The effects of large-scale N fertilization on the interaction between plants and herbivorous insects in a deciduous broad-leaved forest

The increased atmospheric deposition of nitrogen (N) may indirectly affect herbivorous insects by deposition-induced changes in host traits and composition. To avoid the “lamp effect” that can occur in small-scale N fertilizations, large-scale N fertilization (ca. 9 ha, 100 kg N ha\(^{-1}\) year\(^{-1}\)) experiments were performed in a deciduous broad-leaved cool temperate forest.

To estimate the effects of the relationship between plants (oak species, *Quercus crispula* and alder species, *Aluns hirusta*) and its herbivorous insects to the N fertilization, plant traits and their herbivorous insects were investigated in each tree for 3 years including before N fertilization. In oak species, in 2013 but not 2014, N fertilization increased N content and decreased the C/N ratio in leaves. Despite these changes in plant traits in 2013, N fertilization had no effect on herbivorous insects in the same year. However, in 2014, the only diversity index decreased significantly. This suggested that species-specific responses to changes in leaf qualities following N fertilization, in the form of altered insect fecundity, impact the diversity index of herbivorous insects, albeit with a 1-year lag time. Thus, a large-scale N fertilization experiment showed the time-delayed bottom-up effects of N fertilization on insect community structure. In alder species as a N\(_2\)-fixing plant, the N fertilization decreased LMA of leaf traits, and increased chewing herbivory and decreased galler density at the same time, although leaf traits (N and condensed tannin) remained unchanged. Moreover, chewing herbivory significantly increased with decreasing LMA. This suggested that the N fertilization affected chewing herbivory through the change in LMA of alder species. Thus, it implies that N\(_2\)-fixing plants in the same with other plants (e.g., non-N\(_2\)-fixing plants) under elevated N deposition will lead to greater feeding activities of chewing herbivory without the change in leaf nutrients (N and C-based defensive metabolites).

To examine whether “neighborhood tree composition” and “resource availability” influence the stability of herbivorous insects on a focal plant (oak species), I focused on resource concentrations (tree diversity, tree richness, density, and frequency of conspecific species) surrounding the focal plants and responses to the large-scale N fertilization. Oak dominancy increased the stability of galler’s community in only control site, although it did not affect the stability of chewing insects’ communities both control and fertilized sites. It suggested that the mechanism driving the diversity-stability relationships might have
species-specific response, and N deposition might disturb a positive relationship between stability of galler’s community and oak dominancy.

In conclusion, the effects of large-scale N fertilization on the plant-insect interactions were verified by field manipulation experiment, that the interactions were driven by plant traits. In addition, across tree composition, particularly the increase in conspecific species, the N fertilization disturbed the stabilities of herbivorous insects. These results will shed light on the plant-insect interaction under the global environmental change.