

Genetic Variation of Piperidine Alkaloids in *Pinus ponderosa* From a Common Garden

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Abstract

Most species of pine and spruce synthesize and accumulate variable quantities of alkaloids in their tissues. These compounds express numerous types of biological activities in bioassay and could potentially offer resistance against enemies, although this function has never been confirmed for any known enemies of pine or spruce under natural conditions. The present study takes a complementary, and intensive, common garden approach to examine genetic variation in *Pinus ponderosa* Lawson & C. Lawson var. *ponderosa* C. Lawson alkaloid production. It also investigates the potential trade-off between seedling growth and alkaloid production, and associations between topographic/climatic variables and alkaloid production. Piperidine alkaloids were quantified in foliage of 501 nursery seedlings grown from seed sources in west-central Washington, Oregon, and California, roughly covering the western half of the native range of ponderosa pine. A nested mixed model was used to test differences among broad-scale regions and among families within regions. Alkaloid concentrations were regressed on seedling growth measurements to test metabolite allocation theory. Likewise, climate characteristics at the seed sources were also considered as explanatory variables.

Qualitative variation in alkaloid profiles was low. However, quantitative variation from seedling to seedling was high, and regional variation exceeded variation among families. Regions along the western margin of the species range exhibited the highest alkaloid concentrations, while those further east had relatively low alkaloid levels. All measures of seedling growth related negatively to alkaloid concentrations on a natural log (ln) scale; however, coefficients of determination were low. At best, annual height increment explained 19.4 percent of the variation in ln(total alkaloids). Among the climate variables, temperature range showed a negative, linear association that explained 41.8 percent of the variation. Given the wide geographic scope of the seed sources and the uniformity of resources in the seedlings' environment, observed differences in alkaloid concentrations are evidence for genetic regulation of alkaloid secondary metabolism in ponderosa pine. The theoretical trade-off with seedling growth appeared to be real, however slight. The climate variables provided little evidence for adaptive alkaloid variation, especially within regions. This study has been published in full (Gerson, E.A.; Kelsey, R.G.; St Clair, J.B. 2009. Genetic variation of piperidine alkaloids in *Pinus ponderosa*: a common garden study. *Annals of Botany*. 103: 447–457.).

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