DAVIS EXPEDITION FUND

REPORT ON EXPEDITION / PROJECT

Expedition/Project Title:	Comparing the abundance and identities of wildflowers and floral visitors for frequently mowed and rarely mowed grasslands along the Cramond shoreline, Edinburgh.
Travel Dates:	14th May – 31st July
Location:	Cramond/Gypsy brae/Silverknowes foreshore
Group Members:	Isabella Cornwell and Rebecca Atkinson
Aims:	(1) To quantify the abundance and species richness of flowers in 5 replicate areas that are mowed regularly and 5 companion control sites of unimproved grassland.
	(2) To quantify the species richness and abundance of flower visiting insects visiting flowers in the mowed and control plots at three floral survey time points, and so characterising (a) changes in visitation throughout the day, (b) differences in visitation between frequently mowed and control plots, and (c) the visitors associated with each component species at each site.

Photography consent form attached: (*please refer to your award letter)*

☐ Yes
☒ No (not needed)

Outcome (a minimum of 500 words):-

Introduction

Insect pollinators, such as honeybees, hoverflies, and butterflies, are essential for maintaining biodiversity in natural and agricultural ecosystems (Klein et al., 2007). Not only do they pollinate wild plants, which are vital food resources for other wildlife, but they are essential for the pollination of food crops and horticultural plant species. The degradation and loss of key habitats for these pollinators, due to changes in land use and increased levels of intensive agriculture, has led to a depletion in floral diversity and therefore food resources (Baude et al., 2016; Carvell et al., 2006). This reduction in both quality and quantity of pollen and nectar is one of several factors contributing to the decline in pollinator numbers across Europe and North America (Goulson et al., 2015; Roulston and Goodell, 2011). These disrupted habitats include wildflower meadows and species-rich grasslands, with only 2% of meadows that existed in 1930 remaining today and almost 7.5 million acres of wildflower meadows having been lost so far. Those that have managed to survive are often highly fragmented, and therefore at risk of destruction (Magnificent Meadows, 2021).

Numerous studies assessing urban floral resources have shown that there is a positive correlation between flower and pollinator abundances (Ahrné et al., 2009; Pardee and Philpott, 2014; Gunnarsson and Federsel, 2014), suggesting that changes in land use to increase the availability of flowers in urbanised areas could help to increase pollinator numbers. The introduction of urban meadows, through a cessation of mowing or by actively planting wildflower seeds has gained recent

interest from many Scottish conservation charities, including Plantlife Scotland and the Scottish Wildlife Trust (http://www.magnificentmeadows.org.uk).

It is not known how the effects of mowing cessation, in terms of floral biodiversity, will impact the frequency and variety of pollinator visitors to these areas of land. This project aims to address this, by surveying frequently mowed and control grassland plots along the Cramond/Silverknowes/Gypsy Brae foreshore for both floral biodiversity and pollinator frequency and variety.

Background

This project has been carried out by Isabella Cornwell and Rebecca Atkinson, in association with lead PI, Professor Graham Stone, Institute of Evolutionary Biology, University of Edinburgh, and Dr Vladimir Krivtsov. Surveys have been completed at 5x frequently mowed plots and 5x unmodified, grassland control plots on the Cramond/Silverknowes/Gypsy Brae foreshore (Figure 1). This land is owned by Edinburgh City Council and all surveys have their permission, with minimal plant collection and impact on local populations. Each site has been surveyed for floral diversity and for the number and type of floral visitors/insect pollinators.

Aims

The aims of this project were:

1) To quantify the abundance and species richness of flowers in 5 replicate areas that are mowed regularly and 5 companion control sites of unimproved grassland.
2) To quantify the species richness and abundance of flower visiting insects visiting flowers in the mowed and control plots at three floral survey time points, and so characterising (a) changes in visitation throughout the day, (b) differences in visitation between frequently mowed and control plots, and (c) the visitors associated with each component species at each site.

Figure 1: *Map of Cramond/Silverknowes/Gypsy Brae foreshore*

Materials and methods

This project was carried out in groups of two people (Isabella and Rebecca), both of whom were fully involved in the surveying of flowers and insect pollinators. We were trained in the field techniques described below by Prof. Stone and Dr. Krivtsov, who joined us for some of the survey rounds.

Measuring floral abundance

The site contained 5x 200m^2 grassland plots that were mowed by Edinburgh City Council approximately every 4 weeks and 5x companion plots of unmodified, unimproved grassland as controls.

For each survey, on both control and mowed plots, 20x 1m^2 quadrats were used to sample along the plot margin at 4m intervals using a tape measure. The first quadrat at 4m along the margin extended into the plot from the margin by 1m. The second quadrat at 8m extended from 1m to 2m in from the plot margin. Edge quadrats and 1m-in quadrats were then be alternated until a total of 20 quadrats had been reached. This sampling protocol was agreed with the greenspace team of Edinburgh City Council, who manage the sites, and avoids only sampling the edge of the plots whilst minimising trampling of the interior of the plot.

Each quadrat was used to count the floral units of each plant species present, with a floral unit defined as a single flower or small collection of flowers between which a honey-bee sized insect might walk or fly between. This is classed as a capitulum for composite flowers such as Asteraceae, sub-umbels for Umbelliferae and individual flowers for other species. This is a standard approach in quantification of flowers in pollination ecology and will match the approach used in Hicks *et al.* (2016).

***Figure 2**: Photos of the survey sites (a-c) control, unmodified grassland plots (d) frequently mowed plot.*

Quantifying and identifying floral visitors

The same plots were used to survey floral visitors.

At each replicate plot, 2x 30-minute floral visitor surveys were carried out at three time points throughout the day (9am-12pm, 12pm-3pm and 3pm-6pm), where the number of visitors to a plant species within the plot was recorded. Floral visitors were identified to important general types - honeybee, bumblebee, solitary bee, hoverfly, fly (non-hoverfly), butterfly, Hemiptera, Coleoptera – including species ID whenever possible. This is the same level of ID used in previous surveys and by the citizen science component of the UK Pollinator Monitoring Scheme. The lower level of identification necessarily achieved with this approach has the benefit of avoiding any capture of insects, and any associated damage to the plots or concern from the public.

Figure 3*: Photos of some of the main pollinator species found across the plots, including (left-right) Apis mellifera, Bombus terrestris, Bombus lapidaries, pollen beetles.*

Results

Floral diversity

The control plots and the mowed plots had different floral compositions, with frequent mowing causing an increased number of fast-growing species such as *Trifolium repens*, *Bellis perenis* and *Plantago lanceolata*. Control plots had high numbers of grass, rush, and sedge species; however, these were not including in our floral unit counts as they are not insect pollinated.

Notably, the mowed plots showed significantly higher numbers of T. repens ($t(8) = 2.4056$, $p < 0.05$) compared to the control plots. The mowing of other, larger plant species and the clonal, reproductive nature of *T. repens*, likely allows it to colonise mowed areas quickly, especially compared to control plots where the larger grass species outcompete *T. repens* for light and space. The control plots showed higher numbers of *Stellaria graminea* (mean (control) = 16.4 per m^2, mean (mowed)

= 4.69), a small flowering plant that favours meadow-like habitats, compared to mowed plots. Both plots had almost equal numbers of *Ranunculus repens* overall (mean (control) = 3.74, mean (mowed) = 3.67).

Floral species diversity per m^2 varied between plots, with M1 having the highest floral species diversity for a single plot but control plots overall having a higher mean floral species diversity per m^2 compared to the mowed sites (mean (control) = 0.327, mean (mowed) = 0.288) (**Figure 4**). Our data showed no significant difference between mean species diversity at the mowed plots and at control plots. Despite this, two out of the five control plots showed a floral species diversity value of 0, suggesting diversity varies greatly depending on the plot being measured.

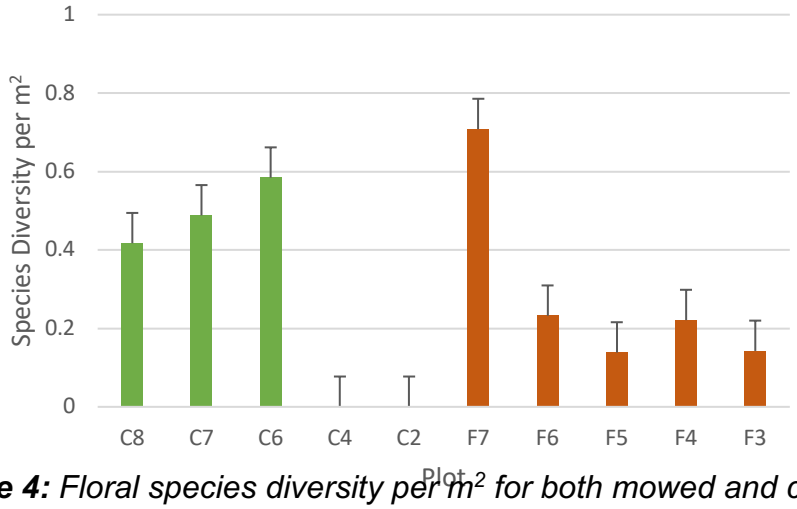

Figure 4: *Floral species diversity per m^2 for both mowed and control sites. C1-5 = Control plots; M1-5 = frequently mowed sites. Species diversity was calculated using Simpsons Diversity Index (SDI)*
Error bars represent SE.

Pollinator visits per m^2 per hour

Figure 5 shows the total mean visits per m^2 per hour for all plant species within the mowed plots (excluding *T. repens*). Notably, *Taraxacum spp.* visitation appears to change dramatically with time, as time point 1 has considerably more visits per hour than 2 or 3. *R. repens* appears to maintain a consistent level of visitation throughout the day however *Cerastium fontanum* appears to be visited more frequently in the middle of the day.

When looking more in-depth at the relationships between plant and pollinator species, this report will focus on visits to *T. repens* due to its high abundance in both control and mowed plots. Additionally, *T. repens* had the highest frequency of visits per m^2 per hour at the mowed plots, likely due to it making up a large proportion of flowers available.

Figure 6a shows pollinator visits to *T. repens* across all mowed sites at each time point, with *Bombus terrestris* having the highest mean number of visits per hour, closely followed by *A. mellifera*. *T. repens* is known to be highly popular with many

bee species as it is a good source of pollen/nectar, and its flower shape has evolved to be optimal for bee foraging ().

Figure 6b shows the difference in visitation frequency to *T. repens* across the day, with no significant difference between visits at each time point.

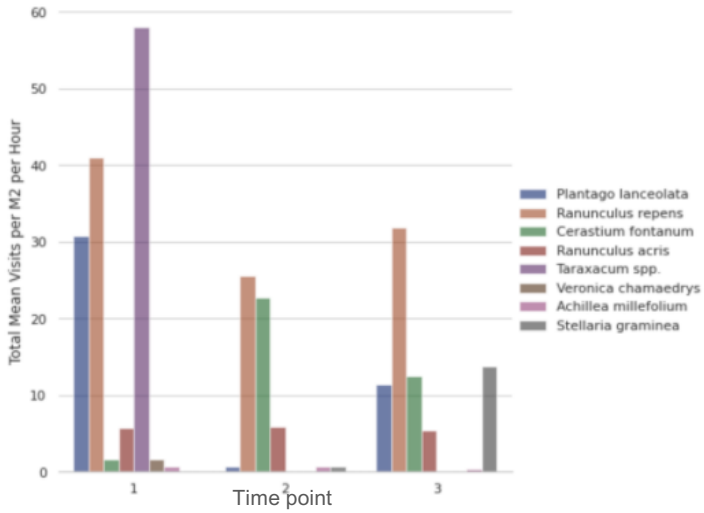

Figure 5: *Total mean visits per m^2 per hour to all plant species in all mowed plots excluding Trifolium repens. Time points: 1 = 9am-12pm; 2 = 12pm-3pm; 3 = 3pm-6pm.*

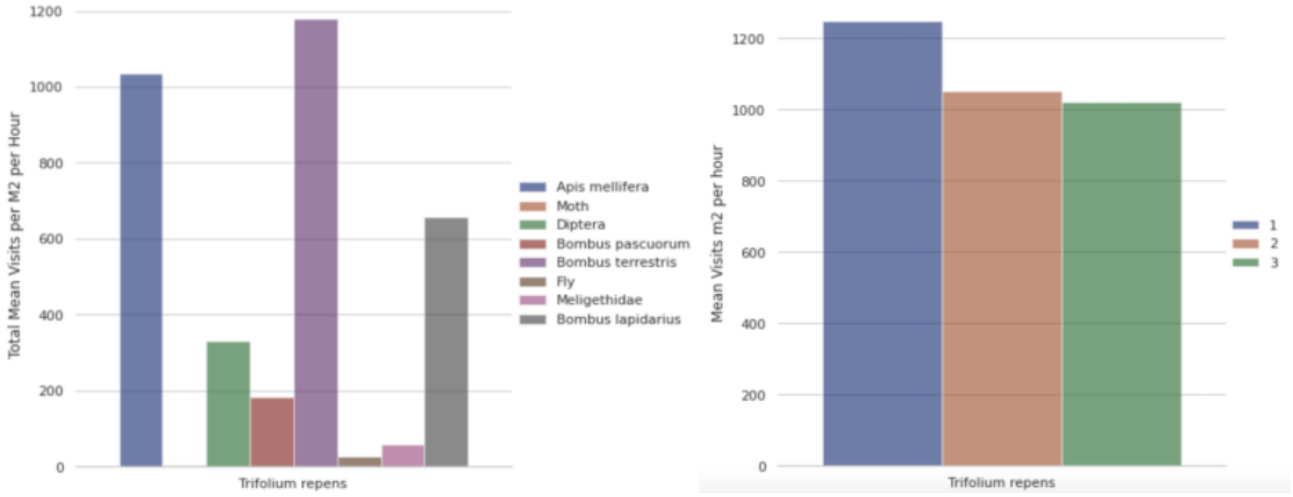

Figure 6: *Mean visits per m^2 per hour for Trifolium repens in mowed plots. (a) total mean visits per m^2 to Trifolium repens across all mowed sites across all time points. (b) Mean visits per hour per m^2 for T. repens for each time point Time points: 1 = 9am-12pm; 2 = 12pm-3pm; 3 = 3pm-6pm*

<u>Difference in visits between sites</u>

The number of pollinator visitors varied between sites, with the mowed sites showing, on average, a higher number of mean visits per m^2 per hour compared to the control plots (mean (control) = 52, mean (mowed) = 810) (**Figure 7**). The mowed plots have a significantly higher mean visits per m^2 per hour ($t(8)= 2.401$, $p < 0.05$) compared to the control plots. This could be linked to the high number of *T. repens*

found in the mowed sites, and their attractiveness for pollinators, especially honeybees and bumblebees.

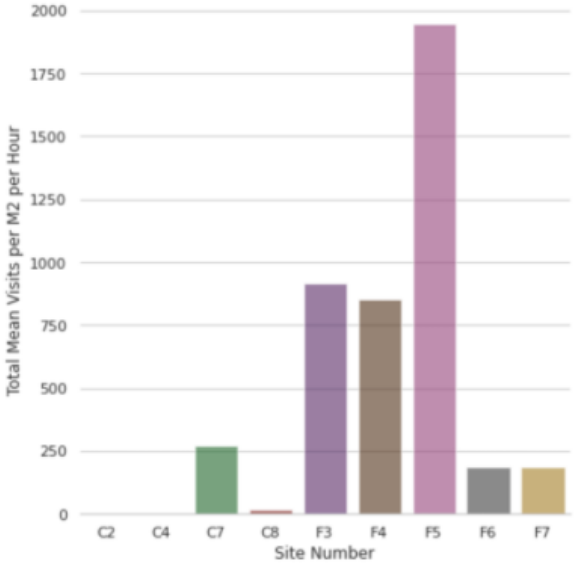

Figure 7: *Total mean visits per m^2 per hour at each plot. C1-5 = Control plots; M1-5 = frequently mowed sites.*

Conclusion

Overall, the mowed plots appear showed high pollinator visitation rates compared to the control plots that had been left to grow for long periods of time, accumulating larger numbers of grass and grass-like plant species, suggesting faster growing species such as *T. repens* are important for pollinator diversity. Here we have only reported our data for *T. repens* in terms of pollinator visits, however data for all floral species and their visitors has been collected for both mowed and control plots. Future work will include more in-depth statical analysis on the relationships between different plant and pollinator species, potentially revealing whether mowing cessation is beneficial or detrimental to pollinator diversity and visitation frequency.
What this study could not cover, and what would be interesting for future studies, is whether there is a set mowing interval that is optimal for both pollinators and floral diversity, for example, what is the difference between mowing a site every four weeks and every six weeks, and which is more beneficial for pollinator abundance? Another interesting future study could be what benefits the control plots lend to pollinator insects through other ways that just pollination, for example egg laying, other food resources, etc.

Acknowledgements

We would like to thank Prof. Graham Stone and Dr Vladimir Krivstov for their help, guidance, and supervision throughout this project. We would also like to express our appreciation to Edinburgh Greenspace team who allowed us to carry out surveys on their land and grassland meadows. Finally, we would like to thank the Davis Expedition Fund who provided all the funding used for this study.

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