Creating Bio-Inspired Artificial Flowers to Support the Standardised Monitoring of Pollinating Insects

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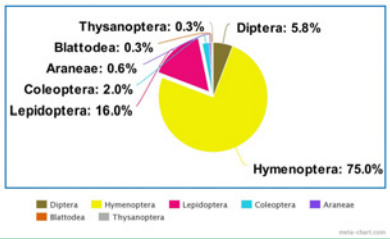
Diurnal Pollinator Attraction Cues and the Use of Artificial Flowers in Pollinator Research

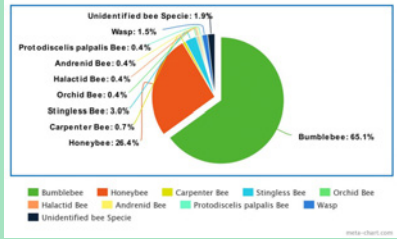
Table of Diurnal Pollinator Attraction Cues

	Colour	Shape	UV Preference	Scent	Nectar Guides	Nectary Depth	Reward	Humidity Sense	Temperature Sense	Electric Field Sense
Bees	White, Blue, Yellow, Violet	Variable	Yes	Light floral scents Linalool	Colour and UV patterns	Variable	Nectar and Pollen	Yes	Yes	Yes
Wasps	White, brown, purple, green	Generalist Umbellifer Globular	No	Green Leaf Volatiles (GLV)	N/A	Variable	Nectar Insect Prey	N/A	N/A	N/A
General Diptera	White, yellow (not as important)	Generalist Umbellifer	N/A	Carrion Faeces	N/A	Shallow	Mimicry	N/A	N/A	N/A
Syrphidae	White, Yellow, Blue, Pink	Generalist Umbellifer Radially Symmetrical	Yes – Yellow 'bullseye'	N/A	UV 'bullseye'	Shallow	Nectar and Pollen	N/A	N/A	Yes
Bombyliidae	Blue, violet, white, yellow	Deep tubular	N/A	Noticeable Floral Scent	Colour patterns	Deep	Nectar and Pollen	N/A	N/A	N/A
Diurnal Lepidoptera	Purple, yellow, orange, red, blue	Tubular, Star Shaped, Radially Symmetrical	Can see but no preference	Not important Fermented fruit	Shape guides Colour 'bullseye' Visible patterns	Deep	Nectar	N/A	N/A	N/A
Coleoptera	Yellow, Green, Red	Bowl shaped	Yes	Unpleasant Linalool	Beetle marks	Shallow	Nectar	N/A	N/A	N/A

Insect Orders Studied Using Artificial Flowers



Hymenopterans Studied Using Artificial Flowers



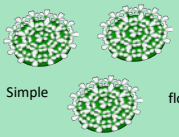
Artificial Flower Designs

All designed using ZBrush

Lavender flowers
liked by bees and butterflies

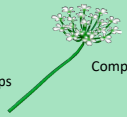
Foxglove flowers
bumblebees love this flower but the shape does not work for monitoring

A big red flower
For insects such as beetles or butterflies



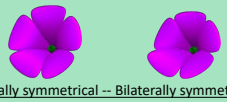
Simple

White umbellifers
Good generalist white flowers for flies and wasps



Complex

Trumpet flower
Attracts butterflies and the shape also works for moths



Radially symmetrical -- Bilaterally symmetrical flower
Could be useful for studying different foraging behaviours based on symmetry

Grape hyacinth flowers
Attracts bees and bee-flies

Borage flower
Loved by honeybees

Beetle daisy flower
Attracts monkey beetles with its beetle-marks

Future Plans

Choice Experiment in Wild Pollinators

3D models used for the experiment

- Compare artificial flowers to pan traps and coloured paper (yellow, blue, and white).
- Record insect visits with a camera.
- Count the number of insect visitors to each attractant.

Specialised, Complex Artificial Flower Systems

- Design flower specialised to different insect groups.
  - Include the attraction cues found in the literature review.
    - Colour, UV, scent, nectar guides, temperature, humidity, electric field
- Test out efficacy using automated monitoring stations such as INSECT DETECT(1).
- Perform experiments in UK and abroad with Project Wallacea.

INSECT DETECT monitoring system

Database of Artificial Flower Systems

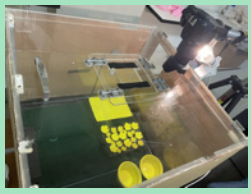
- Create database of different flower designs that can be 3D printed.
  - Choose designs based on shape, colour, complexity.
- Include instructions on how to construct the flower systems.
- Publish as open access for anyone to use.

(1) https://maxsitt.github.io/insect-detect-docs/

Choice Experiment in Naïve Bumblebees

Background

Artificial flowers have not yet been compared to other non-lethal attractants. It is important to measure whether pollinators will prefer a flower shape over a pan trap or UV paper when every attractant is yellow and UV reflective. This will set up a basis for whether artificial flowers are more efficient at attracting pollinators. It is hypothesised that naïve bumblebees will prefer the artificial flowers (by visiting them first when presented with a choice within the experimental flight chamber) and/or spend more time exploring them compared to the other attractants.



Experimental set-up with attractants, light, and camera

Methods

3D model used in experiment

Bumblebees foraging on feeders to acclimatise to the flight arena.

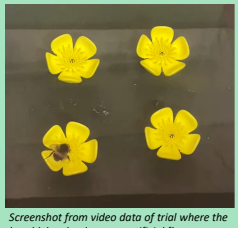
- Designed flowers using ZBrush software and 3D printed with a resin printer.
- Acclimated bumblebees to the flight arena using simple feeders.
- Comparing my artificial flower to a pan trap and coloured paper.
- Recorded which attractant the bumblebee landed on.

Results

Attractant Choice Per Trial

Bee Number	Did Not land	Flower	Pan Trap	Paper
B6	0	1	1	0
B7	0	3	0	0
B8	0	2	0	0
B10	0	4	0	0
B13	0	1	0	0

A table indicating which attractants each bumblebee landed on during the trial session. A number higher than one means that the bumblebee landed on the same attractant multiple times.



Screenshot from video data of trial where the bumblebee lands on an artificial flower.