Pest Management and Plant Defense: *Myzus cerasi* and Extrafloral Nectaries in Cherry

Marcella Venettozzi[1], Victoria Meakem[2], Benjamin Gutierrez[2]

[1]Department of Biochemistry, Hobart and William Smith Colleges, Geneva, NY 14456
[2]United States Department of Agriculture – Agricultural Research Service, Plant Genetic Resources Unit, Geneva, NY 14456

Introduction

The black cherry aphid (*Myzus cerasi*) is a pest in cherries that causes reduced fruit production, fungal growth, and curling leaves during severe infestations. Aphids show preference for sweet cherry (*Prunus avium*) over wild cherries and tart cherry (*P. cerasus*), a hybrid between sweet and wild dwarf cherry. The reason behind aphids' preference for sweet over tart cherries remains unknown. This project explores the chemical differences between wild, sweet, and tart cherry leaves and identifies volatiles that may be responsible for the deterrent nature of tart cherry.

Figure 1
Aphid infestation in a tart cherry tree. Leaves become splotched with yellow, with an almost 'puffy' appearance.

Figure 2
Aphid infestation in a sweet cherry tree. The leaves shrivel and curl inward, protecting the aphids from pesticides.

Extrafloral nectaries (EFN) are nectar-producing glands located outside the flower that have been observed in various species, including cherry. These glands play a role in plant defense and pest management by attracting ants, leading to a mutually beneficial relationship as ants remove other harmful insects. Previous studies have indicated that increased herbivory damage can induce plant defenses and boost EFN abundance and nectar production. This project investigates changes in EFN abundance and surface area over four months in sweet, tart, and wild cherry species.

Figure 3
Sweet cherry extrafloral nectaries; 'Ulster' imaged 7/17/23

Figure 4
Tart cherry extrafloral nectaries; 'Montmorency' imaged 7/17/23

Figure 5
Wild cherry extrafloral nectaries: *P. nipponica* imaged 7/17/23

Materials and Methods

Volatile Quantification

- Healthy and aphid-infested leaves from sweet, tart and wild species were collected from the USDA Tart Cherry Collection
- Leaves were rinsed with water to rid them of aphids and pesticide residue, frozen in liquid nitrogen, and ground using a MiniG ® Tissue Homogenizer at 1500rpm for 45 seconds. Leaves were kept frozen after grinding to preserve tissue chemistry.
- 1g of each sample was added into a glass vial with 2mL of buffer solution and 0.2g of NaCl (Materese et al. 2014)
- Samples were then analyzed using solid-phase microextraction (SPME) on a gas chromatograph-mass spectrometer (GC-MS) (Materese et al. 2014)

Nectary imaging

- Six leaves from sweet, tart, and wild species were collected from the USDA Tart Cherry Collection on five dates ranging from 4/26/23 to 7/17/23.
- Leaf nectaries were imaged using a Dino-Lite Digital Microscope
- Measurements of nectary surface area and abundance were conducted using ImageJ

Results

To determine differences among species and infestation groups, ANOVA and Tukey HSD tests were preformed on each volatile compound. Benzaldehyde peak area in wild species was significantly greater ($p<0.001$) than sweet and tart species. Trans β ionone peak area was significantly higher in healthy tart tissue than in healthy wild tissue ($p=0.008$). Benzopyran was only present in tart cherries and differed significantly between groups ($p=0.025$), although pairwise comparisons were not significant (all $p>0.05$; Fig. 7). Differences in α-terpineol peak area between groups was found to be insignificant by ANOVA (0.056), but this may be due to low sample size.

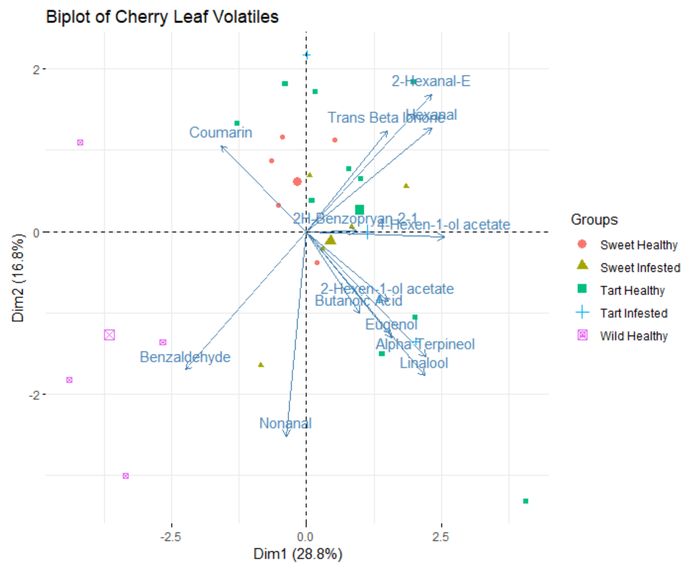

Figure 6
PCA biplot of volatile compounds found within sweet tart and wild cherry species.

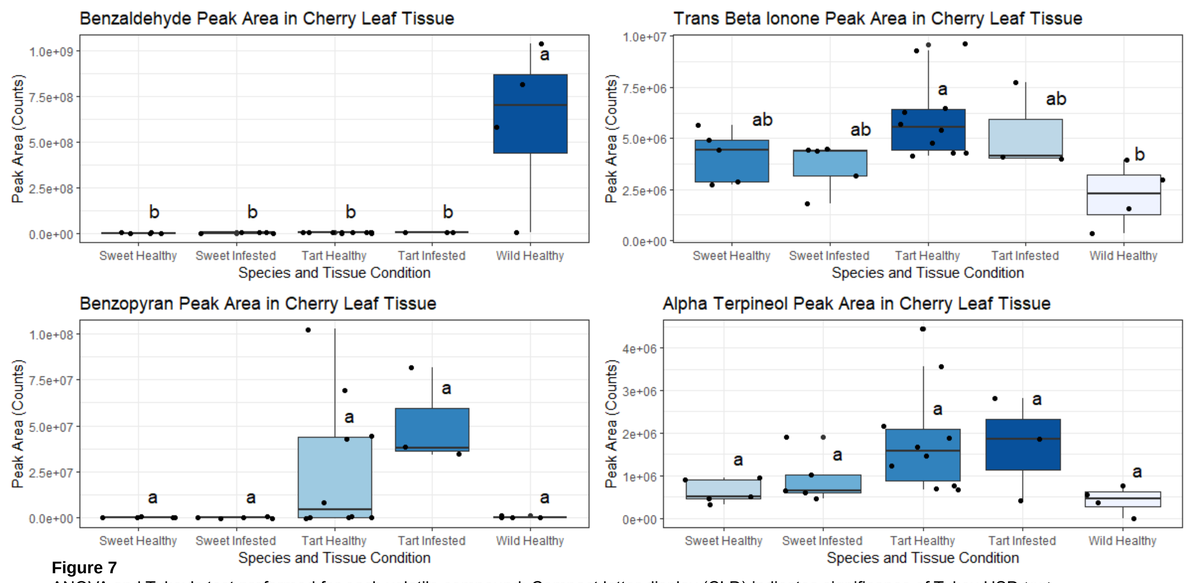

Figure 7
ANOVA and Tukey's test preformed for each volatile compound; Compact letter display (CLD) indicates significance of Tukey HSD test.

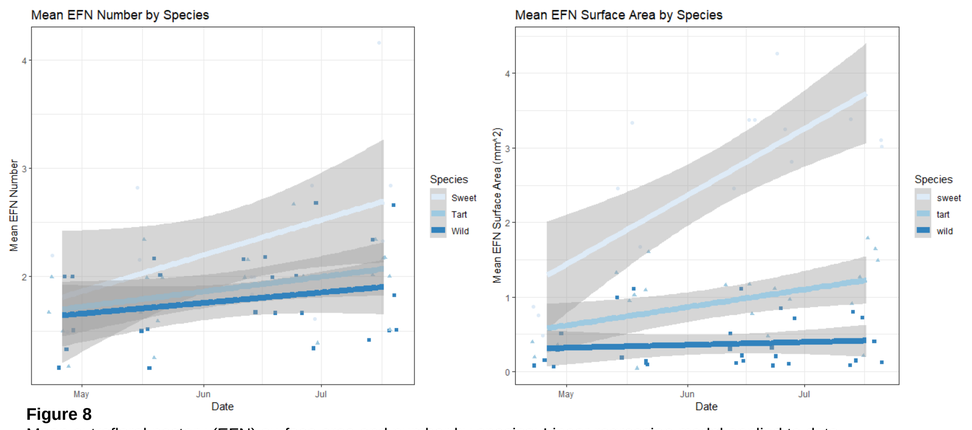

Figure 8
Mean extrafloral nectary (EFN) surface area and number by species; Linear regression model applied to data

Linear regression of mean surface area data showed sweet cherry nectaries are significantly larger than tart and wild nectaries (all $p<0.05$, Fig. 8). Linear regression of mean nectary number showed sweet cherry had significantly more nectaries per leaf than tart or wild species ($p_T = 0.038$, $p_W = 0.004$).

Conclusions

Results revealed that benzopyran was present in some tart cultivars but absent in sweet and wild species. Studies have found this compound, along with α-terpineol, to be a highly effective aphicide, suggesting that its presence in tart cherry leaves makes them undesirable hosts (Pavela et al. 2021, Dardouri et al. 2019). Trans β ionone, found to be significantly higher in healthy tart tissue, was found to play a significant factor in how some insects select egg-laying sites, deterring insects and preventing egg-laying (Li et al. 2019). Wild species showed a high concentration of benzaldehyde, a flavoring compound found in almond and cherry extracts. The abundance of benzaldehyde may be offensive to aphid olfactory receptors, explaining the lack of aphid infestation on wild species (Hardie et al. 1994, Ullah et al. 2015). This research has the potential to inform pest management strategies for sweet and tart cherry orchards.

The significant difference in mean surface area and abundance between species may be due to a higher level of herbivory taking place on sweet cherry. Previous studies have found that increased stress from herbivory increases EFN size, abundance, and EFN production (Jones et al. 2017). Alternatively, size and abundance discrepancy may be due to genetic differences. More research is needed to further explain these differences.

References

Tarek Dardouri, Laurent Gomez, Alexandra Schoeny, Guy Costagliola, Hélène Gautier. Behavioural response of green peach aphid Myzus persicae (Sulzer) to volatiles from different rosemary (Rosmarinus officinalis L.) clones. Agricultural and Forest Entomology, 2019, 21 (3), pp.336-345. ff10.1111/afe.12336ff. ffhal-02267846f

Ullah I, Khan AL, Ali L, Khan AR, Waqas M, Hussain J, Lee IJ, Shin JH. Benzaldehyde as an insecticidal, antimicrobial, and antioxidant compound produced by Photorhabdus temperata M1021. J Microbiol. 2015 Feb;53(2):127-33. doi: 10.1007/s12275-015-4632-4. Epub 2015 Jan 28. PMID: 25626368.

Song X, Qin YG, Yin Y, Li ZX. Identification and Behavioral Assays of Alarm Pheromone in the Vetch Aphid Megoura viciae. J Chem Ecol. 2021 Sep;47(8-9):740-746. doi: 10.1007/s10886-021-01297-4. Epub 2021 Aug 4. PMID: 34347235.

Li F, Li D, Dewer Y, Qu C, Yang Z, Tian J, Luo C. Discrimination of Oviposition Deterrent Volatile β-Ionone by Odorant-Binding Proteins 1 and 4 in the Whitefly *Bemisia tabaci*. Biomolecules. 2019 Oct 3;9(10):563. doi: 10.3390/biom9100563. PMID: 31623354; PMCID: PMC6843521.

Pavela R, Maggi F, Benelli G. Coumarin (2H-1-benzopyran-2-one): a novel and eco-friendly aphicide. Nat Prod Res. 2021 May;35(9):1566-1571. doi: 10.1080/14786419.2019.1660334. Epub 2019 Sep 11. PMID: 31507220.

Matarese F, Cuzzola A, Scalabrelli G, D'Onofrio C. Expression of terpene synthase genes associated with the formation of volatiles in different organs of Vitis vinifera. Phytochemistry. 2014 Sep;105:12-24. doi: 10.1016/j.phytochem.2014.06.007. Epub 2014 Jul 7. PMID: 25014656.

Acknowledgments

I would like to thank the following individuals for their contributions to this project: Erin Galarneau, Sam Page, Abe Porschet, Anna Cohen, and Johnny Aponte. Their assistance with sample collection and data analysis has been instrumental in the success of this project. Additionally, a special thank you is owed to Patricia Mowery and Hobart and William Smith Colleges. It is through the HWS summer research program that I was granted the opportunity for this internship, which has been an enriching and transformative experience. Their support and belief in my potential have been pivotal in shaping the trajectory of my academic and professional journey.