Writing up Science Based Practical Reports

Eight Top Tips for Writing up Science Based Practical Reports

1. General Format of Laboratory Reports

The most common format for a scientific paper is to have sections headed as follows:

- **Introduction** (sets the scene for the work; include suitable references; states clearly the aims/objectives; explains why you are doing the work. May require an abstract, summary of findings or aims of the experiment as required by the brief)

- **Materials and Methods** (rarely reported separately but incorporated in the description of the method; write about what you did in order i.e. "the sample was mounted on a microscope slide and a labelled diagram prepared" not "labelled diagrams were prepared after the sample was mounted on a microscope"; give enough detail for the work to be repeated by any reader)

- **Results** (presented in tables, figures or graphs; must be described in the text but the amount of text should be kept to a minimum)

- **Discussion** (should include statements on what your results have shown but must not be a repeat of the results section; discuss the significance of your observations; point out any limitations to your methods, for example damaged samples; link your observations with references e.g. Figure 1 clearly shows leaf-like spicules of *T.vitrinus* a characteristic of *Trichostrongylus* species)

- **Conclusion** (final statement should be made about the validity of the results and the methods used)

- **References** (all references used in the text should be listed at the end of the report)

1. Style of writing

Style should be simple and straightforward, avoiding elaborate vocabulary and long sentences. Shorter sentences make it easier to understand what you have done and important points are given more emphasis.

Write the 'Materials and Methodology' section in past tense – you have undertaken the work and you are reporting what is in the past.

You should use an impersonal style when writing up your work. An impersonal style uses:
- the third person (**it** rather than **I** or **we**)
- things rather than people as subjects of sentences.

Avoid:	Instead use:
I observed the angle to be…	The angle was observed to be…
I suggest…	It is suggested… or The author suggests that…
We used a standard graphical representation to…	A standard graphical representation was used to…
I found…	It was found that…
I assumed that…	It was assumed that…
I noticed…	Analysis of the raw data indicated…
In this report I show…	This report presents…

2. <u>**Write exactly what you mean**</u>

Take care when using the words "proves" or "definitively". Avoid the use of the term "significantly" unless statistical analysis is taking place. Scientific claims are often expressed with cautious or tentative language i.e.

> Increased nitrate levels in bodies of water **<u>may</u>** cause eutrophication

instead of

> Increased nitrate levels in bodies of water cause eutrophication.

Common words that can you can use:

Nouns	Adverbs	Verbs
Supposition	Presumably	Appear
Idea	Probably	Postulate
Speculation	Possibly	Suggest
Conjecture	Apparently	Seem
Possibility	Not unlikely	May be
Inference	Seemingly	Speculate

3. <u>**Write objectively**</u>

You must avoid bias, emotions or subjective writing (found in personal essays, in autobiographies, and in the editorial section of newspapers where journalists express their opinions about news events). Avoid using colloquialisms such as 'massive change in …' or 'results dramatically showed…'

Objective writing presents facts and figures only. It does not include the writer's beliefs or feelings.

<u>**Look at the examples below:**</u>

Avoid writing like this (subjective style)
These results seem to be really quite good. The model fits very well with the data points as can be interpreted by the R^2 values of 0.32 shown in Table 1 above. But the method used to obtain the best values for a, b, and c was a little silly and time-consuming as it required putting lots of values into a changeable Excel spreadsheet over and over to try and get the lowest R^2 value, even though this is probably the only way to do it accurately. Also, this model can be used to extrapolate the PCB concentrations of fish of ages not measured in the study, but that's about it.

Instead write more objectively like the example below
These results appear to be reasonable as the model fits very well with the data points, as can be interpreted by the R^2 values of 0.32 shown in Table 1 above. However, the method used to obtain the best values for a, b, and c was rather time-consuming as it required putting many values into an Excel spreadsheet many times to obtain the lowest R^2 value. While this is probably the only way to obtain accurate results, a further limitation is that this model can be used only to extrapolate the PCB concentrations of fish within age ranges measured in the study.

(Source: adapted from Skills@Library, 2010)

4. Use figures, tables and photographs to illustrate your points and results

What is a figure?
Graph, diagram, flowchart, photograph (some tutors may ask you to label photographs as 'Plates') and maps etc.

What is a table?
Data that is presented in a labelled grid of columns and rows.

The famous saying 'a picture is worth a thousand words' illustrates that a figure, table or photograph can really add to your work. If you insert one in your report then make sure you:

a) **number it correctly**   i.e. the first figure in your report should be Figure 1, the next Figure 2 etc.… the same goes for Tables

b) **give it a title**   (insert these before for a Table and after for a Figure. Do **not** write Figure 1. Graph to show….   Or Table 1: Table to show….)

Table 1. Bacteria counts on agar plate

Dilutions	Absorbance (X)	Number of bacteria (Y)
Original *E.coli*		
1/2		
1/4		
1/8		
1/16		
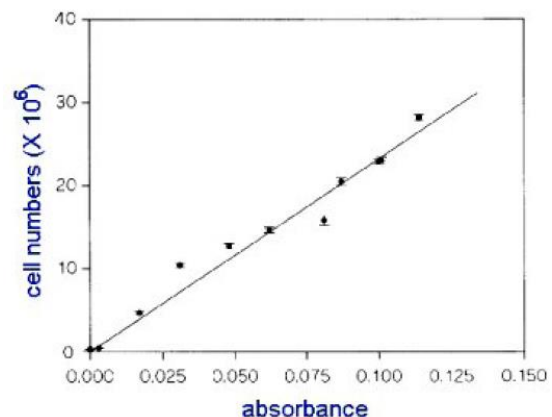
Figure 1. Using turbidimetry to estimate bacterial numbers

c) **refer to it**   i.e you must **always** refer to the table or figure in the text **before** you come to it. Do not repeat details but summarise what it shows e.g. "Grain yield response to successive increments of applied nitrogen shows the law of diminishing returns (Figure 1 Table X)".

d) **source it**   you must **always give the source** of the data depicted - Author's surname/organisation name and year
– see Guide to Referencing 2012 (The Learning Hub/Support for Learning/Study Advice)

5. Write clearly and concisely

George Orwell wrote some helpful rules for scientists who write. In summary he wrote:
a) "Never use a long word where a short one will do.
b) If it is possible to cut a word out, always cut it out"   (Orwell, 1999).

Some examples of word savings are:

Superfluous words	Better English
on account of the fact that	as
in order to	to
at the present time	now
on the occasion of	when
with the result that	so that
in the college environment	in college
it is apparent therefore	thus
forward planning	planning

6. Abbreviations

Abbreviations are commonly used in scientific writing in order to make your writing flow and to avoid long technical words maximising your word count. Remember to always give the term in full when it appears first in your report and show the abbreviations in brackets after i.e. "Magnetic resonance imaging (MRI)" or "polymerase chain reaction (PCR)".

7. Further Support

1. An excellent interactive resource developed by the University of Reading to help undergraduate science students with their scientific writing.

Centre for Excellence in Teaching and Learning in Applied Undergraduate Research Skills. 2007. The interactive resource for bioscience students. [On-line]. University of Reading. Available from: http://www.engageinresearch.ac.uk/ [Accessed on 6th January 2012].

2. A US based interactive guide to writing lab reports that supports you through pre, during and post laboratory activities.

Carter, M., Wiebe, E.N., Ferzli, M. and Wallace, R. 2004. Labwrite for students. [On-line]. NC State University. Available from: http://labwrite.ncsu.edu/index_labwrite.htm [Accessed on 6th January 2012].

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Orwell, G. 1999. *Politics and the English language.* [On-line]. www.orwell.ru. Available from: http://www.orwell.ru/library/essays/politics/english/e_polit [Accessed on 6th January 2012].

Skills@Library. 2010. Writing for Science Subjects: 10 Characteristics of Scientific Writing. [On-line]. University of Leeds. Available from: http://skills.library.leeds.ac.uk/uploads/Writing%20for%20Science%20Subjects747.pdf [Accessed on 6th January 2012].

EXAMPLE - DETAILED LAB REPORT

Does the choice of winter or spring cropping influence the response of soil fauna to cultivation?

Studies have shown that the loss of over-winter stubble, as a result of a shift from spring to winter cultivation, results in a negative impact upon the availability of food for farmland birds over winter and through the breeding season. This investigation seeks to determine whether soil invertebrates are significantly affected by the choice of cultivation season, in particular with reference to those families important for farmland birds. The results revealed that cultivation season did not have a significant effect on the number and composition of soil invertebrates, nor did the effect of cultivation. These results, however, may not be truly indicative and discrepancies in experimental sampling techniques may have flawed the experiment.

Introduction

Soil cultivation has varied in style and purpose throughout UK arable agriculture's history. Traditionally soil inversion was undertaken as a measure to remove previous stubble and weeds, re-establish organic matter into the soil and prepare a favourable seed bed for the new crop. After the Second World War, the majority of cultivation shifted from spring to winter in response to the appearance of winter-hardy, high yielding varieties onto the market (Carter & Stansfield, 1994). This led to the wide scale loss of over-winter stubbles on arable land (Robinson and Sutherland, 2002). Studies have shown that this loss of stubble impacts upon the availability of winter food, in the form of weed seeds, for farmland birds and adversely affects the provision of a fallow sward rich in seeds and invertebrates for the breeding season (Vickery *et al.*, 2004).

Knowledge of the dynamics and diversity of soil biota is particularly limited in comparison to above ground organisms, particularly at the species level (Bardgett, 2005). Animal biomass is dependent on soil conditions, but may often exceed 0.5t/ha. Where earthworms (*Lumbricidae*) are abundant, they represent the bulk of this biomass (Killham, 1994). Soil invertebrates may exist entirely within the soil (Endogeics), in burrows emerging to feed on surface litter (Anecics) or entirely in the litter layer (Epigeics) (Lavelle and Spain, 2001.) Soil fauna benefit from an extensive diversity of prey, feeding habits, mobility and tolerance to disturbance. Bardgett (2005) states that recent interest in soil communities has been driven by the awareness that soil organisms regulate major ecosystem processes such as organic matter turnover and nutrient cycling and act as drivers for change in vegetation. The activity of soil biota is therefore significant in agriculture particularly as some fauna, mainly earthworms, are seen as indicators for soil quality and others, such as ground surface beetles, are useful for pest control (Colman and Crossley, 2003). Other soil invertebrates are pest species themselves, for example the beetle larvae of the wire worm (*Elateridae*) family.

In concurrence with the current focus of relevant UK authorities on farming for conservation, most contemporary studies into soil fauna focus on the effects of reduced tillage on populations in contrast to conventional tillage effects. The majority of studies have found invertebrate abundance is significantly lower in conventionally tilled soils (Anderson, 2003; Brennan *et al.,* 2006; Colman and Crossley, 2003; Holland, 2004; Wall, 2004). The less disturbance a soil has been subjected to, the greater the abundance and diversity of soil animals (Killham, 1994). Cultivation may therefore be regarded as a form of habitat destruction causing a significant alteration to the soil ecosystem.

As a result of the aforementioned changes in arable season, conservation concerns have arisen about the effects of the loss of over-winter stubble to agro-ecosystem diversity, in particular with respect to farmland birds. In this respect, a study by Holland *et al.* (2006) gives the most important orders of invertebrate to be adult beetles (*Coleoptera*), adult bugs (*Hemiptera*), butterflies and

moths (*Lepidoptera*), adult and larval flies (*Diptera*) and spiders (*Arachnida*). Particular families of importance include *Carabidae, Curculonidae, Elateridae* and *Lumbricidae*.

This investigation seeks to determine in addition whether soil invertebrates are significantly affected by the choice of cultivation season. This will be studied in terms of diversity/composition and total number. In accordance with the importance of farmland birds as a UK quality of life indicator, this study will pay particular attention to a selection of families deemed most important for 4 or more UK farmland bird species.

Hypotheses to be tested:
H0: Time of ploughing does not affect invertebrate community composition
H1: Time of ploughing does affect invertebrate community composition

H0: Abundances of families Carabidae, Curculonidae, Elateridae and Lumbricidae are not affected by time of ploughing
H1: Abundances of families Carabidae, Curculonidae, Elateridae and Lumbricidae are affected by time of ploughing

H0: Time of ploughing does not affect total number of soil invertebrates present
H1: Time of ploughing does affect total number of soil invertebrates present

Materials and Methods

This study was carried out at the University of Reading Sonning Farm, Berkshire. The site has been previously used for a range of agricultural trials. The area chosen (outlined in red on Figure 1) has been under production periodically in recent years. During the winter season 2005/2006 the area had undergone three separate trials involving intense cultivation and production on the soil. Following this, the site was left in stubble for the winter season 2006/2007.

A fully randomised block experimental design was used for this study. Nine plots were arranged at random within an area approximately 10 m². The orientation of the plots was also randomised. Each plot was split into three 0.5 m² blocks. These three blocks were designated control, autumn plough and spring plough at random. Initial condition soil samples were taken at this stage (07/11/06). The estimated sample dimensions were 15x15x10cm. Throughout this study, samples were dug using a spade and placed into polythene bags. Following the taking of pre-treatment samples, the blocks designated for the autumn treatment underwent simulated ploughing by turning over the soil with a spade to an approximate depth of 15cm. Care was taken to ensure that the soil of the adjacent blocks was not disturbed. The initial conditions samples were sorted in the laboratory over a period of 20 minutes for each sample and animals discovered were placed into bottles and preserved in alcohol.
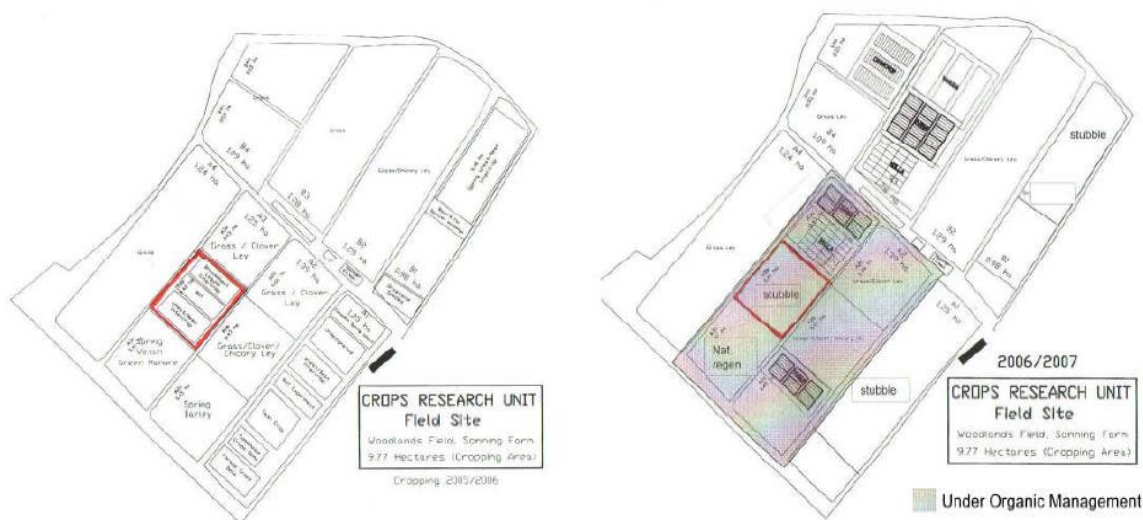
Figure 1. Previous land use at the Sonning Farm field site 05/06 and 06/07

On 20/02/07 simulated ploughing was conducted on the spring plots. Again the soil was turned over to an approximate depth of 15cm and care was taken not to disturb the soil of the adjacent plots. On 27/02/07 the treatment samples were taken from the centre of each of the plots. The sample dimensions were consistent with the initial conditions samples. Samples were once more transported to the lab in polythene bags, hand-sorted and the specimens removed were preserved in alcohol.

Following this, keys were used to identify the specimens to order level. Particular attention was paid to coleoptera larvae which were identified to family level.
The results were analysed using one way ANOVA tables and a P value of 0.05 for confidence. In addition t-testing was used to show any relevant differences between pre-treatment and treatment means.

Results

A distinct lack of significant difference between the autumn tilled, the spring tilled and the control plots was found in the pre-treatment initial condition samples. The average number of invertebrates pre-treatment shows a weak but non-significant (P=0.244) decrease in number from control to autumn to spring (Figure 2). The diversity of invertebrates pre-treatment follows the same weak non-significant (P=0.472) pattern (Figure 3).
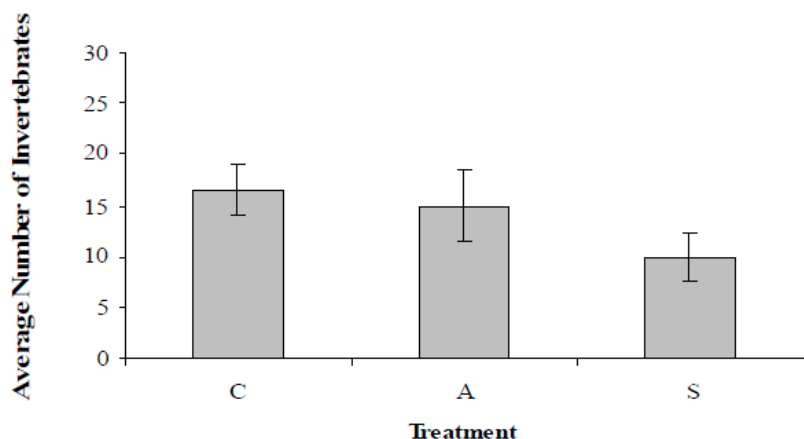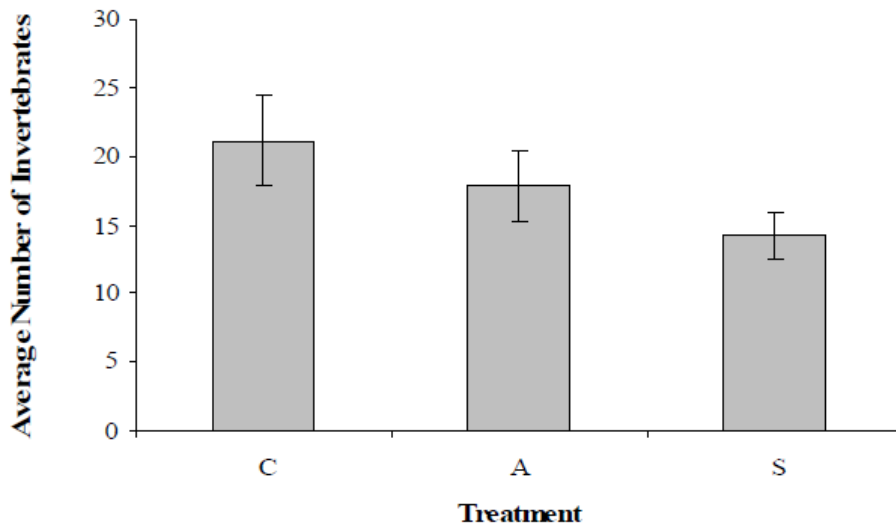

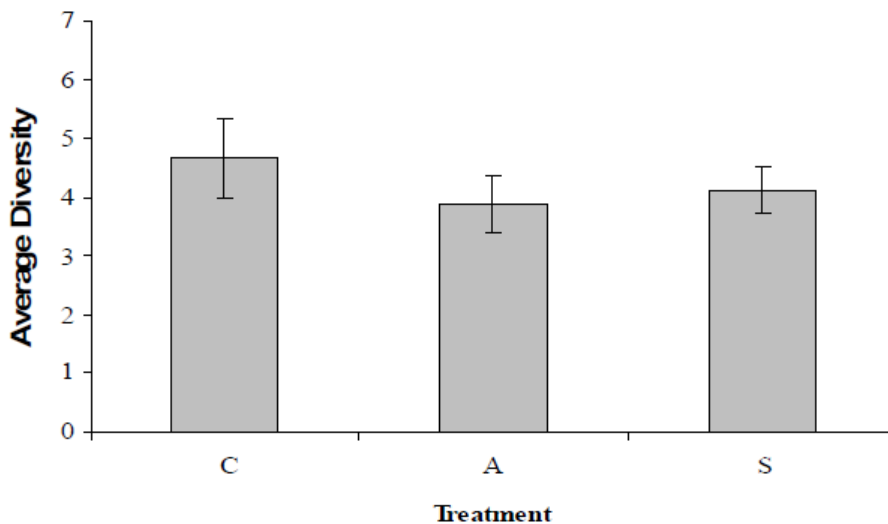**Figure 2. Average number of invertebrates from plots before treatment**
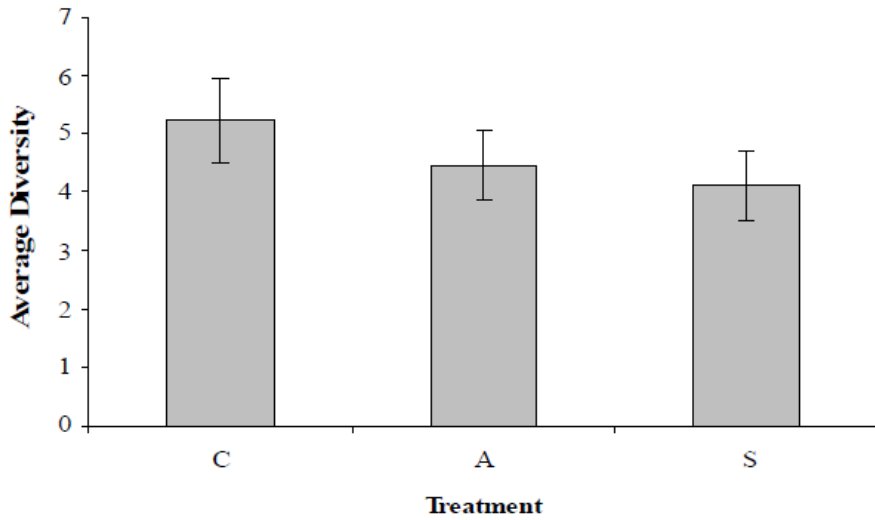
Figure 3. Average diversity of invertebrates from plots before treatment

The treatment does not appear to have a significant effect on the number of invertebrates present in plots. Although the number of invertebrates decreased in the spring treatment compared to autumn tilled and the control, this was not significant (P=0.200; Figure 4). The diversity of invertebrates was highest in the control but showed no significant (P=0.578) pattern (Figure 5). Curiously, the total number of invertebrates found rose after treatment (t=-1.71, P=0.092).

Figure 4. Average number of invertebrates from plots after treatment

Figure 5. Average diversity of invertebrates from plots after treatment

In general, the changes in individual families important for farmland birds decreased slightly from control to autumn to spring in both the pre-treatment and the treatment samples although the change was not significant (Tables 1 & 2). There appears to be an increase in number from pre-treatment to treatment especially in the case of earthworms (Control t=1.44, P=0.172. Autumn t=1.39, P=0.184. Spring t=2.30, P=0.036).

Table 1: Abundances of farmland bird important families (Pretreatment)

Latin name	Common name	Control	Autumn	Spring	P-value
Carabidae	Ground Beetle	2.11	2.78	2.22	0.660
Curculionidae	Weevil	0.67	0.11	0.00	0.179
Elateridae	Wireworm	0.44	0.44	0.33	0.940
Cantharidae	Soldier Beetle	0.11	0.44	0.11	0.282
Lumbricidae	Earthworm	8.78	7.78	4.33	0.139

Table 2: Abundances of farmland bird important families (Treatment)

Latin name	Common name	Control	Autumn	Spring	P-value
Carabidae	Ground Beetle	2.11	0.89	0.89	0.111
Curculionidae	Weevil	0.00	0.00	0.00	
Elateridae	Wireworm	0.33	0.22	0.33	0.945
Cantharidae	Soldier Beetle	0.00	0.00	0.00	
Lumbricidae	Earthworm	12.11	11.78	7.89	0.126

Discussion

The results revealed that cultivation season did not have a significant effect on the number and composition of soil invertebrates. Unusually, they also implied that cultivation itself had no or very little effect which is contrary to previous research (Killham, 1994; Anderson, 2003; Colman and Crossley, 2003; Wall, 2004; Holland, 2004). The grounds for the assertion that cultivation must affect soil invertebrates are plentiful and convincing; at its most basic, soil disturbance itself may kill or displace organisms. Smeaton *et al.* (2003) revealed that habitat disruption and physical damage are the principal causes of earthworm population reduction after traditional cultivation, an effect that can be reduced by the use of a min-till system (Schmidt and Curry, 2001; Birkas *et al.,* 2004). The loss of weed cover and surface litter can adversely affect epigeic species, in particular adult *Carabid* beetles (Kromp, 1999). *Cantharis* beetles are also adversely affected by surface vegetation loss as 75% of their life cycle is spent in larval stages reliant on surface vegetation cover (Traugott, 2006). Soil disturbance may also unfavourably affect the abundance and quantity of fungi present in the soil, therefore reducing the populations of fungivorous invertebrates such as *Collembola* (Brennan *et al.,*2006). The changing fungi prevalence leads to a seasonal dependence of fungi-reliant species, a dependence which is not evident in communities based under minimum-tillage arable systems (Beare, 2004).

However there are also some arguments that seasonal soil disturbance may have a minimal or even encouraging effect on particular invertebrate families. Purvis and Fadl (2002) found that cultivation season has a limiting effect on the flexibility of *Carabid* life-cycles although they show robustness in their response to the constraints. It has additionally been shown that some beetle species, including *T. quadristriatus,* are more abundant in autumn cultivated soils and are dominant in conventional agricultural fields as a result of life-cycle adaptation (Anderson, 2003).

Aside from natural seasonal variation in the numbers of particular orders, further more universally impacting environmental factors may have had an effect on the results of this investigation. The initial conditions samples were taken on a dry day in November whilst the treatment samples were taken in February after a period of rain. This might be responsible for the greater number of invertebrates found in the treatment samples than in the initial samples. Another important

observation for the purposes of these results is the wet soils made the manner of sorting of the treatment samples different from the dry soils sorted in the pre-treatment samples. This too could have had an effect on the number of invertebrates found whilst sorting.

For practicality, the plot sizes chosen in this experiment were small at 0.5m² which did not allow for soil disturbance by farm equipment. Ploughing was simulated using spades to a depth of approximately 15cm, a depth recommended to avoid burying surface nutrients below the extent of crop roots. However it is widely agreed that farm equipment has effects on the soil other than simple disturbance, for example compaction, and it is dubious whether disturbance with a spade would accurately mimic ploughing with farm equipment.

In addition to using the spade for soil disturbance, sampling with a spade selects for less mobile invertebrate species. More larvae than adult beetle families were found probably due to the high mobility of the adults allowing them to move away from the sampling area. The lack of mobility on the part of the beetle larvae is said to be useful in reflecting habitat quality (Juen and Traugott, 2004). Issues of mobility may also explain why few arachnids were sampled despite the family being described as the most abundant epigeic predator (Lavelle and Spain, 2001).

Timing issues may also have had an effect on the composition and number of invertebrates found in each plot. The soil of the autumn tilled plots had lain undisturbed for over three months whereas the spring tilled plots had only one week in a disturbed state before sampling was undertaken. This does not seem to have had an effect on the results but may have counted against the experiment should any significant patterns have occurred. Therefore in any repetition of this work, further consideration of ploughing sampling times is advised. Another fault with the chosen sampling method was an inconsistency in the mass of soil samples taken by different people and with different sizes of spade. Although every effort was taken to approximate the given dimensions as accurately as possible, this task was managed dissimilarly by different people. Use of an auger would produce more standardised sample sizes however this investigation was limited in resources and time.

Further inconsistencies were introduced in the sorting phase as different people were likely to have varied proficiencies and methods of sorting through soil. Furthermore various proficiencies in identification may have also affected the results. Further collaboration between involved parties, or single-person efforts in sampling, sorting and identification may reduce these errors although there may still be issues with waning enthusiasm or increased proficiency throughout each stage. Increased proficiency in addition to the moisture of the soil may go some way towards explaining the higher amount of invertebrates found in the treatment samples.

In conclusion it was not possible to reject the following null hypotheses given the results of this investigation:
H0: Time of ploughing does not affect invertebrate community composition
H0: Abundances of families Carabidae, Curculonidae, Elateridae and Lumbricidae are not affected by time of ploughing
H0: Time of ploughing does not affect total number of soil invertebrates present

However in light of scientific literature to the contrary it may be worthwhile repeating this experiment with the improvements listed above, namely standardising soil sample sizes, using true ploughing equipment, improved timing of sampling and increased effort to reduce bias between participating individuals. Following this, further study might include a greater focus on the farmland bird important families and along with study over a larger area, correlation between invertebrate abundance and farmland bird abundance.

With the current focus on farming conservation and agricultural methods constantly shifting to improve the relationship between farming and environment; more extensive monitoring of the effects on invertebrates and the wider food chain are becoming increasingly important as a means of verification that conservation farming is having a long-term and significant positive effect.

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