3.2 Displacement of Native Natural Enemies by Introduced Biological Control Agents in Agro-Ecosystems: A Serious Non-target Effect or Not?

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Classical biological control has been a fundamental approach to the management of invasive pests throughout the world for over 120 years. Over the last several decades there has been increasing interest and focus on examination of direct and indirect non-target impacts (Van Driesche and Hoddle, 2016). One potential indirect impact is the displacement of native natural enemies by introduced species. Invasive pest species that colonize new crop habitats are frequently attacked by a suite of native natural enemies that opportunistically take advantage of a new and abundant prey or host resource. Often, the mortality supplied by the native community is insufficient and more specific exotic natural enemies are introduced in an attempt to gain enhanced pest control. In the process, these native enemies are sometimes displaced on the target crop(s). This displacement is often interpreted as a negative non-target effect of the introduction because the native natural enemy is now found at lower abundance in the target crop(s) or is perhaps gone altogether (Bennett, 1993; Lynch and Thomas, 2000; van Lenteren *et al.,* 2006). However, this displacement also could represent the fact that the native natural enemy is now continuing to attack native hosts or prey on other host plants as they did before the invasion of the exotic pest (Van Driesche and Hoddle, 2016). The native natural enemy may now exist at lower population densities overall because their large temporary resource base has either declined (through effective biological control) or are less available because the exotic natural enemy is a superior competitor and/or more adapted to finding and exploiting hosts or prey than its native counterpart (Fig. 3.2.1). Unfortunately, the necessary data to determine if true non-target effects exist or not are often absent or weakly documented, particularly when the native enemies are naturally found in non-crop habitats.

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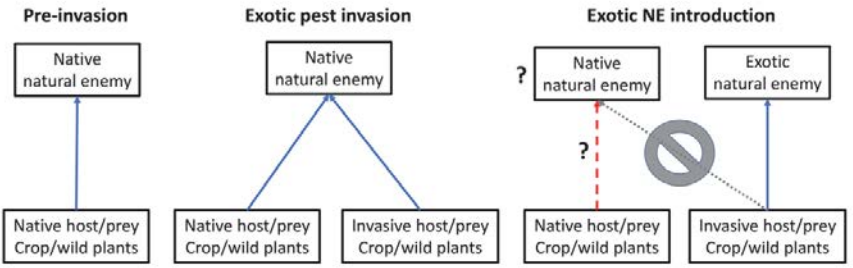

Fig. 3.2.1. Conceptual diagram of the putative displacement of a native natural enemy by an introduced natural enemy. The grey dotted line depicts displacement and the question marks ask if there is a true non-target effect (significant reduction in abundance or extirpation), or if it can now be found attacking its native hosts at approximately the same level as it did before invasion of the exotic pest.

Van Driesche and Hoddle (2016) reassessed several cases from previous reviews (Bennett, 1993; Lynch and Thomas, 2004) in which displacement of many native parasitoids was presumed to have occurred due to the introduction of exotic parasitoids, and several additional cases not reported in these earlier reviews (Table 3.2.1). In large measure, either the original assessment or the reassessments of Van Driesche and Hoddle (2016) show that non-targets have not been extirpated but essentially nothing can be said about population level impacts. Many can still be found attacking the target host to a more limited extent than before, or attacking other native insect hosts in the parasitoid's original habitat. Universally, more work is needed to extend and expand surveys for these native parasitoids, and more importantly, studies are needed to document significant changes in population sizes of the native parasitoids relative to their former status before exotic parasitoid introductions. Such changes in abundance would be the key to understanding if non-target impacts have occurred. It is likely than many of the native species existed at relatively low densities and that populations only increased once native parasitoids began to take advantage of the abundant invasive pest species in managed habitats. The necessary studies to document any non-target effects will be extremely challenging. First, pre-release studies of the composition and abundance of the native natural enemy fauna are rare and second, resources to conduct both pre- and post-release evaluations of this nature are frequently constrained because most of the resources are focused on development and implementation of the classical biological control program.

In conclusion, the simple displacement of native parasitoid species from crop habitats after the introduction of more specialized and efficient natural enemies is not sufficient evidence to claim that a non-target impact has occurred. The assessment of the extant literature suggests that complete extirpation of a native parasitoid is rare or perhaps never happens, but more inclusive surveys and more population level studies will be needed in the systems highlighted above, and in others, before true non-target impacts can be asserted. Here only parasitoids were considered, but similar issues surround introduced insect predators such as *Harmonia axyridis* (Pallas) and *Coccinella septempunctata* (L.) (Coleoptera: Coccinellidae) where the non-target impacts of these species have been more broadly assessed (Van Driesche and Hoddle, 2016).

Table 3.2.1. Putative cases of non-target effects through displacement of native parasitoids by introduced exotic parasitoids and original assessment or reassessment of likely impacts.

Exotic agent	*Target pest*	*Non-target*	*Assessment/Reassessment of impacts*	*Location*	*Reference*
Cotesia flavipes	*Diatraea saccharalis*	*Paratheresia claripalpis Metagonistylum minense*	Non-targets found in some fields and in Colombia; more survey work needed	Brazil	Bennett, 1993
Cotesia flavipes	*Diatraea saccharalis*	*Apanteles diatraeae*	Non-target found in Mexico; more survey work needed in Trinidad	Trinidad, Mexico	Bennett, 1993
Aphytis holoxanthus	*Chrysomphalus aonidum*	*Pseudhomalopoda prima*	Non-target attacking native host on other plants	USA	Bennett, 1993
Aphytis holoxanthus	*Chrysomphalus aonidum*	*Aphytis costalimai*	Non-target attacking hosts on citrus in Argentina	Brazil	Bennett, 1993
Cales noaki	*Aleurothrixus floccosus*	*Encarsia margaritiventris,*	More host range testing and survey work needed on non-targets	Italy	Lynch and Thomas, 2000
Trigonospila brevifacies	*Epiphyas postvittana*	*Xanthopimpla rhopaloceros*	Non-target is not native and continues to attack target pest	New Zealand	Lynch and Thomas, 2000
Diadegma semiclausum	*Plutella xylostella*	*Diadegma mollipla, Oomyzus sokolowskii*	Non-targets still attacking target but at reduced rates; widely distributed and may have other hosts	Kenya	Löhra *et al.*, 2007
Eretmocerus mundus	*Bemisia tabaci*	*Eretmocerus eremicus, Eretmocerus joeballi*	Non-targets found attacking native hosts on other crop and urban plants	USA	Pickett *et al.*, 2013
Eretmocerus sp. (Ethiopia) Encarsia sophia	*Bemisia tabaci*	*Eretmocerus eremicus, Encarsia meritoria, Encarsia luteola*	*Encarsia* non-targets found attacking target at low levels; surveys needed to document native host use	USA	Naranjo and Li, 2016

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