

# Effects of herbivory and non-growing seasonality on plant secondary metabolites: a meta-analysis

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## Abstract

Plant secondary metabolites (PSMs) are produced by plants to overcome environmental challenges, both biotic and abiotic. We were interested in characterizing how non-growing seasonality in temperate climates affects overall PSM production in comparison to herbivory. Typically, herbivory is measured from spring to summer when plants have high resource availability and are prioritizing growth and reproduction. However, autumn seasonality also challenges plants as they cope with limited resources and prepare survival for winter. Using meta-analysis, we recorded overall PSM concentrations across 22 different PSM classes from 58 published papers, as well as compared concentrations of five phenolics PSM classes – hydroxybenzoic acid, flavan-3-ol, flavonol, hydrolysable tannin, and condensed tannin. We then calculated effect sizes for herbivory (absence to presence) and seasonality (growing to non-growing), while considering other variables (e.g., plant type, time after herbivory, temperature, and precipitation). We found that neither herbivory nor seasonality affect overall PSM production. However, we discovered different trends among the individual phenolics classes, including herbivory having a positive effect on flavonol production and non-growing seasonality having a positive effect on flavan-3-ol and condensed tannin production. We discuss how these responses stem from three factors: 1. some PSMs are constitutively produced by plants whereas others are induced only during herbivory or non-growing seasonality, 2. plants produce metabolites with higher costs only during seasons when other resources for growth and reproduction are less available, and 3. some PSM classes serve more than one function for plants and such functions can be season-dependent. The final outcome of our meta-analysis is that non-growing seasonality does affect PSM production differently from herbivory, and we therefore see value in further investigating how non-growing seasonality impacts interactions between PSM production and herbivory.

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