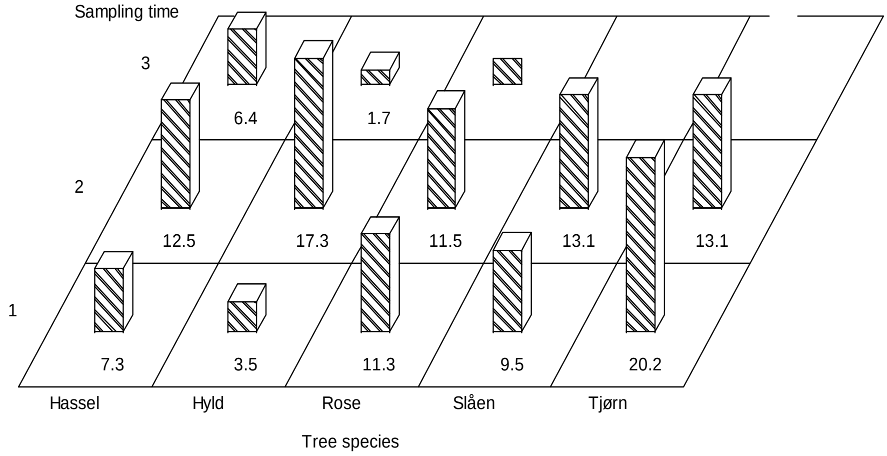


Fig. 3.13 Average numbers of a) Araneae b) Hemiptera and C) Coleoptera caught per sample in hedgerow trees in buffer widths 0, 4, 6, 12 and 24 m. Overall, arthropod densities differed significantly between the hedgerow trees. (note: Hassel = Hazel, Hyld = Elderberry, Rose = Rose, Slåen = blackthorn, Tjørn = Hawthorn)

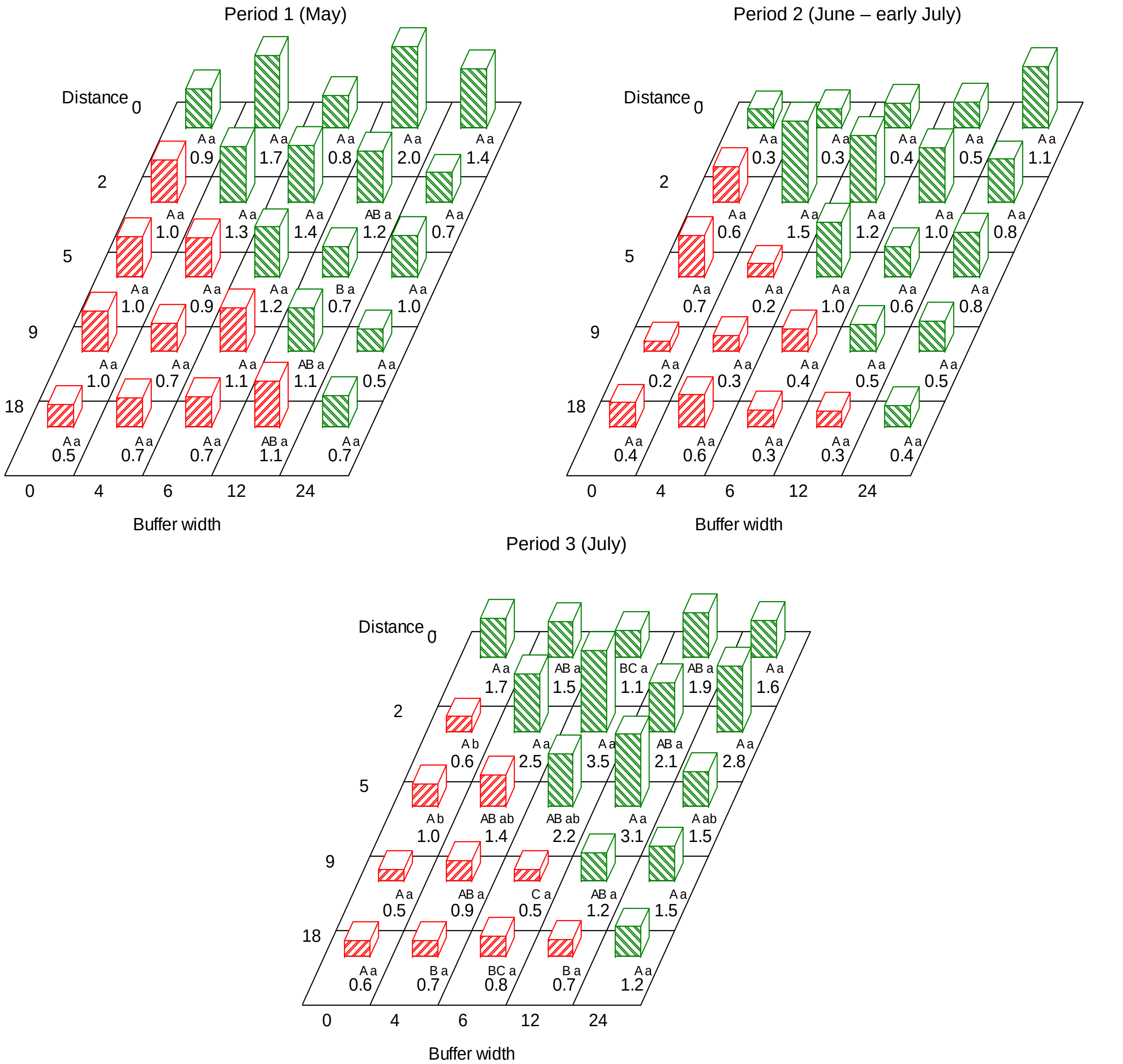


Fig. D.12. Estimated average number of *Harpalus* per pitfall (a ground beetle genus) for each combination of buffer width (m) and distance from hedge (m). Red bars (hatched from lower left to upper right) are numbers in areas treated with fertilizer and pesticides. Green bars (hatched from upper left to lower right) are non-treated area (buffer zone). Within each buffer width, figures with the same capital letter are not significant different (P ≥ 5%). Within each distance, figures with the same lower case letter are not significant different (P ≥ 5%). For 95% confidence limits see Table D.21.

Table D.21. 95% confidence limits for abundance of test taxa of epigaeic arthropods caught in pitfalls

Order	Family	Subfamily/ Genus	Per.	Mean ± CL	Buffer 0 Distance (m) 0	2	5	9	18	Buffer 4 Distance (m) 0	2	5	9	18	Buffer 6 Distance (m) 0	2	5	9	18	Buffer 12 Distance (m) 0	2	5	9	18	Buffer 24 Distance (m) 0	2	5	9	18
Araneae			1	Mean	4.9	6.4	6.7	5.4	4.4	5.4	3.2	6.1	4.8	4.2	6.1	4.2	4.9	4.7	3.1	8.3	3.2	3.4	3.6	4.3	5.9	3.7	4.0	3.3	2.6
				Low	3.4	4.6	4.8	3.8	3.0	3.8	2.1	4.3	3.3	2.9	4.4	2.9	3.4	3.3	2.0	6.1	2.1	2.2	2.4	2.9	4.2	2.5	2.8	2.2	1.6
				Upp	7.0	9.0	9.3	7.7	6.4	7.6	4.8	8.5	6.9	6.1	8.6	6.1	7.0	6.7	4.7	11.4	4.8	5.0	5.3	6.2	8.3	5.5	5.9	4.9	4.0
			2	Mean	1.2	1.7	1.1	1.0	0.6	1.2	3.3	1.9	0.9	0.6	1.4	5.3	5.5	1.1	1.0	2.3	6.7	8.0	5.0	0.9	2.7	8.6	8.1	10.2	10.8
				Low	0.6	0.9	0.5	0.5	0.3	0.6	2.0	1.0	0.4	0.3	0.8	3.3	3.5	0.5	0.5	1.3	4.3	5.1	3.1	0.4	1.6	5.6	5.2	6.6	7.0
				Upp	2.3	3.0	2.2	2.1	1.5	2.3	5.4	3.3	1.9	1.5	2.6	8.5	8.8	2.1	2.1	3.9	10.6	12.4	8.0	1.9	4.6	13.4	12.6	15.8	16.6
			3	Mean	1.0	0.7	0.9	0.5	0.4	3.0	5.8	1.0	0.5	0.3	2.4	8.8	8.3	0.6	0.3	3.6	15.8	14.5	13.9	1.0	3.9	13.0	12.0	12.3	16.6
				Low	0.6	0.4	0.5	0.2	0.2	1.9	4.0	0.6	0.2	0.1	1.6	6.1	5.7	0.3	0.1	2.4	11.2	10.2	9.8	0.5	2.6	9.2	8.4	8.6	11.7
				Upp	1.9	1.4	1.7	1.0	0.9	4.5	8.5	1.8	1.1	0.8	3.8	12.7	11.9	1.2	0.8	5.4	22.5	20.6	19.8	1.8	5.9	18.6	17.1	17.6	23.6
	Linyphiidae		1	Mean	0.8	1.6	3.0	2.9	3.1	1.1	1.3	2.8	2.3	2.5	0.9	0.9	1.7	2.0	1.7	1.3	0.8	1.8	2.1	2.5	1.3	0.9	1.5	1.5	1.6
				Low	0.4	0.9	2.0	1.9	2.1	0.6	0.8	1.8	1.5	1.6	0.5	0.5	1.1	1.3	1.0	0.8	0.4	1.1	1.4	1.6	0.7	0.5	0.9	0.9	1.0
				Upp	1.5	2.6	4.5	4.3	4.6	1.9	2.2	4.2	3.6	3.9	1.7	1.7	2.8	3.2	2.8	2.2	1.5	2.9	3.3	3.8	2.2	1.7	2.5	2.4	2.7
			2	Mean	0.6	1.0	0.7	0.8	0.6	0.6	2.8	1.5	0.7	0.6	0.9	4.4	4.4	0.8	0.8	1.0	5.9	7.3	4.7	0.7	1.7	7.4	7.2	9.1	9.8
				Low	0.2	0.5	0.3	0.4	0.3	0.3	1.6	0.8	0.3	0.3	0.4	2.6	2.6	0.4	0.4	0.5	3.6	4.5	2.9	0.3	0.9	4.6	4.4	5.6	6.1
				Upp	1.4	2.1	1.6	1.8	1.5	1.4	4.8	2.8	1.5	1.5	1.9	7.3	7.3	1.6	1.7	2.0	9.6	11.9	7.9	1.6	3.2	12.0	11.7	14.6	15.7
			3	Mean	0.9	0.7	0.8	0.4	0.4	2.8	5.3	1.0	0.4	0.2	2.4	8.7	8.0	0.6	0.3	3.3	15.7	14.2	13.8	0.9	3.7	12.1	11.5	11.9	16.3
				Low	0.5	0.3	0.4	0.2	0.1	1.8	3.5	0.6	0.2	0.1	1.5	5.9	5.5	0.3	0.1	2.1	10.8	9.8	9.5	0.5	2.4	8.3	7.9	8.2	11.2
				Upp	1.7	1.3	1.6	1.0	0.9	4.5	8.0	1.9	1.0	0.7	3.8	12.7	11.9	1.2	0.9	5.1	22.8	20.6	20.0	1.7	5.6	17.7	16.8	17.4	23.6
Coleoptera	Carabidae		1	Mean	4.9	5.6	6.1	3.7	4.4	7.3	6.0	5.4	2.9	4.1	5.0	4.9	5.4	4.8	5.5	7.0	6.3	4.5	4.4	5.8	5.2	4.3	5.0	3.1	5.9
				Low	3.2	3.7	4.1	2.4	2.8	5.0	4.0	3.6	1.8	2.7	3.3	3.2	3.6	3.2	3.7	4.7	4.3	2.9	2.9	3.9	3.4	2.8	3.3	2.0	3.9
				Upp	7.4	8.4	9.1	5.8	6.7	10.8	8.9	8.2	4.7	6.4	7.6	7.4	8.1	7.3	8.3	10.4	9.5	6.9	6.8	8.7	7.8	6.6	7.5	5.0	8.8
			2	Mean	1.8	2.1	3.4	1.0	1.3	2.6	5.9	2.0	1.6	1.4	1.4	8.1	7.4	1.7	2.0	2.0	5.9	6.3	5.5	2.7	3.1	5.0	7.0	4.3	4.1
				Low	0.9	1.1	1.9	0.4	0.6	1.4	3.5	1.0	0.8	0.7	0.7	4.9	4.4	0.8	1.0	1.0	3.5	3.8	3.2	1.5	1.7	2.9	4.2	2.5	2.3
				Upp	3.5	4.0	6.1	2.3	2.8	4.8	10.1	3.7	3.2	2.8	3.0	13.4	12.3	3.4	3.8	3.9	10.0	10.7	9.4	5.0	5.5	8.5	11.7	7.6	7.2
			3	Mean	8.5	5.4	6.6	4.5	4.6	6.8	10.7	6.7	6.4	4.5	6.4	12.3	11.2	5.7	7.0	8.3	10.0	10.2	8.0	6.1	7.0	10.9	8.4	8.0	9.7
				Low	6.2	3.8	4.7	3.1	3.2	4.9	8.0	4.8	4.6	3.1	4.6	9.2	8.4	4.0	5.1	6.1	7.4	7.6	5.8	4.4	5.1	8.1	6.1	5.8	7.2
				Upp	11.6	7.7	9.1	6.5	6.7	9.4	14.4	9.3	8.9	6.5	8.9	16.3	14.9	8.0	9.7	11.3	13.5	13.7	10.9	8.6	9.7	14.5	11.4	10.9	13.1
		Bembidion	1	Mean	0.2	2.2	3.0	1.5	2.6	0.6	2.5	2.8	1.1	1.7	0.6	1.5	2.9	1.9	2.7	1.0	2.6	2.5	2.2	3.1	0.3	1.2	2.7	1.5	3.7
				Low	0.0	1.3	1.7	0.8	1.5	0.3	1.5	1.7	0.5	1.0	0.3	0.8	1.7	1.1	1.6	0.5	1.5	1.5	1.3	1.8	0.1	0.6	1.6	0.8	2.3
				Upp	0.7	3.9	5.0	2.7	4.5	1.3	4.3	4.8	2.1	3.1	1.4	2.8	4.9	3.3	4.6	1.9	4.4	4.3	3.9	5.2	0.8	2.3	4.6	2.7	6.2
			2	Mean	0.1	0.3	1.2	0.2	0.1	0.2	2.9	0.7	0.2	0.1	0.3	5.0	5.1	0.4	0.3	0.2	2.7	3.8	3.0	0.4	0.6	2.3	4.4	1.7	1.4
				Low	0.0	0.1	0.6	0.0	0.0	0.1	1.6	0.3	0.1	0.0	0.1	2.8	2.9	0.1	0.1	0.1	1.5	2.1	1.7	0.2	0.2	1.2	2.5	0.9	0.7
				Upp	0.6	0.9	2.5	0.7	0.7	0.8	5.4	1.6	0.8	0.6	1.0	8.8	8.9	1.1	0.9	0.9	4.9	6.7	5.5	1.2	1.5	4.3	7.8	3.4	2.7
			3	Mean	1.1	1.0	1.8	1.1	0.6	0.8	1.8	1.2	1.5	0.9	0.8	2.4	3.6	1.3	0.7	1.5	3.2	2.7	2.4	1.0	0.8	2.3	2.2	2.0	3.0
				Low	0.5	0.5	1.0	0.5	0.2	0.4	1.0	0.6	0.8	0.4	0.4	1.4	2.2	0.7	0.3	0.8	1.9	1.6	1.4	0.5	0.4	1.3	1.3	1.1	1.8
				Upp	2.2	2.1	3.3	2.1	1.4	1.7	3.2	2.4	2.8	1.9	1.8	4.2	6.0	2.5	1.6	2.7	5.3	4.6	4.2	2.0	1.8	4.1	3.9	3.6	5.0
		Harpalus	1	Mean	0.9	1.0	1.0	1.0	0.5	1.7	1.3	0.9	0.7	0.7	0.8	1.4	1.2	1.1	0.7	2.0	1.2	0.7	1.1	1.1	1.4	0.7	1.0	0.5	0.7
				Low	0.5	0.6	0.5	0.5	0.3	1.0	0.8	0.5	0.3	0.4	0.4	0.8	0.7	0.6	0.4	1.2	0.7	0.4	0.6	0.6	0.8	0.4	0.6	0.3	0.4
				Upp	1.7	1.8	1.8	1.8	1.1	2.9	2.3	1.7	1.3	1.3	1.5	2.3	2.1	1.9	1.4	3.2	2.2	1.4	1.9	1.9	2.4	1.4	1.8	1.1	1.4
			2	Mean	0.3	0.6	0.7	0.2	0.4	0.3	1.5	0.2	0.3	0.6	0.4	1.2	1.0	0.4	0.3	0.5	1.0	0.6	0.5	0.3	1.1	0.8	0.8	0.5	0.4
				Low	0.1	0.2	0.3	0.0	0.1	0.1	0.6	0.1	0.1	0.2	0.1	0.5	0.4	0.1	0.1	0.1	0.4	0.2	0.2	0.1	0.4	0.3	0.3	0.2	0.1
				Upp	1.1	1.8	2.1	0.7	1.3	1.1	3.8	0.8	1.0	1.6	1.3	3.2	2.7	1.3	1.0	1.4	2.7	1.6	1.5	0.9	2.9	2.1	2.2	1.6	1.2
			3	Mean	1.7	0.6	1.0	0.5	0.6	1.5	2.5	1.4	0.9	0.7	1.1	3.5	2.2	0.5	0.8	1.9	2.1	3.1	1.2	0.7	1.6	2.8	1.5	1.5	1.2
				Low	1.0	0.3	0.5	0.2	0.3	0.9	1.5	0.8	0.5	0.3	0.6	2.1	1.3	0.2	0.4	1.1	1.2	1.9	0.7	0.3	0.9	1.7	0.8	0.9	0.7
				Upp	2.9	1.3	1.8	1.1	1.3	2.7	4.2	2.4	1.7	1.3	2.1	5.7	3.8	1.1	1.6	3.3	3.6	5.1	2.2	1.4	2.7	4.7	2.6	2.7	2.3

Table D.22. 95% confidence limits of estimated family richness of Araneae

Period	Mean± CL	Buffer																								
		0					4					6					12					24				
		Distance (m)					Distance (m)					Distance (m)					Distance (m)					Distance (m)				
		0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18
1	Mean	2.0	1.7	1.8	1.7	1.5	2.0	1.6	1.8	1.8	1.4	2.2	1.4	1.8	1.4	1.4	1.8	1.5	1.7	1.6	1.7	2.1	1.4	1.6	1.2	1.3
	Low	1.4	1.2	1.3	1.2	1.1	1.3	1.1	1.3	1.3	1.0	1.5	1.0	1.3	1.0	1.0	1.3	1.0	1.1	1.1	1.1	1.4	1.0	1.1	0.8	0.9
	upp	2.9	2.4	2.6	2.4	2.2	2.8	2.4	2.7	2.7	2.1	3.1	2.1	2.7	2.1	2.1	2.7	2.2	2.4	2.4	2.4	3.0	2.0	2.4	1.7	1.8
2	Mean	0.8	1.1	0.6	0.6	0.5	0.8	1.2	1.1	0.7	0.5	0.8	1.4	1.2	0.5	0.7	1.3	1.4	1.4	1.1	0.5	1.0	1.5	1.6	1.5	1.3
	Low	0.6	0.8	0.4	0.4	0.3	0.6	0.8	0.7	0.5	0.4	0.6	1.0	0.9	0.3	0.5	0.9	1.0	1.0	0.7	0.4	0.7	1.0	1.1	1.0	0.9
	upp	1.2	1.6	0.9	0.9	0.7	1.2	1.7	1.5	1.0	0.7	1.2	2.0	1.8	0.7	1.0	1.9	2.1	2.1	1.5	0.8	1.5	2.1	2.3	2.1	1.9
3	Mean	0.6	0.4	0.4	0.3	0.4	0.9	1.1	0.6	0.3	0.4	0.7	1.1	1.2	0.5	0.2	1.1	1.1	1.2	1.1	0.6	1.0	1.3	1.3	1.2	1.1
	Low	0.4	0.3	0.3	0.2	0.3	0.6	0.8	0.4	0.2	0.3	0.5	0.8	0.8	0.4	0.2	0.8	0.8	0.8	0.8	0.4	0.7	0.9	0.9	0.8	0.8
	upp	0.9	0.6	0.6	0.5	0.6	1.2	1.6	0.8	0.5	0.5	1.0	1.6	1.7	0.8	0.3	1.7	1.6	1.7	1.7	0.9	1.4	2.0	1.9	1.7	1.6

Table D.23. Schematic summary of significant effects on family richness of Araneae

Effect	Per.	Buffer	Dist.	Per.	Buffer	Dist.	Estimate	StdErr	DF	tValue	Probt
PERIOD*BUFFER*DISTANCE	2	0	5	2	12	5	-0.8625	0.2602	197	-3.32	0.0011
PERIOD*BUFFER*DISTANCE	2	0	5	2	24	5	-0.9587	0.2602	197	-3.68	0.0003
PERIOD*BUFFER*DISTANCE	2	0	9	2	24	9	-0.9010	0.2602	197	-3.46	0.0007
PERIOD*BUFFER*DISTANCE	2	0	18	2	24	18	-1.0358	0.2602	197	-3.98	<.0001
PERIOD*BUFFER*DISTANCE	2	4	9	2	24	9	-0.7439	0.2602	197	-2.86	0.0047
PERIOD*BUFFER*DISTANCE	2	4	18	2	24	18	-0.9553	0.2602	197	-3.67	0.0003
PERIOD*BUFFER*DISTANCE	2	6	9	2	12	9	-0.7823	0.2602	197	-3.01	0.0030
PERIOD*BUFFER*DISTANCE	2	6	9	2	24	9	-1.1077	0.2602	197	-4.26	<.0001
PERIOD*BUFFER*DISTANCE	2	12	18	2	24	18	-0.9344	0.2602	197	-3.59	0.0004
PERIOD*BUFFER*DISTANCE	3	0	2	3	4	2	-0.9061	0.2602	197	-3.48	0.0006
PERIOD*BUFFER*DISTANCE	3	0	2	3	6	2	-0.9446	0.2602	197	-3.63	0.0004
PERIOD*BUFFER*DISTANCE	3	0	2	3	12	2	-0.8990	0.2602	197	-3.46	0.0007
PERIOD*BUFFER*DISTANCE	3	0	2	3	24	2	-1.1129	0.2602	197	-4.28	<.0001
PERIOD*BUFFER*DISTANCE	3	0	5	3	6	5	-0.9608	0.2602	197	-3.69	0.0003
PERIOD*BUFFER*DISTANCE	3	0	5	3	12	5	-0.9608	0.2602	197	-3.69	0.0003
PERIOD*BUFFER*DISTANCE	3	0	5	3	24	5	-1.0743	0.2602	197	-4.13	<.0001
PERIOD*BUFFER*DISTANCE	3	0	9	3	12	9	-1.2982	0.2602	197	-4.99	<.0001
PERIOD*BUFFER*DISTANCE	3	0	9	3	24	9	-1.3246	0.2602	197	-5.09	<.0001
PERIOD*BUFFER*DISTANCE	3	0	18	3	24	18	-1.0284	0.2602	197	-3.95	0.0001
PERIOD*BUFFER*DISTANCE	3	4	5	3	6	5	-0.7317	0.2602	197	-2.81	0.0054
PERIOD*BUFFER*DISTANCE	3	4	5	3	12	5	-0.7317	0.2602	197	-2.81	0.0054
PERIOD*BUFFER*DISTANCE	3	4	5	3	24	5	-0.8452	0.2602	197	-3.25	0.0014
PERIOD*BUFFER*DISTANCE	3	4	9	3	12	9	-1.2263	0.2602	197	-4.71	<.0001
PERIOD*BUFFER*DISTANCE	3	4	9	3	24	9	-1.2527	0.2602	197	-4.81	<.0001
PERIOD*BUFFER*DISTANCE	3	4	18	3	24	18	-1.1003	0.2602	197	-4.23	<.0001
PERIOD*BUFFER*DISTANCE	3	6	9	3	12	9	-0.7784	0.2602	197	-2.99	0.0031
PERIOD*BUFFER*DISTANCE	3	6	9	3	24	9	-0.8047	0.2602	197	-3.09	0.0023
PERIOD*BUFFER*DISTANCE	3	6	18	3	12	18	-0.9678	0.2602	197	-3.72	0.0003
PERIOD*BUFFER*DISTANCE	3	6	18	3	24	18	-1.5273	0.2602	197	-5.87	<.0001

Table D.24. Schematic summary of all sampled arthropods caught in pitfalls

Order	Genus	Species	Stage	Buffer 0					Buffer 4					Buffer 6					Buffer 12					Buffer 24				
				Distance (m)					Distance (m)					Distance (m)					Distance (m)					Distance (m)				
				0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18
Araneae	*Araneidae*	.	Adult	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2	0	0	0	1
Araneae	*Clubionidae*	.	Adult	10	5	2	2	0	2	1	0	1	0	5	1	9	0	0	1	1	2	1	1	2	0	0	0	0
Araneae	*Linyphiidae*	.	Adult	47	68	93	85	84	99	208	111	71	70	88	305	304	71	59	114	468	485	429	83	148	485	459	514	625
Araneae	*Lycosidae*	.	Adult	41	103	81	49	26	40	49	74	50	36	36	89	84	56	28	89	67	47	33	41	57	85	75	59	34
Araneae	*Philodromidae*	.	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0	0	0
Araneae	*Segestriidae*	.	Adult	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Araneae	*Tetragnathidae*	.	Adult	3	2	2	2	0	1	3	3	3	0	4	1	4	4	2	7	4	1	2	2	10	3	2	0	2
Araneae	*Theridiidae*	.	Adult	0	2	0	1	0	2	0	0	0	0	0	0	0	1	2	0	0	1	0	1	0	0	0	0	0
Araneae	*Thomisidae*	.	Adult	45	1	1	1	0	60	9	1	2	0	73	2	1	0	1	86	1	3	2	0	53	3	0	0	0
Araneae	*Zodariidae*	.	Adult	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	2	1	0	1	0	2	0	1	0	0
Araneae	*Lycosidae*	.	Juvenile	0	13	1	0	0	0	55	0	0	0	0	27	21	1	0	0	4	29	0	0	36	40	137	0	0
Carabidae	*Abax*	*parallelepipedus*	Adult	4	0	0	0	0	4	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Carabidae	*Acupalpus*	*meridianus*	Adult	0	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Carabidae	*Acupalpus*	*parvulus*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5	0	0	0	0	0	0	0	0	0	1
Carabidae	*Agonum*	*assimile*	Adult	1	1	0	0	0	2	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	2	0	0	0
Carabidae	*Agonum*	*dorsale*	Adult	30	22	39	16	24	28	41	39	41	24	14	23	21	21	33	17	27	30	19	51	29	30	21	26	26
Carabidae	*Agonum*	*muelleri*	Adult	0	0	1	1	1	0	2	1	1	3	0	10	8	0	4	0	8	5	4	0	0	13	7	7	0
Carabidae	*Agonum*	*obscurum*	Adult	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carabidae	*Amara*	*aenea*	Adult	0	2	0	0	0	1	4	0	0	0	15	2	1	1	1	2	2	0	0	1	9	2	3	2	0

Order	Genus	Species	Stage	Buffer 0					Buffer 4					Buffer 6					Buffer 12					Buffer 24				
				Distance (m)					Distance (m)					Distance (m)					Distance (m)					Distance (m)				
				0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18
Carabidae	*Amara*	*apricaria*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Carabidae	*Amara*	*aulica*	Adult	1	0	1	1	0	2	2	2	1	0	1	4	1	0	1	6	3	1	1	0	3	3	1	0	1
Carabidae	*Amara*	*bifrons*	Adult	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0
Carabidae	*Amara*	*familiaris*	Adult	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Carabidae	*Amara*	*fulva*	Adult	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	1	0	0	0	0	1	0	0	0	0
Carabidae	*Amara*	*lunicollis*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Carabidae	*Amara*	*plebaja*	Adult	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	5	3	0	0	0	3	1	1	0	0
Carabidae	*Amara*	*spreta*	Adult	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Carabidae	*Anisodactylus*	*binolatus*	Adult	0	0	2	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0
Carabidae	*Asaphidion*	*flavipes*	Adult	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Carabidae	*Badister*	*bullatus*	Adult	16	0	1	1	2	13	0	2	0	0	9	0	0	0	0	13	1	0	1	3	23	3	3	1	1
Carabidae	*Bembidion*	*lampros*	Adult	20	57	90	26	38	30	125	68	35	42	28	140	175	50	56	45	123	134	122	82	32	85	132	66	107
Carabidae	*Bembidion*	*obtusum*	Adult	1	9	23	21	25	0	5	19	14	11	2	2	18	12	8	1	5	9	14	3	2	2	17	11	35
Carabidae	*Bembidion*	*properans*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	1	0	1	0	1	0	0	0
Carabidae	*Bembidion*	*quadrimaculatum*	Adult	1	2	7	6	3	0	9	5	2	1	3	24	49	3	3	0	16	15	18	3	0	22	45	22	23
Carabidae	*Bembidion*	*tetracolum*	Adult	9	9	16	7	3	8	26	16	12	3	7	34	23	15	11	12	31	33	11	5	4	19	22	17	9
Carabidae	*Calathus*	*fusipes*	Adult	2	1	0	2	3	6	5	2	0	1	2	3	3	4	2	5	2	2	1	1	2	4	0	0	0
Carabidae	*Calathus*	*melanocephalus*	Adult	0	1	0	0	0	4	1	0	0	0	3	0	3	0	2	2	0	1	4	1	5	0	3	0	1
Carabidae	*Calathus*	*rotundicollis*	Adult	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	2	0	0	2	0	1	0	0	0	0
Carabidae	*Carabus*	*coriaceus*	Adult	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Carabidae	*Carabus*	*granulatus*	Adult	5	1	0	1	1	2	2	1	2	0	1	2	0	1	0	2	1	0	0	3	1	1	0	0	0

Order	Genus	Species	Stage	Buffer 0					Buffer 4					Buffer 6					Buffer 12					Buffer 24				
				Distance (m)					Distance (m)					Distance (m)					Distance (m)					Distance (m)				
				0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18
Carabidae	*Carabus*	*nemoralis*	Adult	11	2	2	2	0	9	1	1	0	0	4	2	0	0	0	10	2	1	0	0	14	4	0	0	0
Carabidae	*Carabus*	*violaceus*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Carabidae	*Cicindela*	*campestris*	Adult	0	1	0	0	1	0	0	0	1	1	0	0	1	1	0	0	0	0	1	0	0	1	1	1	1
Carabidae	*Clivina*	*fossor*	Adult	1	6	7	8	9	0	5	7	11	7	5	3	9	11	13	1	8	13	8	10	4	2	7	8	17
Carabidae	*Cychrus*	*caraboides*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Carabidae	*Demetrias*	*atricapillus*	Adult	1	1	0	0	0	2	0	1	0	0	1	0	0	2	0	0	0	0	0	0	2	0	1	0	0
Carabidae	*Dromius*	*linearis*	Adult	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0
Carabidae	*Dromius*	*sigma*	Adult	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Carabidae	*Harpalus*	*affinis*	Adult	9	12	12	13	14	13	24	26	16	23	9	32	42	21	33	14	31	37	24	33	21	23	32	27	41
Carabidae	*Harpalus*	*latus*	Adult	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	0	1	0	0	0
Carabidae	*Harpalus*	*nitidulus*	Adult	2	0	0	2	1	2	0	0	0	0	1	0	0	0	0	13	0	0	0	0	10	2	0	1	0
Carabidae	*Harpalus*	*puncticeps*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Carabidae	*Harpalus*	*quadripunctatus*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
Carabidae	*Harpalus*	*rubripes*	Adult	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	3	0	0	0	1	0	0	0
Carabidae	*Harpalus*	*rufibarbis*	Adult	4	0	0	0	1	2	2	2	0	0	4	0	0	1	0	5	2	1	0	0	20	4	4	0	2
Carabidae	*Harpalus*	*rufipes*	Adult	55	50	59	25	24	68	111	34	28	26	41	114	68	28	15	67	78	63	46	21	51	71	45	39	19
Carabidae	*Harpalus*	*tardus*	Adult	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	3	2	1	0	0	3	1	3	0	0
Carabidae	*Leistus*	*ferrugineus*	Adult	17	1	1	1	1	22	3	0	0	0	11	0	0	1	0	20	1	0	1	0	5	1	1	2	0
Carabidae	*Loricera*	*pilicornis*	Adult	2	9	1	0	1	0	8	6	6	1	3	12	2	5	0	1	10	1	2	2	0	2	1	3	3
Carabidae	*Nebria*	*brevicollis*	Adult	27	22	15	4	1	41	15	10	4	6	18	10	4	6	1	15	20	14	7	3	15	23	10	8	1
Carabidae	*Notiophilus*	*biguttatus*	Adult	0	0	3	0	0	2	1	1	2	3	1	2	0	3	2	1	0	0	1	1	4	1	1	0	0
Carabidae	*Pterostichus*	*oblongopunctatus*	Adult	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Order	Genus	Species	Stage	Buffer 0					Buffer 4					Buffer 6					Buffer 12					Buffer 24				
				Distance (m)					Distance (m)					Distance (m)					Distance (m)					Distance (m)				
				0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18
Carabidae	*Pterostichus*	*strenuus*	Adult	0	0	0	1	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Carabidae	*Pterostichus*	*vernalis*	Adult	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Carabidae	*Pterosticus*	*cupreus*	Adult	1	1	3	1	4	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0	0	1	0
Carabidae	*Pterosticus*	*melanarius*	Adult	82	43	44	36	34	82	83	51	40	54	75	98	74	56	106	96	72	71	79	71	58	90	72	84	125
Carabidae	*Pterosticus*	*niger*	Adult	21	17	14	12	21	15	7	10	11	5	11	10	7	8	5	15	6	5	7	10	10	3	6	5	3
Carabidae	*Stomis*	*pumicatus*	Adult	3	0	1	0	0	5	1	0	0	1	6	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Carabidae	*Synuchus*	*vivalis*	Adult	0	0	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Carabidae	*Trechus*	*discus*	Adult	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0	1	0	1	0	2	1	0	0	0	0
Carabidae	*Trechus*	*quadristriatus*	Adult	2	2	2	4	1	2	0	1	2	1	0	0	0	0	1	0	0	0	1	0	1	2	3	0	3
Carabidae	*Trerchus*	*secalis*	Adult	0	0	0	0	1	2	0	1	2	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	1
Carabidae	*Carabidae*	*spp*	Juvenile	8	7	6	3	14	3	4	6	8	7	7	6	5	6	7	13	11	5	5	4	11	4	9	4	7
Carabidae	*Carabidae*	*melanarius*	Juvenile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Carabidae	*Carabidae*	*pilicornis*	Juvenile	0	0	1	0	0	0	0	2	4	3	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0
Chilopoda	*Chilopoda*	*.*	.	20	12	5	9	23	9	8	10	9	10	9	10	12	10	15	5	13	4	5	8	9	3	16	5	4
Diplipoda	*Diplipoda*	*.*	.	108	50	21	23	24	108	40	21	36	27	77	30	13	24	25	168	35	19	24	30	151	43	13	22	45
Elateridae	*Elateridae*	*.*	Adult	4	7	38	36	41	5	9	13	21	19	5	8	10	15	13	8	12	18	13	6	2	8	13	10	12
Elateridae	*Elateridae*	*.*	Juvenile	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Halticinae	*AndreHalticinae*	*.*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Halticinae	*Chaetocnema*	*aridella*	Adult	0	0	1	1	0	8	0	0	0	1	0	0	0	0	0	0	0	1	2	2	0	1	2	1	1
Halticinae	*Chaetocnema*	*aridula*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Halticinae	*Chaetocnema*	*concinna*	Adult	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	0	0	0

Order	Genus	Species	Stage	Buffer 0					Buffer 4					Buffer 6					Buffer 12					Buffer 24				
				Distance (m)					Distance (m)					Distance (m)					Distance (m)					Distance (m)				
				0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18
halticinae	*Hermaeophaga*	*mercurialis*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0
Halticinae	*Phyllotreta*	*undulata*	Adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Halticinae	*Psylliodes*	*chrysocephalus*	Adult	3	9	9	6	5	6	3	4	4	4	1	1	3	5	6	0	1	9	6	8	0	3	3	3	5
Halticinae	*Psylliodes*	*napi*	Adult	0	0	1	0	0	0	1	0	0	2	0	0	0	0	0	0	1	1	3	3	0	0	0	1	1
Opiliones	*Opiliones*	*.*	Adult	74	11	1	1	1	20	0	0	1	0	45	3	1	2	0	26	2	1	0	0	37	4	3	0	0
Silphidae	*Silphidae*	*.*	Adult	5	4	3	1	0	4	0	2	0	0	8	0	0	1	1	4	2	0	0	1	7	2	1	0	0
Silphidae	*Silphidae*	*.*	Juvenile	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0
Staphylinidae	*Aleocharinae*	*.*	Adult	62	138	109	102	140	91	82	144	140	148	167	104	75	121	102	164	124	176	156	126	175	163	149	131	137
Staphylinidae	*Bryocharis analis*	*analis*	Adult	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Staphylinidae	*Omaliinae*	*.*	Adult	1	0	0	0	0	1	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Staphylinidae	*Oxytelinae*	*.*	Adult	35	87	100	60	80	30	41	118	97	61	54	28	46	93	58	43	41	39	31	77	36	33	56	38	41
Staphylinidae	*Philonthus*	*.*	Adult	7	4	2	1	0	2	2	1	4	1	5	0	5	1	0	4	2	1	1	4	11	2	3	3	3
Staphylinidae	*Proteininae*	*.*	Adult	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Staphylinidae	*Staphylinidae*	*spp*	Adult	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	3	0	0	0
Staphylinidae	*Staphylininae*	*spp*	Adult	23	19	20	8	24	12	8	12	16	23	28	11	16	16	11	35	22	10	11	8	21	16	37	11	14
Staphylinidae	*Steninae*	*spp*	Adult	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Staphylinidae	*Stenus*	*clavicornis*	Adult	27	4	1	2	0	34	3	4	7	1	26	0	1	1	2	32	2	0	0	1	48	2	1	0	0
Staphylinidae	*Tachinus*	*rufipes*	Adult	21	2	0	3	2	34	2	1	2	1	27	0	0	2	0	48	1	1	0	0	37	1	1	1	0
Staphylinidae	*Tachyporinae*	*spp*	Adult	0	1	0	0	0	0	0	1	3	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0
Staphylinidae	*Tachyporus*	*hypnorum*	Adult	4	7	3	4	9	2	5	7	10	13	3	6	8	12	19	2	1	9	15	12	1	6	8	12	17
Staphylinidae	*Tachyporus*	*obtusus*	Adult	5	3	9	16	17	4	0	8	15	16	5	1	1	15	15	4	3	5	1	20	9	3	2	5	2
Staphylinidae	*Tachyporus*	*chrysomelinus*	Adult	3	1	1	0	0	0	0	1	2	0	0	0	0	5	0	3	0	2	2	0	0	1	1	1	0

Order	Genus	Species	Stage	Buffer 0					Buffer 4					Buffer 6					Buffer 12					Buffer 24				
				Distance (m)					Distance (m)					Distance (m)					Distance (m)					Distance (m)				
				0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18	0	2	5	9	18
Staphylinidae	*Tachyporus*	*solutus*	Adult	1	2	1	1	0	2	0	2	2	0	5	1	0	0	0	4	2	0	0	2	0	0	0	0	0
Staphylinidae	*Staphylinidae*	.	Juvenile	8	2	1	2	1	10	6	1	7	4	8	8	2	4	4	14	6	1	5	2	1	2	2	2	5
Staphylinidae	*Tachyporus*	.	Juvenile	0	1	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0

Supplementary material on accumulated species richness in relation to buffer width

Analysis of accumulated plant species at 5 different distance intervals

Table E.1. Analysis of accumulated plant species at distance 0 m (hedge-bottom)

Differences of Least Squares Means							
Effect	Buffer	_Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	0.1644	0.1469	12	1.12	0.2852
Buffer	0	6	0.03154	0.1469	12	0.21	0.8337
Buffer	0	12	0.05302	0.1469	12	0.36	0.7245
Buffer	0	24	0.2508	0.1469	12	1.71	0.1135
Buffer	4	6	-0.1328	0.1469	12	-0.90	0.3838
Buffer	4	12	-0.1114	0.1469	12	-0.76	0.4632
Buffer	4	24	0.08645	0.1469	12	0.59	0.5672
Buffer	6	12	0.02149	0.1469	12	0.15	0.8862
Buffer	6	24	0.2193	0.1469	12	1.49	0.1614
Buffer	12	24	0.1978	0.1469	12	1.35	0.2031

Table E.2. Analysis of accumulated plant species at distance 0-2 m

Differences of Least Squares Means							
Effect	Buffer	_Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.2088	0.05329	12	-3.92	0.0020
Buffer	0	6	-0.2084	0.05329	12	-3.91	0.0021
Buffer	0	12	-0.1745	0.05329	12	-3.27	0.0067
Buffer	0	24	-0.1620	0.05329	12	-3.04	0.0103
Buffer	4	6	0.000387	0.05329	12	0.01	0.9943
Buffer	4	12	0.03435	0.05329	12	0.64	0.5313
Buffer	4	24	0.04681	0.05329	12	0.88	0.3970
Buffer	6	12	0.03396	0.05329	12	0.64	0.5359
Buffer	6	24	0.04642	0.05329	12	0.87	0.4008
Buffer	12	24	0.01246	0.05329	12	0.23	0.8191

Table E.3. Analysis of accumulated plant species at distance 0-5 m

Differences of Least Squares Means							
Effect	Buffer	_Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.1124	0.05823	12	-1.93	0.0776
Buffer	0	6	-0.1500	0.05823	12	-2.58	0.0243
Buffer	0	12	-0.1111	0.05823	12	-1.91	0.0807
Buffer	0	24	-0.1184	0.05823	12	-2.03	0.0648
Buffer	4	6	-0.03755	0.05823	12	-0.64	0.5311
Buffer	4	12	0.001345	0.05823	12	0.02	0.9820
Buffer	4	24	-0.00596	0.05823	12	-0.10	0.9202
Buffer	6	12	0.03890	0.05823	12	0.67	0.5168
Buffer	6	24	0.03159	0.05823	12	0.54	0.5974
Buffer	12	24	-0.00730	0.05823	12	-0.13	0.9023

Table E.4. Analysis of accumulated plant species at distance 0-9 m

Differences of Least Squares Means							
Effect	Buffer	_Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.07532	0.04810	12	-1.57	0.1434
Buffer	0	6	-0.1126	0.04810	12	-2.34	0.0374
Buffer	0	12	-0.1300	0.04810	12	-2.70	0.0192
Buffer	0	24	-0.1002	0.04810	12	-2.08	0.0593
Buffer	4	6	-0.03725	0.04810	12	-0.77	0.4537
Buffer	4	12	-0.05470	0.04810	12	-1.14	0.2777
Buffer	4	24	-0.02488	0.04810	12	-0.52	0.6144
Buffer	6	12	-0.01745	0.04810	12	-0.36	0.7231
Buffer	6	24	0.01237	0.04810	12	0.26	0.8015
Buffer	12	24	0.02982	0.04810	12	0.62	0.5469

Table E.5. Analysis of accumulated plant species at distance 0-18 m

Differences of Least Squares Means							
Effect	Buffer	_Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.06814	0.04599	12	-1.48	0.1642
Buffer	0	6	-0.1048	0.04599	12	-2.28	0.0418
Buffer	0	12	-0.1343	0.04599	12	-2.92	0.0129
Buffer	0	24	-0.1410	0.04599	12	-3.07	0.0098
Buffer	4	6	-0.03667	0.04599	12	-0.80	0.4408
Buffer	4	12	-0.06613	0.04599	12	-1.44	0.1760
Buffer	4	24	-0.07290	0.04599	12	-1.59	0.1390
Buffer	6	12	-0.02946	0.04599	12	-0.64	0.5338
Buffer	6	24	-0.03623	0.04599	12	-0.79	0.4461
Buffer	12	24	-0.00677	0.04599	12	-0.15	0.8854

Analysis of accumulated arthropod species at diferent distance intervals

Table E.6. Analysis of accumulated Heteroptera species at distance 0 (Hedge bottom)

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.2544	0.1053	12	-2.42	0.0326
Buffer	0	6	-0.2691	0.1053	12	-2.56	0.0252
Buffer	0	12	-0.3203	0.1053	12	-3.04	0.0102
Buffer	0	24	-0.2459	0.1053	12	-2.34	0.0377
Buffer	4	6	-0.01471	0.1053	12	-0.14	0.8912
Buffer	4	12	-0.06593	0.1053	12	-0.63	0.5429
Buffer	4	24	0.008526	0.1053	12	0.08	0.9368
Buffer	6	12	-0.05122	0.1053	12	-0.49	0.6354
Buffer	6	24	0.02324	0.1053	12	0.22	0.8290
Buffer	12	24	0.07446	0.1053	12	0.71	0.4930

Table E.7. Analysis of accumulated Heteroptera species at distance 0-2 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.3441	0.09291	12	-3.70	0.0030
Buffer	0	6	-0.3799	0.09291	12	-4.09	0.0015
Buffer	0	12	-0.3981	0.09291	12	-4.29	0.0011
Buffer	0	24	-0.3984	0.09291	12	-4.29	0.0011
Buffer	4	6	-0.03578	0.09291	12	-0.39	0.7069
Buffer	4	12	-0.05398	0.09291	12	-0.58	0.5719
Buffer	4	24	-0.05430	0.09291	12	-0.58	0.5697
Buffer	6	12	-0.01821	0.09291	12	-0.20	0.8479
Buffer	6	24	-0.01853	0.09291	12	-0.20	0.8453
Buffer	12	24	-0.00032	0.09291	12	-0.00	0.9973

Table E.8. Analysis of accumulated Heteroptera species at distance 0-5 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.2589	0.08402	12	-3.08	0.0095
Buffer	0	6	-0.3350	0.08402	12	-3.99	0.0018
Buffer	0	12	-0.3469	0.08402	12	-4.13	0.0014
Buffer	0	24	-0.3946	0.08402	12	-4.70	0.0005
Buffer	4	6	-0.07616	0.08402	12	-0.91	0.3826
Buffer	4	12	-0.08806	0.08402	12	-1.05	0.3153
Buffer	4	24	-0.1358	0.08402	12	-1.62	0.1321
Buffer	6	12	-0.01190	0.08402	12	-0.14	0.8898
Buffer	6	24	-0.05960	0.08402	12	-0.71	0.4917
Buffer	12	24	-0.04771	0.08402	12	-0.57	0.5807

Table E.9. Analysis of accumulated Heteroptera species at distance 0-9 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.2589	0.09705	12	-2.67	0.0205
Buffer	0	6	-0.3350	0.09705	12	-3.45	0.0048
Buffer	0	12	-0.3855	0.09705	12	-3.97	0.0019
Buffer	0	24	-0.4251	0.09705	12	-4.38	0.0009
Buffer	4	6	-0.07616	0.09705	12	-0.78	0.4478
Buffer	4	12	-0.1266	0.09705	12	-1.30	0.2166
Buffer	4	24	-0.1662	0.09705	12	-1.71	0.1125
Buffer	6	12	-0.05043	0.09705	12	-0.52	0.6128
Buffer	6	24	-0.09003	0.09705	12	-0.93	0.3719
Buffer	12	24	-0.03959	0.09705	12	-0.41	0.6905

Table E.10. Analysis of accumulated Heteroptera species at distance 0-18 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.2589	0.09705	12	-2.67	0.0205
Buffer	0	6	-0.3350	0.09705	12	-3.45	0.0048
Buffer	0	12	-0.3855	0.09705	12	-3.97	0.0019
Buffer	0	24	-0.4251	0.09705	12	-4.38	0.0009
Buffer	4	6	-0.07616	0.09705	12	-0.78	0.4478
Buffer	4	12	-0.1266	0.09705	12	-1.30	0.2166
Buffer	4	24	-0.1662	0.09705	12	-1.71	0.1125
Buffer	6	12	-0.05043	0.09705	12	-0.52	0.6128
Buffer	6	24	-0.09003	0.09705	12	-0.93	0.3719
Buffer	12	24	-0.03959	0.09705	12	-0.41	0.6905

Table E.11. Analysis of accumulated Chrysomelidae and Curculinoidea species at distance o (Hedge bottom)

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.3010	0.3124	11	-0.96	0.3561
Buffer	0	6	-0.4905	0.3434	11	-1.43	0.1810
Buffer	0	12	-0.2747	0.3124	11	-0.88	0.3982
Buffer	0	24	-0.3568	0.3124	11	-1.14	0.2777
Buffer	4	6	-0.1895	0.3434	11	-0.55	0.5921
Buffer	4	12	0.02634	0.3124	11	0.08	0.9343
Buffer	4	24	-0.05579	0.3124	11	-0.18	0.8615
Buffer	6	12	0.2159	0.3434	11	0.63	0.5425
Buffer	6	24	0.1338	0.3434	11	0.39	0.7044
Buffer	12	24	-0.08213	0.3124	11	-0.26	0.7975

Table E.12. Analysis of accumulated Chrysomelidae and Curculinoidea species at distance 0-2 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.4967	0.2001	12	-2.48	0.0288
Buffer	0	6	-0.6714	0.2001	12	-3.36	0.0057
Buffer	0	12	-0.7541	0.2001	12	-3.77	0.0027
Buffer	0	24	-0.5199	0.2001	12	-2.60	0.0233
Buffer	4	6	-0.1747	0.2001	12	-0.87	0.3996
Buffer	4	12	-0.2574	0.2001	12	-1.29	0.2225
Buffer	4	24	-0.02318	0.2001	12	-0.12	0.9097
Buffer	6	12	-0.08269	0.2001	12	-0.41	0.6866
Buffer	6	24	0.1515	0.2001	12	0.76	0.4634
Buffer	12	24	0.2342	0.2001	12	1.17	0.2644

Table E.13. Analysis of accumulated Chrysomelidae and Curculinoidea species at distance 0-5 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.5423	0.1570	12	-3.45	0.0048
Buffer	0	6	-0.7991	0.1570	12	-5.09	0.0003
Buffer	0	12	-0.7541	0.1570	12	-4.80	0.0004
Buffer	0	24	-0.6770	0.1570	12	-4.31	0.0010
Buffer	4	6	-0.2568	0.1570	12	-1.64	0.1277
Buffer	4	12	-0.2118	0.1570	12	-1.35	0.2021
Buffer	4	24	-0.1347	0.1570	12	-0.86	0.4075
Buffer	6	12	0.04501	0.1570	12	0.29	0.7792
Buffer	6	24	0.1221	0.1570	12	0.78	0.4518
Buffer	12	24	0.07708	0.1570	12	0.49	0.6323

Table E.14. Analysis of accumulated Chrysomelidae and Curculinoidea species at distance 0-9 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.4236	0.2024	12	-2.09	0.0582
Buffer	0	6	-0.6419	0.2024	12	-3.17	0.0080
Buffer	0	12	-0.7478	0.2024	12	-3.70	0.0031
Buffer	0	24	-0.6142	0.2024	12	-3.04	0.0104
Buffer	4	6	-0.2183	0.2024	12	-1.08	0.3019
Buffer	4	12	-0.3242	0.2024	12	-1.60	0.1351
Buffer	4	24	-0.1905	0.2024	12	-0.94	0.3650
Buffer	6	12	-0.1059	0.2024	12	-0.52	0.6104
Buffer	6	24	0.02776	0.2024	12	0.14	0.8931
Buffer	12	24	0.1336	0.2024	12	0.66	0.5215

Table E.15. Analysis of accumulated Chrysomelidae and Curculinoidea species at distance 0-18 m

Differences of Least Squares Means							
Effect	Buffer	_Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.3851	0.2283	12	-1.69	0.1174
Buffer	0	6	-0.5700	0.2283	12	-2.50	0.0281
Buffer	0	12	-0.6759	0.2283	12	-2.96	0.0119
Buffer	0	24	-0.6142	0.2283	12	-2.69	0.0197
Buffer	4	6	-0.1849	0.2283	12	-0.81	0.4337
Buffer	4	12	-0.2908	0.2283	12	-1.27	0.2268
Buffer	4	24	-0.2291	0.2283	12	-1.00	0.3354
Buffer	6	12	-0.1059	0.2283	12	-0.46	0.6511
Buffer	6	24	-0.04416	0.2283	12	-0.19	0.8499
Buffer	12	24	0.06172	0.2283	12	0.27	0.7915

Table E.16. Analysis of accumulated Carabidae species at distance o (Hedge bottom)

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	0.06798	0.1446	12	0.47	0.6467
Buffer	0	6	-0.07335	0.1446	12	-0.51	0.6212
Buffer	0	12	-0.00981	0.1446	12	-0.07	0.9471
Buffer	0	24	0.06591	0.1446	12	0.46	0.6567
Buffer	4	6	-0.1413	0.1446	12	-0.98	0.3477
Buffer	4	12	-0.07779	0.1446	12	-0.54	0.6005
Buffer	4	24	-0.00207	0.1446	12	-0.01	0.9888
Buffer	6	12	0.06354	0.1446	12	0.44	0.6682
Buffer	6	24	0.1393	0.1446	12	0.96	0.3546
Buffer	12	24	0.07571	0.1446	12	0.52	0.6101

Table E.17. Analysis of accumulated Carabidae species at distance 0-2 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.1121	0.1106	12	-1.01	0.3308
Buffer	0	6	-0.1942	0.1106	12	-1.76	0.1045
Buffer	0	12	-0.1990	0.1106	12	-1.80	0.0971
Buffer	0	24	-0.1748	0.1106	12	-1.58	0.1400
Buffer	4	6	-0.08213	0.1106	12	-0.74	0.4720
Buffer	4	12	-0.08692	0.1106	12	-0.79	0.4471
Buffer	4	24	-0.06268	0.1106	12	-0.57	0.5813
Buffer	6	12	-0.00479	0.1106	12	-0.04	0.9661
Buffer	6	24	0.01944	0.1106	12	0.18	0.8634
Buffer	12	24	0.02424	0.1106	12	0.22	0.8302

Table E.18. Analysis of accumulated Carabidae species at distance 0-5 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.1553	0.1041	12	-1.49	0.1615
Buffer	0	6	-0.2289	0.1041	12	-2.20	0.0482
Buffer	0	12	-0.1714	0.1041	12	-1.65	0.1254
Buffer	0	24	-0.2081	0.1041	12	-2.00	0.0687
Buffer	4	6	-0.07356	0.1041	12	-0.71	0.4932
Buffer	4	12	-0.01613	0.1041	12	-0.16	0.8794
Buffer	4	24	-0.05283	0.1041	12	-0.51	0.6210
Buffer	6	12	0.05743	0.1041	12	0.55	0.5913
Buffer	6	24	0.02073	0.1041	12	0.20	0.8454
Buffer	12	24	-0.03669	0.1041	12	-0.35	0.7305

Table E.19. Analysis of accumulated Carabidae species at distance 0-9 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.09485	0.1062	12	-0.89	0.3895
Buffer	0	6	-0.1040	0.1062	12	-0.98	0.3470
Buffer	0	12	-0.08926	0.1062	12	-0.84	0.4172
Buffer	0	24	-0.1081	0.1062	12	-1.02	0.3291
Buffer	4	6	-0.00913	0.1062	12	-0.09	0.9329
Buffer	4	12	0.005589	0.1062	12	0.05	0.9589
Buffer	4	24	-0.01322	0.1062	12	-0.12	0.9031
Buffer	6	12	0.01472	0.1062	12	0.14	0.8921
Buffer	6	24	-0.00408	0.1062	12	-0.04	0.9700
Buffer	12	24	-0.01881	0.1062	12	-0.18	0.8625

Table E.20. Analysis of accumulated Carabidae species at distance 0-18 m

Differences of Least Squares Means							
Effect	Buffer	_Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	0.000205	0.1044	12	0.00	0.9985
Buffer	0	6	-0.02175	0.1044	12	-0.21	0.8384
Buffer	0	12	0.01931	0.1044	12	0.19	0.8563
Buffer	0	24	-0.1111	0.1044	12	-1.06	0.3082
Buffer	4	6	-0.02196	0.1044	12	-0.21	0.8369
Buffer	4	12	0.01911	0.1044	12	0.18	0.8578
Buffer	4	24	-0.1113	0.1044	12	-1.07	0.3073
Buffer	6	12	0.04106	0.1044	12	0.39	0.7009
Buffer	6	24	-0.08931	0.1044	12	-0.86	0.4089
Buffer	12	24	-0.1304	0.1044	12	-1.25	0.2354

Table E.21. Analysis of accumulated Lepidoptera species at distance 2 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.3568	0.1741	12	-2.05	0.0630
Buffer	0	6	-0.4024	0.1741	12	-2.31	0.0394
Buffer	0	12	-0.4287	0.1741	12	-2.46	0.0299
Buffer	0	24	-0.4845	0.1741	12	-2.78	0.0166
Buffer	4	6	-0.04558	0.1741	12	-0.26	0.7979
Buffer	4	12	-0.07192	0.1741	12	-0.41	0.6868
Buffer	4	24	-0.1277	0.1741	12	-0.73	0.4774
Buffer	6	12	-0.02634	0.1741	12	-0.15	0.8823
Buffer	6	24	-0.08213	0.1741	12	-0.47	0.6456
Buffer	12	24	-0.05579	0.1741	12	-0.32	0.7542

Table E.22. Analysis of accumulated Lepidoptera species at distance 0-5 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.1835	0.1820	12	-1.01	0.3333
Buffer	0	6	-0.2849	0.1820	12	-1.56	0.1436
Buffer	0	12	-0.3670	0.1820	12	-2.02	0.0667
Buffer	0	24	-0.3568	0.1820	12	-1.96	0.0736
Buffer	4	6	-0.1014	0.1820	12	-0.56	0.5878
Buffer	4	12	-0.1835	0.1820	12	-1.01	0.3333
Buffer	4	24	-0.1733	0.1820	12	-0.95	0.3599
Buffer	6	12	-0.08213	0.1820	12	-0.45	0.6599
Buffer	6	24	-0.07192	0.1820	12	-0.40	0.6997
Buffer	12	24	0.01021	0.1820	12	0.06	0.9562

Table E.23. Analysis of accumulated Lepidoptera species at distance 0-9 m

Differences of Least Squares Means							
Effect	Buffer	Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.05579	0.1786	12	-0.31	0.7601
Buffer	0	6	-0.1116	0.1786	12	-0.62	0.5439
Buffer	0	12	-0.3234	0.1786	12	-1.81	0.0953
Buffer	0	24	-0.2291	0.1786	12	-1.28	0.2239
Buffer	4	6	-0.05579	0.1786	12	-0.31	0.7601
Buffer	4	12	-0.2676	0.1786	12	-1.50	0.1599
Buffer	4	24	-0.1733	0.1786	12	-0.97	0.3511
Buffer	6	12	-0.2118	0.1786	12	-1.19	0.2586
Buffer	6	24	-0.1175	0.1786	12	-0.66	0.5230
Buffer	12	24	0.09432	0.1786	12	0.53	0.6071

Table E.24. Analysis of accumulated Lepidoptera species at distance 0-18 m

Differences of Least Squares Means							
Effect	Buffer	_Buffer	Estimate	Standard Error	DF	t Value	Pr > |t|
Buffer	0	4	-0.05579	0.1873	12	-0.30	0.7709
Buffer	0	6	-0.1116	0.1873	12	-0.60	0.5624
Buffer	0	12	-0.3568	0.1873	12	-1.91	0.0810
Buffer	0	24	-0.2291	0.1873	12	-1.22	0.2447
Buffer	4	6	-0.05579	0.1873	12	-0.30	0.7709
Buffer	4	12	-0.3010	0.1873	12	-1.61	0.1340
Buffer	4	24	-0.1733	0.1873	12	-0.93	0.3730
Buffer	6	12	-0.2452	0.1873	12	-1.31	0.2149
Buffer	6	24	-0.1175	0.1873	12	-0.63	0.5421
Buffer	12	24	0.1277	0.1873	12	0.68	0.5082

Statistical models

A number of different models have been applied and a list of these is given in the following table:

No	Type of data	Where used
1	Continuous normally distributed measurements	
2		Shannons index and species for transect data Shannons index and species from pitfalls Shannons index and species from sweep nets
3		Bird feed from sweep nets
4		Bird feed in hedgerow
5		Shannons index for plants
6	Counts	Plants in hedge
7	Counts	Arthropods in hedgerow
8	Counts	Plants in field
8a*	Counts	Arthropods in pitfalls Arthropods from sweep nets
9	Relative counts	Percentage of flowering plants
10	Counts	Arthropods in transects
11	Counts	Arthropods in transects
12	Counts	Plants in field
13	Continuous normally distributed measurements	Accumulated number of plant species Accumulated number of bugs in transects Accumulated number of ground beetles in pitfalls Accumulated number of butterflies in transects Percent flowering plants in hedge-bottom
14		Shannons index and species for plants
15		Accumulated number of species
16	Counts	Relation between number of species of arthropods and plants

*) The model does not include residual effect as the data are aggregated within each plot

Many of the analyses were carried out for different groups, such as sampling period, Type/class, order, family and specie. However, in order to be able to trust the analyses groups with very sparse occurrence were not analysed. Generally it was required that at least one plant/arthropod should be present in at least 25% of the replicates (when including each replicate in the analyses) or that at least one plant/arthropod should be present in at least 50% of the plots (when using sum of replicates in the analyses). In addition a few groups that fulfilled those requirements were left out because the occurrence of the plants/arthropods made it impossible to do the analyses properly.

All models were either linear mixed models, generalised linear mixed models or non-linear mixed model. The theory of linear mixed models and generalised linear mixed models may be found in books such as McCulloch and Searle (2001) and West et al. (2007). All statistical analyses were performed using the procedures MIXED, GLIMMIX and NLMIXED of SAS (SAS, 2008). Some of the data were visualised using the graphical procedures of SAS (SAS, 2009a and SAS, 2009b)

In all models it was assumed that the fields could be regarded blocks in the same experiment. Therefore analyses that included effects of both buffer width and distance to hedge were analyses at split-block design. Each combination of buffer width and distance from hedge is in the following called a plot.

In all analyses the denummerator degree of freedom were calculated using an extension of the Satterthwaites principle as described by Kenward and Roger (1997).

Pair wise comparisons of buffer widths and distances from hedge were carried out using the method of Tukey and Kramer, which were set up to control the comparison wise error rate at each level of buffer width when comparing distances from hedge and the comparison wise error rate at each level of distance from hedge when comparing buffer width. The method is based on the distribution of Studentized range (for more details see e.g. Miller, 1981).

Model 1 Linear mixed model for comparing width of buffer zones and sampling period. The model include the effect of field, width of buffers and sampling period as well as the 2-way interactions between width of buffers and sampling period as fixed effects. The effect of plot and residual are includes as random effects

$$Y_{fbt} = \mu + \alpha_f + \beta_b + \delta_t + (\beta\delta)_{bt} + B_{fb} + E_{fbt}$$

where

Y_{fbt} is the value for buffer width b at distance d in field f at time t

μ, β_b, δ_t and $(\beta\delta)_{bt}$ are fixed effect of general level, field, width of buffer zone, period and interaction between width of buffer zone and period.

B_{fb} and $\mathrm{E}_{\mathrm{fbt}}$ are random effect of plot and residual, respectively. B_{fb} and E_{fbt} are assumed to be i.i.d normally distributed with mean zero and variance σ_B^2 and σ_{E}^2.

Model 2 Linear mixed model for comparing width of buffers, distance from hedge and sampling period. The model include the effect of field, width of buffers, distance from hedge and sampling period as well as 2- and 3-way interactions between width of buffers, distance from hedge and sampling period as fixed effects. The effect of both types of whole-plot, sub-plots and residual are includes as random effects.

$$Y_{fbdt} = \mu + \alpha_f + \beta_b + \gamma_d + (\beta\gamma)_{bd} + \delta_t + (\beta\delta)_{bt} + (\gamma\delta)_{dt} + (\beta\gamma\delta)_{bdt} + B_{fb} + C_{fd} + D_{fbd} + E_{fbdt}$$

where

Y_{fbdt} is the value for buffer width b at distance d in field f at period t

$\mu, \alpha_f, \beta_b, \gamma_d, \delta_t, (\beta\gamma)_{bd}, (\beta\delta)_{bt}, (\gamma\delta)_{dt}$ and $(\beta\gamma\delta)_{bdt}$ are fixed effect of general level, field, width of buffer zone, distance to hedge, period and interaction between these.

B_{fb}, C_{fd}, D_{fbd} and E_{fbdt} are random effect of plots and residual, respectively. B_{fb}, C_{fd}, D_{fbd} and E_{fbdt} are assumed to be i.i.d normally distributed with mean zero and variance σ^2_{B}, σ^2_C, σ^2_D and σ^2_E, respectively.

Model 3 Linear model for comparing width of buffer zones and distances. The model include the effect of field, width of buffers and distance from hedge as well as the 2-way interactions between width of buffers and distance from hedge as fixed effects. The effect of both types of whole-plot, sub-plots and residual are includes as random effects.

$$Y_{fbdr} = \mu + \alpha_f + \beta_b + \gamma_d + (\beta\gamma)_{bd} + B_{fb} + C_{fd} + D_{fbd} + E_{fbdr}$$

where

Y_{fbdr} is the value for buffer width b at distance d in field f at time t in replicate r

μ, β_b, γ_d and $(\beta\gamma)_{bd}$ are fixed effect of general level, field, width of buffer zone, distance from hedge and interaction between width of buffer zone and distance from hedge.

B_{fb}, C_{fd}, D_{fbd} and E_{fbdr} are random effect of plots and residual, respectively. B_{fb}, C_{fd}, D_{fbd} and E_{fbdr} are assumed to be i.i.d normally distributed with mean zero and variance σ^2_{B}, σ^2_C, σ^2_D and σ^2_E, respectively.

Model 4 Linear mixed model for comparing width of buffer zones after adjusting for tree species. The model include the effect of field, width of buffers and tree species as well as the 2-way interactions between width of buffers and tree species as fixed effects. The effect of plot and residual are includes as random effects

$$Y_{fbr} = \mu + \alpha_f + \beta_b + \gamma_{s[r]} + B_{fb} + E_{fbr}$$

Y_{fbr} is the weight of bird feed sampled in replicate r for buffer width b in field f recorded on species s

$\mu, \alpha_f, \beta_b, \gamma_s$ are fixed effect of general level, field, width of buffer zone and species of the tree.

B_{fb} and E_{fbr} are random effect of plot and residual and are assumed to be i.i.d normally distributed with mean zero and variance σ^2_B and σ^2_{E}.

Model 5 Non-linear mixed model used for describing how Shannons index depends on buffer width and distance from hedge and to estimate the distance at which half the estimated effect was reached. Please note that this model did not include the effect of the whole-plots and therefor the tests of significance and standard errors should be interpreted with caution.

$$H_{fbd} = \gamma_{field} + \frac{\gamma_{hedge} - \gamma_{field}}{1 + e^{\beta(\log(d) - \delta_b)}} + A_f + D_{fbd} \quad \text{and} \quad H_{fbd} = \gamma_{field} + \frac{\gamma_{hedge} - \gamma_{field}}{1 + e^{\beta_b(\log(d) - \delta_b)}} + A_f + D_{fbd} \quad \text{and}$$

where

H_{fbd} is the calcultated value of Shannons index at distance d for Buffer zone b in field f

γ_{hedge} and γ_{field} are Shannons index at distance 0 and ∞, respectively

β_b and β are the maximum change in Shannons index at buffer zone b or for all buffer zones

e^{δ_b} are the distance for bufferzone b where Shannons index has decresed by half the difference between γ_{hedge} and γ_{field}

τ_0 and τ_1 are parameter to model value og δ_b

A_f and D_{fbd} are random effect of field and plot, respectively. A_f and D_{fbd} are assumed to be i.i.d normally distributed with mean zero and variance σ_A^2 and σ_D^2, respectively

Based on the estimated parameters distance at which half the estimated effect would be reached was estimated as: $d_b = \exp(\delta_b)$

Model 6 Generalised linear mixed model for comparing width of buffer zones. The model include the effects of field and width of buffers. The effect of plot and residual are includes as random effects

$Y_{fbr} = \{\text{Poisson distrbuten, Poisson}(\eta_{fbr})$ with a possible overdispersion, λ for individuals

where

$g(\eta_{fbr}) = \mu + \alpha_f + \beta_b + B_{fb}$

Y_{fbr} is the value for buffer width b in replicate r of field f

μ, α_f, β_b are fixed effect of general level, width of field and buffer zone

B_{fb} are random effect of plot.

B_{fb} are assumed to be i.i.d normally distributed with mean zero and variance σ_B^2.

Model 7 Generalised linear mixed model for comparing width of buffer zones after adjusting for tree species. The model include the effect of field, width of buffers and tree as fixed effects. The effect of plot and residual are includes as random effects

$Y_{fbr} = \text{Poisson distrbuten, Poisson}(\eta_{fbr})$ with a possible overdispersion, λ

where

$\log(\eta_{fbr}) = \mu + \alpha_f + \beta_b + \gamma_{s[r]} + B_{fb}$

Y_{fbdt} is the number of individual of replicate r for buffer width b in field f

$\mu, \alpha_f, \beta_b, \gamma_s$ are fixed effect of general level, field, width of buffer zone and species of the tree.

B_{fb} are random effect of plot and are assumed to be i.i.d normally distributed with mean zero and variance σ_B^2.

Model 8 Generalised linear mixed model for comparing counts for width of buffer zones and distances. The model include the effect of field, width of buffers and distance from hedge as well as the 2-way interactions between width of buffers and distance from hedge as fixed effects. The effect of both types of whole-plot, sub-plots and residual are includes as random effects.

Y_{fbdr} = Poisson distributen, Poisson$\left(\eta_{fbdr}\right)$ with a possible overdispersion

where

$\log(\eta_{fbdr}) = \mu + \alpha_f + \beta_b + \gamma_d + (\beta\gamma)_{bd} + B_{fb} + C_{fd} + D_{fbd}$

Y_{fbdr} is the value for buffer width b at distance d in replicate r of field f

n_{fbdr} is the number of replicates in the plot for buffer width b at distance d in replicate r of field f

$\mu, \alpha_f, \beta_b, \gamma_d, (\beta\gamma)_{bd}$ are fixed effect of general level, field, width of buffer zone, distance to hedge and interaction between width of buffer zone and distance to hedge.

B_{fb}, C_{fd} and D_{fbd} are random effect of whole-plots and sub-plots, respectively. B_{fb}, C_{fd} and D_{fbd} are assumed to be i.i.d normally distributed with mean zero and variance $\sigma^2_{\mathrm{B}}, \sigma^2_C$ and σ^2_D, respectively.

Model 8a Generalised linear mixed model for comparing counts for width of buffer zones and distances. The model include the effect of field, width of buffers and distance from hedge as well as the 2-way interactions between width of buffers and distance from hedge as fixed effects. The effect of both types of whole-plot and sub-plots are includes as random effects.

Y_{fbd} = Poisson distributen, Poisson$\left(\eta_{fbd}\right)$ with a possible overdispersion

where

$\log(\eta_{fbd}) = \log(n_{fbd}) + \mu + \alpha_f + \beta_b + \gamma_d + (\beta\gamma)_{bd} + B_{fb} + C_{fd}$

Y_{fbd} is the value for buffer width b at distance d in field f

n_{fbd} is the number of replicates in the plot for buffer width b at distance d in field f

$\mu, \alpha_f, \beta_b, \gamma_d, (\beta\gamma)_{bd}$ are fixed effect of general level, field, width of buffer zone, distance to hedge and interaction between width of buffer zone and distance to hedge

B_{fb} and C_{fd} are random effect of whole-plots. B_{fb} and C_{fd} are assumed to be i.i.d normally distributed with mean zero and variance $\sigma^2_{\mathrm{B}}, \sigma^2_C$ and σ^2_D, respectively.

Model 9 Generalised linear mixed model for comparing relative numbers (percentages) for width of buffer zones and distances. The model include the effect of field, width of buffers and distance from hedge as well as the 2-way interactions between width of buffers and distance from hedge as fixed effects. The effect of both types of whole-plot and sub-plots are includes as random effects.

$P_{fbd} = Y_{fbd} / N_{fbd}$ = Binomial distributed, Bi$\left(\eta_{fbd}, N_{fbd}\right)$ with a possible overdispersion, λ

where

$$\log\left(\frac{\eta_{fbd}}{1-\eta_{fbd}}\right) = \mu + \alpha_f + \beta_b + \gamma_d + (\beta\gamma)_{bd} + B_{fb} + C_{fd}$$

Y_{fbd} is the number of flowering individuals for buffer width b at distance d in field f

N_{fbd} is the total number of indivuals for replicates in the plot for buffer width b at distance d in field f

$\mu, \alpha_f, \beta_b, \gamma_d, (\beta\gamma)_{bd}$ are fixed effect of general level, field, width of buffer zone, distance to hedge and interaction between width of buffer zone and distance to hedge.

B_{fb} and C_{fd} are random effect of whole-plots. B_{fb} and C_{fd} are assumed to be i.i.d normally distributed with mean zero and variance $\sigma^2_{\mathrm{B}}, \sigma^2_C$ and σ^2_D, respectively.

Model 10 Generalised linear mixed model for comparing width of buffer zones and distances after adjusting for climate variables. The model include the effect of field, width of buffers and distance from hedge as well as the 2-way interactions between width of buffers and distance from hedge as fixed effects. The effect of time and climate variables was included as fixed effects (day as a factor and the other as covariates) The effect of both types of whole-plot, sub-plots and residual are includes as random effects.

$Y_{fbdr} = \{\text{Poisson distrbuten, Poisson}\left(\eta_{fbdt}\right)$ with a possible overdispersion, λ for individuals

where

$$\log(\eta_{fbdr}) = \log(m_{fbdr}) + \mu + \alpha_f + \beta_b + \gamma_d + (\beta\gamma)_{bd} + \phi_a + \delta_{0a} t_{fbdr} + \sum_i^c \delta_i C^i_{fbdr} + \delta'_{0a} t^2_{fbd} + \sum_i^c \delta'_i \left(C^i_{fbdr}\right)^2$$
$$+ B_{fb} + C_{fd} + D_{fbd}$$

Y_{fbdr} is the value for replicate r of buffer width b at distance d in field f

m_{fbdt} is the number of decaminutes spent in replicate r of buffer width b at distance d in field f

$\mu, \beta_b, \gamma_d, (\beta\gamma)_{bd}$ are fixed effect of general level, width of buffer zone, distance to hedge and interaction between width of buffer zone and distance to hedge

c is the number of climate and time variables included in the model

ϕ_{a} is the effect of day

$\delta_{0\mathrm{a}}$ is the linear effect of time variable i on day a

δ_{i} is the linear effect of climate variable i

$\delta'_{0\mathrm{a}}$ is the quadratic effect of time variable i

δ'_{i} is the quadratic effect of climate variable i

t_{fbd} is the average time of the recording

C^i_{fbd} is the value recorded for climate variable i for buffer width b at distance d in field f

B_{fb}, C_{fd} and D_{fbd} are random effect of whole-plots and sub-plots, respectively. B_{fb}, C_{fd} and D_{fbd} are assumed to be i.i.d normally distributed with mean zero and variance σ^2_{B}, σ^2_C and σ^2_D, respectively.

Model 11 Generalised linear mixed model for comparing width of buffer zones and distances after adjusting for climate variables and number of host plants and flowering plants (weeds). The model include the effect of field, width of buffers and distance from hedge as well as the 2-way interactions between width of buffers and distance from hedge as fixed effects. In addition the effect of time and climate variables, the number of plants (flowering plants in field and hedge and host plants in field and hedge) was included as covariates. The effect of number of plants in the field was included both as a linear and quadratic effect. The effect of number of plants in hedge was included similarly, but here the effect was allowed to depend on the distance to hedge. For both the number of flowering plants and host plants, which was recorded in frames in each plots, the average value per plot were used for each of the transects as it was not possible to pair frames and the transects in the field. The type of flowering plants and host plants used in the analyses was based on literature knowledge. The effect of both types of whole-plot, sub-plots and residual are includes as random effects.

$Y_{fbdr} = \{\text{Poisson distrbuten, Poisson}\left(\eta_{fbdt}\right)$ with a possible overdispersion, λ for individuals

where

$$\log(\eta_{fbdr}) = \log(m_{fbdr}) + \mu + \alpha_f + \beta_b + \gamma_d + (\beta\gamma)_{bd} + \phi_a + \delta_{0a} t_{fbdr} + \sum_i^c \delta_i C^i_{fbdr} + \sum_i^d \eta_{id} D^i_{fbdr}$$

$$+ \delta'_{0a} t^2_{fbd} + \sum_i^c \delta'_i \left(C^i_{fbdr}\right)^2 + \sum_i^d \eta'_{id} \left(D^i_{fbdr}\right)^2 + B_{fb} + C_{fd} + D_{fbd}$$

Y_{fbdr} is the value for replicate r of buffer width b at distance d in field f

m_{fbdt} is the number of decaminutes spent in reolicate r of buffer width b at distance d in field f

$\mu, \beta_b, \gamma_d, (\beta\gamma)_{bd}$ are fixed effect of general level, width of buffer zone, distance to hedge and interaction between width of buffer zone and distance to hedge

c is the number of climate and time variables included in the model

d is the number of plant variables included in the model

ϕ_{a} is the effect of day

δ_{0a} is the linear effect of time variable i on day a

δ_{id} is the linear effect of climate variable i at distance d (index d only for effect of plants in hedge)

δ'_{0a} is the quadratic effect of time variable i

δ'_{id} is the quadratic effect of climate variable i at distance d (index d only for effect of plants in hedge)

η_{i} is the linear effect of plant variable i

η'_{i} is the quadratic effect of plant variable i

t_{fbd} is the average time of the recording

C^i_{fbd} is the value recorded for climate variable i for buffer width b at distance d in field f

D^i_{fbd} is the value recorded for plant variable i for buffer width b at distance d in field f

B_{fb}, C_{fd} and D_{fbd} are random effect of whole-plots and sub-plots, respectively. B_{fb}, C_{fd} and D_{fbd} are assumed to be i.i.d normally distributed with mean zero and variance σ^2_{B}, σ^2_C and σ^2_D, respectively.

Model 12 Generalised linear mixed model for describing the effect of buffer width and distance to hedge taking buffer widths and distances as continuous variables.

Y_{fbdr} Poisson distibuted with mean λ_{fbd} and possible overdispersion parameter θ

$$\log(\lambda_{fbd}) = \mu + \alpha_f + \gamma_1 \log(d) + \gamma_2 \log(d)^2 + \beta_1 b + \beta_2 b^2 + \delta \log(d) b + B_{fb} + C_{fd} + D_{fbd}$$

where

Y_{fbdr} is the value for replicate r of buffer width b at distance d in field f

β_1 and β_2 is the lienar and quadratic effect of width of buffer zones, γ_1 and γ_2 is the linear and quadratic effect of distance from the headge δ is a linear effect of the cross product between width of bufferzone and distance from the hedge while a and b is distance from the hedge and width of the buffer zone, respectively.

Here the distance of zero from the hedge was taken as 0.05 m from the hedge.

B_{fb}, C_{fd} and D_{fbd} are random effect of whole-plots and sub-plots, respectively. B_{fb}, C_{fd} and D_{fbd} are assumed to be i.i.d normally distributed with mean zero and variance σ_{B}^2, σ_C^2 and σ_D^2, respectively.

This model was reduced in a stepwise maner by removing non-significant terms (at the 5% level).

The estimated number of weeds when excluding buffer zone zero could be approximated by simple equation such as the following:

$W = e^Y$ where $Y = \mu + \gamma \log(d) + \beta_1 b + \beta_2 b^2 + B_{fb} + C_{fd} + D_{fbd}$

W is the number of weeds, b is the width of bufferzo, d is the distance from hedge (with zero distance taken as 0.05 m).

Model 13 Linear model for comparing width of buffer zones at each distance. The model includes the effect of field and width of buffers as fixed effects. The effect of plot are includes as random effects

$Y_{fb} = \mu + \alpha_f + \beta_b + B_{fb}$

Y_{fbr} is the value for buffer width b in replicate r of field f

μ, α_f, β_b are fixed effect of general level, width of field and buffer zone

B_{fb} are random effect of plot.

B_{fb} are assumed to be i.i.d normally distributed with mean zero and variance σ_B^2.

Model 14 Linear mixed model for comparing width of buffers, distance from hedge (including observation "in the middle" of the field) and sampling period. The model include the fixed effects of: field, location (close to hedge or "in the middle" of the field), width of buffers, distance from hedge and sampling period as well as 2-way interaction between location and sampling period, 2- and 3-way interactions between buffer widths, distance from hedge and sampling period. The effect of field, both types of whole-plot, sub-plots and residual are includes as random effects..

$$Y_{fcbdt} = \mu + \alpha_c + \beta_{b:c} + \gamma_{d:c} + (\beta\gamma)_{bd:c} + \delta_t + (\alpha\delta)_{ct} + (\beta\delta)_{bt:c} + (\gamma\delta)_{dt:c} + (\beta\gamma\delta)_{bdt:c}$$
$$+ A_f + B_{fb} + C_{fd} + D_{fbd} + E_{fcbdt}$$

where

Y_{fcbdt} is the value for buffer width b at distance d in field f at period t - with $c = 1$ if $d \geq 30$ and 0 otherwise

$\mu, \alpha_c, \beta_{b:c}, \gamma_{d:c}, \delta_t, (\beta\gamma)_{bd:c}, (\alpha\delta)_{ct}, (\beta\delta)_{bt:c}, (\gamma\delta)_{dt:c}$ and $(\beta\gamma\delta)_{bdt:c}$ are fixed effect of general level, control plot, width of buffer zone, distance to hedge, period and interaction between these.

$A_f, B_{fb}, C_{fd}, D_{fbd}$ and E_{fbdt} are random effect of field, whole-plots, sub-plot and residual, respectively. $A_f, B_{fb}, C_{fd}, D_{fbd}$ and E_{fbdt} are assumed to be i.i.d normally distributed with mean zero and variance $\sigma_A^2,\ \sigma_B^2,\ \sigma_C^2,\ \sigma_D^2$ and σ_E^2, respectively.

Model 15 Linear mixed model for analysing the accumulated number of species. The model assumes that the number of species depends on the area in a non-linear relation (Desmer and Cowling, 2004) where the α-parameters Estimate the number of species at an area of 1 (here the number of species in the distance closest to the hedge) while the β-parameters estimates the steepness of the increase in species with increased area. A β-value of 1 indicate a linear increase with are and a β-valueless than 1 indicate a decreasing increase as the area increases.

$$Y_{bd} = \alpha_b A_d^{\beta_b} + E_{bd}$$

where

Y_{bd} is the accumulated number of species for bufferzone b at distance d

A_d is the accumulated area at distancd d, for convinience $A_d = 1, 2, 3, 4, 5$ for the first, second etc, distance

α_b and β_b are the buffer specific parameters, which has to be estimated

E_{bd} is the deviation from the model, which is assumed to be normalliy distributed with mean zero and variance σ^2

Model 16 Generalised linear model for analysing the possible correlation between arthropods and between arthropods and total number of dicotyledonous species. In order to avoid that the possible correlation was introduced by the difference between treated and untreated plots the model include the effect of treatment as fixed factor as well as possible significant effect of field. The model also allowed the correlation to depend on weather the plot were treated or untreated. The unreduced model may be written as:

Y_{fbd} ~ Poisson distibuted with mean λ_{fbd}

$\lambda_{fbd} = \mu + \alpha_f + \beta_t + \gamma x_{fbd} + \gamma_t x_{fbd}$

where

Y_{fbd} is the number of species for the arthropod to be analysed in the plot with buffer width b at distance d in field f

x_{fbd} is the number of species for the covariate in the plot with buffer width b at distance d in field f

μ is the general level of species for the arthropod to be analysed

α_{f} is the effect of field f

β_t us the effet of tretatment t (untreated or treated)

$$t \text{ is} \begin{cases} \text{untreated} & \text{if } b \leq d \\ \text{treated} & \text{if } b > d \end{cases}$$

γ is the general effect of the covariate

γ_t is the treatment specific effect of the covariate

For the relation between species of arthropods and plants the total number of dicotyledonous species was used as the covariate while the number of butterflies was used as the covariate for the relations between different groups of arthropods.

Local weather data

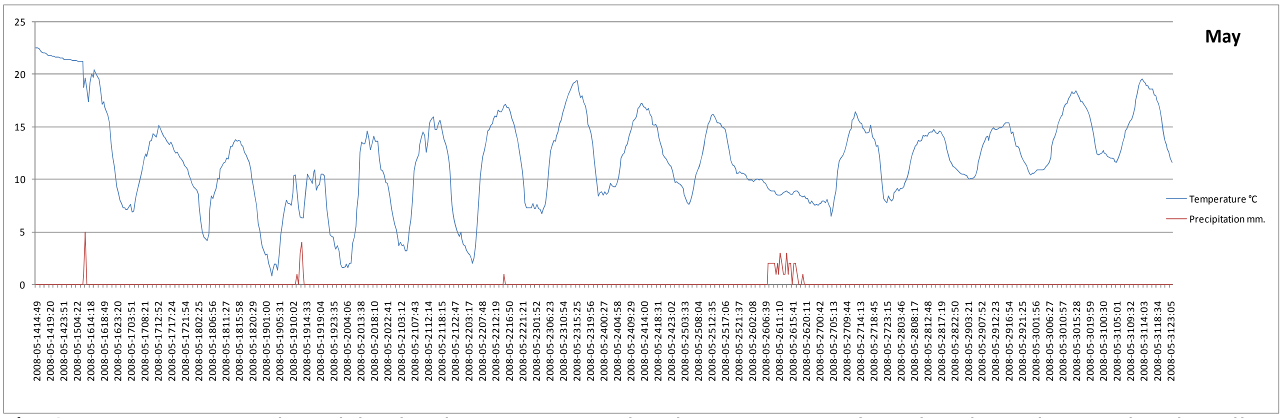


Fig. G.1. Temperature and precipitation in May 2008 at Gjorslev Estate. Data from local weather station (Hardi Klimaspyd) placed in the centre of the experimental field SM (Skovmark).The accumulated precipitation of May was 51 mm.

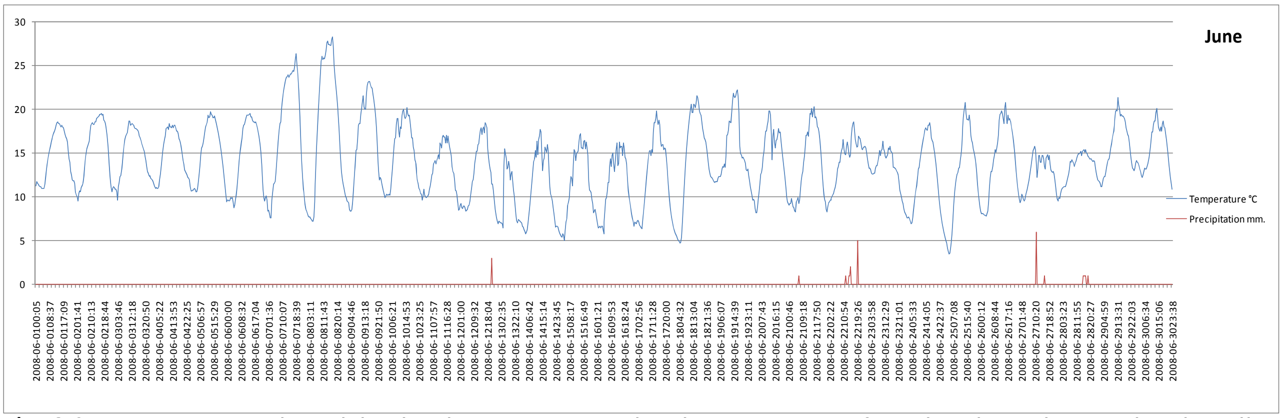


Fig. G.2. Temperature and precipitation in June 2008 at Gjorslev Estate. Data from local weather station (Hardi Klimaspyd) placed in the centre of the experimental field SM (Skovmark).The accumulated precipitation of June was 26 mm.

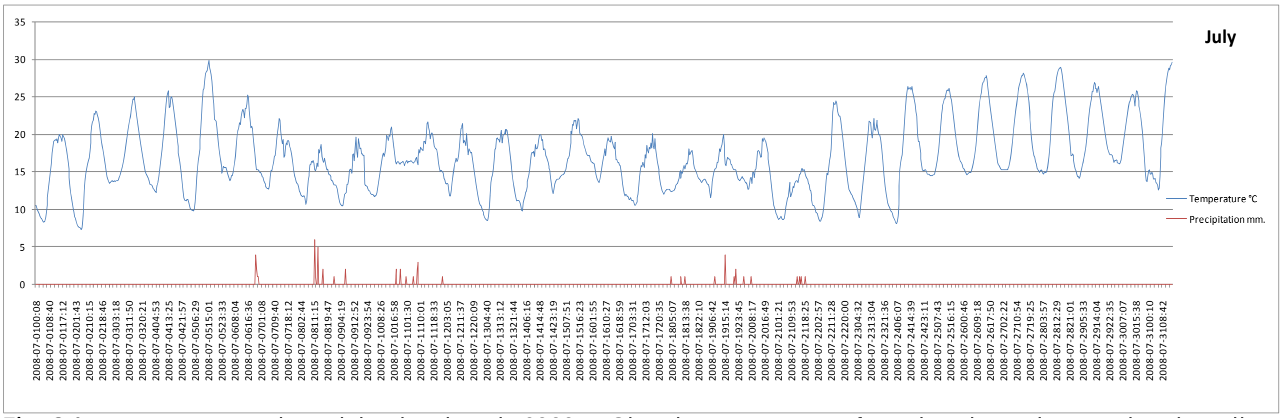


Fig. G.3. Temperature and precipitation in July 2008 at Gjorslev Estate. Data from local weather station (Hardi Klimaspyd) placed in the centre of the experimental field SM (Skovmark).The accumulated precipitation of July was 54 mm.