

Non-target effects of insect biocontrol agents and trends in host specificity since 1985

Roy Van Driesche*¹ and Mark Hoddle²

Address: ¹ Department of Environmental Conservation, University of Massachusetts, Amherst, MA 01003-9285, USA. ² Department of Entomology, University of California, Riverside, CA 92521, USA.

***Correspondence:** Roy Van Driesche, Email: vandries@cns.umass.edu

Received: 6 October 2016

Accepted: 7 November 2016

doi: 10.1079/PAVSNNR201611044

The electronic version of this article is the definitive one. It is located here: <http://www.cabi.org/cabreviews>

© CAB International 2016 (Online ISSN 1749-8848)

Abstract

Non-target impacts of parasitoids and predaceous arthropods used for classical biological control of invasive insects include five types of impact: (1) direct attacks on native insects; (2) negative foodweb effects, such as competition for prey, apparent competition, or displacement of native species; (3) positive foodweb effects that benefited non-target species; (4) hybridization of native species with introduced natural enemies; and (5) attacks on introduced weed biocontrol agents. Examples are presented and the commonness of effects discussed. For the most recent three decades (1985–2015), analysis of literature on the host range information for 158 species of parasitoids introduced in this period showed a shift in the third decade (2005–2015) towards a preponderance of agents with an index of genus-level (60%) or species-level (8%) specificity (with only 12% being assigned a family-level or above index of specificity) compared with the first and second decades, when 50 and 40% of introductions had family level or above categorizations of specificity and only 21–27 (1985–1994 and 1995–2004, respectively) with genus or 1–11% (1985–1994 and 1995–2004, respectively) with species-level specificity. In all three decades, 11–12% of introductions could not be classified in this manner due to lack of information. Recommendations for future actions to improve this record are made: (1) distinguish host use from population-level impact; (2) develop country-level online summaries of relevant information; (3) plan biological control projects with conservation partners; and (4) conduct post-release comparisons of actual impact to predicted risk based on quarantine studies.

Keywords: Non-target impacts, Parasitoids, Predators, Apparent competition, Hybridization, Indirect effect, Trends in host specificity

Review Methodology: The article was designed based on personal knowledge of the discipline based on 40 years of work in biological control of insects by senior author (RVD), using literature accumulated across that period, together with input from second author (MH). Additional information was assembled, especially for Tables 1 and 2, using the CAB abstract library service to assess globally available knowledge concerning hosts of parasitoids or predators listed in tables. Details in tables were further checked whenever possible by email correspondence with researchers conducting the introduction (see Acknowledgments). Comments from Dan Simberloff were used to revise text. Figure 1 and statistical analysis between decades were done by second author (MH).

Introduction

Whether, when and how frequently introductions of biological control agents have important population-level effects on non-target species is a question of continuing importance to both biological control scientists and conservation biologists. This issue was first raised by

Howarth [1], who outlined evidence for significant non-target impacts from biological control agents. While breaking new ground in raising the issue, this paper was, in our opinion, flawed. First, rather than assessing whether non-target impacts had occurred regularly or to what degree on average, Howarth [1] advocated strongly for the proposition that they had occurred, supporting the article's

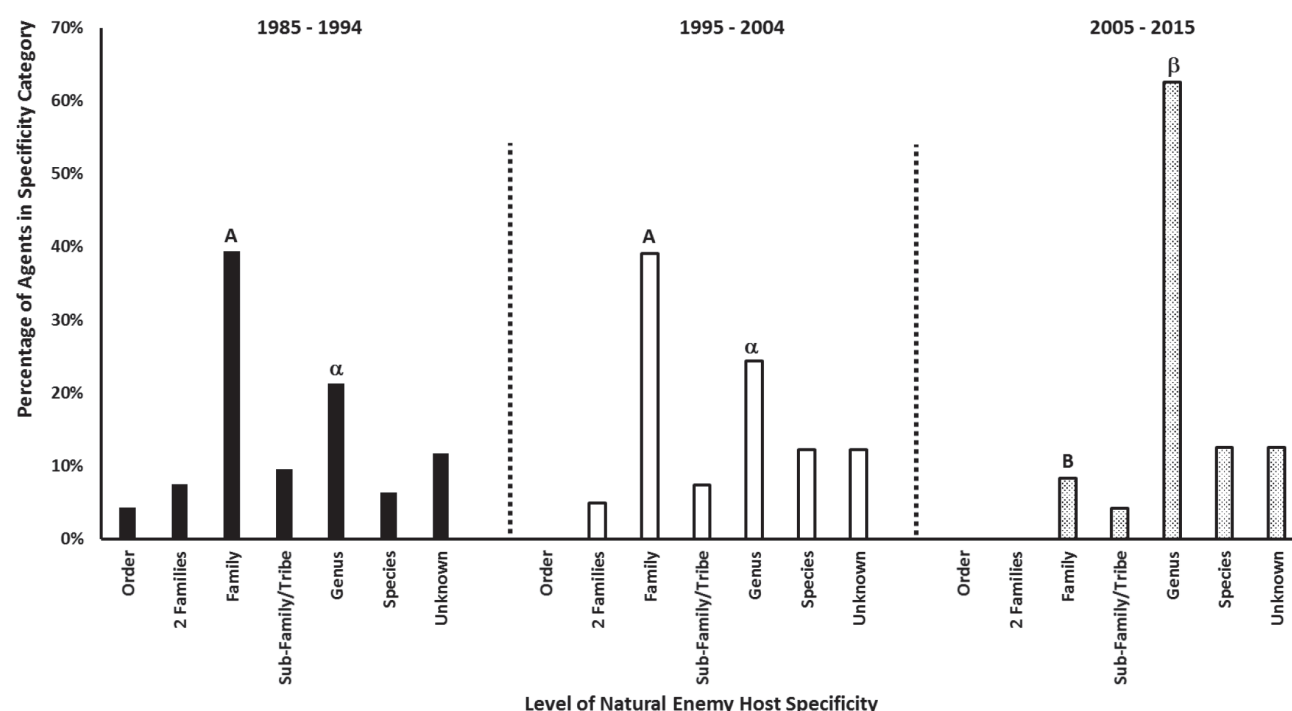


Figure 1. Index of host specificity for parasitoids introduced in three decades for biological control of arthropods, showing use of more specific agents in the third decade (2005–2015). A one-factor logisitic regression model (Wald's Chi-square test and pairwise contrasts) was used to determine if significant differences in agent host specificity by decade existed at the Family, Sub-Family/Tribe, Species and unknown level. Fisher's Exact test was used to test for differences at the Order and two Family level of specificity because of zero counts for some decades. Significant differences were detected across decades for natural enemies specific to the level of Family ($\chi^2 = 6.67$, $df = 2$, $P = 0.04$) and Genus ($\chi^2 = 14.22$, $df = 2$, $P = 0.001$) only. Significant differences across decades within a host specificity class are represented with different letters (A, B for Family-level differences and a, b, for Genus-level differences). Bars lacking letters across decades within a host specificity class indicate no significant differences. All tests were conducted at the 0.05 level of significance.

assertion by selectively assembling instances of possible impact. While it alerted society to this unintended risk, Howarth [1] did little to objectively assess the magnitude of the problem posed by natural enemy introductions. Second, the author grouped vertebrate introductions, some made as far back as the 1700s by farmers, with introductions of biological control agents made by government scientists after biological control began to develop as a science (post 1920s). This greatly enhanced the perceived negative impact of biological control as most vertebrate introductions for pest control did cause ecological damage. Third, the paper did not adequately differentiate between simple use (feeding or parasitism to any degree) and evidence-based, population-level impacts on non-target species. Fourth, Howarth [1] greatly overstated the risk of extinctions from introductions, by emphasizing the effects of vertebrate and mollusk introductions, as opposed to arthropods (e.g., herbivores, parasitoids and predators) that are used most commonly for biocontrol of pest plants and arthropods. While this article opened a conversation on the potential environmental effects of classical biological control, it did not provide a definitive answer. Further discussion of this issue ensued in the following decades [2–12].

Here we focus on potential non-target impacts of parasitoids and predacious arthropods introduced as classical biological control agents. The impacts of these agents are less understood than those of herbivorous insects and pathogens released against invasive plants. Releases of plant biocontrol agents are well documented [13], and population-level impacts of herbivorous biocontrol agents on native plants have been rare [12]. Analysis of all 512 species known to have been released for weed biocontrol worldwide found no evidence of impact for 99% of the agents. Of the few known cases of impacts, most (>90%) were only of minor importance, without long-term harm to non-target plant populations. Important population-level effects are known only in the cases of some thistle and cacti-attacking insects, principally *Cactoblastis cactorum* (Bergroth) on some native cacti [14, 15] and *Rhinocyllus conicus* Fröelich on some native thistles [16, 17]. In contrast, for parasitoids and predators, whose actions are generally invisible to any but specialists, we have less information on population-level impacts. This has led to speculation that non-target impacts are high, based largely on extrapolation from several cases of likely or presumed high-level impact, especially the coccinellid beetles *Harmonia axyridis* (Pallas) and *Coccinella septempunctata* (L.) [18, 19] and the tachinid

flies *Compsilura concinnata* (Meigen) [20] and *Bessa remota* (Aldrich) [21, 22], as discussed below.

Past summaries of impacts of parasitoids and predators on non-target insects and mites include a mini-review for the island of Guam [23], global literature reviews [24, 25] and a detailed analysis of releases of both weed and insect biocontrol agents in Florida [26]. Lynch and Thomas [24] state that non-target effects are recorded for 1.7% of the ca 5000 recorded cases of parasitoid or predator introductions (species \times country releases of about 2000 natural enemy species), as detailed in the database 'BioCat.' Of these 87 records ($87/5000 = 1.7\%$), most were recorded as causing only minor effects (that is 'host use' but not 'population-level impact'). Seventeen cases ($17/5000 = 0.34\%$), however, were classified as causes of population reductions or other severe impacts. (However, below, we show that some of these cases were in fact of no ecological concern.) No credible cases of extinction were found; one such case is claimed by Howarth [1], but see Hoddle [22]. For introduced parasitoids and predators successfully established in Florida [26], grouping cases by 20-year intervals (data from Table 4 in Frank and McCoy [26]), there was no detectable trend in either the average severity of impacts (categories 1–6) or the frequency of instances in high-impact categories suggestive of population-level effects; there were 2–5 such events per 20-year period. No further reviews of non-target effects of insect biocontrol have been published since 2007. Here we discuss known or alleged cases of non-target impacts of parasitoid or predator introductions and review trends in host specificity of agents since 1985 (Tables 1 and 2). We conclude with some caveats and recommendations.

Types of Impacts

Several types of impacts of parasitoids and predators on non-target arthropods have been discussed: (1) direct attacks on native insects, (2) negative foodweb effects, such as competition for prey, apparent competition or displacement of native species, (3) positive foodweb effects that benefited non-target species, (4) hybridization of native species with introduced natural enemies and (5) attacks on introduced weed biocontrol agents. After discussing these categories as concepts, we describe instances of each in the section 'How Common Have Population-Level Nontarget Effects Been?'.

Type 1. Direct attacks on native insects

The concept

Direct attack by a parasitoid introduced for biological control is shown by measuring rates of parasitism in a non-target native species by the introduced natural enemy. Estimating the population-level consequence of various levels of parasitism is not easy [27], but rates below 10%

are probably of little importance, while high rates ($>50\%$) may reduce populations. Actual impacts on long-term population densities, however, may vary depending on other factors present in the life system of a particular host and may vary among hosts, years or geographic regions. For introduced predators, rates of predation are more difficult to determine because there is usually little evidence remaining of attacks (in contrast, parasitism can be measured more easily because hosts can be collected and parasitoids reared out). Once measured, predation rates, as with parasitism, required further analyses to estimate the likely population-level consequences [28, 29].

Examples

Three examples of direct non-target impact have been widely discussed in the literature, and the scientific documentation is best for these three parasitoids: *C. concinnata* (Diptera: Tachinidae), *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae) and *Trichopoda pilipes* (Fabricius) (Diptera: Tachinidae). Details of these cases are discussed below individually because impacts vary spatially, temporally, or among non-target species.

(a) *Compsilura concinnata*. This parasitoid, released in North America in 1905, was one species among a large group of parasitoids and predators introduced against the gypsy moth (*Lymantria dispar* [L.]) (Lepidoptera: Erebidiae), a defoliating forest pest [30]. *C. concinnata* is a highly polyphagous tachinid fly, and at the time of its release was recognized as parasitizing >50 insect species [31, 32], a number now significantly increased to several hundred [20]. The highest rates of parasitism by this fly have been recorded on larvae of native saturniid moths – including silk moths [20], buck moths [33] and the luna moth, *Actias luna* (L.) [34]. Rates of parasitism vary within group and by region, and this fly has likely affected some non-target species' populations in some areas, but not others [10].

For the buck moth *Hemileuca lucina* H. Edwards, Stamp and Bowers [33] found attack rates in Massachusetts (USA) of 26–53%, which likely would reduce populations if sustained for several consecutive years. For *Hemileuca maia* (Drury), also in pitch pine habitats in Massachusetts, Selfridge et al. [35] found low and inconsequential levels of parasitism by *C. concinnata*. In contrast, Boettner et al. [20] found 36% parasitism by *C. concinnata* of this species in the same habitat, also in Massachusetts.

For luna moth (*A. luna*), experimental deployment of larvae at sites in Virginia by Kellogg et al. [34] resulted in high levels of attack on some groups, particularly of older instars. Larvae were deployed on separate leaves, at four per small tree, and left in the field for one instar period only. Of all detected parasitism, 78% was caused by *C. concinnata*, and the level of parasitism suffered by deployed caterpillars varied from 0 to 62%, depending on instar and deployment date. The higher of these rates of attack, if sustained, might be sufficient to depress populations, and more information is needed to determine how attack rates vary over time,

habitat and location, and if densities of experimental cohorts affect outcomes.

For giant silkmoths, some of North America's largest and most attractive moths, Boettner *et al.* [20] found high levels of attack on cohorts of larvae of both promethia (*Callosamia promethea* Drury) and cecropia (*Hyalophora cecropia* [L.]) moths. For cecropia larvae placed five per tree in the field and left for their lifetimes, none (of 500) survived beyond the fifth instar. When individual instars were deployed for one instar period, *C. concinnata* parasitized 81% of the larvae in each of the first three instars. When larvae of *C. promethea* were deployed in groups of different sizes for 6 or 8 days, 70 and 66% of larvae, respectively, were parasitized by *C. concinnata*. These rates, if representative of nature, suggest a high level of impact on populations of these silk moths. Lower levels of attack (25–30%) on these same species are reported from New York by Parry [10]. Goldstein *et al.* [36] report that the island of Martha's Vineyard (Massachusetts) retains an intact macrolepidoptera fauna that includes the imperial moth (*Eacles imperialis* Drury), a species that has declined or disappeared throughout much of New England, and Goldstein *et al.* [36] related the persistence of this population to the absence of *C. concinnata* on Martha's Vineyard, as evidenced by tachinid captures in traps.

These studies collectively support the view that *C. concinnata* has had population-level impacts on several species of macrolepidoptera in the northeastern USA. Further documentation of the variation of this impact in time and space would be useful, especially contrasting areas with and without outbreaks of gypsy moth. Population modelling may provide useful insights here.

(b) *Microctonus aethiopoides*. Biotypes of this parasitoid were introduced into several countries for control of invasive pests of forage crops, including the alfalfa weevil, *Hypera postica* (Gyllenhal) (Coleoptera: Curculionidae), in the USA in 1958 [37, 38] and *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) in Australia (in 1977) [39, 40] and New Zealand (in 1982) [41, 42], successfully suppressing the target pests in all locations. Barratt *et al.* [43, 44] have extensively investigated the effects of this parasitoid on native weevils in New Zealand and, to a lesser degree, Australia. No non-target studies have been carried out with this species in the USA. In general, non-target attacks were found in New Zealand [43, 44] on several native weevils, while no significant effects were found in Australia [45, 46]. In New Zealand, laboratory tests found that a variety of native weevils (nine species) were attacked and yielded offspring (suggesting they were in the 'physiological host range'), while field collections found 14 species of non-target weevils that were parasitized, showing use under natural conditions [43, 47]. Extensive surveys covering altitudinal gradients in three locations collected 12 000 weevils comprising some 36 species, and, of these, eight weevil species were parasitized by *M. aethiopoides* [44]. Overall, parasitism of non-target species was very low (~2%), but varied by region, collecting site, and season.

Of nine sites surveyed, for 6 years, a moderately high level (24%) of parasitism was found for only one species of native weevil (*Nicaeana fraudator* Broun), at just one site. *Irenimus egens* (Broun), another species known to be susceptible to attack, was present at that site, at similar densities, but was attacked at a much lower rate.

Population models were developed for *N. fraudator* and used to estimate levels of population impact associated with particular levels of parasitism. The model indicated that field parasitism rates of 30% implied various levels of population impact depending on the weevil population's reproductive rate, being a 30% population reduction when reproduction rates were low, but only an 8% reduction when reproduction rates were high [48]. Therefore, the level of parasitism sometimes seen in New Zealand on some species of weevils would likely have a greater impact on populations at higher altitudes, where rates of weevil reproduction (measured as intrinsic rate of increase) are lower.

In contrast to New Zealand, in southeastern Australia a survey by Barratt failed to find any evidence of significant impact on native weevils. Some 197 non-target weevils, comprising 29 species from 15 collection sites, produced just a single non-target weevil (*Prosayleus* sp., Curculionidae: Entiminae: Leptopiini) parasitized by *M. aethiopoides* [45]. A second, later survey in Australia [46] detected no further cases of non-target parasitism.

(c) *Trichopoda pilipes*. Howarth [1] correctly noted that the native Hawaiian 'koa bug,' *Coleotichus blackburniae* White (Hemiptera: Scutelleridae), was a suitable host for the egg parasitoid *Trissolcus basalis* Wollaston (Hymenoptera: Scelionidae) [49, 50] and for the nymphal/adult parasitoid *T. pilipes* (F.) (Diptera: Tachinidae), two species that were introduced into Hawaii in 1962 against the invasive pest stink bug *Nezara viridula* (L.) (Hemiptera: Pentatomidae). From these relationships and circumstantial evidence of decline of koa bug on Oahu following the introduction of these parasitoids, Howarth [1] assigned blame for this decline to the biological control project, particularly to the tachinid *T. pilipes*. However, a field investigation by Johnson *et al.* [51] found only partial evidence in support of Howarth's [1] assertion. Johnson *et al.* [51] measured parasitism of life stages of koa bug in several habitats and found that egg parasitism due to *T. basalis* never exceeded 26% and was only detected at sites below 500 m and only on one host plant; in contrast, egg predation by a spider and several species of ants (accidental introductions) was as high as 87%. Parasitism of adult bugs by the tachinid *T. pilipes* was near zero at 21 of 24 sites, but did reach high levels (up to 70% of females and 100% of males) at three sites where bug density was high, suggesting that dense populations of koa bug may no longer be ecologically possible because of density-dependent attacks by *T. pilipes* on koa bug aggregations.

Putting direct attack by parasitoids in context

Whether the type of impact seen in the case of *C. concinnata* is rare or common is critical to determine if

impacts of insect biocontrol agents are likely to harm populations of non-target insects. While the above cases make it clear that non-target attacks are possible (by species first used as biocontrol agents in 1905, 1958 and 1962, respectively) and that at certain times and locations these attacks may be of sufficient magnitude to locally reduce population densities, they do not clarify if such impacts are likely for agents released since non-target effects of introduced arthropod agents for pest insect control became of concern (ca. 1995) and better regulated. Below, in 'How Common Have Population-Level Nontarget Effects Been?' we discuss a longer series of cases to put potential risk from introduced natural enemies to non-target species into perspective.

Mitigation of direct attacks

Since ca. 1995, requirements for determining the likely host ranges of insect biocontrol agents have increased in countries most commonly practicing insect biological control [52]. Our summary of host range information on parasitoids introduced from 1985 to 2015 (Table 1) suggests a reduction in the proportion of agents with family-level specificity and an increase in agents with genus or better level of specificity (Fig. 1). Few insect biological control agents, however, are monophagous, and most are likely to have host ranges that include some other species that are taxonomically related or ecologically similar, which may be attacked, but likely at lesser degrees than the target pest. The key to mitigating direct impacts of introduced parasitoids and predators is to correctly estimate likely host ranges relative to the non-target fauna (i.e., native species or valuable introduced species such as weed biocontrol agents) in the area of release. The goal is not to avoid all host use, but to avoid damaging population-level effects on non-target species.

Type 2. Negative food web effects

The concept

Introduced species can affect native species through food webs [53]. In some cases, they may directly attack native species, but the level of such attack may be significantly increased by the introduced species' ability to maintain larger populations by attacking, but not suppressing, the target pest or other species, a situation termed '*apparent competition*.' In other cases, the introduced species never (or rarely) attacks non-target species, but their populations are still reduced through competition with the introduced natural enemy for food or hosts, a situation often termed '*displacement*.'

Apparent competition grades into simple direct attack and may be difficult to recognize except by an enhanced level of impact when the natural enemy is in association with the other host. For example, *C. concinnata* directly parasitizes larvae of various native moths and butterflies, as discussed above, but *C. concinnata* numbers, and hence the numbers

of such attacks, are likely to rise and fall with the local density of gypsy moth, the target host. Here we have arbitrarily considered this case as one of simple direct attack because the link to gypsy moth densities, while quite likely, is supported by only very limited data [54]. A better example of apparent competition by an introduced biological control agent is that of *Cotesia glomerata* (L.) (Hymenoptera: Braconidae), *Pieris rapae* (L.) and *Pieris oleraceae* Harris (both Lepidoptera: Pieriidae) in southern New England, as discussed below [55–57].

Displacement of one species of parasitoid by another introduced later has been observed during biological control projects [58–60]. This has generally been viewed as a favourable process, as each more efficient parasitoid drives the invasive host insect to a lower level and excludes less efficient biocontrol agents. However, if the displaced species are native parasitoids exploiting an exotic pest, this could be viewed as an undesirable impact on a native species whose 'commonness' declines due to the introduced agent. However, such observations typically are made in the context of studies of mortality of the introduced pest insect, often in a crop. Decline of a native parasitoid (or predator) from former abundance on a non-native host on an introduced crop plant is not by itself evidence of significant ecological impact because both the host and its crop habitat are an artificial human construct. The important question is whether or not the superior introduced parasitoid displaces the native parasitoid from its native hosts in natural habitats. Unfortunately, because the focus of most studies is on pests on crops, observations of displaced native parasitoids on non-pest hosts in native habitats are rare and should receive more emphasis. Therefore, further study is needed to determine the status of affected native parasitoids in non-crop habitats.

(a) *Apparent competition*. This interaction is named apparent competition because superficially after a new herbivore arrives, a related local native herbivore begins to decline, making it appear as if the invasive species is competing with the native one for some resource, while in reality the negative population impacts on the native species are mediated through unequal effects of a shared natural enemy. Evidence for apparent competition has been sought in a variety of systems in which one member of a pair of herbivores is invasive and one native, and the parasitoid attacking them both is a local native species. Apparent competition has been found in some cases [61] but not others [62].

The link to biological control is the subset of apparent competition cases in which the parasitoid (or predator) mediating the interaction is a species introduced for classical biological control of the non-native member of the herbivore pair. Few such cases have been documented, possibly because of a lack of work in this area. Redman and Scriber [54] noted that if they artificially deployed larvae of the butterfly *Papilio canadensis* (Rothschild and Jordan) (Lepidoptera: Papilionidae), those larvae placed near gypsy moth populations suffered higher rates of parasitism (45%)

(most from *C. concinnata*) than larvae deployed in areas without gypsy moths (16%). This difference was statistically significant, although there was no significant effect on the percentage of larvae reaching the adult stage (3.8 versus 4.3%), suggesting the action of some compensatory mechanism later in the life cycle.

A well-documented instance of apparent competition due to a biological control agent is that of the parasitoid *C. glomerata* (Hymenoptera: Braconidae), introduced to control the invasive brassica pest *P. rapae*. This parasitoid appears to be cause of the decline of a related native white butterfly, *P. oleracea* (formerly *Pieris napi oleracea*) in Massachusetts, but not in northern Vermont (USA) due to differences in voltinism [55–57]. Interestingly, this effect was later reversed by *P. oleracea*'s use of a non-native host plant [57] and the displacement of *C. glomerata* from its position as the dominant parasitoid of *P. rapae* in crops by the introduction of *Cotesia rubecula* (Marshall), another biological control agent that is a specialized parasitoid of *P. rapae* [60].

(b) *Displacement via competition for prey*. Perhaps the best-studied example of displacement of native species by introduced predators is the case of two introduced ladybird beetles, *H. axyridis* and *C. septempunctata*, in North America and Europe (*H. axyridis* only). In North America, these species replaced native ladybirds as the common species in a wide variety of crops, causing formerly common native ladybirds to become rare at the study locations [18, 63–66]. Among the most widely affected species were *Adalia bipunctata* (L.) and *Coccinella novemnotata* Herbst. More recently, the invasion in Europe of *H. axyridis* has also begun to affect native ladybirds there [67]. To explain why displacement of native ladybird species happened, several mechanisms have been proposed and to some extent tested, including direct predation effects on native ladybirds ('intraguild predation' or IGP), apparent competition mediated by pathogens, and displacement due to reduction of available prey in sampled habitats.

Asymmetrical IGP effects (ones that are more severe on the native species) have been demonstrated, showing that larger non-native species often have the advantage over smaller native ones [68, 69]. However, while asymmetrical IGP is well demonstrated [70]), whether it has caused population declines of native species is not. Limited attempts to test IGP as the factor responsible for the decline in native ladybirds in crops have not supported the idea [71].

Another possible mechanism, apparent competition mediated by a pathogen, is a novel idea supported by one study [72]. In Europe, the microsporidian *Nosema thompsoni*, found in but harmless to *H. axyridis*, is lethal to *C. septempunctata*, a local native species. When *C. septempunctata* adults or larvae eat eggs or larvae of *H. axyridis*, they die. There is no evidence that pathogens associated with non-native ladybirds affect additional native species of North American or European ladybirds, but this possibility merits investigation.

The third possible mechanism postulated for disappearance of native species following the appearance of non-native ladybirds is that these competing species drive densities of shared prey to levels too low to support the native species. For example, Mizell [73] states that *H. axyridis*' presence on crape myrtle (*Lagerstroemia indica* L.) in northern Florida 8–9 years after its arrival was associated with much lower abundances of both the main aphid on the plant, *Sarucallis kahawaluokalani* (Kirkaldy), and of various native ladybirds, especially *Hippodamia convergens* (Guérin-Méneville), *Olla v-nigrum* (Mulsant), *Coleomegilla maculata* (DeGeer), *Cycloneda sanguinea* L. and *Cycloneda munda* (Say), suggesting that low prey density on crape myrtle plants exposed to *H. axyridis* may have been insufficient to attract or support the native species. Similarly, Alyokhin and Sewell [74] recorded both a substantial reduction in aphid density and of two native ladybirds (*Coccinella transversoguttata* Brown and *Hippodamia tredecimpunctata* [Say]) in potatoes in Maine following the arrival of *H. axyridis* in the region, circumstantially implicating loss of prey as an important factor in the observed decline of the native species. In alfalfa, the decline of various native ladybirds may also be due to a decline in the density of pea aphid (*Acyrtosiphon pisum* Harris) [75, 76], an invasive insect that was brought under biological control through introductions of parasitoids, especially *Aphidius ervi* Haliday (Hymenoptera: Braconidae), released first in the eastern USA in 1959 [77].

The hypothesis of displacement due to competition for prey has as a corollary that either native habitats or some particular subset of agricultural habitats may remain suitable for the declining native species. Consequently, surveys for native ladybird beetles have concentrated on surveying for native species in such locations. For example, in western South Dakota and Nebraska, Bartlett et al. [78] found reproducing populations of one highly suppressed native species, *C. novemnotata*, in sparsely vegetated small-grain fields.

A second corollary of prey-depletion as the cause of decline of native ladybird beetles in crops is that if aphid densities in such crops rebound for any reason, the native ladybird beetles should recolonize such cropping areas. This was confirmed by Evans [75] in Utah using perturbation experiments in alfalfa fields, conducted after the invasion of the region by *C. septempunctata* in 1992–2001, which had been associated with declines of native ladybirds in alfalfa. This decline in native ladybirds paralleled declines in pea aphids, the ladybirds' principal prey in alfalfa. Artificially induced outbreaks of pea aphids caused native ladybirds to rapidly reaccumulate in alfalfa, until *C. septempunctata* again suppressed pea aphid numbers. In Maine, Finlayson et al. [79] surveyed ladybirds and found native species to be present in both native vegetation and crops, but at low densities in both. The ability of native ladybirds to reach high densities in native habitats would require both the presence there of a high-density prey

species and the absence of the highly competitive non-native ladybirds. Hesler and Kieckhefer [80] surveyed putative native ladybird habitats (fields and areas of woody vegetation) in South Dakota but found that the targeted native ladybirds were rare in the habitats surveyed and that both *H. axyridis* and *C. septempunctata* were present in many of the putative refuge habitats. In contrast, Bahlai *et al.* [81], analysing a 24-year data set from Michigan (with larger acreage of semi-natural forest habitats than South Dakota), found that only two species of ladybirds showed statistically significant declines (*A. bipunctata* and *C. maculata*) after the establishment of these two exotic ladybird species. They also found that in semi-natural forested habitats ladybird assemblages were unique in both composition and variability from those in crop fields and concluded that such forested areas acted as refuges for native coccinellids.

The sum of evidence suggests that these two non-native coccinellids, *H. axyridis* and *C. septempunctata*, have greatly lowered the abundance of several native ladybirds in agricultural fields. While the same native coccinellids also seem rare in natural habitats, earlier estimates of their abundance there are lacking, and we cannot, therefore, know if significant changes have occurred in those habitats. Finally, a question not yet raised by researchers on this topic is whether the density of these native coccinellids in crops, where they previously exploited high-density prey species that were often themselves invasive, is the right benchmark against which to measure impacts, or if a more appropriate standard might not be densities of native coccinellids in non-crop habitats (e.g., native forests or grasslands) where these native ladybirds presumably exploited native prey.

(c) *Displacement via competition among parasitoids for hosts.* Introduced parasitoids may displace local species (either native or previously introduced species) if they are more efficient at exploiting hosts (see subsection 'Group 3. Displacement or Other Indirect Impacts'). There is, however, no clear well-documented example in which an introduced parasitoid has had dramatic population-level impacts on a native parasitoid where it is acting on its native hosts in their native habitat. Rather, displacement has only been documented in crops, where an introduced parasitoid displaces native parasitoids that are usually exploiting invasive hosts. However, one case exists where such displacement of native parasitoids from native hosts is likely to have occurred, but has not yet been adequately documented: the release of the American braconid *Lysiphlebus testaceipes* (Cresson) in Europe. This aphid parasitoid (attacking mostly species in the Tribe Aphidini [personal communication, Starý]) was introduced (1973–1974) from Cuba to France for control of pest aphids in citrus [82]. In addition to providing control of the target pests, *L. testaceipes* spread into non-crop habitats and became the dominant parasitoid on a number of native aphids inhabiting various types of vegetation, including forests [82]. The list of aphid species parasitized by

L. testaceipes increased as it spread, reaching at least 32 by 1986 [83], and continued to increase as the parasitoid's range expanded into the Iberian Peninsula [84]. In southeastern Europe, a total of ten host species were recorded (among 115 aphid species sampled from 422 plant species), and this parasitoid was not only found principally on species of *Aphis* (*A. craccivora* Koch, *A. fabae* Scopoli, *A. nerii* Boyer de Fonscolombe, *A. ruborum* [Börner], *A. urticata* Gmelin, *A. gossypii* Glover, *Aphis* sp.), but also occurred on species in *Rhopalosiphum* and *Toxoptera* [85]. It is possible that *L. testaceipes*, which attacks many native European aphids in various habitats, may suppress some species of native parasitoids exploiting native hosts in native habitats. However, this has not yet been documented, in part because the collection of information on the native aphid parasitoids—their presence, abundance, phenology and host ranges — requires an extremely high level of taxonomic training and ecological knowledge and several years work to understand temporal and spatial effects.

(d) *Parasitoid host shifts caused by competitive displacement.* *Diachasmimorpha tryoni* (Cameron) (Hymenoptera: Braconidae), a parasitoid of frugivorous tephritids, attacked lantana gall fly (*Eutreta xanthochaeta* Aldrich [Diptera: Tephritidae]) in the laboratory but did not do so in the field in Hawaii after its release until a superior competitor, *Fopius arisanus* (Sonan) (Hymenoptera: Braconidae), was introduced. After that release, competition apparently caused *D. tryoni* to shift onto lantana gall fly, which was a more available host in the presence of *F. arisanus* [86].

Putting risk in context

Polyphagous and oligophagous parasitoids likely pose risk to native parasitoids. Documenting such events, however, is difficult because of the high level of taxonomic skill needed to separate parasitoid species and make sense of the survey results. Projects assessing these types of non-target effects, especially population-level consequences, require work spanning several consecutive years with study sites that are representative of the various habitats within which the agents of interest are operating.

Mitigation

Looking forward, regardless of what past introductions may have done, the solution to minimize unwanted non-target effects is to introduce parasitoids with narrow host ranges, as estimated by adequate pre-release testing in quarantine and, if reliable data are available, host use in the natural enemy's area of origin.

Type 3. Beneficial food web effects

Beneficial indirect effects on native species can also follow biological control of invasive pest insects. Schreiner and Nafus [87] observed population increases of native moths following biological control of *Penicillaria jocosatrix* Guenée

(Lepidoptera: Noctuidae) on mango in Guam by the tachinid *Blepharella lateralis* Macquart. Pest suppression led to a large increase in flowering by mango that caused several native moths to increase in abundance because this resource had improved.

In Queensland, Australia, biological control of invasive crop-pest scales (*Ceroplastes destructor* Newstead and *Ceroplastes rubens* Maskell [both Hemiptera: Coccidae]) provided benefits in forest ecosystems by reducing densities on native forest plants of invasive ants that were attracted to honey dew produced by invasive scales. Uncontrolled scale populations tended by invasive ants reduced vigour of forest plants and decreased use of plants by larvae of native lycaenid butterflies, such as *Hypochrysops miskini* (Waterhouse) and *Pseudodipsas cephenes* Hewitson. These native butterflies must be tended by native ants, and invasive ants disrupt this important mutualism (as described by Sands in Van Driesche *et al.* [88], with further details in Waterhouse and Sands [40]).

In Tahiti, invasion (due to movement of infested plants) of the glassy-winged sharpshooter, *Homalodisca vitripennis* (Germar) (Hemiptera: Cicadellidae), posed a significant risk for native spiders, for whom this hyperabundant sharpshooter proved to be a poisonous prey [89]. Biological control of the invader by release of the mymarid egg parasitoid *Gonatocerus ashmeadi* Girault greatly reduced the pest's densities [90], which subsequently lowered this threat to native spiders.

Type 4. Hybridization with native congeners

The concept

Natural enemies may sometimes be introduced into areas that contain closely related species that may have different host or prey ranges. If these species have been geographically separated, they may lack the premating barriers needed to sustain their separate species identities, and inter-species matings may occur, leading to hybridization and genetic introgression [91]. Hybridization is common in some groups in nature. For example, the eastern and Canadian tiger swallowtails (*Papilio glaucus* L. and *P. canadensis* Rothschild & Jordan), whose distributions are generally distinct, have a hybrid zone along their common border [92].

When individuals of distinct species mate, several outcomes are possible: (1) mating may occur but be infrequent due to differences in habitat or host plant affiliations, allowing separation of the species even in partial sympatry. In this case a stable, low rate of hybridization may occur due to overlap, accidents, or chance where the species' distributions overlap. This outcome is probably of little or no ecological consequence; (2) in other cases, there may be substantial contact between the species due to similarity in habitat, and mating may be relatively frequent. If offspring are infertile, there may be selection on mating behaviours to reduce the rate of hybridization over time; and

(3) if overlap is substantial, selection for premating segregation is ineffective due to lack of variation in mating behaviours, and offspring are fertile, species may fully introgress with each other and one or both species may cease to exist in their previous taxonomic status, leading to a reduction in biodiversity.

Examples

Several examples of hybridization are discussed in the literature for insect biocontrol agents and they are discussed here.

(a) *Chrysoperla* lacewings. Green lacewings are widely mass produced and sold to home gardeners and commercial growers by insectaries. The most commonly sold forms are European or Asian populations of *Chrysoperla carnea* (Stephens), which are part of a species complex. Such sales have potential to bring commercialized forms into contact with similar, but locally distinct lacewings. In such cases, there is an opportunity for hybridization. For example, in laboratory studies, the Japanese endemic species *Chrysoperla nipponensis* (Okamoto) (a member of the *C. carnea* complex) readily hybridized with the commercially marketed exotic form of *C. carnea* [93, 94]. For this reason, regions with rare or endemic green lacewings may want to prohibit importing closely related, exotic green lacewings from commercial sources [95].

(b) *Chestnut gall wasp parasitoids*. The Chinese gall wasp *Dryocosmus kuriphilus* Yasumatsu (Hymenoptera: Cynipidae) is a pest of chestnuts (*Castanea* spp.) that has invaded Japan and other areas. The Chinese parasitoid *Torymus sinensis* Kamijo (Hymenoptera: Torymidae) was introduced into Japan to suppress *D. kuriphilus*, where it came into contact with a closely related native Japanese species, *Torymus beneficus* Yasumatsu & Kamijo (Hymenoptera: Torymidae), of which two biotypes have been recognized. The introduced parasitoid subsequently hybridized with both of the two native biotypes at rates of about 1% (for the early-spring biotype) and 20% (for the later-spring biotype) [96]. However, despite this difference in hybridization rates, both biotypes of *T. beneficus* were eliminated in Japanese chestnut orchards [97, 98], suggesting that the mechanism of elimination was not solely hybridization but more likely due to displacement through competition for hosts.

(c) *Laricobius adelgid predators*. The predatory beetle *Laricobius nigrinus* Fender (Coleoptera: Derodontidae) has been moved from its native range in western North America (where it is a specialized predator of hemlock woolly adelgid, *Adelges tsugae* Annand) to the eastern USA for biological control of an invasive population of an invasive population of the same adelgid. Following relocation, *L. nigrinus* has hybridized to a degree with its native congener *Laricobius rubidus* LeConte, which mainly attacks adelgids on white pine (*Pinus strobus* L.). Hybridization occurs at a stable rate of 10–15% [99, 100]; hybridization occurs more often on hemlock (*Tsuga canadensis* [L.] Carrière) than on white pine, where *L. rubidus* dominates

[100]. Resource partitioning appears to be happening, with *L. nigrinus* increasingly becoming the dominant predator on hemlock, while *L. rubidus* remains dominant on white pine [100].

Putting risk in context

Hybridization between an introduced species and a local native congener, as described above, is not uniquely associated with biological control agents. Rather, many species moved by people for recreational or sport purposes have hybridized with closely related species when the two are brought into sympatry, in some cases endangering the native form. Well-known examples include the movement of rainbow trout (*Oncorhynchus mykiss* [Walbaum]) throughout the western USA into rivers and lakes where it endangers local trout species through a mix of predation, competition and hybridization [101]. Similar outcomes have occurred in *Anas* ducks, where the introduction of the common mallard (*Anas platyrhynchos* L.) has led to extensive hybridization with closely related species, such as the grey duck (*Anas superciliosa* Gmelin) in New Zealand [102].

Mitigation

Tests to detect hybridization potential between species proposed for introduction and congeners living where releases are planned can be run in quarantine. For example, the proposed introduction of *Laricobius osakensis* Montgomery and Shiyake from Japan into the eastern USA was preceded by tests to measure the potential to hybridize with the previously introduced *L. nigrinus*. In this instance, successful interspecific mating was not detected [103]. In contrast, Naka *et al.* [93, 94] found high potential for hybridization between native Japanese green lacewings (*C. nipponensis*) and commercial *C. carnea* and warned against introduction of the commercially available populations.

Type 5. Attack on weed biocontrol agents

The concept

Some insect biological control agents can, depending on their ecology and host ranges, attack weed biological control agents that are similar, taxonomically or ecologically, to the targeted herbivorous pest.

Examples

Three examples of this are discussed below; others almost certainly exist. Examples discussed include an oligophagous weevil parasitoid (*M. aethiopoides*); braconid parasitoids of tephritid flies, a family that includes both fruit-infesting pests and gall-making weed control agents; and a predaceous mite that attacks spider mites, which mostly are crop pests, but have also been used as weed biological control agents.

(a) *The oligophagous weevil parasitoid*, *M. aethiopoides*. This parasitoid has been used successfully to control several pest weevils of forage crops [38, 42] and is known to attack some native weevils in New Zealand [44] (see earlier discussion of this case). Among the non-target weevils attacked is the introduced weed biocontrol agent *R. conicus*, which has controlled nodding thistle (*Carduus nutans* L.) in parts of the USA and New Zealand [104, 105]. In New Zealand, this weevil has been found to be parasitized by *M. aethiopoides* at rates up to 17% [106].

(b) *Parasitoids of frugivorous tephritid flies*. Several species of parasitoids, including *Diachasmimorpha longicaudata* (Ashmead), *D. tryoni* and *Psytalia fletcheri* (Silvestri) (all Hymenoptera: Braconidae), have been introduced to Hawaii to attack invasive frugivorous tephritid flies. Investigations were later undertaken to determine if these species attacked the gall fly *E. xanthochaeta*, introduced to suppress invasive lantana. In the laboratory, the level of attack on *E. xanthochaeta* larvae by *D. longicaudata* or *P. fletcheri* was reduced but not eliminated if gall fly larvae were presented naturally inside their galls. If attack did occur, *D. longicaudata* developed successfully but *P. fletcheri* did not [107]. In contrast, both *D. tryoni* [108] and *Diachasmimorpha kraussii* (Fullaway) [109] (Hymenoptera: Braconidae) did attack some lantana gall fly larvae in laboratory trials. In the field, however, <1% of lantana gall flies were parasitized by *D. longicaudata* at sites where 37% of this parasitoid's normal host (*Bactrocera dorsalis* [Hendel] [Diptera: Tephritidae]) were attacked [110]. Field attack rates, however, are not reported for the other parasitoids.

(c) *Predatory phytoseiids attacking spider mites*. The gorse spider mite, *Tetranychus lintearius* (Dufor) (Acari: Tetranychidae), has been released in New Zealand and the USA for control of gorse (*Ulex europaeus* L.). This spider mite, however, has failed to have any persistent, significant effect on gorse. Field studies in Oregon (USA) showed this was likely due to feeding on the spider mite by predatory phytoseiid mites, including *Phytoseiulus persimilis* Athias-Henriot, a non-native phytoseiid that established in Oregon after being released for control of pest spider mites in agricultural fields [111].

Putting risk in context

Attacks on weed biocontrol agents by locally existing parasitoids, while potentially damaging from a practical point of view, is a common phenomenon, occurring, for example, in about 40% of all weed biological control agents established in South Africa [112]. Such use of introduced herbivores by native parasitoids may or may not affect their population levels. Attack by *Mesopolobus* sp. (Hymenoptera: Pteromalidae) on rush skeletonweed gall midge (*Cystiphora schmidtii*) (Diptera: Cecidomyiidae), for example, in Washington state (USA) did not prevent development of damaging levels of galls on the target weed [113], and rates of parasitism by native parasitoids on a biological control agent may vary greatly among locations

or plant species [114]. Similarly, native predators may attack herbivores introduced for weed biological control [115, 116], reducing their efficacy in some cases [116].

Mitigation

Safety of new insect biocontrol agents to previously released weed biocontrol agents can be determined during host range testing for the new agent. What cannot be avoided is potential future conflict with unspecified weed biocontrol agents whose release might latter be desired, unless their possible use is foreseen at the time of the insect biocontrol agent's proposed introduction. For example, Nadel *et al.* [117], when estimating the host range of *Bracon celer* Szépligeti (Hymenoptera: Braconidae) for potential introduction to California against olive fruit fly, *Bactrocera oleae* (Rossi) (Diptera: Tephritidae: Dacinae), found the parasitoid could attack and successfully develop in *Parafreutreta regalis* Munro (Tephritidae: Tephritinae), a gall making fly of interest as a potential weed control agent for Cape ivy, *Delairea odorata* Lem. Consequently, *B. celer* was rejected for introduction into California, at least until it is clarified if *P. regalis* is going to be introduced.

How Common Have Population-level Non-target Effects Been?

Deciding how best to assess the risk of biological control introductions has become an important focus of classical biological control of arthropods. New knowledge gained from in-depth studies of particular cases over the last 30 years has improved our ability to assess risk and determine how it can be lowered [118]. However, a comprehensive review of results of all parasitoid and predator releases for insect biological control has not been done and is not likely to be done because of the constraints of resources and scientific expertise. Consequently, any attempt to determine the frequency of such impacts devolves into collecting all the cases for which an attempt to obtain such information has been made (on the basis that cases with no data do not tell us there are no impacts, but only that the case has not been evaluated). It is less likely than for weed biocontrol agents that the impacts of insect biocontrol agents would be observed outside of deliberate scientific studies.

Cases where data exist, however, are not a random sample of all introductions, but rather seem to fall into three groups, each with strong, but different biases. One group consists of cases in which preliminary knowledge suggested that non-target effects had or were likely to have occurred and the researcher was interested in finding such cases because they could produce positive, publishable results that fit into a trending area of emphasis in the science. A second group of studies consists of work by biological control scientists who investigated historical cases where non-target impacts were asserted, but data were lacking. Such studies were often carried out either

because the scientist was located in the affected region or had a personal interest in the system. The third group of cases consists of more recent projects carried out by biological control scientists who developed extensive pre-release information (subject to stricter regulations for new projects) or investigated consequences of previous projects. The purpose of this work was to test hypotheses developed during host specificity testing in quarantine after agents were established in the field (i.e., were agents as host specific as predicted).

This scarcity of well-developed studies on insect biocontrol agents contrasts with weed biocontrol whose herbivorous agents are generally large, visible and reasonably easy to collect and identify. As a consequence, the number of recorded cases of non-target impacts by weed biocontrol agents actually reflects the real number of cases, and in this instance, it is probably reasonable to infer that no information of non-target impacts means that no impacts occurred. This strong difference between non-target impact assessments for insect and weed biocontrol agents is not likely to change because it is caused, in part, by the small size and taxonomic complexity of insect biocontrol agents and the often poorly understood native insect fauna in the receiving environment.

Therefore our ability to assess the level of non-target impacts for insect biocontrol agents (parasitoids and predators) will be imperfect and will consist of collecting and analysing published peer-reviewed information. We should expect knowledge to increase as more effort in this research area is made. However, these types of field studies, reviews, or metastudies may be subjected to the biases because of the research motivations listed above. Here we discuss the literature as of 2016 to the best of our knowledge, grouping studies as: (1) no impact on non-target species, (2) population-level impacts through attack or (3) indirect population-level impacts through mechanisms such as apparent competition or displacement through competition for hosts or prey. For the third case, we exclude displacement from an anthropogenic system (such as a native parasitoid being displaced from attacking an invasive pest on a crop); such evidence by itself does not mean significant ecological impact because the native natural enemy must have had a native host and its displacement in this native habitat by an introduced agent(s) is, in our opinion, the critical issue of most concern. At this point, displacement of native natural enemies in native habitat as opposed to agroecosystems has been inadequately addressed in previous studies assessing non-target impacts of introduced biological control agents.

Below we discuss 22 past cases, selected by us for purposes of this discussion, in which efforts were made to detect non-target impacts. We grouped 12 of these as showing no convincing evidence of significant impact, four showing direct impact, and six showing alleged indirect impacts via displacement, of which in four cases we argue that displacement of native parasitoids from their native hosts has not been shown.

Group 1. No impact

Bessa remota and *leuvana* moth

The introduction to Fiji of the tachinid fly *B. remota* (originally given as *Ptychomyia remota*) successfully controlled a devastating pest of coconut, the defoliating moth *Levuana iridescens* Beth.-Bak. (Lepidoptera: Zygaenidae) [119–121]. This case is portrayed by Howarth [1] as the cause of extinction for two moths, the target *L. iridescens* (asserted by Howarth to be native to Fiji) and another, certainly native, zygaenid called *Heteropan dolens* Druce. If both statements were well substantiated, this would be a case of great importance. However, neither assertion is supported by adequate evidence [22]. The parasitoid is native to the East Indies region [122] and is clearly polyphagous. Host range testing done 50 years later, when its introduction to India was being considered, found parasitism rates in the laboratory of 4–20% in larvae of eight Lepidoptera in various families [123]. However, the target pest on Fiji was considered invasive at the time of the original work [120, 122] and in later analyses [21, 22]. As for *H. dolens*, there are no records of this moth being attacked by *B. remota*, and this species may continue to exist on Fiji [22]. Consequently, there are no data to support claims that *B. remota* has caused the extinction of either *L. iridescens* or *H. dolens*.

Australian mealybug parasitoids in New Zealand

A post-release monitoring program in New Zealand found that four species of Australian parasitoids (*Tetracnemoidea sydneyensis* [Timberlake], *Anagyrus fusciventris* [Girault], *Gyranoidea advena* Beardsley and *Parectromoides varipes* [Girault]) (all Hymenoptera: Encyrtidae) of longtailed mealybug (*Pseudococcus longispinus* [TargioniTozzetti]) that were accidentally introduced by commerce do not affect native mealybugs in New Zealand, which occur in native forest. Longtailed mealybugs placed in native forest on potted citrus were always unparasitized, in contrast to similarly deployed longtail mealybugs placed in orchards, which were consistently parasitized. The native mealybugs *Paracoccus glaucus* (Maskell) and *Paracoccus zealandicus* (Ezzat & McConnell) placed in orchards on potted pigeon-wood plants, *Hedycarya arborea* J. R. Forst. et G. Forst., a native plant host of these mealybugs, were unparasitized by the exotic parasitoids. Collections of native mealybugs from native forest were parasitized by only native parasitoids. Collectively, these experiments and surveys show high specificity of these exotic parasitoids, probably because of an aversion to forage in forest habitats, and no change in the host ranges of any of the introduced parasitoids 14–47 years after their self-introduction [124].

Citrus blackfly parasitoids on the island of Dominica

A survey of 51 sites in the Caribbean Island of Dominica by Lopez et al. [125] found a high degree of suppression of the target citrus blackfly, *Aleurocanthus woglumi* Ashby (Hemiptera: Aleyrodidae), and no instances of parasitism

on other whiteflies (six species, a mix of native and introduced) by either of the two released parasitoids, *Amitus hesperidum* Silvestri (Hymenoptera: Platygasteridae) and *Encarsia perplexa* Huang and Polaszek (Hymenoptera: Aphelinidae).

Neotropical phytoseiid, Typhlodromalus aripo, in Africa

In Malawi and Mozambique, native mite communities on the introduced crop cassava (*Manihot esculenta* Crantz) were monitored for 2 years following the introduction of the phytoseiid predatory mite *Typhlodromalus aripo* De Leon for control of cassava green mite, *Mononychellus tanajoa* (Bondar) [126]. In Mozambique, densities of all the common phytoseiids on cassava – *Euseius baetae* (Meyer & Rodrigues), *Euseius bwende* (Pritchard & Baker) and *Ueckermannseius saltus* (Denmark & Matthysse) – remained stable during the study, despite establishment of *T. aripo* and its suppression of the target pest mite. In Malawi, two of the most common native cassava phytoseiids – *Euseius fustis* (Pritchard and Baker) and *Iphiseius degenerans* (Berlese) – increased in abundance, while that of the third species, *U. saltus*, was not affected.

Parasitoids attacking the endemic Hawaiian moth Udea stellata

Udea stellata (Butler) (Lepidoptera: Crambidae) is a common, non-threatened, endemic Hawaiian moth. Kaufman [127] examined sources of mortality affecting life stages of this moth and found seven polyphagous endoparasitoids attacking it: (a) three species likely moved accidentally in commerce: *Casinarina infesta* (Cresson), *Trathala flavoorbitalis* (Cameron) and *Triclistus* nr. *aitkeni* (all Hymenoptera: Ichneumonidae); (b) two species introduced for biological control: *Meteorus laphygmae* (Viereck) and *Cotesia marginiventris* (Cresson) (both Hymenoptera: Braconidae); and (c) two likely endemic species: *Diadegma blackburni* (Cameron) and *Pristomerus hawaiiensis* (Perkins) (both Hymenoptera: Ichneumonidae). The two biocontrol agents were introduced to Hawaii in 1942 to control the sugarcane pest *Spodoptera exempta* (Walker) (Lepidoptera: Noctuidae). Highest rates of apparent field parasitism were from the accidentally moved species *T. flavoorbitalis* and occurred mainly below 850 m elevation. The parasitoids introduced as biocontrol agents were detected in the target moth only above this elevation [127, 128]. Kaufman and Wright [129] explored these relationships more thoroughly, using demographic techniques such as life tables and marginal rate analyses. They found that the impact of parasitoids on *U. stellata* larvae was much lower than apparent parasitism had suggested, only about a 5% population reduction. The large difference between this finding and their earlier study was caused by a high rate of predation on larvae, which had not been accounted for previously. Furthermore, Kaufman and Wright [129] found that it was the accidentally introduced parasitoid *T. nr. aitkeni* that dominated the parasitoid guild (48.5% of all parasitoids reared in this study), not the accidentally introduced species *T. flavoorbitalis*, as reported earlier.

This study clearly illustrates the ease with which field data drawn from simple samples, unaided by a demographic analysis framework, can be misleading. It also suggests that accidentally introduced parasitoids (never subjected to selection criteria) can be more damaging to local native species than biological control agents. We suggest that these two types of invasions, deliberate (i.e., intentional release of biological control agents) and accidental (i.e., self-introduction or via the live plant trade), should be distinguished during assessments of impact on non-target species.

Peristenus digoneutis Loan (Hymenoptera: Braconidae)

This European parasitoid of certain species of *Lygus* mirid bugs was introduced into eastern North America to suppress a native species, *Lygus lineolaris* (Palisot de Beauvois). Before this introduction, the target pest was parasitized by a presumed native euphorine braconid, *Peristenus pallipes* (Curtis) at a low level (9%) [130]. However, it may be that *P. pallipes* is itself invasive, as it parasitizes at a high rate only two invasive European mirids [131].

After its introduction into the eastern USA, *P. digoneutis*' effects on mirids and their parasitoids were assessed over a 19-year period by Day [130], who found that parasitism of *L. lineolaris*, the target pest of the biocontrol program, increased to 64% and its density dropped by two-thirds. The parasitoid *P. pallipes* remained present in the system throughout the study. Some individuals of the mirid *Adelphocoris lineolatus* (Goeze) were parasitized, but its density was not reduced. *Leptopterna dolabrata* (L.), a European grass-feeding species, was not attacked by *P. digoneutis*. These observations suggest that the introduced parasitoid reduced the target host's density without damaging populations of either its native parasitoid or those of other mirids found in the same habitat.

For this same system, Haye *et al.* [132] assessed the value of laboratory host range test results as a predictor of field events. They did this by first assessing rates of *P. digoneutis* parasitism in the laboratory for a range of European mirids and then measuring parasitism of the same species collected from their native habitats in Europe. They reared *P. digoneutis* from ten field-collected hosts – three species of *Lygus* and seven non-*Lygus* species in the subfamily Mirinae. These findings were consistent with laboratory testing, showing that all seven non-target species that were parasitized in the laboratory were also attacked and successfully parasitized in the field. However, rates of parasitism observed in the field were low (<1% for 8 of 10 species), in contrast to laboratory parasitism (11–100%, by species). Haye *et al.* [132] suggested that such native range host surveys can help interpret quarantine data on parasitism, given that in small cages there is no need to find host habitats or hosts, as would be necessary in the field. So, while negative data in small cage laboratory studies probably indicate a high degree of safety to rejected species, the meaning of acceptance of species for parasitism under confined laboratory conditions is more ambiguous.

In summary, the introduction of *P. digoneutis* into the eastern USA for lygus bug control appears to have achieved its goals without population-level non-target impacts. *Peristenus digoneutis*, however, has also been released (since 1998) into the western USA [133], where there is a larger set of potential non-target mirids. Mason *et al.* [134], considering the possible effects of *P. digoneutis*, concluded from laboratory testing that native *Lygus* spp. in the region were at risk of being parasitized, but other regional non-target mirids were not. Information on actual field outcomes in western North America is not yet available and is needed.

Torymus sinensis Kamijo (Hymenoptera: Torymidae) in Italy

This parasitoid of the chestnut gall wasp, *D. kuriphilus*, has been released in several countries invaded by *D. kuriphilus*. Following its release in Italy, instances of non-target attack were sought by collection of a total of 1371 non-target galls (nine species of gall makers) in north-central Italy over a 2-year period from four species of oak and one of wild rose [135]. Five native torymid parasitoids were reared from the collected galls but *T. sinensis* was recorded from only one non-target galls wasp, *Biorhiza pallida* Galle (Hymenoptera: Cynipidae), from which two males of *T. sinensis* were reared. These field records are consistent with the fact that in the laboratory all the non-target galls tested were unsuitable for *T. sinensis* oviposition, except for the cynipid *Andricus curvator* Milan Zubrik.

Rodolia cardinalis in the Galápagos

Seven years after this lady beetle's release in the Galápagos, Hoddle *et al.* [136] evaluated the effects of *R. cardinalis* (Mulsant) (Coleoptera: Coccinellidae), released for control of the cottony cushion scale, *Icerya purchasi* Maskell (Hemiptera: Monophlebidae), on native insects on the islands to compare observed outcomes with quarantine predictions. Before release, up to 60 native or endemic species of plants on the islands were affected by the scale, causing population declines of some critically endangered plants and associated specialized insects [137, 138]. The assessment (2009–2011) found the project to have been safe and effective [136]. On evaluated plant species, scale densities were reduced by ~60–98% compared with pre-release surveys. Most native plants surveyed were no longer heavily infested by the scale, with the exception of the dune-inhabiting *Scaevola plumieri* (L.) Vahl., which still supported substantial, but fluctuating scale populations. Also, in urban areas, scale-tending by invasive ants kept scale populations high. During 22 h of field-cage observations, *R. cardinalis* adults were offered five non-target arthropod species. A total of 351 predator/prey encounters were observed, 166 with *I. purchasi* and 185 with non-target prey. Encounters with cottony cushion scale resulted in 53 attacks (32% rate) but none of the 185 encounters with non-target species resulted in attacks [136]. Collectively these studies demonstrated that this introduced natural

enemy was beneficial to the biota of the Galápagos Islands and was without observable negative consequences.

Pteromalus puparum on *Bassaris butterflies* in New Zealand
The butterfly known as the yellow admiral, *Vanessa (Bassaris) itea* (F.) (Lepidoptera: Nymphalidae), is listed by Lynch and Thomas [24] as having been significantly affected by the pupal parasitoid *P. puparum* (L.) (Hymenoptera: Pteromalidae) (introduced against *P. rapae* [L.]), on the strength of a personal communication by George Gibbs. Field studies assessing the impact of *P. puparum* on *V. itea* showed that in natural habitats parasitism rates by this species were low ~7%, but they increased to ~73% if study populations were in close proximity to *P. rapae* populations [139]. Despite this, Hicks [139] concluded that the most important factor depressing populations of *V. itea* was loss of its larval food plant, a stinging nettle (*Urtica* sp.), and Patrick and Dugdale [140] do not list *V. itea* in their summary of threatened New Zealand Lepidoptera.

Impacts of this same parasitoid on another New Zealand butterfly, the red admiral (*Bassaris gonerilla* [F.]) (Lepidoptera: Nymphalidae) is not mentioned by Lynch and Thomas [24], but an impact was similarly presumed to have been caused by *P. puparum* [141]. Further analysis, however, using field data and a population growth model [142] found that *P. puparum*'s impact (5%) was minor compared with another generalist pupal parasitoid, *Echthromorpha intricatior* (F.) (Hymenoptera: Ichneumonidae), an accidentally introduced species. This ichneumonid parasitoid reduced the butterfly's density in the same modelling analysis by an estimated 30%.

Trigonospila brevifacies in New Zealand

The tachinid *T. brevifacies* (Hardy) was introduced into New Zealand against light-brown apple moth, *Epiphyas postvittana* (Walker) (Lepidoptera: Tortricidae). It was later found attacking several native tortricids [144]. Of all parasitoids individuals reared from the sampled tortricids, *T. brevifacies* comprised 15.6–79.5% of the total. However, rates of parasitism by *T. brevifacies* on individual host species were not given, but rather it was stated that the whole parasitoid guild caused 13–26.5% parasitism (by host species) [143]. Without rates of attack by *T. brevifacies* on individual host species and without a life-table-based understanding of their meaning, we conclude that there is as yet no evidence of population-level impacts by this parasitoid on non-target tortricids in New Zealand.

Trichopoda giacomellii (Diptera: Tachinidae)

The tachinid *T. giacomelli* (Blanchard) was introduced into Australia in 1996 for control of the stink bug *N. viridula* (L.) following study of its likely host range [144]. Initial laboratory studies found that three non-target bugs were attacked and supported tachinid development: *Plautia affinis* Dallas, *Alciphron glaucus* (F.) and *Glaucias amyoti* (White) (all Hemiptera: Pentatomidae).

After establishment of the tachinid, field studies in New South Wales were conducted in 1999–2000 to measure its relationships with non-target pentatomids and scutellerids. Information was collected from 11 plant species, which collectively supported nine pentatomid species and two scutellerids. Some 1686 host individuals, summed over all species, were examined. Of the 11 bug species collected, nine were not attacked at all, one species had one parasitized individual out of 369 (0.03%), and one, *P. affinis*, had an overall parasitism rate of 4.8% (21/441), although at individual collecting sites, rates of parasitism ranged from 0.5 to 50%, effects likely mediated by attraction to the host plant. Only attack on *P. affinis* might rise to the level of population-level impacts, but only in selected locations [145].

Parasitoids of frugivorous and native gall-making tephritids in Hawaii

Efforts to control pest tephritids in Hawaii that attack fruits or coffee berries have included screening for attack by parasitoids of these pests on native tephritid gall makers. This was done either during consideration of new parasitoids for release or, for species released in the past, as later follow-up studies. The effort examined the propensity of seven parasitoids to probe or attack larvae of *Trupanea dubautiae* (Bryan), a native gall-making tephritid that infests flowerheads of the native composite shrub *Dubautia raillardioides* Hillebrand. Studies included laboratory studies and, for previously released species, field surveys. Duan and Messing [146] found that neither *D. longicaudata* nor *P. fletcheri* attacked *T. dubautiae* larvae in intact galls in laboratory tests. In a further study, Duan and Messing [147] found no attack on this same gall maker by another parasitoid, *Tetrastichus giffardianus* Silvestri (Hymenoptera: Eulophidae), under laboratory conditions, nor in a field survey on Kauai. A fourth parasitoid, *D. kraussi*, also did not attack this gall maker in laboratory tests [110]. Wang et al. [148] also found no attack in laboratory tests of this same gall maker by any of three additional parasitoids: *Fopius caudatus* (Szépligeti), *Fopius ceratitovor* Wharton and *F. arisanus* (all Hymenoptera: Braconidae). Collectively, these studies indicate no risk to this native gall maker from any of these seven introduced parasitoids.

Group 2. Direct trophic impact

Tamarixia (formerly Tetrastichus) dryi in La Réunion

On the island of La Réunion in the Indian Ocean, the parasitoid *T. dryi* (Waterston) (Hymenoptera: Eulophidae) was introduced during a successful programme to control two introduced psyllids that vector bacteria causing citrus greening disease. This case is listed in a review of non-target impacts by van Lenteren et al. [25] as causing 'reductions in population levels' of a local psyllid whose name was given as *Trioza eastopi* Orian [149], but which is a junior synonym of *Trioza litseae* Bordage. This psyllid is known only from two

islands: La Réunion, where it is pest of vanilla cultivation [150] and Mauritius (Diana Percy, personal communication). On La Réunion, populations were high on a widely planted, introduced shrub, *Litsea chinensis* Jacq., which is a traditional medicinal plant from the Andhra Pradesh region of India. While this psyllid may be native and endemic to La Réunion, it is possible that it may not be, and it could have arrived on *L. chinensis* from India. Uncertainty over the area of origin for *T. litseae*, and its abundance on La Réunion, need to be clarified. Until *T. litseae* is confirmed to be a native species and to be endangered by *T. dryi*, the ecological importance of its reduction in density remains unclear and somewhat doubtful.

Brachymeria lasus and two native butterflies on Guam

In Guam, native butterflies have experienced considerable decline. To understand if this was linked to species introduced for biological control, Nafus [151] measured apparent mortality rates for life stages of two native nymphalid butterflies on Guam: *Hypolimnys anomala* (Wallace) and *Hypolimnys bolina* (L.). For the egg stage, native ants were the dominant source of mortality for both species. In neither case did an introduced biological control agent cause important levels of egg parasitism. For larvae, a pathogen was an important source of mortality and larval parasitoids were not found. Only in the pupal stage did a biological control agent, *B. lasus* (Walker) (Hymenoptera: Chalcididae), cause significant levels of mortality, but only for *H. bolina* (25%). These findings demonstrate use of this species as a host in the field by *B. lasus*. However, since data were not placed in a lifetable context so that marginal attack rates could be calculated from apparent mortality rates, the actual population-level significance of this mortality estimate and the subsequent importance of parasitism by *B. lasus* are unclear.

C. glomerata in the Canary Islands

Lozan *et al.* [152] detected *C. glomerata* on the island of La Palma in the western Canary Islands, where it was found parasitizing an island endemic pierid butterfly, *Pieris cheiranthi* (Hübner). While rates of attack are not documented, it appears that the butterfly, a forest species, is principally in contact with the parasitoid at forest edges and not inside intact forests. This observation is consistent with evaluations in Massachusetts, which found that *Pieris virginiensis* (Edwards), also a forest species, was not attacked by *C. glomerata* inside forests [153]. In the Canary Islands, *C. glomerata* was not introduced as a biocontrol agent, having likely hitchhiked on traded goods.

Peristenus relictus Loan (= *P. stygicus*) and the western tarnished plant bug

This parasitoid, introduced into the western USA against the native western tarnished plant bug (*Lygus hesperus* Knight) (Hemiptera: Miridae), is an oligophagous parasitoid of mirid bugs, including *L. hesperus*, *L. lineolaris*, *Polymerus basalis* (Reut.), *Labopidicola geminatus* (Johnston) and *Psallus*

seriatus (Reut.) (= *Pseudatomoscelis seriatus*) [154]. In northern Germany, part of the native range of *P. relictus*, the ecological host range of this parasitoid includes at least 16 mirids in the subfamilies Mirinae, Phylinae or Bryocorinae [155]. These data suggest that *P. relictus* is a generalist mirid parasitoid. However, it was not the primary source of parasitism of most of its hosts [155] and appears to have only minor population-level effects on those it attacks. In laboratory tests in western North America, *P. relictus* was found to attack and develop in a number of non-Lygus mirids, including *Amblytulus nasutus* (Kirsch.), *L. dolabrata* (L.) and *Melanotrichus coagulatus* (Uhler) [134]. Post-release field studies are needed to determine if *P. relictus* has population-level effects on native non-target mirids in its introduced North American range [134].

Group 3. Displacement or other indirect impacts

Several cases of displacement of native parasitoids by introduced parasitoids are listed by Bennett [59], Lynch and Thomas [24], and van Lenteren *et al.* [25]. But a close examination suggests some of these reports may not be ecologically important. Of the 17 cases listed in Table 2 of Lynch and Thomas [24] as having significant effects on non-target species, four (*C. concinnata*, *M. aethiopsoides*, *T. pallipes*, *C. septempunctata*) seem likely or possible cases of important impact on non-target native species, and these have been discussed in earlier sections. Another six cases of presumed displacement (two for *C. flavipes*, two for *A. holoxanthus*, *C. noacki* and *T. brevifacies*) seem to be cases with no ecological importance for native species (for several differing reasons, as discussed below), and their inclusion in Table 2 of Lynch and Thomas [24] may be misleading. The problem here lies with labeling a case as one of impact or displacement as it invites further repetitive citation without consideration of relevant underlying details. One further case in Lynch and Thomas [24], that of *P. puparum* and the yellow admiral in New Zealand, has been discussed above under no impacts, as the impacts of this introduced parasitoid were demonstrated to be unimportant at the population level [139]. Here below we provide details for additional cases where displacement is claimed by Bennett [59] or Lynch and Thomas [24].

Cotesia flavipes Cameron in Trinidad and Brazil

This Asian braconid parasitoid was introduced from India and Pakistan into the Caribbean and, later, throughout the sugarcane-producing regions of Latin America against the sugarcane borer *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae). This and three other economically important species in the genus *Diatraea* are considered native to the Americas, and historically they supported several native parasitoids. One of these borers, *Diatraea lineolata* (Walker), is a maize stock borer attacked by the native braconid *Apanteles diatraeae* Muesebeck, typically at about the 10% level [156].

In Trinidad, after the build-up of *C. flavipes*, parasitism of *D. lineolata* by *A. diatraeae* was undetectable in a 1984–1985 survey [59], suggesting that this species had been displaced by the newly introduced parasitoid. However, the time period over which surveys were conducted was relatively short and Trinidad is only a small part of the range of this parasitoid, which also includes Mexico. In Mexico, Rodríguez-del-Bosque and Smith [157] detected *A. diatraeae* at a low level on another borer, *Diatraea muellerella* Dyar & Heinrich, in Guerrero, Mexico, and noted that it was a common parasitoid of several species of *Diatraea* throughout Mexico. Similarly, Tejada and Luna [158] found it to be the dominant parasitoid of *Diatraea* spp. larvae in the state of Nuevo Leon in Northern Mexico. These records, while in need of greater amplification (and possibly molecular level work to confirm species identities), demonstrate that the introduction of *A. flavipes* has not caused widespread displacement of *A. diatraeae* in Latin America but rather may have displaced it only locally (in Trinidad) or from only one of its hosts. The current status of *A. diatraeae* in Trinidad should be reassessed.

Bennett [59] also reported effects of *C. flavipes* in Brazil (following its 1978 introduction from Pakistan) on the abundance of two native tachinids. These effects were characterized as ‘The native tachinid parasitoids *Metagonistylum minense* and *P. claripalpis* have become scarce. While they are no longer represented in survey collections in many fields, they occur sporadically in collections from other fields.’ Also, Trejos *et al.* [159] recorded the presence of both of these tachinids in the Cauca Valley in Colombia. These survey results suggest that there are likely important temporal and spatial effects on the abundance of native and introduced parasitoids and the hosts that they share. Surveys should be of sufficient duration and across many study sites, so that robust conclusions can be drawn about population-level impacts from natural enemy introductions.

Aphytis holoxanthus DeBach (Hymenoptera: Aphelinidae)

This parasitoid has controlled the armored scale *Chrysomphalus aonidum* (L.), which is native to Asia, but is widely invasive in several citrus-producing regions around the world. It is listed by Bennet [59] and Lynch and Thomas [24] as being responsible for displacing two native parasitoids: one in Florida, *Pseudhomalopoda prima* Girault (Hymenoptera: Encyrtidae), and one in Brazil, *Aphytis costalimai* (Gomes) (Hymenoptera: Aphelinidae). However, in both cases, the same sequence of events seemed to have happened. First, a native parasitoid moved from native hosts and habitats into citrus groves (an artificial habitat created by people with an introduced tree) where it attacked an introduced Asian scale (*C. aonidum*) and became common on that host. Later, because control by native parasitoids was insufficient, the specialized parasitoid *A. holoxanthus* was introduced (into Florida in 1960 and Brazil in 1962). *Aphytis holoxanthus* became the dominant parasitoid on *C. aonidum*, removing it

as an available high-density resource for local native parasitoids that had been opportunistically exploiting the uncontrolled scale populations. This replacement does not mean, however, that native parasitoids suffered a negative ecological impact. Rather, they lost a previous gain due to the proliferation of a pest species in a man-made ecosystem, the citrus crop. In the case of *P. prima* in Florida, Bennett [59] recorded that this parasitoid remained the dominant parasitoid of the diaspidid scale *Acutaspis marrisonorum* Kosztarab on southern red cedar, *Juniperus virginiana* var. *silicicola* (Small) Bailey. This same scale occurs on several native pines in the southern USA, including *Pinus taeda* L. and *Pinus echinata* Mill. [160]. More recently, Ceballos *et al.* [161] reported collection of *P. prima* from *Aspidiotus destructor* Signoret on coconut (*Cocos nucifera* L.) in Cuba. As for the parasitoid in Brazil, Terán *et al.* [162] reported *A. costalimai* from scales on citrus in northern Argentina 23 years after the introduction of *A. holoxanthus* to the region. These records suggest that both of these native parasitoids remain present on various native scales infesting non-crop plants and rarely being collected unless they attack a pest scale on an economically important crop.

Cales noacki Howard (Hymenoptera: Aphelinidae)

This parasitoid was introduced into Europe to control the whitely *Aleurothrixus floccosus* Maskell, and Lynch and Thomas [24] list Viggiani [163] (also repeated by van Lenteren *et al.* [25]) as recording it as displacing *Encarsia margaritiventris* Mercet (Hymenoptera: Aphelinidae) from the viburnum whitefly, *Aleruotuba jelinekii* (Frauenf.), a native species in Europe. Little is known about the host range of *E. margaritiventris* as there are few published records, but it is likely not monospecific, as Malumphy *et al.* [164] recorded it as being reared from the whitefly *Aleurochiton aceris* (Modeer) in Lithuania. More data from field surveys are needed to evaluate this case.

T. brevifacies (Hardy) (Diptera: Tachinidae)

This tachinid, introduced into New Zealand to control light-brown apple moth (*E. postvittana*), is recorded by Lynch and Thomas [24] through Roberts [165] as significantly harming the parasitoid *Xanthopimpla rhopaloceros* Kreiger (Hymenoptera: Ichneumonidae). This latter parasitoid, however, is not native to New Zealand, having been introduced from Australia as part of the same biocontrol program targeting *E. postvittana* [166]. Both parasitoids coexist sympatrically in New Zealand where they attack light-brown apple moth [143].

Diadegma semiclausum (Hymenoptera: Ichneumonidae)

Two additional cases of apparent displacement not reported by Bennett [59] or Lynch and Thomas [24] were noted in this review of the literature: the ichneumonid *D. semiclausum* (Hellén) in Africa and various parasitoids introduced into the USA against the tobacco whitefly, *Bemisia tabaci* (Gennadius) strain B (also known as *B. argentifolii*) (discussed below).

D. semiclausum was released in Kenya in 2002 to control a cabbage pest, the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae). This release increased parasitism of diamondback moth larvae from 14 to 53% and consequently lowered crop damage. At the same time, rates of attack on the pest by several native parasitoids decreased. Attack rates on the pest by *Diadegma mollipla* (Holmgren) (Hymenoptera: Ichneumonidae) and *Oomyzus sokolowskii* (Kurdjumov) (Hymenoptera: Eulophidae) on cabbage in Kenya decreased from 5.4 to 2.8% and 9.0 to 2.2%, respectively [167]. Is such an impact significant to populations of these native parasitoids? In addition to attacking diamondback moth in cabbage fields, these native parasitoids also attack it on a variety of wild crucifers (weeds or native plants), where they were found co-existing with the introduced parasitoid 3–4 years after its release [168]. Also, these native parasitoids remained present, in lower numbers, 3–4 years post release on diamondback moth in cabbage fields [169]. These native parasitoids are known to be widely distributed in southern Africa, having been recovered from diamondback moth, for example, in South Africa [170]. *D. mollipla* has also been recorded in the literature from the potato tuberworm (*Phthorimaea operculella* [Zeller]) (Lepidoptera: Gelechiidae) in Egypt [171]. Since this record is of a host in a different family, it should be confirmed.

While much is not known about the native hosts and habitats of these non-target parasitoids, these records from crop studies suggest both that their densities have been lowered in cabbage fields in some areas, but also that they are widespread geographically, found on many host plants, and several insect species, which likely ensures their continued population-level well-being. Such instances of displacement, in the view of the authors, do not represent loss of biodiversity because of introduced natural enemies.

Parasitoids introduced into the USA against tobacco whitefly

In response to large financial losses in cotton, winter vegetables, melons and greenhouse crops from the invasion of the B strain of the tobacco whitefly (*B. tabaci*), some 20 parasitoid populations were collected from this species in many countries and introduced into the south-western USA [172]. Prominent among 11 released parasitoid populations (species × country combinations) was *Eretmocerus mundus* (Mercet) (Hymenoptera: Aphelinidae) from Spain [173]. Of five species released in California, *E. mundus* later was found in a 10-year survey to have become the dominant parasitoid on *B. tabaci* on cotton in California and to have displaced the native *Eretmocerus* species formerly attacking *B. tabaci* on that crop [174]. However, when non-cotton host plants were surveyed for whiteflies and their parasitoids, it was found that *E. mundus* did not attack either of two likely native whiteflies – the banded-wing whitefly (*Trialeurodes abutiloneus* [Haldeman]) on sunflower (*Helianthus annuus* L.) or mulberry whitefly (*Tetraleurodes mori* Quaintance) on mulberry (*Morus* sp.)

[174]. Furthermore, the native parasitoids formerly attacking *B. tabaci* on cotton, *Eretmocerus eremicus* Rose and Zolnerowitch and *Eretmocerus joeballi* Rose and Zolnerowitch, were found attacking banded-wing whitefly and mulberry whitefly on their respective host plants, indicating that displacement of these parasitoids by *E. mundus* was primarily from the introduced *B. tabaci* on cotton and not from other whitefly hosts on different plants [174].

As part of the same program, introductions into Arizona of the same suite of parasitoids resulted in the displacement (from *B. tabaci* on cotton) of two native species – *E. eremicus* and *Encarsia meritoria* (Gahan) – by the exotic parasitoids *Eretmocerus* sp. (Ethiopia) and *Encarsia sophia* (Gahan) in the early 2000s [175]. Information has not been published, however, concerning the status of these native parasitoids in Arizona on other species of whiteflies on other plants. It is quite possible that niche division, rather than general displacement, is also at work in Arizona, and this possibility needs to be resolved.

Looking Ahead: What Impacts Will New Parasitoid/Predator Introductions Have On Non-Target Species?

Forecasting likely host use

Avoidance of non-target effects from new introductions of parasitoids or predaceous arthropods is based on estimating fundamental host or prey ranges and releasing only species that are adequately specific for where they will be released, where they might naturally spread, and where they have a high risk of being accidentally transported [176, 177]. Part of the selection process is correct species-level recognition of the candidate natural enemy, as candidate natural enemies may be collected from a species complex whose aggregate host range is larger than that of some of its member species [178–180]. Estimating host ranges of parasitoids and predators was considered unimportant until about 1990 because non-target insects were considered to generally be of little economic importance and unimportant as species for conservation [181]. Methods for estimating parasitoid and predator host ranges were developed as extensions of methods used earlier for weed biocontrol agents and are reviewed by Van Driesche and Reardon [182] and discussed by van Lenteren *et al.* [183] and Babendreier *et al.* [176]. Here, framed around some key ideas, we discuss more recent contributions to methods for determination of host ranges.

Herbivore host range estimation, for weed biocontrol, seeks to understand the taxonomic limits of what an agent's adults or offspring can eat, if given the opportunity. The assumption is strongly and correctly made that if plants are closer taxonomically to the target weed, they will be inherently at greater risk of being eaten by the agent [184].

Tests assess what the adult and immature stages will eat, what host species the agents can feed on to maturity, and what plants adult agents will lay eggs on when given access to test species in small cages. Trials are either run one plant species at a time or in pairs (or larger groupings), where one species is the target pest. Alternatively, agents may be offered target and non-target plants in various sequences over time. Small-cage tests in quarantine cannot assess the ability of natural enemies to orient to a plant from a distance, distinguish it upon contact, and choose a preferred plant among locally available hosts.

Given this history, one should ask whether estimating parasitoid and predator host/prey ranges would be a simple extension of methods developed for herbivorous natural enemies. Consider the following. First, plants frequently defend themselves against herbivores with secondary plant compounds, which once developed by a lineage of plants tend to be conserved. These specialized compounds tend to deter generalist-feeding insects that lack an ability to survive possible intoxication following consumption, but these same compounds often are specific attractants for the specialists associated with the plant lineage [185]. Insects, in contrast, generally do not produce specialized chemical defences, although some species sequester toxins from their host plants, such as the cardiac glycosides obtained by larvae of monarchs, *Danaus plexippus* (L.) (Lepidoptera: Nymphalidae), from milkweeds (*Asclepias* spp.). The correlation between herbivore host ranges and plant taxonomy is a core theoretical tenant for screening weed control agents. This approach, however, is weak when applied as the basis to determine the host ranges of insect control agents [186]. Specialized secondary compounds do not have a large influence on parasitoid and predator host ranges, but host taxonomy still functions as a partial predictor of risk for non-target species based on: (1) the general morphology of potential host insects, (2) the manner in which non-target species feed on host plants and (3) where non-target species live in the physical environment. Beyond host taxonomic position, several other important factors must be considered when attempting to assess the host range of entomophagous natural enemies.

The first of these factors is that host odours and odours from the insect's host plant are important attractants for many parasitoids and predators, which orient from a distance towards the plants on which their hosts or prey are feeding [187–189]. Such plant volatiles also play an important role in host finding by herbivorous insects, but this factor has not been widely used in estimating herbivore host ranges because it requires use of olfactometers or wind tunnels to assess long distance responses to odours from different plants, and the use of these devices in quarantine may be difficult due to space limitations. For herbivores, it has been possible to generally ignore the need to assess 'attraction from a distance' because the secondary plant compound signal is strong and its effects are easier to measure in the laboratory. But for parasitoids

and predators, the absence of a strong signal analogous to that provided to herbivores by secondary plant compounds makes the 'attraction from a distance' factor more important to assess.

Second, plant tissues, unlike those of insects, usually do not have mechanisms (other than plant chemistry) that actively attempt to kill attackers. In contrast, insects have blood cell-based immune systems that attempt to defeat parasitism through mechanisms such as encapsulation, and if successful, such measures limit the host ranges of internal parasitoids [190]. In response, parasitoids have developed countermeasures to defeat encapsulation, such as the use of polydnviruses by braconids and ichneumonids [191].

Third, parasitoid and predator host/prey ranges are typically less specialized than those of specialized herbivores used as weed biocontrol agents. The challenge, then, is how are we to estimate the range of hosts whose populations are likely to be reduced by a parasitoid (population-level impact) based on results from laboratory testing, given that this strongly affected group will be some subset of all hosts that the parasitoid can attack. Minor levels of attack on some non-target species by parasitoids is likely to occur during quarantine testing. However, such attacks may not translate into significant population-level impacts in the field, and this possibility needs consideration when data from quarantine tests are being analysed and interpreted.

This distinction between host use under quarantine conditions and population-level impacts in the field was clearly stated by Blossey [192]. How, therefore are predictions about population-level impact to be made from laboratory data designed to measure host use? Several alternative methods of investigation have potential to do so, including literature surveys [193], field surveys in the agents' native range [194], post-release monitoring in the area of release [193] and population modelling [142]. What is currently needed is to expand the inventory of well-studied cases that allow us to examine the strength of such methods for assessing risks of significant non-target impacts and identify reasons for exceptions to anticipated outcomes

Moving from host use to population-level effects

Post-release, estimates of population-level effects on non-target species caused by deliberately introduced biological control agents can be made with life table studies [129], studies of impact using cohorts deployed on host plants [51] or over physical gradients [51], or through the application of population models that use field-collected demographic data [11, 142].

Pre-release prediction of likely non-target impact, however, cannot use the above methods because the agent is not yet present in the field in the country of intended release. Paynter *et al.* [195] propose a pre-release

method for predicting host use by weed biocontrol agents on non-target plants based on the ratio, in quarantine tests, of attacks on the non-target versus target plants. This method, however, only predicts host use, not population-level impact and the approach may not be applicable to entomophagous natural enemies. Wright *et al.* [196] presented a method for assessing risk of use of a non-target species from augmentative release of an egg parasitoid (*Trichogramma ostrinae* Pang and Chen, Hymenoptera: Trichogrammatidae) that assessed risk as the cumulative probability over a series of links in a decision tree (e.g., probability of dispersing to non-target species' habitat \times probability of attacking non-target species, etc.). In principle, this system could be applied to classical biological control agents provided necessary information on habitat use, density in habitat, and attack rate on non-target species could be developed. Risk of introductions, particularly for augmentative biocontrol agents, has also been discussed in terms of the product of risk of establishment \times dispersal \times host range, making it possible to estimate effects on native species. This was done, for example, for eight species of predatory mites introduced into Japan [197]. Such schemes, however, while using knowledge and judgment, are fundamentally forecasts, not facts.

What is needed to improve understanding of the potential impacts of insect biocontrol agents is to conduct replicated (across sites and over time) longitudinal studies that are designed to assess, population-level impacts in the field and compare those estimates with rates of attack on non-target species in pre-release tests. For new agents undergoing release consideration, this would mean conducting impact studies on non-target species of interest. For agents released without host range testing, such studies would require carrying out both field impact studies and after-the-fact laboratory host-specificity tests.

From host impact to determination of a project's risks and benefits

Ideally regulatory agencies should compare potential benefits to program costs (known or anticipated), including monetary costs and ecological damage to non-target species. Predictions of non-target impacts made before releases are largely educated guesses, based on some sense of the likely host range of the agent as determined from quarantine studies or literature reviews, how attack might translate into population-level impacts, and the value of the non-target species likely to be affected. These negative effects then have to be compared with the ecological damage or economic costs that might reasonably be expected if the pest is not controlled, together with an estimate of the chances of successfully controlling the pest. While most of the above quantities are rarely precisely known, the benefits and losses of such actions are easiest to compare if they are in the same currency (either both

ecological damage or both economic losses). When targets are agricultural pests that do not affect natural areas, benefits to nature are indirect in the form of reduced use of pesticides and lower levels of environmental contamination. Direct economic benefits to farmers [198–200] are part of the 'benefits ledger' and are not required as part of these analyses, but can be very important for justifying programmes. In countries with acts intended to protect endangered species, risk to those species may override the larger picture of risks and benefits, as such laws may, as in the USA, be inflexible with regard risk to the protected species, placing their interests above all else.

Risk analysis is complicated, and factors that will need to be taken into account will vary by project. Hoelmer and Kirk [201] discuss how several lines of information can be combined to improve selection of biological control agents. Some risk modelling suggests that even non-target species that are low on the agent's preference scale may be harmed if the agent builds quickly to very high densities when the host is still abundant and if during this period the agent spills over on a small non-target population (i.e., apparent competition [202]). This possibility is not yet part of main stream risk analysis and would likely be very difficult to estimate accurately, but it should receive further investigation, especially if the suspected impact is not going to be transitory. In the context of weed biocontrol agents, it has been suggested that such effects can be minimized by avoiding the release of agents that fail to control the host (and thus remain abundant). The application of this idea to parasitoids is unknown. *C. concinnata*, for example, was highly effective in control of one of its target hosts (brown-tail moth, *Euproctis chrysorrhoea* [L.]) and yet is a wide generalist with important non-target effects as discussed above.

Summing up the risks for an agent's introduction was attempted by Wyckhuys *et al.* [203] for *Binodoxys communis* (Gahan) (Hymenoptera: Braconidae) released against soybean aphid, *Aphis glycines* Matsumura, in North America. This summation was based on information about host suitability (as seen in laboratory tests), seasonal overlap of the parasitoid with susceptible hosts, and protection of native aphids by physical refuges or ant-tending. Ultimately such risk assessments describe probable risks, and it remains the job of regulators to decide on behalf of society if the risks to non-target species posed by introductions of natural enemies are warranted.

Another factor bearing on accuracy of risk prediction is selecting appropriate native species for non-target testing in quarantine. Barratt *et al.* [204] describe a new tool (PRONTI) that is intended to strengthen this process. As a test case, they applied the tool, as an after-the-fact exercise to *M. aethioides*' 1982 introduction to New Zealand, since a great deal is known about its subsequent relationships with native species of non-target weevils. The exercise concluded that if PRONTI had been used, many of

the species subsequently attacked would have been chosen for host-range testing, and thus use of this system would have provided a much clearer assessment of the agent's likely host use. Population-level impacts (as opposed to predicting possible non-target use), however, are not predictable using PRONTI

Recent practice (1985–2016) as predictor of future non-target impacts

A question of interest for this article, in addition to compiling and analysing records of past impacts, is whether safety practices used by biological control practitioners are improving and reducing risk to non-target species. Improving practice is based on better science (e.g., technical aspects of host range and risk estimation) and policy (e.g., societal goals and institutions that determine what risks are acceptable or even recognized). To address this issue of improved practice, we compiled information on cases of parasitoid or predator introductions over the last 30 years (1985–2015) that spans the historical period when the goal of estimating host ranges for insect control agents was adopted and gradually implemented in the USA. In Table 1, we list 158 parasitoid species introduced during this period (94 in the first decade, 41 in the second and 23 in the third; also included in Table 1 are seven species that were studied but not released). While not a complete list of parasitoids introduced over this 30-year period, Table 1's entries are, we believe, unbiased with regard to the level of host specificity exhibited by the natural enemies of interest. Entries were drawn from the senior author's personal files (assembled over the period 1976–2015), reading of additional articles on species mentioned tangentially in the first group of articles, and from the BioCat database records for North America (Canada, Mexico and the USA, including its overseas territories). In Table 2, we list 23 species of predacious arthropods introduced over the same period (1985–2015), compiled in a similar manner as species in Table 1.

For each record, the senior author read the primary literature on the biocontrol agent to understand its likely host range and then used that information to choose a taxonomic rank (order, family, subfamily, tribe, genus or species) most likely to encompass all of the agent's known hosts or prey. This does not imply that all the members of that taxonomic unit are actual hosts, but only that no smaller unit contains all the known hosts. This classification system should be treated as an index of the host range (based on hosts known from the literature and other available data), rather than a true estimate of the fundamental host range based on quarantine studies, which often were not done.

In most cases in Table 1, the parasitoid's host range was not known and was not estimated by the researchers before the agent's introduction. In the first and second decades (with some exceptions in the second decade),

agents were introduced if, based on available information, they were considered to be primary parasitoids of the target pest and likely to be efficacious. Host range was generally not estimated, although some information was usually available in the form of records of attacks on other hosts, or from studies designed to investigate if species related to the target pest could be used as alternative hosts. This approach was largely replaced in the third decade by checking the host status of a list of more or less taxonomically (or ecologically) related non-target species, limited to those species that could be obtained for testing. The transition to formal estimation of the fundamental host range [205] of entomophagous natural enemies based on experimentation, as is done for weed biocontrol agents, is gaining momentum in several countries (e.g., New Zealand and the USA). While continued momentum towards an increased requirement for host range and host specificity data are expected, strong differences exist in the biological factors structuring host ranges of parasitoids/predators versus herbivorous insects that may limit progress towards this goal.

In general, analysis of trends found in Table 1 (see Fig. 1) showed a shift in the third decade (2005–2015) towards a preponderance of agents showing an index of genus- (60%) or species-level (8%) specificity (with only 12% being assigned a family-level or above index of specificity) compared with the first and second decades, when 50 and 40% of introductions had family level or above categorizations of specificity and only 21–27 (1985–1994 and 1995–2004, respectively) with genus, or 1–11% (1985–1994 and 1995–2004, respectively) with species-level specificity. In all three decades, 11–12% of introductions could not be classified in this manner due to lack of information.

Concluding Remarks

From our consideration of the above-cited literature, we drew the following points for our final emphasis and recommend they be incorporated in future practice.

Caveats and clarifications

- *Evaluate original evidence; do not just repeat past claims.* Our views of biocontrol's non-target impacts such derive from facts not assertions. It is important that new works, either in their introductions to research articles or summaries in review articles should do more than just repeat conclusions of earlier studies. Rather, it is required that authors consider the evidence in past studies and make their own critical judgments on the strength of what is being claimed. Otherwise, errors of either pessimism or optimism cannot be expunged and replaced with data-supported conclusions. A good example of the need for this process is that of *B. remota*

and whether or not it caused the extinction of either its host (*L. iridescens*) or a second species (*H. dolens*) on Fiji, as claimed by Howarth [1], disputed by Kuris [21] and Hoddle [22], but not supported by adequate evidence.

- *Distinguish biological control agents from adventive parasitoids and predators.* Some studies considered in this review did not properly distinguish adventive (self-introduced) parasitoids from ones deliberately introduced as biocontrol agents when commenting on non-target impacts of biocontrol agents. Invasions by polyphagous natural enemies occur naturally or because of commercial movement of plants and other goods. The impacts of accidentally introduced species, even if they are classified as biological control agents elsewhere, are not an indictment of sound biological control practice.
- *Critical need for good taxonomy BEFORE releasing new species.* Another theme found in past projects reviewed here was that many biological control agents turn out to be new species or members of a cryptic complex, hidden by an overly broad name. New species are often described as part of the process of exploration related to actual or potential biological control projects [206]. Such descriptions and clarifications of any cryptic species (that might mask the true identity of potential agents) should be completed before agents are released. See Paterson *et al.* [207] for an example of the use of molecular methods to identify cryptic species, as further supported by mating studies. Correct appreciation of the taxonomic status of new agents before their introduction should be a clear goal for future work.
- *Prioritize agents and begin by releasing the likely best species first.* In view of past projects acting to the contrary, it is important to emphasize that in future, thoughtful programs should not operate on the principle that release of all species (sometime referred to as the lottery or shotgun approach) found to be primary parasitoids of the target pest is justified (e.g., as against Russian wheat aphid [208–210]) and sweetpotato whitefly strain B [172]). Rapid release of many species with little time to evaluate impacts of any may be a sign of poor conduct, likely to draw criticism [211].
- *Displacement of native species from a non-native host on a crop is not evidence of actual ecological harm.* An important misconception that we noted when reviewing sources on past projects is that past views of displacement of native species by biological control agents need revision. Denying a native species the opportunity to use an exotic pest on an exotic plant (e.g., agricultural crops) by introducing an effective biological control agent of the pest should not be considered as a non-target impact. Rather displacement is an impact only when the native species is displaced from its native host in its usual ecological niche.

Guides for future thinking

Thinking about non-target impacts associated with past work, there are several points that should be embraced in future work.

Distinguish host use from population-level impact

Feeding on or parasitizing a native species at levels that do not significantly lower its long-term population density should be considered ‘use’ (A eats B), but not ‘impact’ (A makes B scarcer) and should not be considered as ecologically damaging. While exact numbers are not known, we suggest that, in the absence of data, we should assume that rates of attack <10% are likely to have little impact, while rates of >50%, if widespread and sustained over time, may reduce populations of affected non-target species.

Develop country-level online summaries of relevant information

Given the difficulty we experienced in assembling information on past releases in the USA, apart from access to BioCat, we recommend that in the future, all countries making releases of biological control agents should develop and maintain web-accessible databases where lists for newly released agents are given, noting year, location and target pest, as well as references or links to sources of information about the estimated host ranges of the agents. Such information, publically available, would provide a firm basis for future analyses of the impacts of biocontrol projects.

Plan biological control projects with conservation partners

Given the obvious past record of conservation biologists and biological control scientists working separately, at least in the USA, as reflected in the literature we reviewed, it is recommended that in the future, strong efforts be made to reduce that separation. Collaborative studies with conservation biologists are an effective way to build bridges and maximize use of existing expertise. See Van Driesche *et al.* [212] for discussion of potential joint efforts.

Conduct post-release comparisons of actual impact to predicted risk based on quarantine studies

Many past projects considered in this review, seemed to end prematurely, perhaps for lack of funding after pest densities declined. This has left a considerable gap in our knowledge. Post-release activities are central to improving our understanding of the level of accuracy of quarantine predictions in forecasting field non-target impacts. Post-release studies, either retroactively for past projects or as part of current programmes, should improve understanding of the ecological consequences of natural enemy releases and model insect life systems to link observable levels of attack to population-level impacts (which is what matters).

Table 1. Parasitoids introduced between 1985 and 2015, with notes on the level of specificity of each, drawn from literature records (worldwide) and BioCat (for North America, including Canada, Mexico, the USA and US overseas territories, 1985–2004 [end of available records]). Records for North America are relatively complete, but for other regions are partial but not selective. Introductions were only excluded if: (1) species were unidentified (e.g., *Aphytis* sp.), (2) had also been released in the country before 1985), (3) were duplicative (i.e., release of the same agent in more than one country was not generally tracked unless there were important differences the current authors wished to capture, which was done only in a few cases) or (4) no published information could be located on the release of the species

	Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
1985–1994								
1	1985 USA (Hawaii) from Pakistan	<i>Diadegma semiclausum</i> Hellen (Ichneumonidae)	<i>Plutella xylostella</i> (L.) Xylostellidae	0	No laboratory host range estimation done	Species? No other hosts are reported in the literature and the species show a strong responses to cabbage odour, particularly when infested by <i>P. xylostella</i> [214] Genus? Known only from original description, which lists two hosts <i>Anastrepha serpentina</i> (Wiedemann) and <i>Anastrepha striata</i> Schiner	R+/E? 1985	[213, 214]
2	1985 USA	<i>Doryctobracon</i> (formerly <i>Opius</i>) <i>trinidadensis</i> (Gahan) Braconidae	<i>Anastrepha suspensa</i> (Loew) Tephritidae	0	No laboratory host range estimation done	Genus? Known only from original description, which lists two hosts <i>Anastrepha serpentina</i> (Wiedemann) and <i>Anastrepha striata</i> Schiner	R+/E? 1985	[215]
3	1985 USA (Guam)	<i>Ganaspidium utilis</i> Beardsley (now <i>Banacuniculus utilis</i>) [216] Eucollidae	<i>Liriomyza trifolii</i> (Burgess) Agromyzidae	0	No laboratory host range estimation done	Family? All species in <i>Ganaspidium</i> are parasitoids of Agromyzidae (Diptera) [216] Unknown	R+/E+ 1985	[216–219]
4	1985 USA (Texas) from Mexico	<i>Mallochius pyralidis</i> Wharton (Ichneumonidae)	<i>Eoreuma loftini</i> (Dyar) Crambidae	0	No laboratory host range estimation done	Subfamily? (Epilachninae) Literature hosts include principally various epilachnine coccinellids, e.g., <i>Epilachna varivestis</i> Mulsant [221] and <i>Henosepilachna vigintioctopunctata</i> (F.) [222]; unusual records that need confirmation include the skipper <i>Borbo cinnara</i> (Wallace) [223] and a braconid wasp (<i>Cotesia</i> sp.) [224]	R+/E? 1985	[220]
5	1985 USA (Northern Mariana Is.)	<i>Pediobius foveolatus</i> (Crawford) Eulophidae	<i>Epilachna philippinensis</i> Dieke (Coccinellidae)	0	No laboratory host range estimation done	Subfamily? (Epilachninae) Literature hosts include principally various epilachnine coccinellids, e.g., <i>Epilachna varivestis</i> Mulsant [221] and <i>Henosepilachna vigintioctopunctata</i> (F.) [222]; unusual records that need confirmation include the skipper <i>Borbo cinnara</i> (Wallace) [223] and a braconid wasp (<i>Cotesia</i> sp.) [224]	R+/E+ 1985	[222–225]
6	1985–91 Canada from Europe	<i>Phygadeuon wiesmanni</i> Sachtleben (Ichneumonidae)	<i>Rhagoletis pomonella</i> (Walsh) Tephritidae	0	No laboratory host range estimation done	Genus? Literature records include other species of <i>Rhagoletis</i> , such as <i>R. cerasi</i> L. [226]), <i>R. alternata</i> Fallen [227]	R+/E–	[226–228]
7	1985–91 Canada	<i>Psytalia carinata</i> (Thompson) senior synonym of <i>P. (Opius) rhagoleticola</i> (Sachtleben) Braconidae	<i>Rhagoletis pomonella</i> (Walsh) and/or <i>Rhagoletis cerasi</i> (Tephritidae)	0	No laboratory host range estimation done	Unknown Other species in the genus are parasitoids of tephritids	R+/E– 1985	[228]

Table 1. (Continued)

Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
8	1985–87 USA from Mexico	<i>Trichogramma atopovirilia</i> Oatman & Platner (Trichogrammatidae)	<i>Diatraea grandiosella</i> Dyar (Crambidae)	0	No laboratory host range estimation done	Two Families (Noctuidae and Crambidae) Literature records include eggs of noctuids (e.g., <i>Helicoverpa zea</i> [Boddie] [229] and <i>Anticarsia gemmatilis</i> Hübner [230]) and crambids (e.g., <i>Diatraea grandiosella</i> Dyar [231])	R+/E– 1985 [229, 231, 232]
9	Ca 1985 Israel (from USA)	<i>Trichogramma platneri</i> Nagarkatti (Trichogrammatidae)	<i>Ascolis selenaria</i> Denis & Schiffmüller (= <i>Boarmia selenaria</i>) (Geometridae) <i>Cryptoblabes gnidiella</i> (Milliere) Pyralidae	0	No laboratory host range estimation done	Order or multiple families At the time of introduction, it was known to attack eggs of moths in Tortricidae (<i>Cydia pomonella</i> [L.]; <i>Amorbia cuneana</i> [Wism.]), Geometridae (<i>Sabulodes aegrotata</i> [Gn.] [233]; <i>Boarmia selenaria</i> Schiff.), and Pyralidae (<i>Cryptoblabes gnidiella</i> Milliere)	R+/E– (Blumberg, per comm.) Ca 1985 [233–236]
10	1985 New Zealand	<i>Aphidius rhopalosiphii</i> De Stephani-Perez (Braconidae)	<i>Metopolophium dirhodum</i> (Walker) Aphidae	4–6?	Several (4–6?) exotic aphids were examined as hosts, but no native species were tested at the time. In addition host records from the literature were considered.	Tribes Aphidini and Macroshiphini This information was determined ~30 years after the introduction by Cameron <i>et al.</i> , [239]	R+/E+ 1985 [237–239]; David Teulon, per comm.
11	1985–1987 USA (northern TX, from Indo-Australian region)	<i>Cotesia flavipes</i> Cameron (Braconidae)	<i>Diatraea grandiosella</i> Dyar (Crambidae)	0	No laboratory host range estimation done	Two Families (Noctuidae and Crambidae) Known to attack many noctuid and crambid stem borers in grasses [240]	R+/E– This species was released in south Texas, Rio Grande Valley, earlier [241] and established there. It failed, to establish in 1985 in more northern Texas [232, 240–244]
12	1985–1987 USA (Northern TX, from Mexico)	<i>Trichogramma atopovirilia</i> Oatman and Platner (Trichogrammatidae)	<i>Diatraea grandiosella</i> Dyar (Crambidae)	0	Laboratory host testing was done to determine if certain pest borers were susceptible, including various crambids (formerly part of Pyralidae): <i>Diatraea considerata</i> Heinrich, <i>D. saccharalis</i> (F.), <i>D. grandiosella</i> Dyar and <i>Eoreuma loftini</i> (Dyar)	Unknown	R+/E– [232, 245]
13	1985–1987 USA (northern Texas, from Mexico)	<i>Allorhogas pyralophagus</i> Marsh (Braconidae)	<i>Diatraea grandiosella</i> Dyar (Crambidae)	0	Laboratory host testing was done to determine if certain pest borers were susceptible	Two Families Grass stem borers in Crambidae and Noctuidae; known hosts include <i>Diatraea saccharalis</i> , <i>Emmalocera depressella</i> (Swinhoe), several species of <i>Chilo</i> , and the noctuid <i>Acigona stenilius</i> (Hampson), among others	R+/E– 1985–1987 [232, 246–250]

14	1985–1987 USA (northern Texas, from Mexico)	<i>Macrocentrus prolificus</i> Wharton (Braconidae)	<i>Diatraea grandiosella</i> Dyar (Crambidae)	0	No laboratory host range estimation done	Family? Known hosts include several species of <i>Diatraea</i> (<i>D. considerata</i> Heinrich, <i>D. grandiosella</i> Dyar, <i>D. saccharalis</i> [F.]) Two Families Known hosts are <i>Eoreuma</i> <i>loftini</i> and 5 species of <i>Diatraea</i> (all Crambinae, Pyralidae) Two Families Grass stem borers in Pyralidae and Noctuidae Family Literature records include diaspidid scales such as <i>Unaspis yanomensis</i> Kuwana [256] Subfamily (Hadenine) [259, 260]	R+/E– 1985–1987 [232, 251]
15	1985–1987 USA (Northern Texas, from Mexico)	<i>Digonogastra kimballi</i> Kirkland (Braconidae)	<i>Diatraea grandiosella</i> Dyar (Crambidae)	0	No laboratory host range estimation done		R+/E– 1985–1987 [232]
16	1985–1987 USA (Northern Texas, from Mexico)	<i>Pediobius furvus</i> (Gahan) Eulophidae	<i>Diatraea grandiosella</i> Dyar (Crambidae)	0	No laboratory host range estimation done		R+/E– 1985–1987 [232, 252–255]
17	1986–89 USA (Texas and Florida)	<i>Aphytis yanomensis</i> DeBach & Rosen (Aphelinidae)	<i>Parlatoria pergandii</i> Comstock (Texas) <i>Unaspis citri</i> (Florida) Diaspididae	0	No laboratory host range estimation done		R+/E– [256–258]
18	1986–87 Canada	<i>Eurithia</i> (formerly <i>Ernestia</i>) <i>consobrina</i> (Meigen) Tachinidae	<i>Manestra configurata</i> Walker (Noctuidae)	5	Of five NT noctuid species tested by placing a fly maggot on the test larva, four supported maggot development to pupation [259]		R+/E– [259, 260]
19	1986–90 USA	<i>Peristenus conradi</i> Marsh (Braconidae)	<i>Adelphocoris lineolatus</i> (Goeze) Miridae	0	No laboratory host range estimation done	Species? Post-release surveys in two US states found parasitism in only the target mirid, of 7 species surveyed	R+/E+ [131, 132, 261]
20	1986 USA (Hawaii)	<i>Tetrastichus brontispae</i> Ferrière (Eulophidae)	<i>Brontispa chalybepennis</i> (Zacher) Chrysomelidae	0	No laboratory host range estimation done	Family? (coconut-feeding chrysomelid beetles) Field host records include <i>Brontispa froggatti</i> [<i>Brontispa</i> <i>longissima</i>] var. <i>selebensis</i> Gestro [262], <i>Brontispa</i> <i>mariana</i> Spaeth [263], <i>Gestronella centroleinea</i> (Fairm.) and <i>G. lugubris</i> (Fairm.) [264], <i>Ocotonta</i> <i>ripae</i> (Maulik) (Chrysomelidae) [265] Subfamily (Panchaetothripinae) This estimation was made by Froud <i>et al.</i> , [266] based on literature records	R+/E? [213, 262–265]
21	1986–89 USA	<i>Thripobius javae</i> (Girault) (= <i>T. semiluteus</i> Boucek) Eulophidae	<i>Heliothrips haemorrhoidalis</i> (Bouché) Thripidae	0	No laboratory host range estimation done		R+/E+ [266–269]
22	1986 USA (Guam)	<i>Trichogramma platneri</i> Nagarkatti (Trichogrammatidae)	<i>Penicillaria jocosatrix</i> Guenée (Noctuidae)	0	No laboratory host range estimation done	Order or multiple families At the time of introduction, it was known to attack eggs of moths in Tortricidae (<i>Cydia</i> <i>pomonella</i> [L.]; <i>Amorbia</i> <i>cuneana</i> [Wism.]), Geometridae (<i>Sabulodes</i> <i>aegrotata</i> [Gn.]; <i>Boarmia selenaria</i> Schiff.) [233], and Pyralidae (<i>Cryptoblabes gnidiella</i> Milière) Unknown	R+/E? [233–236]
23	1986–1987 Guam (from India)	<i>Aleiodes</i> nr. <i>circumscripatus</i> (Nees) Braconidae	<i>Penicillaria jocosatrix</i> Guenée (Noctuidae)	0	No laboratory host range estimation done		R+/E– 1986–1987 [270]

Table 1. (Continued)

	Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
24	1986–1987 Guam (from India)	<i>Blepharella lateralis</i> Macquart (Tachinidae)	<i>Penicillaria jocosatrix</i> Guenée (Noctuidae)	0	No laboratory host range estimation done	Order Recorded from Noctuidae, Arctidae, and Lymantriinae Unknown	R+/E+ 1986–1987	[270–272]
25	1986–1987 Guam (from India)	<i>Euplectrus nr. parulus</i> Ferrière (Eulophidae)	<i>Penicillaria jocosatrix</i> Guenée (Noctuidae)	0	No laboratory host range estimation done		R+/E+ 1986–1987	[270]
26	1986 Turkey (from California)	<i>Eretmocerus debachi</i> Rose and Rosen (Aphelinidae)	<i>Parabermisia myricae</i> (Kuwana) Aleyrodidae	0	No laboratory host range estimation done	Species? Known only from target host	R+/E+ 1986	[273]
27	1987 Cyprus (from France)	<i>Metaphycus bartlettii</i> (Annecke and Mynhardt) Encyrtidae	<i>Saissetia oleae</i> (Olivier) Coccidae	0	No laboratory host range estimation done	Genus (<i>Saissetia</i> and closely related Coccidae)	R+/E+ 1988–89	[274–276]
28	1987 Togo and later other parts of West Africa (from India by CABI)	<i>Gyrinusoides tebygi</i> Noyes (Encyrtidae)	<i>Rastrococcus invadens</i> Williams (Pseudococcidae)	3	One species each of <i>Pseudococcus</i> , <i>Planococcus</i> , and <i>Phenacoccus</i> were tested but none were parasitized	Species Did not parasitize either <i>R. iceryoides</i> (Green) or <i>R. mangiferae</i> (Green) in laboratory tests [277]	R+/E+ 1988	[277–279]
29	1991 West Africa (from India by CABI)	<i>Anagyrus mangicola</i> Noyes (Encyrtidae)	<i>Rastrococcus invadens</i> Williams (Pseudococcidae)	3	One species each of <i>Pseudococcus</i> , <i>Planococcus</i> , and <i>Phenacoccus</i> were tested but none were parasitized	Species Did not parasitize either <i>R. iceryoides</i> (Green) or <i>R. mangiferae</i> (Green) in laboratory tests [277]	R+/E+ 1991	[277, 279]
30	1987 USA (Hawaii)	<i>Psyllaephagus vaseeni</i> Noyes (Encyrtidae)	<i>Heteropsylla cubana</i> Crawford (Psyllidae)	0	No laboratory host range estimation done	Family (Psyllidae) No other hosts are recorded but there are few studies on this species	R+/E+	[280, 281]
31	1987–89 USA	<i>Trissolcus basalis</i> (Wollaston) (formerly <i>Micropharus basalis</i> and <i>Asolcus basalis</i>) Scellionidae	<i>Nezara viridula</i> L. (Pentatomidae)	0	No laboratory host range estimation done	Family (Pentatomidae) Hosts recorded in the literature are various pentatomids: <i>Euschistus servus</i> Say and <i>Euthyrkynchus flordanus</i> L. [98]; <i>Eurygaster integriceps</i> Put. [283]; <i>Aelia rostrata</i> Boheman [284]; <i>Acrosternum</i> sp. and <i>Thyanta perditor</i> (F.) [285], among others	R+/E+	[282–285]
32	1987 Hawaii (from Tobago)	<i>Psyllaephagus rotundifolius</i> (Howard) (first identified as <i>Psyllaephagus</i> sp. near <i>rotundiformis</i>) (Howard) Encyrtidae	<i>Heteropsylla cubana</i> Crawford (Psyllidae)	2	Two other NT species in the same genus were accepted as hosts [286]	Genus? Recorded hosts include target plus 2 other species in same genus: <i>H. huasachae</i> Caldwell and <i>H. fusca</i> Crawford [286]	R+/E? 1988	[286, 287]
33	1988–89 USA (Guam)	<i>Adelencyrtus oceanicus</i> Doutt (Encyrtidae)	<i>Furcaspis oceanica</i> (Lindinger) Diaspididae	0	No laboratory host range estimation done	Unknown No other host records in literature	R+/E+	[288, 289]

34	1988 USA	<i>Agonaspis</i> (formerly <i>Holothorax</i>) <i>testaceipes</i> (Ratzburg) Encyrtidae	<i>Phyllonorycter</i> (formerly <i>Lithocolletis</i>) <i>crataegella</i> (Clemens) Gracillariidae	0	No laboratory host range estimation done	Genus? Limited to ecological niche of leafminers on deciduous trees? Most literature records are gracillariid (Lep.) leafminers in the genus <i>Phyllonorycter</i> including <i>P. biancardella</i> (F.) [290], <i>P. ringoniella</i> (Matsumura) [291], and <i>Phyllonorycter pyrifoliella</i> (Gerasimov) [292]. However one record is of the gelechiid (Lep.) leafminer <i>Recurvaria syrticis</i> Meyrick [293] (needs verification)	R+/E+ (in Connecticut [294])	[290–294]
35	1988–89 USA	<i>Aphidius rhopalosiphii</i> De Stefani-Perez (Braconidae)	<i>Diuraphis noxia</i> (Kurdjumov) Aphidae	0	No laboratory host range estimation done	Tribes Aphidini and Macroshiphini Biotypes of this species may exist that have different host ranges [295]	R+/E–	[208, 239, 295]
36	1988 USA Florida, from Bolivia	<i>Larva godmani</i> Cameron (Sphecidae)	<i>Scaptiscus</i> spp. (now <i>Neoscapteriscus</i>). This was an accidental contaminant in a shipment of <i>Larva bicolor</i> from Bolivia [296] (Gryllotalpidae)	0	No laboratory host range estimation done	Genus (<i>Neoscapteriscus</i>) +/–? 1988		[296, 297]
37	1988 USA Florida, from Bolivia	<i>Larva bicolor</i> F. (Sphecidae)	<i>Scaptiscus vicinus</i> Scudder (now <i>Neoscapteriscus</i>) Gryllotalpidae	1	No successful attack observed on one native NT species, <i>Neocurtilla hexadactyla</i> (Perty), the only native cricket in the family in the region [296]	Genus (<i>Neoscapteriscus</i>) This parasitoid is functionally specific to the genus level in the US because it does not successfully attack the only native mole cricket in the region, <i>Neocurtilla hexadactyla</i> (Perty) [296]	+/+ 1988	[296, 298]
38	1988–89 USA	<i>Telenomus remus</i> Nixon (Scelionidae)	<i>Spodoptera frugiperda</i> (J. E. Smith) Noctuidae	39	Of 39 NT spp tested, of those not in the Noctuidae, there were seven Arctiidae, one Ctenuchidae, five Geometridae, one Mimallonidae, two Notodontidae, and two Pyralidae. Of these only one pyralid was parasitized. Of the 21 noctuids tested, 11 spp. in 11 genera were parasitized No laboratory host range estimation done	Family (Noctuidae) From <i>Spodoptera mauritia</i> Boisdu., in Malaya [299], <i>Prodenia</i> (<i>Spodoptera</i> ?) <i>litura</i> F. [300], and 11 other noctuids and 1 pyralid [301]	R+/E–	[299–301]
39	1988 Israel (from USA-CA; from Australia originally) Ca. 1986	<i>Cryptochaetum iceryae</i> (Williston) Cryptochaetidae	<i>Icerya purchasi</i> Maskell (Monophlebidae)	0	No laboratory host range estimation done	Family (Monophlebidae) (or perhaps just the genus <i>Icerya</i> or even only the target pest)	R+/E+ 1988	[302]
40		<i>Roctrocerus xylophagorum</i> (Ratzeburg) Pteromalidae	<i>Ips grandicollis</i> (Eichh.) Curculionidae, Scolytinae	0	No laboratory host range estimation done	Subfamily (Scolytinae) Attacks species of <i>Ips</i> [303], <i>Dendroctonus</i> [304], <i>Hylurgops</i> [305], <i>Pityogenes</i> [306]	R+/E+ ca 1986	[303–308]

Table 1. (Continued)

	Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
41	1988 USA Florida	<i>Ormia (Euphasiopteryx) depleta</i> (Wiedemann) Tachinidae	<i>Scaptiscus vicinus</i> Scudder (now <i>Neoscapiscus</i>) Gryllotalpidae	5	<i>Ormia depleta</i> was attracted to three of five <i>Scaptiscus</i> species tested, two of which were programme targets and one a non-target invasive [309]	Genus That North American <i>Anurogryllus</i> species would not be attacked was determined [310] based on song characteristics, which determine parasitoid attraction	R+/E+ 1988	[298, 309–313]
42	1988–91 USA (from both France and Korea)	<i>Agelaius fuscicollis</i> (Dalman) Encyrtidae	<i>Yponomeuta malinellus</i> (Zeller) Yponomeutidae	0	No laboratory-based host range testing prior to release	Genus? At least five species in the target species' genus known to be parasitized in the field [314]	R+/E+ 1988	[314–316]
43	1989–90 USA	<i>Binodoxys</i> (formerly <i>Troxys brevicornis</i>) (Haliday)	<i>Brachycorynella asparagi</i> (Mordv.)	0	No laboratory-based host range testing prior to release	Family? A polyphagous aphid parasitoid known from at least three genera of aphids in addition to that of the target (<i>Binodoxys</i>): namely <i>Myzus cerasi</i> (F.) [317], <i>Cavariella</i> sp. [318], and <i>Hyadaphis cortandri</i> (Das) [319]	R+/E+	[317, 318, 320, 321]
44	1989–91 USA	<i>Eurythoea scutellaris</i> (Robineau-Desvoidy) Braconidae, Aphelinidae	<i>Yponomeuta malinellus</i> (Zeller) Yponomeutidae	0	No laboratory-based host range testing prior to release	Order (Three moth families) Hosts recorded in the literature include species in three families: the pyralid <i>Acrobasis consociella</i> (Hübner) [322], various yponomeutids including <i>Yponomeuta padellus</i> (L.) [323], and the geometrid <i>Abraxas pantaria</i> (L.) [324] Tribe? or Subfamily? The one NT that supported development was in new genus Subfamily Hosts appears to be restricted to the Vespinae Family? Known from species in two genera of Yponomeutidae, including <i>Yponomeuta rorellus</i> (Hb.) [328], <i>Y. evonymella</i> L. [329], and <i>Prays oleae</i> (Bernard) [330]	R+/E–	[316, 322, 324]
45	1989 New Zealand (from Argentina)	<i>Microctonus hyperodae</i> Loan Braconidae, Euphorinae	<i>Lissonotus bonariensis</i> (Kuschel) Curculionidae <i>Vespula germanica</i> (F.) and <i>Vespula vulgaris</i> (L.) Vespididae <i>Yponomeuta malinellus</i> (Zeller) Yponomeutidae	24	Of 24 NT weevils tested, one NT supported complete development No NT species tested were regularly attacked (three instances observed) Four NT species in the genus were suitable hosts, while three others were not, due to encapsulation	Tribe? or Subfamily? The one NT that supported development was in new genus Subfamily Hosts appears to be restricted to the Vespinae Family? Known from species in two genera of Yponomeutidae, including <i>Yponomeuta rorellus</i> (Hb.) [328], <i>Y. evonymella</i> L. [329], and <i>Prays oleae</i> (Bernard) [330]	R+/E+ 1992	[325, 326]
46	1989 Australia (from Europe via New Zealand)	<i>Sphecohypha vesparum</i> (Curtis) Ichneumonidae	<i>Vespula vulgaris</i> (L.) Vespididae	8	No NT species tested were regularly attacked (three instances observed)	Subfamily Hosts appears to be restricted to the Vespinae Family? Known from species in two genera of Yponomeutidae, including <i>Yponomeuta rorellus</i> (Hb.) [328], <i>Y. evonymella</i> L. [329], and <i>Prays oleae</i> (Bernard) [330]	R+/E+? 1989	[327]
47	1989–1991 USA (from both France and Korea)	<i>Diadegma</i> (formerly <i>Nyctobia armillata</i>) (also <i>armillatum</i>) (Gravenhorst) (perhaps now in <i>Angitia</i>) Ichneumonidae	<i>Yponomeuta malinellus</i> (Zeller) Yponomeutidae	7	Four NT species in the genus were suitable hosts, while three others were not, due to encapsulation	Family? Known from species in two genera of Yponomeutidae, including <i>Yponomeuta rorellus</i> (Hb.) [328], <i>Y. evonymella</i> L. [329], and <i>Prays oleae</i> (Bernard) [330]	R+/E–?	[315, 316, 328, 329, 331] (see also Wagener <i>et al.</i> , 2006 [332] for notes on phylogeny of parasitoid genus); Agrò <i>et al.</i> , 2009 [330]
48	1989–1991 USA (from France, Korea, and Japan)	<i>Herpestomus brunnicornis</i> (Gravenhorst) Ichneumonidae	<i>Yponomeuta malinellus</i> (Zeller) Yponomeutidae	3	Three NT hosts in the same genus in the native range were suitable hosts	Genus? R+/E+?	R+/E?	[316, 333]
49	1989–1996 Samoa, Tonga, Fiji, and the Cook Islands	<i>Telenomus lucidus</i> (Nixon) Scelionidae	<i>Eudocima fullonia</i> (Clerck) Noctuidae	11	All three NT in same genus were attacked; zero of eight NT noctuids in other genera were attacked	Genus Considered adequate for island fauna.	R+/E+ 1989–1996	[334]

50	Same era-Australia Not released	<i>Telenomus lucullus</i> (Nixon) Scelionidae	<i>Eudocima fullonia</i> (Clerck) Noctuidae	11	All three NT in same genus were attacked; zero of eight NT noctuids in other genera were attacked: The rare native species <i>Eudocima iridescens</i> (T. P. Lucas) could not be found for testing	Genus Considered insufficiently specific in view of known rare congeneric species in Australia	R- Not released	[334]
51	1989–1996 Samoa, Tonga, Fiji and the Cook Islands	<i>Ooencyrtus</i> sp. in <i>papilionis</i> group (Encyrtidae)	<i>Eudocima fullonia</i> (Clerck) Noctuidae		All three NT in same genus and eight of eight NT noctuids in other genera were attacked	Family Considered adequate for island fauna.	R+/E+ 1989–1996	[334]
52	Same era-Australia Not released	<i>Ooencyrtus</i> sp. in <i>papilionis</i> group (Encyrtidae)	<i>Eudocima fullonia</i> (Clerck) Noctuidae		All three NT in same genus and eight of eight NT noctuids in other genera were attacked; The rare native species <i>Eudocima iridescens</i> (T. P. Lucas) could not be found for testing	Family Considered insufficiently specific.	R-Not released	[334]
53	1989–1990 USA	<i>Encarsia inaron</i> (Walker) Aphelinidae	Ash whitefly, <i>Siphoninus phillyrae</i> (Haliday) Aleyrodidae	0	No formal host range testing was done before release. The parasitoid is known to attack species of whiteflies in several genera, including <i>Siphoninus</i> , <i>Bemisia</i> , <i>Trialetrodes</i> and <i>Pealius</i>	Family Medium? Not reported from non-pest, native U.S. whiteflies.	R+/E+ 1990	[335–337]
54	1990 Canada	<i>Apanteles murinanae</i> Capek, and Zwölfer (Braconidae)	<i>Choristoneura fumiferana</i> (Clemens) Tortricidae	0	No laboratory host range estimation done This species was collected in Europe from the closely related species <i>Choristoneura murinana</i> (Hübner) and after confirming its ability to develop in the target host, released in Canada as single release	Family? The only other known field host is <i>Eucosma nigricana</i> (H.-S.), another tortricid of similar biology as <i>C. murinana</i> , with which it shares a common host and habitat [338]	R+/E–	[338, 339]
55	1990–94 USA, Florida, from Hong Kong	<i>Eretmocerus rui</i> Zolnerowich and Rose (Aphelinidae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family? No other host records from field or laboratory studies were located	R+/E–	[340]
56	1990–1995 (USA from China)	<i>Coccobius</i> nr. <i>fulvus</i> (Aphelinidae)	<i>Unaspis euonymi</i> (Constock) Diaspididae	0	No laboratory host range estimation done	Genus? <i>C. fulvus</i> is known only from two species <i>Unaspis</i> scales [341, 342], assuming that <i>C. fulvus</i> and <i>C. nr fulvus</i> are the same, which was never determined	R+/E+ 1984/1990–1995	[341–344]
57	1990–1995 (USA from China)	<i>Encarsia</i> (formerly <i>Prospatella</i>) nr. <i>diaspidicola</i> Silvestri (Aphelinidae)	<i>Unaspis euonymi</i> (Constock) Diaspididae	0	No laboratory host range estimation done	Family? Assuming this is the same as <i>E. diaspidicola</i> and that it is not a species complex, then several diaspidid scales (including <i>Pseudaulacaspis pentagona</i> [Targioni-Tozzetti] and <i>Quadraspidiolus perniciosus</i> [Constock]) are known hosts, but others are not hosts [345]	R+/E–? 1990–1995	[342–348]

Table 1. (Continued)

	Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
58	1990–1995 (USA from China)	<i>Aphytis proclia</i> (Walker) (Aphelinidae)	<i>Unaspis euonymi</i> (Constock) (Diaspididae)	0	No laboratory host range estimation done	Family? Several diaspidid scales (including <i>Pseudaulacaspis pentagona</i> [Targioni-Tozzetti] and <i>Quadraspidoletus perniciosus</i> [Constock] among others) are known hosts. Note, however, that <i>A. proclia</i> as a name may refer to more than one species	R+/E–? 1990–1995	[342, 343, 347–349]
59	1992 USA Colorado, Washington and others, from Morocco and the Middle East	<i>Ephedrus plagiator</i> (Nees) (Braconidae, Aphelininae)	<i>Diuraphis noxia</i> (Kurdjumov) (Aphidae)	0	No laboratory host range estimation done	Family? Several aphids are recorded as hosts, including <i>Aphis pomi</i> de Geer [350], <i>Schizaphis graminum</i> (Rondani), <i>Rhopalosiphum padi</i> (L.), <i>Macrosiphum (Sitobion) avenae</i> (F.) [351], <i>Aulacorthum solani</i> (Kaltenbach) [352], among others	R+/E–	[208, 351–353]
60	1992 USA	<i>Aphelinus atriplicis</i> Kurdjumov (Aphelinidae)	<i>Diuraphis noxia</i> (Kurdjumov) (Aphidae)	0	Limited to Aphididae; species identity misunderstood initially but sorted out after introduction	Family Safe to non-aphids; parasitizes many NT aphids; but population impacts are unknown	R+/E+ 1992	[208–210, 354–357]
61	About 1990 Mexico (from Africa)	<i>Prorops nasuta</i> Waterson (Bethyridae)	<i>Hypothenemus hampei</i> (Ferrari) (Curculionidae, Scolytinae)	2	Both NT species were used successfully as hosts	Family? Several genera of weevils are known to support oviposition and development. Boundaries of host range are not known	R+/E+ 1988	[258, 359]
62	1988 Mexico (from Africa)	<i>Cephalonomia stephanoderis</i> Betrem (Bethyridae)	<i>Hypothenemus hampei</i> (Ferrari) (Curculionidae, Scolytinae)	2	Both NT species were used successfully as hosts	Family? Several genera of weevils are known to support oviposition and development. Boundaries of host range are not known	R+/E+ 1989	[358, 359]
63	Ca. 1990 Guatemala (from Africa)	<i>Phymastichus coffea</i> (LaSalle) (Eulophidae)	<i>Hypothenemus hampei</i> (Ferrari) (Curculionidae, Scolytinae)	5	Two NT <i>Hypothenemus</i> sp. were attacked, one <i>Hypothenemus</i> sp. was not and two species in other bark beetle genera were not	Genus?	R+/E+? 1990?	[360]
64	1991 Canada (from Europe)	<i>Aphanthorhaphopsis (Ceranthis) samarensis</i> (Villeneuve) (Tachinidae)	<i>Lymantria dispar</i> (L.) (Erebidae, Lymantriinae)	11	Of the 11 North America species (in five families) only one species, <i>Orygia leucostigma</i> (J. E. Smith) (Lymantriinae) was a suitable host	Subfamily (Lymantriinae)	R+/E? 1991	[30, 361, 362]
65	1992 USA	<i>Aphelinus nr asychis</i> (Aphelinidae)	<i>Diuraphis noxia</i> (Kurdjumov) (Aphidae)	0	Limited to Aphididae; species identity misunderstood initially but sorted out after introduction	Family Safe to non-aphids; certainty of 'use' of many NT aphids; uncertainty about population impacts	R+/E+ 1992	[208–210, 354–357]

66	1992 Australia	<i>Citrostichus phyllocnistoides</i> (Naryanin) Eulophidae	<i>Phyllocnistis citrella</i> Stainton (Gracillariidae)	17 ¹	Zero NT species attacked (including one leafminer in same genus, five leafminers in other genera and 11 other foliovores, leafminers, or gall makers in other families and gall makers)	Genus? relative to Australia biota	R+/E- 1992	[363]
67	1992 Australia	<i>Agonaspis citricola</i> (Longinovskaya) Encyrtidae	<i>Phyllocnistis citrella</i> Stainton (Gracillariidae)	17 ¹	0 NT species attacked (including one leafminer in same genus, five leafminers in other genera and 11 other foliovores, leafminers, or gall makers in other families and gall makers)	Genus? relative to Australia biota	R+/E+ 1992	[363]
68	1992 Australia	<i>Cirrospilus ingenuus</i> (=quadristriatus) Gahan (Eulophidae)	<i>Phyllocnistis citrella</i> Stainton (Gracillariidae)	17 ²	Zero NT species attacked (including one leafminer in same genus, five leafminers in other genera and 11 other foliovores, leafminers, or gall makers in other families and gall makers)	Genus? relative to Australia biota	R+/E+ 1992	[363]
69	1992 Italy (from USA)	<i>Neodryinus typhlocybae</i> (Ashmead) Dryinidae	<i>Metacalla pruinosa</i> (Say) Flatidae	8	Eight NT-no attack, but no tested species were other flatids	Family?	R+/E+	[364, 365]
70	1993 USA, California (Turkmenistan)	<i>Aphelinoides turanica</i> Triapitzin (Trichogrammatidae)	<i>Circulifer tenellus</i> (Baker) (sometimes given as <i>Neosalticus tenellus</i>) Cicadellidae	0	No formal host range testing done	Family (Cicadellidae) No information found in CAB on hosts, field or laboratory, apart from its success in attacking the target species after release	R+/E+	[366]
71	1993–2000 USA, California and Washington (from Kazakhstan)	<i>Lytopylus rufipes</i> (Nees von Esenbeck) (previous generic assignments include <i>Agathis</i> , <i>Microdus</i> , <i>Bassus</i>) Braconidae	<i>Cydia pomonella</i> (L.) Tortricidae	0	No formal host range testing done	Two Families A number of tortricids and pyralids (Mill, pers. comm.; [367])	R+/E-	[367–370]
72	1993–2000 USA California and Washington (from Kazakhstan)	<i>Liotryphon caudatus</i> (Ratzeburg) (former generic placements were <i>Apistephialtes</i> , <i>Calliphialtes</i> , and <i>Ephialtes</i>) Ichneumonidae	<i>Cydia pomonella</i> (L.) Tortricidae	0	No formal host range testing done	Family? (Tortricidae) Attacks various fruit-boring and cocoon-forming tortricids such as <i>Cydia molesta</i> (Busck) and <i>Grapholita funebrana</i> (Treitschke) (Mills, pers. comm.)	R+/E+? (temporarily established)	[368, 369]
73	1993 USA (CA) from Australia	<i>Avetianella longoi</i> Siscaro (Mymaridae)	<i>Phoracantha semipunctata</i> F. (Cerambycidae)	0	No formal host range testing done	Unknown Likely restricted to hosts on eucalypts due to attraction to host plant odours	R+/E+ Ca 1993	[371, 372]
74	Ca 1993 USA (CA) from Australia	<i>Syngaster lepidus</i> Brulé (Braconidae)	<i>Phoracantha semipunctata</i> F. and <i>P. recurva</i> Newman (Cerambycidae)	0	No formal host range testing done	Unknown Likely restricted to hosts on eucalypts due to attraction to host plant odours	R+/E+ Ca 1993	[373]
75	Ca 1993 USA (CA) from Australia	<i>Jarra phoracantha</i> Austin, Quicke, and Marsh (Braconidae)	<i>Phoracantha semipunctata</i> F. (Cerambycidae)	0	No laboratory host range estimation done	Unknown Likely restricted to hosts on eucalypts due to attraction to host plant odours	R+/E?	[374]
76	1993 Kenya (from Pakistan)	<i>Cotesia flavipes</i> Cameron (Braconidae)	<i>Chilo partellus</i> Swinhoe (Crambidae)	3	Two NT pest hosts (both noctuids, one in same genus) were suitable hosts; one was not (noctuid, non- <i>Chilo</i>)	Two Families Known to attack some noctuid and some crambid stem-borers in grasses	R+/E+ 1993	[243, 375]

Table 1. (Continued)

Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
77	1993 California (from Australia); 1994 Britain; 1997 France and Ireland; 2001 Chile	<i>Psyllaephagus pilosus</i> Noyes (Encyrtidae)	<i>Ctenarytaina eucalypti</i> (Maskell) Psyllidae	0	No formal host range testing done but this is likely a eucalypt specialist [376], conferring high host specificity in the invaded range via the influence of the host plant	Family High specificity in invaded ranges due to attraction to eucalyptus	[376–379]
78	1993–1999, USA (from United Arab Emirates)	<i>Eretmocerus emiratus</i> Zolnerowich & Rose	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done Plans to test <i>Trialeurodes vaporariorum</i> (Westwood), <i>T. abutilonia</i> (Haldeman), and <i>Bemisia berbericola</i> (Cockerell) were made but not carried out	Family (Aleyrodidae) No field hosts recorded other than <i>Bemisia</i>	[172, 380–383]
79	1993–1999, USA (from Ethiopia)	<i>Eretmocerus</i> (nr) <i>emiratus</i> Zolnerowich & Rose (Aphelinidae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) Known from <i>Aleyrododes loniceræ</i> Walker in China [384]	[172, 381–384]
80	1993–1999, USA (from Pakistan)	<i>Eretmocerus hayati</i> Zolnerowich & Rose (Aphelinidae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) No field hosts recorded other than <i>Bemisia</i>	[172, 380, 382, 383]
81	1993–1999, USA (from Thailand, Taiwan)	<i>Eretmocerus melanoscultus</i> Zolnerowich & Rose (Aphelinidae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) No field hosts recorded other than <i>Bemisia</i>	[172, 380, 382, 383]
82	1993–1999, USA (from Taiwan)	<i>Eretmocerus</i> nr. <i>furuhashii</i> Rose & Zolnerowich (Aphelinidae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) No field hosts recorded other than <i>Bemisia</i>	[172, 382, 383]
83	1993–1999, USA (from Spain, Israel)	<i>Eretmocerus mundus</i> Mercet (Aphelinidae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) Field surveys in CA found <i>E. mundus</i> only from <i>B. tabaci</i> , not non-target whiteflies [174]; In the laboratory two species of <i>Trialeurodes</i> were attacked (<i>T. abutilonea</i> [Haldeman] and <i>T. vaporariorum</i> [Westwood]) [385]	[170, 172, 381–383, 385]
84	1993–1999, USA (from Puerto Rico)	<i>Amitus benmetti</i> Viggiani & Evans (Platygasteridae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) No field hosts recorded other than <i>Bemisia</i>	[382]
85	1993–1999, USA (from Israel)	<i>Encarsia lutea</i> (Masi) Aphelinidae	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) Females: (Aleyrodidae) Males: Lepidoptera Known to attack several genera of whiteflies, including <i>Trialeurodes abutilonea</i> (Hald.) and <i>T. vaporariorum</i> (Westw.) and for males to emerge from eggs of noctuid moths [386], and <i>Acaudaleyrododes citri</i> (Priesn. & Hosni) [387]; <i>Parabemisia myricae</i> (Kuwana) [388]; <i>Aleurolobus</i> spp. [389]	[382, 383, 386–389]

86	1993–1999, USA (from Pakistan)	<i>Encarsia sophia</i> (=E: <i>transvena</i>). (Girault & Dodd) Aphelinidae	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) Known to attack <i>T. vaporariorum</i> (Westw.) [390] and <i>Bemisia tuberculata</i> Bondar [391]	R+/E+ <2000 (Established in California [392] and Texas [393])	[172, 381–383, 390, 391]
87	1993–1999, USA (from Brazil)	<i>Encarsia</i> nr. <i>pergandellia</i> Howard (Aphelinidae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) Females: Aleyrodidae or below Males: Aphelinid parasitoids Males develop as hyperparasitoids on whitefly parasitoids, including <i>E. mundus</i> [394]	R+/E– <2000	[172, 381–383, 394]
88	1993–1999, USA (from Brazil)	<i>Encarsia</i> nr. <i>hispidula</i> De Santis (Aphelinidae)	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory host range estimation done	Family (Aleyrodidae) Known to attack <i>T. vaporariorum</i> (Westw.) [395], <i>Trialeurodes variabilis</i> (Quaintance) [396], <i>Paraleyrodies minei</i> Iaccarino [397], and <i>Aleurotrachelus socialis</i> Bondar [391]	R+/E– <2000	[172, 382, 383, 391, 396, 397]
89	1993–2000 USA (from Central Asia [Kazakhstan])	<i>Mastrus ridens</i> Horstmann (formerly <i>M. rufibundus</i>) Ichneumonidae	<i>Cydia pomonella</i> L. (Tortricidae)	0	No laboratory host range estimation done at the time of the introduction to USA. Later, in New Zealand [398] some post-facto host range testing showed that of five species tested, 1 NT <i>Cydia</i> species and four others in the target's family (Tortricidae) were attacked, but offspring were small and mostly male; known in native range only from target; but little sampling other than of the target	Genus? Other tortricids could be killed by this parasitoid but seem unlikely themselves to support <i>M. ridens</i> populations due to a too rapid death from the paralyzing venom of the parasitoid	R+/E+ 1993–2000	[368, 398]
90	1994 USA California	<i>Anaphes nitens</i> (Girault) (other generic placements include <i>Palasson</i> and <i>Anaphothoea</i>) Mymaridae	<i>Gonipterus scutellatus</i> Gyllenhal See Mapondera <i>et al.</i> [399] for notes on cryptic species in genus. Curculionidae	0	No laboratory host range estimation done	Genus? Field records include <i>Gonipterus gibberus</i> Boisduval [400]	R+/E+	[400, 401]
91	1994 Spain (from South Africa??)	<i>Anaphes nitens</i> (Girault) (other generic placements include <i>Palasson</i> and <i>Anaphothoea</i>) (Mymaridae)	<i>Gonipterus platensis</i> (Marelli) (see Mapondera <i>et al.</i> , [399] for notes on cryptic species in genus. Curculionidae)	0	No laboratory host range estimation done	Genus? Field records include <i>Gonipterus gibberus</i> Boisduval [400]	R+/E+ ca 1994	[399, 400, 402]
92	1994 Brazil (Bahia) (from Colombia or Venezuela)	<i>Apoanagyrus diversicornis</i> (Howard) Encyrtidae	<i>Phenacoccus herreni</i> Cox and Williams (Pseudococcidae)	0	No laboratory host range estimation done	Genus? Known only from species of <i>Phenacoccus</i>	R+/E+ 1994–1995	[403–405]
93	1994 Brazil (Bahia) (from Colombia or Venezuela)	<i>Aenasius vexans</i> (Kerich) Encyrtidae	<i>Phenacoccus herreni</i> Cox and Williams (Pseudococcidae)	7 (6 years post-release)	No laboratory host range estimation done before release in Brazil, but subsequent studies of sene mealybug species found that <i>A. vexans</i> did not attack any of the non-target mealybugs tested	Species? No attack in laboratory tests and no other known field hosts	R+/E+ 1994–1995	[405, 406]

Table 1. (Continued)

	Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
94	1994 Brazil (Bahia) (from Colombia or Venezuela)	<i>Acerophagus coccois</i> Smith (Encyrtidae)	<i>Phenacoccus herreni</i> Cox and Williams (Pseudococcidae)	7 (six years post-release)	No laboratory host range estimation done before release in Brazil, but subsequent studies of seven mealybug species found that <i>A. coccois</i> attacked three (two species of <i>Phenacoccus</i> and <i>Ferrisia virgata</i> [Cockerell])	Family (Pseudococcidae) Known from <i>Oracella acuta</i> (Lodbel) [407, 408]; <i>Ferrisia virgata</i> (Cockerell) [406] and several species of <i>Phenacoccus</i>	R+/E+ 1994–1995	[403–406, 408]
95	1994 USA/Florida (via Australia from Thailand)	<i>Agonaspis citricola</i> Longvinovskaya (Encyrtidae)	<i>Phylloxera citrella</i> Stainton (Gracillariidae)	0	No laboratory host range estimation done relative to US <i>Phylloxera</i> species; specificity assumed based on testing in Australia	Unknown relative to North American fauna	R+/E+ 1994	[409–411]
96	1994 USA/Florida (via Australia from Thailand)	<i>Cirrospilus ingenuus</i> (= <i>quadristriatus</i>) Gahan (Eulophidae)	<i>Phylloxera citrella</i> Stainton (Gracillariidae)	0	No laboratory host range estimation done relative to US <i>Phylloxera</i> species; specificity assumed based on testing in Australia	Unknown relative to North American fauna	R+/E+ 1994	[409, 412]
1995–2004								
1	1995 USA, California	<i>Aphelinodea anatolica</i> Nowicki (Mymaridae)	<i>Circulifer tenellus</i> (Baker) (sometimes given as <i>Neolittoridius tenellus</i>) Cicadellidae	0	No laboratory host range estimation done	Family (Cicadellidae) No information found in CAB on hosts, field or laboratory	R+/E+	[413–415]
2	1995–1999 Canada from Europe	<i>Lathrolestes ensator</i> (Brauns) Ichneumonidae	<i>Hoplocampa testudinaria</i> (Klug) Tenthredinidae	0	No laboratory host range estimation done	Species? This species is known only from one host, but this does not exclude its existence on hosts not sampled	R+/E+	[416–418]
3	1995 (Texas), 1997 (Florida) USA, from South America	<i>Pseudacteon tricuspis</i> Borgmeier (Phoridae)	<i>Solenopsis invicta</i> , <i>S. richteri</i> and hybrids. Formicidae	13 + 1	Zero NT attack on 13 NT ants not in <i>Solenopsis</i> ; zero NT attack on one NT in <i>Solenopsis</i> ; Post-release, zero NT attacks on 15 NT ants, including one native NT congener	Species Group level within Genus	R+/E+ 1997	[419–423]
4	1995 (Texas), 1997 (Florida) USA, from South America	<i>Pseudacteon littoralis</i> Borgmeier (Phoridae)	<i>Solenopsis invicta</i> , <i>S. richteri</i> , and hybrids (Formicidae)	27 + 1	Zero NT attack on 27 NT ants not in <i>Solenopsis</i> ; one NT <i>Solenopsis</i> (<i>S. geminata</i>) attacked (at 9% of target rate) but no successful development	Species Group level within Genus	R+/E+ 2003	[419–421, 424, 425]
5	USA Not petitioned for release	<i>Pseudacteon wasmanni</i> Schmitz (Phoridae)	<i>Solenopsis invicta</i> , <i>S. richteri</i> , and hybrids Formicidae	27 + 2	Zero NT attack on 27 NT ants not in <i>Solenopsis</i> ; two NT <i>Solenopsis</i> attacked (<i>S. geminata</i> , <i>S. saevissima</i> , <i>S. geminata</i> at 11% target rate)	Genus level or better	R-N/A ³	[219, 421, 424]
6	1996 Australia (from Argentina)	<i>Trichopoda giacomellii</i> (Blanchard) Tachinidae	<i>Nezara viridula</i> (L.) Pentatomidae	14	Of ten NT pentatomids, six attracted oviposition, but only three supported complete development; two at levels equal to target and one at one-third level of target. Species in other families were rejected	Family Including target, acceptable hosts were found in four genera o pentatomids	R+/E+ Ca 1997	[144, 426]

7	1996–1999 Spain	<i>Citrostichus phyllocnistoides</i> (Naryanin) Eulophidae	<i>Phyllocnistis citrella</i> Stainton (note about eight other parasitoids were introduced into Spain for this pest that are not listed here) Gracillariidae	0	Unknown No testing done relative to European leafminers. Post-release attack on an unidentified Nepticulidae on <i>Pistacia lentiscus</i> L. and <i>Stigmella</i> sp. on <i>Rubus ulmifolius</i> Schott in Sicily and Jordan respectively [427], and in Sicily this parasitoid <i>Cosmopterix pulcherimella</i> , Chambers (Cosmopterigidae), on <i>Parietaria diffusa</i> Mert. & W. D. J. Koch and <i>Liriomyza</i> sp. (Agrimyzidae) on <i>Mercurialis annua</i> L. [428]. See Karamaouna <i>et al.</i> [429] for details on displaced parasitoids	Unknown relative to European fauna	R+/E+ 1996–1999	[427–432]
8	1996–2004 China (from USA)	<i>Allotropa oracellae</i> Masner (Platygastridae)	<i>Oracella acuta</i> (Lodbell) Pseudococcidae	0	No laboratory host range estimation done	Unknown No other hosts records in literature	R+/E– (as of 2010) 1996–2004	[433]
9	1996–2004 China (from USA)	<i>Acerophagus coccis</i> E. Smith (Encyrtidae)	<i>Oracella acuta</i> (Lodbell) Pseudococcidae	0	No laboratory host range estimation done	Family? Records exist of use of several mealybugs, including <i>Phenacoccus herreni</i> Cox & Williams [434], <i>P. gossypii</i> Ben-Dov [403], <i>P. madeirensis</i> , and <i>Ferrisia virgata</i> (Cockerell) [406]	R+/E– (as of 2010) 1996–2004	[403, 406, 433, 434]
10	1996–2004 China (from USA)	<i>Zarhopalus debarri</i> Sun (Encyrtidae)	<i>Oracella acuta</i> (Lodbell) Pseudococcidae	0	No laboratory host range estimation done	Unknown No other hosts records in literature	R+/E– (as of 2010)	[433, 435]
11	1997–1998 USA	<i>Coccobius fulvus</i> (Compere and Annecke) (also given as <i>Physcus fulvus</i>) Aphelinidae	<i>Aulacaspis yasumatsui</i> Takagi (Diaspididae)	0	No laboratory host range estimation done	Two Families Literature records include use of scales in the Coccidae (one record: <i>Parthenolecanium corni</i> Bouché [436] and Diaspididae (many records of <i>Unaspis yanonensis</i> Kuwana [437])	R+/E+ [436–438]; see Wang <i>et al.</i> [439] for taxonomy of <i>Coccobius</i>	
12	1997–2000 USA, California from Mexico	<i>Encarsiotella noyesi</i> Hayat (Aphelinidae)	<i>Aleurodicus dugesii</i> Cockerell (Aleyrodidae)	0	No laboratory host range estimation done	Genus? The only other recorded host is <i>Aleurodicus dispersus</i> Russell [440]	R+/E+ [440, 441]	
13	1997 US Virgin Islands, from Egypt or Pakistan; also, 1998 Puerto Rico; 1999–2000 continental USA; and 2004 Mexico	<i>Gyranusoidea indica</i> Shafee, Alam & Agarwal (Encyrtidae)	<i>Maconellicoccus hirsutus</i> (Green) Pseudococcidae	0	No laboratory host range estimation done	Family? No other information on other hosts was found. <i>Post-hoc</i> sampling of other mealybugs in California following release of the parasitoid and its establishment there on the target did not detect any parasitism of either <i>Phenacoccus solenopsis</i> Tinsley or <i>Ferrisia</i> species [442]	R+/E+ [442]	

Table 1. (Continued)

	Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
14	1997 USA Florida	<i>Ceratogramma effennei</i> Delvare (Trichogrammatidae)	<i>Diaprepes abbreviatus</i> (L.) Curculionidae	8	No parasitism of seven NT species of Lepidopteran eggs or those of one NT species of weevil	Family? Attacks eggs of weevils concealed in plant tissues	R+/E– 1994	[443–446]
15	1998–1999, Guam from India	<i>Euplectrus maternus</i> Bhatnagar (Eulophidae)	<i>Eudocima (Othreis) fulonia</i> (Clerck) Noctuidae	0	No host range testing reported	Genus? Two additional species of underwing moths in the genus <i>Eudocima</i> are known to be parasitized: <i>E. materna</i> L. and <i>E. homaena</i> (Hübner) [452]	R+/E–	Bhumannavar and Viraktamath [452]; Muniappan <i>et al.</i> [453]
16	1998–2000 USA from Central America	<i>Idiopus affinis</i> La Salle et Polaszek (Pteromalidae)	<i>Aleurdicus dugesii</i> Cockerell (Aleyrodidae)	0	No host range testing reported	Family? No other hosts reported but little literature of any kind	R+/E+	[441]
17	1998 USA Florida	<i>Quadrastichus haitiensis</i> (Gahan) Eulophidae	<i>Diaprepes abbreviatus</i> (L.) Curculionidae	0	No host range testing reported	Family? Attacks eggs of weevils concealed in plant tissues	R+/E+ 1998	[445, 446]
18	1998 USA	<i>Tetrastichus serifor</i> Thomson (Eulophidae)	<i>Lilioceris lili</i> Scopoli (Chrysomelidae)	10	Two NT European species of <i>Lilioceris</i> tested and both were attacked; eight species of North American non- <i>Lilioceris</i> (six same family; two other families) and none were attacked	Genus High as there are no native congeners in North America)	R+/E+ 1999	[451, 454–456]
19	1999 USA	<i>Pseudacteon curvatus</i> Borgmeier (Phoridae)	<i>Solenopsis invicta</i> Buren, <i>S. richteri</i> Forel and hybrids (Formicidae)	19 + 2 ⁴	Zero NT – attack of 19 NT ants not in <i>Solenopsis</i> ; two NT – attack of two NT <i>Solenopsis</i> , but at lower rates than on target; two positive NT but no significant attack in field in post-release evaluation	Genus	R+/E+ 1999/2000	[419, 423, 457–459]
20	ca 1999 USA, Florida (from Japan?)	<i>Lysiphlebia japonica</i> Ashmead (Braconidae)	<i>Toxoptera citricida</i> (Kirkaldy) Aphidae	0	No laboratory host range estimation done	Unknown	R+/E–	[460, 461]
21	2000–2003 Mexico; and Guam 2002	<i>Acerophagus papayae</i> Noyes and Schauff (Encyrtidae)	<i>Paracoccus marginatus</i> Williams and Granara De Willink (Pseudococcidae)	0	No laboratory host range estimation done	Family?	R+/E+	[462]
22	2000 USA, Florida (from Guam)	<i>Lipolexis oregmae</i> Gahan (introduced as <i>L. scutellaris</i> Mackauer) Braconidae, Aphelinidae	<i>Toxoptera citricida</i> Kirkaldy (Aphidae)	0	No laboratory host range estimation done	Family? Post-release field studies found parasitism of two black citrus aphid species, <i>Toxoptera citricida</i> (Kirkaldy) and <i>T. aurantii</i> (Boyer de Fonscolombe), and cowpea aphid (<i>Aphis craccivora</i> Koch), spirea aphid (<i>Aphis spiraeicola</i> Patch) and melon aphid (<i>Aphis gossypii</i> Glover) [463]	R+/E+ 2001–2002	[463]

23	Ca. 2000 Caribbean and Florida (USA) from China	<i>Anagyrus kamali</i> Moursi (Encyrtidae)	<i>Maonelliscoccus hirsutus</i> Green (Pseudococcidae)	8	Two NT species of <i>Planococcus</i> were attacked, but failed to support complete development	Species In the context of the the Caribbean, the target species was the only suitable host. In a larger geographic context, the host range is likely greater	R+/E+ ?? 2000	[464, 465]
24	2000 (USA, California, from Australia)	<i>Psyllaephagus bliteus</i> Riek (Encyrtidae)	<i>Glycaspis brimblecombei</i> Moore (Psyllidae)	3	None of the three NT eucalyptus-feeding psyllids tested (<i>Trioza eugeniae</i> Froggatt, <i>Ctenarytaina eucalypti</i> [Maskell], <i>Boreioglycaspis melaleuca</i> Moore) were attacked No host range testing reported	Unknown , Other species in target genus were not tested	+/? 2000	[466]
25	2000 Trinidad	<i>Amitus hesperidum</i> Silvestri (Platygasteridae)	<i>Aleurocanthus woglumi</i> Ashby (Aleyrodidae)	0	No host range testing reported	Family This parasitoid controlled citrus blackfly in other locations earlier, before host range testing was begun. Reuse in other areas later did not do host range testing, but a post-release survey in Dominica [125] did not detect attacks on non-target whiteflies there	+/? 2000	[125, 467, 468]
26	2000 USA Florida	<i>Aprostocetus vaquitarum</i> Wolcott (Eulophidae)	<i>Diaprepes abbreviatus</i> (L.) Curculionidae	0	No host range testing reported	Family? Likely within-family (Curculionidae) of eggs concealed in plant tissue	R+/E+ 2000	[445, 446]
27	2001 Mexico	<i>Phymastichus coffea</i> (LaSalle)	<i>Hypothenemus hampei</i> (Ferrari)	5	Of three NT species in same genus as target, two were successfully parasitized and one was not. Two other species in other weevil genera were not parasitized. Attack on two <i>Hypothenemus</i> species were at levels of 14 and 6% One NT was as suitable as target hosts; one NT was inferior with a low proportion of accepted hosts producing parasitoid progeny	Genus?	R+/E 2001+5	[447]
28	2001 Kenya (via South Africa, via Mauritius, but originally from Sri Lanka)	<i>Xanthopimpla stemmator</i> Thunberg	<i>Chilo partellus</i> (Swinhoe) <i>Busseola fusca</i> Fuller	2	Two NT Panchaetothripinae thrips were exposed – the native <i>Sigmothrips aotearocana</i> (Ward) and the African thrips <i>Hercinothrips bicinctus</i> Bagnall (adventive in NZ). Both were successfully parasitized No host range testing reported	Two families (Noctuidae, Crambidae) Known to attack several noctuid and crambid stemborers in its native range Complete list of known hosts in [448] Subfamily (Panchaetothripinae) This estimation was made by Froud <i>et al.</i> [266] was made based on literature host records	R+/E+ 2002 in Mozambique, later in Malawi, Tanzania, Zimbabwe, Ethiopia, Eritrea and Kenya	[448, 449]
29	2001 New Zealand	<i>Thripobius javae</i> (Girault) (= <i>T. semiluteus</i> Boucek	<i>Heliothrips haemorrhoidalis</i> (Bouché)	2	Two NT Panchaetothripinae thrips were exposed – the native <i>Sigmothrips aotearocana</i> (Ward) and the African thrips <i>Hercinothrips bicinctus</i> Bagnall (adventive in NZ). Both were successfully parasitized No host range testing reported	Family?	R+/E?	[450]
30	2002 USA (Guam)	<i>Anagyrus loeckii</i> Noyes (Encyrtidae)	<i>Paracoccus marginatus</i> Williams and Granara De Willink (Pseudococcidae)	0	No host range testing reported	Family?	R+/E?	[450]
31	2002 USA (Guam)	<i>Pseudoleptomastix mexicana</i> Noyes and Schauff (Encyrtidae)	<i>Paracoccus marginatus</i> Williams and Granara De Willink (Pseudococcidae)	0	No host range testing reported	Family?	R+/E?	[450]

Table 1. (Continued)

	Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
32	2002 USA	<i>Diaparsis jucunda</i> (Holmgren)	<i>Lilloceris lilii</i> Scopoli	10	Two NT European species of <i>Lilloceris</i> tested and both were attacked; eight species of North American non- <i>Lilloceris</i> (six same family; two other families) and none were attacked	Genus There are no native congeners in North America	R+/E+ 2003	[451, 454, 456]
33	2002 USA	<i>Lemophagus errabundus</i> Gravenhorst	<i>Lilloceris lilii</i> Scopoli	10	Two NT European species of <i>Lilloceris</i> tested and both were attacked; eight species of North American non- <i>Lilloceris</i> (six same family; two other families) and none were attacked	Genus There are no native congeners in North America	R+/E+ 2003	[456]
34	~2002 USA Never petitioned	<i>Lemophagus pulcher</i> Szépligeti	<i>Lilloceris lilii</i> Scopoli	10	Two NT European species of <i>Lilloceris</i> tested and both were attacked; eight species of North American non- <i>Lilloceris</i> (six same family; two other families) and were two were attacked	Subfamily level: ⁶ Criocerinae at best	Not released	[451, 454]
35	2002 USA, California (from Egypt)	<i>Allotropa nr. mecirida</i> (Walker)	<i>Maconellicoccus hirsutus</i> (Green)	4	Four NT-no parasitism in four mealybugs from three other genera (<i>Pseudococcus</i> , <i>Paracoccus</i> , and <i>Phenacoccus</i>)	Genus?	R+/E- Released in 2003–2004	[442, 469]
36	~2004 USA Not petitioned for release	<i>Bracon celer</i> Szépligeti	<i>Bactrocera oleae</i> Gmelin	3	one NT species affected by host feeding No attack on one NT gall making tephritid, but successful parasitism on another, <i>Parafreutreta regalis</i> Munro, and host deaths without successful parasitism on another	Family? Hosts included valuable weed biocontrol gall making tephritids and so rejected by scientists in charge	R- N/A-	[117]
37	2005 Tahiti (USA)	<i>Gonatocerus ashmeadi</i> Girault	<i>Homalodisca vitripennis</i> (Germar)	3	One of three NT species was an acceptable host, another <i>Homalodisca</i> sp.	Tribe Hosts are in the Proconiini, especially species in the same genus as target and with similar egg size and deposition pattern	R+/E+ 2005	[91, 470, 471]
38	2002 California (from Southeastern USA)	<i>Gonatocerus fasciatus</i> Girault	<i>Homalodisca vitripennis</i> (Germar)	3	One of three NT species was an acceptable host, another <i>Homalodisca</i> sp.	Tribe Hosts are in the Proconiini, especially species in the same genus as target and with similar egg size and deposition pattern	R+/E+ 2002	[471, 472]
39	2005 New Zealand (from Ireland)	<i>Microctonus aethiopoides</i> Loan (all female strain)	<i>Sitona Lepidus</i> Gyllenhal	9	Five NT native species were parasitized at rates from 2–28%; risk perceived to be lower than the already established Moroccan strain of this species	Family? Several genera of Curculionidae	R+/E+ 2006	[473, 474]

40	2005 USA	<i>Haackelia sperata</i> Pinto	<i>Diaprepes abbreviatus</i> (L.)	4	No attack on eggs of two NT Lepidoptera or two NT Coleoptera (one Coccinellidae and one non- <i>Diaprepes</i> Curculionidae)	Family? Likely within-family (Curculionidae) of eggs concealed in plant tissue	R+/E+ 2006	[446]
41	2005 USA	<i>Fidobla dominica</i> Evans and Peña	<i>Diaprepes abbreviatus</i> (L.)	0?	No host range testing reported	Family? Likely within-family (Curculionidae) of eggs concealed in plant tissue. Assumed to have low to medium specificity, given records of other species' hosts in genus	R+/E+ 2006	[475]
42	2005 USA	<i>Psytalia lounsburyi</i> Sylvestri	<i>Bactrocera oleae</i> Gmelin	3	No attack on three NT tephritids tested	Genus?	R+/E+ 2005	[476]
43	2005 (Texas), 2007 (Florida) USA	<i>Pseudacteon obtusus</i> Borgmeier (Phoridae)	<i>Solenopsis invicta</i> , <i>S. richteri</i> and hybrids (Formicidae)	1	One NT species in <i>Solenopsis</i> tested (<i>S. geminata</i>) and found not to be attacked	Species	R+/E+ 2006/2008	[477–479]
44	2005 USA	<i>Pseudacteon nocens</i> Borgmeier (Phoridae)	<i>Solenopsis invicta</i> , <i>S. richteri</i> and hybrids (Formicidae)	1	Low attack rates with one NT native <i>Solenopsis</i>	Genus	R+/E+ 2006	[478]
2005-present (mid-2016)								
1	Ca 2006 USA (Florida)	<i>Citrostichus phyllocnistoides</i> (Nyanin) Eulophidae	<i>Phyllocnistis citrella</i> Stainton (Gracillariidae)	0	No testing done relative to North American leafminers	Unknown relative to North American fauna. But see Massa <i>et al.</i> [250] relative to European leafminers	R+/E+ Ca 2006	P. Stansly (pers. comm.)
2	2006 USA Minnesota	<i>Binodoxys communis</i> (Gahan)	<i>Aphis glycines</i> Matsumura	19	Six of eight NT, <i>Aphis</i> species were highly suitable, while two were either not or only marginally so. For 11 NT non- <i>Aphis</i> species, one was suitable, while three were marginally so and seven were not	Genus Of native <i>Aphis</i> spp., risk modelling based on ant-tending and phenological overlap suggest high exposure for <i>Aphis</i> exposure to <i>Aphis oestlundii</i> asclepiades Fitch but low exposure to <i>Aphis oestlundii</i> Gillette; ant tending suggests medium exposure to <i>Aphis monardae</i> Oestlund	R+/E– 2007	[203, 480, 481]
3	2006 Israel (from Australia) (thereafter, many other countries)	<i>Closterocerus chamaeleon</i> (Girault)	<i>Ophelimus maskelli</i> (Ashmead)	0	No testing done relative to Mediterranean gall makers	Unknown Assumed to be safe to nontarget insects outside the native range of the pest's host-plant group	R+/E+ 2006	[482, 483]
4	2007 Israel (from Australia)	<i>Stethynium ophelimi</i> Huber	<i>Ophelimus maskelli</i> (Ashmead)	0	No testing done relative to Mediterranean gall makers. It may develop on other unidentified <i>Ophelimus</i> species (Zvi Mendel, pers. com.)	Genus?	R+/E+ 2007	[482, 484]
5	2007 Comoros Islands (Indian Ocean) (from La Réunion)	<i>Eretmocerus coccis</i> Delvare	<i>Aleurotrachelus atratus</i> Hempel	# unpublished	Tested against native whiteflies of Comoros Islands and none were attacked	Unknown Names of non-target species tested not published	R+/E+ 2007	[385, 486]
6	2007 USA Hawaii	<i>Binodoxys communis</i> (Gahan)	<i>Aphis gossypii</i> Glover	6	Three NT, non-native <i>Aphis</i> species were highly suitable while three NT, non-native non- <i>Aphis</i> species were either not suitable (one sp.) or marginally so (two spp.)	Largely Genus specific but not entirely Safe because there are no native aphids or biocontrol aphids in Hawaii	R+/E+ 2010	[487]

Table 1. (Continued)

Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
7 ~2006 USA Not petitioned for release	<i>Fopius arisanus</i> (Sonan)	<i>Bactrocera oleae</i> Gmelin	2	Known from the literature to develop on many fruit-feeding tephritids, including over 20 <i>Bactrocera</i> species and various species of <i>Anastrepha</i> , <i>Carponya</i> , <i>Ceratitis</i> , <i>Dacus</i> and <i>Euphranta</i> (at least 30 hosts). Did not attack two species of weed biocontrol gall-making tephritids tested	Family level, for fruit-feeders Given extensive list of host genera attached, it was rejected by scientists in charge	R- N/A-	[488]
8 ~2006 La Réunion (from Hawaii)	<i>Fopius arisanus</i> (Sonan)	Various pest frugivorous tephritids (no single target)	8	All eight local tephritids tested were attacked. This was seen as desirable	Family Known to attack at least 20 species of tephritids	R+/E+ ~2006	[489, 490]
9 2006? Not petitioned for release	<i>Trichomalus perfectus</i> (Walker)	<i>Ceutorhynchus obstrictus</i> (Marshall)	16 ⁷	Four NT attacked equal to target five NT attacked <target seven NT not attacked	Genus level Not pursued as species-level specificity would be required to protect weed biocontrol agents	R-	[491–493]
10 2007 USA	<i>Spathius agrili</i> Yang	<i>Agilus planipennis</i> (Fairmaire)	17 (F) + 9 (L)	Of 17 NT wood-boring species collected in the field in China, zero were attacked. Of nine NT <i>Agilus</i> species, three were attacked and six not attacked in laboratory tests	Genus	R+/E+ 2007	[494–496]
11 2007 USA	<i>Oobius agrili</i> Zhang and Huang	<i>Agilus planipennis</i> (Fairmaire)	12	In the laboratory, of six NT <i>Agilus</i> , three were attacked and of six NT, non- <i>Agilus</i> , none were attacked	Genus	R+/E+ 2007	[494, 496]
12 2007 USA	<i>Tetrastichus planipennisi</i> Yang	<i>Agilus planipennis</i> (Fairmaire)	6 (F) + 11 (L)	Of six NT <i>Agilus</i> species collected in the field in China, zero were attacked. Of five NT <i>Agilus</i> and six other buprestids, zero were attacked in laboratory tests	Species?	R+/E+ 2007	[494, 496]
13 2007 USA	<i>Lixadmontia franki</i> Wood	<i>Metamasius callizona</i> (Chevrolat) ⁸	1	One NT native Floridian congener, <i>Metamasius mosieri</i> Barber, was tested and found to be attacked at significant rates in choice and no-choice tests	Genus Limited host range testing done	R+/E- 2007	Frank, unpub.
14 2007 USA/Hawaii	<i>Eurytoma erythrinae</i> Gates	<i>Quadrastichus erythrinae</i> Kim	7	None of the seven NT gall-makers tested (one native, four biocontrol agents, two adventive) were attacked	Genus	R+/E+ 2008	[497]
15 ~2008 Australia	<i>Diaeretus essigellae</i> Stary and Zuparko	<i>Essigella californica</i> (Essig)	8	Eight NT-no parasitism on any tested species	Genus?	R+/E+ ~2009	[498]
16 2008 USA/Hawaii	<i>Aroplectus dimerus</i> L.	<i>Darna pallivitta</i> (Moore)	25	None of the 25 NT gall-makers tested (= no family-level native species in HI; tested used 13 families, two or which were endemic, and 19 are immigrant pests) were attacked	Family level, same as species level In Hawaii, there are not con-familial natives	R+/E+ 2010	[499]

17	2008 USA/ California	<i>Tamarix radiata</i> (Waterson)	<i>Diaphorina citri</i> Kuwayama	7	Six NT-no parasitism 1-adv pest-attacked (5%)	Genus?	R+/E+ 2010	[500]
18	2009 USA	<i>Pseudacteon cultellatus</i> Borgmeier (Phoridae)	<i>Solenopsis invicta</i> , <i>S. richteri</i> , and hybrids (Formicidae)	15	12 NT ant species in ten genera – no parasitism: low rates of parasitism in three native NT <i>Solenopsis</i>	Genus More host specific than <i>P. curvatus</i> but less than other <i>Pseudacteon</i>	R+/E+ 2010	[478, 501] Unpublished environmental assessment [502]
19	Ca 2008 Canada (from Europe) but never released	<i>Aleochara bipustulata</i> L.	<i>Delia radicum</i> (L.)	18	11 NT species supported parasitoid development: most frequently attacked species had small pupae or were in families related to target	Order level Species in eight families supported attack and development	Never released	[503]
20	Ca 2009 Switzerland (from Mexico) but never released	<i>Celatoria compressa</i> (Wulp)	<i>Diabrotica virgifera</i> <i>virgifera</i> Leconte	9	Of nine NT species tested, the agent developed, at low rates, in only one test species	<i>Two Subtribes</i> Fundamental host range restricted to subtribes <i>Diabroticina</i> and <i>Aulacophorina</i>	Never released (hard to rear)	[503]
21	2010 USA	<i>Pseudacteon cultellatus</i> Borgmeier (Phoridae)	<i>Solenopsis invicta</i> , <i>S. richteri</i> and hybrids (Formicidae)	1	One NT species in <i>Solenopsis</i> tested (<i>S. geminata</i>) and found to be attacked in about one-third of cases	Genus	R+/E+ 2010	[504]
22	2010 USA	<i>Aphelinus glycines</i> Wooley and Hopper	<i>Aphis glycines</i> Matsumura	12	No NT attacks on aphids outside of genus <i>Aphis</i> . Of seven NT <i>Aphis</i> species, four were suitable for parasitism, while three were not	Genus	R+/E? 2013	[504, 505]
23	Ca 2011 New Zealand (from Tasmania, Australia)	<i>Cotesia urabae</i> (Austin & Allen)	<i>Uraba lugens</i> Walker	2	One NT – substitute not attacked in native range one NT attacked by no development	Species Given limited New Zealand fauna and nature of host plant of target pest, <i>C. urabae</i> is expected to be nearly host specific.	R+/E+	[506–509]
24	2013 USA/ California	<i>Diaphorencyrtus</i> <i>aligarhensis</i> (Shafee <i>et al.</i>)	<i>Diaphorina citri</i> Kuwayama	7	Six NT – no parasitism; one adventive pest psyllid attacked (at 14% rate)	Genus?	+/-?	[510]
25	2013 USA	<i>Spathius galinae</i> Belokobylskij and Strazanac	<i>Agilus planipennis</i> Fairmaire	15	14 NT – no attack one pest NT-attacked ⁹	Genus	+/- 2015	[511, 512]
26	2013 USA/Hawaii	<i>Encarsia diaspidicola</i> (Silvestri)	<i>Pseudaulacaspis</i> <i>pentagona</i> (Targioni)	7	None of the seven NT were parasitized or killed	Family? Several diaspidid scales (including <i>Pseudaulacaspis</i> <i>pentagona</i> [Targioni-Tozzetti] and <i>Quadraspidotus</i> <i>permiosus</i> [Cornstock]) are known hosts, but others are not hosts [345]	R+/E+	[345, 513]

Table 1. (Continued)

Year released	Agent	Target	No. of test spp.	Test outcomes	Smallest taxon including all likely hosts	Released Established ¹ (year if given equals of first release)	References
27 Not yet petitioned for release but under study for release in the USA	<i>Apanteles opuntiarum</i> Martinez & Berta	<i>Cactoblastis cactorum</i>	6	Six NT – five spp. in native range were not attacked; one sp. attacked	Genus While laboratory tests have not yet been run, field surveys in the native range (Argentina) found this species attacking only the target pest and one other species in the target's genus. One other species in the target's genus was not attacked	N/A ¹⁰	[514, 515]

¹Outcomes: – (not released), +/- (released and established), +/- (released but not established).

²Species tested in Australia included a range of other leafminers (one in target genus, three others in target family, seven more in four other families), as well as four gall makers and two less related weed biocontrol agents.

³Research group concluded this was primarily a parasitoid of *S. saevissima* and did not petition for release.

⁴Nineteen ants in genera other than that of the target (*Solenopsis*) and two in *Solenopsis*; same format used in following additional species of *Pseudacteon*.

⁵Assessments of coffee berry borer parasitoid host range was done after release had already occurred.

⁶Attack in laboratory was found on *Lepra trilineata* White (Cricetinae), a native North American insect [454]; also, for all parasitoids of lily leaf beetle, potential conflict exists with use of *Lilioceris* beetles as future weed biological control agents of various invasive plants.

⁷All non-target species were in the same genus as the target pest.

⁸In Florida, there are three *Metamasius* weevils, two of which (including the target pest) attack bromeliads and one not. The nontarget species in bromeliads was attacked by the tachinid, but the NT species not in a bromeliad host was not. No other weevils outside of *Metamasius* attack bromeliads in Florida.

⁹Attack in field on *Agrilus auroguttatus* Shaeffer unlikely because of extremely thick bark of oak hosts, but would be beneficial if it occurred, as this is highly damaging and invasive in California.

¹⁰Laboratory testing of this newly recognized species has yet to be done.

Table 2. Predacious insects (28 species) introduced between 1985 and 2015, with notes on the level of specificity of each, drawn from literature records (worldwide) and BioCat (for North America, including Mexico and the US overseas territories, 1985–2004 [end of available records]).

	Year released	Agent	Target	No. of Test spp.	Test outcomes	Likely safety	Reg. dec. ¹	Ref.
1	1984 USA (from Korea) and 1990– 1995 (from China)	<i>Chilocorus kuwanae</i> (Silvestri) Coccinellidae	<i>Unaspis euonymi</i> (Comstock) (Diaspididae)	0	No laboratory prey range estimation done	Order (Multiple families in the Coccoidea) Known field prey of this species include various diaspidid scales, e.g., <i>Unaspis yanonenis</i> (Kuwana) [516], <i>Quadraspidiotus</i> <i>periculosus</i> (Comstock) [517], <i>Quadraspidiotus</i> <i>macroporatus</i> Takagi [518]; more broadly it is known to feed on at least 28 scale species in five scale families [519], including the mealybug <i>Pseudococcus citriculus</i> Green [520], the coccid <i>Protopulvinaria mangiferae</i> (Green) [521], and the erilococcid <i>Eriococcus</i> <i>lagerstroemiae</i> Kuwanae [522]; see also Bull <i>et al.</i> [523]	R+/E+ 1984/ 1990–1995	[342, 343, 516–523]
2	1984 USA (from Korea) and 1990– 1995 (from China)	<i>Cybocephalus</i> nr. <i>nipponicus</i> Enrody-Younga (for this analysis we conflate <i>C. nipponicus</i> and <i>C. nr.</i> <i>nipponicus</i>) Nitidulidae	<i>Unaspis euonymi</i> (Comstock) Diaspididae	0	No laboratory prey range estimation done No host range testing done before the introduction	Family (Diaspididae) Known field prey of this species include various diaspidid scales, e.g., <i>Quadraspidiotus</i> <i>macroporatus</i> Takagi [518], <i>Unaspis yanonenis</i> Kuwana [524], as well as (for adult feeding) eggs of the tetranychid <i>Panonychus citri</i> (McGregor) [525]; while adult feeding ranges include multiple families, oviposition and development only occurred in diaspidid scales, with reproduction on six of nine species tested [526], as reproduction is more similar to that of a parasitoid than predator	R+/E+ 1984/ 1990–1995	[342, 343, 518, 524–526]

Table 2. (Continued)

Year released	Agent	Target	No. of Test spp.	Test outcomes	Likely safety	Reg. dec. ¹	Ref.
3 1985 Oman (from India)	<i>Chilocorus nigritus</i> (F.) Coccinellidae	<i>Aspidiotus destructor</i> Sign. (Diaspididae)	0	No laboratory prey range estimation done	Order (Hemiptera) n effective biocontrol agent of diaspid scales [527–529] and some species of Coccidae and Asterolecaniidae [530]. Also recorded feeding on some aphids [531] and whiteflies [532]	R+/E+ 1985	[527–532]
4 1986, Guam and Mariana Islands from Hawaii	<i>Curinus coeruleus</i> (Mulsant) Coccinellidae	<i>Heteropsylla cubana</i> Crawford (Psyllidae)	0	No laboratory prey range estimation done	Order (Hemiptera) Known prey include aphids, e.g., <i>Rhopalosiphum maidis</i> (Fitch) [533]; whiteflies, e.g., <i>Aleurodicus dispersus</i> Russell [534]; and psyllids, e.g., <i>Diaphorina citri</i> Kuwayama [535]	R+/E+	[533–536]
5 1980–1990	<i>Clitostethus arcuatus</i> (Rossi) Coccinellidae	<i>Siphoninus phillyrae</i> (Haliday) Aleyrodidae	0	No laboratory prey range estimation done	Family (Aleyrodidae) Known field prey of this species are whiteflies, including <i>Dialeurodes citri</i> (Ashmead) [544], <i>Aleurodes prolella</i> L. [538], <i>Aleurothrix floccosus</i> Maskell [539] among others	R+/E+	[537–540]
6 1988, USA from Europe	<i>Rhizophagus grandis</i> Gyllenhal Rhizophagidae	<i>Dendroctonus terebrans</i> (Olivier) Curculionidae: Scolytinae	0	No laboratory prey range estimation done	Genus Known field prey of this species are bark beetles in the genus <i>Dendroctonus</i> , including <i>D. micans</i> Kugelmann [541], <i>Dendroctonus valens</i> LeConte [542]	R+/E+	[541, 542]
7 1989, USA	<i>Hippodamia undecimnotata</i> (Schneider) (other generic placements include <i>Semiadalia</i> and <i>Adonia</i> ; also know as <i>Hippodamia oculata</i>) (Coccinellidae) Note: this species apparently invaded North America on its own about the same time it was being introduced into other parts of the continent [543] Coccinellidae	<i>Diuraphis noxia</i> (Kurdjumov) Aphidae	0	No laboratory prey range estimation done	Family (Aphididae) Adults feed on various aphids. Larvae develop on <i>Aphis fabae</i> Scopoli in the French lower Alps [545], on <i>Myzus persicae</i> (Sulzer) in France [538], and <i>Toxoptera aurantii</i> (Boyer de Fonscolombe) in the country of Georgia [546]	R+/E?	[543–547]

8	1989, USA	<i>Propylea quatuordecimpunctata</i> (L.) (Coccinellidae) Note: this species apparently invaded North America on its own about the same time it was being introduced into other parts of the continent [543, 551] Coccinellidae <i>Scymnus frontalis</i> (F.) Coccinellidae	<i>Diuraphis noxia</i> (Kurdjumov) Aphidae	0	No laboratory prey range estimation done	Family (Aphididae) Field prey include <i>Aphis fabae</i> Scopoli [548]; larvae can develop on <i>Acyrtosiphon pisum</i> Harris and <i>Rhopalosiphum maidis</i> (Fitch) [547] and <i>Schizaphis graminum</i> (Rondani) [550]	R+/E+	[543, 547–551]
9	1990 USA		<i>Diuraphis noxia</i> (Kurdjumov) Aphidae	0	No laboratory prey range estimation done	Family (Aphididae) Larvae develop well on several aphids, including <i>Schizaphis graminum</i> (Rondani), <i>Macrosiphum</i> (<i>Sitobion</i>) <i>avenae</i> (F.) and <i>Acyrtosiphon pisum</i> Harris [552]	R+/E?	[547, 552]
10	1990 USA	<i>Oenopia</i> (<i>Synharmonia</i>) <i>conglobata</i> (L.) Coccinellidae	<i>Diuraphis noxia</i> (Kurdjumov) Aphidae	0	No laboratory prey range estimation done	Two or most Orders Feeds on several families, including Aphididae, Monophlebidae, Coccidae, Chrysomelidae, and Aphidae Field prey records include a monophlebid scale (<i>Matsucoccus josephi</i> Bodenheimer et Harpaz) [553], a coccid scale, <i>Ceroplastes rusci</i> (L.) [554], and various aphids, e.g., <i>Aphis craccivora</i> Koch [555] and <i>Hyadaphis tataricae</i> (Aizenberg) [556], and eggs of flea beetles (Chrysomelidae) [557], the psyllid <i>Euphyllura straminea</i> Loginova [558]	R+/E?	[547, 553–558]
11	1991 Canada	<i>Leucopis ninae</i> Tanasijtshuk (Chamaemyiidae)	<i>Diuraphis noxia</i> (Kurdjumov) Aphidae	0	No laboratory prey range estimation done	Family (Aphididae) Prey include aphids, i.e., <i>Aphis nerii</i> Boyer de Fonscolombe [559] and <i>Rhopalosiphum padi</i> (L.) [560]	R+/E–	[559, 560]
12	1991 Canada	<i>Leucopis atritarsis</i> Tanasijtshuk (Chamaemyiidae)	<i>Diuraphis noxia</i> (Kurdjumov) Aphidae	0	No laboratory prey range estimation done	Family? or Unknown No other prey records were found	R+/E–	[561]

Table 2. (Continued)

	Year released	Agent	Target	No. of Test spp.	Test outcomes	Likely safety	Reg. dec. ¹	Ref.
13	1991–1992-Togo, Benin, Kenya, from Central America	<i>Teretris (Teretriosoma) nigrescens</i> (Lewis) Histeridae	<i>Prostephanus truncatus</i> (Horn) Bostrichidae	0	No laboratory prey range estimation done	Species? Predator is attracted to the sex pheromone of the target pest [562]. No other field hosts have been reported	R+/E+ 1991-Togo and Benin 1992-Kenya	[562–565]
14	1993–1999, USA, including Puerto Rico	<i>Serangium parcesetosum</i> Sicard (formerly <i>Catana parcesetosa</i>) Coccinellidae	<i>Bemisia tabaci</i> (Gennadius) strain B (Aleyrodidae)	0	No laboratory prey range estimation done	Family (Aleyrodidae) Prey records include various other whiteflies, e.g., <i>Dialeurodes citri</i> (Ashmead) [566], but not lepidopteran eggs [567]; the predator appears to be limited to whitefly species as prey for both larvae and adults [568]	R+/E?	[566–568]
15	1995 USA, Hawaii	<i>Rodolia blackburni</i> Ukrainsky; formerly <i>Rodolia limbata</i> (Blackburn) Coccinellidae	<i>Icerya aegyptiaca</i> (Douglas) Monophlebidae	0	No laboratory prey range estimation done	Two Families (Monophlebidae and Diaspididae) Known from the monophlebs <i>Drosicha contrahens</i> Walker [569] and <i>Icerya</i> sp. [570] and the diapsidid <i>Comstockaspis macroporatus</i> Normark, Morse, Krawinski & Okusu [571]	R+/E+	[569–571]
16	1997–98 USA, Florida, from Thailand	<i>Cybocephalus binotatus</i> Grouvelle (Nitidulidae)	<i>Aulacaspis yasumatsui</i> Takagi (Diaspididae)	0	No laboratory prey range estimation done	Family? (Diaspididae) Host records include several diapsidids including <i>Aonidiella aurantii</i> (Maskell) and <i>Chrysomphalus aonidium</i> (L.) but not <i>Aspidiotus nerii</i> Bch. and attempts to rear the species on spider mites or moth eggs failed [572, 573]	R+/E+	[438, 572, 573]
17	1997 US Virgin Islands and 2004, Mexico	<i>Cryptolaemus montrouzieri</i> (Mulsant) Coccinellidae	Mealybugs and other Hemiptera	0	No laboratory prey range estimation done	Order level >8 families of Hemiptera known as prey	Past releases in many locations	[574]

18	ca 2000 Caribbean, from India	<i>Scymnus coccivora</i> Ram. Ayyar (Coccinellidae)	<i>Maconelliococcus hirsutus</i> Green (Pseudococcidae)	0	No laboratory prey range estimation done	Order, several families (Pseudococcidae, Coccidae, Aphidae) Recorded prey are predominately mealybugs in a variety of genera, including <i>Pseudococcus saccharifolii</i> (Green) [575], <i>Ferrisia virgata</i> (Cockerell) [576], with some records of other families, such as the coccid <i>Saissetia privigna</i> De Lotto [577] and the aphid <i>Aphis puniceae</i> Shinji [583] Genus level or better Functionally monophagous under conditions of use in the Galapagos	R+/E? Ca. 2000	[575–579]
19	2002 Ecuador	<i>Rodolia cardinalis</i> (Mulsant) Coccinellidae	<i>Icerya purchasi</i> Maskell (Monophlebidae)	16 (L) 8 (A)	Of 16 species tested, larvae fed on only one NT species (same genus); none supported development. Adults did not fed on any of the eight NT species Three NT adelgids and one NT aphid were fed on by adult beetles but at low rates compared with target; no non-adelgid prey was able to support development [582]		R+/E+	[136, 580, 581]
20	1994, USA from Japan	<i>Sasajiscymnus</i> (<i>Pseudoscyrmnus</i>) <i>tsugae</i> Sasaji and McClure (Coccinellidae)	<i>Adelges tsugae</i> Annand (Adelgidae)	4	Three NT adelgids and one NT aphid were fed on by adult beetles but at low rates compared with target; no non-adelgid prey was able to support development [583]	Family level for adults Genus level or lower for larvae Other suitable prey include <i>Adelges piceae</i> Ratzburg [583]	R+/E+	[582, 583]
21	2003, USA, Virginia, from Washington	<i>Laricobius nigrinus</i> Fender (Derodontidae)	<i>Adelges tsugae</i> Annand (Adelgidae)	6	All three NT adelgids tested received eggs, but none supported full development [584]	Species No other field prey are known	R+/E+ 2005	[584–587]
22	Ca. 2005, USA from China	<i>Scymnus ningshanensis</i> Yu and Yao (Coccinellidae)	<i>Adelges tsugae</i> Annand (Adelgidae)	4	Two of the three NT adelgids and the NT aphid were fed on by adult beetles but at low rates compared with the target pest; development was assessed only on the aphid, which did not support development	Family-level Both <i>Pineus strobi</i> (Hartig) and <i>Adelges cooleyi</i> (Gillette) were accepted as prey	R+/E+	[582]
23	2009	<i>Laricobius osakensis</i> Montgomery and Shiyake (Derodontidae)	<i>Adelges tsugae</i> Annand (Adelgidae)	6	No oviposition and no development on six NT species; Some feeding by adults on three adelgids and one aphid, but not two scales	Species level for larvae Family level for adults	R+/E+ 2010	[588]

Acknowledgements

We thank the following scientists who commented on the accuracy of various points relative to particular introductions that they had personal knowledge of: Barbara Barratt, Dani Blumberg, Jacque Brodeur, Richard Casagrande, Peter Follett, Howard Frank, George Heimpel, Keith Hopper, Tracy Johnson, Ulrich Kuhlmann, Nicholas Mills, William Overholt, Tim Paine, Jorge Peña, Diana Percy, Sanford Porter, David Prokrym, Petr Stary, Robert Tichenore, Charles Vincent and Juliana Yalembar. We also thank Matthew Cock of CABI for access to records from BioCat for North America for this project. Remaining errors are ours.

References

- Howarth FG. Environmental impacts of classical biological control. *Annual Review of Entomology* 1991;36:485–509.
- Follett PA, Duan JJ, editors. *Nontarget Effects of Biological Control*. Kluwer Academic Publishers, Norwell, UK; 2000.
- Follett PA, Duan J, Messing RH, Jones VP. Parasitoid drift after biological control introductions: re-examining Pandora's box. *American Entomologist* 2000;46:82–94.
- van Lenteren JC, Loomans AJM. Biological control of insects: always safe? Risks of introduction and release of exotic natural enemies. In: Sommeijer MJ, Meeuwsen FJAJ, editors. *Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society*. 2000;11:3–22.
- Louda SM, Pemberton RW, Johnson MT, Follett PA. Nontarget effects – the Achilles' heel of biological control? Retrospective analyses to reduce risk associated with bio-control introductions. *Annual Review of Entomology* 2003;48:365–96.
- Hoddle MS. Restoring balance: using exotic natural enemies to control invasive pests. *Conservation Biology* 2004;18:38–49.
- Hoddle MS. The strength of biological control in the battle against invasive pests: a reply. *Conservation Biology* 2004;18:61–4.
- Hoddle MS. Biological control in support of conservation: friend or foe? In: Gordon MS, Bartol SM, editors. *Experimental Approaches to Conservation Biology*. University of California Press Berkeley, California, USA; 2004. p. 202–37.
- Stewart AJA, New TR. Insect conservation in temperate biomes: issues, progress and prospects. In: Stewart AJA, New TR, Lewis OT, editors. *Insect Conservation Biology*. CAB International, Wallingford, UK; 2007. p. 1–33.
- Parry D. Beyond Pandora's Box: quantitatively evaluating non-target effects of parasitoids in classical biological control. *Biological Invasions* 2009;11:47–58.
- Barratt BIP, Howarth FG, Withers TM, Kean JM, Ridley GS. Progress in risk assessment for classical biological control. *Biological Control* 2010;52:245–54.
- Suckling DM, Sforza RFH. What magnitude are observed non-target impacts from weed biocontrol? *PLoS ONE* 2014;9(1):e84847.
- Winston RL, Schwarzländer M, Hinz HL, Day MD, Cock MJW, Julien MH, editors. *Biological Control of Weeds: A World Catalogue of Agents and Their Target Weeds*. 5th ed. FHTET-2014-04, USDA Forest Service, Morgantown, West Virginia; 2014.
- Stiling P, Moon D, Gordon D. Endangered cactus restoration: mitigating the non-target effects of a biological control agent (*Cactoblastis cactorum*) in Florida. *Restoration Ecology* 2004;12:605–10.
- Pemberton RW, Liu H. Control and persistence of native *Opuntia* on Nevis and St. Kitts 50 years after the introduction of *Cactoblastis cactorum*. *Biological Control* 2007;41:272–82.
- Louda SM. Population growth of *Rhinocyllus conicus* (Coleoptera: Curculionidae) on two species of native thistles in Prairie. *Environmental Entomology* 1998;27:834–41.
- Louda SM, Rand TA, Arnett AE, McClay AS, Shea K, McEachern AK. Evaluation of ecological risk to populations of a threatened plant from an invasive biological control insect. *Ecological Applications* 2005;15:234–49.
- Harmon JP, Stephens E, Losey J. The decline of native coccinellids (Coleoptera: Coccinellidae) in the United States and Canada. *Journal of Insect Conservation* 2007;11:85–94.
- Losey JE, Perlman JE, Hoebeke ER. Citizen scientist redis-covers rare nine-spotted lady beetle, *Coccinella novemnotata*, in eastern North America. *Journal of Insect Conservation* 2007;11:415–7.
- Boettner GH, Elkinton JS, Boettner CJ. Effects of a biological control introduction on three nontarget native species of Saturniid moths. *Conservation Biology* 2000;14:1798–806.
- Kuris AM. Did biological control cause extinction of the coconut moth, *Levuana iridescens*, in Fiji? *Biological Invasions* 2003;5:133–41.
- Hoddle M. Historical review of control programs for *Levuana iridescens* (Lepidoptera: Zygaenidae) in Fiji and examination of possible extinction of this moth by *Bessa remota* (Diptera: Tachinidae). *Pacific Science* 2006;60:439–53.
- Nafus DM. Movement of introduced biological control agents onto nontarget butterflies, *Hypolimnas* spp. (Lepidoptera: Nymphalidae). *Environmental Entomology* 1993;22:265–72.
- Lynch LD, Thomas MB. Nontarget effects in the biocontrol of insects with insects, nematodes and microbial agents: the evidence. *Biocontrol News and Information* 2000;21(4):117N–30N.
- van Lenteren JC, Bale J, Bigler F, Hokkanen HHT, Loomans AJM. Assessing risks of releasing exotic biological control agents of arthropod pests. *Annual Review of Entomology* 2006;51:609–34.
- Frank JH, McCoy ED. The risk of classical biological control in Florida. *Biological Control* 2007;41:151–74.
- Van Driesche RG. The meaning of 'percent parasitism' in studies of insect parasitoids. *Environmental Entomology* 1983;12:1611–22.
- Van Driesche RG, Hoddle MS, Center T. *Control of Pests and Weeds by Natural Enemies*. Blackwell, Malden, Massachusetts, USA; 2008.
- Van Driesche RG. Methods for evaluation of natural enemy impacts on invasive pests of wildlands. In: Van Driesche RG, Simberloff D, Blossey B, Causton C, Hoddle MS, Marks C, Heinz K, Wagner D, Warner K, editors. *Integrating Biological*

- Control into Conservation Practice. Wiley/Blackwell, Oxford, UK; 2016. p. 189–207.
30. Fuester RW, Hajek AE, Elkinton JS, Schaefer PW. Gypsy moth (*Lymantria dispar* L.) (Lepidoptera: Erebiidae: Lymantriinae). In: Van Driesche RG, Reardon R, editors. The Use of Classical Biological Control to Preserve Forests in North America. FHTET- 2013-02. USDA Forest Service, Morgantown, West Virginia, USA; 2014. p. 49–82. Available from: URL: http://www.fs.fed.us/foresthealth/technology/pub_titles.shtml
 31. MacClaine LS. Rearing the parasites of the brown-tail moth in New England for colonization in Canada. *Agricultural Gazette* 1916;3(1):22–5.
 32. Culver JA. Study of *Compsilura concinnata*, an Imported tachinid Parasite of the Gipsy Moth and the Brown-Tail Moth. Bulletin No. 766. United States Department of Agriculture, Washington, DC; 1919. 27 p.
 33. Stamp NE, Bowers MD. Parasitism of New England buckmoth caterpillars (*Hemileuca lucina*: Saturniidae) by tachinid flies. *Journal of the Lepidopterists' Society* 1990;44(3):199–200.
 34. Kellogg SK, Fink LS, Brower LP. Parasitism of native luna moths, *Actias luna* (L.) (Lepidoptera: Saturniidae), by the introduced *Compsilura concinnata* (Meigen) (Diptera: Tachinidae) in central Virginia, and their hyperparasitism by trigonalid wasps (Hymenoptera: Trigonalidae). *Environmental Entomology* 2003;32:1019–27.
 35. Selfridge JA, Parry D, Boettner GH. Parasitism of barrens buck moth, *Hemileuca maia* Dury, in early and later successional pine barrens habitats. *Journal of the Lepidopterists' Society* 2007;61(4):213–21.
 36. Goldstein PZ, Morita S, Capshaw G. Stasis and flux among Saturniidae and Sphingidae (Lepidoptera) on Massachusetts' offshore islands and the possible role of *Compsilura concinnata* (Meigen) (Diptera: Tachinidae) as an agent of mainland New England moth declines. *Proceedings of the Entomological Society of Washington* 2015;117:347–66.
 37. Clausen CP, editor. Introduced Parasites and Predators of Arthropod Pests and Weeds: A World Review. USDA Agricultural Handbook No. 480. Washington, DC; 1978.
 38. Kingsley PC, Bryan MD, Day WH, Burger TL, Dysart RJ, Schwalbe CP. Alfalfa weevil (Coleoptera: Curculionidae) biological control: spreading the benefits. *Environmental Entomology* 1993;22:1234–50.
 39. Cullen JM, Hopkins DC. Rearing, release and recovery of *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae) imported for the control of *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) in south eastern Australia. *Journal of the Australian Entomological Society* 1982;21:279–84.
 40. Waterhouse DF, Sands DPA. Classical Biological Control of Arthropods in Australia. Australian Centre for International Agricultural Research, Canberra, Australia; 2001.
 41. Stufkens MW, Farrell JA. *Sitona discoideus* Gyllenhal, sitona weevil (Coleoptera: Curculionidae). In: Cameron PJ, Hill RL, Bain J, Thomas WP, editors. A Review of Biological Control of Invertebrate Pests and Weeds in New Zealand 1874–1987. Technical Communication No. 10. CAB International, Wallingford, UK; 1989. p. 27–8.
 42. Barlow ND, Goldson SL. A modelling analysis of the successful biological control of *Sitona discoideus* (Coleoptera: Curculionidae) by *Microctonus aethiopoides* (Hymenoptera: Braconidae) in New Zealand. *Journal of Applied Ecology* 1993;30:165–79.
 43. Barratt BIP, Evans AA, Ferguson CM, Barker GM, McNeill MR, Phillips CB. Laboratory nontarget host range of the introduced parasitoids *Microctonus aethiopoides* and *M. hyperodae* (Hymenoptera: Braconidae) compared with field parasitism in New Zealand. *Environmental Entomology* 1997;26:694–702.
 44. Barratt BIP, Ferguson CM, Bixley AS, Crook KE, Barton DM, Johnstone PD. Field parasitism of nontarget weevil species (Coleoptera: Curculionidae) by the introduced biological control agent *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae) over an altitude gradient. *Environmental Entomology* 2007;36:826–39.
 45. Barratt BIP, Oberprieler RG, Ferguson CM, Hardwick S. Parasitism of the lucerne pest *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) and non-target weevils by *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae) in south-eastern Australia, with an assessment of the taxonomic affinities of non-target hosts of *M. aethiopoides* recorded from Australia and New Zealand. *Australian Journal of Entomology* 2005;44:192–200.
 46. Barratt BIP, Oberprieler RG, Barton DM, Mouna M, Stevens M, Alonso-Zarazaga MA, *et al.* Could research in the native range, and non-target host range in Australia, have helped predict host range of the parasitoid *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae), a biological control agent introduced for *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) in New Zealand? *BioControl* 2012;57:735–50.
 47. Ferguson CM, Kean JM, Barton DM, Barratt BIP. Ecological mechanisms for non-target parasitism by the Moroccan ecotype of *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae) in native grassland. *Biological Control* 2016;96:28–38.
 48. Barlow ND, Barratt BIP, Ferguson CM, Barron MC. Using models to estimate parasitoid impacts on nontarget host abundance. *Environmental Entomology* 2004;33:941–8.
 49. Davis CJ. The introduction, propagation, liberation, and establishment of parasites to control *Nezara viridula* variety *smaragdula* (Fabricius) in Hawaii (Heteroptera: Pentatomidae). *Proceedings of the Hawaiian Entomological Society* 1964;18:369–75.
 50. Shahjahan M, Beardsley Jr JW. Egg viability and larval penetration in *Trichopoda pennipes pilipes* Fabricius (Diptera: Tachinidae). *Proceedings of the Hawaiian Entomological Society* 1973;22(1):133–6.
 51. Johnson MT, Follett PA, Taylor AD, Jones VP. Impacts of biological control and invasive species on a non-target native Hawaiian insect. *Oecologia* 2005;142:529–40.
 52. Sheppard AW, Warner KD. Societal values expressed through policy and regulations concerning biological control releases. In: Van Driesche RG, Simberloff D, Blossey B, Causton C, Hoddle MS, Marks C, Heinz K, Wagner D, Warner K, editors. Integrating Biological Control into Conservation Practice. Wiley/Blackwell, Oxford, UK; 2016. p. 247–63.
 53. Holt RD, Hochberg ME. Indirect interactions, community modules and biological control: a theoretical perspective. In: Wajnberg E, Scott JK, Quimby PC, editors. Evaluating Indirect Ecological Effects of Biological Control. CABI, Wallingford, UK; 2001. p. 13–37.
 54. Redman AM, Scriber JM. Competition between the gypsy moth, *Lymantria dispar*, and the northern tiger swallowtail, *Papilio canadensis*: interactions mediated by host plant

- chemistry, pathogens, and parasitoids. *Oecologia* 2000;125:218–28.
55. Benson J, Van Driesche RG, Pasquale A, Elkinton J. Introduced braconid parasitoids and range reduction of a native butterfly in New England. *Biological Control* 2003;28:197–213.
 56. Van Driesche RG, Nunn C, Kreke N, Goldstein B, Benson J. Laboratory and field host preferences of introduced *Cotesia* spp. parasitoids (Hymenoptera: Braconidae) between native and invasive *Pieris* butterflies. *Biological Control* 2003;28:214–21.
 57. Herlihy MV, Van Driesche RG, Wagner DL. Persistence in Massachusetts of the veined white butterfly due to use of the invasive form of cuckoo flower. *Biological Invasions* 2014;16:2713–24.
 58. DeBach P, Sundby RA. Competitive displacement between ecological homologues. *Hilgardia* 1963;34(5):105–66.
 59. Bennett FD. Do introduced parasitoids displace native ones? *Florida Entomologist* 1993;76:54–63.
 60. Herlihy MV, Van Driesche RG, Abney MR, Brodeur J, Bryant AB, Casagrande RA, *et al.* Distribution of *Cotesia rubecula* (Hymenoptera: Braconidae) and its displacement of *Cotesia glomerata* in eastern North America. *Florida Entomologist* 2012;95:461–7.
 61. Péré C, Augustin S, Tomov R, Peng L-H, Turlings TCJ, Kenis M. Species richness and abundance of native leaf miners are affected by the presence of the invasive horse-chestnut leaf miner. *Biological Invasions* 2010;12:1011–21.
 62. Péré C, Bell R, Turlings TCJ, Kenis M. Does the invasive horse-chestnut leaf mining moth, *Cameraria ohridella*, affect the native beech leaf mining weevil, *Orchestes fagi*, through apparent competition? *Biodiversity and Conservation* 2011;20:3003–16.
 63. Wheeler Jr AG, Hoebeke ER. *Coccinella novemnotata* in northeastern North America: histological occurrence and current status (Coleoptera: Coccinellidae). *Proceedings of the Entomological Society of Washington* 1995;97(3):701–16.
 64. Elliott N, Kieckhefer R, Kauffman W. Effects of an invading coccinellid on native coccinellids in an agricultural landscape. *Oecologia* 1996;105(4):537–44.
 65. Turnock WJ, Wise IL, Matheson FO. Abundance of some native coccinellines (Coleoptera: Coccinellidae) before and after the appearance of *Coccinella septempunctata*. *The Canadian Entomologist* 2003;135:391.
 66. Fothergill K, Tindall KV. Lady beetle (Coleoptera: Coccinellidae: Coccinellinae) occurrences in southeastern Missouri agricultural systems: differences between 1966 and present. *Coleopterists Bulletin* 2010;64(4):379–82.
 67. Brown PMJ, Frost R, Doberski J, Sparks T, Harrington R, Roy HE. Decline in native ladybirds in response to the arrival of *Harmonia axyridis*: early evidence from England. *Ecological Entomology* 2011;36:231–40.
 68. Snyder WE, Clevenger GM, Eigenbrode SD. Intraguild predation and successful invasion by introduced ladybird beetles. *Oecologia* 2004;140:559–65.
 69. Katsanis A, Babendreier D, Nentwig W, Kenis M. Intraguild predation between the invasive ladybird *Harmonia axyridis* and non-target European coccinellid species. *BioControl* 2013;58:73–83.
 70. Gagnon A-È, Heimpel GE, Brodeur J. The ubiquity of intraguild predation among predatory arthropods. *PLoS ONE* 2011;6:e28061.
 71. Smith CA, Gardiner MM. Biodiversity Loss following the introduction of exotic competitors: does intraguild predation explain the decline of native lady beetles? *PLoS ONE* 2013;8(12):e84448.
 72. Vilcinskis A, Stoecker K, Schmidtberg H, Röhrich CR, Vogel H. Invasive harlequin ladybird carries biological weapons against native competitors. *Science (Washington)* 2013;340(6134):862–3.
 73. Mizell RF. Impact of *Harmonia axyridis* (Coleoptera: Coccinellidae) on native arthropod predators in pecan and crape myrtle. *Florida Entomologist* 2007;90:524–36.
 74. Alyokhin A, Sewell G. Changes in a lady beetle community following the establishment of three alien species. *Biological Invasions* 2004;6:463–71.
 75. Evans EW. Habitat displacement of North American ladybirds by an introduced species. *Ecology* 2004;85:637–47.
 76. Day WH, Tatman KM. Changes in abundance of native and adventive Coccinellidae (Coleoptera) in alfalfa fields, in northern New Jersey (1993–2004) and Delaware (1999–2004), USA. *Entomological News* 2006;117(5):491–502.
 77. Angelet GW, Fuester R. The *Aphidius* parasites of the pea aphid, *Acyrtosiphon pisum*, in the eastern half of the United States. *Annals of the Entomological Society of America* 1977;70:87–96.
 78. Bartlett PB, Hesler LS, French BW, Catangui MA, Gritzner JH. Lady beetle assemblages (Coleoptera: Coccinellidae) in western South Dakota and western Nebraska and detection of reproducing populations of *Coccinella novemnotata*. *Annals of the Entomological Society of America* 2015;108:474–86.
 79. Finlayson CJ, Landry KM, Alyokhin AV. Abundance of native and non-native lady beetles (Coleoptera: Coccinellidae) in different habitats in Maine. *Annals of the Entomological Society of America* 2008;101:1078–87.
 80. Hesler LS, Kieckhefer RW. Status of exotic and previously common native coccinellids (Coleoptera) in South Dakota landscapes. *Journal of the Kansas Entomological Society* 2008;81:29–49.
 81. Bahlai CA, Colunga-Garcia M, Gage SH, Landis DA. The role of exotic ladybeetles in the decline of native ladybeetle populations: evidence from long-term monitoring. *Biological Invasions* 2015;17:1005–24.
 82. Stary P, Lyon JP, Leclant F. Biocontrol of aphids by the introduced *Lysiphlebus testaceipes* (Cress.) (Hym., Aphidiidae) in Mediterranean France. *Journal of Applied Entomology* 1988;105:74–87.
 83. Stary P, Lyon JP, Leclant F. Post-colonisation host range of *Lysiphlebus testaceipes* in the Mediterranean area (Hymenoptera, Aphididae). *Acta Entomologica Bohemoslovaca* 1988;85(1):1–11.
 84. Stary P, Lumbierres B, Pons X. Opportunistic changes in the host range of *Lysiphlebus testaceipes* (Cr.), an exotic aphid parasitoid expanding in the Iberian Peninsula. *Journal of Pest Science* 2004;77(3):139–44.
 85. Kavallieratos NG, Tomanović ŽE, Stary P, Athanassiou CG, Sarlis GP, Petrović O, *et al.* A survey of aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) of Southeastern

- Europe and their aphid-plant associations. *Applied Entomology and Zoology* 2004;39:527–63.
86. Messing RH, Wang XG. Competitor-free space mediates non-target impact of an introduced biological control agent. *Ecological Entomology* 2009;34:107–13.
 87. Schreiner IH, Nafus DM. Population increases of native moths following biological control of an introduced pest moth. *Micronesica* 1993;4(suppl):49–56.
 88. Van Driesche RG, *et al.* Classical biological control for the protection of native ecosystems. In: Carruthers RJ, Center T, Hoddle MS, Hough-Goldstein J, Morin L, editors. *Biological Control* 2010;54:S 1–S 33.
 89. Suttle KB, Hoddle MS. Engineering enemy-free space: an invasive pest that kills its predators. *Biological Invasions* 2006;8:639–49.
 90. Grandgirard J, Hoddle MS, Petit JN, Roderick GK, Davies N. Classical biological control of the glassy-wing sharpshooter, *Homalodisca vitripennis*, by the egg parasitoid *Gonatocerus ashmeadi* in the Society, Marquesas, and Austral archipelagos of French Polynesia. *Biological Control* 2009;48:155–63.
 91. Hopper KR, Britch SC, Wajnberg E. Risks of interbreeding between species used in biological control and native species, and methods for evaluating their occurrence and impact. In: Bigler F, Babendreier D, Kuhlmann U, editors. *Environmental Impact of Invertebrates for Biological Control of Arthropods: Methods and Risk Assessment*. CABI, Wallingford, UK; 2006. p. 78–97.
 92. Mercader RJ, Aardema ML, Scriber JM. Hybridization leads to host-use divergence in a polyphagous butterfly sibling species pair. *Oecologia* 2009;158:651–62.
 93. Naka H, Mitsunaga T, Mochizuki A. Laboratory hybridization between the introduced and the indigenous green lacewings (Neuroptera: Chrysopidae: *Chrysoperla*) in Japan. *Environmental Entomology* 2005;34:727–31.
 94. Naka H, Haruyama N, Ito K, Mitsunaga T, Nomura M, Mochizuki A. Interspecific hybridization between introduced and indigenous green lacewings (Neuropt., Chrysopidae: *Chrysoperla*) at different adult densities. *Journal of Applied Entomology* 2006;130:426–8.
 95. Henry CS, Wells MM. Can what we don't know about lacewing systematics hurt us? *American Entomologist* 2007;53(1):42–7.
 96. Yara K, Sasawaki T, Kunimi Y. Hybridization between introduced *Torymus sinensis* (Hymenoptera: Torymidae) and indigenous *T. beneficus* (late-spring strain), parasitoids of the Asian chestnut gall wasp *Dryocosmus kuriphilus* (Hymenoptera: Cynipidae). *Biological Control* 2010;54:14–8.
 97. Yara K, Sasawaki T, Kunimi Y. Displacement of *Torymus beneficus* (Hymenoptera: Torymidae) by *T. sinensis*, an indigenous and introduced parasitoid of the chestnut gall wasp, *Dryocosmus kuriphilus* (Hymenoptera: Cynipidae), in Japanese chestnut fields: possible involvement in hybridization. *Biological Control* 2007;42:148–54.
 98. Yara K. Interaction between *Torymus sinensis* (Hymenoptera: Torymidae) and *T. beneficus*, introduced and indigenous parasitoids of the chestnut gall wasp *Dryocosmus kuriphilus* (Hymenoptera: Cynipidae). *Japan Agricultural Research Quarterly* 2014;48(1):35–40.
 99. Havill NP, Davis G, Mausel DL, Klein J, McDonald R, Jones C, *et al.* Hybridization between a native and introduced predator of Adelgidae: an unintended result of classical biological control. *Biological Control* 2012;63:359–69.
 100. Fischer MJ, Havill NP, Brewster CC, Davis GA, Salom SM, Kok LT. Field assessment of hybridization between *Laricobius nigrinus* and *L. rubidus*, predators of Adelgidae. *Biological Control* 2015;82:1–6.
 101. Henderson R, Kershner JL, Toline CA. Timing and location of spawning by nonnative wild rainbow trout and native cutthroat trout in the South Fork Snake River, Idaho, with implications for hybridization. *North American Journal of Fisheries Management* 2000;20:584–96.
 102. Haddon MW. Introgressive hybridisation, ducks, and ecological character displacement. *New Zealand Journal of Zoology* 1998;25:245–8.
 103. Fischer MJ, Brewster CC, Havill NP, Salom SM, Kok LT. Assessment of the potential for hybridization between *Laricobius nigrinus* (Coleoptera: Derodontidae) and *Laricobius osakensis*, predators of the hemlock woolly adelgid (Hemiptera: Adelgidae). *Biocontrol Science and Technology* 2015;25:1467–82.
 104. Kok LT, Surles WW. Successful biological control of musk thistle by an introduced weevil, *Rhinocyllus conicus*. *Environmental Entomology* 1975;4:1025–7.
 105. Jessep CT. Biological control programmes against nodding thistle (*Carduus nutans* L) and Californian thistle (*Cirsium arvense* L) in New Zealand. *FRI Bulletin* 1990;155:25.
 106. Murray TJ, Barratt BIP, Ferguson CM. Field parasitism of *Rhinocyllus conicus* Froelich (Coleoptera: Curculionidae) by *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae) in Otago and South Canterbury. *New Zealand Plant Protection* 2002;55:263–6.
 107. Duan JJ, Messing RH. Response of two opiine fruit fly parasitoids (Hymenoptera: Braconidae) to the lantana gall fly (Diptera: Tephritidae). *Environmental Entomology* 1996;25:1428–37.
 108. Duan JJ, Messing RH, Dukas R. Host selection of *Diachasmimorpha tryoni* (Hymenoptera: Braconidae): comparative response to fruit-infesting and gall-forming tephritid flies. *Environmental Entomology* 2000;29:838–45.
 109. Duan JJ, Messing RH. Host specificity tests of *Diachasmimorpha kraussii* (Hymenoptera: Braconidae), a newly introduced opiine fruit fly parasitoid with four nontarget tephritids in Hawaii. *Biological Control* 2000;19:28–34.
 110. Duan JJ, Mukhtar A, Joshi K, Messing RH. Evaluation of the impact of the fruit fly parasitoid *Diachasmimorpha longicaudata* (Hymenoptera: Braconidae) on a nontarget tephritid, *Eutreta xanthochaeta* (Diptera: Tephritidae). *Biological Control* 1997;8:58–64.
 111. Pratt PD, Coombs EM, Croft BA. Predation by phytoseiid mites on *Tetranychus lintearius* (Acari: Tetranychidae), an established weed biological control agent of gorse (*Ulex europaeus*). *Biological Control* 2003;26:40–7.
 112. Hill MP, Hulley PE. Host-range extension by native parasitoids to weed biocontrol agents introduced to South Africa. *Biological Control* 1995;5:297–302.
 113. Wehling WF, Piper GL. Efficacy diminution of the rush skeletonweed gall midge, *Cystiphora schmidtii* (Diptera: Cecidomyiidae), by an indigenous parasitoid. *Pan-Pacific Entomologist* 1988;64:83–5.
 114. Dowd PF, Kok LT. Parasitism of *Rhinocyllus conicus* in Virginia. *Environmental Entomology* 1982;11:71–7.

115. Nechols JR, Obrycki JJ, Tauber CA, Tauber MJ. Potential impact of native natural enemies on *Galerucella* spp. (Coleoptera: Chrysomelidae) imported for biological control of purple loosestrife: a field evaluation. *Biological Control* 1996;7:60–6.
116. Hunt-Joshi TR, Root RB, Blossey B. Disruption of weed biological control by an opportunistic mirid predator. *Ecological Applications* 2005;15:861–70.
117. Nadel H, Daane KM, Hoelmer KA, Pickett CH, Johnson MW. Non-target host risk assessment of the idiobiont parasitoid *Bracon celer* (Hymenoptera: Braconidae) for biological control of olive fruit fly in California. *Biocontrol Science and Technology* 2009;19:701–15.
118. Barratt BIP. Assessing safety of biological control introductions. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* 2011;6(042):1–12.
119. Tothill JD. *Levuana iridescens* Campaign. Legis. Council, Fiji, Suva; 1926. 4 pp.
120. Tothill JD, Taylor THC, Paine RW. The Coconut Moth in Fiji. The Imperial Institute of Entomology, London, UK; 1930.
121. DeBach P. *Biological Control by Natural Enemies*. Cambridge University Press, Cambridge, UK; 1974. (see pp. 124–129).
122. Simmonds HW. Problems in biological control. The gap in the sequence of generations in *Artana catoxantha*, the coconut leaf moth of Malaya. *Tropical Agriculture* 1930;7(8):215–9.
123. Jayanth KP, Nagarkatti S. Testing *Bessa remota* (Dip.: Tachinidae) against *Opisina arenosella* (Lep.: Cryptophasidae) and other lepidopterous hosts in India. *Entomophaga* 1984;29:415–9.
124. Charles JG, Forgie SA, Chhagan A, Edwards RD. Field study demonstrates that exotic parasitoids (Hymenoptera: Encyrtidae) of mealybugs (Hemiptera: Pseudococcidae) are absent from a native forest habitat in New Zealand. *BioControl* 2015;60:13–25.
125. Lopez VF, Kairo MTK, Pollard GV, Pierre C, Commodore N, Dominique D. Post-release survey to assess impact and potential host range expansion by *Amitus hesperidum* and *Encarsia perplexa*, two parasitoids introduced for the biological control of the citrus blackfly, *Aleurocanthus woglumi* in Dominica. *BioControl* 2009;54:497–503.
126. Zannoua ID, Hannaa R, Agbotona B, José de Moraes G, Kreiter S, Phirid G, *et al.* Native phytoseiid mites as indicators of non-target effects of the introduction of *Typhlodromalus aripo* for the biological control of cassava green mite in Africa. *Biological Control* 2007;41:190–8.
127. Kaufman LV. Non-target impacts of introduced parasitoids and validation of probabilistic risk assessment for biological control introductions [Doctoral Dissertation]. University of Hawaii at Manoa Entomology; 2008.
128. Kaufman LV, Wright MG. Parasitism of a Hawaiian endemic moth by invasive and purposely introduced Hymenoptera species. *Environmental Entomology* 2010;39:430–9.
129. Kaufman LV, Wright MG. The impact of exotic parasitoids on populations of a native Hawaiian moth assessed using life table studies. *Oecologia* 2009;159:295–304.
130. Day WH. Changes in abundance of native and introduced parasites (Hymenoptera: Braconidae), and of the target and non-target plant bug species (Hemiptera: Miridae), during two classical biological control programs in alfalfa. *Biological Control* 2005;33:368–74.
131. Day WH. Host preference of introduced and native parasites (Hymenoptera: Braconidae) of phytophagous plant bugs (Hemiptera: Miridae) in alfalfa-grass fields in the north-eastern USA. *BioControl* 1999;44:249–61.
132. Haye T, Goulet H, Mason PG, Kuhlmann U. Does fundamental host range match ecological host range? A retrospective case study of a *Lygus* plant bug parasitoid. *Biological Control* 2005;35:55–67.
133. Pickett CH, Rodriguez R, Brown J, Coutinot D, Hoelmer KA, Kuhlmann U, *et al.* Establishment of *Peristenus digoneutis* and *P. relictus* (Hymenoptera: Braconidae) in California for the control of *Lygus* spp. (Heteroptera: Miridae). *Biocontrol Science and Technology* 2007;17:261–72.
134. Mason PG, Broadbent AB, Whistlecraft JW, Gillespie DR. Interpreting the host ranges of *Peristenus digoneutis* and *Peristenus relictus* (Hymenoptera: Braconidae), biological control agents of *Lygus* spp. (Hemiptera: Miridae) in North America. *Biological Control* 2011;57:94–102.
135. Ferracini C, Ferrari E, Saladini MA, Pontini M, Corradetti M, Alma A. Non-target host risk assessment for the parasitoid *Torymus sinensis*. *BioControl* 2015;60:583–94.
136. Hoddle MS, Crespo-Ramírez C, Hoddle CD, Loayza J, Lincango MP, Van Driesche RG, *et al.* Post release evaluation of *Rodolia cardinalis* (Coleoptera: Coccinellidae) for control of *Icerya purchasi* (Hemiptera: Monophlebidae) in the Galápagos Islands. *Biological Control* 2013;67:262–74.
137. Causton CE. Dossier on *Rodolia cardinalis* Mulsant (Coccinellidae), a Potential Biological Control Agent for the Cottony Cusion Scale, *Icerya purchasi* Maskell (Margarodidae). Charles Darwin Research Station, Galápagos Islands; 2001.
138. Causton CE. Ensuring compatibility of biological control of *Icerya purchasi* Maskell with conservation in Galápagos: development of procedures to evaluate risk. In: Van Driesche RG, editor. *Proceedings of the First International Symposium for the Biological Control of Arthropods*, 14–18, 2002, Honolulu, Hawaii. FHTET-03-05. USDA Forest Service, Morgantown, West Virginia, USA; 2003. p. 448–57.
139. Hicks B. The effects of the white butterfly's (*Pieris rapae*) introduced parasitoid (*Pteromalus puparum*) on the native yellow admiral, *Bassaritis izea* [MSc thesis]. University of Auckland New Zealand; 1997. 97 pp.
140. Patrick BH, Dugdale JS. Conservation status of the New Zealand Lepidoptera. Science for Conservation Pub. no. 136. Department of Conservation, Wellington, New Zealand; 2000. Available from: URL: <http://www.doc.govt.nz/Documents/science-and-technical/sfc136.pdf>
141. Barron MC, Barlow ND, Wratten SD. Non-target parasitism of the endemic New Zealand red admiral butterfly (*Bassaritis gonerilla*) by the introduced biological control agent *Pteromalus puparum*. *Biological Control* 2003;27:329–35.
142. Barron MC. Retrospective modelling indicates minimal impact of non-target parasitism by *Pteromalus puparum* on red admiral butterfly (*Bassaritis gonerilla*) abundance. *Biological Control* 2007;41:53–63.
143. Munro VMW, Henderson IM. Nontarget effect of entomophagous biocontrol: shared parasitism between native lepidopteran parasitoids and the biocontrol agent *Trigonospila brevifacies* (Diptera: Tachinidae) in forest habitats. *Environmental Entomology* 2002;31:388–96.

144. Sands DPA, Coombs MT. Evaluation of the Argentinian parasitoid, *Trichopoda giacomellii* (Diptera: Tachinidae), for biological control of *Nezara viridula* (Hemiptera: Pentatomidae) in Australia. *Biological Control* 1999;15:19–24.
145. Coombs M. Post-release evaluation of *Trichopoda giacomellii* (Diptera: Tachinidae) for efficacy and non-target effects. In: Van Driesche RG, editor. *Proceedings of the First International Symposium on Biological Control of Arthropods*, Honolulu, Hawaii, 14–18 January 2002, USDA FHTET-03-05. USDA Forest Service, Morgantown, West Virginia, USA; 2003. p. 399–406.
146. Duan JJ, Messing RH. Effect of two opiine parasitoids (Hymenoptera: Braconidae) introduced for fruit fly control on a native Hawaiian tephritid, *Trupanea dubautiae* (Diptera: Tephritidae). *Biological Control* 1997;8:177–84.
147. Duan JJ, Messing RH. Effect of *Tetrastichus giffardianus* (Hymenoptera: Eulophidae) on nontarget flowerhead-feeding tephritids (Diptera: Tephritidae). *Environmental Entomology* 1998;27:1022–8.
148. Wang XG, Bokonon-Ganta AH, Ramadan MM, Messing RH. Egg-larval opiine parasitoids (Hym., Braconidae) of tephritid fruit fly pests do not attack the flowerhead-feeder *Trupanea dubautiae* (Dipt., Tephritidae). *Journal of Applied Entomology* 2004;128:716–22.
149. Aubert B, Quilici S. New biological equilibrium in populations of psyllids observed in Réunion after the establishment of hymenopterous chalcids. *Fruits* 1983;38(11):771–80.
150. Chalot C, Bernard U. Cultivation and preparation of vanilla. *Agronomie Coloniale* 1918;3(21):72–86.
151. Nafus DM. Biological control agents and native parasitoids in the population system of the butterfly *Hypolimnas bolina* (L.) (Lepidoptera: Nymphalidae). *Micronesica* 1993;4 (suppl): 17–23.
152. Lozan AI, Monaghan MT, Spitzer K, Jaroš J, Žurovcová M, Brož V. DNA-based confirmation that the parasitic wasp *Cotesia glomerata* (Braconidae, Hymenoptera) is a new threat to endemic butterflies of the Canary Islands. *Conservation Genetics* 2008;9:1431–7.
153. Benson J, Pasquale A, Van Driesche RG, Elkinton J. Assessment of risk posed by introduced braconid wasps to *Pieris virginiensis*, a native woodland butterfly in New England. *Biological Control* 2003;26:83–93.
154. Condit BP, Cate JR. Determination of host range in relation to systematics for *Peristenus stygicus* (Hym.: Braconidae), a parasitoid of Miridae. *Entomophaga* 1982;27:203–10.
155. Haye T, Kuhlmann U, Goulet H, Mason PG. Controlling *Lygus* plant bugs (Heteroptera: Miridae) with European *Peristenus relictus* (Hymenoptera: Braconidae) in Canada – risky or not? *Bulletin of Entomological Research* 2006;96:187–96.
156. Kevan DK McE. The bionomics of the neotropical cornstalk borer, *Diatraea lineolata* Wlk. (Lep., Pyral.) in Trinidad, B. W. I. *Bulletin of Entomological Research* 1945;35:23–30.
157. Rodríguez-del-Bosque LA, Smith Jr JW. Parasitization of *Diatraea muellerella* on corn in Guerrero, Mexico. *Southwestern Entomologist* 1991;16:367–9.
158. Tejada M, LO, Luna JF, S. Natural parasitism on *Heliothis zea* Boddie eggs and *Diatraea* spp. larvae in maize sown on different dates in Apodaca, NL. Informe de Investigación – División de Ciencias Agropecuarias y Marítimas, Instituto Tecnológico y de Estudios Superiores de Monterrey, Mexico 1986;19:33–4.
159. Trejos AJA, Londoño GF, Gomez LA, Raigosa JD. Distribution of the species of *Diatraea* (Pyralidae) in sugarcane (*Saccharum* sp.) in the geographic valley of the river Cauca and some observations on their parasitism. *Acta Agronómica, Universidad Nacional de Colombia* 1986;36:59–68.
160. Anon. Forest and shade trees: insects. United States Department of Agriculture, Cooperative Plant Pest Report 1978;3(1/4). 6 pp.
161. Ceballos M, Baños HL, Chico R, Sánchez A. Chalcid parasitoids (Hymenoptera, Chalcidoidea) associated with coccoidea (Hemiptera) in coconut (*Cocos nucifera* L.) (Arecaceae). *Revista de Protección Vegetal* 2011;26(1):62–5.
162. Terán AL, Collado de Manes ML, Glenross S, Alvarez R, Lázaro H. Primary and secondary parasitoid Hymenoptera of scale insects, except *Aonidiella aurantii* (Mask.) (Homoptera: Coccoidea), in citrus trees of Tucumán (Argentina). *Revista de Investigación, Centro de Investigaciones para la Regulación de Poblaciones de Organismos, Nocivos, Argentina* 1985;3(3–4):25–33.
163. Viggiani G. Recent cases of interspecific competition between parasitoids of the family Aphelinidae (Hymenoptera: Chalcidoidea). *Norwegian Journal of Agricultural Sciences* 1994;16(Supp):353–9.
164. Malumphy C, Ostrauskas H, Pye D. A faunistic review of whiteflies (Hemiptera, Aleyrodidae) of Lithuania. *Acta Zoologica Lituanica* 2009;19(1):49–57.
165. Roberts LIN. The practice of biological control – implications for conservation, science, and the community. *Weta News Bulletin of the Entomological Society of New Zealand* 1986;9:76–84.
166. Munro VMW. A record of the releases and recoveries of the Australian parasitoids *Xanthopimpla rhopaloceros* Krieger (Hymenoptera: Ichneumonidae) and *Trigonospila brevifacies* (Diptera: Tachinidae) introduced into New Zealand for leafroller control. *New Zealand Entomologist* 1998;21:81–91.
167. Löhra B, Gathua R, Kariukia C, Obiero J, Gichinia G. Impact of an exotic parasitoid on *Plutella xylostella* (Lepidoptera: Plutellidae) population dynamics, damage and indigenous natural enemies in Kenya. *Bulletin of Entomological Research* 2007;97:337–50.
168. Kahuthia-Gathu R, Löhr B, Poehling HM, Mbugua PK. Diversity, distribution and role of wild crucifers in major cabbage and kale growing areas of Kenya. *Bulletin of Entomological Research* 2009;99:287–97.
169. Kahuthia-Gathu R. Seasonal incidence of *Plutella xylostella* (Lepidoptera: Plutellidae) and its associated natural enemies in major crucifer growing areas of Kenya. *Journal of Plant Breeding and Crop Science* 2013;5(5):73–9.
170. Nofemela RS, Kfir R. The role of parasitoids in suppressing diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), populations on unsprayed cabbage in the North West Province of South Africa. *African Entomology* 2005;13(1):71–83.
171. Abbas MST, Abdel-Samad SSM. Larval parasitoids of the potato tuber moth *Phthorimaea operculella* in potato and tomato fields. *Arab Universities Journal of Agricultural Sciences* 2006;14(1):439–45.
172. Goolsby JA, Ciomperlik MA, Legaspi Jr BC, Legaspi JC, Wendel LE. Laboratory and field evaluation of exotic parasitoids of *Bemisia tabaci* (Gennadius) (Biotype 'B')

- (Homoptera: Aleyrodidae) in the Lower Rio Grande Valley of Texas. *Biological Control* 1998;12:127–35.
173. Kirk AA, Lacey LA, Brown JK, Ciomperlik MA, Goolsby JA, Vacek DC, *et al.* Variation in the *Bemisia tabaci* s.l. species complex (Hemiptera: Aleyrodidae) and its natural enemies leading to successful biological control of *Bemisia biotype* B in the USA. *Bulletin of Entomological Research* 2000;90:317–27.
 174. Pickett CH, Keaveny D, Rose M. Spread and non-target effects of *Eretmocerus mundus* imported into California for control of *Bemisia tabaci*: 2002–2011. *Biological Control* 2013;65:6–13.
 175. Naranjo SE, Li S. Long term dynamics of aphelinid parasitoids attacking *Bemisia tabaci*. *Biological Control* 2016;93:56–64.
 176. Babendreier D, Bigler F, Kuhlmann U. Methods used to assess nontarget effects of invertebrate biological control agents of arthropod pests. *BioControl* 2005;50:821–70.
 177. Babendreier D, Bigler F, Kuhlmann U. Current status and constraints in the assessment of non-target effects. In: Bigler F, Babendreier D, Kuhlmann U, editors. *Environmental Impact of Invertebrates for Biological Control of Arthropods: Methods and Risk Assessment*. CABI, Wallingford, UK; 2006. p. 1–14.
 178. Smith MA, Rodriguez JJ, Whitfield JB, Deans AR, Janzen DH, Hallwachs W, *et al.* Extreme diversity of tropical parasitoid wasps exposed by iterative integration of natural history, DNA barcoding, morphology, and collections. *Proceedings of the National Academy of Sciences of the United States of America* 2006;105(34):12359–64.
 179. Smith MA, Wood M, Janzen DH, Hallwachs W, Hebert PDN. DNA barcodes affirm that 16 species of apparently generalist tropical parasitoid flies (Diptera, Tachinidae) are not all generalists. *Proceedings of the National Academy of Sciences of the United States of America* 2006;104(12):4967–72.
 180. Zhang Y-Z, Si S-L, Zheng J-T, Li H-L, Fang Y, Zhu C-D, *et al.* DNA barcoding of endoparasitoid wasps in the genus *Anicetus* reveals high levels of host specificity (Hymenoptera: Encyrtidae). *Biological Control* 2011;58:182–91.
 181. Van Driesche RG, Hoddle M. Should arthropod parasitoids and predators be subject to host range testing when used as biological control agents? *Agriculture and Human Values* 1997;14:211–26.
 182. Van Driesche RG, Reardon R, editors. *Assessing Host Ranges of Parasitoids and Predators Used for Classical Biological Control: A Guide to Best Practice*. FHTET-04-03 USDA Forest Service, Morgantown, West Virginia, USA; 2004.
 183. van Lenteren JC, Cock MJW, Hoffmeister TS, Sands DPA. Host specificity in arthropod biological control, methods for testing and interpretation of the data. In: Bigler F, Babendreier D, Kuhlmann U, editors. *Environmental Impact of Invertebrates for Biological Control of Arthropods: Methods and Risk Assessment*. CABI, Wallingford, UK; 2006. pp. 38–63.
 184. Pemberton RW. Predictable risk to native plants in weed biological control. *Oecologia* 2000;125:489–94.
 185. Bernays EA, Chapman RF. Chemical deterrence of plants. In: Law JH, editor. *Molecular Entomology*. Proceedings of a Monsanto-UCLA Symposium held in Steamboat Springs, Colorado, April 6–13, 1986. *UCLA Symposium on Molecular and Cellular Biology, New Series*, vol. 49. Alan R. Liss, Inc., New York; 1987. p. 107–16.
 186. Sands DPA. Taxonomic Relationships of Parasitoids: Poor Indicators for their Suitability or Effectiveness as Biological Control Agents. In: Austin AD, Downton M, editors. *Hymenoptera: Evolution, Biodiversity and Biological Control*. CSIRO, Collingwood, Australia; 2000. p. 410–6.
 187. Bouchard Y, Cloutier C. Role of olfaction in host finding by aphid parasitoid *Aphidius nigripes* (Hymenoptera: Aphididae). *Journal of Chemical Ecology* 1985;11:801–8.
 188. Vet LEM, Dicke M. Ecology of infochemical use by natural enemies in a tritrophic context. *Annual Review of Entomology* 1992;37:141–72.
 189. Wajnberg E, Bernstein C, van Alphen JM, editors. *Behavioral Ecology of Insect Parasitoids*. Blackwell, Oxford, UK; 2008.
 190. Blumberg D. Parasitoid encapsulation as a defense mechanism in the Coccoidea (Homoptera) and its importance in biological control. *Biological Control* 1997;8:225–36.
 191. Gundersen-Rindal D, Dupuy C, Huguet E, Drezen J-M. Parasitoid polydnaviruses: evolution, pathology and applications. *Biocontrol Science and Technology* 2013;23:1–161.
 192. Blossey B. Measuring and evaluating ecological outcomes of biological control introductions. In: Van Driesche RG, Simberloff D, Blossey B, Causton C, Hoddle MS, Marks C, Heinz K, Wagner D, Warner K, editors. *Integrating Biological Control into Conservation Practice*. Wiley/Blackwell, Oxford, UK; 2016. p. 161–88.
 193. de Nardo EAB, Hopper KR. Using the literature to evaluate parasitoid host ranges: a case study of *Macrocentrus grandii* (Hymenoptera: Braconidae) introduced into North America to control *Ostrinia nubilalis* (Lepidoptera: Crambidae). *Biological Control* 2004;31:280–95.
 194. Kuhlmann U, Mason PG. Use of field host range surveys for selecting candidate non-target species for physiological host specificity testing of entomophagous biological control agents. In: Van Driesche RG, editor. *Proceedings of the First International Symposium on Biological Control of Arthropods*, Honolulu, Hawaii, 14–18 January 2002. FHTET-03-05. United States Department of Agriculture, Forest Service, Morgantown, West Virginia; 2002. p. 370–7.
 195. Paynter Q, Fowler SV, Gourlay AH, Peterson PG, Smith LA, Winks CJ. Relative performance on test and target plants in laboratory tests predicts the risk of non-target attack in the field for arthropod weed biocontrol agents. *Biological Control* 2015;80:133–42.
 196. Wright MG, Hoffmann MP, Kuhar TP, Gardner J, Pitcher SA. Evaluating risks of biological control introductions: a probabilistic risk-assessment approach. *Biological Control* 2005;35:338–47.
 197. Sato Y, Mochizuki M, Mochizuki A. Introduction of non-native predatory mites for pest control and its risk assessment in Japan. *Japan Agricultural Research Quarterly* 2012;46(2):129–37.
 198. Jetter K, Klonsky K, Pickett CH. A cost/benefit analysis of the ash whitefly biological control program in California. *Journal of Arboriculture* 1997;23(2):65–72.
 199. Bangsund DA, Leistritz FL, Leitch JA. Assessing economic impacts of biological control of weeds: the case of leafy spurge in the northern Great Plains of the United States. *Journal of Environmental Management* 1999;56:35–43.
 200. Hill G, Greathead D. Economic evaluation in classical biological control. In: Perrings C, Williamson M, Dalmazzone S, editors. *The Economics of Biological Invasions*. Edward Elgar, Cheltenham, UK; 2000. p. 208–23.

201. Hoelmer KA, Kirk AA. Working at the interface of art and science: how best to select an agent for classical biological control? *Biological Control* 2005;34:255–64.
202. Lynch LD, Ives AR, Waage JK, Hochberg ME, Thomas MB. The risks of biocontrol: transient impacts and minimum nontarget densities. *Ecological Applications* 2002;12:1872–82.
203. Wyckhuys KAG, Koch RL, Kula RR, Heimpel GE. Potential exposure of a classical biological control agent of the soybean aphid, *Aphis glycines*, on non-target aphids in North America. *Biological Invasions* 2009;11:857–71.
204. Barratt BIP, Todd JH, Malone LA. Selecting non-target species for arthropod biological control agent host range testing: evaluation of a novel method. *Biological Control* 2016;93:84–92.
205. van Klinken RD, Heard TA. Estimating fundamental host range: a host-specificity study of a potential biocontrol agent for *Prosopis* species (Leguminosae). *Biocontrol Science and Technology* 2000;10:331–42.
206. Japoshvili G, Abell KJ, Van Driesche RG. Aphelinid and encyrtid (Hymenoptera, Chalcidoidea) parasitoids of armored scales (Hemiptera: Diaspididae) attacking hemlocks (*Tsuga* spp.) in Japan and the USA, with description of eight new species. *Annals of the Entomological Society* 2013;106:541–54.
207. Paterson ID, Mangan R, Downie DA, Coetzee JA, Hill MP, Burke AM, *et al.* Two in one: cryptic species discovered in biological control agent populations using molecular data and cross breeding experiments. *Ecology and Evolution* 2016;6:6139–50.
208. Tanigoshi LK, Pike KS, Miller RH, Miller TD, Allison D. Search for, and release of, parasitoids for the biological control of Russian wheat aphid in Washington State (USA). *Agriculture, Ecosystems, and Environment* 1995;52(1):25–30.
209. Kazmer DJ, Maiden K, Ramualde N, Coutinot D, Hopper KR. Reproductive compatibility, mating behavior, and random amplified polymorphic DNA variability in some *Aphelinus asychis* derived from the Old World. *Annals of the Entomological Society of America* 1996;89:212–20.
210. Bernal JS, González D, di Mariano ED. Overwintering potential in California of two Russian wheat aphid parasitoids (Hymenoptera: Aphelinidae et Aphidiidae) imported from central Asia. *Pan-Pacific Entomologist* 2001;77:28–36.
211. Strong DR, Pemberton RW. Food webs, risks of alien enemies, and reform of biological control. In: Wajnberg E, Scott JK, Quimby PC, editors. *Evaluating Indirect Ecological Effects of Biological Control*. CABI, Wallingford, UK; 2001. p. 57–79.
212. Van Driesche RG, Simberloff D, Blossey B, Causton C, Hoddle MS, Marks C, *et al.*, editors. *Integrating Biological Control into Conservation Practice*. Wiley/Blackwell, Oxford, UK; 2016. p. 189–207.
213. Funasaki GY, Nakahara LM, Kumashiro BR. Introductions for biological control in Hawaii: 1985 and 1986. *Proceedings of the Hawaiian Entomological Society* 1988;28:101–4.
214. Rosssbach A, Lühr B, Vidal S. Generalism versus specialism: responses of *Diadegma mollipla* (Holmgren) and *Diadegma semiclausum* (Hellen), to the host shift of the diamondback moth (*Plutella xylostella* L.) to peas. *Journal of Insect Behavior* 2005;18:491–503.
215. Wharton RA, Marsh PM. New World Opiinae (Hymenoptera: Braconidae) parasitic on Tephritidae (Diptera). *Journal of the Washington Academy of Sciences* 1978;68:147–67.
216. Buffington ML. Taxonomic notes on *Nordlandiella* Diaz and *Ganaspidium* Weld (Hymenoptera: Figitidae: Eucolilinae). *Proceedings of the Entomological Society of Washington* 2004;106:192–8.
217. Beardsley Jr JW. Eucolilid parasites of agromyzid leafminers in Hawaii (Hymenoptera: Cynipidae). *Proceedings of the Hawaiian Entomological Society* 1988;28:33–47.
218. Johnson MW. Biological control of *Liriomyza* leafminers in the Pacific Basin. *Micronesica* 1993;4:81–92.
219. Buffington ML. A revision of *Ganaspidium* Weld, 1952 (Hymenoptera, Figitidae, Eucolilinae): new species, bionomics, and distribution. *Zookeys* 2010;37:81–101.
220. Wharton RA. A new species of *Mallochia* (Hymenoptera: Ichneumonidae) introduced to Texas to control *Eoreuma loftini* (Dyar) (Lepidoptera: Pyralidae) in sugarcane. *Pan-Pacific Entomologist* 1985;61:160–2.
221. Nakamura H, Shiratori S. The progress of invasion of insect pest, the Mexican bean beetle, *Epilachna varivestis*, in Nagano Prefecture. *Journal of the Faculty of Agriculture, Shinshu University* 2010;46(1/2):105–11.
222. Varma S, Anandhi P. Seasonal incidence of brinjal hadda beetle, *Henosepilachna vigintioctopunctata* (Fab.) and its natural enemies. *Indian Journal of Entomology* 2008;70:31–9.
223. Gupta A, Kalesh S. Reared parasitic wasps attacking hesperiids from Western Ghats (Kerala, India) with description of a new species of *Dolichogenidea* (Hymenoptera: Braconidae) as a larval parasitoid of *Thoressa evershedii* (Evans) (Lepidoptera: Hesperidae). *Zootaxa* 2012;3413:29–43.
224. Paulraj MG, Ignacimuthu S. Occurrence of hyperparasitism on *Cotesia* sp. (Hymenoptera: Braconidae), an effective parasitoid of *Pericallia ricini* (Lepidoptera: Arctiidae). *Entomol* 2007;32:231–4.
225. Chiu CH, Moore A. Biological control of the Philippine lady beetle, *Epilachna philippinensis* (Coleoptera: Coccinellidae), on solanaceous plants by the parasitoid, *Pediobius foveolatus* (Hymenoptera: Eulophidae), on Saipan. *Micronesica* 1993;4(suppl):79–80.
226. Weismann RA. Parasite of the cherry fruit-fly (*Rhagoletis cerasi* L.). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 1933;15:553–7. (in German)
227. Rygg T. Investigations on the rose hip fly, *Rhagoletis alternata* Fall. (Diptera: Trypetidae). *Forskning og Forsoek i Landbruket* 1979;30:269–77.
228. Hoffmeister TS. *Rhagoletis pomonella* (Walsh), apple maggot (Diptera: Tephritidae). In: Mason PG, Huber JT, editors. *Biological Control Programmes in Canada, 1981–2000*. CABI, Wallingford, UK; 2001. p. 238–41.
229. Tejada M, LO, Pablo P, R. Species of the family Trichogrammatidae collected in the states of Nuevo Leon and Sinaloa and the centre for reproduction of beneficial insects. December 1984–October 1985. Informe de Investigación – División de Ciencias Agropecuarias y Maritimas, Instituto Tecnológico y de Estudios Superiores de Monterrey, Mexico 1988;20:42–3.

230. Foerster LA, Avanci MRF. Egg parasitoids of *Anticarsia gemmatilis* Hübner (Lepidoptera: Noctuidae) in soybeans. *Anais da Sociedade Entomológica do Brasil* 1999;28:545–8.
231. Rodríguez-del-Bosque LA, Smith Jr JW, Pfannenstiel RS. Parasitization of *Diatraea grandiosella* eggs by trichogrammatids on corn in Jalisco, Mexico. *Southwestern Entomologist* 1989;14:179–80.
232. Overholt WA, Smith Jr JW. Colonization of six exotic parasites (Hymenoptera) against *Diatraea grandiosella* (Lepidoptera: Pyralidae) in corn. *Environmental Entomology* 1990;19:1889–902.
233. Oatman ER, McMurtry JA, Waggoner M, Platner GA, Johnson HG. Parasitization of *Amorbia cuneana* (Lepidoptera: Tortricidae) and *Sabulodes aegrotata* (Lepidoptera: Geometridae) on avocado in southern California. *Journal of Economic Entomology* 1983;76:52–3.
234. Nagarkatti S, Oatman ER, Platner GR. Two new species of Trichogramma (Hym.: Trichogrammatidae) from the USA. *Entomophaga* 1975;20:245–8.
235. Wysoki M, Renneh S. Introduction into Israel of *Trichogramma platneri* Nagarkatti, an egg parasite of Lepidoptera. *Phytoparasitica* 1985;13:139–40.
236. Wysoki M, de Jong M, Rene S. *Trichogramma platneri* Nagarkatti (Hymenoptera: Trichogrammatidae), its biology and ability to search for eggs of two lepidopterous avocado pests, *Boarmia (Ascotis) selenaria* (Schiffermüller) (Geometridae) and *Cryptoblabes gnideilla* (Milliere) (Phycitidae) in Israel. *Colloques de l'INRA* 1988;43:295–301.
237. Farrell JA, Stufkens MW. The impact of *Aphidius rhopalosiphii* (Hymenoptera: Aphidiidae) on populations of the rose grain aphid (*Metopolophium dirhodum*) (Hemiptera: Aphididae) on cereals in Canterbury, New Zealand. *Bulletin of Entomological Research* 1990;80:377–83.
238. Teulon DAJ, Drayton GM, Scott IAW. Exotic introductions of primary parasitoids of aphids in New Zealand: the good and the bad. In: Mason PG, Gillespie DR, Vincent C, editors. *Proceedings of the 3rd International Symposium on Biological Control of Arthropods*, Christchurch, New Zealand, 8–13 February, 2009. FHTET 2008-06. USDA Forest Service, Morgantown, West Virginia, USA; 2009. p. 421–30.
239. Cameron PJ, Hill RL, Teulon DAJ, Stufkens MAW, Connolly PG, Walker GP. A retrospective evaluation of the host range of four *Aphidius* species introduced to New Zealand for the biological control of pest aphids. *Biological Control* 2013;67:275–83.
240. Rutledge CE, Wiedenmann RN. Habitat preferences of three congeneric braconid parasitoids: implications for host-range testing in biological control. *Biological Control* 1999;16:144–54.
241. Fuchs TW, Huffman FR, Smith Jr JW. Introduction and establishment of *Apanteles flavipes* [Hym.: Braconidae] on *Diatraea saccharalis* [Lep.: Pyralidae] in Texas. *Entomophaga* 1979;24:109–14.
242. Polaszek A Walker AK. The *Cotesia flavipes* species-complex: parasitoids of cereal stem borers in the tropics. *Redia* 1991;74:335–41.
243. Overholt WA, Ngi-Song AJ, Kimani SK, Mbapila J, Lammers P, Kioko E. Ecological considerations of the introduction of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) for biological control of *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) in Africa. *Biocontrol News and Information* 1994;15(2):19N–24N.
244. Rodríguez-del-Bosque LA, Smith Jr JW. Biological control of maize and sugarcane stemborers in Mexico: a review. *Insect Science and Application* 1997;17:305–14.
245. Browning HW, Melton CW. Indigenous and exotic trichogrammatids (Hymenoptera: Trichogrammatidae) evaluated for biological control of *Eoreuma loftini* and *Diatraea saccharalis* (Lepidoptera: Pyralidae) borers on sugarcane. *Environmental Entomology* 1987;16:360–4.
246. Bennett FD, Cock MJW, Diaz CFA. *Allorhogas* sp. n. [Braconidae] a potential biological control agent for graminaceous stem borers from Mexico. *ISSCT Entomology Newsletter* 1983.
247. Marsh PM. A new species of Braconidae (Hymenoptera) from Mexico introduced into Texas to control a sugar cane borer, *Eoreuma loftini* (Lepidoptera: Pyralidae). *Proceedings of the Entomological Society of Washington* 1984;86:861–3.
248. Varma A, Nigam H., Singh K. Laboratory and field evaluations of an exotic parasite, *Allorhogas pyralophagus* Marsh (Hymenoptera: Braconidae) against sugarcane stalk borer, *Chilo auricilius* Ddgn. (Lepidoptera: Pyralidae). *Entomophaga* 1987;12:367–72.
249. Hawkins BA, Browning HW, Smith Jr JW. Field evaluation of *Allorhogas pyralophagus* (Hym.: Braconidae), imported into Texas for biological control of the stalkborer *Eoreuma loftini* (Lep.: Pyralidae) in sugar cane. *Entomophaga* 1987;32:483–91.
250. Smith Jr JW, Browning HW, Bennett FD. *Allorhogas pyralophagus* (Hym.: Braconidae), a gregarious external parasite imported into Texas, USA, for biological control of the stalkborer *Eoreuma loftini* (Lep.: Pyralidae) on sugar cane. *Entomophaga* 1987;32:477–82.
251. Wharton RA. The status of certain Braconidae (Hymenoptera) cultured for biological control programmes, and description of a new species of Macrocentrus. *Proceedings of the Entomological Society of Washington* 1984;86:902–12.
252. Vignes WG. des. The use and availability of *Trachylepidia fructicassella* Ragworth (Lepidoptera: Pyralidae) as a laboratory host for rearing parasitoids for the biological control of *Diatraea* spp. (Lepidoptera: Pyralidae) on sugar cane in Trinidad. In: Anon, editor. *Proceedings of the 24th West Indies Sugar Technologists' Conference*, Kingston, 8–12 April 1991. Sugar Association of the Caribbean, Bridgetown; 1991. pp. 74–9.
253. Oloo GW. Life tables and intrinsic rate of natural increase of *Pediobius fuvus* (Hym.: Eulophidae) on *Chilo partellus* (Lep.: Pyralidae). *Entomophaga* 1992;37:29–35.
254. Pfannenstiel RS, Browning HW, Smith Jr JW. Searching behavior of *Pediobius fuvus* (Hymenoptera: Eulophidae) for *Eoreuma loftini* (Lepidoptera: Pyralidae) in sugarcane. *Journal of Economic Entomology* 1992;85:384–8.
255. Yitaferu K, Gebre-Amlak A. Phenology and survival of the maize stalk borer, *Busseola fusca* in eastern Ethiopia. *Insect Science and its Application* 1994;15:177–84.
256. Tanaka M, Inoue K. Introduction of an efficient parasite of the arrowhead scale, *Unaspis yanonensis* (Kuwana), from Hong Kong. *Bulletin of the Fruit Tree Research Station, D (Kuchinotsu)* 1977;1:69–85.

257. DeBach P, Rosen D. *Aphytis yanonensis* n.sp. (Hymenoptera, Aphelinidae), a parasite of *Unaspis yanonensis* (Kuwana) (Homoptera, Diaspididae). *Kontyu* 1982;50:626–34.
258. Browning HW. Classical biological control of citrus scale insects. In: Rosen D, Bennett FD, Capinera JL, editors. *Pest Management in the Subtropics: Biological Control – a Florida Perspective*. Intercept, Andover, UK; 1994. p. 49–78. (see p. 67).
259. Turnock WJ, Carl KP. Evaluation of the Palaearctic *Eurithia consobrina* (Diptera: Tachinidae) as a potential biocontrol agent for *Mamestra configurata* (Lepidoptera: Noctuidae) in Canada. *Biocontrol Science and Technology* 1995;5:55–67.
260. Erlandson MA. *Mamestra configurata* Walker, bertha armyworm (Lepidoptera: Noctuidae). In: Mason PG, Gillespie DR, editors. *Biological Control Programmes in Canada, 2001–2012*. CABI, Wallingford, UK; 2013. p. 228–32.
261. Day WH, Marsh PM, Fuester RW, Hoyer H, Dysart RJ. Biology, initial effect, and description of a new species of *Peristenus* (Hymenoptera: Braconidae), a parasite of the alfalfa plant bug (Hemiptera: Miridae), recently established in the United States. *Annals of the Entomological Society of America* 1992;85:482–8.
262. Lever RJAW. Control of *Brontispa* in Celebes by the parasite *Tetrastichodes* of Java. *British Solomon Islands Agricultural Gazette* 1936;3(4, Suppl) Tulagi, 6 pp.
263. Lange Jr WH. The biology of the Mariana coconut beetle, *Brontispa mariana* Spaeth, on Saipan, and the introduction of parasites from Malaya and Java for its control. *Proceedings of the Hawaiian Entomological Society* 1950;14:143–62.
264. Appert J. On two Hispine beetles of the genus *Gestronella* injurious to coconut palm in Madagascar. *Oleagineux* 1974;29(12):559–64.
265. Tang B-Z, Xu L, Hou Y-M. Effects of rearing conditions on the parasitism of *Tetrastichus brontispae* on its pupal host *Octodonta nipae*. *BioControl* 2014;59:647–57.
266. Froud KJ, Stevens PS, Cowley DR. A potential biological control agent for greenhouse thrips. In: O'Callaghan M, editor. *Proceedings of the Forty Ninth New Zealand Plant Protection Conference, Quality Hotel Rutherford, Nelson, New Zealand, 13–15 August, 1996*. New Zealand Plant Protection Society, Rotorua, New Zealand; 1996. p. 17–20.
267. McMurtry JA. Biological control on greenhouse thrips. *Citrograph* 1988;73(4):81–2.
268. McMurtry JA, Johnson HG, Newberger SJ. Imported parasite of greenhouse thrips established on California avocado. *California Agriculture* 1991;45(6):31–2.
269. Froud KJ, Stevens PS. Importation biological control of *Heliothrips haemorrhoidalis* by *Thripobius semiluteus* in New Zealand – a case study of non-target host and environmental risk assessment. In: Van Driesche RG, editor. *Proceedings of the First International Symposium on Biological Control of Arthropods, Honolulu, Hawaii, 14–18 January 2002, USDA FHTET-03-05*. USDA Forest Service, Morgantown, West Virginia, USA; 2003. p. 366–9.
270. Nafus D. Biological control of *Penicillaria jocosatrix* (Lepidoptera: Noctuidae) on mango on Guam with notes on the biology of its parasitoids. *Environmental Entomology* 1991;20:1725–31.
271. Battu GS, Dhaliwal GS. A note on the occurrence of *Blepharella lateralis* Macquart as a parasite of *Euproctis lunata* (Walker). *Science and Culture* 1977;43(6):271.
272. Kumar N, Yadav RP. Records of *Blepharella lateralis* Macquart and *Carcelia* sp. – two indigenous parasitoids of *Spilosoma* (= *Diacrisia*) *obliqua* Walker from Bihar (India). *Current Science, India* 1987;56(22):1192–3.
273. Sengonca Ç, Uygun N, Kersting U, Ulusoy MR. Successful colonization of *Eretmocerus debachi* (Hym.: Aphelinidae) in the eastern Mediterranean citrus region of Turkey. *Entomophaga* 1993;38:383–90.
274. Annecke DP, Mynhardt MJ. The species of the insidiosus group of *Metaphycus Mercet* in South Africa with notes on some extralimital species (Hymenoptera Encyrtidae). *Revue de Zoologie et de Botanique Africaines* 1972;85:227–74.
275. Blumberg D, Swirski E. Comparative studies of the development of two species of *Metaphycus* (Hymenoptera: Encyrtidae), introduced into Israel for the control of the Mediterranean black scale, *Saissetia oleae* (Olivier) (Homoptera: Coccidae). *Acta Oecologica, Oecologia Applicata* 1982;3:281–6.
276. Orphanides GM. Control of *Saissetia oleae* (Hom.: Coccidae) in Cyprus through establishment of *Metaphycus bartletti* and *M. helvolus* (Hym.: Encyrtidae). *Entomophaga* 1993;38:235–9.
277. Narasimham AU, Chacko MJ. *Rastrococcus* spp. (Hemiptera: Pseudococcidae) and their natural enemies in India as potential biocontrol agents for *R. invadens* Williams. *Bulletin of Entomological Research* 1988;78:703–8.
278. Agricola U, Agoukéné D, Fischer HU, Moore D. The control of *Rastrococcus invadens* Williams (Hemiptera: Pseudococcidae) in Togo by the introduction of *Gyranoidea tebygi* Noyes (Hymenoptera: Encyrtidae). *Bulletin of Entomological Research* 1989;79:671–8.
279. Moore D. Biological control of *Rastrococcus invadens*. *Biocontrol News and Information* 2004;25(1):17N–27N.
280. Beardsley JW, Uchida GK. Parasites associated with leucaena psyllid, *Heteropsylla cubana* Crawford, in Hawaii. *Proceedings of the Hawaiian Entomological Society* 1990;30:155–6.
281. Noyes JS. A new encyrtid (Hymenoptera) parasitoid of the leucaena psyllid (Homoptera: Psyllidae) from Mexico, Central America and the Caribbean. *Bulletin of Entomological Research* 1990;80:37–41.
282. Miller RL. *Telenomus megacephalus*, Ashm., an egg parasite of the green pumpkin bug, *Nezara viridula* Linn., in Florida. *Florida Entomologist* 1928;12:17–20.
283. Shapiro VA, Gusev GV, Kapustina OV. Comparative evaluation of the biological properties of egg parasites of the family Scelionidae, both introduced and indigenous species. *Trudy Vsesoyuznogo Nauchno-issledovatel'skogo Instituta Zashchity Rastenii* 1975;44:57–69.
284. Gallego C, Sanchez-Boccherini J, Polo E, Notario A, Castresana L. Contribution to the study of the parasites of *Aelia rostrata* Boheman. *Anales del Instituto Nacional de Investigaciones Agrarias, Serie: Proteccion Vegetal* 1979;11:67–72.
285. Corrêa-Ferreira BS. Natural occurrence of the egg parasitoid complex of stink bugs on soyabean in Parana, Brazil. *Anais da Sociedade Entomológica do Brasil* 1986;15:189–99.
286. Nakahara LM, Funasaki GY. Release of *Psyllaephagus* sp. nr. *rotundiformis* (Howard) (Hymenoptera: Encyrtidae) for the biological control *Heteropsylla cubana* Crawford (Homoptera: Psyllidae) and other *Heteropsylla* species in Hawaii. *Leucaena Research Reports* 1987;8:11–3.

287. Nakahara L, Nagamine W, Matayoshi S, Kumashiro B. Biological control program of the leucaena psyllid, *Heteropsylla cubana* Crawford (Homoptera: Psyllidae) in Hawaii. *Leucaena Research Reports* 1987;7(2):39–44.
288. Muniappan R, Marutani M. Biology and biological control of the red coconut scale, *Furcaspis oceanica* (Lindinger). In: Anon, editor. *Tropical and Subtropical Agricultural Research under PL 89–106, Special Research Grants. Progress and Achievements, the Pacific Basin Group, 1989. University of Hawaii at Manoa, Honolulu, Hawaii; 1989. p. 17–8.*
289. Muniappan R, Bamba J, Cruz J, Reddy GVP. Diaspididae and its parasitoid, *Adelencyrtus oceanicus* Doutt (Hymenoptera: Encyrtidae), in Guam. *Plant Protection Quarterly* 2003;18(2):52–4.
290. Kadubowski W. The parasite complex of the leaf-miner *Lithocolletis blancardella* (F.) (Lepidoptera, Gracilariidae) in western Poland. *Polskie Pismo Entomologiczne* 1981;51:493–9.
291. Sun YZ, Ma GF, Zhao XF. A preliminary study of parasitic wasps of *Lithocolletis ringoniella* Matsumura. *Natural Enemies of Insects* 1987;9(3):156–9. 134.
292. Kharchenko GL, Ryabchinskaya TA. A method for counting the natural enemy *Holcothorax* – a parasitoid of the apple leaf miner. *Sel'skokhozyaistvennaya Biologiya* 1995;5:103–5.
293. Cao KC, Guo SF. Preliminary observations on the bionomics of *Recurvaria syrtictis* Meyrick. *Insect Knowledge* 1987;24(5):279–81.
294. Maier CT. Potential for the biological control of apple leafminers by parasitic wasps. *Proceedings of the Annual Meeting of the Massachusetts Fruit Growers' Association* 1990;96:60–74.
295. Höller C. Evidence for the existence of a species closely related to the cereal aphid parasitoid *Aphidius rhopalosiphii* De Stefani-Perez based on host ranges, morphological characters, isoelectric focusing banding patterns, cross-breeding experiments and sex pheromone specificities (Hymenoptera, Braconidae, Aphidiinae). *Systematic Entomology* 1991;16:15–28.
296. Frank JH, Parkman JP, Bennett FD. *Larra bicolor* (Sphecidae), a biological control agent of *Scapteriscus* mole crickets (Orthoptera: Gryllotalpidae). *Florida Entomologist* 1995;78:619–23.
297. Menke AS. Mole cricket hunters of the genus *Larra* in the New World (Hymenoptera: Sphecidae, Larrinae). *Journal of Hymenoptera Research* 1992;1:175–234.
298. Frank JH, Walker TJ. Permanent control of pest mole crickets (Orthoptera: Gryllotalpidae) in Florida. *American Entomologist* 2006;52(3):138–44.
299. Nixon GEJ. Some Asiatic Telenominae (Hym., Proetotrupoidea). *Annual Magazine of Natural History* 1937;20:444–75.
300. Lever RJAW. The cutworm *Prodenia litura* Fabr. *Agricultural Journal of Fiji* 1943;14(1):11–3.
301. Wojcik B, Whitcomb WR, Habeck DH. Host range testing of *Telenomus remus* (Hymenoptera: Scelionidae). *Florida Entomologist* 1976;59:195–8.
302. Blumberg D, Mendel Z, Assael F, Rasis A. Outbreak of the cottony cushion scale, *Icerya purchasi*, and acclimatization of the parasitic fly, *Cryptochaetum iceryae* in Israel. *Alon Hanotea* 1989;43(4):395–400.
303. Mokrzecki Z. Report of the Institute of Forest Protection and Entomology at Skierniewice, Poland. *Ecole sup. Agric. a Varsovie 1 Skierniewice* 1923;1922–3. (in Polish)
304. Bedard WD. Biology and control of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins (Coleoptera-Scolytidae) with notes on associated insects. *Research Studies* 1937;5(2):103–5.
305. Lovaszy PA. Contribution to the knowledge of the hymenopterous parasites of certain injurious bark beetles. *Annales Entomologici Fennici* 1941;7:194–204. (in German)
306. Galoux A. Note on the biology of *Pachyceras xylophagorum* Ratzeburg (Hymenoptera Chalcididae). *Communications de la Station de Recherches de Greonendal* 1947;7:10 pp. (in French)
307. Samson PR, Smibert J. Preliminary studies on the efficacy and establishment of *Roptrocercus xylophagorum* (Hym.: Torymidae), a parasitoid of *Ips grandicollis* (Col.: Scolytidae), in Australia. *Entomophaga* 1986;31:173–82.
308. Berisford CW. Biological control of pine bark beetles: new approaches to an old problem. *Information Series – Virginia Polytechnic Institute and State University, College of Agriculture and Life Science* 1991;91–92:57–66.
309. Fowler HG. Field behavior of *Euphasiopteryx depleta* (Diptera: Tachinidae): Phonotactically orienting parasitoids of mole crickets (Orthoptera: Gryllotalpidae: *Scapteriscus*). *Journal of the New York Entomological Society* 1987;95:474–80.
310. Walker TJ. Phonotaxis in female *Ormia ochracea* (Diptera: Tachinidae), a parasitoid of field crickets. *Journal of Insect Behavior* 1993;6:389–410.
311. Fowler HG, Mesa A. Alternate orthopteran hosts (*Anurogryllus* sp.) of *Euphasiopteryx depleta* (Diptera: Tachinidae). *Florida Entomologist* 1987;70:408–9.
312. Fowler HG. Suitability of *Scapteriscus* moles crickets (Ort.: Gryllotalpidae) as hosts of *Euphasiopteryx depleta* (Dipt.: Tachinidae). *Entomophaga* 1988;33:397–401.
313. Frank JH, Walker TJ, Parkman JP. The introduction, establishment, and spread of *Ormia depleta* in Florida. *Biological Control* 1996;6:368–77.
314. Slavgorodskaya-Kurpieva LE. *Ageniaspis*: a parasitoid of yponomeutid moths. *Zashchita Rastenii* (Moskva) 1986;6:29–30.
315. Hérard F, Prévost G. Suitability of *Yponomeuta mallinellus* and *Y. cagnagellus* (Lepidoptera: Yponomeutidae) as hosts of *Diadegma armillata* (Hymenoptera: Ichneumonidae). *Environmental Entomology* 1997;26:933–8.
316. Unruh T, Short R, Herard F, Chen K, Hopper K, Pemberton R, et al. Introduction and establishment of parasitoids for the biological control of the apple ermine moth, *Yponomeuta malinellus* (Lepidoptera: Yponomeutidae), in the Pacific Northwest. *Biological Control* 2003;28:332–45.
317. Wimbush FM. The cherry black fly (*Myzus cerasi*). *Bulletin of Entomological Research* 1925;16:85–94.
318. Tremblay E. The species of the genus *Trioxys* Hal. (Hymenoptera Ichneumonidae) parasites of aphids of the genus *Cavariella* Del. Guer. (Homoptera Aphidoidea). *Bollettino del Laboratorio di Entomologia Agraria 'Filippo Silvestri', Portici* 1975;32:37–46.
319. Mescheloff E, Rosen D. Biosystematic studies on the Aphidiidae of Israel (Hymenoptera: Ichneumonidae).

5. The genera *Trioxys* and *Binodoxys*. Israel Journal of Entomology 1993;27:31–47.
320. Starý P. The asparagus aphid, *Brachycorynella asparagi* (Mordv.) (Hom., Aphididae) and its natural enemy spectrum in Czechoslovakia. Journal of Applied Entomology 1990;110:253–60.
321. Daane KM, Yokota GY, Gill RF, Caltagirone LE, Hagen KS, González D, *et al.* Imported parasite may help control European asparagus aphid. California Agriculture 1992;46(6):12–4.
322. Lerer AZ, Plugar SG. The tachinid parasites (Diptera, Larvaevoridae) of pests of oak in Moldavia. Entomologicheskoe Obozrenie 1962;41(2):359–65.
323. Heusinger G. Comparative study of mortality factors of the small ermine moth, *Yponomeuta padellus* L. (Yponomeutidae), on *Prunus spinosa* L. at different sites. Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie 1981;3:21–5.
324. Pernek M, Lukić I, Lacković N, Cota E, Tschorsnig HP. Tachinid (Diptera: Tachinidae) parasitoids of spotted ash looper (*Abraxas pantaria*) in Krka National Park in Croatia. Periodicum Biologorum 2015;117(4):533–5.
325. Goldson SL, McNeill MR, Phillips CB, Proffitt JR. Host specificity testing and suitability of the parasitoid *Microctonus hyperodae* (Hym.: Braconidae, Euphorinae) as a biological control agent of *Listronotus bonariensis* (Col.: Curculionidae) in New Zealand. Entomophaga 1992;37:483–98.
326. Barker GM, Addison PJ. Early impact of endoparasitoid *Microctonus hyperodae* (Hymenoptera: Braconidae) after its establishment in *Listronotus bonariensis* (Coleoptera: Curculionidae) populations of northern New Zealand pastures. Journal of Economic Entomology 2006;99:273–87.
327. Field RP, Darby SM. Host specificity of the parasitoid *Sphecochaga vesparum* (Curtis) (Hymenoptera: Ichneumonidae), a potential biological control agent of the social wasps *Vespa germanica* (Fabricius) and *V. vulgaris* (Linnaeus) (Hymenoptera: Vespidae) in Australia. New Zealand Journal of Zoology 1991;18:193–7.
328. Koehler W, Kolk A. The large-scale occurrence of two species of the genus *Hyponomeuta* (Lep., Hyponomeutidae) in afforestations and forests. Polskie Pismo Entomologiczne 1971;41(1):193–6.
329. Bartninkaite I. Influence of the physiological state of the ermine moth *Yponomeuta evonymella* L. to its relations with parasites and microorganisms. Lietuvos entomologu darbai 1996;30:150–7.
330. Agrò A, Cusumano A, Io Pinto M. Study on the parasitoid complex of *Prays oleae* (Bernard) and parasitism levels in an organic olive orchard in western Sicily (Italy). Protezione delle Colture 2009;1:33–9.
331. Dijkerman HJ. Suitability of eight *Yponomeuta*-species as hosts of *Diadegma armillata*. Entomologia Experimentalis et Applicata 1990;54:173–80.
332. Wagener B, Reineke A, Löhr B, Zebitz CPW. Phylogenetic study of *Diadegma* species (Hymenoptera: Ichneumonidae) inferred from analysis of mitochondrial and nuclear DNA sequences. Biological Control 2006;37:131–40.
333. Fischer R. Ecological studies on the pupal parasites (Hym., Ichneumonidae) of four native species of *Yponomeuta* (Lepid., Yponomeutidae). Journal of Applied Entomology 1987;103:515–23.
334. Sands D, Liebegts W. Biological control of fruit piercing moth (*Eudocima fullonia* [Clerck]) (Lepidoptera: Noctuidae) in the Pacific: exploration, specificity, and evaluation of parasitoids. In: Hoddle MS, editor. Second International Symposium on Biological Control of Arthropods, Davos, Switzerland, 12–16 September, 2005. FHTET-2005-08, USDA Forest Service, Morgantown, West Virginia, USA; 2005. p. 267–76.
335. Mohyuddin AI, Khan AG, Goraya AA. Population dynamics of cotton whitefly *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) and its natural enemies in Pakistan. Pakistan Journal of Zoology 1989;21:273–88.
336. del Bene G. Biological control of *Trialeurodes vaporariorum* and *Bemisia tabaci*, with *Encarsia formosa* and indigenous parasitoids. Rivista di Agricoltura Subtropica e Tropicale 1990;84:237–48.
337. del Bene G, Gargani E, Landi S. Notes on *Pealius azaleae* (Baker and Moles) (Hom. Aleyrodidae), a species new to Italy. Redia 1991;74:163–75.
338. Čapek M. On knowledge of larval parasites of *Eucosma nigricana*. Journal of Applied Entomology 1961;4–8(1):75–93.
339. Smith SM, van Frankenhuyzen K, Nealis GG, Bouchier RS. *Choristoneura fumiferana* (Clemens), eastern spruce budworm (Tortricidae). In: Mason PG, Huber JT, editors. Biological Control Programmes in Canada, 1981–2000. CABI, Wallingford, UK; 2002. p. 58–68.
340. Zolnerowich G, Rose M. *Eretmocerus rui* n. sp. (Hymenoptera: Chalcidoidea: Aphelinidae), an exotic natural enemy of *Bemisia (tabaci group)* (Homoptera: Aleyrodidae) released in Florida. Florida Entomologist 2004;87:283–7.
341. Takagi M. Host stage selection in *Aphytis yanonensis* DeBach et Rosen and *Coccobius fulvus* (Compere et Annecke) (Hymenoptera: Aphelinidae), introduced parasitoids of *Unaspis yanonensis* (Kuwana) (Homoptera: Diaspididae). Applied Entomology and Zoology 1991;26:505–13.
342. Van Driesche RG, Idoine K, Rose M, Bryan M. Release, establishment and spread of Asian natural enemies of euonymus scale (Homoptera: Diaspididae) in New England. Florida Entomologist 1998;81:1–9.
343. Drea JJ, Carlson RW. The establishment of *Chilocorus kuwanae* (Coleoptera: Coccinellidae) in eastern United States. Proceedings of Entomological Society of Washington 1987;89:821–4.
344. O'Reilly A, Van Driesche RG. Status of *Coccobius* nr. *fulvus* (Hymenoptera: Aphelinidae), a parasitoid of Euonymus scale (Hemiptera: Diaspididae), 12–16 years after its release in Massachusetts. Florida Entomologist 2009;92:645–7.
345. Neumann G, Follett PA, Hollingsworth RG, de León JH. High host specificity in *Encarsia diaspidicola* (Hymenoptera: Aphelinidae), a biological control candidate against the white peach scale in Hawaii. Biological Control 2010;54:107–13.
346. Sands DPA, Broe R, Liebegts WJMM. Identity of *Encarsia* spp. (Hymenoptera: Aphelinidae) introduced into Western Samoa for biological control of *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Hemiptera: Diaspididae). Proceedings of the Entomological Society of Washington 1990;92:135–8.
347. Matadha D, Hamilton GC, Hughes MG, Lashomb JH. Distribution of natural enemies of euonymus scale, *Unaspis euonymi* (Comstock) (Homoptera: Diaspididae), in New Jersey. Environmental Entomology 2003;32:602–7.
348. Matadha D, Hamilton GC, Lashomb JH, Hang JX. Ovipositional preferences and functional response of

- parasitoids of euonymus scale, *Unaspis euonymi* (Comstock) and San Jose scale, *Quadraspidiotus perniciosus* (Comstock) (Homoptera: Diaspididae). Biological Control 2005;32:337–47.
349. Graora D, Spasić R. Natural enemies of *Pseudaulacaspis pentagona* Targioni-Tozzetti in Serbia. Pesticidi i Fitomedicina 2008;23:11–6.
 350. Cierniewska B. Parasites of aphids occurring in the orchards near Poznan (Hymenoptera, Aphidiidae). Polskie Pismo Entomologiczne 1973;43(3):837–9.
 351. Rakhshani E, Tomanović Z, Starý P, Talebi AA, Kavallieratos NG, Zamani AA, et al. Distribution and diversity of wheat aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) in Iran. European Journal of Entomology 2008;105:863–70.
 352. Ji C-W, Kang E-J, Byeon Y-W, Kim J-H, Choi B-R. Comparative analysis of the biological characteristics of *Ephedrus plagiator* (Nees) and *Aphidius ervi* Haliday according to different aphid hosts. Korean Journal of Applied Entomology 2014;53:427–33.
 353. Elliott NC, Burd JD, Armstrong JS, Walker CB, Reed DK, Peairs FB. Release and recovery of imported parasitoids of the Russian wheat aphid in eastern Colorado. Southwestern Entomologist 1995;20:125–9.
 354. Burd JD, Shufran KA, Elliott NC, French BW, Prokrym DA. Recovery of imported hymenopterous parasitoids released to control Russian wheat aphids in Colorado. Southwestern Entomologist 2001;26:23–31.
 355. Noma T, Brewer MJ, Pike KS, Gaimari SD. Hymenopteran parasitoids and dipteran predators of *Diuraphis noxia* in the west-central Great Plains of North America: species records and geographic range. BioControl 2005;50:97–111.
 356. Hopper KR, de Farias AMI, Woolley JB, Heraty JM, Britch SC. Genetics: relation of local populations to the whole 'species' - implications for host range tests. In: Hoddle MS, editor. Second International Symposium on Biological Control of Arthropods, Davos, Switzerland, 12–16 September, 2005. FHTET-2005-08, USDA Forest Service, Morgantown, West Virginia, USA; 2005. p. 665–71.
 357. Heraty JM, Woolley JB, Hopper KR, Hawks DL, Kim JW, Buffington M. Molecular phylogenetics and reproductive incompatibility in a complex of cryptic species of aphid parasitoids. Molecular Phylogenetics and Evolution 2007;45:480–93.
 358. Barrera JF, Baker PS, Valenzuela JE, Schwarz A. Introduction of two African parasitoid species to Mexico for biological control of the coffee borer *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae). Folia Entomológica Mexicana 1990;79:245–7.
 359. Pérez-Lachaud G, Hardy ICW. Alternative hosts for bethylid parasitoids of the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Scolytidae). Biological Control 2001;22:265–77.
 360. Gálvez GC. Biological control of the coffee berry borer as a viable alternative for Central America. Boletín de Promecafé, Coronado: Instituto Interamericano de Cooperación para la Agricultura (IICA) 1992;57:6–11.
 361. Mills NJ, Nealis VG. European field collections and Canadian releases of *Ceranthia samarensis* (Dipt.: Tachinidae), a parasitoid of the gypsy moth. Entomophaga 1992;37:181–91.
 362. Nealis VG, Quednau FW. Canadian field releases and overwinter survival of *Ceranthia samarensis* (Villeneuve) (Diptera: Tachinidae) for biological control of the gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae). Proceedings of the Entomological Society of Ontario 1996;127:11–20.
 363. Neale C, Smith D, Beattie GAC, Miles M. Importation, host specificity testing, rearing and release of three parasitoids of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) in eastern Australia. Journal of the Australian Entomological Society 1995;34:343–8.
 364. Villani A, Zandigiacomo P. Successful introduction of the entomophagous *Neodryinus typhlocybae* (Ashmead) against *Metcalfa pruinosa* (Say) in Friuli-Venezia Giulia. Notiziario ERSO 2000;13(3):41–5.
 365. Strauss G. Host range testing of the Nearctic beneficial parasitoid *Neodryinus typhlocybae*. BioControl 2009;54:163–71.
 366. Trjapitzin SV. A new species of *Aphelinoidea* (Hymenoptera: Trichogrammatidae), with a key to species of the Holarctic Region. Journal of the Kansas Entomological Society 1994;67:301–10.
 367. Simbolotti G, van Achterberg C. Revision of the West Palaearctic species of the genus *Bassus* Fabricius (Hymenoptera: Braconidae). Zoologische Verhandlungen 1992;281:80 p.
 368. Mills N. Selecting effective parasitoids for biological control introductions: codling moth as a case study. Biological Control 2005;34:274–82.
 369. Mills N. Classical biological control of codling moth: the California experience. In: Hoddle MS, editor. Second International Symposium on Biological Control of Arthropods, Davos, Switzerland, 12–16 September, 2005. FHTET-2005-08, USDA Forest Service, Morgantown, West Virginia, USA; 2005. p. 126–31.
 370. Stevens NB, Austin AD, Jennings JT. Diversity, distribution and taxonomy of the Australian agathidine genera *Camptothlipsis* Enderlein, *Lytopylus* Foerster and *Therophilus* Wesmäl (Hymenoptera: Braconidae: Agathidinae). Zootaxa 2011;2887:1–49.
 371. Hanks LM, Paine TD, Millar JG. Tiny wasp helps protect eucalypts from eucalyptus longhorned borer. California Agriculture 1996;50:14–6.
 372. Luhning KA, Paine TD, Millar JG, Hanks LM. Suitability of the eggs of two species of eucalyptus longhorned borers (*Phoracantha recurva* and *P. semipunctata*) as hosts for the encyrtid parasitoid *Avetianella longoi*. Biological Control 2000;19:95–104.
 373. Paine TD, Millar JG, Hanks LM. Integrated program protects trees from eucalyptus longhorned borer. California Agriculture 1995;49:34–7.
 374. Paine TD, Millar JG. Biological control of introduced pests of eucalyptus in California. In: Van Driesche RG, editor. Proceedings of the First International Symposium on Biological Control of Arthropods, January 14–18, 2002. Honolulu, Hawaii, USA. FHTET-03-05. USDA Forest Service, Morgantown, West Virginia, USA; 2003. p. 66–71. Available from: URL: <http://www.fs.fed.us/foresthealth/technology/webpubs/FHTET-2003-05/day1/paine.pdf>
 375. Overholt WA, Ngi-Song AJ, Omwega CO, Kimani-Njogu SW, Mbapila J, Sallam MN, et al. A review of the introduction and establishment of *Cotesia flavipes* Cameron in East Africa for biological control of cereal stem borers. Insect Science and its Application 1997;17:79–88.

376. Withers TM. Colonization of eucalypts in New Zealand by Australian insects. *Austral Ecology* 2001;26:467–76.
377. Malausa JC, Girardet N. Biological control of the blue gum psyllid. Acclimatization on the Côte de Azur of a promising beneficial, *Psyllaephagus pilosus*. *Phytoma* 1997;50 (498):49–51 (in French).
378. Dahlsten DL, Rowney DL, Copper WA, Fassan RL, Chaney WE, Robb KL, *et al.* Parasitoid wasp controls blue gum psyllid. *California Agriculture* 1998;52:31–4.
379. Hodkinson ID. Biocontrol of eucalyptus psyllid *Ctenarytaina eucalypti* by the Australian parasitoid *Psyllaephagus pilosus*: a review of current programmes and their success. *Biocontrol New and Information* 1999;20(4):129N–34N.
380. Zolnerowich G, Rose M. *Eretmocerus* Haldeman (Hymenoptera: Aphelinidae) imported and released in the United States for control of *Bemisia (tabaci)* complex (Homoptera: Aleyrodidae). *Proceedings of the Entomological Society of Washington* 1998;100:310–23.
381. Roltsch WJ. Establishment of silverleaf whitefly parasitoids in Imperial Valley. In: Hoddle MS, editor. *California Conference on Biological Control II*, Riverside, California, USA, 11–12 July, 2000. Center for Biological Control, College of Natural Resources, University of California, Riverside, California, USA; 2000. p. 176–9.
382. Hoelmer K, Goolsby J. Release, establishment and monitoring of *Bemisia tabaci* natural enemies in the United States. In: Van Driesche RG, editor. *Proceedings of the First International Symposium on Biological Control of Arthropods*, January 14–18, 2002. Honolulu, Hawaii, USA. FHTET-03-05. USDA Forest Service, Morgantown, West Virginia, USA; 2003. p. 58–65. Available from: URL: <http://www.fs.fed.us/foresthealth/technology/webpubs/FHTET-2003-05/day1/hoelmer.pdf>
383. Goolsby JA, DeBarro PJ, Kirk AA, Sutherst RW, Canas L, Ciomperlik MA, *et al.* Post-release evaluation of biological control of *Bemisia tabaci* biotype 'B' in the USA and the development of predictive tools to guide introductions for other countries. *Biological Control* 2005;32:70–7.
384. Yu G-Y. First discovery of the honeysuckle whitefly, *Aleyrodes loniceræ* Walker (Hemiptera: Aleyrodidae) in China. *Acta Entomologica Sinica* 2015;58:1368–72.
385. Greenberg SM, Jones WA, Liu TX. Tritrophic interactions among host plants, whiteflies, and parasitoids. *Southwestern Entomologist* 2009;34:431–45.
386. Stoner A, Butler Jr GD. *Encarsia lutea* as an egg parasite of bollworm and cabbage looper in Arizona cotton. *Journal of Economic Entomology* 1965;58:1148–50.
387. Rosen D. Notes on the parasites of *Acaudaleyrodes citri* (Priesner & Hosni) (Hem. Aleyrodidae) in Israel. *Entomologische Berichten* 1966;26:55–9.
388. Longo S, Rapisarda C, Russo A, Siscaro G. Preliminary studies on the bioethology of *Parabemisia myricæ* (Kuwana) and its natural enemies in Sicily and Calabria. *Bollettino di Zoologia Agraria e di Bachicoltura* 1990;22:161–71.
389. Abd-Rabou S. Parasitoids attacking genus *Aleurolobus* (Homoptera: Aleyrodidae) in Egypt. *Acta Phytopathologica et Entomologica Hungarica* 1997;32:363–7.
390. Kumar R, Gupta PR. Natural enemies associated with the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), on vegetable crops in the mid-hill region of Himachal Pradesh. *Pest Management and Economic Zoology* 2006;14:73–8.
391. Vásquez-Ordóñez AA, Hazzí NA, Escobar-Prieto D, Paz-Jojoa D, Parsa SA. A geographic distribution database of the Neotropical cassava whitefly complex (Hemiptera, Aleyrodidae) and their associated parasitoids and hyperparasitoids (Hymenoptera). *ZooKeys* 2015;545:75–87.
392. Gould JR, Hoelmer KA, Goolsby JA. *Classical Biological Control of Bemisia tabaci in the United States: A Review of Interagency Research and Implementation*, Progress in Biological Control 4. Springer, Dordrecht, The Netherlands; 2008. 343 pp.
393. Goolsby JA, Pfannenstiel RS, Evans GA. New state record for the silverleaf whitefly parasitoid *Encarsia sophia* in Texas. *Southwestern Entomologist* 2009;34:327–8.
394. Zhang Y-B, Castañé C, Gabarra R, Albajes R, Wan F-H. Host selection by the autoparasitoid *Encarsia pergandiella* on primary (*Bemisia tabaci*) and secondary (*Eretmocerus mundus*) hosts. *Insect Science* 2015;22:793–802.
395. Maignet P, Onillon JC. Initial data on the biotic potential of *Encarsia hispida* De Santis (Hymenopt.: Aphelinidae), endoparasitoid of biotype 'B' of *Bemisia tabaci* (Gennadius) and of *Trialeurodes vaporariorum* West. (Homoptera: Aleyrodidae). *Bulletin OILB/SROP* 1997;20(4):121–5.
396. Lourenção AL, Fancelli M, Costa VA, Ribeiro NC. Parasitism in *Trialeurodes variabilis* (Quaintance) (Hemiptera: Aleyrodidae) by *Encarsia hispida* De Santis (Hymenoptera: Aphelinidae), in papaya, in Brazil. *Neotropical Entomology* 2007;36:147–9.
397. Telli Ö, Yigit A. Natural enemies of citrus woolly whitefly, *Aleurothrix floccosus* (Maskell) and nesting whitefly, *Paraleyrodes minei* Iaccarino (Hemiptera: Aleyrodidae) in Hatay Province, Turkey. *Türkiye Entomoloji Dergisi* 2012;36:147–54.
398. Charles JG, Sandanayaka WRM, Chhagan A, Page-Weir NEM. Survival of the gregarious ectoparasitoid *Mastrus ridens* on codling moth, *Cydia pomonella*, and non-target species. *BioControl* 2013;58:505–13.
399. Mapondera TS, Burgess T, Matsuki M, Oberprieler RG. Identification and molecular phylogenetics of the cryptic species of the *Goniapterus scutellatus* complex (Coleoptera: Curculionidae: Goniapterini). *Australian Journal of Entomology* 2012;51:175–88.
400. Sanches MA. Parasitism of eggs of *Goniapterus scutellatus* Gyllenhal, 1833 and *Goniapterus gibberus* Boisduval, 1835 (Coleoptera, Curculionidae) by the mymarid *Anaphes nitens* (Girault, 1928) (Hymenoptera, Mymaridae) in Colombo, PR, Brazil. *Arquivos do Instituto Biológico (São Paulo)* 2000;67:77–82.
401. Hanks LM, Millar JG, Paine TD, Campbell CD. Classical biological control of the Australian weevil *Goniapterus scutellatus* (Coleoptera: Curculionidae) in California. *Environmental Entomology* 2000;29:369–75.
402. Rivera AC, Carbone SS, Andrés JA. Life cycle and biological control of the *Eucaplytus* snout beetle (Coleoptera, Curculionidae) by *Anaphes nitens* (Hymenoptera: Mymaridae) in north-west Spain. *Agricultural and Forest Entomology* 1999;1:103–9.
403. Van Driesche RG, Bellotti A, Herrera CJ, Castillo JA. Encapsulation rates of two encyrtid parasitoids by two *Phenacoccus* spp. of cassava mealybugs in Colombia. *Entomologia Experimentalis et Applicata* 1986;42:79–82.
404. Van Driesche RG, Bellotti A, Herrera CJ, Castillo JA. Host preferences of two encyrtid parasitoids for the Colombian

- Phenacoccus* spp. of cassava mealybugs. *Entomologia Experimentalis et Applicata* 1987;43:261–6.
405. Bento JMS, de Moraes GJ, De Matos AP, Bellotti AC. Classical biological control of the mealybug *Phenacoccus herreni* (Hemiptera: Pseudococcidae) in northeastern Brazil. *Environmental Entomology* 2000;29:355–9.
 406. Dorn B, Mattiacci L, Bellotti AC, Dorn S. Host specificity and comparative foraging behaviour of *Aenasius vexans* and *Acerophagus coccois*, two endoparasitoids of the cassava mealybug. *Entomologia Experimentalis et Applicata* 2001;99:331–9.
 407. Sun J-H, Clarke SR, Debarr GL, Berisford CW. Parasitoid complex of the mealybug *Oracella acuta* (Lobdell) (Hemiptera: Pseudococcidae), in Georgia, USA. *Journal of Entomological Science* 2004;39:11–22.
 408. Clarke SR, DeBarr GL, Berisford CW. Life history of *Oracella acuta* (Homoptera: Pseudococcidae) in loblolly pine seed orchards in Georgia. *Environmental Entomology* 1990;19:99–103.
 409. Smith JM, Hoy MA. Rearing methods for *Ageniaspis citricola* (Hymenoptera: Encyrtidae) and *Cirrospilus quadristriatus* (Hymenoptera: Eulophidae) released in a classical biological control program for the citrus leafminer *Phyllocnistis citrella* (Lepidoptera: Gracillariidae). *Florida Entomologist* 1995;78:600–8.
 410. Pomerinke MA, Stansly PA. Establishment of *Ageniaspis citricola* (Hymenoptera: Encyrtidae) for biological control of *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) in Florida. *Florida Entomologist* 1998;81:361–72.
 411. Xiao YF, Qureshi JA, Stansly PA. Contribution of predation and parasitism to mortality of citrus leafminer *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) populations in Florida. *Biological Control* 2007;40:396–404.
 412. LaSalle J, Duncan RE, Peña JE. The recovery and apparent establishment of *Cirrospilus ingenuus* (Hymenoptera: Eulophidae) in Florida. *Florida Entomologist* 1992;82:371–3.
 413. Huffaker CB, Holloway JK, Douth RL, Finney GL. Introduction of egg parasites of the beet leafhopper. *Journal of Economic Entomology* 1954;47:785–9.
 414. Walker GP, Zareh N, Bayoun IM, Triapitsyn SV. Introduction of western Asian egg parasitoids into California for biological control of beet leafhopper, *Circulifer tenellus*. *Pan-Pacific Entomologist* 1997;73:236–42.
 415. Bayoun IM, Walker GP, Triapitsyn SV. Parasitization of beet leafhopper eggs, *Circulifer tenellus*, in California. *Journal of Applied Entomology* 2008;132:412–24.
 416. Vincent C, Babendreier D, Kuhlmann U. *Hoplocampa testudinea* (Klug), European apple sawfly (Hymenoptera: Tenthredinidae). In: Mason PG, Huber JT, editors. *Biological Control Programmes in Canada, 1981–2000*. CABI, Wallingford, UK; 2001. p. 135–9.
 417. Vincent C, Rancourt B, Sarazin M, Kuhlmann U. Releases and first recovery of *Lathrolestes ensator* (Hymenoptera: Ichneumonidae) in North America, a parasitoid of *Hoplocampa testudinea* (Hymenoptera: Tenthredinidae). *The Canadian Entomologist* 2001;133:147–9.
 418. Vincent C, Appleby M, Eaton A, Lasnier J. Dissemination of *Lathrolestes ensator* (Ichneumonidae), a larval parasite of the European apple sawfly, *Hoplocampa testudinea* (Tenthredinidae), in eastern North America. *Biological Control* 2016;100:1–6.
 419. Gilbert LE, Morrison LW. Patterns of host specificity in *Pseudacteon* parasitoid flies (Diptera: Phoridae) that attack *Solenopsis* fire ants (Hymenoptera: Formicidae). *Environmental Entomology* 1997;26:1149–54.
 420. Porter SD. Host-specific attraction of *Pseudacteon* flies (Diptera: Phoridae) to fire ant colonies in Brazil. *Florida Entomologist* 1998;81:423–9.
 421. Porter SD, Alonso LE. Host specificity of fire ant decapitating flies (Diptera: Phoridae) in laboratory oviposition tests. *Journal of Economic Entomology* 1999;92:110–4.
 422. Morrison LW, Porter SD. Post-release host-specificity testing of *Pseudacteon tricuspidis*, a phorid parasitoid of *Solenopsis invicta* fire ants. *BioControl* 2006;51:195–205.
 423. Callcott A-M A, Porter SD, Weeks Jr RD, Graham LC, Johnson SJ, Gilbert LE. Fire ant decapitating fly cooperative release programs (1994–2008): Two *Pseudacteon* species, *P. tricuspidis* and *P. curvatus*, rapidly expand across imported fire ant populations in the southeastern United States. *Journal of Insect Science* 2011;11(19):1–25.
 424. Porter SD, Fowler HG, Campiolo S, Pesquero MA. Host specificity of several *Pseudacteon* (Diptera: Phoridae) parasites of fire ants (Hymenoptera: Formicidae) in South America. *Florida Entomologist* 1995;78:70–5.
 425. Porter SD, Graham LC, Johnson SJ, Thead LG, Briano JA. The large decapitating fly *Pseudacteon litoralis* (Diptera: Phoridae): successfully established on fire ant populations in Alabama. *Florida Entomologist* 2011;94:208–13.
 426. Coombs M, Sands DPA. Establishment in Australia of *Trichopoda giacomellii* (Blanchard) (Diptera: Tachinidae), a biological control agent for *Nezara viridula* (L.) (Hemiptera: Pentatomidae). *Australian Journal of Entomology* 2000;39:219–22.
 427. Massa B, Rizzo MC, Caleca V. Natural alternative hosts of Eulophidae (Hymenoptera: Chalcidoidea) parasitoids of the citrus leafminer *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) in the Mediterranean Basin. *Journal of Hymenoptera Research* 2001;10:91–100.
 428. Rizzo MC, Io Verde V, Caleca V. Role of spontaneous plants as a reservoir of alternative hosts for *Semiachar petiolatus* (Girault) and *Citrostichus phyllocnistoides* (Narayanan) (Hymenoptera, Eulophidae) in citrus groves. *Bulletin OILB/SROP* 2006;29(6):109–12.
 429. Karamaouna F, Pascual-Ruiz S, Aguilar-Fenollosa E, Verdú NJ, Urbaneja A, Jacas JA. Changes in predation and parasitism of the citrus leafminer *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) populations in Spain following establishment of *Citrostichus phyllocnistoides* (Hymenoptera: Eulophidae). *Biological Control* 2009;52:37–45.
 430. Vercher R, García Marí F, Costa Comelles J, Marzal C, Granda C. Importation and establishment of parasitoids of the citrus leaf miner *Phyllocnistis citrella* (Lepidoptera: Gracillariidae). *Boletín de Sanidad Vegetal, Plagas* 2000;26(4):577–91.
 431. Vercher R, García-Marí F, Costa-Comelles J, Marzal C, Villalba M. Biological control of the citrus leafminer *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) in Spain: native parasitoids and establishment of *Citrostichus phyllocnistoides* (Hymenoptera: Eulophidae). *Bulletin OILB/SROP* 2003;26(6):7–15.
 432. García-Marí F, Vercher R, Costa-Comelles J, Marzal C, Villalba M. Establishment of *Citrostichus phyllocnistoides*

- (Hymenoptera: Eulophidae) as a biological control agent for the citrus leafminer *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) in Spain. *Biological Control* 2004;29:215–26.
433. Clarke SR, Yu H-B, Chen M-R, DeBarr GL, Sun J-H. Classical biological control program for the mealybug *Oracella acuta* in Guangdong Province, China. *Insect Science* 2010;17:129–39.
 434. Bellotti AC. More on the mealybug: a major cassava pest. *Cassava Newsletter* 1983;7(1):1 and 3–4.
 435. Sun J-H, DeBarr GL, Berisford CW, Schauff ME. Description of a new primary parasitoid, *Zarhopalus* Ashmead (Hymenoptera: Encyrtidae), of *Oracella acuta* (Homoptera: Pseudococcidae). *The Canadian Entomologist* 1998;130:793–7.
 436. Basheer A, Mahmalji MZ, Berawe A. Survey of the parasitoids of the fruit scale insect, *Parthenolecanium corni* Bouché (Homoptera: Coccidae) on almond trees at Kalamon, Damascus countryside, Syria. *Egyptian Journal of Biological Pest Control* 2011;21(1):27–31.
 437. Matsumoto T, Itoika T, Nishida T. Why can arrowhead scales, *Unaspis yanonensis* Kuwana (Homoptera: Diaspididae), which burrow and settle below conspecifics, successfully avoid attack by its parasitoid, *Coccobius fulvus* Compere et Annecke (Hymenoptera: Aphelinidae)? *Applied Entomology and Zoology* 2004;39:147–54.
 438. Howard FW, Weissling TJ. Questions and answers about the cycad *Aulacaspis* scale insect. *Proceedings of the Florida State Horticultural Society* 1999;112:243–5.
 439. Wang Z-H, Huang J, Pan D-M. Taxonomic review of *Coccobius* species (Hymenoptera: Aphelinidae) from China, with notes on their use in biological control of scale insect pests (Homoptera: Diaspididae), and description of a new species. *Journal of Natural History* 2014;48(5/6):359–73.
 440. Blanco-Metzler H, Laprade S. Natural enemies of the spiralling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae): Parasitoids and predators. *Agronomia Mesoamericana* 1998;9(2):41–4.
 441. Bellows TS, Meisenbacher C. Biological control of giant whitefly, *Aleurodicus dugesii*, in California. In: Hoddle MS, editor. *Proceedings of the 2nd California Conference on Biological Control*, Riverside, California, USA, 11–12 July, 2000. Center for Biological Control of the University of California, Berkeley, California, USA; 2000. p. 113–6.
 442. Roltsch WJ, Meyerdirk DE, Warkentin R, Andress ER, Carrera K. Classical biological control of the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green), in southern California. *Biological Control* 2006;37:155–66.
 443. Delvare G. *Ceratogramma etiennei* n. sp., a parasite, in Guadeloupe, of *Diaprepes abbreviatus* L. (Hymenoptera, Trichogrammatidae; Coleoptera, Curculionidae). *Revue Française d'Entomologie* 1998;10:1–4.
 444. Hall DG, Peña J, Franqui R, Nguyen R, Stansly P, McCoy C, et al. Status of biological control by egg parasitoids of *Diaprepes abbreviatus* (Coleoptera: Curculionidae) in citrus in Florida and Puerto Rico. *BioControl* 2001;46:61–70.
 445. Peña JE, Hall DG, Nguyen R, McCoy CW, Amalin D, Stansly P, et al. Recovery of parasitoids (Hymenoptera: Eulophidae and Trichogrammatidae) released for biological control of *Diaprepes abbreviatus* (Coleoptera: Curculionidae) in Florida. *Proceedings of the International Citrus Congress* 2004;3:879–84.
 446. Peña JE, Jacas JA, Ulmer B, Trypazin S, Duncan RE. Biological control with egg parasitoids other than *Trichogramma* -the citrus and grape cases. In: Consoli LF, Parra JRP, Zucchi RA, editors. *Egg Parasitoids in Agroecosystems with Emphasis on Trichogramma*. Springer, London; 2010. p. 341–71.
 447. Castillo A, Infante F, López G, Trujillo J, Kirkendall JR, Vega FE. Laboratory parasitism by *Phymastichus coffea* (Hymenoptera: Eulophidae) upon non-target bark beetles associated with coffee plantations. *Florida Entomologist* 2004;87:274–7.
 448. Gitau CW, Ngi-Song AJ, Otieno SA, Overholt WA. Host preference of *Xanthopimpla stemmator* (Hymenoptera: Ichneumonidae) and its reproductive performance on selected African lepidopteran stem borers. *Biocontrol Science and Technology* 2007;17:499–511.
 449. Gitau CW, Ngi-Song AJ, Overholt WA, Otieno SA. Acceptance and suitability of four lepidopteran stemborers for the development of the pupal parasitoid *Xanthopimpla stemmator* (Hymenoptera: Ichneumonidae). *Biocontrol Science and Technology* 2005;15:585–600.
 450. Meyerdirk DE, Muniappan R, Warkentin R, Bamba J, Reddy GVP. Biological control of the papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae) in Guam. *Plant Protection Quarterly* 2004;19(3):110–4.
 451. Gold MS. Biological Control of the Lily Leaf Beetle, *Lilioceris lili*, in North America. PhD Environmental Sciences, University of Rhode Island, North Kingston, Rhode Island; 2003.
 452. Bhumannavar BS, Viraktamath CA. Biology and behaviour of *Euplectrus maternus* Bhatnagar (Hymenoptera: Eulophidae), an ectoparasitoid of *Othreis* spp. (Lepidoptera: Noctuidae) from southern India. *Pest Management in Horticultural Ecosystems* 2000;6:1–14.
 453. Muniappan R, Bamba J, Cruz J, Reddy GVP. Biology, rearing and field release on Guam of *Euplectrus maternus*, a parasitoid of the fruit-piercing moth, *Eudocima fullonia*. *BioControl* 2004;49:537–51.
 454. Casagrande RA, Kenis M. Evaluation of lily leaf beetle parasitoids for North American introduction. In: Van Driesche RG, Reardon R, editors. *Assessing Host Ranges of Parasitoids and Predators Used for Classical Biological Control: A Guide to Best Practice*. FHTET-04-03 USDA Forest Service, Morgantown, West Virginia, USA; 2004. p. 121–37.
 455. Tewksbury L, Gold MS, Casagrande RA, Kenis M. Establishment in North America of *Tetrastichus setifer* Thomson (Hymenoptera: Eulophidae), a parasitoid of *Lilioceris lili* (Coleoptera: Chrysomelidae). In: Hoddle M, editor. *Second International Symposium on Biological Control of Arthropods*, Davos, Switzerland, 12–16 September, 2005. FHTET-2005-08, USDA Forest Service, Morgantown, West Virginia, USA; 2005. p. 142–3.
 456. Tewksbury EA. Introduction and establishment of three parasitoids of the lily leaf beetle, *Lilioceris lili* (Coleoptera: Chrysomelidae) in North America [PhD dissertation]. Environmental Science, University of Rhode Island North Kingston, Rhode Island, USA; 2014.
 457. Porter SD. Host specificity and risk assessment of releasing the decapitating fly *Pseudacteon curvatus* as a classical biocontrol agent for imported fire ants. *Biological Control* 2000;19:35–47.
 458. Vazquez RJ, Porter SD. Re-confirming host specificity of the fire ant decapitating fly *Pseudacteon curvatus* (Diptera:

- Phoridae) after field release in Florida. *Florida Entomologist* 2005;88:107–10.
459. Vazquez RJ, Porter SD, Briano JA. Host specificity of a biotype of the fire ant decapitating fly *Pseudacteon curvatus* (Diptera: Phoridae) from Northern Argentina. *Environmental Entomology* 2004;33:1436–41.
 460. Takanashi M. Development and reproductive ability of *Lysiphlebus japonicus* Ashmead (Hymenoptera: Aphididae) parasitizing the citrus brown aphid, *Toxoptera citricidus* (Kirkaldy) (Homoptera: Aphididae). *Japanese Journal of Applied Entomology and Zoology* 1990;34:237–43.
 461. Michaud JP. Classical biological control: a critical review of recent programs against citrus pests in Florida. *Annals of the Entomological Society of America* 2002;95:531–40.
 462. Noyes JS, Schauff ME. New Encyrtidae (Hymenoptera) from papaya mealybug (*Paracoccus marginatus* Williams and Granara De Willink) (Hemiptera: Sternorrhyncha: Pseudococcidae). *Proceedings of the Entomological Society of Washington* 2003;105:180–5.
 463. Persad AB, Hoy MA, Nguyen R. Establishment of *Lipolexis oregmae* (Hymenoptera: Aphididae) in a classical biological control program directed against the brown citrus aphid (Homoptera: Aphididae) in Florida. *Florida Entomologist* 2007;90:204–13.
 464. Kairo MTK, Pollard GV, Peterkin DD, Lopez VK. Biological control of the hibiscus mealybug, *Maconellicoccus hirsutus* Green (Hemiptera: Pseudococcidae) in the Caribbean. *Integrated Pest Management Reviews* 2000;5:241–54.
 465. Sagarra LA, Vincent C, Stewart RK. Suitability of nine species (Homoptera: Pseudococcidae) as hosts for the parasitoids *Anagyrus kamali* (Hymenoptera: Encyrtidae). *Florida Entomologist* 2001;84:112–6.
 466. Dahlsten DL, Rowney DL, Robb KL, Downer JA, Shaw DA, Kabashima JN. Biological control of introduced psyllids on eucalyptus. In: Van Driesche RG, editor. *Proceedings of the 1st International Symposium on Biological Control of Arthropods*, Honolulu, Hawaii, 14–18 January 2002. FHTET 03-05. USDA Forest Service, Morgantown, West Virginia, USA; 2003. p. 356–61. Available from: URL: <http://www.fs.fed.us/foresthealth/technology/webpubs/FHTET-2003-05/index.html>
 467. Dowell RV, Fitzpatrick GE, Reinert JA. Biological control of citrus blackfly in southern Florida. *Environmental Entomology* 1979;8:595–7.
 468. White GL, Kairo MTK, Lopez V. Classical biological control of the citrus blackfly *Aleurocanthus woglumi* by *Amitus hesperidum* in Trinidad. *BioControl* 2005;50:751–9.
 469. Roltsch WJ, Ertle LR, Meyerdirk DE. No-choice host range tests for *Allotropa* sp. near *mecrida*, a parasitoid of the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae). *Biocontrol Science and Technology* 2007;17:977–81.
 470. Grandgirard J, Hoddle MS, Petit JN, Percy DM, Roderick GK, Davies N. Pre-introductory risk assessment studies of *Gonatocerus ashmeadi* (Hymenoptera: Mymaridae) for use as a classical biological control agent against *Homalodisca vitripennis* (Hemiptera: Cicadellidae) in the Society Islands of French Polynesia. *Biocontrol Science and Technology* 2007;17:809–22.
 471. Boyd EA, Hoddle MS. Host specificity testing of *Gonatocerus* spp. egg parasitoids used in a classical biological control program against *Homalodisca vitripennis*: a retrospective analysis of non-target impacts in southern California. *Biological Control* 2007;43:56–70.
 472. Pilkington LJ, Hoddle MS. Use of life table statistics and degree-day values to predict the invasion success of *Gonatocerus ashmeadi* (Hymenoptera: Mymaridae), an egg parasitoid of *Homalodisca coagulata* (Hemiptera: Cicadellidae), in California. *Biological Control* 2006;37:276–83.
 473. Goldson SL, McNeill MR, Proffitt JR, Barratt BIP. Host specificity testing and suitability of a European biotype of the braconid parasitoid *Microctonus aethiopoides* as a biological control agent against *Sitona lepidus* (Coleoptera: Curculionidae) in New Zealand. *Biocontrol Science and Technology* 2005;15:791–813.
 474. Gerard PJ, Eden TM, Hardwick S, Mercer CF, Slay MWA, Wilson DJ. Initial establishment of the Irish strain of *Microctonus aethiopoides* in New Zealand. In: Anon, editor. *Proceedings of the New Zealand Plant Protection Society 60th Annual Conference*, Napier, New Zealand, 14–16 August 2007. New Zealand Plant Protection, Hastings, New Zealand; 2007. p. 203–8.
 475. Evans GA, Peña JE. A new *Fidiobia* species (Hymenoptera: Platygasteridae) reared from eggs of *Diaprepes doublierii* (Coleoptera: Curculionidae) from Dominica. *Florida Entomologist* 2005;88:61–6.
 476. Daane KM, Sime KR, Wang XG, Nadel H, Johnson MW, Walton VM, et al. *Psytalia lounsburyi* (Hymenoptera: Braconidae), potential biological control agent for the olive fruit fly in California. *Biological Control* 2008;44:79–89.
 477. Morrison LW, Gilbert LE. Host specificity in two additional *Pseudacteon* spp. (Diptera: Phoridae), parasitoids of *Solenopsis* fire ants (Hymenoptera: Formicidae). *Florida Entomologist* 1999;82:404–9.
 478. Estrada C, Patrock RJW, Folgarait PJ, Gilbert LE. Host specificity of four *Pseudacteon* spp. (Diptera: Phoridae), parasitoids of fire ants in Argentina (Hymenoptera: Formicidae). *Florida Entomologist* 2006;89:462–8.
 479. Porter SD, Calcaterra LA. Dispersal and competitive impacts of a third fire ant decapitating fly (*Pseudacteon obtusus*) established in North Central Florida. *Biological Control* 2013;64:66–74.
 480. Wyckhuys KAG, Koch RL, Heimpel GE. Physical and ant-mediated refuges from parasitism: implications for non-target effects in biological control. *Biological Control* 2007;40:306–13.
 481. Desneux N, Blahnik R, Delebecque CJ, Heimpel GE. Host phylogeny and specialisation in parasitoids. *Ecology Letters* 2012;15:453–60.
 482. Mendel Z, Protasov A, Blumberg D, Brand D, Saphir N, Madar Z, et al. Release and recovery of parasitoids of the eucalyptus gall wasp *Ophelimus maskelli* in Israel. *Phytoparasitica* 2007;35(4):330–2.
 483. Protasov A, Blumberg D, Brand D, La Salle J, Mendel Z. Biological control of the eucalyptus gall wasp *Ophelimus maskelli* (Ashmead): taxonomy and biology of the parasitoid species *Clostercerus chamaeleon* (Girault), with information on its establishment in Israel. *Biological Control* 2007;42:196–206.
 484. Huber JT, Mendel Z, Protasov A, La Salle J. Two new Australian species of *Stethynium* (Hymenoptera: Mymaridae), larval

- parasitoids of *Ophelimus maskelli* (Ashmead) (Hymenoptera: Eulophidae) on *Eucalyptus*. *Journal of Natural History* 2006;40:1909–21.
485. Borowiec N, Quilici S, Reynaud B. Biocontrol of whitefly on coconut palm in the Comoros. *Biocontrol News and Information* 2008;29(1):2N–3N.
 486. Borowiec N, Quilici S, Martin J, Issimaila MA, Chadhouliati AC, Youssoufa M, *et al.* Increasing distribution and damage to palms by the Neotropical whitefly, *Aleurotrachelus atratus* (Hemiptera: Aleyrodidae). *Journal of Applied Entomology* 2010;134:498–510.
 487. Acebes AL, Messing RH. Host range of a newly introduced parasitoid, *Binodoxys communis* among common aphid species in Hawaii. *BioControl* 2013;58:635–44.
 488. Sime KR, Daane KM, Wang XG, Johnson MW, Messing RH. Evaluation of *Fopius arisanus* as a biological control agent for the olive fruit fly in California. *Agricultural and Forest Entomology* 2008;10:423–31.
 489. Rousse P, Gourdon F, Quilici S. Host specificity of the egg pupal parasitoid *Fopius arisanus* (Hymenoptera: Braconidae) in La Réunion. *Biological Control* 2006;37:284–90.
 490. Deguine JP, Atiama-Nurbel T, Quilici S. Net choice is key to the augmentorium technique of fruit fly sequestration and parasitoid release. *Crop Protection* 2011;30:198–202.
 491. Kuhlmann U, Mason PG, Hinz HL, Blossey B, de Clerck-Floate RA, Dosdall LM, *et al.* Avoiding conflicts between insect and weed biological control: selection of non-target species to assess host specificity of cabbage seedpod weevil parasitoids. *Journal of Applied Entomology* 2006;130:129–41.
 492. Muller FJ, Mason PG, Dosdall LM, Kuhlmann U. European ectoparasitoids of two classical weed biological control agents released in North America. *The Canadian Entomologist* 2011;143:197–210.
 493. Haye T, Mason PG, Gillespie DR, Miall JH, Gibson GAP, Diaconu A, *et al.* Determining the host specificity of the biological control agent *Trichomalus perfectus* (Hymenoptera: Pteromalidae): the importance of ecological host range. *Biocontrol Science and Technology* 2015;25:21–47.
 494. Gould J. Proposed release of three parasitoids for the biological control of the emerald ash borer (*Agrilus planipennis*) in the continental United States. Marketing and Regulatory Programs Animal and Plant Health Inspection Service. Environmental Assessment, July 2007; 2007. Available from: URL: https://www.aphis.usda.gov/plant_health/ea/downloads/eab-ea07-07.pdf
 495. Yang Z-Q, Wang X-Y, Gould JR, Wu H. Host specificity of *Spathius agrili* Yang (Hymenoptera: Braconidae), an important parasitoid of the emerald ash borer. *Biological Control* 2008;47:216–21.
 496. Van Driesche RG, Pratt PD, Center TD, Rayamajhi MB, Tipping PW, Purcell M, *et al.* Cases of biological control restoring natural systems. In: Van Driesche RG, Simberloff D, Blossey B, Causton C, Hoddle MS, Marks C, Heinz K, Wagner D, Warner K, editors. *Integrating Biological Control into Conservation Practice*. Wiley/Blackwell, Oxford, UK; 2016. p. 208–46.
 497. HDOA. Field release of *Eurytoma* sp. (Hymenoptera: Eurytomidae), for biological control of the erythrina gall wasp, *Quadrastichus erythrinae* Kim (Hymenoptera: Eulophidae), in Hawaii. Final Environmental Assessment April 7, 2008; 2008. Available from: URL: http://oeqc.doh.hawaii.gov/Shared%20Documents/EA_and_EIS_Online_Library/Statewide/2000s/2008-04-23-ST-FEA-Field-Release-of-Eurytoma-Erythrina-Gall-Wasp-BioControl.pdf
 498. Kimber W, Glatz R, Caon G, Roocke D. *Diaeretus essigellae* Starý and Zuparko (Hymenoptera: Braconidae: Aphidiini), a biological control for Monterey pine aphid, *Essigella californica* (Essig) (Hemiptera: Aphididae: Cinarini): host-specificity testing and historical context. *Australian Journal of Entomology* 2010;49:377–87.
 499. HDOA. Field release of *Aroplectrus dimerus* Lin. (Hymenoptera: Eulophidae) for biological control of the nettle caterpillar, *Darna pallivitta* (Moore) (Lepidoptera: Limacodidae), in Hawaii. Draft Environmental Assessment November 2007; 2007. Available from: URL: http://oeqc.doh.hawaii.gov/Shared%20Documents/EA_and_EIS_Online_Library/Statewide/2000s/2008-04-23-DEA-Nettle-Caterpillar-Biocontrol-and-Agent-Host-Specificity-Report.pdf
 500. Hoddle MS, Pandey R. Host range testing of *Tamarixia radiata* (Hymenoptera: Eulophidae) sourced from the Punjab of Pakistan for classical biological control of *Diaphorina citri* (Hemiptera: Liviidae: Euphyllurinae: Diaphorinini) in California. *Journal of Economic Entomology* 2014;107:125–36.
 501. Porter SD, Kumar V, Calcaterra LA, Briano JA, Seal DR. Release and establishment of the little decapitating fly *Pseudacteon cultellatus* on imported fire ants in Florida. *Florida Entomologist* 2013;96:1567–73.
 502. Andreassen LD, Kuhlmann U, Mason PG, Holliday NJ. Host range testing of a prospective classical biological control agent against cabbage maggot, *Delia radicum*, in Canada. *Biological Control* 2009;48:210–20.
 503. Toepfer S, Zhang F, Kuhlmann U. Assessing host specificity of a classical biological control agent against western corn rootworm with a recently developed testing protocol. *Biological Control* 2009;51:26–33.
 504. Hopper KR. Petition for the Release of *Aphelinus glycinis* (Hymenoptera: Aphelinidae) for the Biological Control of the Soybean aphid, *Aphis glycines* (Hemiptera: Aphididae). USDA APHIS, Washington, D.C.; 2010. 32 p.
 331. USDA APHIS. Field release of *Aphelinus glycinis* (Hymenoptera: Aphelinidae) for biological control of the soybean aphid, *Aphis glycines* (Hemiptera: Aphididae), in the continental United States. Environmental Assessment, September 2012; 2012. Available from: URL: https://www.aphis.usda.gov/plant_health/ea/downloads/soybeanaphid-EA-FONSI.pdf
 506. Berndt LA, Withers TM, Mansfield S, Hoare RJB. Non-target species selection for host range testing of *Cotesia urabae*. In: Zydenbos SM, editor. *Proceedings of the New Zealand Plant Protection Society's Annual Conference, Dunedin, New Zealand, 11–13 August 2009*. New Zealand Plant Protection Society, Hastings, New Zealand; 2009. p. 168–73.
 507. Avila G, Berndt LA. Release of a new biological control agent, *Cotesia urabae*, against *Uraba lugens* in New Zealand. In: Anon, editor. *Proceedings of the New Zealand Plant Protection Society's Annual Conference, Rotorua, New Zealand, 9–11 August 2011*. New Zealand Plant Protection Society, Hastings, New Zealand; 2011. p. 282–94.
 508. Rowbottom RM, Allen GR, Walker PW, Berndt LA. Phenology, synchrony and host range of the Tasmanian population of *Cotesia urabae* introduced into New Zealand for the biocontrol of *Uraba lugens*. *BioControl* 2013;58:625–33.

509. Avila GA, Withers TM, Holwell GI. Host testing of the parasitoid *Cotesia urabae* (Austin & Allen, 1989) (Hymenoptera: Braconidae) to assess the risk posed to the New Zealand nolid moth *Celama parvitis* (Howes, 1917) (Lepidoptera: Nolidae): do host deprivation and experience influence acceptance of non-target hosts? *Austral Entomology* 2015;54:270–7.
510. Bistline-East A, Pandey R, Kecici M, Hoddle MS. Host range testing of *Diaphorencyrtus aligarhensis* (Hymenoptera: Encyrtidae) for use in classical biological control of *Diaphorina citri* (Hemiptera: Liviidae) in California. *Journal of Economic Entomology* 2015;108:940–50.
511. Duan JJ, Gould JR, Fuester RW. Evaluation of the host specificity of *Spathius galinae* (Hymenoptera: Braconidae), a larval parasitoid of the emerald ash borer (Coleoptera: Buprestidae) in northeast Asia. *Biological Control* 2015;89:91–7.
512. USDA APHIS. Field release of the parasitoid *Spathius galinae* for the biological control of the emerald ash borer (*Agrilus planipennis*) in the contiguous United States. Environmental Assessment. March 2015; 2015. Available from: URL: https://www.aphis.usda.gov/plant_health/ea/downloads/2015/spathius-galinae-eab-biocontrol.pdf
513. Follett P, Neumann G, Hollingsworth R, Swedman A, Sibucan R. Release and establishment of *Encarsia diaspidicola* (Hymenoptera: Aphelinidae) against white peach scale (Hemiptera: Diaspididae) in Papaya. *Proceedings of the Hawaiian Entomological Society* 2015;47:51–4.
514. Martínez JJ, Berta C, Varone L, Logarzo G, Zamudio P, Zaldivar-Riverón A, et al. DNA barcoding and morphological identification of Argentine species of *Apanteles* (Hymenoptera: Braconidae), parasitoids of cactus-feeding moths (Lepidoptera: Pyralidae: Phycitinae), with description of a new species. *Invertebrate Systematics* 2012;26:435–44.
515. Varone L, Logarzo G, Martínez JJ, Navarro F, Carpenter JE, Hight SD. Field host range of *Apanteles opuntiarum* (Hymenoptera: Braconidae) in Argentina, a potential biocontrol agent of *Cactoblastis cactorum* (Lepidoptera: Pyralidae) in North America. *Florida Entomologist* 2015;98:803–6.
516. Nohara K. Studies on the biology of *Unaspis yanonenis* (Kuwana) (Homoptera: Diaspididae). *Science Bulletin of the Faculty of Agriculture, Kyushu University* 1962;20:13–27.
517. Chumakova BM. The San José scale and the natural supply of entomophagous insects attacking it in Sakhalin. *Byulleten' Vsesoyuznogo Nauchno-issledovatel'skogo Instituta Zashchity Rastenii, Leningrad* 1967;1(9):9–13.
518. Tachikawa T. Natural enemies of *Quadraspidiotus macroporanus* Takagi (Homoptera: Diaspididae). *Transactions of the Shikoku Entomological Society* 1974;12(1/2):31–2.
519. Xia BC, Zhang Y, Shen BY. Biology of *Chilocorus kuwanae* and its control of coccids in the field. *Chinese Journal of Biological Control* 1986;2:70–4.
520. Itoaka T, Inoue T. The role of predators and attendant ants in the regulation and persistence of a population of the citrus mealybug *Pseudococcus citriculus* in a satsuma orange orchard. *Applied Entomology and Zoology* 1996;31:195–202.
521. Kim J-K, Morimoto K. Studies on the natural enemies of *Protopulvinaria mangiferae* (Green) (Homoptera: Coccidae). *Journal of Forest Science* 1998;14:128–37.
522. Luo Q-H, Xie X-L, Zhou L, Wang SW, Xu Z-Y. A study on the dynamics and biological characteristics of *Eriococcus lagerstroemiae* Kuwanae population in Guiyang. *Acta Entomologica Sinica* 2000;43:35–42.
523. Bull BC, Raupp MJ, Hardin MR, Sadof CS. Suitability of five horticulturally important armored scale insects as hosts for an exotic predaceous lady beetle. *Journal of Environmental Horticulture* 1993;11:28–30.
524. Huang LL, Wang DW, Zhang Q, Zhu W, Matsumoto K. A study on the biology and control of the arrowhead scale (*Unaspis yanonenis* Kuwana). *Proceedings of the International Society of Citriculture* 1981;2:640–3.
525. Tanaka M, Inoue K. Biology of *Cybocephalus nipponicus* Endroy Yonga (Cybocephalidae) and its role as a predator of citrus red mites, *Panonychus citri* (McGregor). *Bulletin of the Fruit Tree Research Station, Japan, D (Kuchinotsu)* 1980;2:91–110.
526. Song S-Y, Tan C-W, Hwang S-Y. Host range of *Cybocephalus flavocapitis* and *Cybocephalus nipponicus*, two potential biological control agents for the cycad aulacaspis scale, *Aulacaspis yasumatsui*. *Journal of Asia-Pacific Entomology* 2012;15:595–9.
527. Hutson JC. The coconut scale (*Aspidiotus destructor*). *Tropical Agriculturist* 1933;80(4):254–6.
528. Samways MJ. Biology and economic value of the scale predator, *Chilocorus nigrinus* (F.) (Coccinellidae). *Biocontrol News and Information* 1984;5(2):91–104.
529. Kinawy MN. Biological control of the coconut scale insect (*Aspidiotus destructor* Sign., Homoptera: Diaspididae) in the southern region of Oman (Dhofar). *Tropical Pest Management* 1991;37:387–9.
530. Ponsonby DJ. Factors affecting utility of *Chilocorus nigrinus* (F.) (Coleoptera: Coccinellidae) as a biocontrol agent. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* 2009;4(046):1–20.
531. Omkar, Bind RB. Records of aphids-natural enemies complex of Uttar Pradesh, IV. The coccinellids. *Journal of Advanced Zoology* 1995;16(2):67–71.
532. Kapur AP. A note on the lady-bird beetles (Coccinellidae) preying upon the cane whitefly, *Aleurolobus barodensis* Mask. *Current Science* 1942;9(3):134.
533. Nawanich S, Fudsiri S, Chongrattanameteekul W. Predatory efficiency study of *Curinus coeruleus* Mulsant on *Rhopalosiphum maidis* (Fitch) and *Phenacoccus manihoti* Matile-Ferrero. In: Anon, editors. *Proceedings of the 51st Kasetsart University Annual Conference, Bangkok, Thailand, 5–7 February 2013*. Kasetsart University, Bangkok, Thailand; 2013. p. P125.
534. Villacarlos LT, Robin NM. Biology and potential of *Curinus coeruleus* Mulsant, an introduced predator of *Heteropsylla cubana* Crawford. *Philippine Entomologist* 1992;8(6):1247–58.
535. Michaud JP. Biological control of Asian citrus psyllid, *Diaphorina citri* (Hemiptera: Psyllidae) in Florida: a preliminary report. *Entomological News* 2002;113(3):216–22.
536. Nafus D, Schreiner I. Biological control activities in the Mariana Islands from 1911 to 1988. *Micronesica* 1989;22(1):65–106.
537. Priore R. *Dialeurodes citri* (Ashmead) (Homoptera Aleyrodidae) in Campania (Notes on morphology and biology). *Bollettino del Laboratorio di Entomologia Agraria 'Filippo Silvestri' Portici* 1969;27:287–316.

538. Bathon H, Pietrzyk J. Food uptake by the ladybird *Clitostethus arcuatus* (Rossi) (Col., Coccinellidae), a predator of the cabbage whitefly, *Aleurodes proletella* Linné (Hom., Aleurodidae). *Journal of Applied Entomology* 1986;102:321–6.
539. Katsoyannos P, Ifantis K, Kontodimas DC. Phenology, population trend and natural enemies of *Aleurothrixus floccosus* (Hom.: Aleyrodidae) at a newly invaded area in Athens, Greece. *Entomophaga* 1997;42:619–28.
540. Bellows TS, Paine TD, Arakawa KY, Meisenbacher C, Leddy P, Kabashima J. Biological control sought for ash whitefly. *California Agriculture* 1990;44:4–6.
541. Gregoire JC. Note on two natural enemies of *Dendroctonus micans* Kugelmann in Belgium (Coleoptera: Scolytidae). *Bulletin et Annales de la Societe Royale Belge d'Entomologie* 1976;112(7/9):208–12.
542. Wei J-R, Ding B-F, Tang Y-L, Zhao J-X, Yang Z-Q. Study on the relationship between growth and environmental temperature of *Rhizophagus grandis* (Coleoptera: Rhizophagidae), an important predator of *Dendroctonus valens* (Coleoptera: Scolytidae). *Forest Research* 2010;23(3):478–81.
543. Day WH, Prokrym DR, Ellis DR, Chianese RJ. The known distribution of the predator *Propylea quatuordecimpunctata* (Coleoptera: Coccinellidae) in the United States, and thoughts on the origin of this species and five other exotic lady beetles in eastern North America. *Entomological News* 1994;105(4):244–56.
544. Iperiti G. Contribution to the study of host-specificity among the main Coccinellids attacking aphids in the Alpes-Mari-times and the Basses-Alpes. *Entomophaga* 1965;10:159–78 (in French)
545. Ferran A, Larroque MM. Study of host-predator relations: the consumption and utilisation of an aphid, *Myzus persicae* Sulz. by different larval stages of the coccinellid *Semiadalia undecimnotata* Sch. (Col. Coccinellidae). *Annales Zoologie, Ecologie Animale* 1977;9:665–91.
546. Sikharulidze AM. Tea aphid, a pest of feijoa, and results obtained with Ambush for its control. *Subtropicheskie Kul'tury* 1986;1:139–41.
547. Gordon RD, Vandenberg N. Field guide to recently introduced species of Coccinellidae (Coleoptera) in North America, with a revised key to North American genera of Coccinellini. *Proceedings of the Entomological Society of Washington* 1991;93:845–64.
548. Čamprag D, Kereši T, Sekulić R, Almaši R, Rageb T, Taloši B. Study of the population dynamics and distribution of *Aphis fabae* Scop. and coccinellid predators, in 1981–1985, on sugarbeet in Vojvodina. *Zaštita Bilja* 1990;41(2):129–40.
549. Obrycki JJ, Orr CJ. Suitability of three prey species for Nearctic populations of *Coccinella septempunctata*, *Hippodamia variegata*, and *Propylea quatuordecimpunctata* (Coleoptera: Coccinellidae). *Journal of Economic Entomology* 1990;83:1292–7.
550. Michels GJ, Flanders RV. Larval development, aphid consumption and oviposition for five imported coccinellids at constant temperature on Russian wheat aphids and greenbugs. *Southwestern Entomologist* 1992;17:233–43.
551. Wheeler Jr AG. *Propylea quatuordecimpunctata*: additional US records of an adventive lady beetle (Coleoptera: Coccinellidae). *Entomological News* 1990;101(3):164–6.
552. Gibson RL, Elliott NC, Schaefer P. Life history and development of *Scymnus frontalis* (Fabricius) (Coleoptera: Coccinellidae) on four species of aphid. *Journal of the Kansas Entomological Society* 1992;65:410–5.
553. Bodenheimer FS, Neumark S. The Israel Pine Matsucoccus (*Matsucoccus josephi* nov. spec.). Kiryath Sepher Ltd, Jerusalem; 1955.
554. Özsemerci F, Aksit T. Investigations on some biological characteristics and population fluctuation of *Ceroplastes rusci* L. (Homoptera: Coccidae) harmful to fig trees in Aydn province. *Türkiye Entomoloji Dergisi* 2003;27(1):13–25.
555. Kesten LA. Insect enemies of the lucerne aphid. *Zashchita Rastenii* 1975;11:28.
556. Toros S. *Hyadaphis tataricae* (Aizenberg) (Hom.: Aphididae); a species new to the fauna of Turkey. *Türkiye Bitki Koruma Dergisi* 1986;10(3):141–8.
557. Chen HQ. A preliminary observation on *Altica* sp. *Kunchong Zhishi* 1982;19(6):21–3.
558. Baki MHAA, Ahemed MS. Ecological studies on olive psyllid *Euphyllura straminea* Log. at Mosul Region with special reference to its natural enemies. *Iraqi Journal of Agricultural Sciences "Zanco"* 1985;3(1):1–14.
559. Abdul-Satar S, Al-Saadi NA, Ouda A, Haidar S, Al-Haidari, Al-Azzawi A. Insect predators of *Aphis nerii* in Baghdad area and their predatory efficiency and feeding preference. *Journal of Biological Science Research* 1988;19:31–40.
560. Dabiré R, Hopper KR, Leclant F. Food preference of *Leucopis ninae* Tanasijtshuk larva vis-à-vis of *Diuraphis noxia* (Mordvilko). In: *Proceedings of International Conference on Pests in Agriculture*, 6–8 January 1997, at le Corum, Montpellier, France, Vol. 3. Association Nationale pour la Protection des Plantes (ANPP)Paris; 1997. p. 879–86.
561. Olfert OO, Doane JF, Carl K, Erlandson MA, Goettel MS. *Diuraphis noxia* (Kurdjumov), Russian wheat aphid (Homoptera: Aphididae). In: Mason PG, Huber JT, editors. *Biological Control Programmes in Canada, 1981–2000*. CABI, Wallingford, UK; 2001. p. 110–4.
562. Boeye J, Laborius GA, Schultz FA. The response of *Teretriosoma nigrescens* Lewis (Col.: Histeridae) to the pheromone of *Prostephanus truncatus* (Horn) (Col.: Bostrichidae). *Anzeiger für Schädlingskunde, Pflanzenschutz, Umweltschutz* 1992;65:153–7.
563. Borgemeister C, Djossou F, Adda C, Schneider H, Djomamou B, Degbey P, et al. Establishment, spread, and impact of *Teretriosoma nigrescens* (Coleoptera: Histeridae), an exotic predator of the larger grain borer (Coleoptera: Bostrichidae) in southwestern Benin. *Environmental Entomology* 1997;26:1405–15.
564. Hill MG, Nang'ayo FLO, Wright DJ. Biological control of the larger grain borer *Prostephanus truncatus* (Coleoptera: Bostrichidae) in Kenya using a predatory beetle, *Teretrius nigrescens* (Coleoptera: Histeridae). *Bulletin of Entomological Research* 2003;93:299–306.
565. Schneider H, Borgemeister C, Sétamou M, Affognon H, Bell A, Zweigert ME, et al. Biological control of the larger grain borer *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) by its predator *Teretrius nigrescens* (Lewis) (Coleoptera: Histeridae) in Togo and Benin. *Biological Control* 2004;30:241–55.
566. Antadze AI, Timofeeva TV. A predator of the citrus whitefly. *Zashchita Rastenii* 1976;10:46.

567. Legaspi JC, Legaspi Jr BC, Meagher Jr RL, Ciomperlik MA. Evaluation of *Serangium parcesetosum* (Coleoptera: Coccinellidae) as a biological control agent of the silverleaf whitefly (Homoptera: Aleyrodidae). *Environmental Entomology* 1996;25:1421–7.
568. Al-Zyoud FA. Prey species preference of the predator *Serangium parcesetosum* Sicard (Col., Coccinellidae) and its interaction with another natural enemy. *Pakistan Journal of Biological Sciences* 2007;10(13):2159–65.
569. Chu J-T. On the mulberry coccid, *Drosicha contrahens* Walker. *Entomology and Phytopathology* 1933;1(19–20):410–4.
570. Lethane R. Breadfruit pest succumbs to a ladybird beetle. *Partners in Research for Development* 1998;11:25–31.
571. Choi K-S, Kim J-K, Lee S-M. Host plants of *Comstockaspis macroporatus* and its predators. *FRI Journal of Forest Science* (Seoul) 1995;51:143–6.
572. Blumberg D, Swirski E. Prey consumption and preying ability of three species of *Cybocephalus* (Coleoptera: Cybocephalidae). *Phytoparasitica* 1974;2:3–11.
573. Blumberg D, Swirski E. The development and reproduction of Cybocephalid beetles on various foods. *Entomophaga* 1974;19:437–43.
574. Kairo MTK, Paraiso O, Gautam RD, Peterkin DD. *Cryptolaemus montrouzieri* (Mulsant) (Coccinellidae: Scymninae): a review of biology, ecology, and use in biological control with particular reference to potential impact on non-target organisms. *CAB Reviews* 2013;8(005):1–20.
575. Mohammad AS. A preliminary note on the natural enemies of sugarcane mealybug, *Pseudococcus saccharifolii* (Green) in Bihar (India). *Indian Journal of Sugarcane Research and Development* 1963;7(2):131–2.
576. Rawat RR, Modi BN. A record of natural enemies of *Ferrisia virgata* Ckll. in Madhya Pradesh (India). *Mysore Journal of Agricultural Sciences* 1968;2(1):51–3.
577. Muzaffar N, Ahmad R. A note on *Saissetia privigna* (Hem.: Coccidae) in Pakistan and the breeding of its natural enemies. *Entomophaga* 1977;22:45–6.
578. Karuppuchamy P, Balasubramanian G, Babu PCS. Seasonal incidence and management of aphid *Aphis punicae* on pomegranate. *Madras Agricultural Journal* 1998;85(5/6):224–6.
579. Gautam RD. Classical biological control of pink hibiscus mealy bug, *Maconellicoccus hirsutus* (Green) in the Caribbean. *Plant Protection Bulletin* (Faridabad) 2003;55(1/2):1–8.
580. Causton CE, Lincango MP, Poulson TGA. Feeding range studies of *Rodolia cardinalis* (Mulsant), a candidate biological control agent of *Icerya purchasi* Maskell in the Galápagos Islands. *Biological Control* 2004;29:315–25.
581. Causton CE. Evaluating risks of introducing a predator to an area of conservation value: *Rodolia cardinalis* in Galápagos. In: Hoddle MS, editor. *Second International Symposium on Biological Control of Arthropods*, Davos, Switzerland, 12–16 September, 2005. FHTET-2005-08, USDA Forest Service, Morgantown, West Virginia, USA; 2005. p. 64–76.
582. Butin EE, Havill NP, Elkinton JS, Montgomery ME. Feeding preferences of three lady beetle predators of the hemlock woolly adelgid (Homoptera: Adelgidae). *Journal of Economic Entomology* 2004;97:1635–41.
583. Jetton RM, Monahan JF, Hain FP. Laboratory studies of feeding and oviposition preference, developmental performance, and survival of the predatory beetle, *Sasajiscymnus tsugae* on diets of the woolly adelgids, *Adelges tsugae* and *Adelges piceae*. *Journal of Insect Science* 2011, Article 68. Available from: 10.1673/031.011.6801.
584. Zilahi-Balogh GMG, Kok LT, Salom SM. Host specificity of *Laricobius nigrinus* Fender (Coleoptera: Derodontidae), a potential biological control agent of the hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera: Adelgidae). *Biological Control* 2002;24:192–8.
585. Lamb AB, Salom SM, Kok LT, Mausel DL. Confined field release of *Laricobius nigrinus* (Coleoptera: Derodontidae), a predator of the hemlock woolly adelgid, *Adelges tsugae* (Homoptera: Adelgidae), in Virginia. *Canadian Journal of Forest Research* 2006;36:369–75.
586. Mausel DL, Salom SM, Kok LT, Fidgen JG. Propagation, synchrony, and impact of introduced and native *Laricobius* spp. (Coleoptera: Derodontidae) on hemlock woolly adelgid in Virginia. *Environmental Entomology* 2008;37:1498–507.
587. Mausel DL, Salom SM, Kok LT, Davis GA. Establishment of the hemlock woolly adelgid predator, *Laricobius nigrinus* (Coleoptera: Derodontidae), in the eastern United States. *Environmental Entomology* 2010;39:440–8.
588. Vieira LC, McAvoy TJ, Chantos J, Lamb AB, Salom SM, Kok LT. Host range of *Laricobius osakensis* (Coleoptera: Derodontidae), a new biological control agent of hemlock woolly adelgid (Homoptera: Adelgidae). *Environmental Entomology* 2011;40:324–32.