ozone impedes the ability of a herbivore to find its host

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Introduction

- Insects distinguish senent molecules with olafactory neuron receptors(ORNs) on their antennae
  - VOCs(volatile organic compounds) is found in these molecules
  - It has a agricultural role in relationships of pollinator-host plant
- VOCs easily react with O3 in the atmosphere
  - Higher reactive VOCs are concerned to become diluted under O_3 exposure

->Insects may not be able to detect their host plants

Question

- (1)Do the reactions of SCBs（striped cucumber beetle）to flower volatiles remain under an increasing O_3 concentration?

- （2）Do SCBs distinguish two VOC streams, when one stream is reacted with an increasing O_3.

- （3）Do SCBs responds to O3, independent of host flower volatiles.

materials

Acalymma vittatum (a kind of SCBs)

- Specialist herbivore of the family Cucurbitaceae
- considered agricultural pest of cucurbit crops
- find its host plant by using flower volatiles

参照：wikipedia

Curcubita foetidissima

- Individual grown in a herbivore-free enclosure
- Flower volatiles for this testing were extracted from this plant

Brief explanation of Y-tube experiment

air A→

record line

air B→

○Record which air the insects prefer

Brief explanation of Y-tube experiment

air A→

attractive

air B→

attractive

record line

○Record which air the insects prefer

Experimental approach

- Y-tube olfactometry
  - (A)cleaned air versus flower + O_3
    - O3 control : 0～120ppb
  - (B)flower versus flower + O_3
    - O3 control : 0～120ppb
  - (C)cleaned air versus O_3
    - O3 control : 20～120ppb

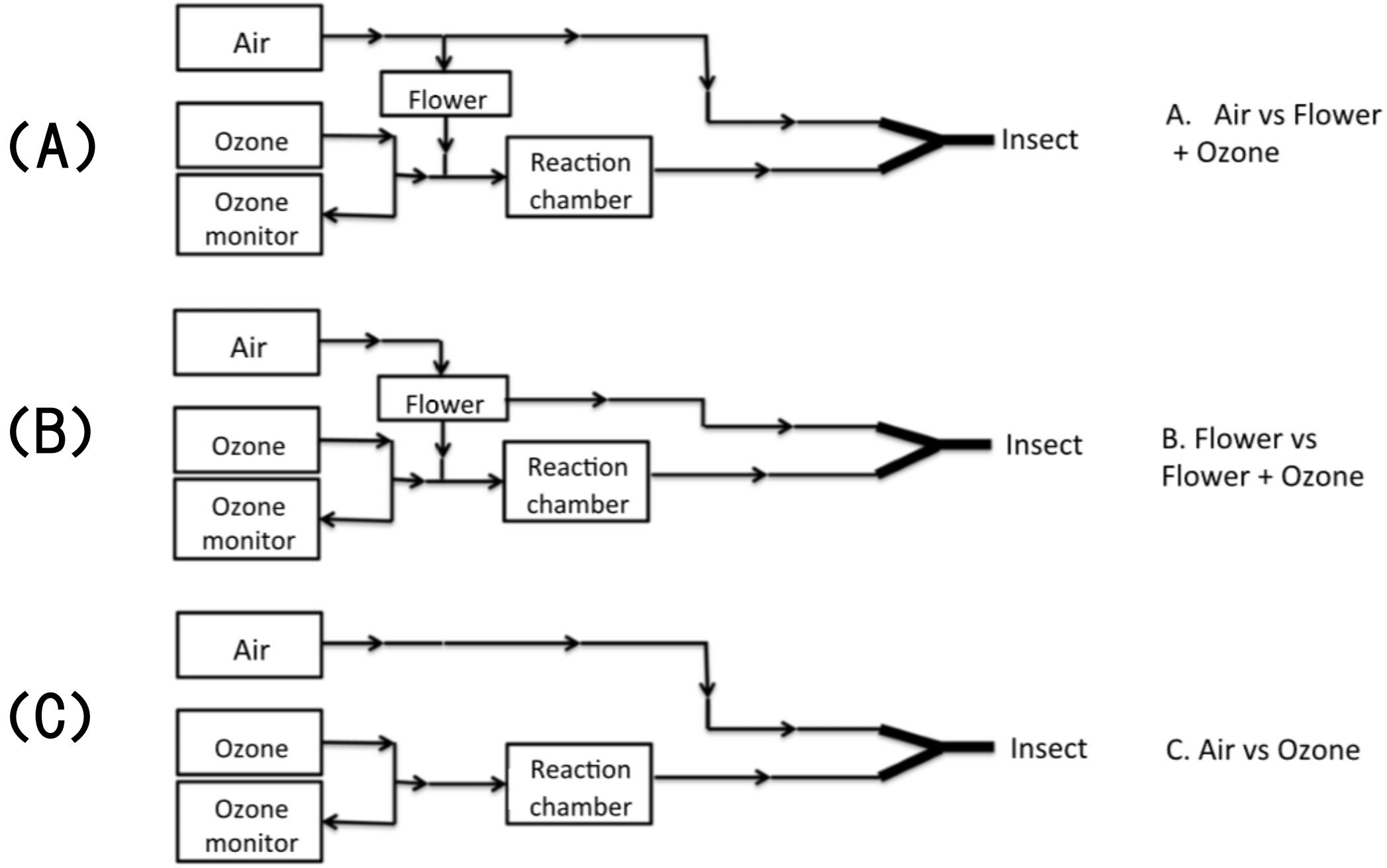

Figure 1. Y-tube experimental set up showing the arrangement of equipment during each of the three experiments.

Rules of experiment

- The Y-tube is rotated 180° about its axis after every trial
  - Prevent directional biases (caused background in the lab)
- Y-tube is covered with a small blanket to reduce visual cues
  - they choose secent only with their olfactory ability
- When a insect get to neither after 5min, that trial is discarded
  - (A) and (B):redo until 30completes
  - (C)redo until 20completes

Result (A)

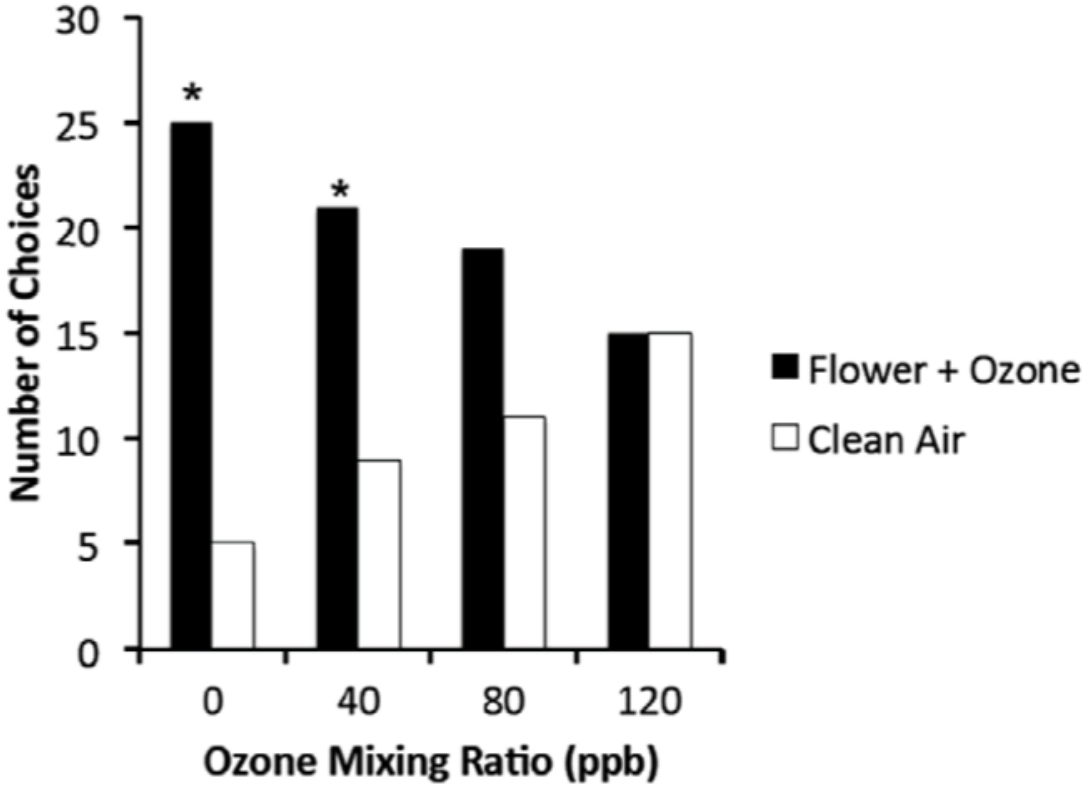

Figure 2. Y-tube choices by striped cucumber beetles when presented with ozonated floral volatiles versus clean air. Asterisks denote statistical significance (* indicates $p < 0.05$).

- Under 80ppb O3
  - SCBs chose flower + O3 air better
- Above 80ppb O3
  - their preference of clean air become not remacable.
  - as O3 concentration increased, SCBs no longer chose their host flower less frequently.

Discussion (A)

- SCBs preference leans toward “flower +ozone” at low O_3 level
  - VOCs were little reacted with O3, thus SCBs can detect their host plants.
- There is no difference between two air at high O_3 level
  - Almost VOCs were reacted, thus SCBs can`t detect.
    ->insect recognition is collapsed, or extremely inefficient

Result (B)

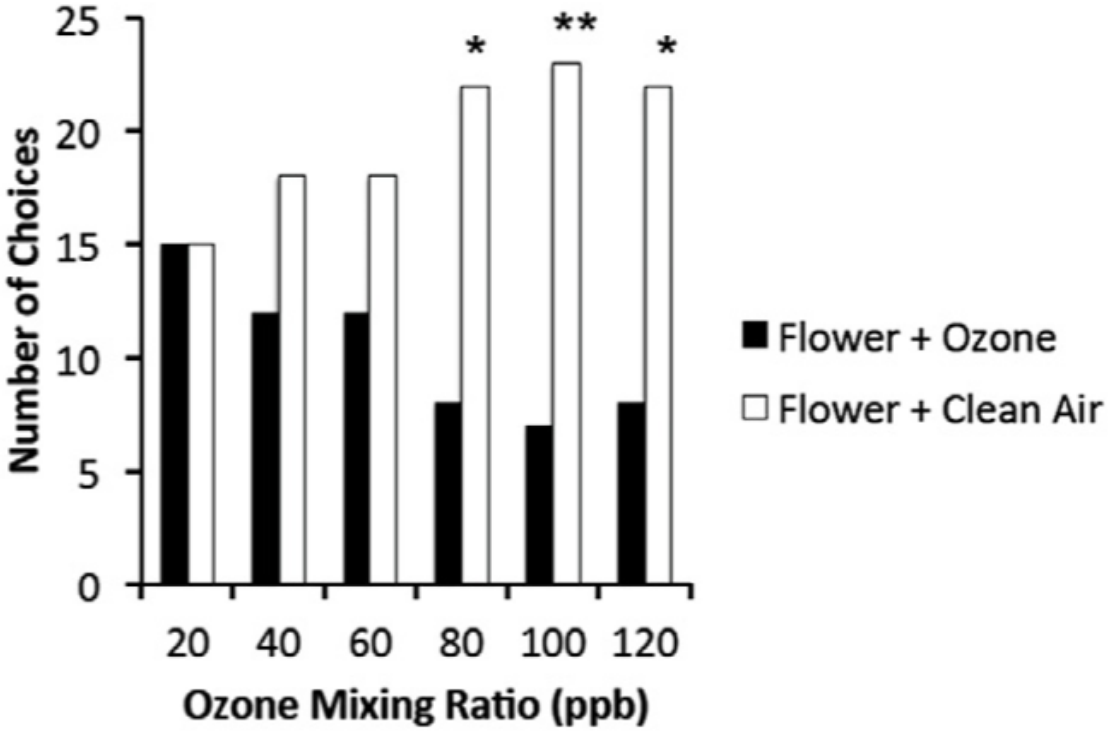

Figure 3. Y-tube choices by striped cucumber beetles when presented with ozonated floral volatiles versus non-ozonated floral volatiles. Asterisks denote statistical significance (* indicates $p < 0.05$, ** $p < 0.01$).

- Low O3 levels
  - choices of SCBs were random
- High O3 levels
  - Their choices became biased toward flower + clean air increasingly (particularly above 80 ppb)

Discussion (B)

- There is no difference between two air at low O_3 level
  - VOCs were little reacted with O3, thus both air have odor cues from flower

- SCBs preference leans to “flower + clean air” at high O_3 level
  - Almost VOCs were reacted, thus the cue remains only in “flower + clean air”

–>this result supports Discussion (A) - insect recognition is collapsed…

Result (C)

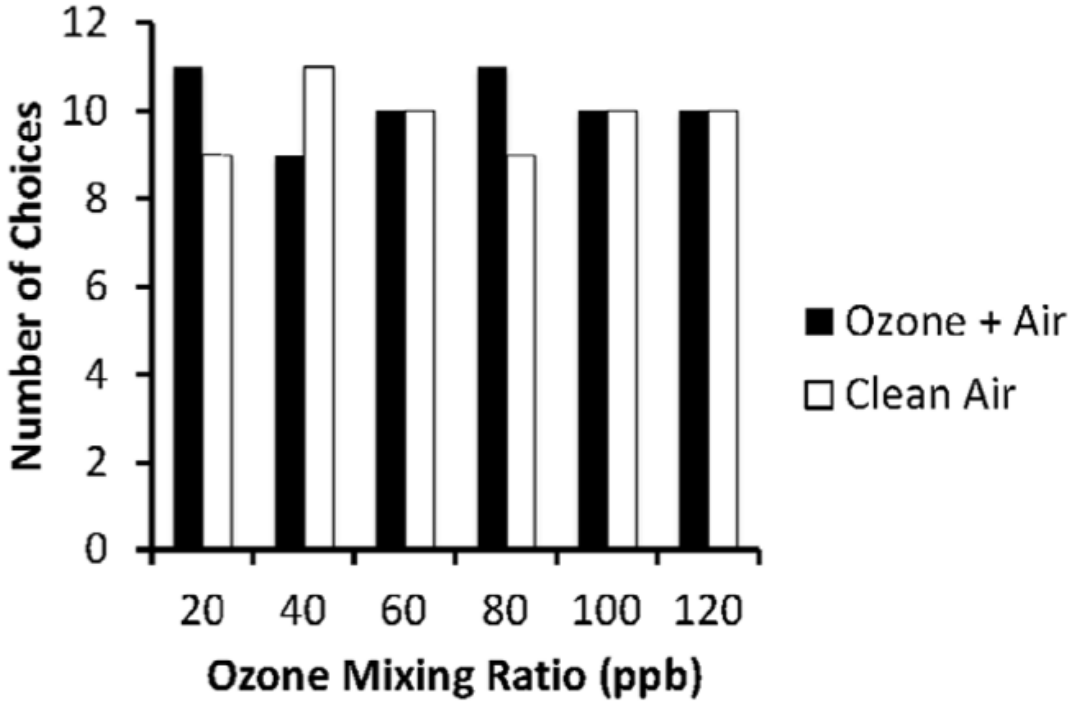

Figure 4. Y-tube choices by striped cucumber beetles when presented with ozonated air versus non-ozonated air.

- All O3 levels
  - SCBs showed no preferences to O_3

⇒SCBs may not respond to O_3 directly

Discussion (C)

- **O_3 itself didn`t influence movement behavior of SCBs at any level**
  - this indicate that O_3 is not related with SCBs preference

The primary factor is chemical destruction of floral VOCs
->O3 is not directly, but indirectly related through chemical reaction

low O_3 level : SCBs can locate their hosts by detecting floral VOCs
high O_3 level : SCBs can`t locate due to less floral VOCs

Points of attention

- smaller ozone levels may restrict SCBs detection limit in nature
  - In Y-tube, VOCs are moved along only one direction and short distance
  - In nature, VOCs are less concentrated due to division from long distance
- In nature, do VOCs actually disappear in elevated O_3 ?
  - In general, VOCs have positive feedback with O_3 (photoreaction)

  ->When O_3 level increased, VOCs also increase. Then, O3 are produced…
- At least, this study found that…

  SCBs show preference to VOCs and O3 doesn`t affect directly it.

Example : plant-herbivor relationship

- *Acacia*（アカシア）
  - damaged plant release methyl-jasmonate (MeJA) in neighboring
  ->Not-damaged plants synthesize tannin more in leaves
  ->herbivore, for instance Giraffe, can`t eat due to bitters of tannin
- *Brassica napus*（セイヨウアブラナ）
  - plant increase production of floral nectar, when damaged by herbivorous
  ->recruit natural enemies as their defense
  - damaged plants release VOCs that stimulate neighbors to do same action
  ->not-damaged plants can take a preventive measure on their own

Source

- Jose D Fuentes, Tai H Roulston, John Zenker (2013) Ozone impedes the ability of a herbivore to find its host. IOP Science, Environmental Research Letters
- C. Calfapietra, S. Fares, F. Manes, A. Morani, G. Sgrigra, F. Loreto (2013) Role of Biogenic Volatile Organic Compounds (BVOC) emitted by urban trees on ozone concentration in cities: A review. ELSEVIER, environmental pollution, 183, 71-80

Example

- SCBs as a pest is attracted to indole
  - Indole is reactive with ozone
- Squash bees as a pollinator is attracted to Cinnamaldehyde
  - Cinnamaldehyde is less reactive than indole

In this example…

SCBs may be more affected by ozone than Squash bees

-> but… both insects respond to 1,2,4-trimethoxybenzene, a intermediate reactive

-> both insects respond at least one compound when ozone level is not so high.