Is capsaicin toxic for insects?

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Consequences of chili domestication on plant-insect interactions

Effect of capsaicin on insect herbivores
Different plant traits have been targeted by the domestication process and diversification of chili pepper e.g.

- Fruit color, size and position
- Germination rate
- **Pungency level**
Introduction

Capsaicin C18H27NO3
Alkaloid specific to *Capsicum* genus
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Capsaicin C18H27NO3
Alkaloid specific to Capsicum genus

What about insects?

Bacteria: eg. Streptococcus pyogenes (Group A streptococci, GAS)

Fungi:

\[ \text{Fig 1. Relative growth rate of } Fusarium \text{ as a function of capsaicin (circles, solid line) and dihydrocapsaicin (squares, dashed line) concentrations.} \]

1. (Marini, Magi et al. 2015)
2. (Tewksbury, Reagan et al. 2008)
Research question?

What is the effect of capsaicin on the performance of generalist herbivores?

Spodoptera latifascia
Garden armyworm

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What is the effect of capsaicin on the performance of generalist herbivores?
**Experiment 1:** Herbivore performance on chili fruits

- Non pungent (Padron) => 0 SU*
- Mildly pungent (Cayenne) => 30 000-50 000 SU
- Highly pungent (Habanero) =>200 000- 350 000 SU

*N=20

*SU: Scoville Unit
Experiment 2: Herbivore performance on artificial diet spiked with capsaicin

- No capsaicin
- 20 ppm (mildly pungent)
- 200 ppm (highly pungent)

N=20
**Results:** Larval development on chili fruits with three pungency levels.

**S. latifascia**

- Non pungent
- Mild
- Highly pungent

**S. exigua**

- Non pungent
- Mild
- Highly pungent

\[ p = 0.472 \]

\[ p = 0.096 \]
**Results**: Pupation rate & pupae weight

Pupation rate of *S.latifascia*

- **Non pungent**: 80%
- **Mild**: 20%
- **Highly pungent**: 10%

Pupae weight of *S.latifascia*

- **Non pungent**: 600 mg
- **Mild**: 500 mg
- **Highly pungent**: 400 mg

**p=0.0013** **p=0.89**
**Results:** Pupation rate & adult emergence

Pupation rate of *S.latifascia*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Pupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non pungent</td>
<td>a</td>
</tr>
<tr>
<td>Mild</td>
<td>b</td>
</tr>
<tr>
<td>Highly pungent</td>
<td>b</td>
</tr>
</tbody>
</table>

Adult emergence of *S.latifascia*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Adult Emergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non pungent</td>
<td>a</td>
</tr>
<tr>
<td>Mild</td>
<td>b</td>
</tr>
<tr>
<td>Highly pungent</td>
<td>b</td>
</tr>
</tbody>
</table>

p = 0.0013 **

p < 0.001 ***

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**Results:** Mortality of *S. exigua*

*Chili peppers are not a suitable host for *S. exigua*.*

Feeding on highly pungent varieties, *S. exigua* died faster.

**Survival time**
- **Non pungent:** 30 days
- **Mild:** 27 days
- **Highly pungent:** 24 days

**p value =0.05**
- *a*
- *ab*
- *b*
Experiment 2: Herbivore performance on artificial diet spiked with capsaicin

0, 20 and 200 ppm of pur capsaicin
**Results:** Effect of capsaicin on larval development of herbivores.

*S.latifascia*

- No capsaicin
- 20 ppm
- 200 ppm

*P*=0.9668

*S.exigua*

- No capsaicin
- 20 ppm
- 200 ppm

*P*=0.9929
Results: Pupation rate

% pupation = (number of pupae/number of remaining larvae) * 100

S.latifascia

S.exigua

p=0.0091**

p=0.36
**Results:** Adult emergence

% adult emergence = \( \frac{\text{number of adults}}{\text{number of remaining larvae}} \times 100 \)

**S. latifascia**

- No capsaicin: 40%
- 20 ppm: 80%
- 200 ppm: 20%

**S. exigua**

- No capsaicin: 80%
- 20 ppm: 80%
- 200 ppm: 80%

- p = 0.0012**
- p = 0.4558

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Conclusions

- Overall capsaicin has a negative effect on herbivores especially at high concentration

*Pungent varieties:*
- Larval development was longer for *S.latifascia*.
- Pupation rate & negatively affects adult emergence of *S.latifascia*.
- Survival time of *S.exigua* larvae.

*Higher concentration of capsaicin (200 ppm)*
- Survival, pupation rate & adult emergence of *S.latifascia*.
- No effect on *S.exigua*. Capsaicin might not fully explain the reduction of survival time of larvae observed in the fruit experiment.

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### General conclusion

The chart illustrates the scoville heat units of various types of peppers and their corresponding pepper spray strengths. The chart shows a range from 0 to 15,000,000 scoville heat units, indicating the intensity of heat and pepper spray potency.

- **Better protected against insect herbivores**: Peppers with higher scoville heat units generally have a stronger chemical defense against herbivores.

- **More vulnerable to insect herbivores**: Peppers with lower scoville heat units are more susceptible to damage from insect herbivores.

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- Other compounds (carbohydrates, phenolics...) might be involved in chili plant-insect interactions.

- Consequence of domestication -> Correlated traits
Next steps

Effect of capsaicin on the third trophic levels?

Effect of capsaicin on the specialist herbivore Pepper weevil and its respective parasitoid?

Cotesia mariginiventris
Braconidae (endoparasitoid)

Euplectrus platyhypenae
Eulophidae (ectoparasitoid)

Pepper weevil
(Anthonomus eugenii)

Catolacus hunteri
Pteromalidae (endoparasitoid)

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