Mutant Bees: Making colour choices in different illuminations

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A little about bee research

• Sniffing out explosives *Los Almos National Lab, 2006*


• Recognise human faces *Dyer AG, et al (2005)*
Training bees

• Bees can be trained to a flower species based on nectar reward:

• However, flower species can only be distinguished based on some cue, like **colour**, **pattern** or **scent**

• **Bees are Flower Constant**
Bee Colour Vision

Peitsch et al. (1992), Chittka (1992), Endler (1993), Skorupski et al. (2007)

\[ P = R \int_{300}^{700} I_s(\lambda)S(\lambda)D(\lambda)d\lambda \]

\( R = \) Adaptation to background
PATCHINESS = 0
Experiment 1:
Colour Choice Behaviour: Flowers

Chittka et al, 1997
Bee Colour Vision:
JND-Just noticeable difference

• Just Noticeable Differences can be seen on the colour space model:

15 flowering plants, 6 aphid bee species perception
Adapted from Chittka et al, 2001
• One Foraging/Search Strategy:
  – area-restricted search:
  
  – Given the nature of naturally-occurring flower distribution, this strategy is optimised (Heinrich 1979, Heinrich et al 1977, Pyke 1978, Zimmerman 1981)
Experiment 1:
Colour Choice Behaviour: Patchiness

P = 0
P = 0.2
P = 0.4
P = 0.6
P = 0.8
P = Patchiness
Modelling the Environment
measuring colour choice (1 of 3)

MEADOW P
5 species occur in the same frequency

MEADOW Q
5 species occur in the different frequency

Is visitation to flower species based on if a flower species is REWARDING or occurring FREQUENTLY? (Or both?)
Modelling the Environment
measuring colour choice (2 of 3)

MEADOW P – Flowers occurring in the same frequency

[Bar chart with data points and error bars for different species across varying patchiness levels.]

- o.circium
- p.lathyrus
- s.lythrum
- c.lotus
- c.vicia

REWARD
Modelling the Environment
measuring colour choice (3 of 3)

MEADOW Q – Flowers occurring in different frequencies

![Graph showing the frequency of different flowers]

- c.vicia
- c.lotus
- p.lathyrus
- o.circium
- s.lythrum

Constant Flights

Frequency

Patchiness
Experiment 1: Summary

- Nectar Reward is a better incentive (than high frequency of the flower species) to visit the flower

- Patchiness encourages flower constancy

- Different flower distribution strategies can be established to optimise the mutual plant-pollinator interaction
So, what affect does changing light have on colour perception?
Change in illumination

Different lighting conditions caused by weather or different times of day can change reflected object colour.

Banana sample
Change in Illumination: faced by honeybees (1-4)

- This would be a problem in honeybee colour vision without COLOUR CONSTANCY:
- What is the severity of the errors made by bees when light changes?

Endler, 1993
Change in Illumination:
faced by honeybees (2-4)
Change in Illumination: faced by honeybees (3-4)

• Training timeline (for 1 simulation run):

  - D65 Daylight
    - 5 foraging bouts
  - Forest shade
    - another 5 foraging bouts
  - Lighting Condition is changed
  - WRITE access to the bee memory is blocked

  Learning process

  Colour choice in new light
Change in Illumination: faced by honeybees (4-4)

D65 Daylight
Flower Constancy index

Lotus
-0.01448
304
Lathyrus
-0.015
240

Forest Shade
Flower Constancy index

Lotus
0.020032
424
Lathyrus
0.02172
287

P<0.001
Experiment 2: Summary

• Biological relevance of having flower constant bees and colour constancy

• Flower Constancy measurement only shows one side of the story – nectar influx?

• Only tested one lighting condition, showing shift and one divergence of colour
Conclusions (1-2)

• Bees and flowers have evolved in a mutual plant-pollinator relationship

• Bees visual system must have some colour constancy if it is to collect nectar efficiently

• We can measure costs when there is “no colour constancy”

• Modelling teaches us what is important: patchiness, reward/frequency of reward etc...
Conclusions (2-2)

“You don’t really understand it until you’ve built it” (words of Barbara Webb)
Thank you!

Questions?