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Weevils as Targets for Biological Control, and the Importance of Taxonomy and Phylogeny for Efficacy and Biosafety

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Abstract: Curculionidae are a large mainly herbivorous family of beetles, some of which have become crop pests. Classical biological control has been attempted for about 38 species in 19 genera, and at least moderate success has been achieved in 31 % of cases. Only two weevil species have been considered to be completely controlled by a biological control agent. Success depends upon accurately matching natural enemies with their hosts, and hence taxonomy and phylogeny play a critical role. These factors are discussed and illustrated with two case studies: the introduction of the braconid parasitoid *Microctonus aethioides* into New Zealand for biological control of the lucerne pest *Sitona discoideus*, a case of complex phylogenetic relationships that challenged the prediction of potential non-target hosts, and the use of a mymarid egg parasitoid, *Anaphes nitens*, to control species of the eucalypt weevil genus *Gonipterus*, which involves failure to match up parasitoids with the right target amongst a complex of very closely related species. We discuss the increasing importance of molecular methods to support biological control programmes and the essential role of these emerging technologies for improving our understanding of this very large and complex family.

Keywords: Curculionidae; biological control; target host; non-target host; taxonomy; phylogeny

1. Introduction

Risk assessment for biological control agent (BCA) introduction has increasingly become standard best practice in recent years, and regulatory legislation has been adopted in many countries [1]. Risks associated with biological control can range from direct impacts of a biocontrol agent on non-target species to indirect impacts, which can sometimes be hard to predict (e.g., [2]). These include impacts resulting from food-web effects [3], hybridization with related natural enemies [4] and apparent competition [5].

Decisions made by regulators considering BCA applications depend heavily on information on a wide range of factors including, where possible, that available from the native range of the proposed BCA and its host(s), from introductions to new areas elsewhere and from data on laboratory host range tests usually carried out under quarantine conditions. The latter is one of the key datasets that regulators have on which to base their assessment of risk to native and non-target species in the new proposed area of introduction [6]. In Europe, a Commission of the International Organisation for Biological Control, established to harmonize regulations, recommended that a list of all known hosts from the natural range and new areas of introduction should be documented [7]. Since then it has

become widely accepted that information on host range (natural and novel) should be included in applications to import and release new biological control agents [8–10].

The Curculionoidea are one of the most speciose taxonomic groups of insects, estimated to comprise over 200,000 species [11], with members inhabiting most ecosystems throughout the world. The evolutionary steps that have resulted in the “phenomenal diversification and success of weevils” that we see today have been discussed by Oberprieler, Marvaldi and Anderson [11]. Whereas the diversity of weevils has been studied and progressed extensively over the last 250 years, since the first species was described, the identities and delimitations of natural family-group taxa and their phylogenetic relationships have remained the subject of much debate. Recent molecular techniques in combination with analyses of morphological characters have increasingly helped to clarify some of these quandaries and have mostly confirmed Kuschel’s proposed 6–7 main weevil lineages as based only on morphology [12]. In the large family Curculionidae, however, phylogenetic relations still remain largely unresolved [13–16].

As weevils are essentially herbivorous, it is unsurprising that many species have been used for biological control of weeds with significant success [17]. However, by the same token, many species of the Curculionidae have become agricultural and horticultural pests, in particular those in the subfamily Entiminae. Species in this very large and diverse group of more than 12,000 species [11] comprise mainly live-plant-feeding adults with root-feeding larvae, often with a wide plant host range that predisposes them to become crop pests. Consequently, some members of this subfamily, amongst others, have become the target of biological control programs. The large family Curculionidae, therefore, represents a useful taxon for an analysis of biological control deployment and the challenges it presents for practitioners and regulators.

In this contribution we review classical biological control programs for which species of Curculionidae have been the target species and the range of insect biological control agents (predators and parasitoids) that have been used globally to assist in the management of weevil pest species. We emphasize in particular the importance of taxonomy for correct matching of host–parasitoid relationships and understanding phylogenetic relationships within the family in order to more accurately predict non-target hosts and assess other risks of biological control introductions for weevils. Case studies are used to exemplify each of these issues and to highlight the complexities of working with such a speciose and diverse family.

2. Weevils as Targets of Biological Control

With reference to the BIOCAT database [18], as updated by Kenis, et al. [19], 23 genera (approximately 38 species) of Curculionidae have been the subject of a classical biological control programme; of these 24 weevil species (63 %) have BCAs permanently established in at least one of the countries of release (Table A1 in Appendix A). Impact of BCAs on weevil hosts has ranged from complete control (no other control method required) to no impact at all on pest populations (Table A1). Some level of control has been achieved on 12 target species, a success rate of approximately 31 % (Table 1(A)). The most common subfamilies of weevils that have been targets of biocontrol are the Entiminae, Scolytinae and Curculioninae, while most successes have been achieved with biological control of entimines (Table 1(A)).

The biological control agents listed in BIOCAT that have been used for classical biological control of weevil target pests comprise parasitoids and predators from four insect orders, 22 families and 81 species, and 15 species have had some positive impact on pest weevils (Table 1(B)). The most commonly used and successful BCAs have been hymenopteran parasitoids, of which six families and 12 species have had some impact on the target (Table 1(A)). Only two cases of complete control of a pest weevil are listed in BIOCAT (Table A1). One is that of *Lixophaga sphenophori* (Villeneuve) (Diptera: Tachnidae) released in the United States for biocontrol of the Sugar-cane Weevil, *Rhabdoscelus obscurus* (Boisduval); however, no control with this tachinid was reported from Australia or Fiji. The other case is that of the egg parasitoid *Anaphes nitens* (Girault) (Hymenoptera: Mymaridae) used for the control of

Gonipterus scutellatus Gyllenhal defoliating eucalypts in Madagascar, but again such complete control has not been the case for all releases; incomplete control has been reported in New Zealand, South America, Europe and Africa (Table A1).

Table 1. (A) Summary of weevil taxa for which biological control agents (BCAs) have been established and those that are having an impact. (B) Number of biological control agents that are established and those having an impact on the target host.

(A)		Target Weevil Taxa	
Species × Subfamily	BCA Permanently Established	BCAs Having Some Impact	
Entiminae	8	5	
Curculioninae	3	1	
Cyclominae	2	1	
Dryophthorinae	2	2	
Molytinae	1	0	
Scolytinae	8	3	
(B)		Biological Control Agents	
Category	Released	Permanently Established	Having Some Impact
No. orders	4	4	3
No. families	22	13	9
No. species	81	37	15

Referring to biological control of the Banana Weevil, *Cosmopolites sordidus* (Germar), with predatory histerids in Fiji, it was noted that “weevils as a group seem to be poor candidates for biological control” [20], although some success was reported in reducing the pest status of the Banana Weevil. However, there have been notable successes, for example with weevil pests of forage crops in Australasia. In New Zealand in particular, species of the wasp genus *Microctonus* Wesmael (Hymenoptera: Braconidae) have provided substantial levels of control of the Lucerne Weevil, *Sitona discoideus* Gyllenhal. These wasps are parasitoids of the adult stage of the host, and although the weevil hosts survive for the duration of the parasitoid larval development inside them, the female weevils become reproductively incapable almost immediately after parasitism [21].

3. Importance of Taxonomy and Phylogeny

For risk assessment for biological control it is vital to have a good understanding of the taxonomy and phylogenetic relationships of the organisms involved (biocontrol agent, target host, potential non-target hosts) for many reasons [22]. Clearly, certainty of the identity of the BCA is paramount, so that the correct and intended organism is selected for release and reliable literature can be accessed on efficacy, host range, climatic and geographical distribution, as well as basic biology and ecology [23]. This is also essential information usually required by regulators (e.g., [24,25]). Furthermore, taxonomic certainty when selecting test species for host range testing in quarantine is paramount so that organisms closely related to the target pest can be identified [8]. Molecular methods have become increasingly important in supporting taxonomic determination [26,27], and they can provide an interim alternative where the taxonomic impediment prevents a name from being available (Cock in preparation).

The identity of potential BCAs determined on morphological grounds alone is no longer sufficient in many taxonomic groups, particularly when working with the less well known tropical faunas. Thus, the inventory of Lepidoptera caterpillars, their food plants and natural enemies in Costa Rica [28] has revealed numerous apparently polyphagous parasitoids, particularly Braconidae and Tachinidae (so far), which on closer examination comprise a species complex of variously monophagous, oligophagous or polyphagous species that can initially be distinguished on their DNA CO1 barcodes [29,30].

Natural enemies and their hosts have usually coevolved together, with a dynamic interplay or even “power struggle” between the two both spatially and temporally. When selected for a biological control program, natural enemies are often transported to a new area, where, for the first time, they may encounter new organisms that are within their host range as might be anticipated based on close phylogenetic relationships. While this is often considered to be a ‘host shift’, it should more appropriately be seen as host range expansion onto new host species that have always been within the host range of the natural enemy [31]. Understanding of phylogenetic relationships between natural enemy and host taxa in the native range is therefore vital for predicting potentially novel hosts that might be physiologically suitable (or permissive) hosts for the natural enemy, whether for weed targets [9,32] or insect targets [8]. Naturally, a range of other ecological and behavioural factors also comes into play that might preclude hosts in the receiving environment from becoming a suitable host.

As mentioned above, risk assessment for weevils as target hosts can present a particularly challenging task because of the complexity of determining phylogenetic relationships in such a large and imperfectly resolved group of organisms.

3.1. Case Study: *Microctonus aethioides* (Loan) for Biological Control of *Sitona discoideus*

Microctonus aethioides Loan (Hymenoptera: Braconidae) is a solitary, koinobiont endoparasitoid of the adult stage of its host. This parasitoid was introduced into Australia in 1977 from the Mediterranean region [33,34] for biological control of the weevil *S. discoideus* (Curculionidae: Entiminae: Sitonini), an introduced pest of lucerne (alfalfa) (*Medicago sativa* L.). Specimens of *M. aethioides* sourced from Australia were released in New Zealand in 1982 [35] also to control *S. discoideus*. Later molecular studies suggested that the *M. aethioides* population introduced into New Zealand comprised specimens that originated from Morocco [36]. In Australia the parasitoid was released mainly in south-eastern regions between 1977 and 1980 [37], and in New Zealand it was released at 17 lucerne-growing sites in the South Island [35].

The initial exploration research for biocontrol agents for *S. discoideus* in Europe and North Africa involved extensive surveys of potential candidate biocontrol agents for *Sitona* but did not consider their natural host ranges [38]. However, following the identification of *M. aethioides* as a potentially suitable BCA, its native host range in Morocco was investigated and found to comprise weevil species in the genera *Sitona* Germar and *Hypera* Germar (Curculionidae: Hyperinae) [39]. Evidence was later presented for the existence of two sympatric biotypes of *M. aethioides* associated with *Sitona* and *Hypera* as hosts respectively [40]. As the parasitoids sent from Morocco to Australia and then to New Zealand were in the form of parasitised adult *S. discoideus* weevils [34], it has been assumed that the introduced parasitoids were *Sitona*-associated biotypes.

Despite the knowledge that *M. aethioides* was not entirely host-specific in its native range, there was little pre-release risk assessment of it undertaken in Australia. A single weevil species being introduced as a weed biological control agent, *Perapion antiquum* (Gyllenhal) (Brentidae: Apioninae), was tested, and no parasitism was recorded (J. Cullen pers. comm.). In New Zealand, quarantine testing was also carried out with weed biological control agents [41] to identify any adverse impacts on beneficial insects, as required by regulation at the time. In both countries, no native insects were tested, because it was argued that there are no native *Sitona* species present and no members of the tribe Sitonini. In Australia, however, there are several native genera of Hyperini [42]. Post-release recovery rates of the parasitoid from *S. discoideus* (and hence efficacy of parasitism) in Australia during 1977–1979 ranged from 0–22.7 % [33]. A survey of 25 sites in New South Wales, Victoria and South Australia in November 2001 found a mean level of parasitism of *S. discoideus* of 2.6 %, with a range of 0–24.6 % [43]. In New Zealand, *M. aethioides* has been considered a successful biological control agent of *S. discoideus*, especially in Canterbury, where parasitism levels of 50–70 % have been reported in summer [44] and similar levels of parasitism are still found currently (S. Goldson, pers. comm.). A survey of 88 lucerne sites in Otago and Southland (southern New Zealand) found mean parasitism levels ranging from 16–67 % with parasitism reaching 100 % at some sites [45].

In Australia, no post-release studies had been carried out to determine whether non-target parasitism was also occurring in that country, until a survey conducted in south-eastern Australia in 2001 discovered a single incidence of parasitism by *M. aethiopoidea* of the native species “*Prosayleus*” sp. 2 [43]. This species, now assignable to the genus *Agroicus* Jekel [46], belongs to the subfamily Entiminae (currently placed in the tribe Leptopiini) but is not closely related to *Sitona* [46]. However, in Australia the Entiminae are the second-largest subfamily of weevils, and Leptopiini comprise about 90 % of the species [46], and so further non-target hosts might be discovered in the future.

The non-target weevils recorded as parasitised in the field by *M. aethiopoidea* in New Zealand are shown in Table 2, spanning four subfamilies, five tribes and ten genera. Leptopiini are clearly common hosts, and given the number of species present in New Zealand including in the genera *Irenimus* Pascoe (seven species) and *Chalepistes* Brown (62 species) [47,48] and *Austromonticola* Brown (eight species) [49], it is likely that the actual number of potential hosts is much higher.

Table 2. Genera of Curculionidae known to be hosts of the Moroccan biotype of *Microctonus aethiopoidea* in New Zealand and the number of species known to be attacked in the laboratory and in the field. NT = not tested; ND = not determined.

Subfamily: Tribe	Genus	Species Attacked		Status in New Zealand
		Lab	Field	
Entiminae: Leptopiini	<i>Irenimus</i>	NT	1	endemic
“	<i>Chalepistes</i>	5	6	endemic
“	<i>Nicaeana</i>	1	4	endemic
“	<i>Nonnotus</i>	NT	1	endemic
	<i>Protolobus</i>	1	ND	endemic
Entiminae: Naupactini	<i>Atrichonotus</i>	NT	1	adventive
Curculioninae: Eugnomini	<i>Eugnomus</i>	NT	1	endemic
Cyclominae: Listroderini	<i>Listronotus</i>	1	1	adventive
“	<i>Listroderes</i>	0	1	adventive
“	<i>Steriphus</i>	1	1	endemic
Lixinae: Cleonini	<i>Rhinocyllus</i>	1	1	adventive

As the early exploratory work involving *M. aethiopoidea* in Morocco did not aim to determine the extent to which a wider range of possible host species might be present, further research was carried out in Morocco with this goal [50]. Using this retrospective example, we wanted to advise New Zealand regulators on whether information on host breadth in the natural range (Morocco) could have helped predict the greater than expected host range that we had found post-release in New Zealand. This was considered as a model case study to test the value of natural-range research, particularly natural host range in general. Monthly sampling in lucerne crops in three regions of Morocco over a nine-month period collected over 3500 specimens of weevils, of which the majority were *S. discoideus*. However, almost 600 specimens of other weevils (46 species in four families and 11 subfamilies) were found. *Hypera postica* (Gyllenhal) was also commonly collected. In all, 13 weevil species containing parasitoids consistent with *M. aethiopoidea* were found by dissection: eight species of *Sitona*, *Charagmus gressorius* (Fabricius) and *C. griseus* (Fabricius) and three species of *Hypera* [51]. This study increased the known number of genera parasitised by *M. aethiopoidea* by only the two species of *Charagmus* Schoenherr, but as *Charagmus* had been considered as a subgenus of *Sitona* until 2007 [52], in effect the natural host range had not been expanded at all by this study.

As it was already known in 1977 that *M. aethiopoidea* also attacks *Hypera* in its native range [39], the potential for the parasitoid to attack native species, at least in Australia where species of Hyperinae were known to occur, should have been recognised. The phylogenetic relationship between Hyperinae and Sitonini (and Entiminae overall) was poorly understood in the 1970s and is still not resolved. All recent molecular phylogenetic analyses [13–16,53–55] recovered a close relationship between Hyperinae and Entiminae, although taxon sampling was too small and patchy in all of them to

properly elucidate this relationship. Both *Hypera* (Hyperini or Hyperinae) and *Sitona* have usually been recovered in basal positions in relation to Entiminae, either separate from each other [55] or in some clade together [14,15,53], although in the analysis of McKenna et al. [54] both genera appeared bedded inside different, mixed clades of Entiminae and Cyclominae and in that of Gunter et al. [13] the three Australian genera of Hyperinae (*Hypera* not included) clustered with the genus *Steriphus* Erichson (Cyclominae: Listroderini) in some analyses, whereas *Sitona* grouped separately on a long branch. Strong support for a position of *Hypera* (Hyperinae) as sister-group of Entiminae + Cyclominae was found by Shin et al. [16], but their analysis did not include *Sitona* nor a sufficient number of other Entiminae, Hyperinae and Cyclominae to resolve the exact relationships between *Sitona* and *Hypera* and between Entiminae and Hyperinae overall.

This uncertainty notwithstanding, it is evident that a deep-level relationship exists between *Hypera* and Entiminae-Cyclominae, estimated to date back ca. 60 million years [16], implying that any parasitoid that develops in both *Hypera* and *Sitona* has the potential to also parasitise most other taxa of Entiminae and Cyclominae. The existence of different biotypes of *M. aethiopoidea* seemingly adapted to either *Hypera* or *Sitona* (or even different species of *Sitona*) suggests that its host range is not nearly as wide as encompassing all Entiminae and Cyclominae, but it appears impossible to predict which taxa of these subfamilies from outside the native range of *M. aethiopoidea* may be susceptible to parasitism by one or another of its biotypes. In our view, such non-target parasitism stands not only to negatively affect such taxa but also to dilute the intended biocontrol of the target species.

3.2. Case Study: *Anaphes nitens* (Girault) for Biological Control of *Gonipterus scutellatus*

The mymarid wasp *Anaphes nitens* is a parasitoid of the eggs of weevils in the genus *Gonipterus* Schoenherr and perhaps other genera of the small Australo-Pacific tribe Gonipterini, which, like Hyperinae, is related to the subfamilies Entiminae and Cyclominae but with its precise relationships to these also unclear [16,56]. Both adults and larvae of *Gonipterus* (and of some other Gonipterini) feed on the leaves of *Eucalyptus* and related genera of Myrtaceae. One species of *Gonipterus*, named *G. scutellatus* Gyllenhal, was accidentally introduced into South Africa in 1916 and rapidly became a major defoliator of eucalypt plantations there, spreading in a span of 30 years from the Western Cape province eastwards across the country and then northwards along the eastern side of Africa to Kenya and Uganda, as well as to Mauritius and Madagascar in the Indian Ocean. In 1925 *Gonipterus* weevils also appeared in Argentina and gradually spread northwards along the east coast of South America, reaching Espirito Santo in Brazil in 2018, and from the 1990s they also appeared in Chile, California, Hawaii, the Canary Islands and south-western Europe (Italy, France, Portugal and Spain). In all locations where it established, the weevil caused major defoliation of eucalypt plantations and significant losses for the timber and paper industries based on these trees. In 1925 the South African government embarked on a search for natural enemies of the weevil in Australia, discovering and importing a suitable egg-parasitic wasp (*A. nitens*) and releasing, between 1927 and 1933, about 0.75 million parasitoids in the country [57]. The biocontrol was a huge success, parasitism levels reached 98 % and by 1940 *Gonipterus* was effectively under total control in the country, except for a small region on the Transvaal Highveld and surrounding montane regions. This effort of classical biological control was considered so successful that a monument and plaque was erected for it in 1995 at Cedara in KwaZulu-Natal [58].

Following the success of this biological control, other countries suffering under *Gonipterus* imported the parasitoid species from South Africa, but while it proved equally successful in other African countries, it was far less effective in other parts of the world, particularly in Spain [59,60], Portugal [61] and Chile [62]. Also in Western Australia, where *Gonipterus* weevils had appeared in plantations of *Eucalyptus globulus* in about 1995, control by *A. nitens* was patchy and ineffective [63]. The limited success to failure of the biocontrol efforts in these countries was generally ascribed to climatic factors, in particular low temperatures during winter and at higher altitudes, which were thought to exceed the temperature tolerance of the parasitoid but not that of the weevil. However,

Loch [63] raised the possibility that *G. scutellatus* may be a complex of sibling species and that the identity of the weevil species could play a role in the differential successes of the biocontrol efforts.

The identity of the *Gonipterus* weevil in South Africa had been controversial from the start. It was originally identified by the Commonwealth Institute of Entomology in London (G. A. K. Marshall) as *G. reticulatus* Boisduval in 1916 but revised to *G. scutellatus* by Marshall in 1921, whereas in Australia it was identified as *G. rufus* Blackburn by N. Tindale in 1924 and as *G. gibberus* Boisduval by A. M. Lea in 1926 [57]. At the same time, the *Gonipterus* weevils introduced to New Zealand were identified as *G. exaratus* Fåhraeus by H. M. Nicholls in 1924 [57] and those in Argentina were described by C. A. Marelli as *Dacnirotatus bruchi* and *D. platensis* [64], but Marshall changed the names of the latter two species to *Gonipterus gibberus* and *G. platensis* after he examined Marelli's specimens and recognised them as being Australian, not South American [65,66]. Tooke [57] eventually settled on the name *G. scutellatus* for the weevil in South Africa, and this name was accepted in other countries as well, especially after the name *G. platensis* was synonymised with *G. scutellatus* [67] and later also the names *G. gibberus*, *G. exaratus* and *G. notographus* [68]. Only Rosado-Neto and Marques [69] did not agree, drawing attention to differences in the male genitalia of the *Gonipterus* weevils in Argentina (detected and illustrated before by Vidal Sarmiento [70]) and recognising two species in South America, named *G. gibberus* and *G. scutellatus*.

Against this background of uncertainty about the identities of the weevils and the varying success of the biocontrol programs using *A. nitens*, a molecular analysis was conducted in Australia [71] in conjunction with a taxonomic study of the genus *Gonipterus* (Oberprieler, in prep.). Together these studies revealed that *G. "scutellatus"* is indeed a complex of externally similar species, though well distinct in their male genitalia as well as genetically [71]. Specifically, they showed that: (1) none of the invasive *Gonipterus* species outside of Australia represent *G. scutellatus* (which is a comparatively rare species restricted to Tasmania); (2) the species occurring throughout Africa and into Italy is undescribed; (3) the species present in France, Spain, Portugal, California, Hawaii, Chile, Argentina, Brazil, Uruguay, New Zealand and Western Australia is a different one, named *G. platensis* (Marelli), which is native to Tasmania but had not been described from Australia; (4) there is indeed a second species in Argentina, Brazil and Uruguay, described as *G. pulverulentus* Lea from Australia; (5) the *G. scutellatus* complex comprises three further undescribed species (in fact there are more); (6) *G. exaratus*, *G. gibberus* and *G. notographus* are all different species but do not belong in the *G. scutellatus* complex. The COI-based phylogenetic reconstruction of the *G. scutellatus* complex [71] indicates that *G. platensis* and *G. pulverulentus* are not too closely related to the undescribed species (sp. n. 2) in Africa and Italy, which is closer to *G. scutellatus* and also to *G. balteatus* Pascoe. This relationship is also borne out by the male genitalia; the differences in the copulatory sclerite between *G. platensis* and *G. pulverulentus* (as illustrated by Rosado-Neto and Marques [69]) and *Gonipterus* sp. n. 2 are distinct and very consistent.

It is thus evident that the hailed story of the successful biocontrol of *Gonipterus scutellatus* is based on a mistake in identification as well as on a fundamental flaw of the biocontrol program. The *Gonipterus* species in Africa was thought to have originated from Tasmania [57,72], yet the *Anaphes* parasitoid imported into South Africa to control it was collected at Penola in South Australia. Unbeknown to Tooke and his colleagues, the *Gonipterus* species in South Africa (sp. n. 2) is native in South Australia (it occurs throughout south-eastern Australia), so Tooke quite by chance collected the correct parasitoid species for it. In contrast, *G. platensis*, the species introduced into South America, western Europe and the U.S.A., is native in Tasmania and does not occur on the Australian mainland, whereas *A. nitens* does not occur in Tasmania, as far as is known (though other species of *Anaphes* do [73]). By importing *A. nitens* from South Africa, countries such as Argentina, France, Spain, the U.S.A. and Chile released a parasitoid against *G. platensis* that is not ideally equipped to control it. It was recently shown that net reproductive rates of *A. nitens* are higher at temperatures between 20 and 25 °C, whereas those of *A. inexpectatus* Huber & Prinsloo, sourced from the native range of *P. platensis* in Tasmania, are higher at temperatures between 10 and 15 °C, making the latter parasitoid species better

equipped to control this weevil in colder conditions (spring and higher altitudes) [60]. The ecologically mismatched *A. nitens* is able to control *G. platensis* adequately in warmer areas of Portugal and has thus provided an economic benefit of 1.8–6.5 billion Euro over 20 years (1996–2016) [74], but the weevil still causes wood loss of up to 86 % in plantations of *Eucalyptus globulus* in some areas [61]. If Tooke had searched for natural enemies of *Gonipterus* sp. n. 2 in Tasmania and imported *A. inexpectatus* into South Africa, the biocontrol program there may have been similarly less effective and far less successful than that achieved with *A. nitens*. He imported the correct parasitoid purely by chance.

4. Discussion

A recent analysis of the entire BIOCAT database of insect biological control agents up to 2010 reported that 32 % of biological control introductions have resulted in establishment and about 10 % have resulted in satisfactory control [18]. The equivalent metrics for weevils as targets of biological control are 63 % established and 31 % providing some control. Those providing complete or substantial control comprise almost 16 % of those established, although this would not necessarily be the case throughout the range where each biological control agent has been introduced. Nevertheless, these data do indicate that biological control of pest weevils has enjoyed a higher level of success than would be expected on average, contrary to the observation of Waterhouse and Norris [20], working in the Pacific region, that weevils are poor candidates for biological control. More research effort has gone into biological control programs in recent years, for example to ensure an appropriate climate match between a BCA and its intended target (e.g., [75]), to assist in the exploration for the best-adapted biotypes or provenance of BCAs [76] and to ensure that the most effective natural enemy biotypes [40] are selected for introduction, and consequently success rates have increased [18].

The two case studies included in this contribution have demonstrated how phylogeny and taxonomy have been important factors in risk assessment and biocontrol efficacy, respectively. It is well accepted that host phylogeny is an important determining factor in most parasitoid/host relationships and hence its importance in risk assessment (e.g., [8]). The close dependence of successful biological control on taxonomy has also been emphasized by many practitioners (e.g., [22]), and the careful alignment of these disciplines is vital for a desirable outcome. These examples demonstrate the challenges of working with target species from such a large, complex and phylogenetically poorly resolved family as the Curculionidae. The importance of accurate taxonomy both for the pest and biological control agent has long been recognised [77,78], and there are well known examples of biological control failure resulting from poor differentiation between species. For example, initial attempts to control California Red Scale (*Aonidiella aurantii* (Maskell)) failed not only because the pest species was not accurately identified, but confusion between species of the natural enemy *Aphytis* Howard (Hymenoptera: Aphelinidae) delayed the selection of effective species for biological control [22]. Nowadays, molecular techniques have become commonplace tools for resolving problems of differentiation between morphologically cryptic or indistinct species [79].

Insects and their natural enemies, parasitoids in particular, have generally coevolved in their natural range, and therefore phylogenetic relationships understandably feature prominently in biological control risk assessment. Host-specific parasitoids are generally selected in preference over generalists (for reasons of biosafety), and so it is expected that closely related hosts are more likely to be at risk from attack of a parasitoid than a more distantly related species. This principle is well accepted and tested in weed biological control [80,81]. Insect biological control is complicated by an extra trophic level (host food plant), not to mention the much larger number of potential non-target hosts, and although studies have shown that host phylogeny is often a strong factor in host selection by parasitoids and indeed parasitoid performance in a host (e.g., [82]), host ecology can also be a determinant of host selection. For example, host use by parasitoids of leaf-mining insects was shown to be capable of spanning several orders of insects [83].

The biosafety record of biological control programs targeting weevils is poorly known, as indeed for most insect biological control programs. Other than the research carried out in Australasia for

M. aethiopoides, there appear to be few records of non-target attack by natural enemies of weevil hosts. For the two examples from the BIOCAT database mentioned above, for which complete control has been reported (*Anaphes nitens* and *Lixophaga sphenophori*), the literature has revealed no example of non-target attack by either BCA. Another species of the tachinid genus *Lixophaga* (*L. diatraeae* (Townsend)), which attacks Crambidae stem borers of Poaceae, has been cultured on alternative Crambidae hosts in the laboratory. However, this tachinid is larviparous, and the rearing technique is based on dissecting the active first-instar larvae from the gravid female *L. diatraeae* and physically transferring them onto other potential hosts. This gives no useful indication of what may happen in the field, from where non-target records are not reported [84].

Undoubtedly more research post-release of biological control agents to verify pre-release predictions would help to provide greater certainty in biosafety risk assessments. Our research in New Zealand, Australia and Morocco on *M. aethiopoides* was carried out with the intention of providing information on the predictive value of natural host range research [51], the expectation at the outset being that a wider range of hosts would be revealed in Morocco, given what we had discovered post-release in New Zealand in particular. However, our findings showed that the taxonomic breadth of the natural host range was actually quite narrow and that host range testing could have been much better informed by the current understanding of phylogenetic relationships within the family Curculionidae. This is clearly a conclusion that can probably be extended more widely across many target groups.

Poor knowledge of the taxonomy, phylogeny and ecology of potential non-target species in the receiving environment is often a severe challenge for predicting non-target impacts as part of a biological control risk assessment (e.g., [85,86]). A risk assessment for the eulophid wasp *Phymastichus coffea* La Salle for biological control of the scolytine weevil *Hypothenemus hampei* (Ferrari) in coffee was carried out [87], and although some non-target attack on scolytines was predicted in genera related to the target, it was argued that so little is known about the scolytine fauna in Colombia that identifying potential non-target hosts for laboratory testing was impossible.

The discovery that *Gonipterus scutellatus* as referred to in the literature comprises a complex of several very similar species with different geographical ranges and host preferences [71,88] illustrates the critical need of accurate identification of both the target (host) and the biocontrol agent. In taxonomically complicated cases the biocontrol program may need to commission specific taxonomic research into the relevant taxa, as occurs in biological control of weeds, e.g., of *Salvinia* by *Cyrtobagous* Hustache weevils [89] and of *Carduus* and *Onopordum* thistles by *Trichosirocalus* Colonnelli weevils [90]. Molecular markers (such as DNA “barcoding”) can often help in distinguishing closely related species, but generally morphological assessment (including examination of old type specimens) is needed to assign the correct names to the different species. Further, biocontrol programs of apparently the same target species in different countries need to ensure that this is indeed the case and confirm the identity of the targets in different regions or countries both macroscopically and genetically/biologically (races, biotypes).

In view of the non-target parasitism displayed by *M. aethiopoides* in New Zealand and how this may have been predicted by an understanding of the phylogenetic relationships of its natural hosts, the success of the biocontrol of *Gonipterus* is probably in part ascribable to the fact that the tribe Gonipterini is restricted to the Australo-Pacific region and has no known close relatives in Africa, America and Europe. It does, however, belong in the same clade as the tribe Hyperini (or subfamily Hyperinae), which occurs in Africa as in other areas where *Gonipterus* has become invasive and which also has ectophytic larvae [56]. For egg parasitoids such as *Anaphes nitens* this may not be so relevant as *Gonipterus* lays its eggs in a hard capsule on the surface of leaves, whereas the eggs of Hyperini as known are laid between plant parts. However, for larval parasitoids such as the eulophid *Entedon* Dahlman [62] the nature of the phylogenetic relationship between Gonipterini and Hyperini would be of greater importance if these parasitoids were considered as biocontrol agents.

5. Conclusions

We do not believe that the issues raised by this review of classical biological control of Curculionidae are unusual compared to other groups for which biological control has been used, although the enormous diversity of and the lack of clear phylogenetic relationships in Curculionidae have exacerbated this. The combination of traditional taxonomy and new molecular tools will remain an essential component of the good practice of biological control in the future.

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Appendix A

Table A1. Weevil species that have become targets for biological control programs, their origin and countries where biological control agents have been recorded as established and their impact. Data from BIOCAT2010.1. The BIOCAT database maintained by CABI aims to be comprehensive, but inevitably some relevant publications have been overlooked, and records of introductions focus on what is perceived to be the primary target pest, and may omit or condense data on actual or potential secondary targets.

Target Taxon				Biological Control Agent						
Subfamily	Genus Species	Crop	Origin	Biocontrol Agent	Ord: Family	BCA Origin	Stage Attacked	Release Country	Impact *	Ref. in BIOCAT
Curculioninae	<i>Anthonomus eugeni</i>	<i>Piper</i> spp.	Mexico	<i>Eupelmus cushmani</i>	Hymenoptera: Eupelmidae	Guatemala	larva	USA, Mexico, Central America	NC	[91]
Curculioninae	<i>Anthonomus eugeni</i>	<i>Piper</i> spp.	Mexico	<i>Pteromalus hunteri</i>	Hymenoptera: Pteromalidae	Guatemala	larva	USA, Hawaii	NC	[91]
Curculioninae	<i>Gonipterus</i> sp.n. 2	eucalypts	Australia	<i>Anaphes nitens</i>	Hym: Mymaridae	Australia	egg	NZ, S. America, Europe, Africa, USA, Madagascar	CC Madagascar, PC-SC elsewhere	[92]
Curculionidae	<i>Gonipterus pulverulentus?</i>	eucalypts	Australia	<i>Anaphes nitens</i>	Hymenoptera: Mymaridae	Australia	egg	Argentina	NC	[93]
Cyclominae	<i>Listronotus bonariensis</i>	pasture grasses	South America	<i>Microctonus hyperodae</i>	Hymenoptera: Braconidae	Argentina	adult	NZ	SC	[94]
Cyclominae	<i>Listroderes difficilis "costirostris"</i>	vegetables	South America	<i>Stethantyx parkeri</i>	Hymenoptera: Ichneumonidae	Argentina, Uruguay	larva	Australia	NC	[95]
Dryophthorinae	<i>Cosmopolites sordidus</i>	banana	Malaysia	<i>Dactylosternum abdominale</i>	Coleoptera: Hydrophilidae		predator	Australia, Jamaica	PC Jamaica, NC Australia	[20,84,96]
Dryophthorinae	<i>Cosmopolites sordidus</i>	banana	Malaysia	<i>Dactylosternum hydrophiloides</i>	Coleoptera: Hydrophilidae	Malaysia, Pacific	predator	Jamaica, Australia	PC Jamaica, NC Australia	[95]
Dryophthorinae	<i>Cosmopolites sordidus</i>	banana	Malaysia	<i>Plaesius javanus</i>	Coleoptera: Histeridae	Indonesia	predator	France, Jamaica, Mexico, Palau, Samoa, Tonga, Trinidad and Tobago, USA	PC Jamaica, NC elsewhere	[20]
Dryophthorinae	<i>Cosmopolites sordidus</i>	banana	Malaysia	<i>Plaesius laevigatus</i>	Coleoptera: Histeridae	Indonesia	predator	Cook Islands, Fiji	PC Fiji, NC Cook Isls.	[20]
Hyperinae	<i>Hypera postica</i>	lucerne	Europe	<i>Bathyplectes anurus</i>	Hymenoptera: Ichneumonidae	Europe	larva	USA, Canada, Japan	PC Japan, NC elsewhere	[93,97,98]
Hyperinae	<i>Hypera postica</i>	lucerne	Europe	<i>Bathyplectes curculionis</i>	Hymenoptera: Ichneumonidae	Europe	larva	USA, Canada	PC USA, NC Canada	[93,98]
Hyperinae	<i>Hypera punctata</i>	lucerne, clover	Europe	<i>Bathyplectus infernalis</i>	Hymenoptera: Ichneumonidae	Italy	larva	USA	SC	[93]
Hyperinae	<i>Hypera postica</i>	lucerne	Europe	<i>Oomyzus (syn Tetrastichus) incertus</i>	Hymenoptera: Eulophidae	Europe	larva	USA, Canada	NC	[93,98]
Hyperinae	<i>Hypera postica</i>	lucerne	Europe	<i>Microctonus colesi</i>	Hymenoptera: Braconidae	Iran	adult	USA	NC	[93,98]

Table A1. Cont.

Target Taxon				Biological Control Agent						
Subfamily	Genus Species	Crop	Origin	Biocontrol Agent	Ord: Family	BCA Origin	Stage Attacked	Release Country	Impact *	Ref. in BIOCAT
Hyperinae	<i>Hypera postica</i>	lucerne	Europe	<i>Bathyplectes stenostigma</i>	Hymenoptera: Ichneumonidae	Europe	larva	USA	NC	[93]
Hyperinae	<i>Hypera postica</i>	lucerne	Europe	<i>Coelopisthia extenta</i>	Hymenoptera: Pteromalidae	Europe	larva	USA	NC	[93]
Hyperinae	<i>Hypera postica</i>	lucerne	Europe	<i>Peridesmia discus</i>	Hymenoptera: Pteromalidae	Europe	egg predator	USA	NC	[99]
Hyperinae	<i>Hypera brunnipennis</i>	lucerne	Europe	<i>Coelopisthia extenta</i>	Hymenoptera: Pteromalidae	Europe	larva	USA	NC	[93]
Entiminae	<i>Diaprepes abbreviatus</i>	citrus	Caribbean	<i>Aprostocetus vaquitarum</i>	Hymenoptera: Eulophidae	Dominica	egg	USA (Florida)	PC	[100]
Entiminae	<i>Diaprepes abbreviatus</i>	citrus	Caribbean	<i>Quadrastichus haitiensis</i>	Hymenoptera: Eulophidae	Puerto Rico	egg	USA	NC	[101]
Entiminae	<i>Sitona discoideus</i>	lucerne (<i>Medicago sativa</i>)	Mediterranean	<i>Microctonus aethiopoies</i>	Hymenoptera: Braconidae	Morocco, Greece	adult	Australia, NZ, USA, Canada	SC NZ, PC elsewhere	[95,102,103]
Entiminae	<i>Sitona obsoletus</i>	white clover		<i>Microctonus aethiopoies</i>	Hymenoptera: Braconidae	Ireland	adult	NZ	SC	[104]
Entiminae	<i>Sitona cylindricollis</i>	Sweet clover		<i>Pygostolus falcatus</i>	Hymenoptera: Braconidae	Sweden	adult	Canada	NC	[105]
Entiminae	<i>Sitona hispidulus</i>	lucerne		<i>Anaphes diana</i>	Hymenoptera: Mymaridae	Europe	egg	USA	NC	[106]
Molytinae	<i>Syagrius fulvitaris</i>	ferns	Australia	<i>Jarra syagrii</i>	Hymenoptera: Braconidae	Australia	larva?	USA, Hawaii	NC	[91]
Dryophthorinae	<i>Rhabdoscelus obscurus</i>	sugar cane	Papua New Guinea	<i>Dactylosternum hydrophiloides</i>	Coleoptera: Hydrophilidae	Philippines	predator	USA, Hawaii	NC	[91]
Dryophthorinae	<i>Rhabdoscelus obscurus</i>	sugar cane	Papua New Guinea	<i>Fulvius brevicornis</i>	Hemiptera: Miridae	Philippines		USA, Hawaii	NC	[91]
Dryophthorinae	<i>Rhabdoscelus obscurus</i>	sugar cane	Papua New Guinea	<i>Lixophaga sphenophori</i>	Diptera: Tachinidae	Papua New Guinea	larva	Australia, Fiji, USA, Hawaii	CC USA, NC elsewhere	[91,95]
Scotyinae	<i>Dendroctonus micans</i>	spruce	Europe, Asia	<i>Rhizophagus grandis</i>	Coleoptera: Monotomidae	Belgium	predator on larva	France, Georgia, UK	PC Georgia and UK, NC France	[107,108]
Scotyinae	<i>Dendroctonus terebrans</i>	<i>Pinus</i> spp.	USA	<i>Rhizophagus grandis</i>	Coleoptera: Monotomidae	Belgium	predator on larva	USA	U	[109]
Scotyinae	<i>Ips grandicollis</i>	<i>Pinus</i> spp.	USA, Canada	<i>Dendrosoter sulcatus</i>	Hymenoptera: Braconidae	USA	adult	Australia	NC	[95]
Scolytinae	<i>Ips grandicollis</i>	<i>Pinus</i> spp.	USA, Canada	<i>Roptrocercus xylophagorum</i>	Hymenoptera: Pteromalidae	USA	larva	Australia	PC	[95]
Scolytinae	<i>Orthotomicus erosus</i>	<i>Pinus</i> spp.		<i>Dendrosoter caenopchoides</i>	Hymenoptera: Braconidae	Israel		South Africa	NC	[110]

Table A1. Cont.

Target Taxon			Biological Control Agent							
Subfamily	Genus Species	Crop	Origin	Biocontrol Agent	Ord: Family	BCA Origin	Stage Attacked	Release Country	Impact *	Ref. in BIOCAT
Scolytinae	<i>Scolytus rugulosus</i>	peach		<i>Rhaphitelus maculatus</i>	Hymenoptera: Pteromalidae	USA	larva?	Chile	PC	[111]
Scolytinae	<i>Scolytus multistriatus</i>	Elm		<i>Dendrosoter protruberans</i>	Hymenoptera: Braconidae	France	larva	USA	NC	[112]
Scolytinae	<i>Hypothenemus hampei</i>	coffee	Africa	<i>Cephalonomia stephanoderis</i>	Hymenoptera: Bethyidae	Africa	larva/pupa	Central America, India	U	[113,114]
Scolytinae	<i>Hypothenemus hampei</i>	coffee	Africa	<i>Phymastichus coffea</i>	Hymenoptera: Eulophidae	Africa	adult	Central America, India	U	[115,116]
Scolytinae	<i>Hypothenemus hampei</i>	coffee	Africa	<i>Prorops nasuta</i>	Hymenoptera: Bethyidae	Africa	larva/pupa	Central America, Brazil, India	U	[113,114]
Scolytinae	<i>Hylastes ater</i>	Pinus spp		<i>Thanasimus formicarius</i>	Coleoptera: Cleridae	Austria	predator	New Zealand	NC	[102]

* NC = no control, PC = partial control, SC = substantial control, CC = complete control, U = unknown impact.

References

1. Barratt, B.I.P.; Ehlers, G.A.C. Impacts of exotic biological control agents on non-target species and biodiversity: Evidence, policy and implications. In *Environmental Pest Management: Challenges for Agronomists, Ecologists, Economists and Policymakers*; Coll, M., Wajnberg, E., Eds.; John Wiley & Sons Ltd.: Oxford, UK, 2017; pp. 325–346.
2. Kenis, M.; Auger-Rozenberg, M.; Roques, A.; Timms, L.; Péré, C.; Cock, M.J.W.; Settele, J.; Augustin, S.; Lopez-Vaamonde, C. Ecological effects of invasive alien insects. *Biol. Invasions* **2009**, *11*, 21–45. [[CrossRef](#)]
3. Tylianakis, J.M.; Binzer, A. Effects of global environmental changes on parasitoid–host food webs and biological control. *Biol. Control* **2013**, *75*, 77–86. [[CrossRef](#)]
4. Hopper, K.R.; Wajnberg, E. Risks of interbreeding between species used in biological control and native species, and methods for evaluating their occurrence and impact. In *Environmental Impact of Arthropod Biological Control: Methods and Risk Assessment*; Kuhlmann, U., Bigler, F., Babendreier, D., Eds.; CABI Publishing: Delemont, Switzerland, 2006; pp. 78–97.
5. Van Veen, F.J.; Memmott, J.; Godfray, H.C.J. Indirect effects, apparent competition and biological control. In *Trophic and Guild Interactions in Biological Control*; Brodeur, J., Boivin, G., Eds.; Springer: Dordrecht, The Netherlands, 2006; pp. 145–169.
6. Barratt, B.I.P. Assessing safety of biological control introductions. *CAB Rev. Perspect. Agric. Vet. Sci. Nutr. Nat. Resour.* **2011**, *6*, 1–12. [[CrossRef](#)]
7. Bigler, F.; Bale, J.S.; Cock, M.J.W.; Dreyer, H.; Greatrex, U.; Kuhlmann, U.; Loomans, A.J.M.; Van Lenteren, J.C. Guidelines on information requirements for import and release of invertebrate biological control agents in European countries. *Biocontrol News Inf.* **2005**, *26*, 115N–123N. [[CrossRef](#)]
8. Kuhlmann, U.; Schaffner, U.; Mason, P.G. Selection of non-target species for host specificity testing. In *Environmental Impact of Invertebrates for Biological Control of Arthropods: Methods and Risk Assessment*; Bigler, F., Babendreier, D., Kuhlmann, U., Eds.; CABI Publishing: Wallingford, Oxford, UK, 2006; pp. 15–37.
9. Goolsby, J.A.; Klinken, R.D.V.; Palmer, W.A. Maximizing the contribution of native-range studies towards the identification and prioritization of weed biological control agents. (Special issue: Agent selection in weed biocontrol). *Aust. J. Entomol.* **2006**, *45*, 276–286. [[CrossRef](#)]
10. Barratt, B.I.P. BIREA—Biocontrol Information Resource for ERMA New Zealand applicants. *Forest Health News Magazine*, May 2007; 2.
11. Oberprieler, R.G.; Marvaldi, A.E.; Anderson, R.S. Weevils, weevils, weevils everywhere. *Zootaxa* **2007**, *1668*, 491–520.
12. Kuschel, G. A Phylogenetic Classification of Curculionoidea to Family and Subfamily Level, Biology and Phylogeny of Curculionoidea. *Mem. Entomol. Soc. Wash.* **1995**, *14*, 5–33.
13. Gunter, N.L.; Oberprieler, R.G.; Cameron, S.L. Molecular phylogenetics of Australian weevils (Coleoptera: Curculionoidea): Exploring relationships in a hyperdiverse lineage through comparison of independent analyses. *Aust. Entomol.* **2016**, *55*, 217–233. [[CrossRef](#)]
14. Gillett, C.P.D.T.; Crampton-Platt, A.; Timmermans, M.J.T.N.; Jordal, B.; Emerson, B.C.; Vogler, A.P. Bulk de novo mitogenome assembly from pooled total DNA elucidates the phylogeny of weevils (Coleoptera: Curculionoidea). *Mol. Biol. Evol.* **2014**, *31*, 2223–2237. [[CrossRef](#)] [[PubMed](#)]
15. Gillett, C.P.D.T.; Lyal, C.H.C.; Vogler, A.P.; Emerson, B.C. Statistical evaluation of monophyly in the ‘broad-nosed weevils’ through molecular phylogenetic analysis combining mitochondrial genome and single-locus sequences (Curculionidae: Entiminae, Cyclominae, and Hyperinae). *Diversity* **2018**, *10*, 21. [[CrossRef](#)]
16. Shin, S.; Clarke, D.J.; Lemmon, A.R.; Moriarty-Lemmon, E.; Aitken, A.L.; Haddad, S.; Farrell, B.D.; Marvaldi, A.E.; Oberprieler, R.G.; McKenna, D.D. Phylogenomic data yield new and robust insights into the phylogeny and evolution of weevils. *Mol. Biol. Evol.* **2017**, *35*, 823–836. [[CrossRef](#)] [[PubMed](#)]
17. Clewley, G.D.; Eschen, R.; Shaw, R.H.; Wright, D.J. The effectiveness of classical biological control of invasive plants. *J. Appl. Ecol.* **2012**, *49*, 1287–1295. [[CrossRef](#)]
18. Cock, M.J.W.; Murphy, S.T.; Kairo, M.T.K.; Thompson, E.; Murphy, R.J.; Francis, A.W. Trends in the classical biological control of insect pests by insects: An update of the BIOCAT database. *BioControl* **2016**, *61*, 349–363. [[CrossRef](#)]

19. Kenis, M.; Hurley, B.P.; Hajek, A.E.; Cock, M.J.W. Classical biological control against insect pests of trees: Facts and figures. *Biol. Invasions* **2017**, *19*, 3401–3417. [[CrossRef](#)]
20. Waterhouse, D.F.; Norris, K.R. *Biological Control Pacific Prospects*; Inkata Press: Melbourne, Australia, 1987; p. 454.
21. Barratt, B.I.P.; Evans, A.A.; Johnstone, P.D. Effect of the ratios of *Listronotus bonariensis* and *Sitona discoideus* (Coleoptera: Curculionidae) to their respective parasitoids *Microctonus hyperodae* and *Microctonus aethiopoidea* (Hymenoptera: Braconidae), on parasitism, host oviposition and feeding in the laboratory. *Bull. Entomol. Res.* **1996**, *86*, 101–108.
22. Rosen, D. The role of taxonomy in effective biological control programs. *Spec. Issue Invertebr. Biodivers. Bioindic. Sustain. Landsc.* **1986**, *15*, 121–129. [[CrossRef](#)]
23. Sands, D.P.A.; van Driesche, R.G. Using the scientific literature to estimate the host range of a biological control agent. In *Assessing Host Ranges for Parasitoids and Predators Use for Classical Biological Control: A Guide to Best Practice*; van Driesche, R.G., Reardon, R., Eds.; Forest Health Technology Enterprise Team, Forest Service, USDA: Morgantown, WV, USA, 2004; pp. 15–23.
24. European and Mediterranean Plant Protection Organization. Import and release of non-indigenous biological control agents. *Bull. OEPP/EPPO Bull.* **2010**, *40*, 335–344.
25. HSNO Act (Hazardous Substances and New Organisms Act). Available online: http://www.chemsafetypro.com/Topics/NZ/HSNO_Act_Hazardous_Substances_and_New_Organisms_Act.html (accessed on 15 June 2018).
26. Sheppard, A.W. Prioritising agents based on predicted efficacy: Beyond the lottery approach. In *Improving the Selection, Testing and Evaluation of Weed Biocontrol Agents*; Spafford-Jacobs, H., Briese, D.T., Eds.; Cooperative Research Centre for Australian Weed Management: Adelaide, Australia, 2003; pp. 11–21.
27. Stouthamer, R. Molecular methods for the identification of biological control agents at the species and strain level. In *Environmental Impact of Invertebrates for Biological Control of Arthropods: Methods and Risk Assessment*; Bigler, F., Babendreier, D., Kuhlmann, U., Eds.; CABI Publishing: Wallingford, Oxon, UK, 2006; pp. 187–201.
28. Janzen, D.H.; Hallwachs, W.; Blandin, P.; Burns, J.M.; Cadiou, J.-M.; Chacon, I.; Dapkey, T.; Deans, A.R.; Epstein, M.E.; Espinoza, B.; et al. Integration of DNA barcoding into an ongoing inventory of complex tropical biodiversity. *Mol. Ecol. Resour.* **2009**, *9*, 1–26. [[CrossRef](#)] [[PubMed](#)]
29. Smith, M.A.; Wood, D.M.; Janzen, D.H.; Hallwachs, W.; Hebert, P.D.N. DNA barcodes affirm that 16 species of apparently generalist tropical parasitoid flies (Diptera, Tachinidae) are not all generalists. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 4967–4972. [[CrossRef](#)] [[PubMed](#)]
30. Smith, M.A.; Rodriguez, J.J.; Whitfield, J.B.; Deans, A.R.; Janzen, D.H.; Hallwachs, W.; Hebert, P.D.N. Extreme diversity of tropical parasitoid wasps exposed by iterative integration of natural history, DNA barcoding, morphology, and collections. *Proc. Natl. Acad. Sci. USA* **2008**, *105*, 12359–12364. [[CrossRef](#)] [[PubMed](#)]
31. Cory, J.S.; Myers, J.H. Direct and indirect ecological effects of biological control. *Trends Ecol. Evol.* **2000**, *15*, 137–139. [[CrossRef](#)]
32. Briese, D.T.; Walker, A. Choosing the right plants to test: The host-specificity of *Longitarsus* sp. (Coleoptera: Chrysomelidae) a potential biological control agent of *Heliotropium amplexicaule*. *Biol. Control* **2008**, *44*, 271–285. [[CrossRef](#)]
33. Cullen, J.M.; Hopkins, D.C. Rearing, release and recovery of *Microctonus aethiopoidea* Loan (Hymenoptera: Braconidae) imported for the control of *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) in south eastern Australia. *J. Austr. Entomol. Soc.* **1982**, *21*, 279–284. [[CrossRef](#)]
34. Aeschlimann, J.P. Sources of importation, establishment and spread in Australia of *Microctonus aethiopoidea* Loan (Hymenoptera: Braconidae), a parasitoid of *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae). *J. Austr. Entomol. Soc.* **1983**, *22*, 325–331. [[CrossRef](#)]
35. Stufkens, M.W.; Farrell, J.A.; Goldson, S.L. Establishment of *Microctonus aethiopoidea*, a parasitoid of the sitona weevil in New Zealand. In *Proceedings of the 40th New Zealand Weed and Pest Control Conference, Quality Inn, Nelson, New Zealand, 11–13 August 1987*; Popay, A.J., Ed.; The New Zealand Weed and Pest Control Society: Quality Inn, Nelson, New Zealand, 1987; pp. 31–32.
36. Vink, C.J.; Phillips, C.B.; Mitchell, A.D.; Winder, L.M.; Cane, R.P. Genetic variation in *Microctonus aethiopoidea* (Hymenoptera: Braconidae). *Biol. Control* **2003**, *28*, 251–264. [[CrossRef](#)]

37. Hopkins, D.C. Establishment and spread of the sitona weevil parasite *Microctonus aethioides* in South Australia. In Proceedings of the 3rd Australasian Conference on Grassland Invertebrate Ecology, Adelaide, Australia, 30 November–4 December 1982; Lee, K.E., Ed.; CSIRO: Adelaide, Australia, 1982; pp. 177–182.
38. Aeschlimann, J.P. The *Sitona* (Col.: Curculionidae) species occurring on *Medicago* and their natural enemies in the Mediterranean region. *Entomophaga* **1980**, *25*, 139–153. [[CrossRef](#)]
39. Aeschlimann, J.P. Notes on the variability of *Microctonus aethioides* Loan (Hymenoptera: Braconidae: Euphorinae). *Contrib. Am. Entomol. Inst.* **1983**, *20*, 329–335.
40. Phillips, C.B.; Vink, C.J.; Blanchet, A.; Hoelmer, K.A. Hosts are more important than destinations: What genetic variation in *Microctonus aethioides* (Hymenoptera: Braconidae) means for foreign exploration for natural enemies. *Mol. Phylogenet. Evol.* **2008**, *49*, 467–476. [[CrossRef](#)] [[PubMed](#)]
41. Barratt, B.I.P.; Todd, J.; Malone, L.A. Selecting non-target species for arthropod biological control agent host range testing: Evaluation of a novel method. *Biol. Control* **2016**, *93*, 84–92. [[CrossRef](#)]
42. Zimmermann, E.C. *Australian Weevils (Coleoptera: Curculionidae). Volume VI—Colour Plates 305-632*; CSIRO: Melbourne, Australia, 1992; p. 707.
43. Barratt, B.I.P.; Oberprieler, R.G.; Ferguson, C.M.; Hardwick, S. Parasitism of the lucerne pest *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) and non-target weevils by *Microctonus aethioides* Loan (Hymenoptera: Braconidae) in south-eastern Australia, with an assessment of the taxonomic affinities of non-target hosts of *M. aethioides* recorded from Australia and New Zealand. *Austr. J. Entomol.* **2005**, *44*, 192–200.
44. Goldson, S.L.; Proffitt, J.R.; McNeill, M.R. Seasonal biology and ecology in New Zealand of *Microctonus aethioides* (Hymenoptera: Braconidae), a parasitoid of *Sitona* spp. (Coleoptera: Curculionidae), with special emphasis on atypical behaviour. *J. Appl. Ecol.* **1990**, *27*, 703–722. [[CrossRef](#)]
45. Ferguson, C.M.; Roberts, G.M.; Barratt, B.I.P.; Evans, A.A. The distribution of the parasitoid *Microctonus aethioides* Loan (Hymenoptera: Braconidae) in southern South Island *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) populations. In Proceedings of the 47th New Zealand Plant Protection Conference, Waitangi Hotel, Pahia, New Zealand, 9–11 August 1994; Popay, A.J., Ed.; New Zealand Plant Protection Society Inc.: Waitangi Hotel, Pahia, New Zealand, 1994; pp. 261–265.
46. Pullen, K.R.; Jennings, D.; Oberprieler, R.G. Annotated catalogue of Australian weevils (Coleoptera: Curculionoidea). *Zootaxa* **2014**, *3896*, 1–481. [[CrossRef](#)] [[PubMed](#)]
47. Brown, S.D.J. A revision of the New Zealand weevil genus *Irenimus* Pascoe, 1876 (Coleoptera: Curculionidae: Entiminae). *Zootaxa* **2017**, *4263*, 1–42. [[CrossRef](#)] [[PubMed](#)]
48. Brown, S.D.J.; Armstrong, K.F.; Barratt, B.I.P.; Cruickshank, R.H.; Phillips, C.B. Taxonomy and evolution of New Zealand broad-nosed weevils (Coleoptera: Curculionidae: Entiminae). In *XXV International Congress of Entomology*; Entomological Society of America: Orlando, FL, USA, 2016.
49. Brown, S.D.J. *Austromonticola*, a new genus of broad-nosed weevil (Coleoptera, Curculionidae, Entiminae) from montane areas of New Zealand. *Zookeys* **2017**, *707*, 73–130. [[CrossRef](#)] [[PubMed](#)]
50. Barratt, B.I.P.; Oberprieler, R.G.; Barton, D.M.; Mouna, M.; Stevens, M.; Alonso-Zarazaga, M.A.; Vink, C.J.; Ferguson, C.M. Does knowledge of natural host range always help predict host range in new areas of introduction? A case study with the braconid parasitoid *Microctonus aethioides* Loan. In Proceedings of the XXIV International Congress of Entomology, Daegu, Korea, 19–25 August 2012.
51. Barratt, B.I.P.; Oberprieler, R.G.; Barton, D.; Mouna, M.; Stevens, M.; Alonso-Zarazaga, M.A.; Vink, C.J.; Ferguson, C.M. Could research in the native range, and non-target host range in Australia, have helped predict host range of the parasitoid *Microctonus aethioides* Loan (Hymenoptera: Braconidae), a biological control agent introduced for *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) in New Zealand? *BioControl* **2012**, *57*, 735–750.
52. Velazquez De Castro, A.J.; Alonso-Zarazaga, M.A.; Outerelo, R. Systematics of Sitonini (Coleoptera: Curculionidae: Entiminae), with a hypothesis on the evolution of feeding habits. *Syst. Entomol.* **2007**, *32*, 312–331. [[CrossRef](#)]
53. Hundsdoerfer, A.K.; Rheinheimer, J.; Wink, M. Towards the phylogeny of the Curculionoidea (Coleoptera): Reconstructions from mitochondrial and nuclear ribosomal DNA sequences. *Zool. Anz.* **2009**, *248*, 9–31. [[CrossRef](#)]
54. McKenna, D.M.; Sequeira, A.S.; Marvaldi, A.E.; Farrell, B.D. Temporal lags and overlap in the diversification of weevils and flowering plants. *Proc. Natl. Acad. Sci. USA* **2009**, *106*, 7083–7088. [[CrossRef](#)] [[PubMed](#)]

55. Haran, J.; Timmermans, M.J.T.N.; Vogler, A.P. Mitogenome sequences stabilize the phylogenetics of weevils (Curculionoidea) and establish the monophyly of larval ectophagy. *Mol. Phylogenet. Evol.* **2013**, *67*, 156–166. [[CrossRef](#)] [[PubMed](#)]
56. Oberprieler, R.G.; Caldara, R.; Skuhrovec, J. Bagoini Thomson, 1859; Gonipterini Lacordaire, 1863; Hyperini Marseul, 1863. In *Handbook of Zoology, Volume 3: Morphology and Systematics (Phytophaga)*; Leschen, R.A.B., Beutel, R.G., Eds.; Walter de Gruyter: Berlin, Germany, 2014; pp. 452–476.
57. Tooke, F.G.C. The Eucalyptus Snout-beetle, *Gonipterus scutellatus* Gyll. A study of its ecology and control by biological means. *Entomol. Mem. Union S. Afr.* **1955**, *3*, 1–282.
58. Londt, J. Milestone in biological control. *Antenna (Lond.)* **1996**, *20*, 24.
59. Cordero Rivera, A.; Santolamazza Carbone, S.; Andres, J.A. Life cycle and biological control of the Eucalyptus snout beetle (Coleoptera, Curculionidae) by *Anaphes nitens* (Hymenoptera, Mymaridae) in north-west Spain. *Agric. For. Entomol.* **1999**, *1*, 103–109. [[CrossRef](#)]
60. Valente, C.; Gonçalves, C.I.; Reis, A.; Branco, M. Pre-selection and biological potential of the egg parasitoid *Anaphes inexpectatus* for the control of the Eucalyptus snout beetle, *Gonipterus platensis*. *J. Pest Sci.* **2017**, *90*, 911–923. [[CrossRef](#)]
61. Reis, A.R.; Ferreira, L.; Tomé, M.; Clara Araujo, C.; Branco, M. Efficiency of biological control of *Gonipterus platensis* (Coleoptera: Curculionidae) by *Anaphes nitens* (Hymenoptera: Mymaridae) in cold areas of the Iberian Peninsula: Implications for defoliation and wood production in *Eucalyptus globulus*. *For. Ecol. Manag.* **2012**, *270*, 216–222. [[CrossRef](#)]
62. Gumovsky, A.; De Little, D.; Rothmann, S.; Jaques, L.; Mayorga, S.E.I. Re-description and first host and biology records of *Entedon magnificus* (Girault & Dodd) (Hymenoptera, Eulophidae), a natural enemy of *Gonipterus* weevils (Coleoptera, Curculionidae), a pest of Eucalyptus trees. *Zootaxa* **2015**, *3957*, 577–584. [[PubMed](#)]
63. Loch, A.D. Parasitism of the Eucalyptus weevil, *Gonipterus scutellatus* Gyllenhal, by the egg parasitoid, *Anaphes nitens* Girault, in *Eucalyptus globulus* plantations in southwestern Australia. *Biol. Control* **2008**, *47*, 1–7. [[CrossRef](#)]
64. Marelli, C.A. La plaga de los gorgojos de los eucaliptos. *Rev. Soc. Entomol. Argent.* **1926**, *1*, 14–22.
65. Marshall, G.A.K. New injurious Curculionidae (Col.). *Bull. Entomol. Res.* **1927**, *17*, 199–218. [[CrossRef](#)]
66. Marshall, G.A.K. New injurious Curculionidae (Col.). *Bull. Entomol. Res.* **1928**, *18*, 257–266. [[CrossRef](#)]
67. Wibmer, G.J.; O'Brien, C.W. Annotated checklist of the weevils (Curculionidae sensu lato) of South America (Coleoptera: Curculionoidea). *Mem. Am. Entomol. Inst.* **1986**, *39*, 1–563.
68. Zimmermann, E.C. *Australian Weevils (Coleoptera: Curculionidae). Volume I—Orthoceri. Anthribidae to Attelabidae. The Primitive Weevils*; CSIRO: Melbourne, Australia, 1994; p. 741.
69. Rosado-Neto, G.H.; Marques, M.I. Características do adulto, genitália e formas imaturas de *Gonipterus gibberus* Boisduval and *G. scutellatus* Gyllenhal (Coleoptera, Curculionidae). *Rev. Bras. Zool.* **1996**, *13*, 77–90. [[CrossRef](#)]
70. Vidal Sarmiento, J.A. Contribución a la aclaración definitiva del problema existente entre las especies “*Gonipterus gibberus*” Boisd. y “*G. platensis*” Mar. *Notas Mus. La Plata* **1955**, *18*, 31–41.
71. Mapondera, T.S.; Burgess, T.; Matsuki, M.; Oberprieler, R.G. Identification and molecular phylogenetics of the cryptic species of the *Gonipterus scutellatus* complex (Coleoptera: Curculionidae: Gonipterini). *Austr. J. Entomol.* **2012**, *51*, 175–188. [[CrossRef](#)]
72. Mally, C.W. The Eucalyptus Snout-beetle (*Gonipterus scutellatus*, Gyll.). *J. Depart. Agric. Union S. Afr.* **1924**, *51*, 1–30.
73. Huber, J.T.; Prinsloo, G.L. Redescription of *Anaphes nitens* (Girault) and description of two new species of *Anaphes* Halliday (Hymenoptera: Mymaridae), parasite of *Gonipterus scutellatus* Gyllenhal (Coleoptera: Curculionidae) in Tasmania. *J. Austr. Entomol. Soc.* **1990**, *29*, 333–341. [[CrossRef](#)]
74. Valente, C.; Gonçalves, C.I.; Monteiro, F.; Gaspar, J.; Silva, M.; Sottomayer, M.; Paiva, M.R.; Branco, M. Economic outcome of classical biological control: A case study of the Eucalyptus snout beetle *Gonipterus platensis* and the parasitoid *Anaphes nitens*. *Ecol. Econ.* **2018**, *149*, 40–47. [[CrossRef](#)]
75. Avila, G.A.; Charles, J.G. Modelling the potential geographic distribution of *Trissolcus japonicus*: A biological control agent of the brown marmorated stink bug, *Halyomorpha halys*. *Biocontrol* **2018**, *63*, 505–518. [[CrossRef](#)]
76. Robertson, M.P.; Kriticos, D.J.; Zachariades, C. Climate matching techniques to narrow the search for biological control agents. *Biol. Control* **2008**, *46*, 442–452. [[CrossRef](#)]

77. Clausen, C.P. The relation of taxonomy to biological control. *J. Econ. Entomol.* **1942**, *35*, 744–748. [[CrossRef](#)]
78. Sabrosky, C.W. The interrelations of biological control and taxonomy. *Econ. Entomol.* **1955**, *48*, 710–714. [[CrossRef](#)]
79. Hewitt, G.M.; Johnston, A.W.B.; Young, J.P.W. *Molecular Techniques in Taxonomy*; Springer: Berlin, Germany, 1991; Volume 57, p. 412.
80. Briese, D.T. Phylogeny: Can it help us to understand host choice by biological weed control agents? In *Proceedings of the 9th International Symposium on Biological Control of Weeds, 19–26 January 1996*; Moran, V.C., Hoffmann, J.H., Eds.; University of Cape Town: Stellenbosch, South Africa, 1996; pp. 63–70.
81. Pemberton, R.W. Predictable risk to native plants in weed biological control. *Oecologia* **2000**, *125*, 489–495. [[CrossRef](#)] [[PubMed](#)]
82. Desneux, N.; Blahnik, R.; Delebecque, C.J.; Heimpel, G.E. Host phylogeny and specialisation in parasitoids. *Ecol. Lett.* **2012**, *5*, 453–460. [[CrossRef](#)] [[PubMed](#)]
83. Askew, R.R. Parasitoids of leaf-mining Lepidoptera: What determines their host ranges? In *Parasitoid Community Ecology*; Hawkins, B.A., Sheehan, W., Eds.; Oxford University Press: Oxford, UK, 1994; pp. 177–202.
84. Bennett, F.D.; Cock, M.J.W.; Hughes, I.W.; Simmonds, F.J.; Yaseen, M. A Review of Biological Control of Pests in the Commonwealth Caribbean and Bermuda up to 1982. In *Technical Communication No. 9*; Cock, M.J.W., Ed.; Commonwealth Institute of Biological Control: Farnham Royal, UK, 1985; p. 218.
85. Van Driesche, R. Predicting host ranges of parasitoids and predacious insects—What are the issues. In *Assessing Host Ranges for Parasitoids and Predators Used for Classical Biological Control: A Guide to Best Practice*; van Driesche, R., Reardon, R., Eds.; USDA Forest Service: Morgantown, WV, USA, 2004; Volume FHTET, pp. 1–3.
86. Hopper, K.R. Research needs concerning non-target impacts of biological control introductions. In *Evaluating Indirect Ecological Effects of Biological Control*; Wajnberg, E., Scott, J.K., Quimby, P.C., Eds.; CABI Publishing: Wallingford, Oxfordshire, UK, 2001; pp. 39–56.
87. Lopez-Vaamonde, C.; Baker, P.S.; Cock, M.J.W.; Orozco, J. *Dossier on Phymastichus coffea (Hymenoptera: Eulophidae: Tetrastichinae), a Potential Biological Control Agent for Hypothenemus Hampei (Ferrari) (Col.: Scolytidae) in Colombia*; International Institute of Biological Control: Ascot, UK, 1997; p. 26.
88. Newete, S.W.; Byrne, M.J.; Oberprieler, R.G. The host range of the Eucalyptus Weevil, *Gonipterus “scutellatus”* Gyllenhal (Coleoptera: Curculionidae), in South Africa. *Ann. For. Sci.* **2011**, *68*, 1005–1013. [[CrossRef](#)]
89. Calder, A.; Sands, D.P.A. A new Brazilian *Cyrtobagous* Hustache (Coleoptera: Curculionidae) introduced into Australia to control *Salvinia*. *J. Austr. Entomol. Soc.* **1985**, *24*, 57–64. [[CrossRef](#)]
90. Alonso-Zarazaga, M.A.; Sánchez-Ruiz, M. Revision of the *Trichosirocalus horridus* (Panzer) species complex, with description of two new species infesting thistles (Coleoptera: Curculionidae, Ceutorhynchinae). *Austr. J. Entomol.* **2002**, *41*, 199–208. [[CrossRef](#)]
91. Lai, P.Y.; Funasaki, G.Y. *List of Biological Control Introductions in Hawaii*; Hawaii Department of Agriculture: Honolulu, USA, 1983.
92. Greathead, D.J. *A Review of Biological Control in the Ethiopian Region*; Commonwealth Institute of Biological Control: Farnham Royal, UK, 1971; p. 162.
93. Clausen, C.P. *Introduced Parasites and Predators of Arthropod Pests and Weeds: A World Review*; Handbook No. 480; United States Department of Agriculture: Washington, DC, USA, 1978.
94. Goldson, S.L.; Proffitt, J.R.; Baird, D.B. Establishment and phenology of the parasitoid *Microctonus hyperodae* (Hymenoptera: Braconidae) in New Zealand. *Environ. Entomol.* **1998**, *27*, 1386–1392. [[CrossRef](#)]
95. Waterhouse, D.F.; Sands, D. *Classical Biological Control of Arthropods in Australia*; CSIRO Entomology; Australian Centre for International Agricultural Research: Canberra, Australia, 2001; p. 559.
96. Ooi, P.A.C.; Lim, G.S.; Khoo, S.G. Biological control in Malaysia. In *Proceedings of the Plant Protection Seminar, Kuala Lumpur, Malaysia, 1–2 March 1979*; pp. 1–35.
97. Shoubu, M.; Okumura, M.; Shiraishi, A.; Kimura, H.; Takagi, M.; Ueno, T. Establishment of *Bathyleptes anurus* (Hymenoptera: Ichneumonidae), a larval parasitoid of the alfalfa weevil, *Hypera postica* (Coleoptera: Curculionidae) in Japan. *Biol. Control* **2005**, *34*, 144–151. [[CrossRef](#)]
98. Kelleher, J.S.; Hulme, M.A. *Biological Control Programmes against Insects and Weeds in Canada 1969–1980*; Commonwealth Agricultural Bureau: Farnham Royal, UK, 1984; p. 410.

99. Dysart, R.J. Establishment in the United States of *Peridesmia discus* (Hymenoptera: Pteromalidae), an egg predator of the alfalfa weevil (Coleoptera: Curculionidae). *Environ. Entomol.* **1988**, *17*, 409–411. [[CrossRef](#)]
100. Jacas, J.A.; Peña, J.E.; Duncan, R.E. Successful oviposition and reproductive biology of *Aprostocetus vaquitarum* (Hymenoptera: Eulophidae): A predator of *Diaprepes abbreviatus* (Coleoptera: Curculionidae). *Biol. Control* **2005**, *33*, 352–359. [[CrossRef](#)]
101. Frank, J.H.; McCoy, E.D. The introduction of insects into Florida. *Fla. Entomol.* **1993**, *76*, 1–52. [[CrossRef](#)]
102. Cameron, P.J.; Hill, R.L.; Bain, J.; Thomas, W.P. *A Review of Biological Control of Invertebrate Pests and Weeds in New Zealand 1874 to 1987*; Technical Communication No. 10; CAB International and DSIR: Oxford, UK, 1989; p. 424.
103. Carmako, H.; Vankosky, M.A. *Sitona* spp. Germar, broad nosed weevils (Coleoptera: Curculionidae). In *Biocontrol Programmes in Canada 2001–2012*; Mason, P.G., Gillespie, D.R., Eds.; CABI: Wallingford, UK, 2013; pp. 277–284.
104. Gerard, P.J.; Wilson, D.J.; Eden, T.M. Field release, establishment and initial dispersal of Irish *Microctonus aethiopoidea* in *Sitona lepidus* populations in northern New Zealand pastures. *Biocontrol* **2011**, *56*, 861–870. [[CrossRef](#)]
105. Commonwealth Agricultural Bureaux. *Biological Control Programmes against Insects and Weeds in Canada 1959–1968*; Commonwealth Institute of Biological Control, Technical Communication: Slough, UK, 1971; Volume 4, p. 266.
106. Dysart, R.J. The introduction and recovery in the United States of *Anaphes diana* [Hym.: Mymaridae], an egg parasite of *Sitona* weevils [Col.: Curculionidae]. *Entomophaga* **1990**, *35*, 307–313. [[CrossRef](#)]
107. Evans, H.; Fielding, N.J. Restoring the natural balance: Biological control of *Dendroctonus micans* in Great Britain. In *Proceedings of the British Crop Protection Conference Symposium, 18 November 1996*; Waage, J.K., Ed.; British Crop Protection Council: Farnham, UK, 1996; Volume 67, pp. 47–57.
108. Fielding, N.J.; Evans, H.F. Biological control of *Dendroctonus micans* (Scolytidae) in Great Britain. *Biocontrol News Inf.* **1997**, *18*, 51N–60N.
109. Coulson, J.R.; Vail, P.V.; Dix, M.E.; Nordlund, D.A.; Kauffman, W.C. *110 Years of Biological Control Research and Development in the United States Department of Agriculture, 1883–1993*; U.S. Department of Agriculture, Agricultural Research Service: Washington, DC, USA, 2000; p. 645.
110. Neuenschwander, P.; Borgemeister, C.; Langewald, J. *Biological Control in IPM systems in Africa*; CABI Publishing: Wallingford, UK, 2003; p. 414.
111. Zúñiga, E. Ochenta años de control biológico en Chile. *Agric. Tech.* **1985**, *45*, 175–182.
112. Sailer, R.I. Beneficial Foreign Species of Hymenoptera Known to Be Established in the 48 Contiguous United States. 1983; 10, unpublished typescript.
113. Quintero, H.; Bustillo, P.; Benavides, M.; Chaves, E. Evidencias del establecimiento de *Cephalonomia stephanoderis* y *Prorops nasuta* (Hymenoptera: Bethyridae) en cafetales del departamento de Nariño, Colombia. *Rev. Colomb. Entomol.* **1998**, *24*, 141–147.
114. Murphy, S.T.; Moore, D. Biological control of the coffee berry borer *Hypothenemus hampei* (Ferrari) (Coleoptera, Scolytidae): Previous programmes and possibilities for the future. *Biocontrol News Inf.* **1990**, *11*, 107–117.
115. Baker, P. Managing the coffee berry borer. *Biocontrol News Inf.* **2001**, *21*, 61N–64N.
116. Singh, S.P. Biocontrol progress in India. *Biocontrol News Inf.* **2001**, *21*, 78N–79N.

