COMMENTARY

Pest pressure relates to similarity of crops and native plants

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Since the Green Revolution, scientists have documented countless unanticipated consequences of widespread pesticide use in agriculture. These consequences are balanced by the growing necessity to manage agricultural pests. The trade-offs have motivated research to produce inexpensive and accessible food while simultaneously improving the sustainability of agriculture from field to fork. Although decades of research inform our understanding of relationships between pests, crops, and pesticides, the general systemic drivers and patterns of crop-specific pesticide use remain unclear. Understanding fundamental ecological factors that motivate pesticide use on crops is a key knowledge gap that perpetuates this ongoing dependence on pesticides. Pearse and Rosenheim (1) study several general drivers of pest pressure and associated pesticide use in California, one of the most intensive agricultural production regions worldwide. Because of the immense crop diversity and accessible data about the pesticide inputs used on those crops, the authors are able use this complex agricultural system as a test bed to ask whether pest pressure and pesticide use on agricultural crops are related to the evolutionary distance between important crop plants and their native relatives growing in noncrop areas of California (1).

This study (1) builds on a growing body of evidence that the phylogenetic structure of plant communities can have predictable impacts on pests and diseases of plants in managed and natural systems (2–5). Pearse and Rosenheim examine economic crop value and evolutionary history to describe the numbers of arthropod pest and crop pathogen species affecting each crop in the study region. To do this, they investigate 93 major annual and perennial Californian crops (>600-ha average area) and link economic crop value, plant community ecology, and phylogenetic relationships to describe crop-specific pest pressure and associated pesticide use (1, 6). Findings show that phylogenetic distance between crops and their closest relative in the native plant community was negatively associated with pesticide inputs (1). This result suggests phylogenetic escape in which the number of arthropod pests species associated with a crop decreased with increasing phylogenetic distance between the crop species and their closest native relative in California. Direct measures of crop-specific pest communities confirmed this relationship for arthropod pest species, but not for crop pathogens. Fungicide and insecticide use were positively associated with crop value.

This study (1) builds on prior research on resistance of natural plant communities to invasion by nonnative plants. Numerous but not all such studies have found that nonnative plants with close relatives in their new range are less likely to invade than those that lack close relatives (7). Interplant competition influencing plant community dynamics is regulated by many abiotic and biotic factors. Release from herbivores and pathogens via greater phylogenetic distance between invaders and native plants is one factor influencing success. The putative mechanism underlying this relationship is based on abundant evidence that phytophagous insects and plant pathogens are more likely to be shared among close than distant relatives (4, 7) and the assumption that release from damage due to higher herbivore and pathogen pressure renders invading plants more competitive with native plants.

Because most agricultural crops are derived from nonnative plants (8), and crops are protected from competition by human interventions in the form of cultural practices and pesticides, Pearse and Rosenheim (1) are able to apply the same conceptual framework and use a phylogenetic ecology approach (4, 9) to examine broad patterns of crop-specific pest and pathogen pressure and associated pesticide use. Because pesticide use has been shown to relate strongly to crop value in many studies, including a

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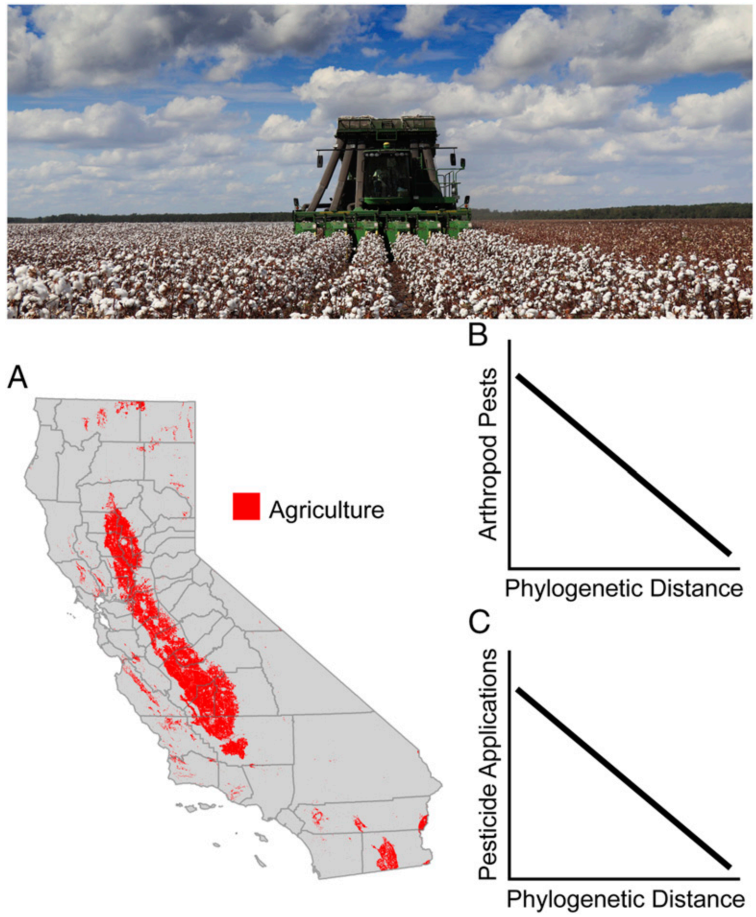

Fig. 1. **Pest and pathogen infestations and interventions are associated with crop plants and related native plants in the California floristic region (photograph example crop: cotton). The distributions of major annual and perennial crops are focused in several major production regions of the state (*A*) (12). Shorter phylogenetic distance between crop host plants and native relatives favors a greater number of pests (*B*). Relatedness of crop-native plants reduces the potential for escape, due to reservoirs of arthropod herbivores persisting in natural habitats surrounding agricultural fields. The number of pesticide applications to control arthropods and pathogens decreases with increasing phylogenetic distance between crop plants and native relatives (*C*). Together, the implications of phylogenetic distance suggest that introduced status of crop plants may be useful to understand general trends in pest infestations and concomitant pesticide use.**

recent study using the same dataset (6), its inclusion in their analyses provides greater power in detecting phylogenetic associations with pest and pathogen pressure and pesticide use.

The spatial scale of the study spans California. Encompassing >400,000 km^2 of land, the study crops are differentially represented across multiple agricultural production areas and ecological regions (Fig. 1*A*), but the study does not include any measure of spatiotemporal association between native plant species and crops (1). Hence, the strength of the relationships showing decreasing pesticide use and decreasing pest pressure with increasing phylogenetic distance between the crop and closest native is surprising. However, confidence in these relationships is greatly enhanced by the authors' separate analyses of native and nonnative arthropod pests. A significant negative association between pest pressure and phylogenetic distance between a crop and its nearest related native was observed for native but not for introduced arthropod pests. Further evidence is provided by studies involving natural systems in which phylogenetic similarity between introduced and native plants explained 13 to 18% of variation in herbivory on nonnatives (10). Confidence in the associations between phylogenetic distance and pesticide use targeting insects and plant pathogens is provided by the authors' analysis of herbicide use, which revealed no relationship between number of herbicide applications and phylogenetic distance. In this case, herbicide use serves as an important negative control because most herbicides are applied preventatively, and weed pressure is driven by many factors, including composition of surrounding plant communities, prior and current cropping practices, and an extremely low tolerance for weed populations regardless of species.

The associations with phylogenetic distance reported in this study and in studies of natural systems reflect general but important patterns that enhance understanding of pest pressure and pesticide inputs. But variability is high among individual observations that collectively define the pattern. This is not unexpected, given the strong influence of local factors including environment; species richness of local plant communities; and variation in host range, abundance, and dispersal capabilities of arthropods and pathogens. This variation limits the value of these phylogenetic relationships in predicting local outcomes, as pointed out by the authors and others (1, 2, 4, 10). In the context of agriculture, local effects on pest pressure and pesticide use are particularly strong and well documented (11).

Pesticides used on a given crop are applied at the individual field and farm level with the goal of maximizing profits (6), although, for farmers facing uncertain prices for their harvested product, this often translates into applying pesticides prophylactically or in response to presence of subeconomic pest populations. In addition, individual farms typically produce multiple crops. Pesticide application decisions for individual crops are influenced by farm-level management considerations based on many factors, including farm size and trade-offs intended to maximize farm-level rather than crop-specific profits, as well as farmer experience, education, and the sources of pest management advice (6).

Practical application of these findings to agriculture will be a challenge. Extending this study's general finding to account more effectively for fine-scale spatial or temporal movement dynamics among native and crop host plants will be an important step to practically predict crop colonization by pests in a mosaic of endemic and introduced crops within an agroecosystem. As the authors point out (1), phylogenetic escape may not apply to more simplified agricultural production systems where a small number of crops are grown across a wide geographic extent. In these systems, specialist pests are favored, and area-wide deployment of crop protection technologies to suppress them is common (e.g., western corn rootworm and genetically engineered maize expressing *Bacillus thuringiensis* toxins in the midwestern United States). Translating Pearse and Rosenheim's findings to inform crop composition within landscapes may, in turn, reduce pest pressure and production costs. Future studies that incorporate evolutionary associations between crops and pests with known local relationships will be an important step to reduce reliance on pesticides.

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