Visual ecology of herbivorous pest insects

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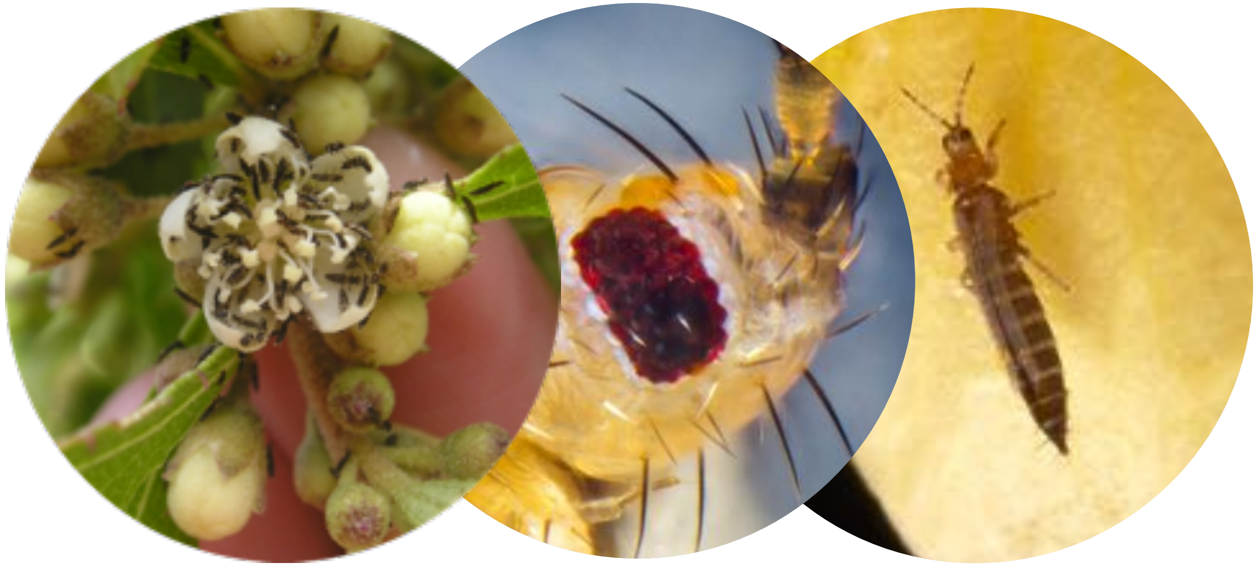

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Development of a refuge-kairomone device for monitoring and control of the vine weevil, *Otiorhynchus sulcatus*, by lure-and-kill and lure-and-infect

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Otiorhynchus sulcatus (Fabricius) (Coleoptera: Curculionidae)
Beauveria bassiana
Linseed oil
Kairomone
Lure and kill
Monitoring

ABSTRACT

Root weevils in the genus *Otiorhynchus* are an important pest in the nursery and small fruit production worldwide. The night-activity of the adult weevils obstruct timely monitoring and oviposition often starts before effective control measures are taken. The primary objective of this research goal was to develop an effective trap for monitoring that can be used in conjunction with the kairomone (Z)-2-pentenol and an effective means to kill the insects that enter the trap.

A novel ruffle refuge trap (WeevilGrip) caught on average 4 to 5 times more weevils than a grooved board refuge in a field trial. Addition of the kairomone to the WeevilGrip further increased catches 52%. Linseed oil increased mortality to 59% and addition of Botanigard (ai *Beauveria bassiana*, strain GHA, Certis, BotaniGard WP 10–25%) increased mortality to 79%.

The lure-refuge device consists of a flexible ruffle that can be wrapped around trees or placed on the soil within ground covers. This flexible shape maximizes contact with weevils compared to other available weevil trap designs. The WeevilGrip is an improved monitoring tool to support growers in integrated control strategies.

Problem

- Available visual trap designs have low efficacy.
- Trap designs are based on human vision and ignore the fundamental aspects of how insects see.
- New tools for mass-trapping insects are needed to contribute to biological control.


Himba Classification of Color
buru
dambu
zuzu


Himba Classification of Color
buru
dambu
zuzu


80 186 15
80 186 15
97 192 4
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RGB Value

Goals

- Understanding the role of visual aspects in finding and landing on attractive targets by insects
- Integration with odour orientation and new trap materials
- Use for improved monitoring, mass-trapping and lure&infect strategies to control pest insects

- Insects: *F. occidentalis* (Western flower thrips), *Lygus rugulipennis* (European tarnished plant bug), *Halyomorpha halys* (Brown marmorated stink bug)

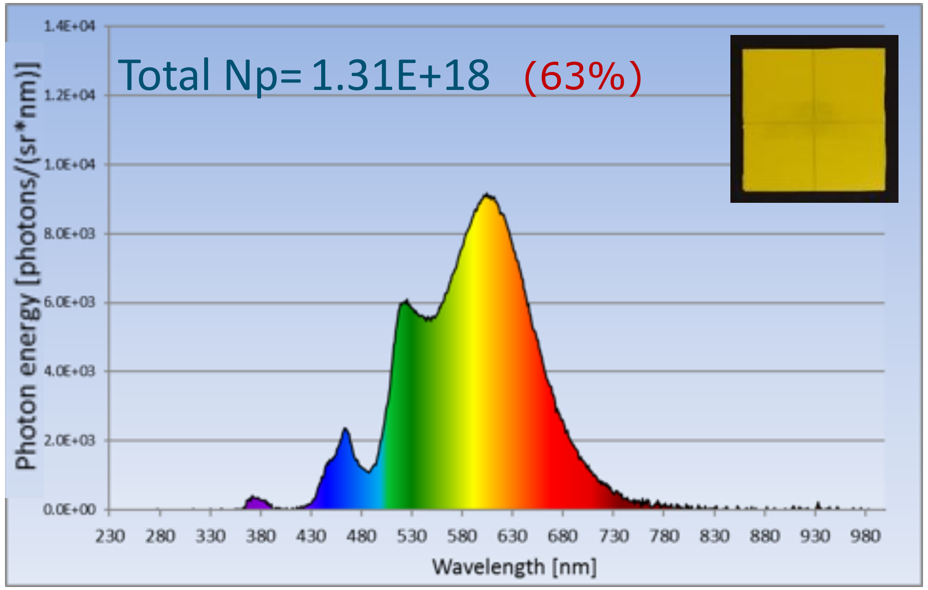


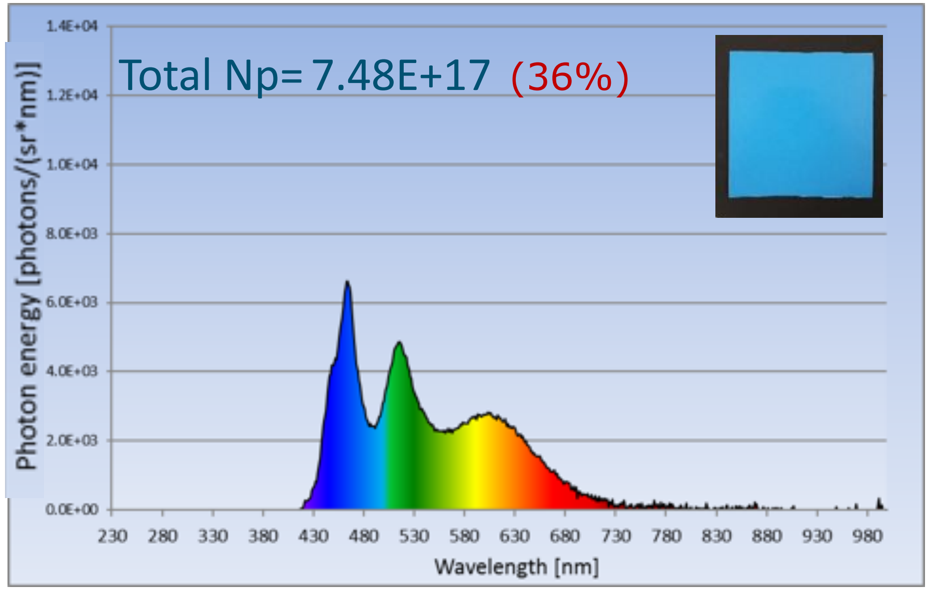
Chrysanthemum thrips damage

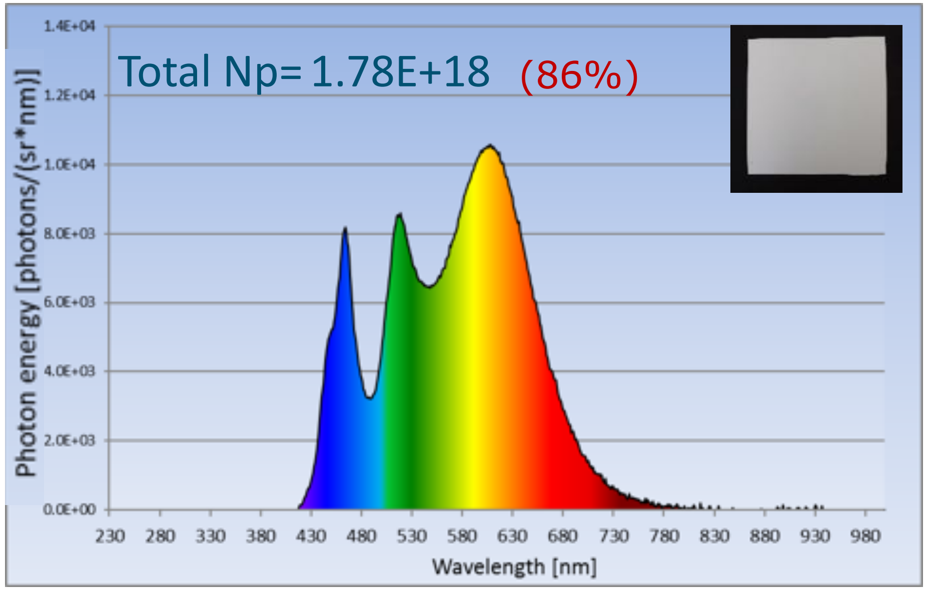


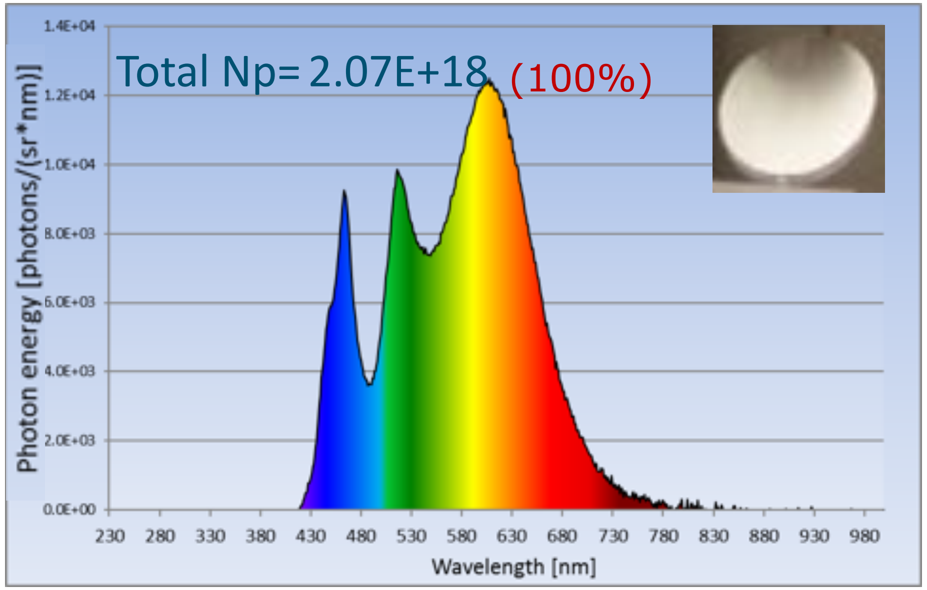


Lygus rugulipennis


Total Np= 1.31E+18 (63%)
Photon energy [photons/(sr*nm)]
Wavelength [nm]


Total Np= 7.48E+17 (36%)
Photon energy [photons/(sr*nm)]
Wavelength [nm]


Total Np= 1.78E+18 (86%)
Photon energy [photons/(sr*nm)]
Wavelength [nm]


Total Np= 2.07E+18 (100%)
Photon energy [photons/(sr*nm)]
Wavelength [nm]

Type of glue increases attraction to yellow or attraction to blue

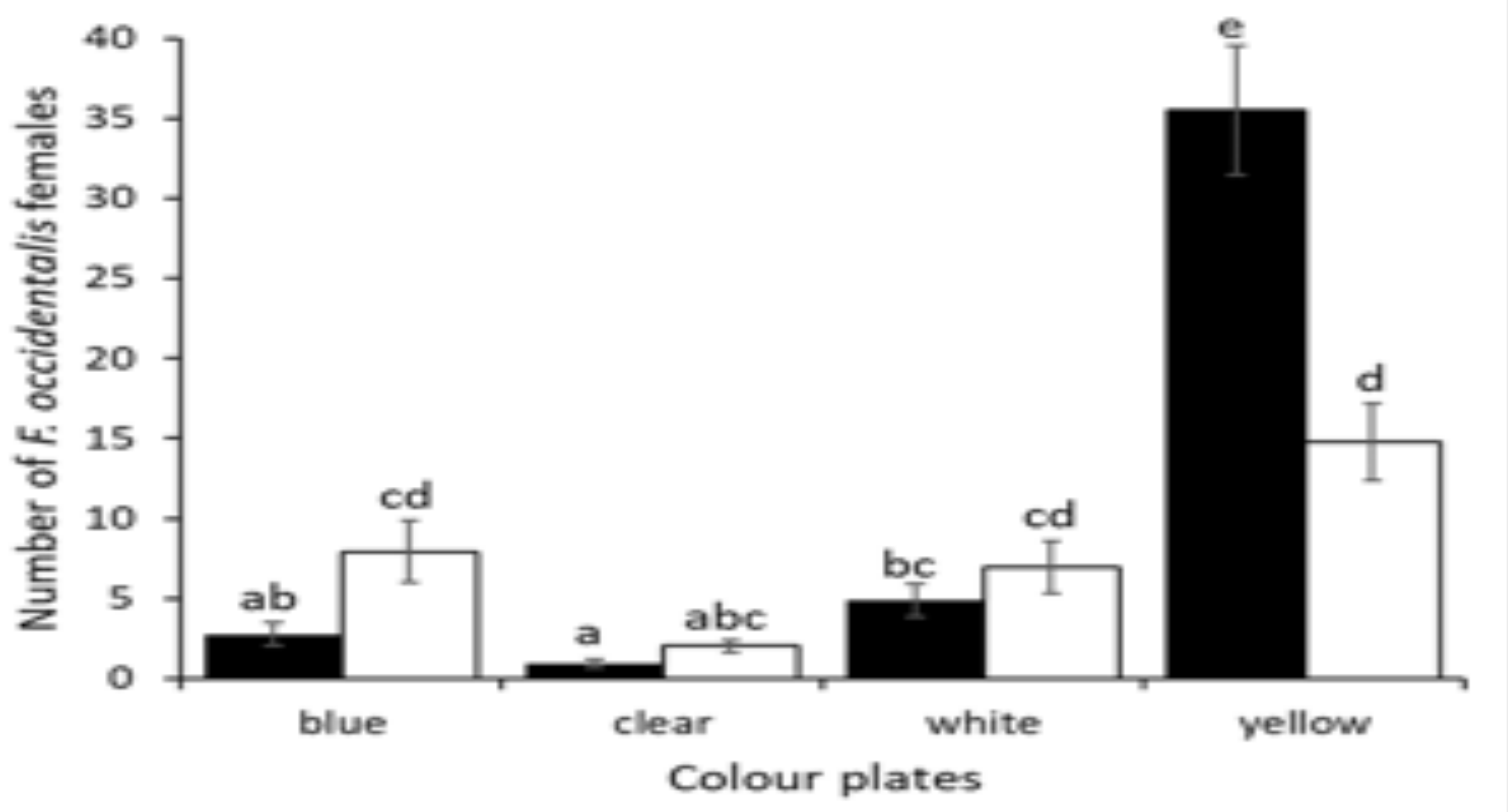


Figure 4: Number of *Frankliniella occidentalis* females caught on coloured plates with xxx glue (white bars) or yy glue (black bars) in a wind tunnel (N=18). Different letters (a, b, c, ...) above the bars are significantly different values from each other at *P*=0.05.

Results Chrysanthemum greenhouse

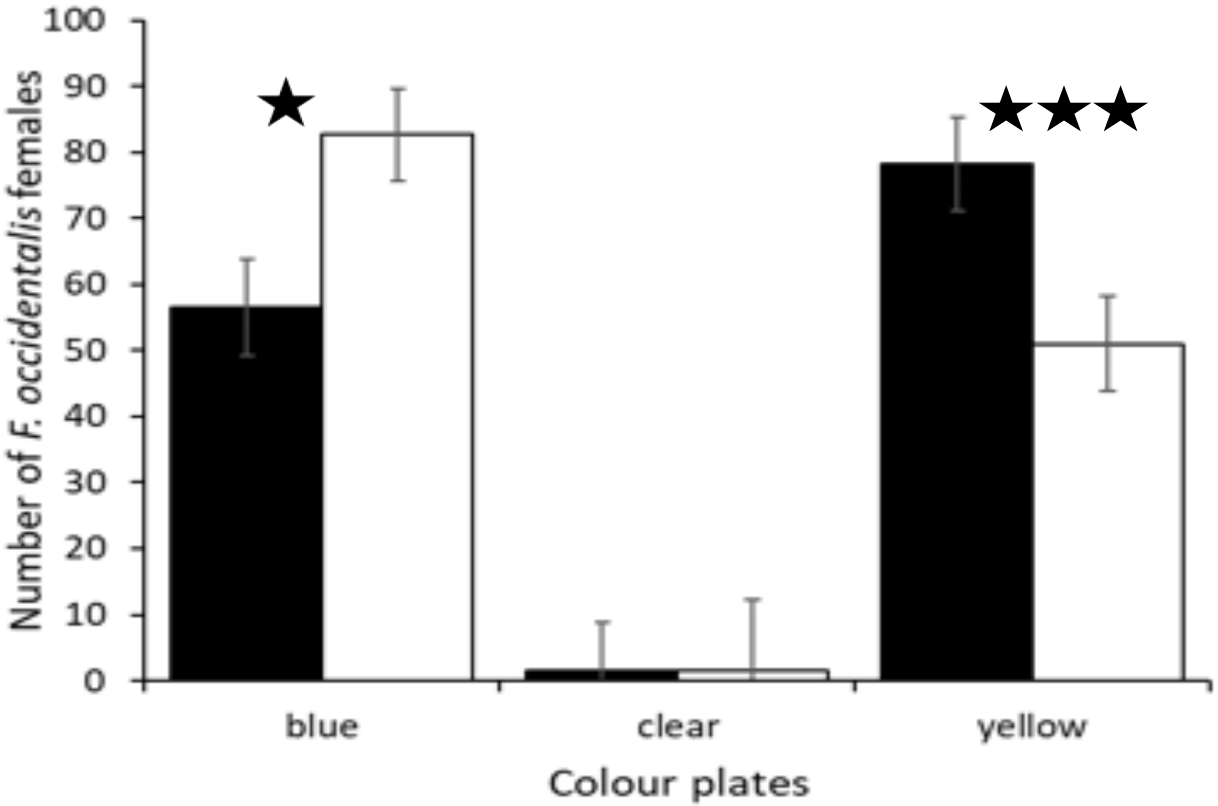
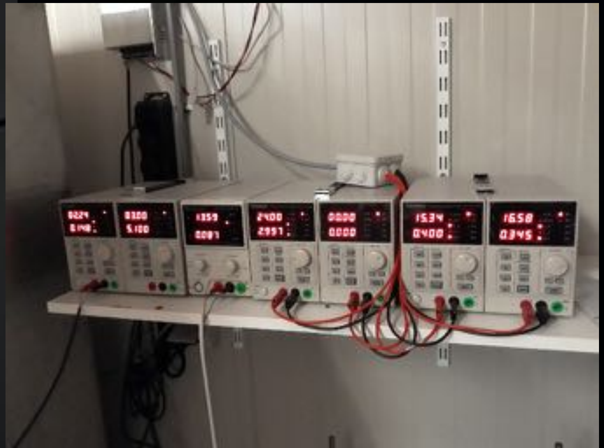


Figure 5. Number of *Frankliniella occidentalis* females caught on coloured plates with xxx glue (white bars) and yy glue (black bars) in greenhouses (N=14 to 17). Statistical result are based on normalised values.

Blue: 77% *F. occidentalis*
Yellow: 91% *F. occidentalis*



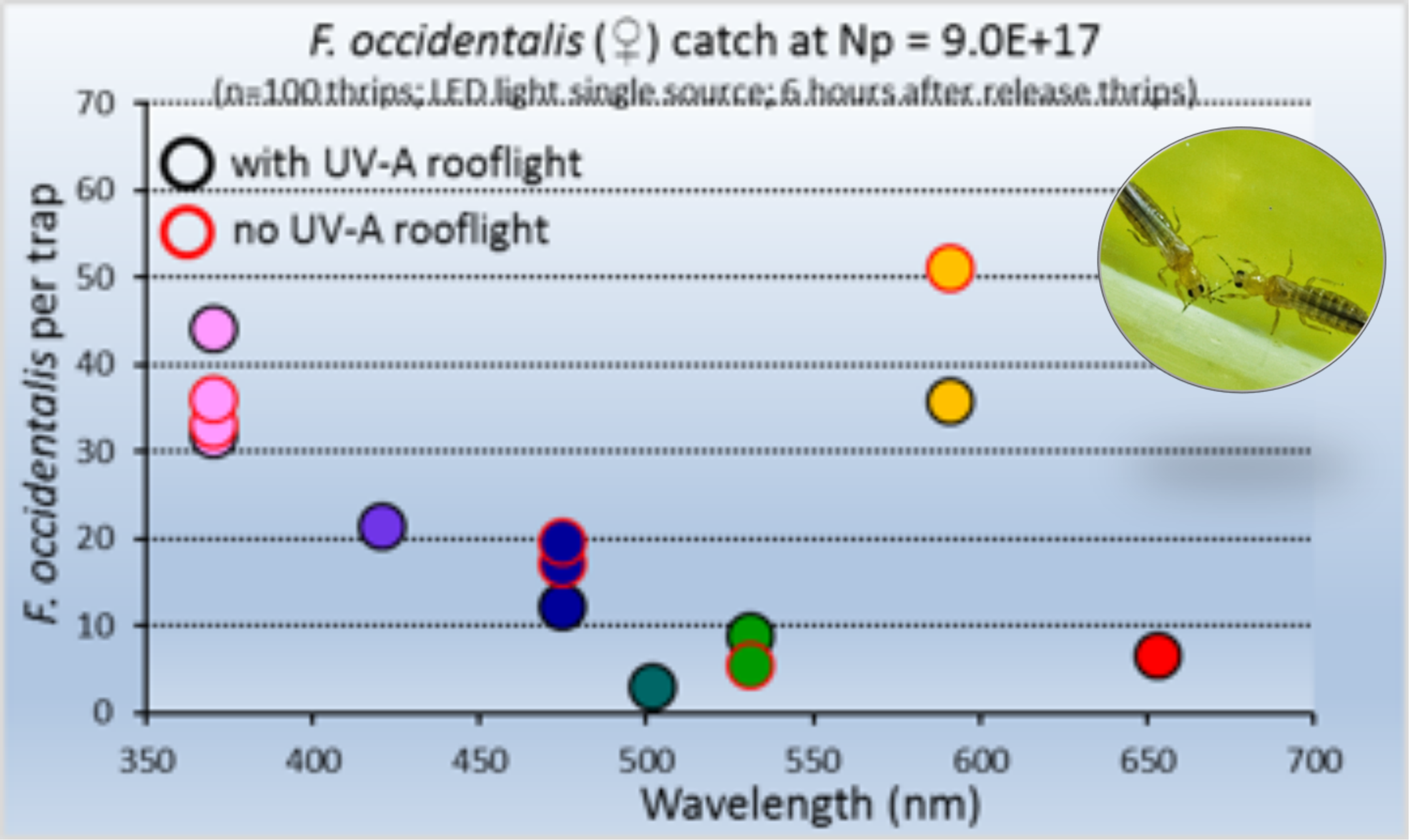


LED test schedule

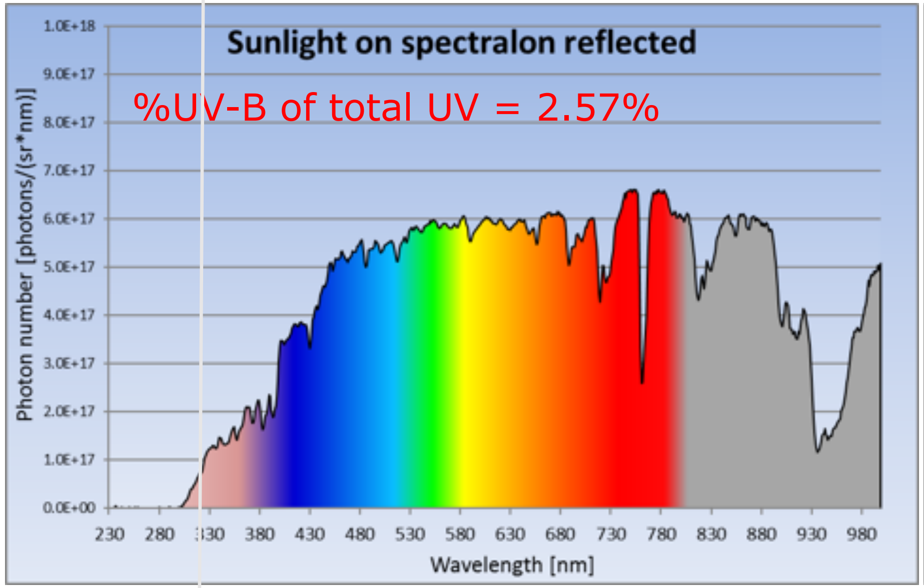
***Frankliniella occidentalis* (Western flower thrips)**

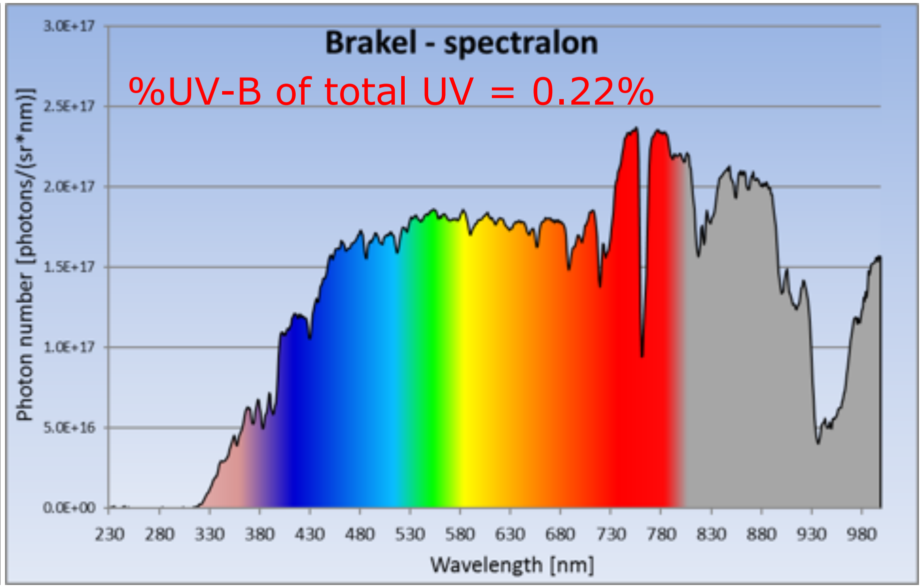
	Peak test current (A)						
Bandwith	**650**	**590**	**530**	**490**	**470**	**420**	**365**
energy (Np 60 nm)	653 nm	591 nm	529 nm	502 nm	475 nm	421nm	370 nm
9.00E+17	**0.168**	**0.150**	**0.034**	**0.054**	**0.031**	**0.024**	**0.024**
3.50E+18	**0.650**	**0.594**	**0.172**	**0.232**	**0.116**	**0.107**	**0.092**

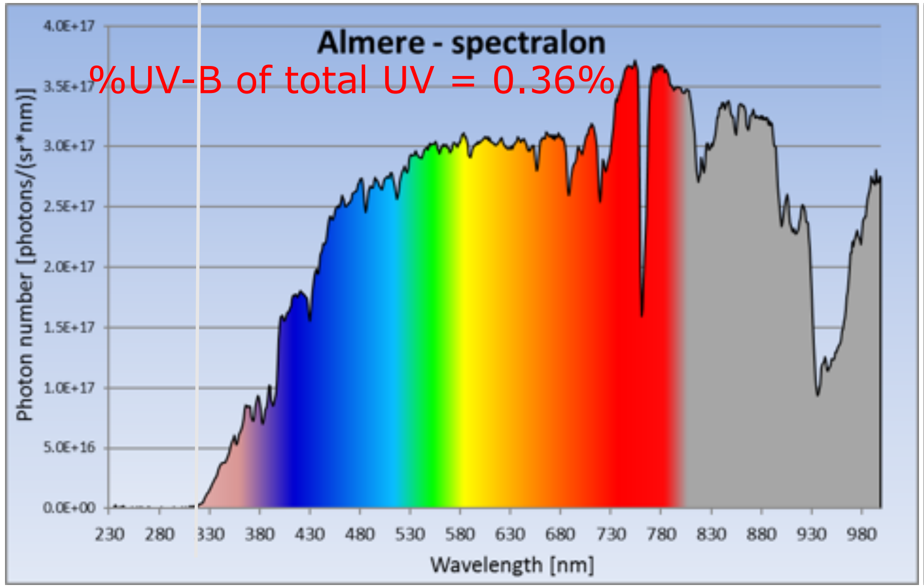
Thrips response to different wavelength LED's

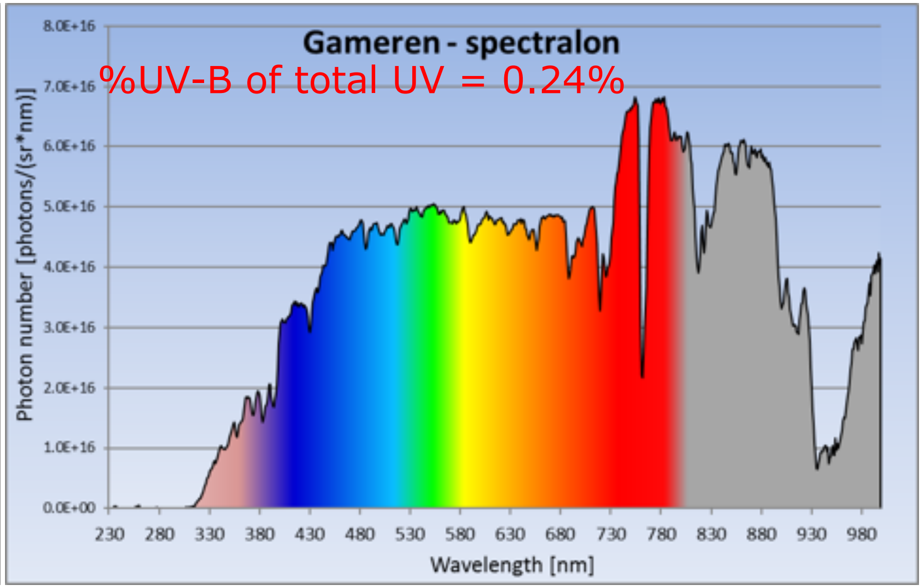


Greenhouse light composition

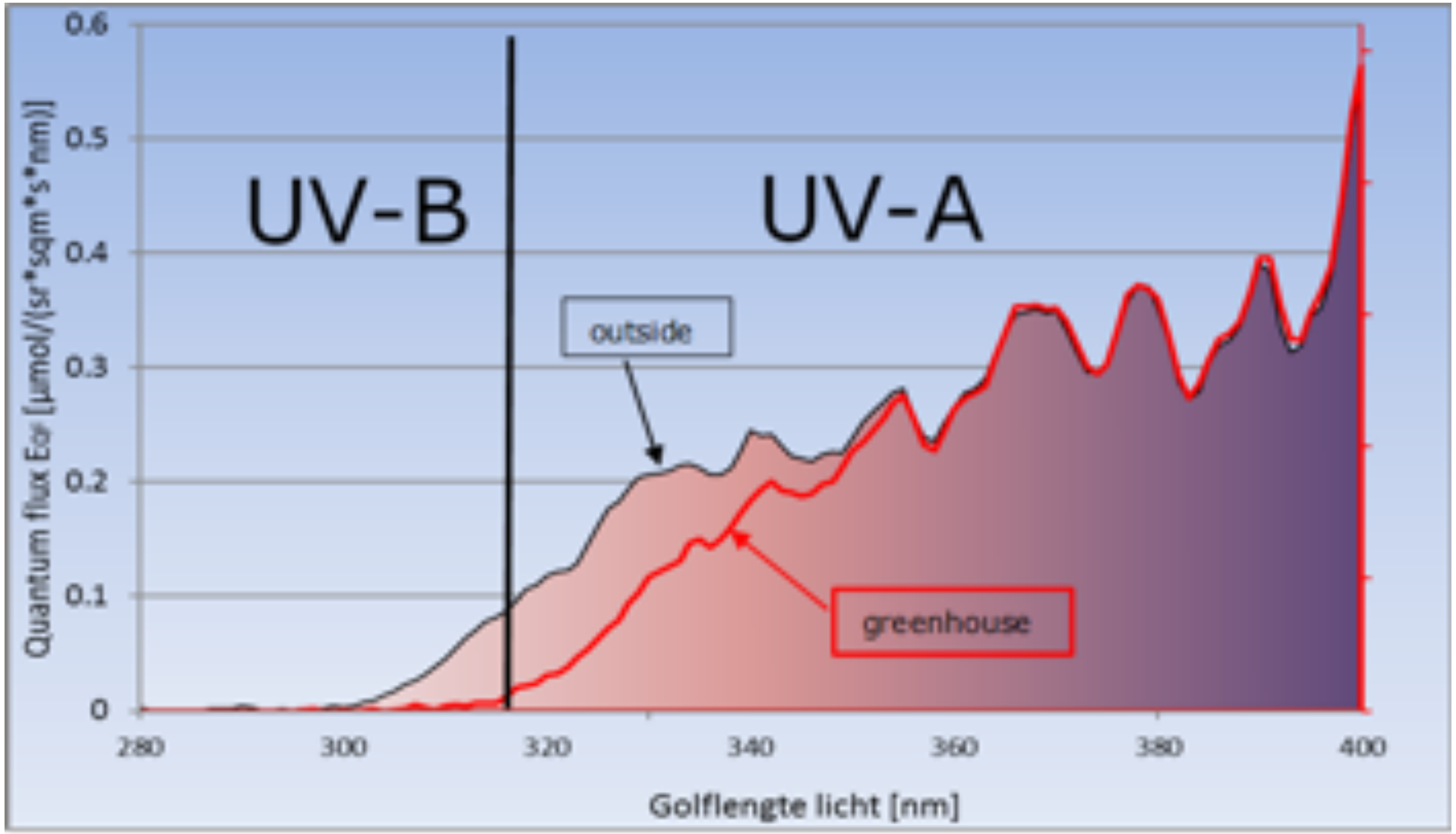




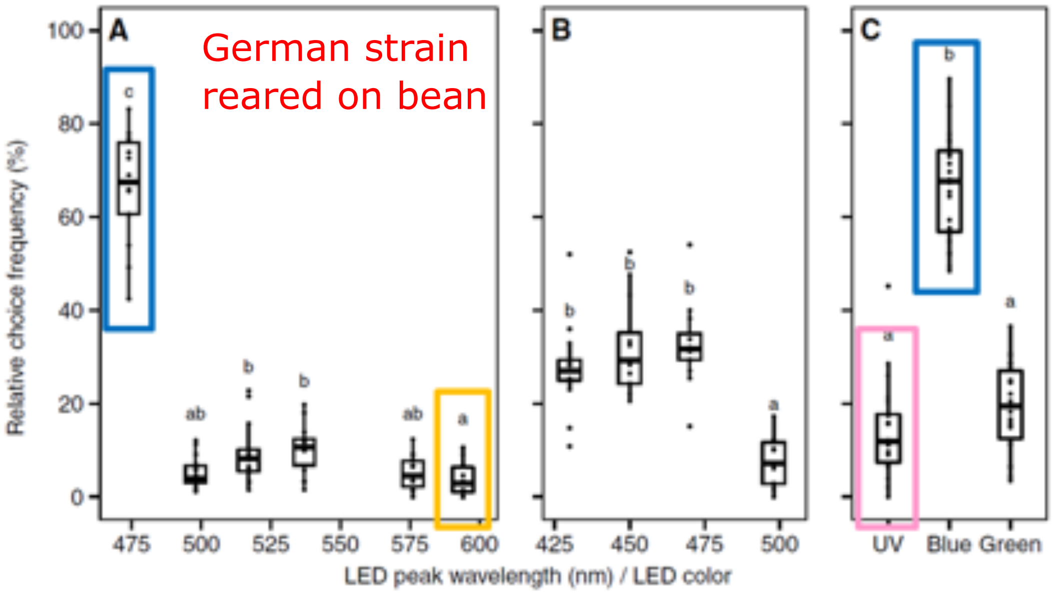




Greenhouse light composition



Comparison German with Dutch study on LED and thrips response

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ORIGINAL PAPER

Efficacy of LED-enhanced blue sticky traps combined with the synthetic lure Lurem-TR for trapping of western flower thrips (*Frankliniella occidentalis*)

Jacinter A. Otieno[1] · Niklas Stukenberg[1] · Jessica Weller[1] · Hans-Michael Poehling[1]

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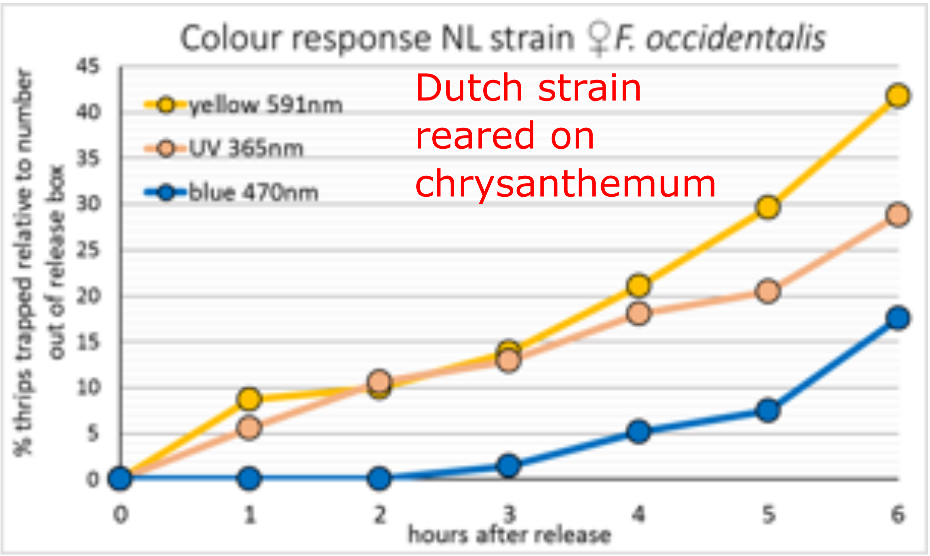
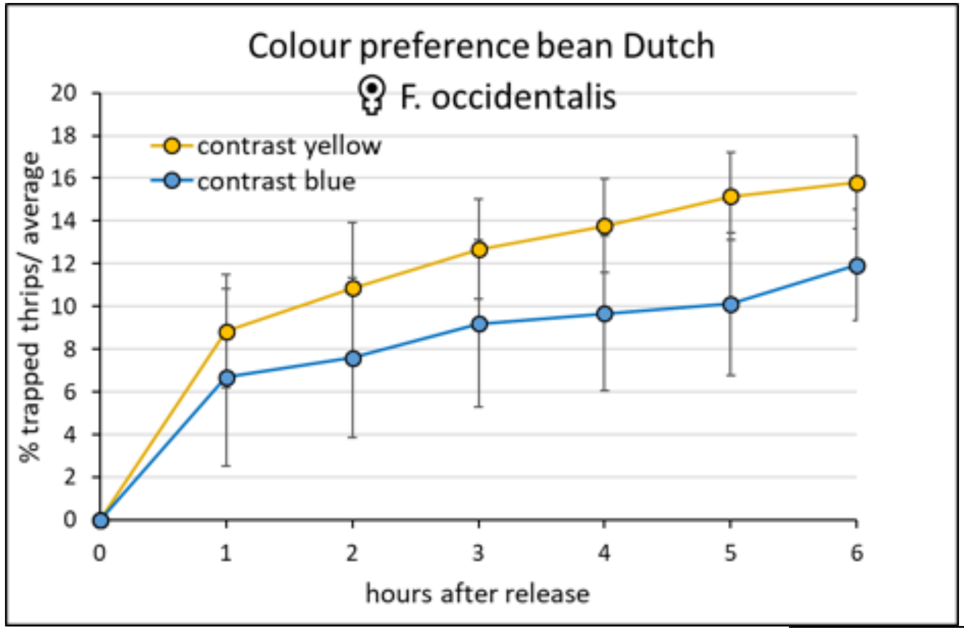
German strain response to blue only (multiple colour choice tests)

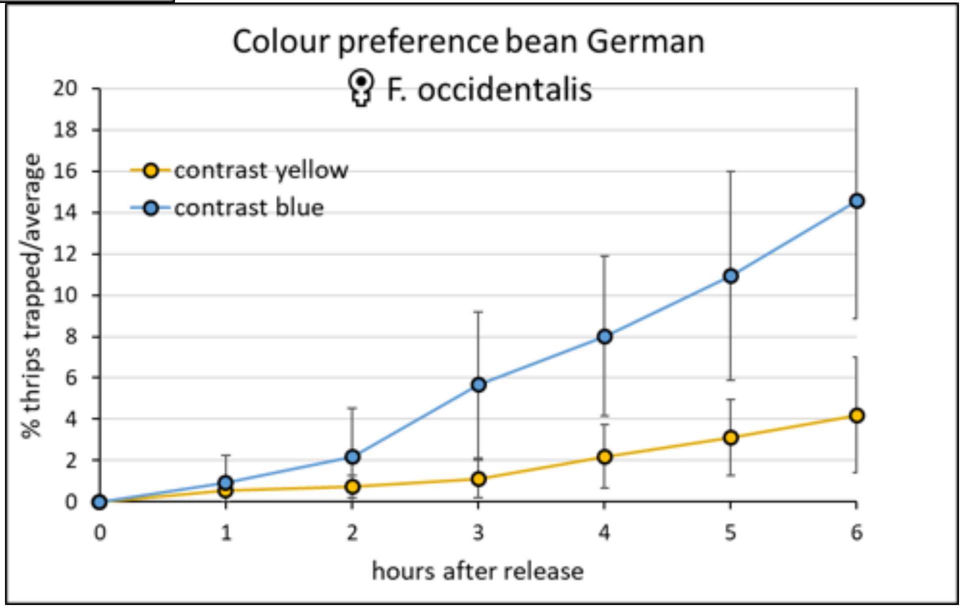


Dutch strain to yellow and UV-A and limited to blue (single colour choice tests)

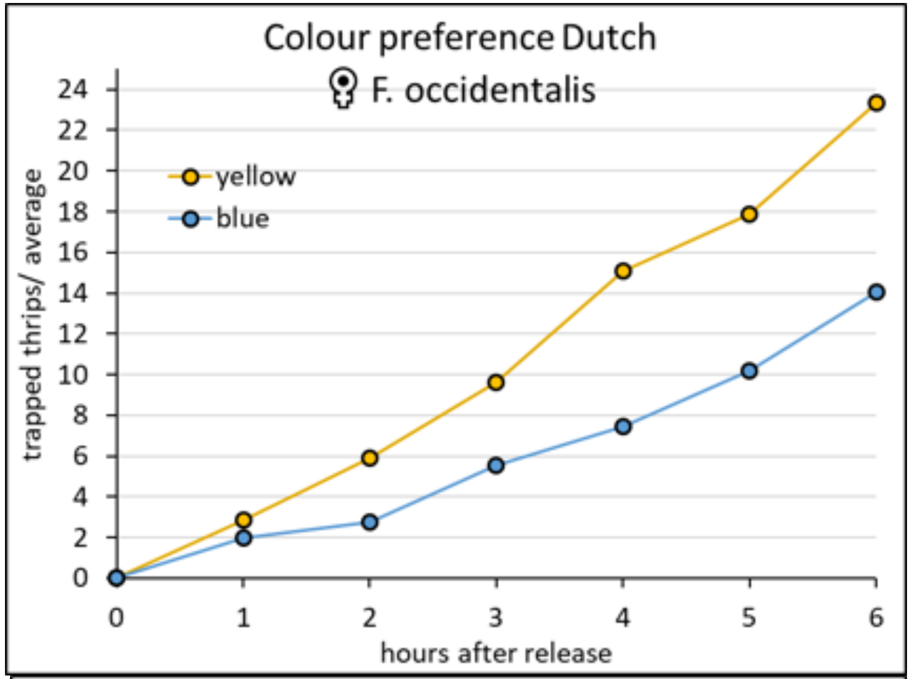
Attractiveness to blue and yellow on bean pods reared WFT

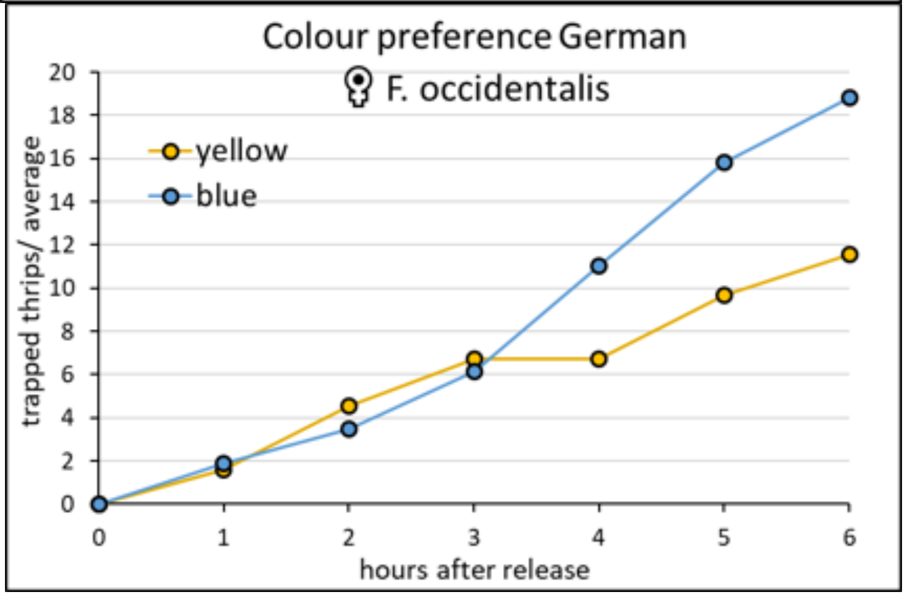


Both strains reared on bean pods tested for colour response to blue and yellow in the Dutch set-up

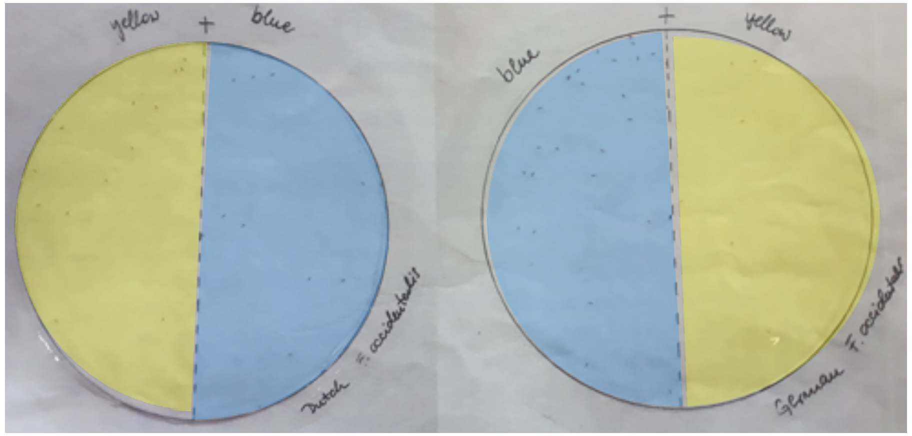


Attractiveness to blue and yellow 8-12 weeks Chrysanthemum WFT

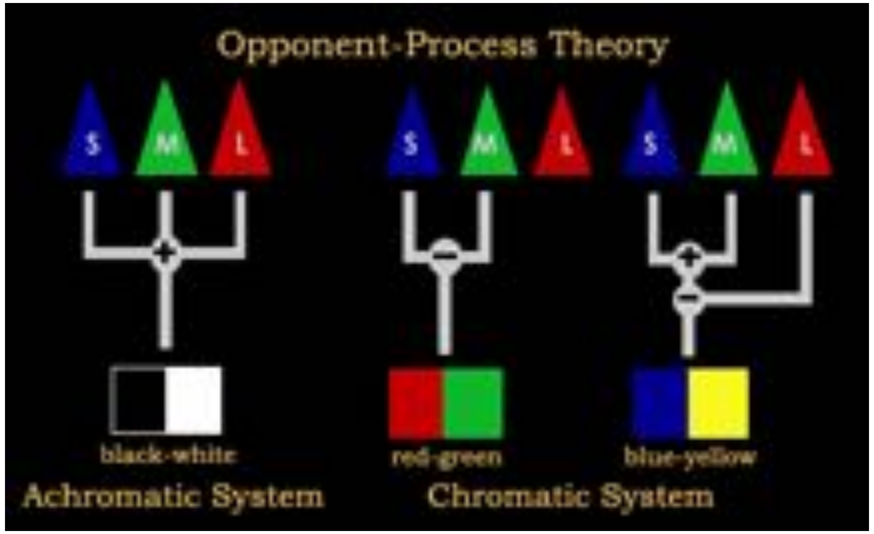




Both strains response 8-12 weeks after transfer to Chrysanthemum as food source



https://psyc.ucalgary.ca/PACE/VA-Lab/colourperceptionweb/theories.htm



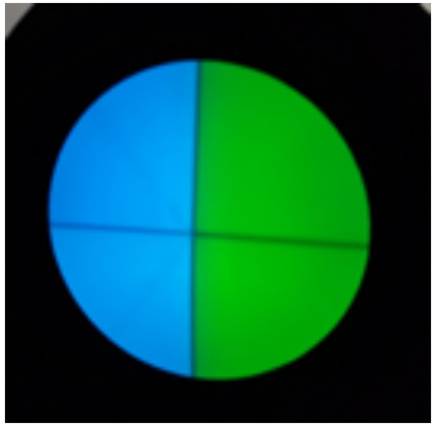
Opponent-Process Theory

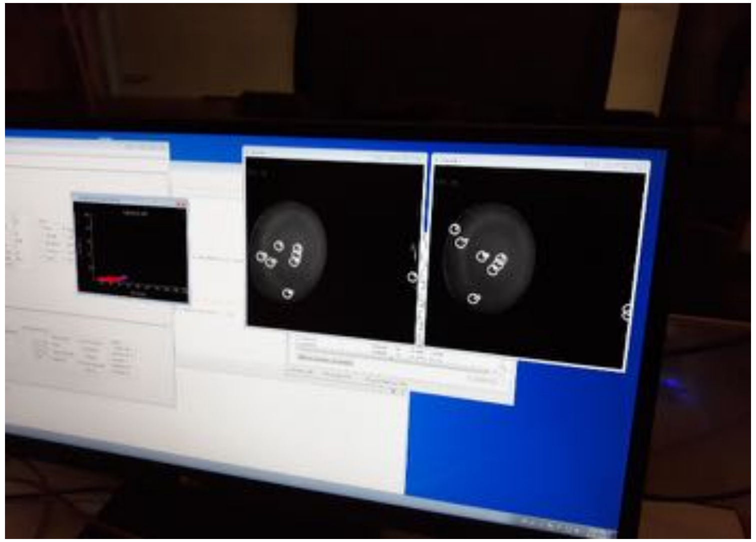
Developed by Ewald Hering(1920/1964), the opponent-process theory states that the cone photoreceptors are linked together to form three opposing colour pairs: blue/yellow, red/green, and black/white. Activation of one member of the pair inhibits activity in the other. Consistent with this theory, no two members of a pair can be seen at the same location, which explains why we don't experience such colours as "bluish yellow" or "reddish green".

The opponent-process theory explains how we see yellow though there is no yellow cone. It results from the excitatory and inhibitory connections between the three cone types. Specifically, the simultaneous stimulation of red (L cones) and green (M cones) is summed and in turn inhibits B+Y-, which results in the perception of yellow. However, when blue light is present, the S cone is activated, the B+Y- cell receives excitatory input and blue is perceived.

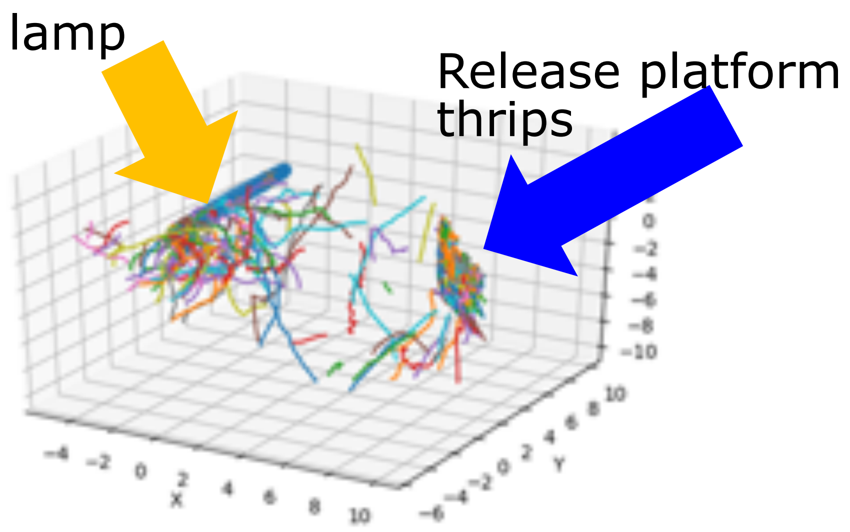
Single and two colour contrast video monitoring

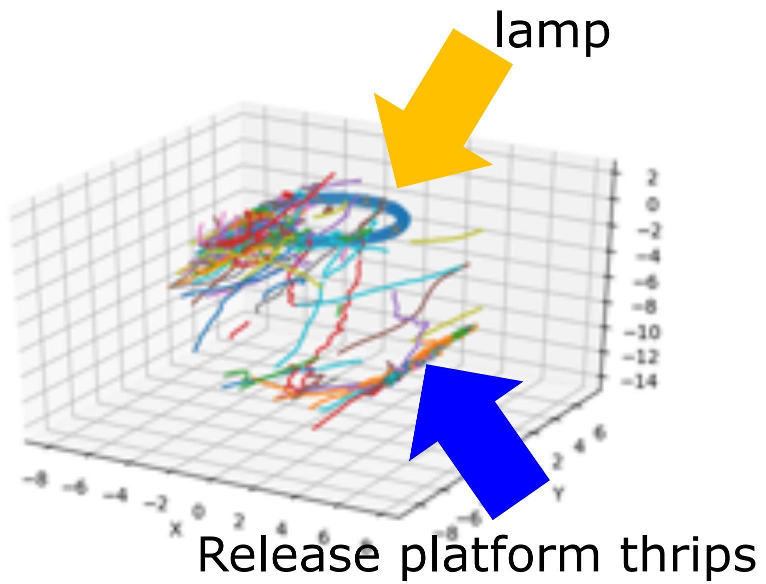
3D video tracking thrips (using infrared for visualization)





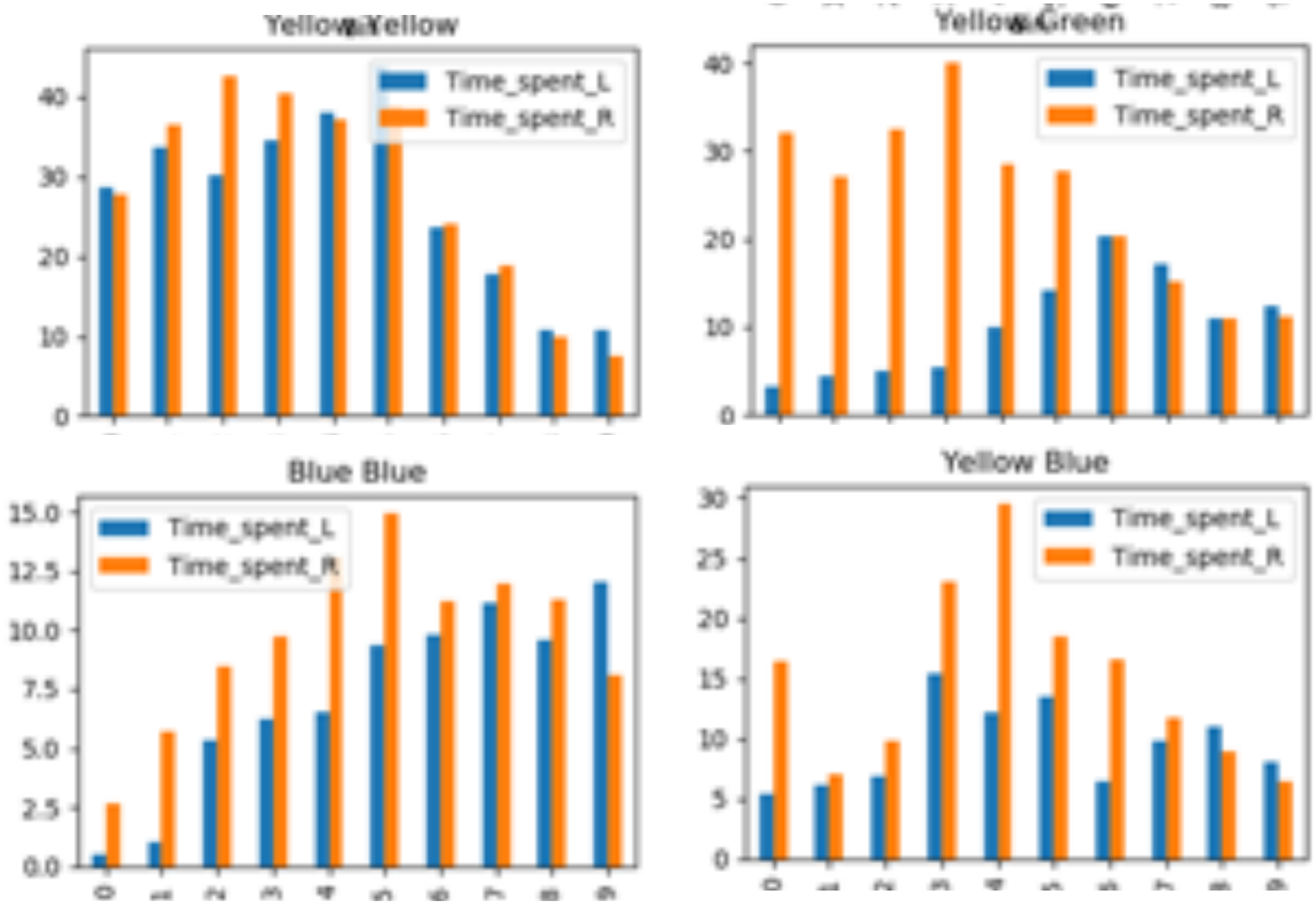
Colour contrast video observations





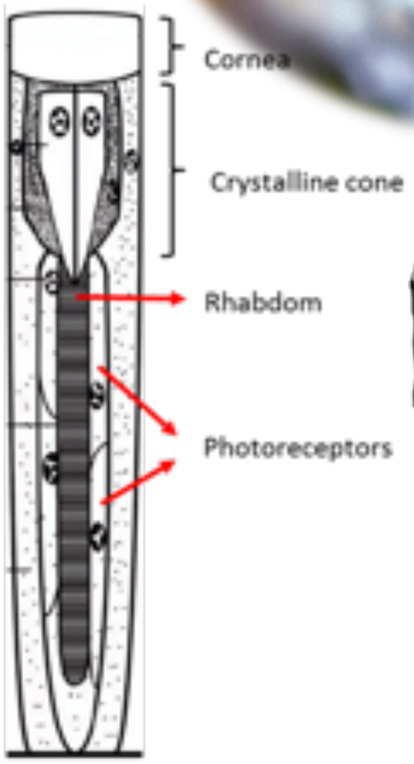
- There is no correlation between taking flight and flight to/landing on the lamp
- There is a clear preference for yellow to land

Colour contrast video observations

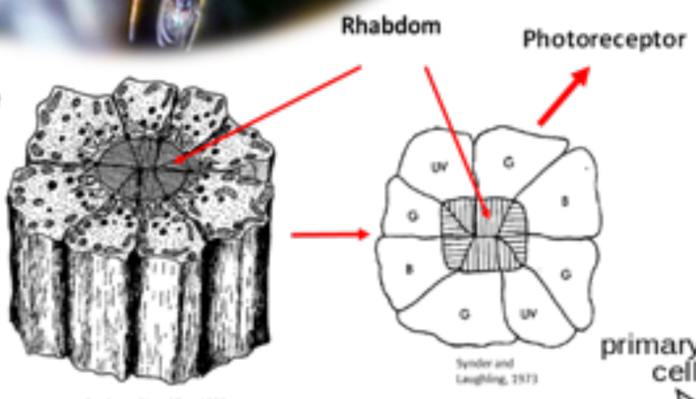


- No influence of green on yellow
- Negative influence of blue on yellow

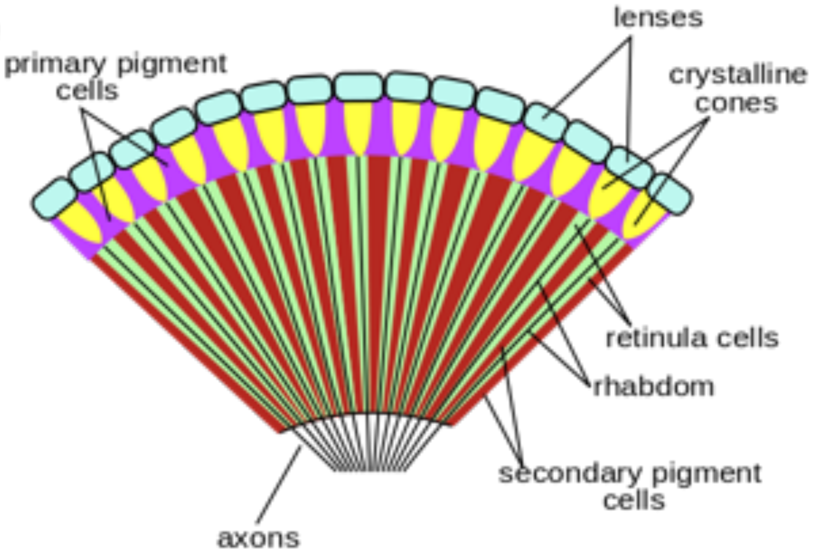
compound eye is constructed of multiple small eyes (ommatidia)



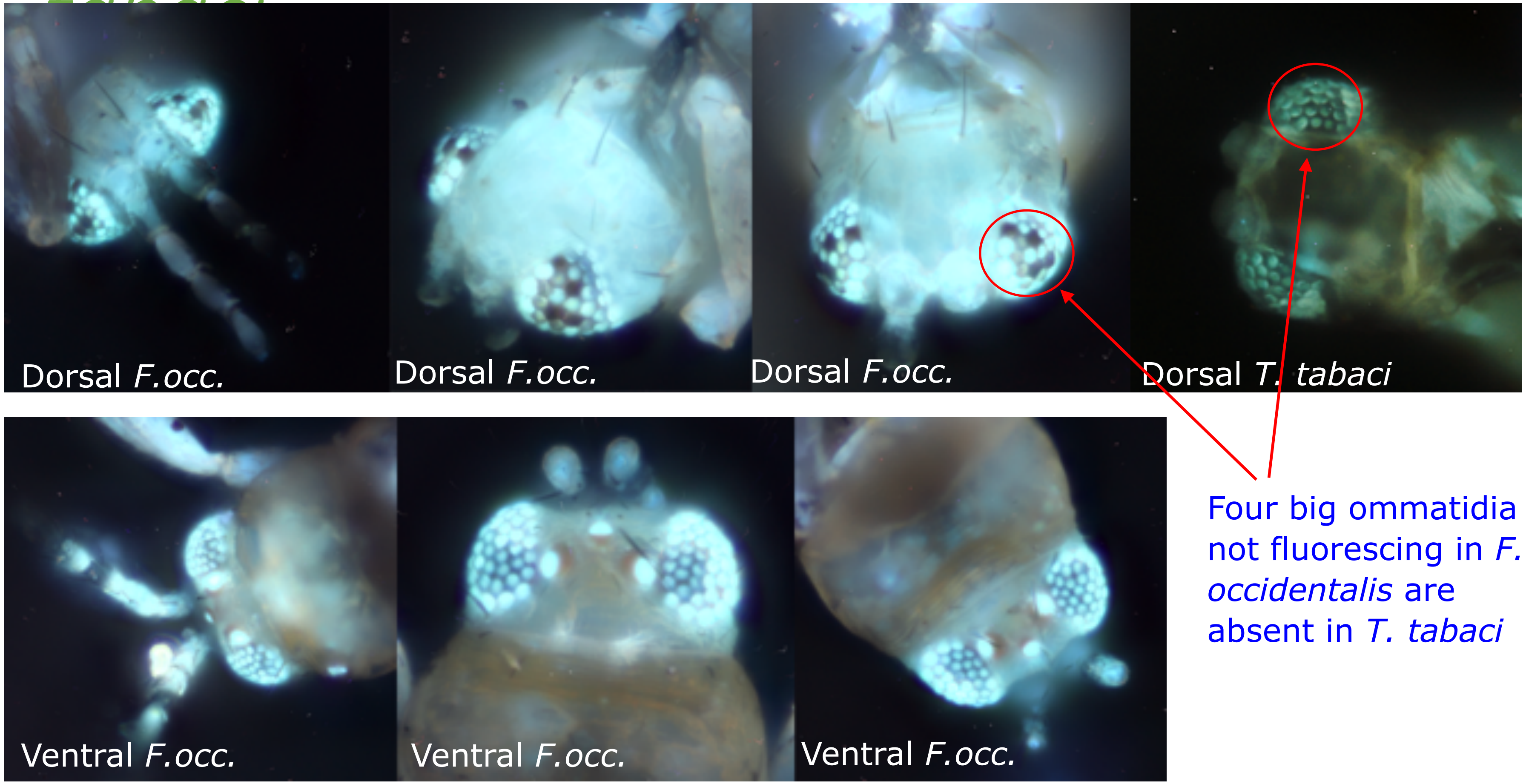
Jia and Lang, 2015



Synder and Laughling, 1973



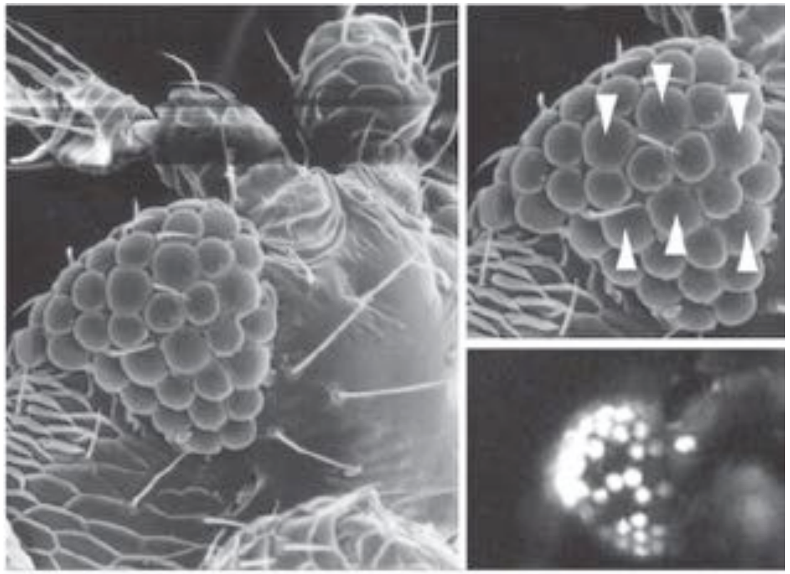
Fluorescence *F. occidentalis* and *T. tabaci*



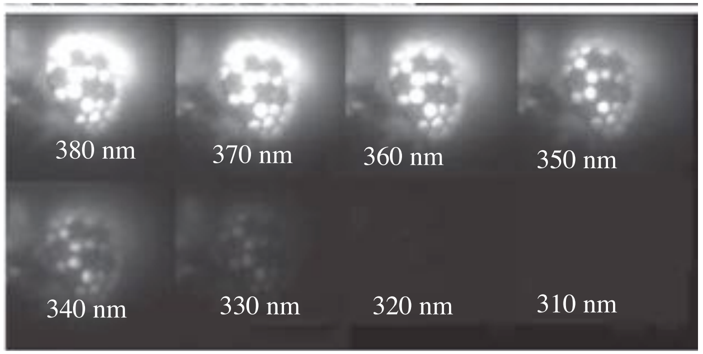
Four big ommatidia not fluorescing in *F. occidentalis* are absent in *T. tabaci*

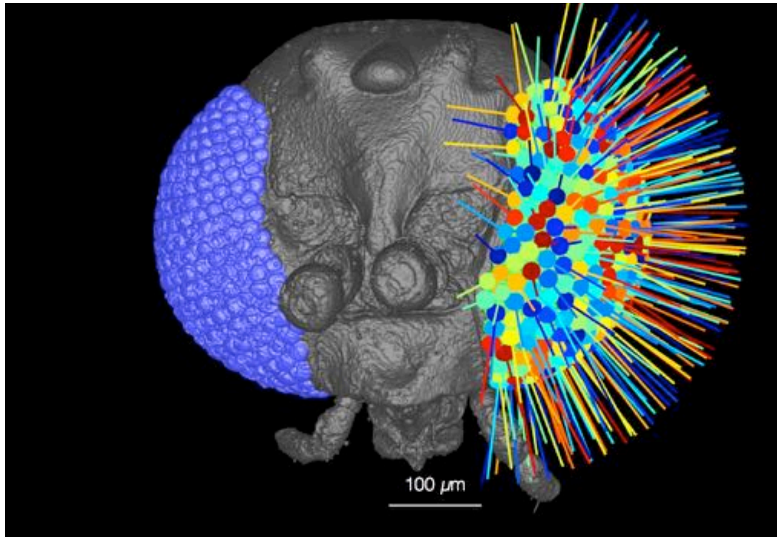
1) German and Dutch strain *F. occidentalis* identical eye fluorescence
2) Onion thrips missing 4 bigger ommatidia that do not fluoresce as for *F.occ.*
3) Opsins present different between two strains of *F.occidentalis*?

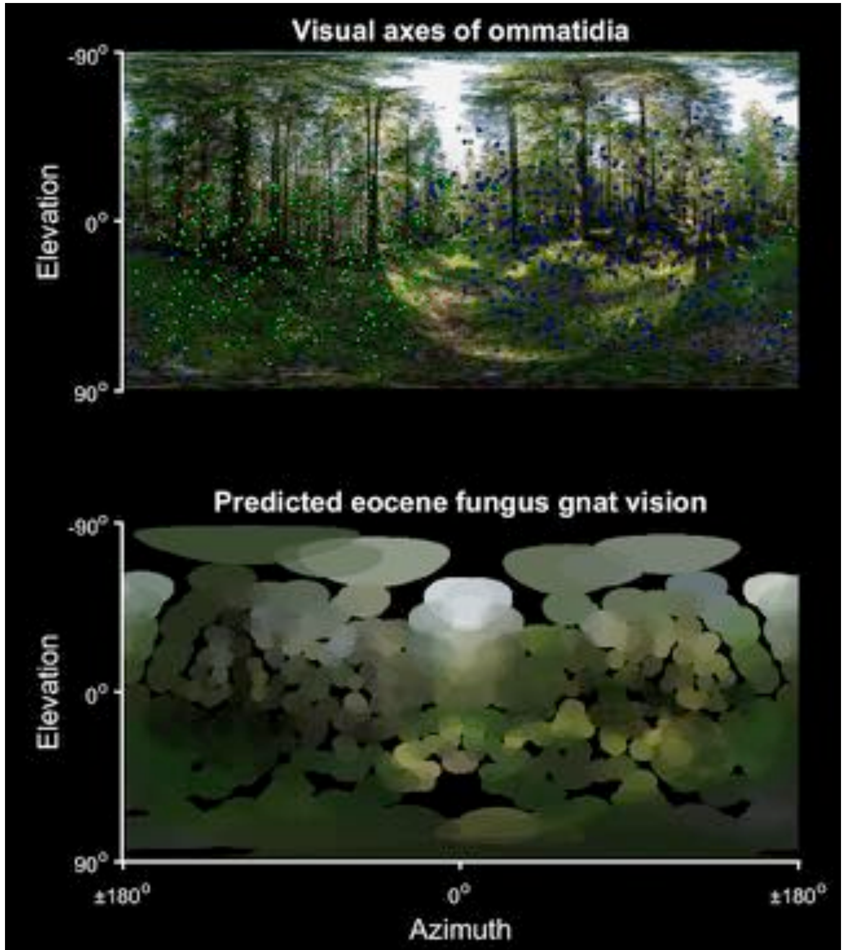
What does the insect eye actually see?



Mazza et al. 2010. Proc. R. Soc. B








Karla
Mike

LED traps for research

Conclusions

- Glue influences blue-yellow preference WFT
- Strain origin determines blue-yellow preference WFT
- Certain colour combinations are synergistic in attraction, others are antagonistic for WFT
- Synergistic attractive colours are used to develop test traps for glasshouse tests in 2020 for WFT
- Interaction blue-yellow negative in video observations (chromatic decision)
- European tarnished plant bug LED trap in test stage glasshouses (2020)

Project partners

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