# Changes in Conservation Grazing Regime and Pollinator Specialisation at Kingcombe Meadows National Nature Reserve, Dorset.

[redacted]

Field Project Report

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Figure 1 Devils Bit Scabious *Succisa pratensis* at Kingcombe Meadows National Nature Reserve, Dorset, UK.

Postgraduate Certificate in Ecological Survey Techniques

University of Oxford

Oxford University Department for Continuing Education

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Separate Field Project Journal attached

# Abstract

The aim of this project is to investigate floral diversity and abundance, pollinators and associated forage interaction frequency; within 5 separate sets of field blocks under differing conservation management techniques at Kingcombe Meadows National Nature Reserve. The 5 fields are maintained by two different grassland management techniques, including cattle grazing and a hay-cut.

Transects and Flower Insect Timed (FIT) counts where randomly assigned in each field, before and after the grassland management event. Pollinator, flora interactions were recorded (number and length of interactions) to look at potential preferences in forage: and to be utilised as a proxy for specialism of the taxa. The pollinator assemblages at both management stages were recorded, as were the abundance and diversity of the vegetation in blossom.

Secondary data was utilised from Kingcombe Floral Group to create a complete picture of the floral resources available at Kingcombe.

Data collection was largely hampered by the British 'summer'. Limiting the amount and range of data collected.

682 pollinators were recorded across all of Kingcombe: 252 of them foraged on 25 different species of inflorescence. There where no conclusive findings found for pollinator specialism associated with grazing stage: or hay-cutting technique. There were dramatic losses in plant and pollinator biodiversity and abundance, associated with the hay-cut management technique.

# Acknowledgements

I would like to thank [redacted], Living Landscape Ecologist at Dorset Wildlife Trust. For his continuing support, advice, and ideas in the preparation of this project. Providing me with access to useful documentation and data from the Kingcombe Floral group. And for letting me attend any potential learning opportunity that arose.

[redacted], for your dedication to helping me sample on the single hottest day of the year! Thank you.

Thanks, is also essential for my family; to my parents and my husband for entertaining a toddler, for every available hour and minute, that I could spare (after work) to get to the laptop or into the field for this project. Without this support, I would not have been able to undertake the entire PGCert. And my husband's belief that I was capable of getting onto this course, far surpassed my own confidence in myself. His patience and guidance have been unwavering.

I would also like to thank Dr Cecilia Dahlsjö and Dr Thomas Hesselberg, for their support and guidance in starting up this project, and for their help, for me to quickly rework the project proposal after the initial project subject (Black Bees *Apis Mellifera Mellifera*) had succumbed to a disease, destroying the introduced apiary.

# Contents

# List of Figures

# List of Tables

# 1.0 Introduction

## 1.1 Pollinator declines

Globally there is rapid decline in insect populations: 'almost half of the species are rapidly declining' (Sánchez-Bayo and Wyckhuys, 2019). A 'global pollination crisis' has been established (Potts et al., 2003) and has been receiving increasing interest and concern in recent years. Sánchez-Bayo and Wyckhuys (2019), has calculated that the current rates of decline may lead to extinction of 40% of the invertebrates, worldwide, in the next 'few decades', Figure 1.1.1.

Hallmann et al. (2017) monitored populations of flying insects in Germany (in protected sites): in 2017 they concluded the 27-year study, with a 76% loss of biomass. 'Bees, Ants and Beetles are disappearing eight times faster than mammals, birds or reptiles' (Briggs, 2019).

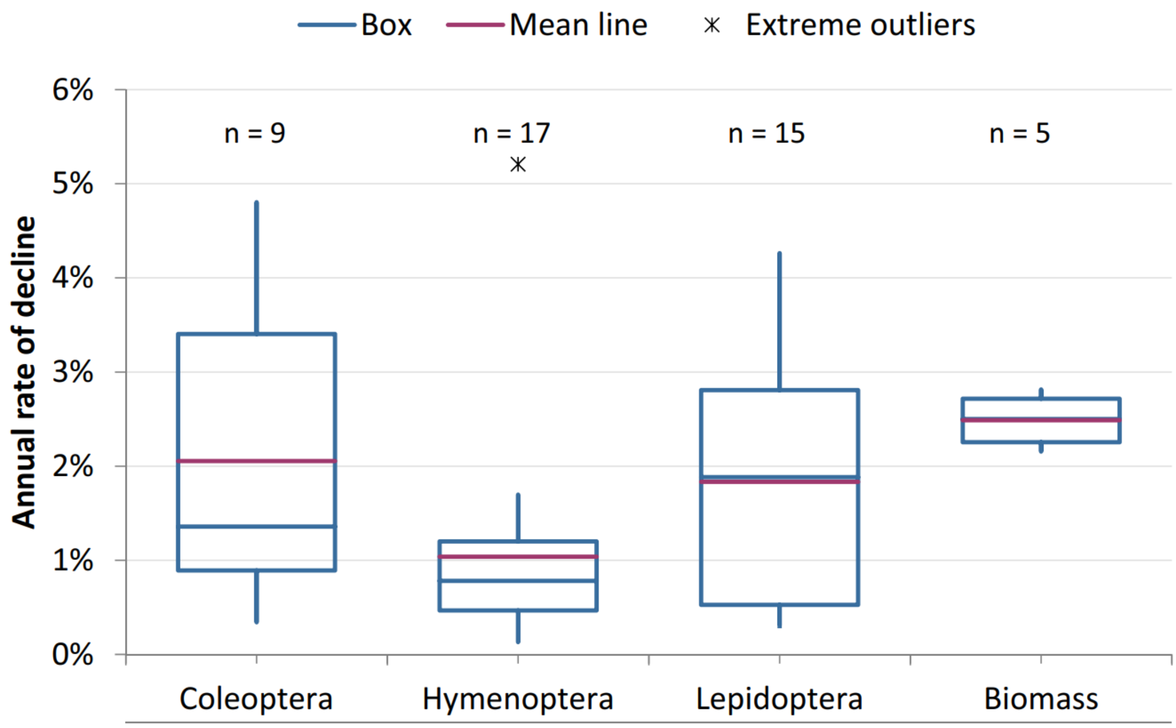



Figure 1.1. 1 Excerpt from Sánchez-Bayo and Wyckhuys (2019), Annual rates of decline of Coleoptera, Hymenoptera, Lepidoptera and Biomass; percent of species decline, per year, worldwide.

From an estimated 7.7 billion people globally (2019), population projections calculate 'that the global population could grow to around' 9.7 billion by 2050 (United Nations, 2019). As our reliance on intensive agriculture rises with population growth, the need for pollinators also rises, they provide 'essential ecosystem services' (Potts et al., 2003). 'The importance of pollination, and our dependence on it, will only intensify' (Davis et al., 2012). Invertebrate pollinators are vitally important for entomophilous plants: 87.5% of angiosperms rely on them (Ollerton et al., 2010). Globally, insect pollination is required for 75% of the global food supply (Dirzo et al., 2014).

Pollinators play a crucial role in the ecosystem and have seen a period of decline in all areas of Britain, since the 1970s, See Figure 1.1.2 (Potts et al., 2003).

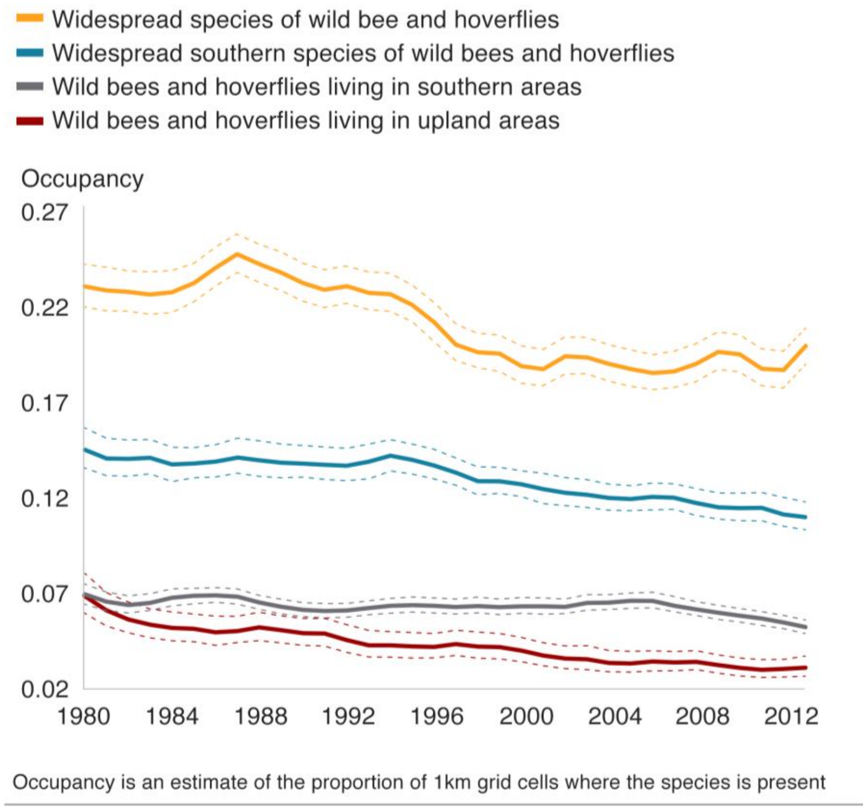



Figure 1.1. 2 Pollinators - Bee and hoverfly decline in the UK over 30 years (Briggs, 2019).

## 1.2 Habitats in decline

Increasingly more land is being intensified for agricultural use or transformed to provide accommodation for growing populations (Sánchez-Bayo and Wyckhuys, 2019). Agricultural intensification is 'often associated with the use of high-yielding crop varieties, fertilisation and pesticides'; simplified habitats and lower biodiversity (Hudewenz et al., 2012). Globally, Intensive agriculture is the largest contributing factor (23.9%) to insect declines, See Figure 1.2.1.

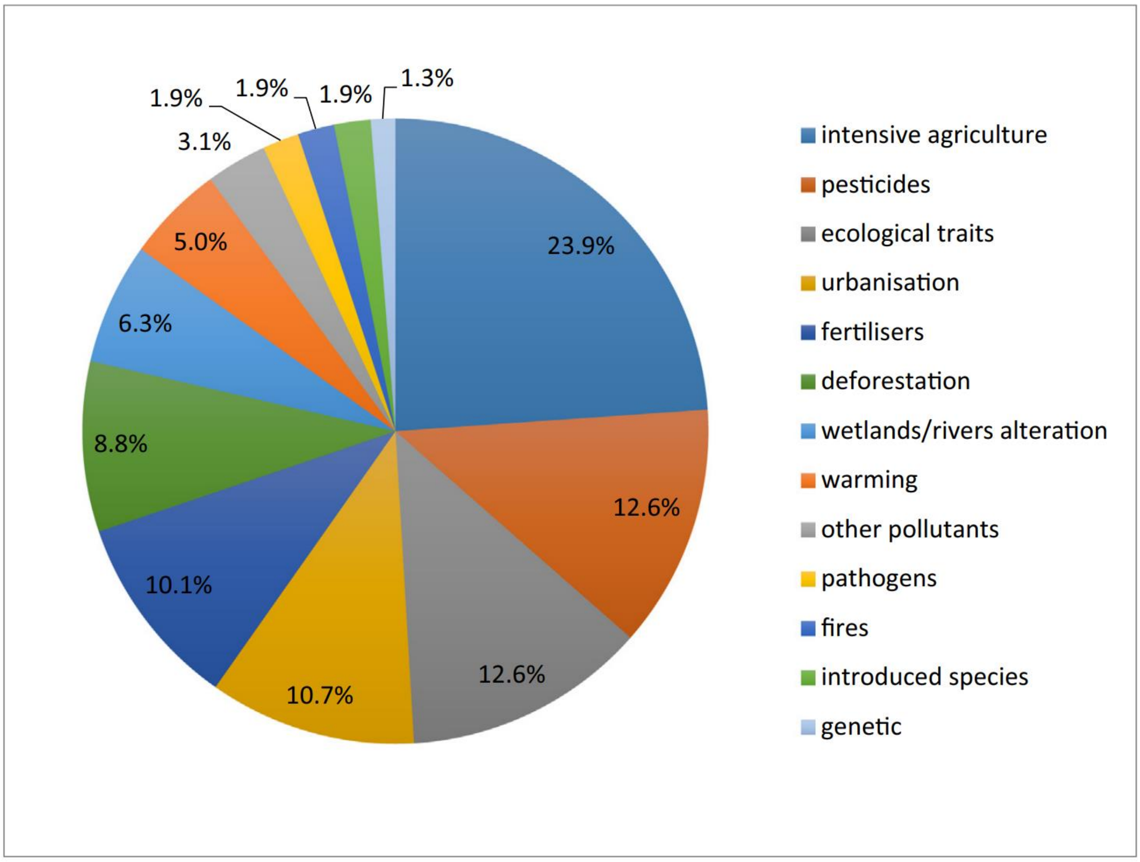



Figure 1.2. 1 Excerpt from Sánchez-Bayo and Wyckhuys (2019), Main factors associated with insect declines.

As agricultural intensification rises, agriculture will increasingly relying on artificial colonies of pollinators. Goulson (2012) has suggested supporting the natural populations of bees might be a solution to these growing issues. Maintaining ecologically diverse landscapes and investigating ways to support naturally occurring assemblages of pollinators has never been more critical.

Nature reserves are important in maintaining refuges for wildlife, they also have the potential to demonstrate how grassland can be managed to benefit biodiversity, with the potential for supporting cattle or hay production. Hay Meadows and semi-natural grasslands represent some of the most biodiverse plant communities in the UK (Forup and Memmott, 2005, Sjodin, 2007). For this reason, an exemplary, organic hay meadow and semi-natural grassland site was sought for this study.

Sánchez-Bayo and Wyckhuys (2019) suggested that 'more sustainable, ecologically-based practices, [are] urgently needed to slow or reverse current trends, [to] allow the recovery of declining insect populations'. It is known that pollinators benefit from low management intensities, with 1-2 mowing events/year and no fertiliser addition (Hudewenz et al., 2012, Sjodin, 2007). Sjodin (2007) noted that many investigations have demonstrated the need for 'low intensity management for certain insect groups' and invertebrates that visit flowers have received less attention.

Hudewenz et al. (2012) found that higher diversity of flora and 'blossom cover was associated with enhanced pollinator species richness and flower visitation', but that even in areas with high flora diversity, fertilisation and mowing 'are more important drivers of … flower visitation by pollinators'.

Davis et al. (2012) identified specialisation/narrowing of foraging niche 'as traits associated with decline' of wild bees in the UK and Netherlands. Little work exists on the specialism of insects and the effect of changes of grassland management practices.

## 1.3 Pollinator specialism

The degree of forage specialism versus generalism, may rely on a species biological traits, ability to locate, forage reward, access different food types, as well as supply and distance between forage (Baumgartner et al., 2014, Davis et al., 2012). The 'factors determining the degree' of 'specialism are central in ecology' (Baumgartner et al., 2014).

Habitats in decline; can lead 'to a reduction in the range and status of many' invertebrates, due to the 'specialisation and limited powers of dispersal' (Curson et al., 2019). Local conservation management techniques may have a direct effect on the range and number of pollinators, if the invertebrates on site show high degrees of specialism. Globally and locally, there is a lack of pollinator data, for wildflower insect interactions on which to develop the conservation strategies. It is vital to understand the effects of conservation management on pollinators resource utilisation and specialism to inform best practice. This may have the potential to be tailored for agricultural, best practice protocols too.

This project will focus on floral diversity and pollinator assemblages and undertake a comparison between 2 types of grassland management practice: conservation grazing and hay-cuts. Conservation management techniques need to maintain a diverse and abundant floral rich grassland to provision for pollinators, typical techniques such as intensive grazing, 'might not be the optimal choice to preserve diversity of insects' (Sjodin, 2007).

Potts et al. (2003) found that bee abundance was a 'positive function of the abundance of flowers', habitats abundant in flowers have a greater chance of invertebrates utilising specific inflorescences (or parts of) – or partitioning resources. Reduced inflorescences availability (such as that estimated after a hay-cut), may create more competition for the limited resources, and see a larger number of varied pollinators from all taxa utilising the same inflorescence.

## 1.4 Study area: Kingcombe Meadows NNR


Figure 1.4. 1 Location of Kingcombe Meadows NNR, in Dorset, UK.

Kingcombe Meadows (KM) National Nature Reserve (NNR) is near Toller Porcorum, Dorset, Figure 1.4.1. Owned by Dorset Wildlife Trust (DWT), Figure 1.4.2. It was upgraded to an NNR on the 2/7/21 (Natural England, 2021b). The reserve has sections of SAC, SSSI and SNCI; it is an organic farm, grazed for conservation. A rarity in the 20th century, it has escaped intensification and has never been farmed by current intensive standards. This combined with geology, size and topography creates a farmland reserve with unparalleled biodiversity in wildlife, in lowland Britain (Dorset Wildlife Trust, 2019). Natural England Chair, has said "the working organic farm at the heart of this beautiful place is a brilliant example of working in harmony with nature" (Natural England, 2021b).

Less than 0.05%(6,000ha) of England is unimproved neutral grassland (MG5, including hay meadows) (Natural England, 2013). Since the 1960's the old and lowland meadows have 'sustained large losses due to drainage, ploughing and re-seeding and from the use of high rates of fertilisers' (Natural England, 2013). KM has 157ha of grassland; 40.8 ha of lowland meadow that is the focus for this study.


Figure 1.4. 2 Kingcombe Meadows Nature Reserve map. Field names are included (Dorset Wildlife Trust, 2021b).

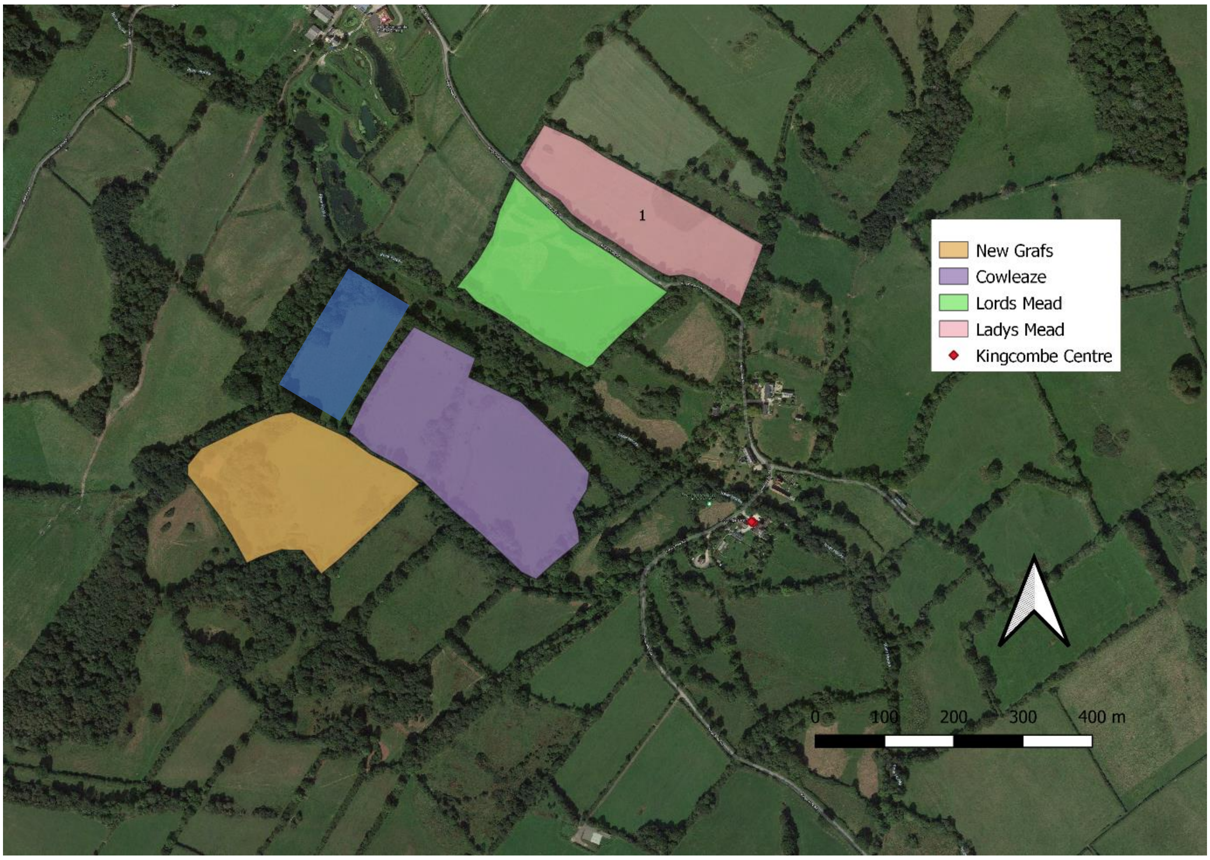



Figure 1.4. 3 Field blocks for study, Kingcombe NR. Created on QGIS. Blue rectangle is Yonder Cowleaze; compared with Cowleaze and New Grafs in this project. Lords and Ladys Mead are compared to each other.

The field blocks chosen for this study were identified as comparable: similar location, elevation, water influx, geology and soil. 5 fields where chosen, after discussion with DWT's ecologist. These include 2 intra-comparable field sets:

- Lords Mead (LoM) & Ladys Mead (LaM)
- Cowleaze (Cl), Yonder Cowleaze (YCl) & New Grafs (NG).

'LoM' and 'LaM' (See Figure 1.4.3) will be compared: LoM is subjected to conservation grazing, Lam's conservation technique involves an annual hay-cut, defining it as a lowland hay meadow. Both fields have a bedrock, of Holywell Nodular chalk cap, upper greensand formation sandstone, to the Northwest, changing to Frome clay formation, mudstone in the southeast of the field, resulting in calcareous grassland.

'Cl' will be compared to 'NG' and 'YCl' they are under the same management technique: conservation grazing, at varying times of year. These fields have Fullers Earth formations, mudstone – neutral soils.

## 2.0 Aims and Research Questions

Despite the ecological importance of insects 'relatively little is known about their biology, distribution, or diversity' (Hughes et al., 2000). This, combined with KM's recent upgraded status to NNR and the fact that it's an exemplary reserve, whose last conservation management plan, questioned the efficacy of the current grazing regime (Dorset Wildlife Trust, 2017); means that this paper focuses on three research questions central to biodiversity conservation and management of the site. (1) How does the grassland management technique effect the floristic composition seen? (2) What are the relationships between pollinator assemblage and the grassland management techniques? (3) Do pollinators show decreased specialisation associated with lower floral diversity?

By understanding more about pollinator specialism links to flora and thus the management of the site, it can inform 'which taxa, might be vulnerable' to habitat management changes (Hughes et al., 2000). Forage interaction frequency is used as a surrogate for specialism. The aim is to investigate pollinators and associated forage interaction frequency, within 2 intra-comparable field sets under different management.

One might expect the larger the floral diversity and abundance, the more specialised the pollinators can be. Picking the same flora out of preference or enhanced forage reward. Sites with decreased blossom may see decreased specialism, all taxa will have to diversify and utilise a greater variety of plants.

It is anticipated that grazing, depending on the intensity, height of the vegetation beforehand and the length of grazing; could produce an initially lower floral abundance, larger distances between flowers and possibly a temporarily less diverse landscape.

# 3.0 Methodology

The term 'pollinator' is defined as "something, such as an insect, that carries pollen from one plant or part of a plant to another" (Cambridge Dictionary, 2021). In this project all-day flying species of invertebrate that utilise the survey area, will be counted as pollinators. 'Pollinators' will be identified to 'Order': Diptera, Lepidoptera, Hymenoptera, Coleoptera and Odonata. As a non-specialist, ID to 'Order' is suitable as a 'surrogate' for species 'when comparing richness of sites' (Oliver and Beattle, 1996).

Survey methods focus on pollinator interactions and the underlying floral resources:

- Floral quadrats
    - Kingcombe Floral Group (KFG) (full floral diversity) (x19)
    - Blossom abundance only (at FIT count site) (x31)
- Flower Insect Timed (FIT) counts of pollinator/plant interactions (x31)
- Transects of invertebrates seen (x10)

The pollinator interaction with forage sources and preference of inflorescence will be studied by surveying strategic random quadrats throughout the meadows and recording pollinator species (species assemblages and abundance) and flora preference (forage choice and length of interaction time).

The original project plan was to compare different grazing pressure: the author could not gain access to the grazing records for the fields in time for the project write up. Grazing has been listed as time since grazing activity ceased, rather than Livestock Units for this reason.

Specialism of pollinators and flower species is characterised as the number of interactions between them. Specialisation or generalisation 'of interactions are most commonly characterized as the number of partners (or 'links')' (Blüthgen et al., 2006). This is often qualitative, presence/absence: during this study the author attempted to quantify the number/timing of interactions. The FIT count dataset included timings for each visit, indicating the strength of these interactions, but the author hasn't had time to review these.

## 3.1 Weather

For consistent sampling, and 'good' pollinator days (Forup and Memmott, 2005), the weather conditions must remain within certain limits: warm temperature 16-32°C, no precipitation, low level of wind. This often meant that the sampling day had to be changed or abandoned due to the UK weather conditions. FIT counts occurred between 0900-1900, June until August 2021.

## 3.2 Pollinator surveys

### 3.2.1 Flower Insect Timed Counts (FIT)

1m$^2$ quadrats were utilised and randomly assigned within Polygons on QGIS, to enable strategic locations to be chosen – *i.e.,* within a specific field block. See Appendix 8. FIT counts took place for 15 minutes each (timer utilised) and record all pollinator species that visit it. The floral choice for forage, activity (Table 3.2.1.1) and length of time were recorded per visit. The observer sat at floor level, 50cms from the edge of the quadrat.

Table 3.2.1. 1 Classification of Pollinator behaviour in FIT counts

| **Activity** | **Explanation** |
|---|---|
| Flew-Through | Pollinator flew-through the quadrat, did not land, or interact with any vegetation. |

| | |
|---|---|
| Forage | Pollinator landed on blossom of vegetation in flower. This includes harvesting pollen and nectar. |
| Walking | Pollinator walked around on vegetation: stem, leaves and edge of petals. |
| In Cop | Pollinators pair in copulation. If the bottom of the pair was foraging, then this was listed as a forage interaction. |

Data sheet in Appendix 7. There was no height limit to the pollinators that 'flew-through'. Pollinators in the quadrat before or after survey (See Figure 3.2.1.1), where removed from results data. 3 counts should take place before and after each management technique, per field.

Figure 3.2.1. 1 Pollinators in before or remaining after the FIT count were removed from calculations.

### 3.2.2 Pollinator Transects

The walking transects recording zone was 1.5m either side of the observer and 333m long (3x333m), centred on the transect line (~1000m$^2$). Recorded sightings took place to a height of 2 metres. See Appendix 8 for data sheet, recording pollinators seen.

Each field will have 2 transects before and after the management technique (Totalling 4). Walk the transect at a maintained constant speed.

2 transects were conducted in each field, from start positions selected near the edges of the field, strategically randomised directions, the length of transect was plotted in Viewranger to enable calculation of the overall length, See Figure 3.2.2.1.

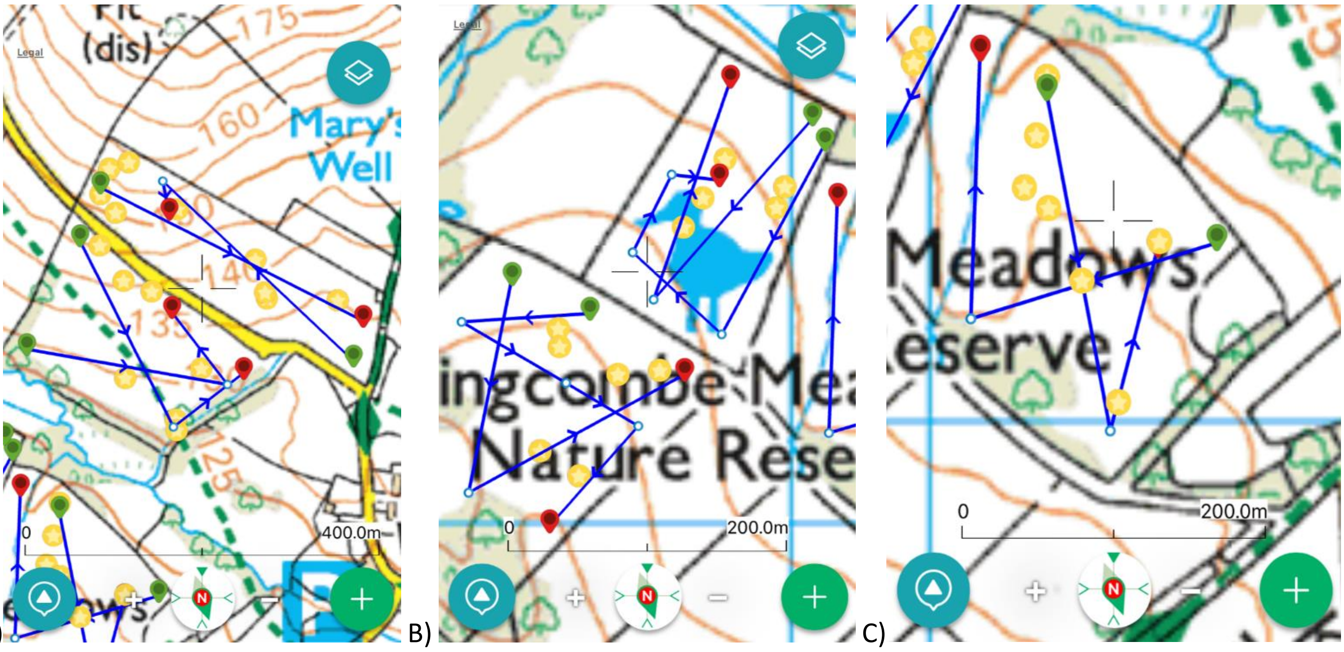



Figure 3.2.2. 1 Pollinator transect locations (Augmentra Ltd. Software, 2011). Maps orientated North. Grid references available in Appendix 2. A) LoM (South) and LaM (North), B) YCl (North) and NG (South), C) Cl.

## 3.3 Vegetation surveys

### 3.3.1 Kingcombe Floral Group (KFG) Quadrats

KFG sampled utilising a randomly assigned 1m$^2$ quadrat, percent coverage was recorded for all vegetative species. See associated spreadsheet for dates and locations. This enabled an insight into the flora available to pollinators during this period and any major differences in floral assemblages between sites.

### 3.3.1 FIT count site quadrats (blossom only)

Floral resource availability to the pollinators was recorded by recording blossom coverage (species and coverage), after FIT counts – a 50cm$^2$ quadrat. Only in flower, inflorescence was utilised. Dead/dried flower heads and flower heads that bent in from outside the quadrat, weren't counted. Large multi-floret heads such as raceme and panicle inflorescence (>45cm), such as Marsh Thistle *Cirsium palustre* where estimated as lateral coverage of blossom. See Appendix 6.

A)

B)

Figure 3.3.1. 1 Flora count after FIT counts, utilising A) segmented quadrat. Lowered with care to limit crushing of plants. b) FIT count site – FIT count took place before quadrat was put in situ.

Sward height was measured by averaging the measurements of 5 heights within the quadrat.

# 4.0 Results

## 4.1 Vegetation Surveys

### 4.1.1 Kingcombe Floral Group (KFG) Quadrats

KFG data has been synthesized to provide an overall image of the vegetation present (flowering and non-flowering). 26 quadrats were undertaken: 8 in NG, 8 in Cl, 3 in YCl and 7 in LoM. Each field has been averaged to create Figures 8.9.1-8.9.3, in Appendix 9. The graphs demonstrate the floral assemblage as a composition of 100%; the values in the legends, demonstrate the average percent cover of the species found in quadrats in that field (not of the composition of the graphs).

The average floral diversity in each field was: NG, 14.4 species and a average sward height of 12cm. YCl, 18.6 species, sward of 10.67cm. Both of those fields where pre-graze. Cl was the only site, post grazing mangement, its diversity averages as 22.25 species, sward height 11.75cm. Counts for LaM, and the LoM data were from 2020, so they are not compared here.

Across all 3 fields *Lotus corniculatus* was found in blossom in 21 quadrats, *Hypochaeris radicata* & *Centaurea nigra* both in 12; *Cirsium palustre* 10; *Trifolium pratense* 15; *Potentilla erecta* 15.

### 4.1.2 FIT count site quadrats

From this point forward the data presented, only record blossom coverage.

For 'coding' details and environmental conditions, see Appendix 2 and 5: 'A' Quadrats are in NG, 'B' in Cl, 'C' in YCl, 'D' in LaM, 'E' in LoM. Numbers '1-9' in Figure 4.1.i indicate, which quadrat within the same field, these are at different stages of conservation mangement technique.

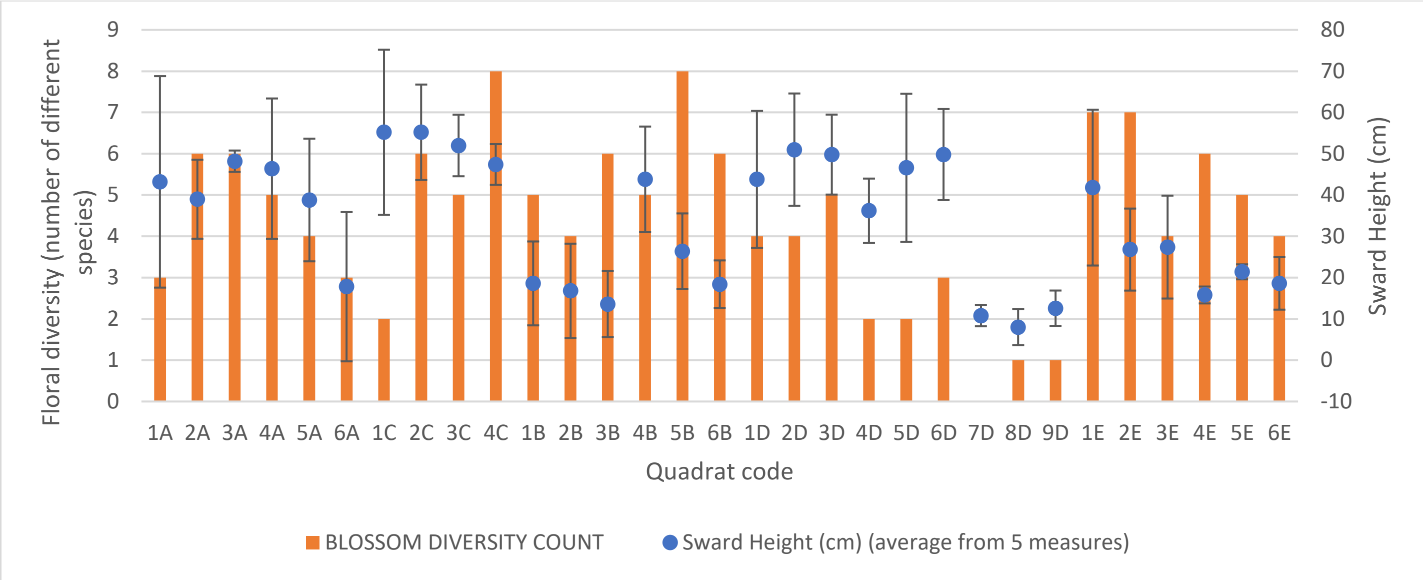



Figure 4.1. i: Composite graph, blossom diversity count bar chart, overlain with sward height. Standard deviation error bars for sward height averages. This graph contains all stages of grazing and cutting methods.

## 4.2 Pollinator Surveys

### 4.2.1 Pollinator Transects

A summary of locations and data can be seen in Appendix 3 and 4. Due to the weather, the transects remain incomplete, each site was visited once, 2 transects were completed in each field. The data is presented (4.2.i & 4.2.ii) but with no comparable set of 'after' management results. The transects only provide a point in time, image of the composition of the pollinators.

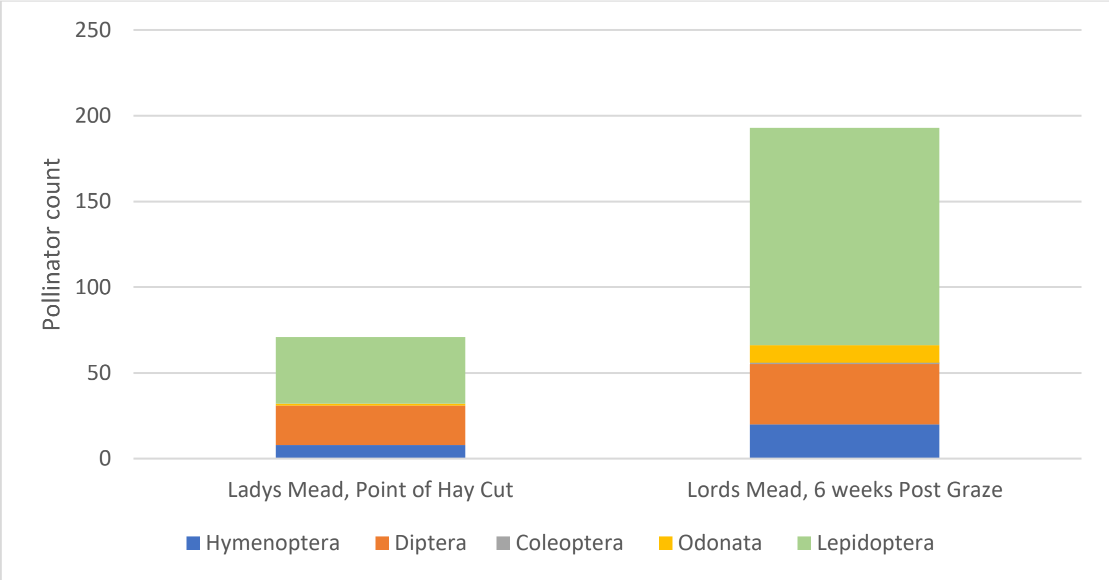



Figure 4.2. i: Counts of pollinators totalled from 2 transects, in each lady's and LoM.

71 pollinators were counted in 2 LaM transects, on the day of the hay-cut: 11.3% Hymenoptera, 32.4% Diptera and 54.9% Lepidoptera. 193 were counted in LoM, on the same day (6-weeks post-graze). The amount of Hymenoptera in LoM: 20 individuals, 10.4% proportionate representation of the total count. Diptera and Lepidoptera constitute 18.1% and 65.8% respectively.

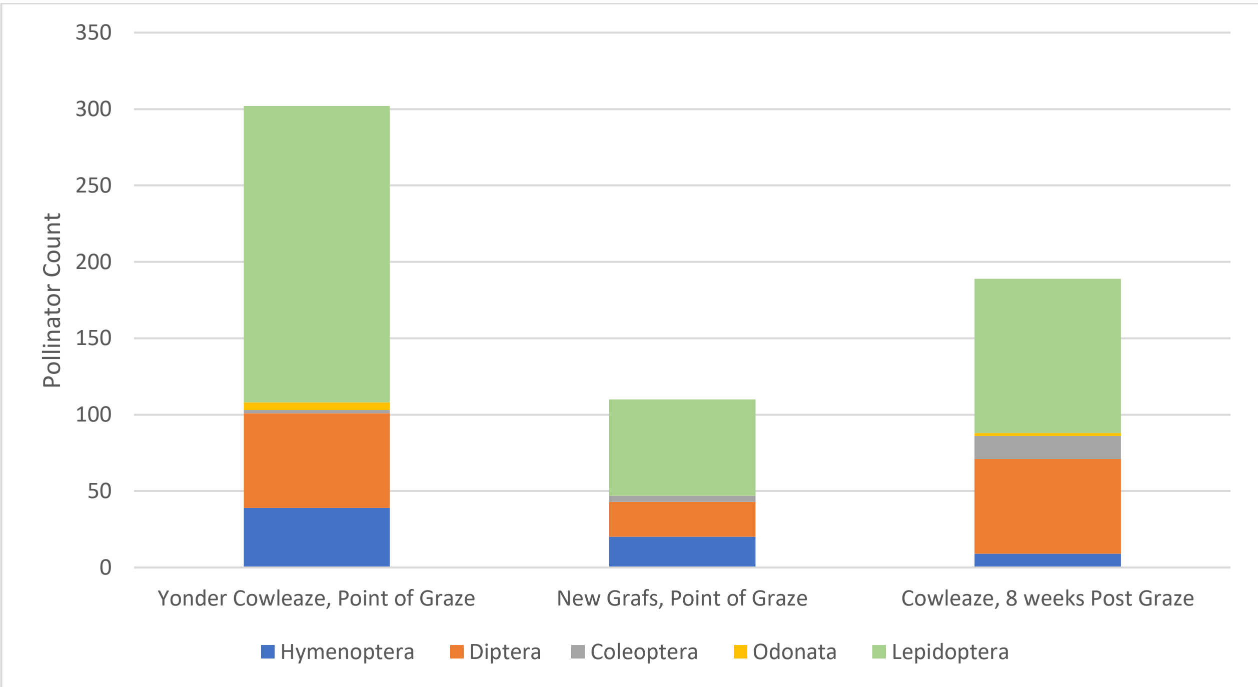


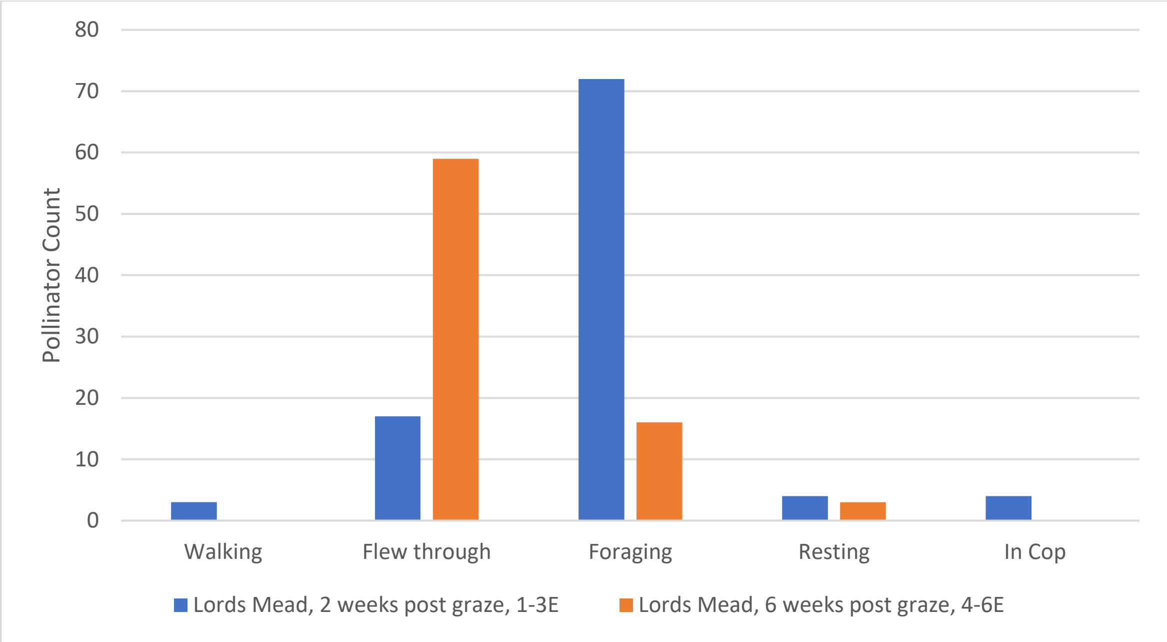

Figure 4.2. ii: Counts of pollinators from 2 transects, in each YCl, NG and Cl.

302 pollinators were totalled in YCl, 110 in NG, both at point-of-graze. 189 in Cl. They were all surveyed on the same day. Lepidoptera comprised more than 50% of the pollinators in every field (YCl, 64.2%, NG, 57.3%, Cl, 53.4%).

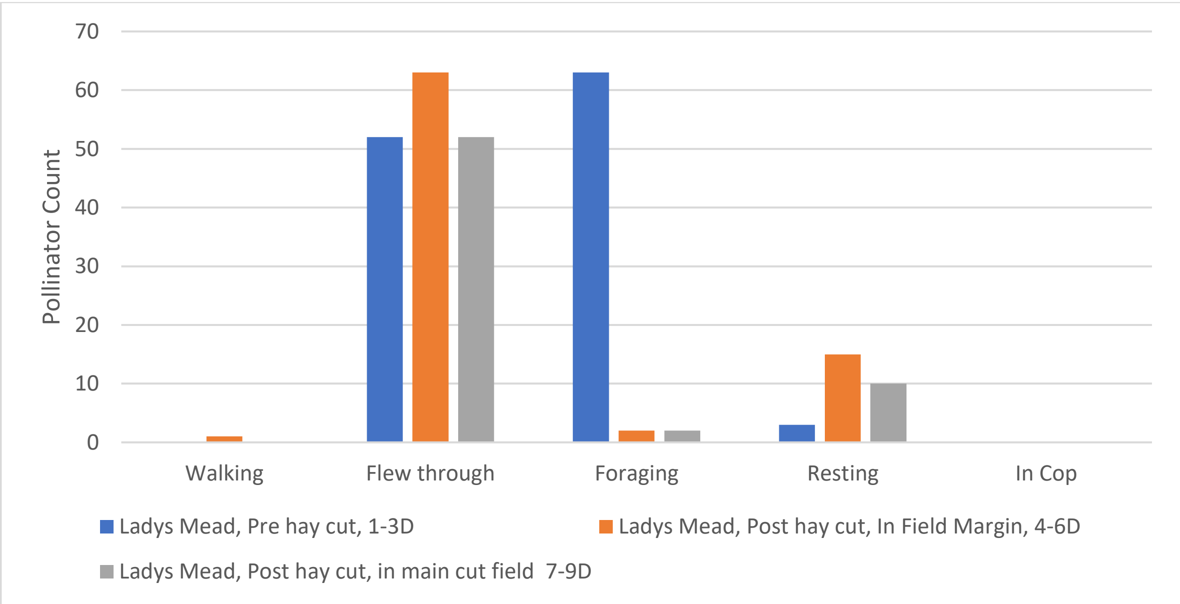
### 4.2.2 Flower Insect Timed Counts (FIT)

The dataset also includes the length of time each pollinator stayed on each flower, but the author has not had enough time to work through this too, it is available in the accompanying spreadsheet.

#### 4.2.2.1 Pollinator behaviour




A)




B)

Figure 4.2. iii: Pollinator activity in A) LoM B) LaM, pre-hay-cut, post-hay-cut: in the field margin (long grass) and centre field where the grass has been cut.

Pollinator behaviour in LaM, saw similar numbers of species flying through the site, at all grassland management stages: Pre-hay-cut 52, post-hay-cut margin 63 and post-hay-cut central field 52. The most dramatic change was in the pollinators foraging – 63 individuals were foraging before the hay-cut, and 2 after (in margin and central locations).

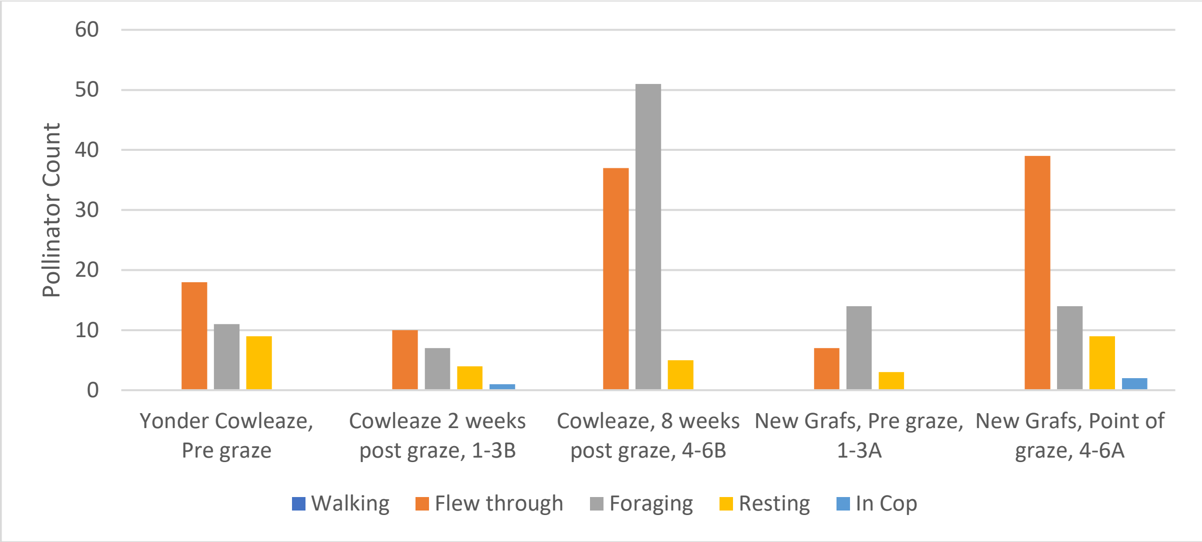



Figure 4.2. iv: Pollinator activity in 3 field blocks, under the same grazing pressure, differing times of succession.

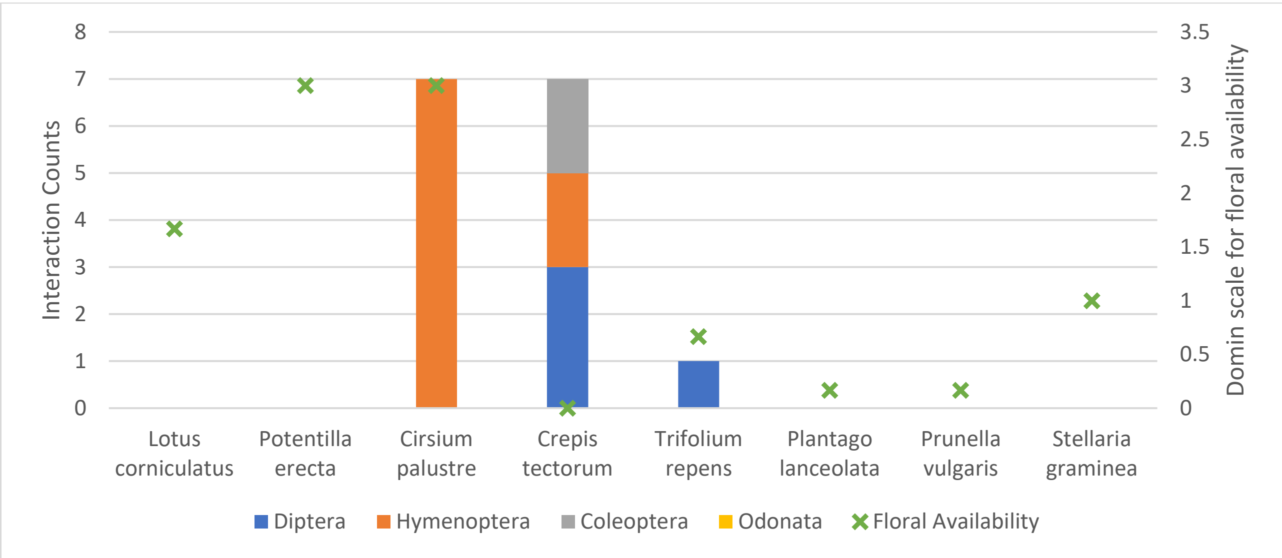
Foraging counts remained constant in NG (14 pollinators), before and at point-of-graze, but the number of invertebrates flying through increased from 7 to 39 pollinators.

### 4.2.2.2 Pollinator assemblages and floral availability

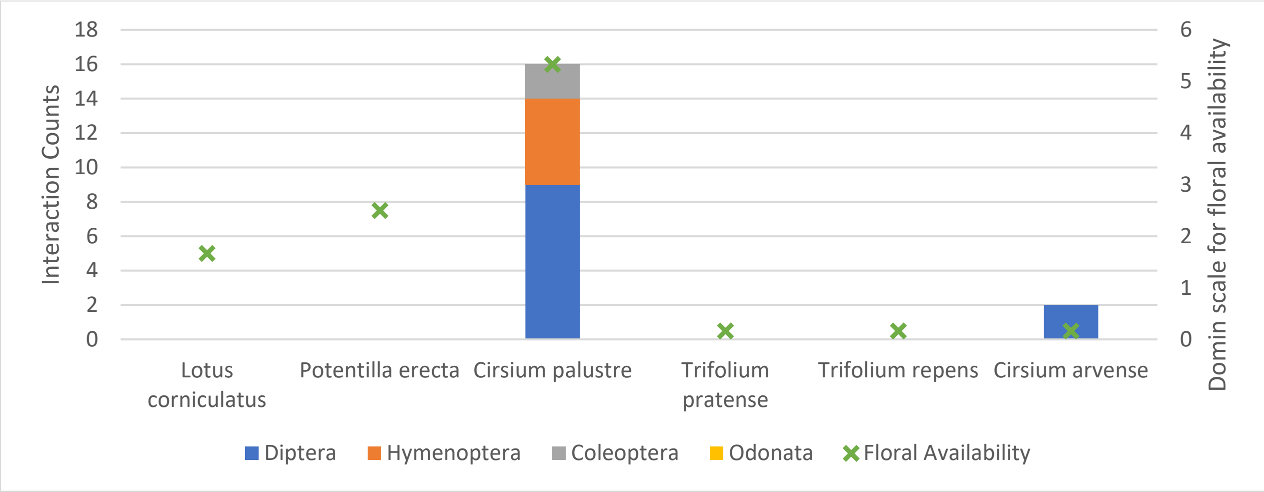
Interactions that included 'flying through' or interacting with 'grasses, sedges or rush' are not included in the following results. Only in-flower, vegetation is included as part of the floral availability Domin counts plotted. '+' scores were updated to 0.5 for use in excel.

Domin scale has overlain on Figures 4.2.v-4.2.ix to represent the flora in blossom demonstrating what was most abundant.

#### *4.2.2.2.1 New Grafs*




A)




B)

Figure 4.2. v: Flora, pollinator assemblage interaction counts for NG, A) Pre-graze, B) Point-of-graze. Floral availability overlain for visual comparison of what was available within local area flora resources (Domin scale).

*Pre-graze* - FIT counts in NG recorded 9 interactions from Hymenoptera, favouring *Cirsium palustre (*9 interactions) and 2 interactions with *Crepis tectorum.* 4 occurred from Diptera, 3 of them on *C.tectorum.* 2 from Coleoptera also occurred on this plant.

*Point-of-graze* - There were 18 interactions between vegetation and Diptera, 7 were with grass and discounted from theses graphs. 9 were with *C.palustre,* 2 with *C.arvense*. Hymenoptera and Coleoptera only interacted with *C.palustre. C.palustre* was the most abundant plant in flower in these quadrats.

#### *4.2.2.2.2 Yonder Cowleaze*

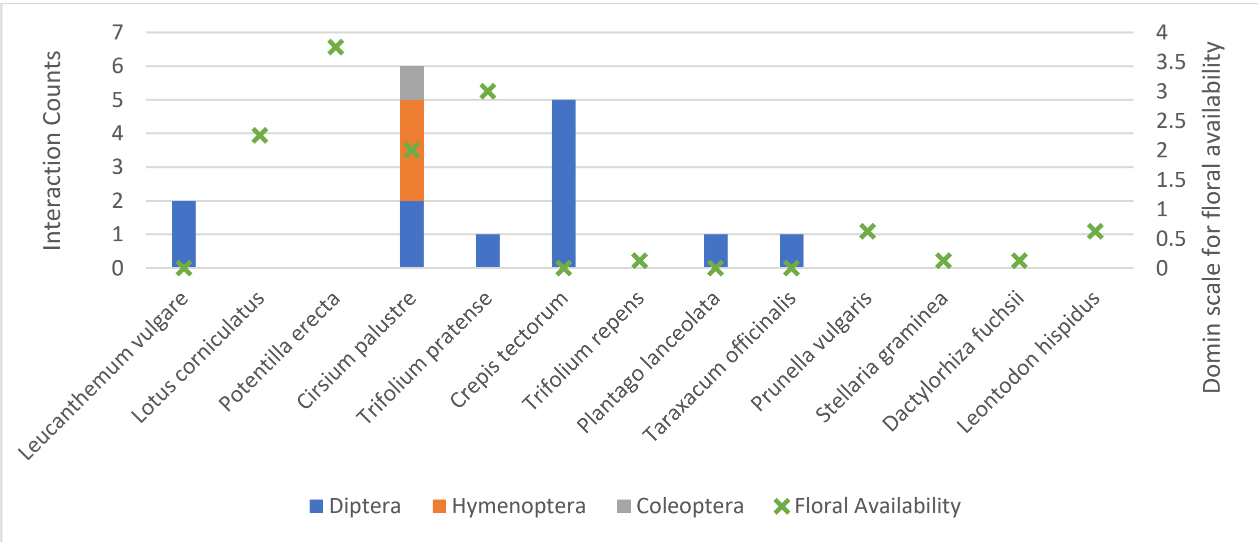
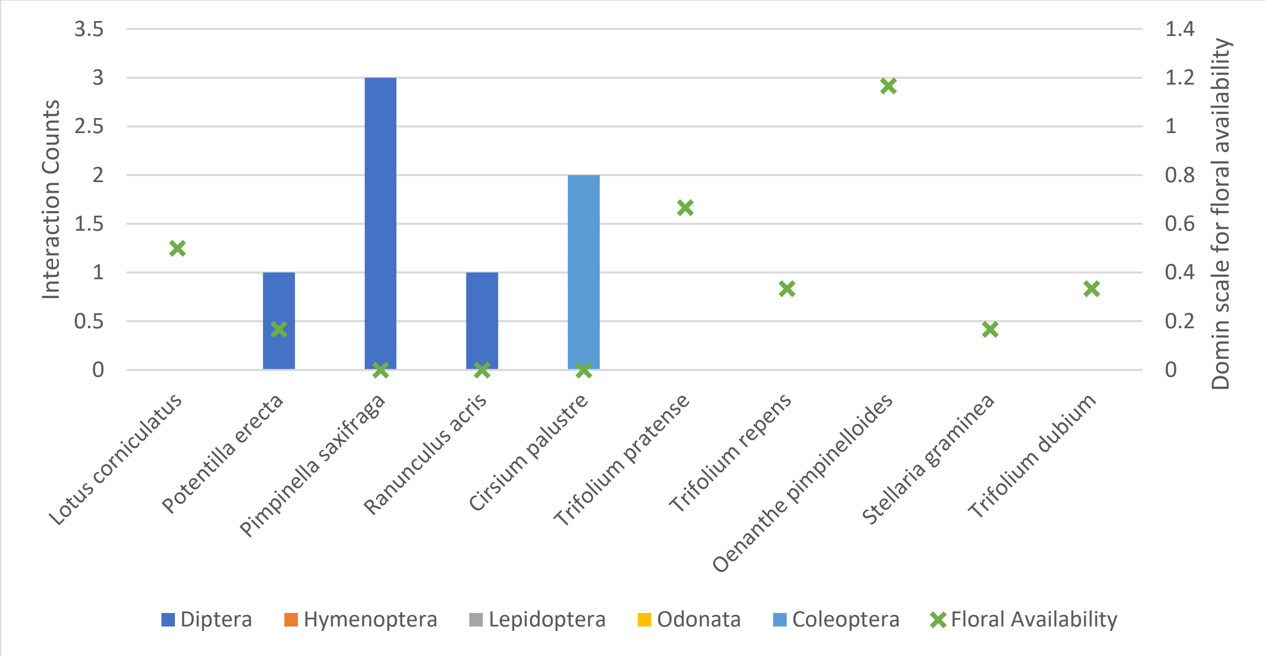


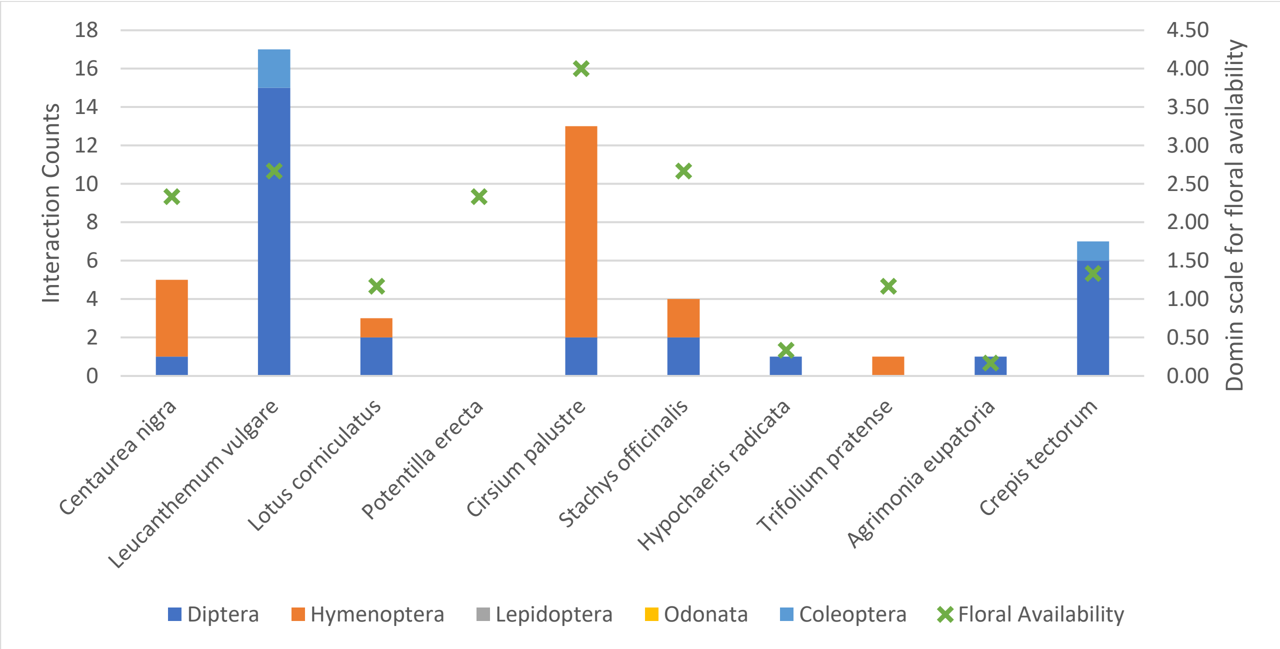

Figure 4.2. vi: Pollinator plant interactions: YCl, Pre-graze. Floral availability overlain.

In 2 of the 4 quadrats, *C.palustre* dominated the blossom coverage, 4-10% in both. There was no *C.palustre* in 2 quadrats. *P.erecta* and *T.pratense*, dominated the 4 quadrats, both with <4% (many individuals) blossom coverage. Diptera interacted with mixed flora, 15 times. Hymenoptera interacted 3 times, all with *C.palustre*. The only interaction with blossom from Coleoptera was also with *C.palustre.* 18 invertebrates flew-through the site, without interacting with any vegetation. There is no accompanying second post-graze data, as the weather meant that this site, needed revisiting to achieve 4 quadrats to complete a pre-graze data set.

*4.2.2.2.3 Cowleaze*




A)




B)

Figure 4.2. vii: Pollinator plant interactions: Cl A) 2-weeks post-graze, B) 8-weeks post-graze. Floral availability overlain.

Cl was surveyed on 9/7/21 and 1/8/21, the first survey that took place was 2-weeks after grazing had occurred. 5 Diptera interacted with flora, and 2 Coleoptera.

*8-weeks post-graze - L.vulgare, C.palustre* and *S.officinalis* dominated (4-10% coverage by each species), 8-weeks after grazing. 32 Diptera interactions were recorded and 19 Hymenoptera. Hymenoptera (11) favoured *C.palustre* and Diptera (15) favoured *L.vulgare.*

### *4.2.2.2.4 Lords Mead*

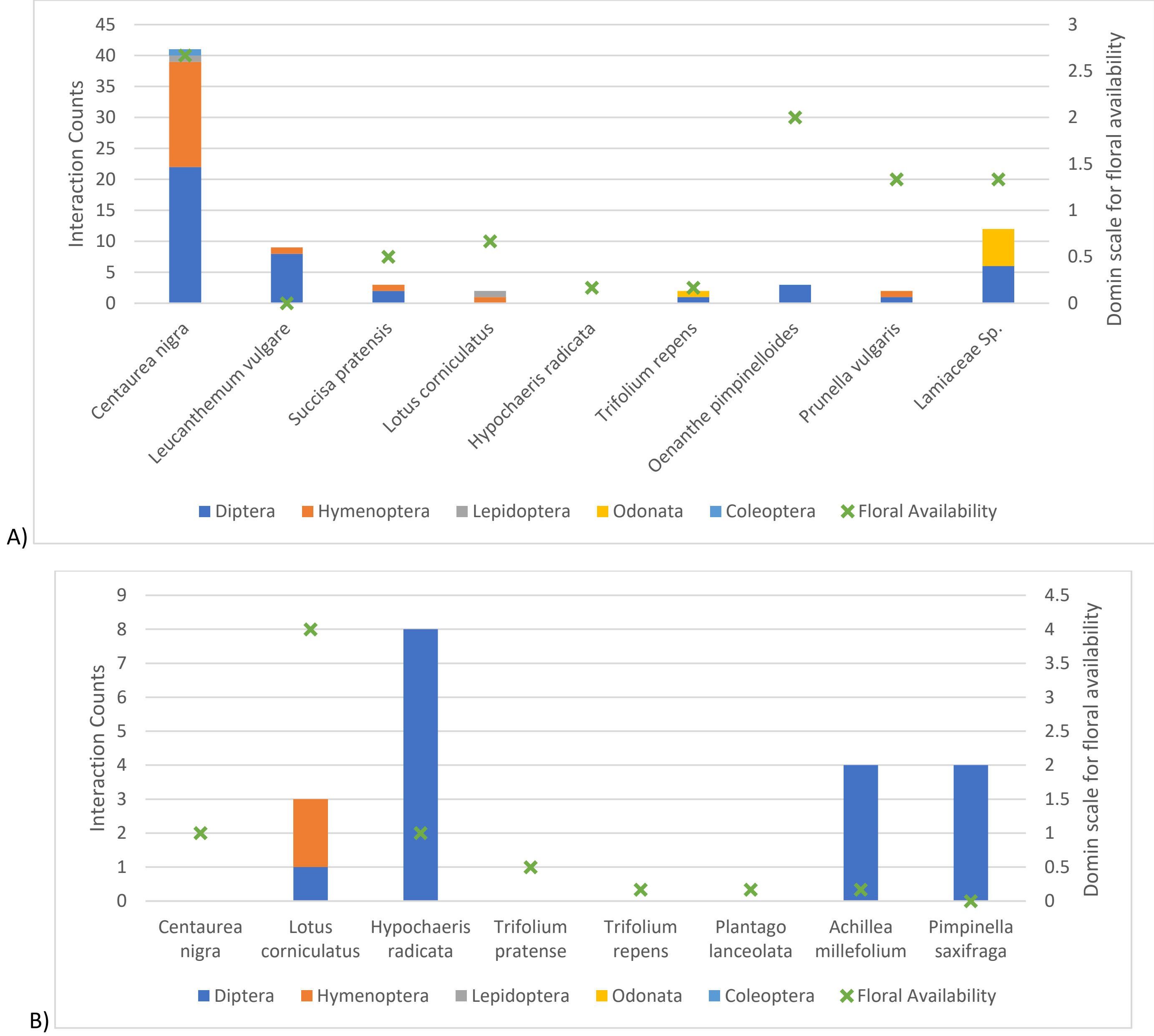
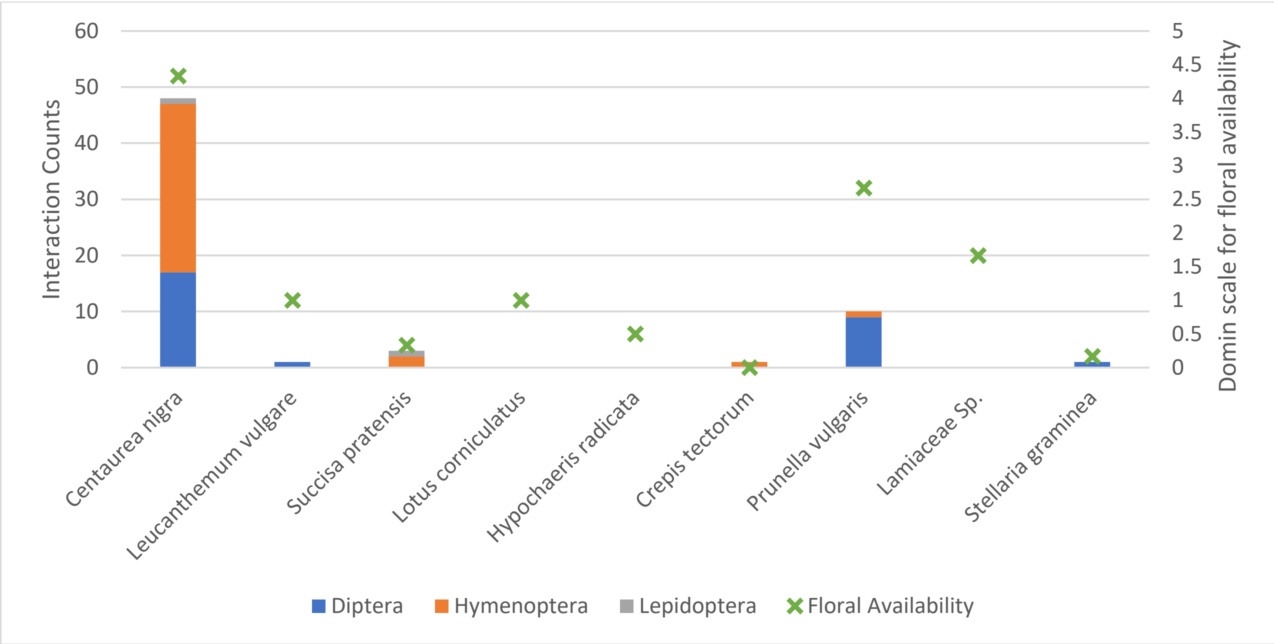



Figure 4.2. viii: Flora, pollinator assemblage interaction counts for LoM: A) 6-weeks post-graze B) 8-weeks post-graze. Floral availability overlain.

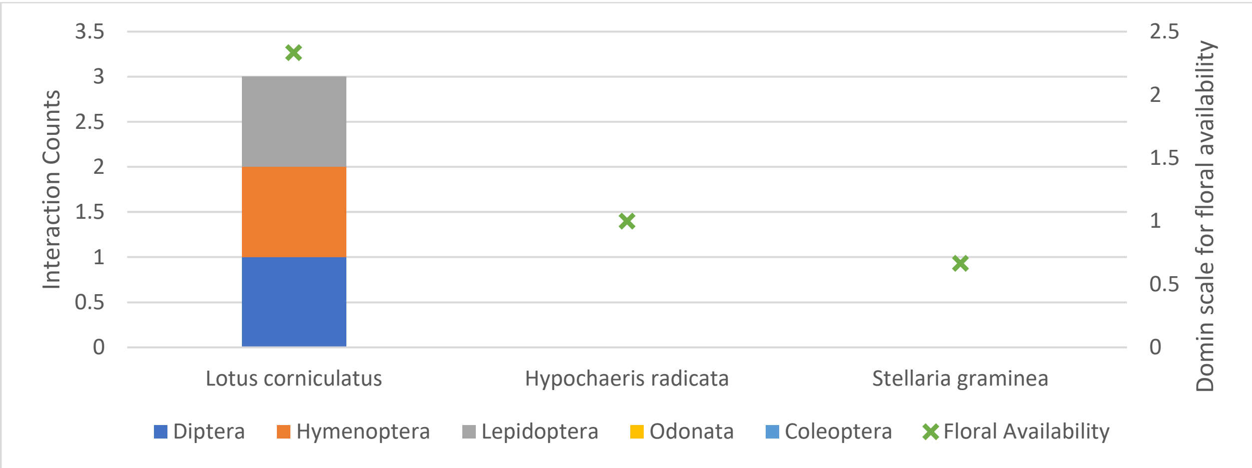
*6-weeks Post-Graze* -73 individuals (72%) of the pollinators, were foraging. 17% 'flew-through'. There were 44 interactions with flora from Diptera (57.2%) and 21 (27.3%) from Hymenoptera. 2 (2.6%) from Lepidoptera, 7 (9%) from Odonata and 3 (3.9%) from Coleoptera. *C.nigra* was the most abundant plant, in flower, covering <4% (several) of the quadrats. 9 species of flowering vegetation were available in these quadrats.

*8-weeks Post-Graze* - Diptera interacted 17 times with inflorescence. 8 Diptera interactions occurred with *H.radicata*. There were 2 Hymenoptera interactions both with *L.corniculatus*. 75% (59) of the pollinators seen in these quadrats, 'flew-through', 20.5% foraged.

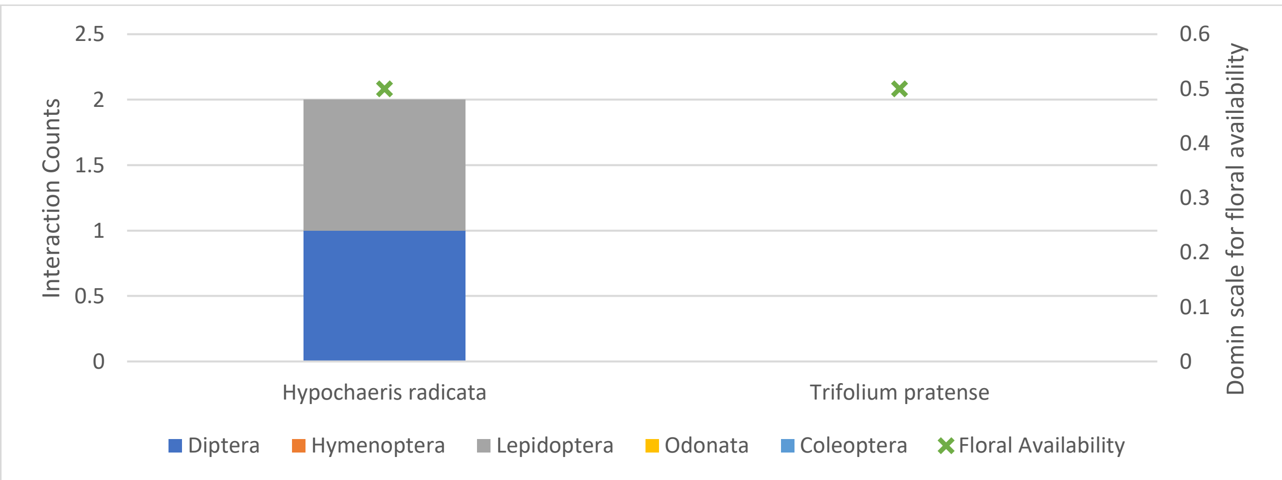
### *4.2.2.2.5 Ladys Mead*




A)




B)




C)

Figure 4.2. ix: Pollinator plant interactions: LaM, A) Pre-Hay-Cut, B) Post-Hay-Cut (in Margin), C) Post-Hay-Cut (in centre). Floral availability overlain.

*Pre-Hay-cut* - There were a total of 64 interactions: 28 from Diptera, 34 from Hymenoptera and 2 by Lepidoptera. A further 52 invertebrates flew-through during survey. *C.nigra* was the most visited plant species (48 visits). *C.nigra* was the most abundant plant in the samples in this field, at 4-10% coverage of blossom.

*Post-Hay-cut (in Margin)* - There were 3 interactions, 1 from each Diptera, Hymenoptera and Lepidoptera. These were all on the most abundant plant *L.corniculatus*, <4% coverage by this blossom, 'few' individuals.

*Post-Hay-cut (in centre of cut field)* - 2 interactions, 1 from Diptera and 1 from Lepidoptera. These were all on the most abundant plant *H.radicata*. There were 1-2 individuals of this blossom, it appeared as the single stem of the flower had been rolled flat by the hay-cut, and avoiding being cut, springing back up after. It was taller than the surrounding cut vegetation. There were few plants left in flower, in these quadrats, the only other blossom left was, 1 individual flower head of *T.pratense*.

# 5.0 Discussion

## 5.1 How does the grassland management technique effect the floristic composition seen?

At all sites receiving grazing management, the average sward height of grass was associated with the floral diversity, (see Figure 4.1.i): lower sward heights saw lower floral diversity. This wasn't seen with hay-cut management of LaM. Grazed grassland sward height has the potential for increased vertical, structural complexity with increased length of grass, up to an unknown limit before smothering flowers. Field observations (See Figure 5.1.1) have led the author to want to consider and measure the heights of the flowers for future work.

Figure 5.1. 1 *C.palustre* a tall forage plant for pollinators.

KFG data (Appendix 9) demonstrates more diversity seen in Figure 8.9.3, than 8.9.1 & 8.9.2, this site is 8-weeks post-graze. Suggesting increased diversity after management. There is no accompanying dataset before this grazing occurred.

NG was at point-of-graze (cattle in for less than 24 hours), when the 'after' FIT quadrats occurred: therefore, it isn't representative of a landscape altered by cattle grazing. The only increase in flora was in *C.palustre* (See Figure 4.2.v), due to growth over the 3 weeks between surveys. The floral availability of *L.corniculatus* and *P.erecta* remained the same pre- and post-graze.

Data from YCl also doesn't provide a before and after management dataset, as the weather meant that the pre-graze sampling had to occur again.

There were 7 flowering species present in the flora quadrats in Cl (Figure 4.2.vii), 2-weeks post-graze, this increased to 11 species, 8-weeks post grazing. Coverage also increased between the first and second survey, for example *C.palustre* averaged a Domin score of 0.8 at 2-weeks post-graze, >3 at 8-weeks post-graze. *L.corniculatus* blossom coverage increased from 0.5 to 2.4.

LoM floral availability (Figure 4.2.viii): of the species in flower only 4 species seen on the 8-weeks post survey were present in the initial, 6-week-post survey. 5 were no longer in flower or not present at this site (these are small areas of blossom abundance counts). *C.nigra* was the most abundant plant in the initial survey, this reduced by the time of the second surveys. Successional recovery from a pulse graze, might be a controlling factor here. As is seasonality: the influence of the seasonal cycle on the flora present.

LaM hay-cut had a drastic effect on the blossom present. Pre-hay-cut there where 8 species present, some abundant, such as *C.nigra* (4-25% coverage). In the centre of the field, post-hay-cut there were only, 2 flower heads of *T.pratense and H.radicata.* 3 inflorescence species were left in the margins: the most abundant was *L.corniculatus,* which only had 'several individuals'. There was no *C.nigra* recorded in either the margin or central areas – this could be to do with phenology too, the plant was naturally 'going over'.

## 5.2 What are the relationships between pollinator assemblage and the grassland management techniques?

Pollinator count transects - These are a reference from a point in time, rather than the planned for before and after grazing. Unfortunately, LaM transects occurred after the hay-cut had occurred: almost certainly effecting the pollinator assemblage.

Lepidoptera rarely interacted and foraged within any of the fields (under both management), possibly due to foodplant choices, not being available, at FIT count sites.

LoMs pollinator activity counts (See Figure 4.2.iii) took place on 2 different temperature days: the 6-week post-graze count was 27°C, the 8-weeks post-graze counts took place on a 19°C day. The decrease from 72 pollinators foraging to 16 may be attributable to this as it may link with the temperature, and energy expenditure; as it is known to effect pollinators (such as Hymenoptera-Bombus) forage (Goulson, 2012).

The increase seen in Figure 4.2.iv, 7 pollinators flying through, pre-graze, rising to 39 pollinators flying through NG at point-of-graze, might be down to avoidance of the livestock. This author and Sjodin (2007) noted the same personal observation: cattle altered the foraging behaviour of some pollinators. When cattle encroached, Hymenoptera stopped feeding and removed themselves from the site.

A)  B) 

Figure 5.2. 1 Observations of the effect of grazing cattle A) After 1 week grazing: trampling, concentrating under trees, concentrating areas of dung, B) At Point-of-graze, dung immediately attracting Diptera.

Cl saw an increase in flora abundance but not diversity, coincided with an increase in different taxa. A marked increase in the number of interactions by all pollinators, especially by Hymenoptera. They were not present in first survey (2-weeks-post), and interacted with 5 different species blossom, at 8-weeks post-graze.

The initial survey on Cl, at 2-weeks post-graze was dominated by Diptera, this could be a residual effect of the elevated levels of dung present from when the cattle where on site or localised water sources (See Figure 5.2.1 & 5.2.2). The extent of a localised feature such as this, on the geographic distribution and pollinator assemblages, remains unknown. Weiner et al. (2014) noted that 'Dipteran pollinators showed the lowest specialisation for plant species, whereas bees, other hymenopterans, butterflies, and beetles were more specialized'. This could explain their presence at all sites, at a variety of different floral species.

Figure 5.2. 2 Naturally occurring water sources in Cl.

According to Kent Wildlife Trust (2021) 'cattle do not graze selectively', aiding the creation of a florally diverse area; they leave tussocks (beneficial to invertebrates and small mammals') and can eat coarse and dead vegetation. However, the author noted that the cattle in LoM preferred eating the flowering heads of the *C.nigra*, rather than eating the whole plant or surrounding vegetation (on site reccy, not survey). On visitation after 6-weeks the *C.nigra* had grown back even more profusely, and had recovered, if not improved, abundance over the whole field block. This early graze left enough time for this flower species to regenerate and recover within the summer period. The recovery of each plant after grazing, to get back to the in-blossom stage would potentially interfere with the specialist choices of pollinators. Quick to recover ephemeral species might become the only forage species available in the field: the pollinator would either need to travel further afield or utilise what is available.

Livestock's presence might have a knock on effect too: if their presence is 'enhancing the dominance of less efficient pollinator species', such as Diptera, the pollination success of the flora might become compromised, if grazing was for prolonged periods of time, setting less seed (Tadey, 2015).

After the Hay-cut the pollinator assemblage deteriorated (in abundance of each taxa), as there where very few plants to interact with; 34 interactions from Hymenoptera in the pre-cut surveys, dropped to 1 interaction, in both margins and central hay-cut area.

## 5.3 Do pollinators show decreased specialisation associated with lower floral diversity?

In NG (See Figure 4.2.v) the availability of *C.palustre* rose from Domin 3 to 5; with this the associated interactions rose from 7 Hymenoptera to 16 interactions (all taxa). If anything at this site, the pollinator assemblage concentrated on the *C.palustre.*

The floral diversity and abundance increased at Cl. The flora the Diptera used went from 3 species to 8. Coleoptera increased from 1 species to 2. And Hymenoptera increased from 0 floral interactions to 5 with different plant species. *L.corniculatus* blossom coverage increased from 0.5 to 2.4; in the first survey at 2-week post-graze, it was not utilised by any pollinators, at 8-weeks post-graze, Hymenoptera and Diptera species utilised it. 2-weeks post-graze, Diptera were split over *R.acris* (1 interaction), *P.erecta* (1) and *P.saxifraga* (3); these weren't utilised by any pollinators, 8-weeks post-graze. Diptera interactions were concentrated on *L.vulgare* and *C.tectorum.* Neither had been present in the earlier survey, suggesting that they preferentially feed on these, but are generalists. Hymenoptera had no interactions with the first 3 quadrats sampled on the first visit, 2-weeks post-graze; these increase in the 8-weeks post data: concentrating on *C.palustre* (11) and *C.nigra* (4).

The hay-cut in LaM was detrimental to the floral abundance and diversity: Pre-cut, there were 7 species recorded in blossom, to 3 species in margins and 2 species in the centre (each of a single flowerhead). The reduction in floral abundance, also coincides with a reduction of pollinator interactions, from 64 (pre) to 5, a drastic reduction in utilisation by Hymenoptera and Diptera. *C.nigra,* pre-hay-cut had 48 interactions, none of this present to interact with post-hay-cut.

After the hay-cut, Hymenoptera and Syrphidae were visibly attracted to the recorder and 'yellow' colouring on the recorders bag, this had not occurred in other fields where flora in bloom remained.

There is more work on this dataset to be able to answer this research question.

A)

B)

Figure 5.3. 1 Hay-cut LaM – removing all flowering plants sooner than anticipated. A) Annual hay-cut occurred, B) LaM after hay-cut.

# 6.0 Conclusion

The study remains incomplete and unable to conclude statistically. Data collection for this study was severely hampered and cut short by the UK weather and the time available, as well as the scope and size of the projects ambition. The author was unable to gain access to the grazing records, that would have enabled a quantitative approach to grazing pressure.

Although seen as negative quality indicator, *C.palustre*, remained popular with the pollinators. The utilisation of this flora over other floral resources demonstrates that it provides a vital resource for the invertebrate population and should be managed to provide forage and if management is required – don't remove it all and remove only before going to seed, not early in the season. *C.palustre* and *C.nigra* remained a preferential choice for pollinators to forage on.

The benefits of the cattle for grazing, and creating a heterogeneous landscape remain, though a few down sides accompany utilising cattle. Including concentrated nutrient inputs at areas of congregation, such as figure 5.2.1, trampling of plants (removing the structural integrity needed for flora for pollinators) and localised interest from Diptera pollinators to dung, as well as 'scaring off' Hymenoptera.

Hay-cuts of these grasslands (Figure 5.3.1), may benefit from further survey at this site. Along with other fields that this project hasn't surveyed, that also receive a hay-cut. Johansen et al. (2019) noted that late-mown meadows are the main pollen source in July, early mown meadows provide forage in August to the end of the season. For pollinator conservation, it is suggested that hay-cut timings are varied between neighbouring fields, to ensure season long forage, and not remove all forage at one time. Which may not recover to provide forage within the same season and 'may lead to shortage of flower resources late in the summer' (Johansen et al., 2019). Margins are beneficial to leave long, but should be varied in size, enabling the whole margin to not sit in shade from the hedgerow, which will not benefit pollinators.

The study of KM demonstrates the drastic effect that hay-cut management has on pollinator abundance and biodiversity. The general positive outcome for flora, of letting grasslands get long, to increase the structural diversity of the plant community: balanced with not getting overgrown. As improved monitoring of pollinators remains critical it is suggested that methods that do not rely on humans accessing the site might be the way forward: no human interference and no reliance on weather. Possible applications for future pollinator survey and monitoring (Also consider Appendix 10), includes automatic devices as 'POLY', See Appendix 11. This might provide invaluable data that can be utilised to reliably conclude this study.

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# 8.0 Appendix

## 8.1 Appendix 1


Figure 8.1. 1 Demonstrating random plot sampling through QGIS, assigned in Polygons: not final sampling points used.

## 8.2 Appendix 2

Table 8.2. 1 FIT and floral quadrat survey - environmental data. Successful completed surveys included, data interrupted by rain, not included. Environmental data not collected in this format for KFG quadrats.

| Date | Time at start of FIT | Weather | Field Block? | Sample number | Grid Ref | Temp (Degrees C) | Grass management stage at that time | Notes |
|---|---|---|---|---|---|---|---|---|
| 09/07/2021 | 12:17 | Muggy/overcast/hot | New Grafs | 1A | SY54907 99108 | 21 | Not yet grazed | |
| 09/07/2021 | 12:53 | Muggy/overcast/hot | New Grafs | 2A | SY54834 99127 | 21 | Not yet grazed | |
| 09/07/2021 | 13:38 | Overcast/between showers | New Grafs | 3A | SY54799 99110 | 21 | Not yet grazed | |
| 01/08/2021 | 16:34 | Overcast, cloudy, slight breeze | New Grafs | 4A | SY 54876 99107 | 19 | Post graze ~ 1 week | Too cloudy/cool for inverts? |
| 01/08/2021 | 16:56 | Overcast, intermittent cloudy, warm | New Grafs | 5A | SY 54848 99034 | 19 | Post graze ~ 1 week | |
| 01/08/2021 | 17:17 | Warmer, Cloudy, sunny | New Grafs | 6A | SY 54820 99053 | 19 | Post graze ~ 1 week | |
| 09/07/2021 | 15:06 | Sunny/Overcast/slight breeze (gone by end of count) | Cowleaze | 1B | SY55126 99012 | 21 | Post Graze (2 weeks) | |
| 09/07/2021 | 15:39 | Hot/Overcast/slight breeze | Cowleaze | 2B | SY55100 99089 | 21 | Post Graze (2 weeks) | |
| 09/07/2021 | 16:07 | Overcast/warm/slight breeze | Cowleaze | 3B | SY55071 99132 | 21 | Post Graze (2 weeks) | |
| 01/08/2021 | 17:46 | Cloudy, sunny intervals, warm, slight breeze | Cowleaze | 4B | SY 55114 99101 | 19 | Post Graze (8 weeks) | |
| 01/08/2021 | 18:07 | Warm, sunny, little cloud | Cowleaze | 5B | SY 55072 99181 | 19 | Post Graze (8 weeks) | |
| 01/08/2021 | 18:29 | light Cloudy, sunny intervals, warm, slight breeze | Cowleaze | 6B | SY 55109 99149 | 19 | Post Graze (8 weeks) | |
| 09/07/2021 | 16:38 | Overcast/slight breeze | Yonder Cowleaze | 1C | SY54954 99262 | 18 | Too Cold? Breeze picked up | |
| 11/07/2021 | 12:02 | Overcast, bottom of temperature range for survey. Post rain | Yonder Cowleaze | 2C | SY 54993 99223 | 17 | Not yet grazed | |
| 11/07/2021 | 12:30 | Cold, grey/overcast, Post rain, approx 16C low temp | Yonder Cowleaze | 3C | SY 54922 99212 | 17 | Not yet grazed | Too Cold? Wet? Started light rain 5 minutes into FIT. Invertebrates present just representative of the bad weather? |
| 11/07/2021 | 12:58 | Overcast, grey, intermittent rain through day. Post rain | Yonder Cowleaze | 4C | SY 54938 99234 | 17 | Not yet grazed | This is a resample due to rain |
| 17/07/2021 | 10:20 | V. hot, sunny | Ladys Mead | 1D | SY 55212 99550 | 27 | Not yet cut | |
| 17/07/2021 | 11:51 | V. hot, sunny | Ladys Mead | 2D | SY 55300 99493 | 27 | Not yet cut | |
| 17/07/2021 | 12:19 | V. hot, sunny, slight breeze | Ladys Mead | 3D | SY 55309 99451 | 27 | Not yet cut | |
| 01/08/2021 | 12:08 | Overcast, warm, post rain, Low breeze | Ladys Mead | 4D | SY 55157 99603 | 19 | Point of hay cut, Infield Margin (in long grasses) | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 01/08/2021 | 12:31 | Overcast, warm, threatening to rain, Low breeze | Ladys Mead | 5D | SY 55135 99596 | 19 | Point of hay cut, Infield Margin (in long grasses) | |
| 01/08/2021 | 14:10 | Overcast, warm, post downpour | Ladys Mead | 6D | SY 55131 99567 | 19 | Point of hay cut, Infield Margin (in long grasses) | |
| 01/08/2021 | 11:47 | Overcast, warm, post rain, Low breeze | Ladys Mead | 7D | SY 55142 99544 | 19 | Point of hay cut, in central field (cut) | |
| 01/08/2021 | 14:36 | Overcast, warm, post rain, Low breeze | Ladys Mead | 8D | SY 55310 99456 | 19 | Point of hay cut, in central field (cut) | |
| 01/08/2021 | 14:53 | Overcast, warm, Low breeze | Ladys Mead | 9D | SY 55310 99456 | 19 | Point of hay cut, in central field (cut) | |
| 17/07/2021 | 14:57 | V. hot, sunny, no cloud cover, slight breeze | Lords Mead | 1E | SY 55210 99312 | 27 | Post Graze (6 weeks) | |
| 17/07/2021 | 15:56 | V. hot, sunny, no cloud cover, slight breeze | Lords Mead | 2E | SY 55153 99359 | 27 | Post Graze (6 weeks) | Shorter Sward overall |
| 17/07/2021 | 17:22 | V. hot, sunny, no cloud cover, slight breeze | Lords Mead | 3E | SY 55239 99373 | 27 | Post Graze (6 weeks) | |
| 01/08/2021 | 15:18 | Overcast, warm, Slight Breeze | Lords Mead | 4E | SY 55123 99509 | 19 | Post Graze (8 Weeks) | Too cool/breezy for Butterflies? |
| 01/08/2021 | 15:40 | Overcast, warm, Slight Breeze | Lords Mead | 5E | SY 55150 99469 | 19 | Post Graze (8 Weeks) | |
| 01/08/2021 | 15:59 | Overcast, warm, Slight Breeze | Lords Mead | 6E | SY 55182 99457 | 19 | Post Graze (8 Weeks) | |

## 8.3 Appendix 3

Table 8.3. 1 Transect survey – Background data.

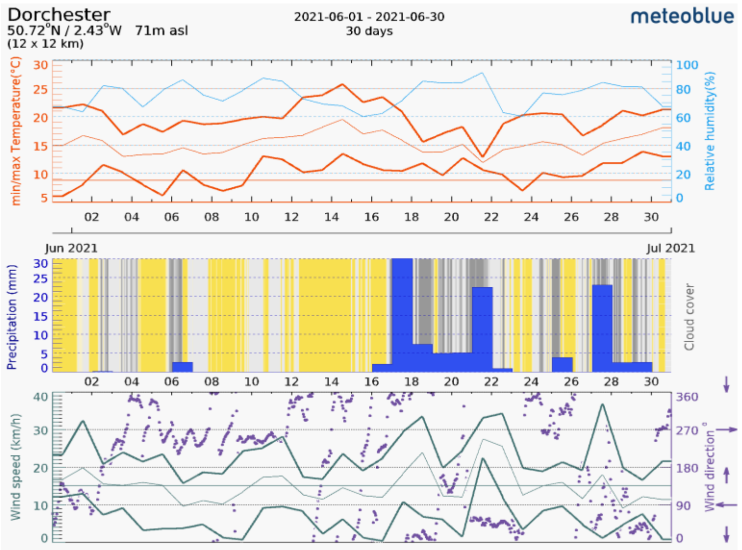
| Date | Time at start of Transect | Weather | Field Block? | Transect number (Field letter, 'T' numbered) | Grid Refs (start to finish) | Direction of Transect | Total Area (Length (m) by 3m wide) | Current Management |
|---|---|---|---|---|---|---|---|---|
| 18/07/2021 | 11:36 | v. hot, slight breeze (moderate) | Yonder Cowleaze | CT1 | SY 55017 99291 to SY54956 99239 to SY 54957 99321 | SW to begin with then NNE | 1017 | Point of Graze (cattle in for <48hrs) |
| 18/07/2021 | 16:23 | V.hot, sunny, tiny breeze | Yonder Cowleaze | CT2 | SY 55025 99273 to 4 more points (see view ranger app) | SW & NW & N & NE | 1017 | Point of Graze (cattle in for <48hrs) |
| 18/07/2021 | 12:12 | v. hot, slight breeze, V sunny | Cowleaze | BT1 | SY 55078 99208 to SY 55120 98994 to SY 55151 99109 | SE to begin with then NE | 1011 | Post Graze (8 weeks) |
| 18/07/2021 | 16:11 | v. hot, sunny, slight breeze | Cowleaze | BT2 | SY 55190 99113 to 2 more points (see view ranger app) | SW & N | 1011 | Post Graze (8 weeks) |
| 18/07/2021 | 13:10 | V.hot, sunny, tiny breeze | Ladys Mead | DT1 | SY 55124 99575 to SY 55421 99424 | SE | 999 | Post cut (hay cut within last 24hrs) |
| 18/07/2021 | 13:20 | V.hot, sunny, tiny breeze | Ladys Mead | DT2 | SY 55410 99379 to SY 55195 99582 to SY 55202 99545 | NW & S | 999 | Post cut (hay cut within last 24hrs) |
| 18/07/2021 | 16:30 | V.hot, sunny, tiny breeze | New Grafs | AT1 | SY 54856 99151 to SY 54764 99145 to SY 54891 99070 | W & SE & SW | 999 | Point of Graze (cattle in for <48hrs) |
| 18/07/2021 | 16:59 | V.hot, sunny, tiny breeze | New Grafs | AT2 | SY 54800 99176 to SY 54769 99022 to SY 54924 99107 | S & NE | 1008 | Point of Graze (cattle in for <48hrs) |
| 18/07/2021 | 12:44 | V.hot, sunny, slight breeze | Lords Mead | ET1 | SY 55041 99392 to SY 55268 99352 to SY 55205 99434 | SE & NW | 999 | Post Graze (6 weeks) |
| 18/07/2021 | 12:56 | V.hot, sunny, slight breeze | Lords Mead | ET2 | SY 55101 99515 to SY 55207 99304 to SY 55286 99365 | SE & NE | 1005 | Post Graze (6 weeks) |

## 8.4 Appendix 4

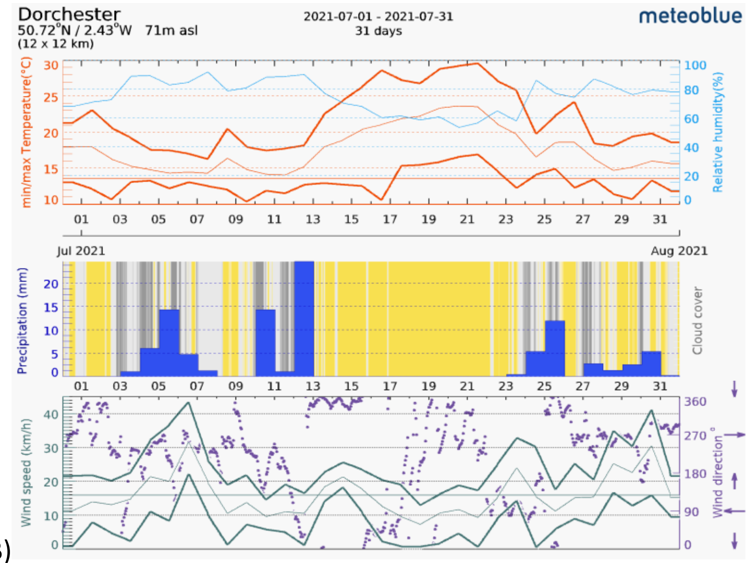
Table 8.4. 1 Transect survey – Pollinator data, counts grouped into Orders, where Identification was not possible.

| **Common name or notes on ID** | **Tally** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **CT1** | **CT2** | **AT1** | **AT2** | **BT1** | **BT2** | **DT1** | **DT2** | **ET1** | **ET2** |
| | **Yonder Cowleaze, Point of Graze** | **Yonder Cowleaze, Point of Graze** | **New Grafs, Point of Graze** | **New Grafs, Point of Graze** | **Cowleaze, 8 weeks Post Graze** | **Cowleaze, 8 weeks Post Graze** | **Ladys Mead, Point of Hay Cut** | **Ladys Mead, Point of Hay Cut** | **Lords Mead, 6 weeks Post Graze** | **Lords Mead, 6 weeks Post Graze** |
| Hymenoptera - Bombus | 15 | 16 | 11 | 6 | 2 | 5 | 4 | 3 | 6 | 4 |
| Hymenoptera - Apis | 4 | | 1 | 1 | 1 | | | 1 | 5 | 2 |
| Hymenoptera | 1 | 3 | | 1 | | 1 | | | 1 | 2 |
| Hymenoptera - Vespidae | | | | | | | | | | |
| Diptera - Syrphidae | 6 | 8 | 1 | 1 | 20 | 4 | | | 7 | 1 |
| Diptera | 11 | 36 | 6 | 15 | 25 | 13 | 13 | 10 | 12 | 14 |
| Coleoptera - Cantharidae | | 2 | 1 | 2 | 8 | 4 | | | | |
| Small insects (<3mm) | 25 | | 8 | | | | | | | |
| Odonata - Zygoptera | 2 | 3 | | | | 2 | | 1 | 8 | 2 |
| Coleoptera - Coccinellidae | | | 1 | | 3 | | | | 1 | |
| Lepidoptera | 113 | 81 | 34 | 29 | 52 | 49 | 19 | 20 | 74 | 53 |
| Diptera - Bombyliidae | | 1 | | | | | | | | |
| Diptera - Asilidae | | | | | | | | | 1 | |
| **TOTAL COUNTS** | **177** | **149** | **63** | **55** | **111** | **78** | **36** | **35** | **114** | **78** |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Unknown butterflies and moths | | 1 | 2 | 2 | 1 | 3 | | | 5 | |
| Lepidoptera - *Melanargia galathea* | 16 | 12 | 4 | | 4 | 4 | 3 | 1 | 5 | 4 |
| Lepidoptera - *Thymelicus sylvestris* | 19 | 6 | 5 | 3 | 5 | 6 | | | 6 | 2 |
| Lepidoptera - *Maniola jurtina* | 66 | 61 | 21 | 23 | 41 | 35 | 15 | 19 | 56 | 46 |
| Lepidoptera - *Zygaena* | 4 | 1 | 1 | | | | | | | |
| Lepidoptera - *Aphantopus hyperantus* | 7 | | 1 | 1 | | | | | 1 | |
| Lepidoptera - Pieridae | 1 | | | | 1 | 1 | 1 | | 1 | 1 |
| | | | | | | | | | | |
| **Totalled for Butterflies & Moths** | **113** | **81** | **34** | **29** | **52** | **49** | **19** | **20** | **74** | **53** |

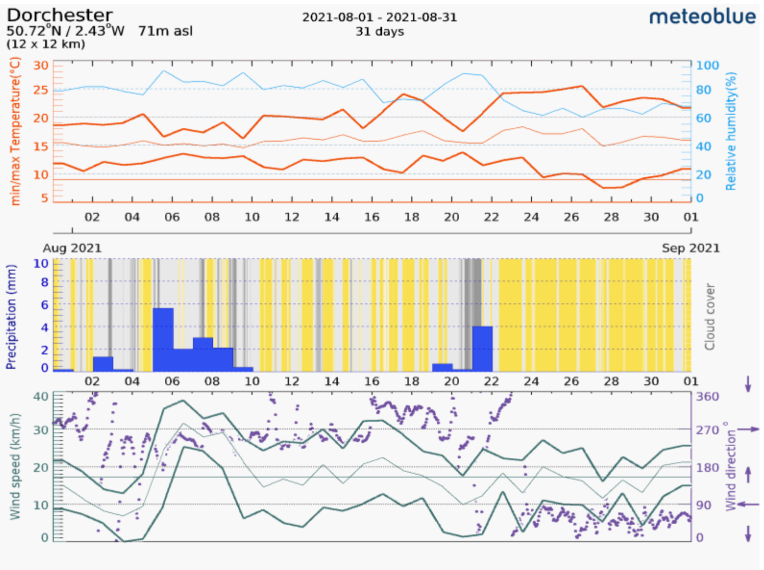
## 8.5 Appendix 5



A)



B)



C)

Figure 8.5 1 Climatic conditions, 2021, Dorchester, Dorset. A) June B) July C) August (Meteoblue, 2021).

## 8.6 Appendix 6

| | | | |
|---|---|---|---|
| Site Name: | *Kingcombe NNR* | Date: | / / |
| Field/Down Name:<br>*(tick 1)*<br>*Refer to site map; if needed.*<br><br>○ *New Grafs*<br>○ *Cowleaze*<br>○ *Yonder Cowleaze*<br>○ *Lords Mead*<br>○ *Ladys Mead* | Quadrat Size and frequency:<br>Number: *10*<br>Size: *0.5x0.5m*<br>Weather:<br><br>Temperature:<br><br>Only count flowering blossom percentage | | |
| Grid reference: | | | |
| Surveyor(s) name(s): | | | |
| Current Management: | | Other notes: | |

| Cover (%) | Domin value |
|---|---|
| 91–100% | 10 |
| 76–90% | 9 |
| 51–75% | 8 |
| 34–50% | 7 |
| 26–33% | 6 |
| 11–25% | 5 |
| 4–10% | 4 |
| <4% (many individuals) | 3 |
| <4% (several individuals) | 2 |
| <4% (few individuals) | 1 |
| 1-2 individuals; no measurable cover | + |

| **IN FLOWER ONLY** | **Domin value for percent in Inflorescence?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Quadrat number** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| **Percent of flower coverage for quadrat?** | | | | | | | | | | |
| **Bare ground (Domin value)** | | | | | | | | | | |
| **Sward Height (cm) (average from 5 measures)** | | | | | | | | | | |
| Autumn Hawkbit (*Leontodon autumnalis*) | | | | | | | | | | |
| Betony (*Stachys officinalis*) | | | | | | | | | | |
| Bird's-foot Trefoil (Lotus corniculatus) | | | | | | | | | | |
| Bitter Vetch *(Lathyrus linifolius)* | | | | | | | | | | |
| Black Knapweed (*Centaurea nigra*) | | | | | | | | | | |
| Bryophyte spp. | | | | | | | | | | |
| Bugle (*Ajuga reptans)* | | | | | | | | | | |
| Burnet Saxifrage (Pimpinella saxifraga) | | | | | | | | | | |
| Common Bird's-foot Trefoil (*L. corniculatus*) | | | | | | | | | | |
| Common Cat's Ear (*Hypochaeris radicata*) | | | | | | | | | | |
| Common Knapweed (Centaurea nigra) | | | | | | | | | | |
| Common Marsh-bedstraw *(Galium palustre)* | | | | | | | | | | |
| Common Mouse-ear (*Cerastium fontanum*) | | | | | | | | | | |
| Common Sorrel (*Rumex acetosella)* | | | | | | | | | | |
| Common Spotted Orchid (*Dactylorhiza fuchsii*) | | | | | | | | | | |
| Corky-fruited Water-dropwort (*Oenanthe pimp*) | | | | | | | | | | |
| Cowslip (*Primula veris*) | | | | | | | | | | |
| Creeping Buttercup (*Ranunculus repens*) | | | | | | | | | | |
| Dandelion (*Taraxacum officinalis*) | | | | | | | | | | |
| Devil's-bit Scabious (*Succisa pratensis*) | | | | | | | | | | |
| Dyer's Greenweed (Genista tinctoria) | | | | | | | | | | |
| Great Bird's-foot Trefoil (*Lotus pedunculatus*) | | | | | | | | | | |
| Heath Speedwell *(Veronica officinalis)* | | | | | | | | | | |
| Hogweed (*Heracleum sphondylium*) | | | | | | | | | | |
| Lady's Bedstraw *(Galium verum)* | | | | | | | | | | |
| Lesser Hawkbit (*Leontodon saxatilis*) | | | | | | | | | | |
| Lesser Spearwort (*Ranunculus flammula*) | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|
| Lesser Stitchwort (*Stellaria graminea*) | | | | | | | | | | |
| Lesser Trefoil (*Trifolium dubium)* | | | | | | | | | | |
| Meadow Buttercup (*R. acris*) | | | | | | | | | | |
| Meadow saxifrage *(Saxifraga granulata)* | | | | | | | | | | |
| Meadow Vetchling (*Lathyrus pratensis*) | | | | | | | | | | |
| Oxeye Daisy (*Leucanthemum vulgare*) | | | | | | | | | | |
| Pepper-saxifrage (*Silaum silaus*) | | | | | | | | | | |
| Pignut *(Conopodium majus)* | | | | | | | | | | |
| Ragged Robin (*Lychnis flos-cuculi*) | | | | | | | | | | |
| Red Clover (*Trifolium pratense*) | | | | | | | | | | |
| Ribwort Plantain (*Plantago lanceolata*) | | | | | | | | | | |
| Rough Hawkbit (*Leontodon hispidus*) | | | | | | | | | | |
| Saw Wort *(Serratula tinctoria)* | | | | | | | | | | |
| Selfheal (*Prunella vulgaris*) | | | | | | | | | | |
| Tormentil *(Potentilla erecta*) | | | | | | | | | | |
| White Clover (*Trifolium repens*) | | | | | | | | | | |
| Wood Anemone (Anemone nemorosa) | | | | | | | | | | |
| Yarrow (*Achillea millefolium*) | | | | | | | | | | |
| Yellow Rattle (*Rhinanthus minor*) | | | | | | | | | | |
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| Notes: |
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Print double sided. One sheet is to be filled out per field block. Quadrats have been randomly sampled, for location grid reference see GIS grid ref's. Take survey protocol description and map, into field for data collection reference. All original data sheets to be returned to Colleen Smith-Moore, C/O Dorset Wildlife Trust, Brooklands Farm, Forston, Dorchester, DT2 7AA.

Figure 8.6. 1 Data Collection Sheet for Flora Quadrats.

## 8.7 Appendix 7

| Site Name: | *Kingcombe NNR* | Date: | / / |
|---|---|---|---|
| Field/Down Name:*(tick 1)*<br>*Refer to site map; if needed.*<br>○ *New Grafs*<br>○ *Cowleaze*<br>○ *Yonder Cowleaze*<br>○ *Lords Mead*<br>○ *Ladys Mead* | Quadrat Size and frequency: 3 per field<br>Number:<br>Size: *1x1m*<br>Length of sit: 15 minutes | Time:<br><br>Weather:<br><br>Temp:<br>Notes: | |
| Grid Ref: | | | |
| Surveyor(s) name(s): | | | |
| Current Management: | | Other notes: | |

| **List species seen**<br>*(Include pollinators in flight, note behaviour)* | **Number of stops on flowers?**<br>**Flower species** | **Tally of stops** | **Time spent on that flower?**<br>*Put comma between times, if they repeatedly visited* |
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Print double sided. One sheet is to be filled out per field block. Quadrats have been randomly sampled, for location grid reference see GIS. Take survey protocol description and map, into field for data collection reference. All original data sheets to be returned to Colleen Smith-Moore, C/O Dorset Wildlife Trust, Brooklands Farm, Forston, Dorchester, DT2 7AA.

Figure 8.7. 1 Data Collection Sheet for FIT Counts.

## 8.8 Appendix 8

| Site Name: | *Kingcombe NNR* | Date: | / / |
|---|---|---|---|
| Field/Down Name:*(tick 1)*<br>*Refer to site map; if needed.*<br>○ *New Grafs*<br>○ *Cowleaze*<br>○ *Yonder Cowleaze*<br>○ *Lords Mead*<br>○ *Ladys Mead* | Quadrat Size and frequency:<br>Number: *2*<br>Size: *3x333m* | Grid Ref and direction of travel (*Take at each turn around point too):* | |
| Surveyor(s) name(s): | | | |
| Current Management: | | Other notes: | |

| **List species seen as invertebrate transects (Pollinators in flight)** | **Transect number and Tally** | |
|---|---|---|
| | **1** | **2** |
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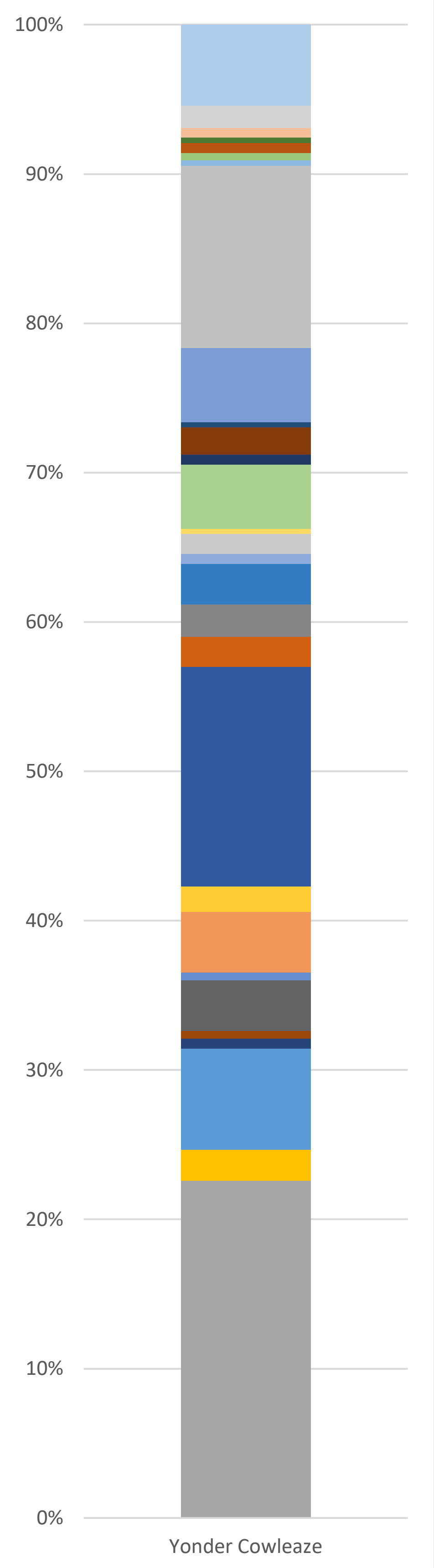
Print double sided. One sheet is to be filled out per field block. Take survey protocol description and map, into field for data collection reference. All original data sheets to be returned to Colleen Smith-Moore, C/O Dorset Wildlife Trust, Brooklands Farm, Forston, Dorchester, DT2 7AA.

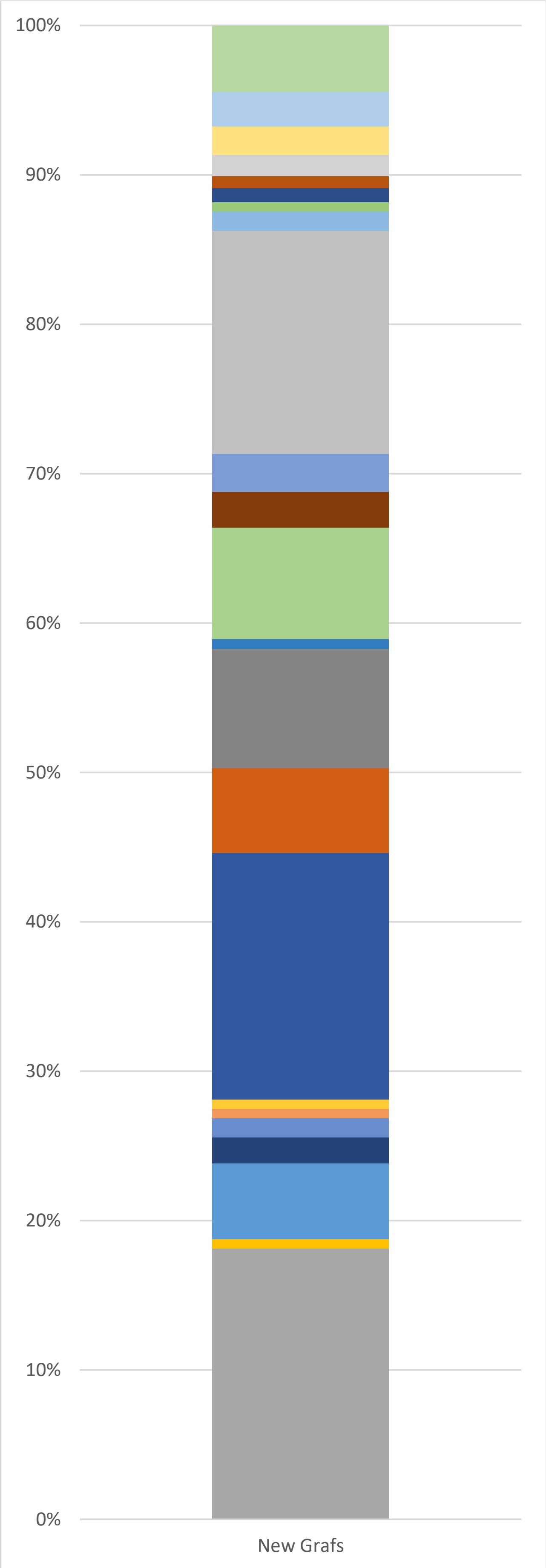
Figure 8.8. 1 Data Collection Sheet for Pollinator Transects.

## 8.9 Appendix 9



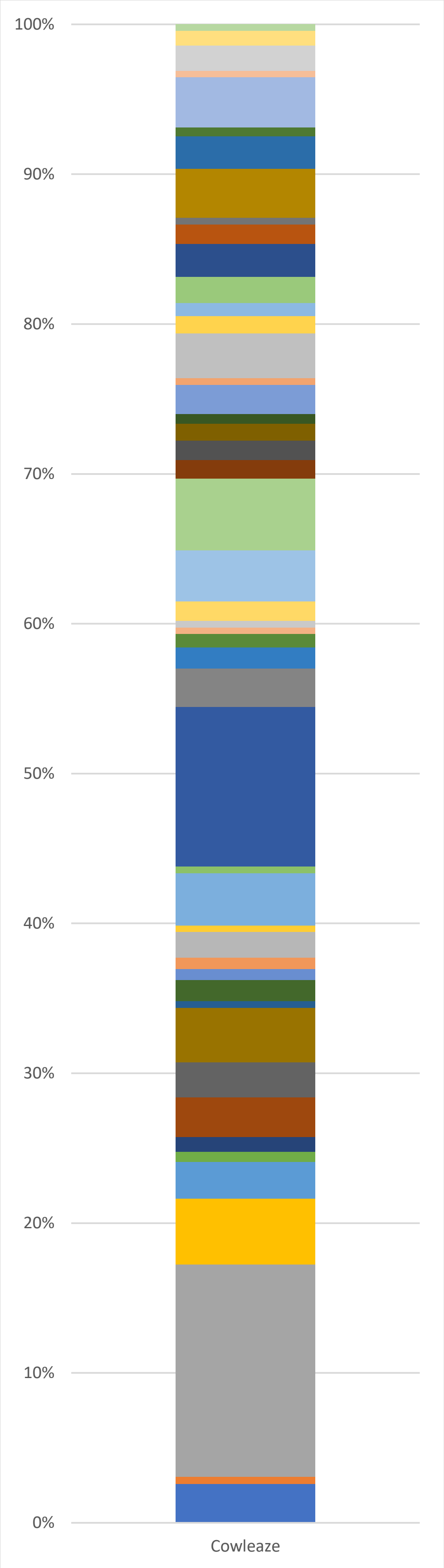

| | Yonder Cowleaze |
|---|---|
| Potentilla anglica | |
| Viola riviniana | |
| Veronica officinalis | 8.00 |
| Trifolium repens | |
| Trifolium pratense | 2.17 |
| Taraxacum agg | 1.00 |
| Succisa pratensis | |
| Stellaria graminea | 0.50 |
| Stachys officinalis | |
| Serratula tinctoria | |
| Scorzoneroides autumnalis | |
| Rumex acetosa | 1.00 |
| Ranunculus repens | |
| Ranunculus acris | 0.75 |
| Prunella vulgaris | 0.50 |
| Potentilla reptans | |
| Potentilla erecta | 18.00 |
| Poa pratensis | |
| Plantago lanceolata | 7.33 |
| Phleum pratense | |
| Pedicularis sylvatica | 0.50 |
| Oenanthe pimpinelloides | |
| Molinia caerulea | |
| Luzula campestris | 2.67 |
| Lotus pedunculatus | 1.00 |
| Lotus corniculatus | 6.33 |
| Lolium perenne | |
| Leucanthum vulgare | 0.50 |
| Leontodon hispidus | 2.00 |
| Juncus inflexus | |
| Juncus conglomeratus | 1.00 |
| Juncus acutiflorus | |
| Hypochaeris radicata | 4.00 |
| Hypericum pulchrum | |
| Holcus lanatus | 3.17 |
| Galium saxatile | 3.00 |
| Festuca rubra | 21.67 |
| Festuca arundinacea | |
| Deschampsia cespitosa | |
| Danthonia decumbens | 2.50 |
| Dactylis glomerata | |
| Cynosaurus cristatus | 6.00 |
| Cirsium palustre | 0.75 |
| Cirsium arvense | |
| Cerastium fontanum | |
| Centaurea nigra | |
| Carex hirta | 5.00 |
| Carex flacca | 0.75 |
| Carex caryophyllea | 1.00 |
| Briza media | |
| Anthoxanthum odoratum | 10.00 |
| Ajuga reptans | 3.00 |

Figure 8.9. 1 The average floral composition of YCl. Graph demonstrates assemblage as a composition of 100%. Percent value on table averaged from 3 samples recorded on the 25/6/21, by 1x1m$^2$ quadrats . Sampling by KFG. Pre grazing.




| | |
|---|---|
| Potentilla anglica | |
| Viola riviniana | 7.00 |
| Veronica officinalis | 3.67 |
| Trifolium repens | 3.00 |
| Trifolium pratense | 2.25 |
| Taraxacum agg | |
| Succisa pratensis | |
| Stellaria graminea | |
| Stachys officinalis | |
| Serratula tinctoria | |
| Scorzoneroides autumnalis | |
| Rumex acetosa | 1.25 |
| Ranunculus repens | 1.50 |
| Ranunculus acris | 1.00 |
| Prunella vulgaris | 2.00 |
| Potentilla reptans | |
| Potentilla erecta | 23.60 |
| Poa pratensis | |
| Plantago lanceolata | 4.00 |
| Phleum pratense | |
| Pedicularis sylvatica | |
| Oenanthe pimpinelloides | |
| Molinia caerulea | |
| Luzula campestris | 3.75 |
| Lotus pedunculatus | |
| Lotus corniculatus | 11.80 |
| Lolium perenne | |
| Leucanthum vulgare | |
| Leontodon hispidus | |
| Juncus inflexus | |
| Juncus conglomeratus | |
| Juncus acutiflorus | |
| Hypochaeris radicata | 1.00 |
| Hypericum pulchrum | |
| Holcus lanatus | 12.60 |
| Galium saxatile | 9.00 |
| Festuca rubra | 26.00 |
| Festuca arundinacea | |
| Deschampsia cespitosa | |
| Danthonia decumbens | 1.00 |
| Dactylis glomerata | |
| Cynosaurus cristatus | 1.00 |
| Cirsium palustre | 2.00 |
| Cirsium arvense | |
| Cerastium fontanum | |
| Centaurea nigra | |
| Carex hirta | |
| Carex flacca | |
| Carex caryophyllea | 2.75 |
| Briza media | |
| Anthoxanthum odoratum | 8.00 |
| Ajuga reptans | 1.00 |
| Agrostis capillaris | 28.60 |
| Agrimonia eupatoria | |
| Achillea millefolium | |

Figure 8.9. 2 The average floral composition of NG. Graph demonstrates assemblage as a composition of 100%. Percent value on table averaged from 8 samples recorded on 25/06/21 and 09/07/2021, 1x1m$^2$ quadrats. Sampling by KFG. Both dates are pre grazing in this block.




| | |
|---|---|
| Potentilla anglica | |
| Viola riviniana | 1.00 |
| Veronica officinalis | |
| Trifolium repens | 2.25 |
| Trifolium pratense | 3.80 |
| Taraxacum agg | 1.00 |
| Succisa pratensis | 7.67 |
| Stellaria graminea | 1.33 |
| Stachys officinalis | 5.00 |
| Serratula tinctoria | 7.50 |
| Scorzoneroides autumnalis | 1.00 |
| Rumex acetosa | 3.00 |
| Ranunculus repens | 5.00 |
| Ranunculus acris | 4.00 |
| Prunella vulgaris | 2.00 |
| Potentilla reptans | 2.60 |
| Potentilla erecta | 6.86 |
| Poa pratensis | 1.00 |
| Plantago lanceolata | 4.50 |
| Phleum pratense | 1.50 |
| Pedicularis sylvatica | |
| Oenanthe pimpinelloides | 2.50 |
| Molinia caerulea | 3.00 |
| Luzula campestris | 2.80 |
| Lotus pedunculatus | |
| Lotus corniculatus | 11.00 |
| Lolium perenne | 7.80 |
| Leucanthum vulgare | 3.00 |
| Leontodon hispidus | 1.00 |
| Juncus inflexus | 1.00 |
| Juncus conglomeratus | |
| Juncus acutiflorus | 2.00 |
| Hypochaeris radicata | 3.25 |
| Hypericum pulchrum | |
| Holcus lanatus | 5.86 |
| Galium saxatile | |
| Festuca rubra | 24.38 |
| Festuca arundinacea | 1.00 |
| Deschampsia cespitosa | 8.00 |
| Danthonia decumbens | 1.00 |
| Dactylis glomerata | 3.88 |
| Cynosaurus cristatus | 1.80 |
| Cirsium palustre | 1.67 |
| Cirsium arvense | 3.20 |
| Cerastium fontanum | 1.00 |
| Centaurea nigra | 8.40 |
| Carex hirta | 5.33 |
| Carex flacca | 6.00 |
| Carex caryophyllea | 2.33 |
| Briza media | 1.50 |
| Anthoxanthum odoratum | 5.63 |
| Ajuga reptans | 10.00 |
| Agrostis capillaris | 32.50 |
| Agrimonia eupatoria | 1.00 |
| Achillea millefolium | 6.00 |

Figure 8.9. 3 The average floral composition of Cl. Graph demonstrates assemblage as a composition of 100%. Percent value on table averaged from 8 sample recorded on the 30/7/21, by 1x1m$^2$ quadrats. Sampling by KFG. 8-weeks post-graze.

## 8.10 Appendix 10

Considerations and limitations within this investigation, to be considered if the survey is to be edited and reused for a longer-term project, include:

- It is not representative of the entire pollinator assemblage: Diurnal FIT counts were undertaken, omitting any night flying pollinators such as moths. Other pollinators may utilise the fields, but not fly, *i.e.,* ground dwelling insects. Very small pollinators where not sampled, such as thrips, Thysanoptera. Flower visitation is not distinguishable or suitable as a proxy to determine effective pollination (King et al., 2013).
- Weather: the time available to survey, and the accompanying weather meant that numerous survey sessions where cancelled or aborted. Limiting the time available to return to survey certain fields after management techniques had commenced.
- The hay-cut occurred a day earlier than the author anticipated. Meaning that the before transect for this field didn't commence in time. Field margins where left and the survey plan was quickly reworked to incorporate.
- Recording the behaviour of the pollinators was subjective – foraging, resting, walking: by the observer.
- Grazing data density has not been acquired in time for this project. There was no quantitative measure to the management technique to enable analysis.
- Natural phenology - Seasonal variation in the invertebrate community and floral assemblages.
- Visibility - The size of the invertebrates and the speed moving through the transects and quadrats will have influenced their detectability by the recorder.
- Human influence - The reaction of the pollinators to the recorder, in some fields, notably after grazing or near water sources (personal observation), the recorder acted as an attractant to Diptera. This might have artificially elevated results. The opposite effect may also be prevalent: certain taxa may avoid the site, due to human presence.
- Cattle were the only known grazers at 4 fields, grazers such as rabbits and deer were not included.
- Potts et al. (2003) noted that a previous season's floral abundance may directly influence the bee's abundance in the current season. The conservation management techniques (current and past), weather, and season, will control the flowers available. Thus, directly affecting the bee's success, the current generation of bees 'developed on the resources provisioned to the nest in the previous season'. The author suggests that this could potentially occur for all invertebrates that are univoltine, require provisioning and are provisioned in one season, for the following year.

## 8.11 Appendix 11

Figure 8.11. 1 ‘POLY’ an automatic in-field sensor for Pollinator surveys at Inverewe gardens, Poolewe, Wester Ross. In collaboration with National Trust for Scotland, AgriSound and Innovate UK (AgriSound, 2021).

Attached documents:

Field Journal

Primary data – “Data Digitalised Spreadsheet” (includes FIT counts, transects, flora quadrats and KFG data)