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Preface: Induced Resistance from Theory to Practice

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It has been more than 50 years since Green and Ryan (1972) demonstrated that tomato and potato plants respond to feeding by Colorado potato beetles by rapidly accumulating high levels of proteinase inhibitors throughout the plant. Since that time, the study of herbivore-induced biochemical and morphological changes in plants and the increases in resistance to herbivores that often accompany these changes has become one of the most active and dynamic areas of chemical ecology. Herbivore-induced plant responses have been found in virtually all plants in which they have been investigated, and a wide array of resistance-related morphological, biochemical, and physiological traits have been implicated in induced resistance (Karban 2015). Tremendous progress has been made in understanding many aspects of herbivore-induced responses and induced resistance, including perception of herbivore attack, early signaling following attack, phytohormonal mediation of responses, involvement of higher trophic levels in induced resistance, and coordinated changes in primary and secondary metabolism that allow plants to recover from herbivore injury. However, much remains to be discovered. Importantly, the application of herbivore-induced responses to protect crop plants is an area in which insufficient progress has been made.

This collection was developed to highlight papers at the leading edge of thought and practice in herbivore-induced responses. The papers included in the collection cover a wide variety of topics. Some of the papers serve as reminders that much basic information about the resistance-related arsenals and induced responses of plants remains to be discovered. Luo et al. (2023), for example, characterize 16 compounds, including a new isopentenyl disaccharide, from the latex of damaged *Euphorbia jolkinii*. Musso et al. (2023) describe terpene responses in the phloem of two *Pinus* species, lodgepole and jack pine, following attack by mountain pine beetles (*Dendroctonus ponderosae*), a pest of forests that has only recently expanded its range into regions where jack and lodgepole pines are present. Costan et al. (2023) investigate the resistance-related arsenals of the roots and shoots of three *Rumex* species from the United Kingdom (native range) and New Zealand (introduced range), and found that levels of oxalates, tannins, and phenols did not differ substantially between the native and introduced ranges, despite lower levels of herbivory in the introduced range.

Several of the papers in this collection place induced responses in larger context by comparing the influence of herbivore-induced responses with the influence of various other drivers of variation in plant chemistry and plant resistance, including plant genotype, environmental factors, and plant ontogeny. Among these, Chappuis et al. (2023), document the importance of growing conditions and plant and leaf ontogeny in determining the strength of constitutive and inducible resistance in two species of cotton, and Lindroth et al. (2023) and Rubert-Nason et al. (2023) explore the interplay of genotypic, ontogenetic, and environmental factors (including herbivory) in determining levels of foliar nitrogen, phenolic glycosides, and various types of condensed tannins in *Populus tremuloides*. Mason et al. (2023) and Valle et al. (2023) explore interactions among herbivore-induced responses and natural enemies of herbivores - an opportunistic bacterial entomopathogen and lacewing larvae, respectively - highlighting an area of intense interest over the past three decades. Other papers report on under-studied but potentially significant phenomena involving induced resistance. Bustos et al. (2022), for example, demonstrate intergenerational effects of aphid-induced resistance in *Lolium multiflorum* plants harboring fungal endophytes. Schnurrer and Paetz (2023) provide an example of the countermeasures used by some insects to overcome the toxic effects of induced secondary metabolites, specifically the mechanisms used by several species in the Notodontidae to detoxify salicortinoids in their poplar and willow hosts.

With respect to the application of induced resistance to crop protection, Poelman et al. (2023) present a useful overview of the relevance and applicability of ecological theories

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of induced responses to resource-intensive agriculture and discuss the potential for induced resistance to contribute to more sustainable ecology-based cropping systems. Gökalp (2023) reports on the interactions of two secondary metabolites from marigold, α-terthienyl and quercetagetin, with receptors in whiteflies and nematodes, information relevant to the use of these compounds as natural insecticides.

It is our sincere hope that this collection stimulates further thought and research on the importance, ecological role, and practical application of induced responses in plants.

References

Bustos LMB, Ueno AC, Biganzoli F et al (2022) Can Aphid Herbivory Induce Intergenerational Effects of Endophyte-conferred Resistance in Grasses? J Chem Ecol 48:867–881. https://doi.org/10.1007/s10886-022-01390-2

Chappuis L, Egger A, Roeder G et al (2023) Experimental growth conditions affect direct and indirect defences in two cotton species. J Chem Ecol. https://doi.org/10.1007/s10886-023-01422-5

Costan CA, Godsoe W, Bufford JL et al (2023) Comparing the above and below-ground chemical defences of three rumex species between their native and introduced provenances. J Chem Ecol. https://doi.org/10.1007/s10886-023-01427-0

Gökalp F (2023) A study on natural control against nematodes and whiteflies with marigold, known as an Antagonist plant. J Chem Ecol. https://doi.org/10.1007/s10886-023-01421-6

Green TR, Ryan CA (1972) Wound-induced proteinase inhibitor in plant leaves: a possible defense mechanism against insects. Science 175(4023):776–7. https://doi.org/10.1126/science.175.4023.776

Karban R (2015) Plant sensing & communication. The University of Chicago Press, Chicago, 240 pp

Lindroth RL, Wooley SC, Donaldson JR et al (2023) Phenotypic variation in phytochemical defense of trembling aspen in Western North America: genetics, development, and geography. J Chem Ecol. https://doi.org/10.1007/s10886-023-01409-2

Luo S, Huang C, Hua J et al (2023) Defensive specialized metabolites from the latex of *Euphorbia jolkinii*. J Chem Ecol. https://doi.org/10.1007/s10886-023-01413-6

Mason CJ, Peiffer M, Hoover K et al (2023) Tomato chemical defenses intensify corn earworm (*Helicoverpa zea*) mortality from opportunistic bacterial pathogens. J Chem Ecol. https://doi.org/10.1007/s10886-023-01420-7

Musso AE, Fortier C, Huber DPW et al (2023) Naïve pine terpene response to the mountain pine beetle (*Dendroctonus ponderosae*) through the seasons. J Chem Ecol. https://doi.org/10.1007/s10886-023-01418-1

Poelman EH, Bourne ME, Croijmans L et al (2023) Bringing fundamental insights of induced resistance to agricultural management of herbivore pests. J Chem Ecol. https://doi.org/10.1007/s10886-023-01432-3

Rubert-Nason KF, Yang P, Morrow CJ et al (2023) Environment and genotype influence quantitative and qualitative variation in condensed tannins in aspen. J Chem Ecol. https://doi.org/10.1007/s10886-023-01430-5

Schnurrer F, Paetz C (2023) Reductive conversion leads to detoxification of salicortin-like chemical defenses (Salicortinoids) in Lepidopteran specialist herbivores (Notodontidae). J Chem Ecol. https://doi.org/10.1007/s10886-023-01423-4

Valle D, Mujica V, Gonzalez A (2023) Herbivore-dependent induced volatiles in pear plants cause differential attractive response by lacewing larvae. J Chem Ecol. https://doi.org/10.1007/s10886-023-01403-8