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All Leaves Are Not Created Equal: Variation Among Leaves in Chemical Defenses and Nutritional Quality

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Abstract

Coevolution among plants and herbivores has led to variation in plant defenses and herbivore foraging. Plants must defend against herbivores, whereas herbivores must find ways to overcome plant defenses and meet nutritional needs. Variation in plant quality is important because it can influence selection of plants by herbivores for food. Few studies have investigated the variation occurring within a single plant. Sagebrush offers an excellent system for studying the variation in dietary and chemical quality within a plant. First, variation in nutrition and chemical content exists between subspecies (Kelsey 1982) and between plants of a single subspecies of sagebrush from different geographic locations (Welch 1981). Second, sagebrush has two types of leaves, ephemeral and persistent, and our preliminary data demonstrates that pygmy rabbits prefer ephemeral over persistent leaves leaf types indicating leaf types differ in quality.

All leaves are not created equal: Variation among leaves in chemical defenses and nutritional quality

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Background

Coevolution among plants and herbivores has led to variation in plant defenses and herbivore foraging. Plants must defend against herbivores, whereas herbivores must find ways to overcome plant defenses and meet nutritional needs. Variation in plant quality is important because it can influence selection of plants by herbivores for food. Few studies have investigated the variation occurring within a single plant. Sagebrush offers an excellent system for studying the variation in dietary and chemical quality within a plant. First, variation in nutrition and chemical content exists between subspecies (Kelsey 1982) and between plants of a single subspecies of sagebrush from different geographic locations (Welch 1981). Second, sagebrush has two types of leaves, ephemeral and persistent, and our preliminary data demonstrates that pygmy rabbits prefer ephemeral over persistent leaves indicating leaf types differ in quality.

Objectives and Hypothesis

Objective: Compare the dietary quality of different leaf types which may influence diet selection by herbivores.

1) Chemical Quality

Examine chemical defenses

2) Nutritional Quality

Examine protein content

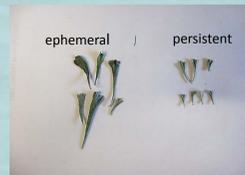
Hypothesis: Ephemeral leaves are lower in chemical defenses and higher in nutrient quality than persistent leaves.

Methods

1. Collected branches of sagebrush and divided leaves according to type: ephemeral or persistent.



Leaves on branch



Leaves separated

2. One portion of leaves was analyzed for terpenes using gas chromatography and phenolics using a colorimetric assay.

3. The other portion of leaves was analyzed for protein using an in-vitro digestion and the Kjeldahl method.

4. Parameters were compared between ephemeral and persistent leaves using paired t-tests.



In vitro digester

Ephemeral Leaves are of Better Quality

Chemical Quality

- Persistent leaves have significantly higher concentrations of monoterpenes (Figures 1 & 2) and phenolics (Figure 3).

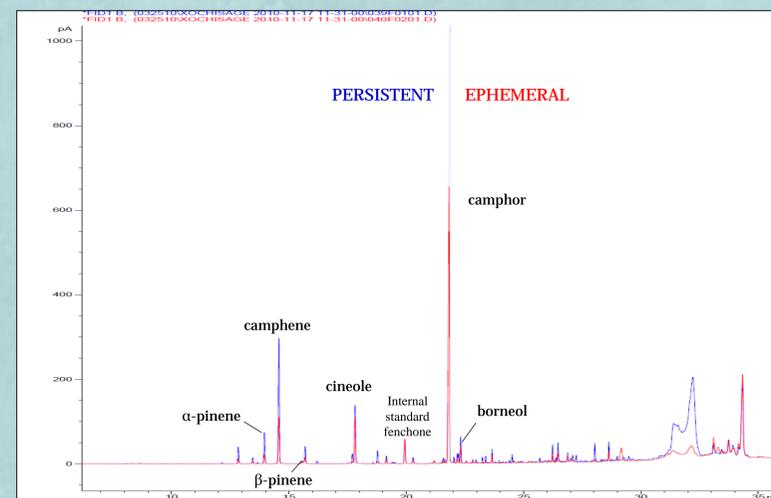


Figure 1: A representative chromatogram of monoterpene concentrations for persistent (blue) and ephemeral (red) leaves. All compounds except cineole were found to be at significantly higher levels in persistent leaves.

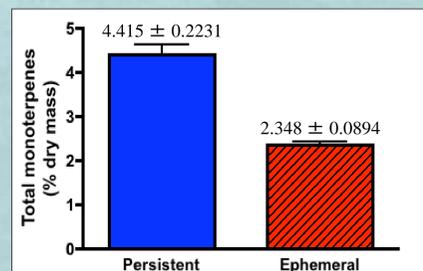


Figure 2: Mean % monoterpenes in persistent and ephemeral sagebrush leaves ($P < 0.0001$).

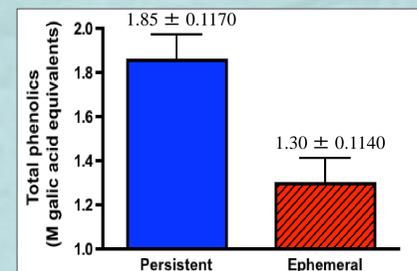


Figure 3: Mean total phenolics (in M gallic acid equivalents) in persistent and ephemeral sagebrush leaves ($P < 0.0001$).

Nutritional Quality

- Ephemeral leaves have significantly higher levels of digestible crude protein and higher water content.

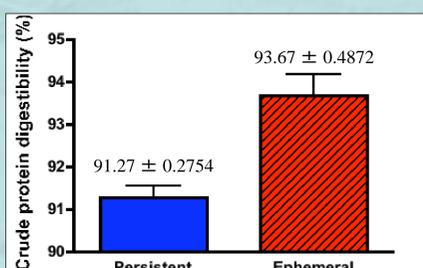


Figure 3: Mean % digestible crude protein in persistent and ephemeral sagebrush leaves ($P = 0.0002$).

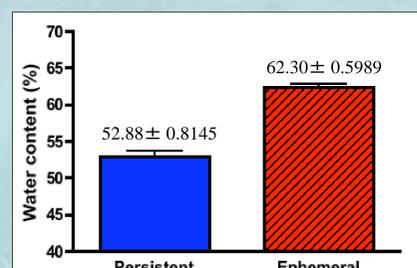


Figure 4: Mean % water content in persistent and ephemeral sagebrush leaves ($P < 0.0001$).

Discussion

Results show that ephemeral leaves are lower in chemical defenses and are of higher nutritional quality. For these reasons, ephemeral leaves should be more palatable to herbivores. This variation among leaves within a plant contributes to the known variation that exists in sagebrush between sites, species and subspecies. Variation within a plant may have various ecological implications for both herbivores and plants:

Implications for herbivores

- 1) As herbivores forage, they are concerned about food quality as well as exposure to predators. Higher quality food should reduce the time spent foraging, thus reducing predation risk.
- 2) The proportion of quality food present on the plant will influence how herbivores feed. During winter, only persistent leaves are present, whereas both leaf types are present in spring.
 - Herbivores should prefer sagebrush in the spring. However, during this time, other vegetation such as grasses of higher quality are abundant and therefore may be preferred.
 - Herbivores consuming sagebrush in winter, such as pygmy rabbits, are forced to select among the low quality persistent leaves.

Implications for plants

- 1) A mix of high and low quality leaves within a plant may deter herbivores more than plants with homogenous leaf quality.
- 2) Since co-occurring persistent leaves are already highly chemically defended, plants may reduce energy invested in defending higher quality ephemeral leaves.

Conclusion

Knowing the variation of nutritional and chemical qualities of a plant provides important information in determining how different scales of variation in vegetation drive foraging behavior. By knowing this, we will have a better understanding of animal and plant interactions which is useful in the areas of land management and conservation.

Literature Cited

Kelsey, R.G., et al. 1982. *Journal of Range Management*, 35: 617-622.
Welch, B.L., McArthur, E.D. 1981. *Journal of Range Management*, 34: 380-384.

Acknowledgements

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