

**BIOLOGICAL CONTROL IN ONTARIO 1952–2012:  
A SUMMARY OF PUBLICATIONS IN THE  
“JOURNAL OF THE ENTOMOLOGICAL SOCIETY OF  
ONTARIO”**

P. G. MASON

Agriculture and Agri-Food Canada, Research Centre  
960 Carling Avenue, Ottawa, ON K1A 0C6  
email: peter.mason@agr.gc.ca

*J. ent. Soc. Ont.* 144: 27–111

**Introduction**

Biological control involves the manipulation of natural enemies to regulate populations of pest species. This biologically based approach is key to the successful management of pest species, and requires a sound understanding of the pest, its associated organisms and their interactions. A first step is to understand the biology of a target species which allows determination of such things as number of generations per growing season, life stages that cause damage, and life stages that are appropriate for control. Knowledge of the natural enemy community associated with a pest species will provide an indication of the potential for biological control to suppress and maintain populations below economically damaging levels. In Ontario, biological control began in 1882 when W. Saunders imported *Trichogramma minutum* Riley (Hymenoptera: Trichogrammatidae) from New York state for release in Ontario gardens to control the Imported Currantworm *Nematus ribesii* (Scopoli) (Hymenoptera: Tenthredinidae) (Glen 1962).

The present compilation summarizes the biological control contributions published in the *Annual Report of the Entomological Society of Ontario / Proceedings of the Entomological Society of Ontario / Journal of the Entomological Society of Ontario* (together, JESO) from 1952–2012 as part of the commemorative activities to celebrate the 150<sup>th</sup> anniversary of the Entomological Societies of Canada and Ontario. Although most cover work in Ontario, several (e.g., James 1952; Maxwell and Morgan 1952; Robinson 1952), address studies in other regions. Glen (1956) summarized work in entomology, including biological control in Canada to 1956 and this should be consulted for information on studies prior to 1952. It should be noted that studies published in JESO document only a portion of the work on each species. More comprehensive accounts can be found in the *Biological Control Programmes in Canada* series (McLeod et al. 1962; Kelleher et al. 1971; Kelleher and Hulme 1984; Mason and Huber 2002; Mason and Gillespie 2013).

Several contributions provide general summaries of the knowledge at the time of their publication. Chant (1957) provided an overview of papers relevant to biological control

*Published December 2013*

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Agriculture and Agri-Food Canada.

presented at the 10<sup>th</sup> International Congress of Entomology. Cameron (1952) conducted a review of diseases of insects to 1951 and Cameron (1969) reviewed the problems and prospects in the use of pathogens for insect control. Putnam (1963) reviewed the biology and management of codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae). Wallace and Sullivan (1985) reviewed the status of the white pine weevil, *Pissodes strobi* (Peck) (Coleoptera: Curculionidae).

Proverbs (1962) and Van Whervin & Wilde (1970) reported on sterile insect release for control of codling moth, however this technique falls outside of the definition used in this summary (i.e., manipulation of natural enemies) as does work with plant extracts such as that reported for neem, *Azadirachta indica* A. de Jussieu (Meliaceae), by Lyons et al. (1996) on the Pine False Webworm, *Acantholyda erythrocephala* (L.) (Hymenoptera: Pamphiliidae) and by Li (2000) against Balsam Fir Sawfly, *Neodiprion abietis* (Harris) (Hymenoptera: Diprionidae).

In Ontario, more than 75 species have been the subject of studies in which associated natural enemies have been documented. Introduction of exotic natural enemy species were implemented for 12 invasive alien arthropods and five exotic weeds. The contributions published in JESO on these species are varied but can be divided into broad categories, Pest Life History and Natural Enemy Complexes, General Studies of Natural Enemy Communities, Natural Enemy Biology, Classical Biological Control of Weeds, Classical Biological Control of Arthropods, and Inundative Biological Control using Pathogens. Fundamental to successful biological control is correct identification of their natural enemies so taxonomic studies treating relevant species are therefore also summarized under Natural Enemy Taxonomy. The approach used here summarizes, under each of the categories mentioned above, the findings published in JESO for each species studied. The 140 full length scientific papers, scientific notes and abstracts include those that identified natural enemies (arthropods and pathogens) associated with a host species and those reporting on aspects of the biology of natural enemies of pest and beneficial species. A list of the updated names of natural enemies and known hosts published in JESO from 1952–2012 is provided in the Appendix.

## 1. Pest Life History and Natural Enemy Complexes

The development of intensive agriculture brings with it a host of species that exploit a food source that, grown in large uniform plots, provides one of the optimum conditions that contributes to exponential population increases. Fundamental to implementing successful biological control is understanding the biology of target species well and identifying which natural enemies already present in the system attack the various life stages of the host. In Ontario, numerous studies have documented the natural enemies of native and non-native species, usually in response to outbreaks in particular crops or regions. In addition to greater knowledge of pest biologies these studies have increased knowledge of their natural enemies present in Ontario. A summary of the findings published in JESO for each species follows.

**Apple Maggot**, *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae) is a native species that occurs in Ontario and Quebec (Hoffmeister 2002). Monteith (1977; 1978) studied potential predators of apple maggot, e.g., the sowbug, *Porcellio laevis* Latreille (Isopoda: Oniscidae), centipede, *Lithobius forficatus* (L.) (Lithobiomorpha: Lithobiidae), earwig, *Forficula auricularia* L. (Dermaptera: Forficulidae), and beetles, including

*Calosoma calidum* (Fabricius), *Harpalus pensylvanicus* DeGeer (Coleoptera: Carabidae), and *Staphylinus badipes* LeConte (Coleoptera: Staphylinidae), which effectively attacked and consumed apple maggot larvae. Millipedes, *Trachelipus rathkei* (Koch) (Polydesmida: Paradoxosomatidae), attacked puparia. Monteith (1978) also reported on apple maggot parasitoids, including *Diachasma mellea* (Gahan), *D. lectus* Gahan, *D. lectoides* (Gahan), *D. alloeum* (Muesebeck) and *D. ferrugineum* (Gahan) (Hymenoptera: Braconidae). Although these parasitoid species survived in wild habitats with apple and *Crataegus* spp. (Rosaceae), their numbers were not sufficient to migrate into and reduce apple maggot populations in managed orchards where even low numbers of this pest could not be tolerated. Poinar et al. (1978) isolated the potential pathogens, *Pseudomonas aeruginosa* (Schroeter) Migula, *Bacillus cereus* Frankland and Frankland (Bacilliaceae), and *Streptococcus* sp. (Streptococcaceae) from larvae and puparia. A nematode, *Neoaplectana* sp. (Rhabditida: Steinernematidae) was also associated with puparia. The study suggested that natural infestation by microorganisms might play an important role in regulating apple maggot populations.

**Armyworm**, *Mythimna unipuncta* (Haworth) (Lepidoptera: Noctuidae), a Nearctic species, was studied by Goble (1965) during an outbreak in 1964. The nuclear polyhedrosis virus *Betabaculovirus* sp. (Baculoviridae) killed 35% of larvae. Parasitoids caused an additional 25% mortality, particularly two *Apanteles* spp. (Hymenoptera: Braconidae) and other Hymenoptera (20% and 3.3% mortality, respectively) as well as Diptera (1%). *Winthemia* sp. (Diptera: Tachinidae) was abundant at one site and birds consumed large numbers of larvae. It was concluded that overall, natural control was of such magnitude that the population was likely to crash without intervention.

**Birch Leaf Edgeminer**, *Scolioneura betuleti* (Klug) (Hymenoptera: Tenthredinidae), first discovered in Ontario in 1983 near Newmarket, represented a first record for North America (Nystrom and Evans 1989). They reported 12% parasitism by three larval parasitoids, *Chrysocharis laricinellae* (Ratzeburg), *Pnigalio minio* (Walker), and *Zagrammosoma multilineatum* (Ashmead) (Hymenoptera: Eulophidae).

**Black Army Cutworm**, *Actebia fennica* (Tauscher) (Lepidoptera: Noctuidae), a Holarctic species, was studied in black spruce plantations in Newfoundland by West (1992). Parasitism levels of up to 60% were documented. *Tachinomyia panaetius* (Walker) (Diptera: Tachinidae), and *Campoletis* sp. (Hymenoptera: Ichneumonidae) were reared from larvae. *Gonia* sp. (Diptera: Tachinidae), and *Enicospilus* sp., *Ichneumon creperus* Cresson, and *Arenetra rufipes* Cresson (Hymenoptera: Ichneumonidae) were reared from pupae. The nematode, *Steinernema feltiae* (Filipjev) (Rhabditida: Steinernematidae) also showed promise as a potential control agent. West (1992) recommended that since only *I. creperus* was known to occur in British Columbia, where black army cutworm was also a problem, relocation of the other spp. may be useful for biological control of *A. fennica* in that province.

**Cabbage Looper**, *Trichoplusia ni* (Hübner) (Lepidoptera: Noctuidae), is an annual migrant from the southern USA. Harcourt (1963) determined that *T. ni* was significantly impacted by *Copidosoma truncatellum* (Dalman) (Hymenoptera: Encyrtidae) but less so by the polyphagous *Itoplectis conquisitor* (Say), *Stenichneumon culpator cincticornis* (Cresson) (Hymenoptera: Ichneumonidae) and *Compsilura concinnata* (Meigen) (Diptera: Tachinidae). Polyhedral virus disease frequently killed larvae. Murillo et al. (2012) studied

the larval parasitoids of *T. ni* in field tomatoes in southwestern Ontario. Nine primary parasitoids were reared from *T. ni* larvae, including an unidentified Tachinidae, *Exeristes comstockii* (Cresson) (Hymenoptera: Ichneumonidae), *Copidosoma floridanum* (Ashmead) (Hymenoptera: Encyrtidae), *Cotesia marginiventris* (Cresson), *C. plathypenae* (Muesebeck), *Meteorus* sp., and *Microplitis alaskensis* (Ashmead), one unidentified species (Hymenoptera: Braconidae), and *Euplectrus* sp. (Hymenoptera: Eulophidae). One hyperparasitoid, *Trichomalopsis viridescens* (Walsh) (Hymenoptera: Pteromalidae) was reared from *E. comstockii*, the most abundant parasitoid (17.6% and 39.2% parasitism levels in 2005 and 2006, respectively). Although common parasitoids of *T. ni* in other parts of North America, *C. floridanum* and *C. marginiventris* occurred in <2% of the host populations in Ontario. The association of *C. plathypenae* with *T. ni* was a new host record.

**Corn Aphid**, *Rhopalosiphum maidis* (Fitch) (Hemiptera: Aphididae), is an important introduced pest of corn. Foot (1974) studied the Coccinellidae (Coleoptera) community in corn fields in southwestern Ontario. He found that *Hippodamia convergens* Guérin-Méneville, *H. tredecimpunctata tibialis* (Say), and *Coleomegilla maculata lengi* Timberlake were the most abundant species. *Adalia bipunctata* (L.), *Cyclonedda sanguinea* (L.), *H. parenthesis* (Say), and *Coccinella transversoguttata* Faldermann were present but either not abundant or did not occur in all years. It was concluded that coccinellid numbers overall were insufficient to control corn aphid as high populations of beetles occurred only after aphid populations peaked and had damaged the crop.

**Diamondback Moth**, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), first found in the Ottawa area in 1854, is a global pest of cole crops. Harcourt (1963) determined that native parasitoids were a major mortality factor, the most important being the larval-prepupal parasitoid *Diadegma insulare* (Cresson) (33%), the prepupal-pupal parasitoid *Diadromus subtilicornis* (Gravenhorst) (21%) (Hymenoptera: Ichneumonidae), and the larval parasitoid *Microplitis plutellae* (Muesebeck) (Hymenoptera: Braconidae). Several species were of lesser significance including, *Oomyzus sokolowskii* (Kurdjumov) (Hymenoptera: Eulophidae), *Conura albifrons* (Walsh) (Hymenoptera: Chalcididae), *Gelis tenellus* (Say), *Campoletis* sp. (Hymenoptera: Ichneumonidae), *Dibrachys microgastri* (Bouché), *Pteromalus* sp. near *phycidis* Ashmead, and *Trichomalopsis viridescens*. According to Harcourt (1963) predators and diseases did not significantly affect *P. xylostella* populations.

**European Red Mite**, *Panonychus ulmi* (Koch) (Trombidiformes: Tetranychidae), a non-native species, is a serious pest of fruit crops in Canada (Thistlewood et al. 2013). Herbert (1953) studied the predaceous phytoseid mites associated with European red mite in orchards. More than nine species were collected, including *Typhlodromus tilae* Oudemans, *T. rhenanus* (Oudemans), *T. pomi* (Parrot, Hodgkiss and Shoene), *Neoseiulus fallacis* (Garman), *T. conspicuous* var. *herbertae* Nesbitt, *T. finlandicus* (Oudemans), *T. masseei* (Nesbitt), *Phytoseius macropilis* (Banks) and *Amblyseius* spp. (Trombidiformes: Phytoseiidae). Abundance and species compositions varied among locations and years. Populations were denser in the centre of orchards in spring and early summer but increased at the periphery in midsummer, then decreased as autumn approached. Cadogan and Laing (1982) surveyed apple orchards in southern Ontario for the European red mite and its predator *Balaustium putnami* Smiley (Trombidiformes: Erythraeidae). Two distinct generations of *B. putnami* occurred, the 1<sup>st</sup> generation having an abundance of larvae and the 2<sup>nd</sup> generation being dominated by nymphs and adults (motile stages). *Balaustium putnami* coexisted with

Phytoseiidae and Stigmaeiidae and fed on both *P. ulmi* and the twospotted spider mite, *Tetranychus urticae* Koch (Trombidiformes: Tetranychidae). *Balaustium putnami* was also present in orchards with low volume pesticide application regimes suggesting that spray regimes and schedules could be designed to preserve natural enemies.

**European Skipper**, *Thymelicus lineola* (Ochsenheimer) (Lepidoptera: Hesperiidae), was first collected in 1910 near London, Ontario (Pengelly 1961). He studied its biology near Bradford, Ontario in 1958. Several native parasitoid species were recovered. Parasitism of pupae was low at 4.9%, mainly by *Itoplectis conquisitor*. Also reared from pupae were *Pimpla pedalis* Cresson and *Camposcopus* sp. (Hymenoptera: Ichneumonidae). Larval parasitoids included *Meteorus hyphantriae* Riley, *Rogas* sp. and *Casinaria* sp. (Hymenoptera: Braconidae). The hyperparasitoid *Gelis* sp. (Hymenoptera: Ichneumonidae) was reared from *M. hyphantriae*. Several Tachinidae were also reared from larvae.

**Forest Tent Caterpillar**, *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae), a cyclical pest of deciduous trees, was studied by Harmsen and Rose (1984). They documented differential mortality in wet low-lying and dry higher-ground habitats. Parasitism by *Aleiodes malacosomatos* (Mason) (Hymenoptera: Braconidae) and *Phobocampe clisiocampae* (Weed) (Hymenoptera: Ichneumonidae) and predation by unspecified species were lower in the low-lying areas, likely due to limited accessibility of appropriate sites for pupation and the greater accessibility for predators offered by drier habitats.

**Goldenrod Gall Moth**, *Epiblema scudderiana* (Clemens) (Lepidoptera: Tortricidae) was the subject of a parasitoid survey by Laing and Heraty (1982) who found the primary parasitoids *Apanteles cacoeciae* Riley, *Macrocentrus pallisteri* DeGant, *Bassus binominatus* (Muesebeck) (Hymenoptera: Braconidae) and *Scambus pterophori* Ashmead (Hymenoptera: Ichneumonidae), and the hyperparasitoid *Perilampus fulvicornis* Ashmead (Hymenoptera: Perilampidae), which attacked all the primary parasitoids. Overall parasitism was 32.4% in 1978–1979, 64.4% in 1979–1980, and 76.6% in 1980–1981. Parasitism by *M. pallisteri* was the major factor influencing the large annual fluctuations (19.4% in 1978–79, 57.5% in 1979–1980, and 67.5% in 1980–81) in *E. scudderiana* populations. *Perilampus fulvicornis* appeared to be an important regulator of *M. pallisteri*, preventing it from drastically reducing *E. scudderiana* populations.

**Horse and deer flies** (Diptera: Tabanidae) were the subject of natural enemy surveys in Churchill, Manitoba by James (1952). The chalcid larval-pupal parasitoid *Diglochis occidentalis* (Ashmead) (Hymenoptera: Pteromalidae) was found to parasitize 13.9% of *Tabanus* spp., including *T. affinis* Kirby and the *T. frontalis-septentrionalis* complex, and 20.8% of *Chrysops* spp., including *C. frigidus* Osten-Sacken, and *C. furcatus* Walker. Numbers of *D. occidentalis* that emerged from *Tabanus* spp. averaged 45.5 while the smaller *Chrysops* spp. yielded an average of 16.1.

**McDaniel Spider Mite**, *Tetranychus mcdanieli* McGregor, the **Apple Mite**, *Tetranychus pacificus* McGregor, and the **Clover Mite**, *Bryobia praetiosa* Koch (Trombidiformes: Tetranychidae) in Manitoba were the subject of a survey by Robinson (1952) to document their predators. The following species were collected: *Stethocorus punctum* (LeConte), *Adalia punctata* (L.) (Coleoptera: Coccinellidae), *Stilbus probatus* Casey (Coleoptera: Phalacrididae), *Orius insidiosus* (Say), *Anthocoris musculus* (Say) (Hemiptera: Anthocoridae), *Diaphnidia pellucida* Uhler, *Hyaloides harti* Knight, *H. vitripennis* (Say),

*Plagiognathus obscurus* (Uhler) (Hemiptera: Miridae), *Nabis ferus* (L.) (Hemiptera: Nabidae), *Scolothrips sexmaculatus* (Pergande) (Thysanoptera: Thripidae), *Aeolothrips melaleucus* Haliday (Thysanoptera: Aelothripidae), *Feltiella* sp. (Diptera: Cecidomyiidae), *Toxomerus geminatus* (Say) (Diptera: Syrphidae), *Chrysopa carnea* (Stephens), *C. chi* Fitch (Neuroptera: Chrysopidae), *Hemerobius simulans* Walker, *H. stigmaterus* Fitch (Neuroptera: Hemerobiidae), *Typhlodromus fallacis* (Garman), *T. longipilus* Nesbit (Megostigmata: Phytoseiidae), and *Anystis agilis* Banks (Trombidiformes: Anystidae).

**Northern Corn Rootworm**, *Diabrotica barberi* Smith and Lawrence (Coleoptera: Chrysomelidae), native to North America, is a minor pest in Ontario. Tyler and Ellis (1980) studied the importance of ground beetles as its predators. Among the 26 species collected, *Pterostichus melanarius* (Illiger), *Clivina fossor* (L.), *Agonum muelleri* (Herbst), *Bembidion quadrimaculatum oppositum* Say, *Poecilus lucublandus* (Say), and *Harpalus affinis* (Schrank) (Coleoptera: Carabidae) were most numerous. Radioactive labelling trials indicated that carabids were probably more important as larval than egg predators.

**Obliquebanded Leafroller**, *Choristoneura rosaceana* (Harris), the **Eyespotted Bud Moth**, *Spilonota ocellana* (Dennis and Schiffermüller), and the **Pale Apple Budworm**, *Pseudexentera mali* Freeman (Lepidoptera: Tortricidae) all native species, were present at all sites surveyed by Hagley and Barber (1992). Although parasitism levels in unmanaged apple orchards in southern Ontario were low (4–10%), parasitoids reared included 24 species of Hymenoptera and two species of Diptera. *Itoplectis conquisitor* was the most frequently reared parasitoid from obliquebanded leafroller and pale apple budworm and *Bassus dimidiator* (Nees) (Hymenoptera: Braconidae) was most frequently reared from eyespotted bud moth. The first records of *Colpoclypeus florus* (Walker) (Hymenoptera: Eulophidae) from obliquebanded leafroller and eyespotted bud moth were reported. *Colpoclypeus florus* had earlier been introduced from Europe to control the redbanded leafroller (see below). Highest parasitism levels were found in *Coleophora* spp. (Lepidoptera: Coleophoridae) (30.2%) and *Sparganothis* spp. (Lepidoptera: Tortricidae) (62%), primarily due to *Scambus* spp. and *Orgilus scaber* Muesebeck (Hymenoptera: Braconidae) in the former and *Triclistus* spp. (Hymenoptera: Ichneumonidae) in the latter.

**Pine Shoot Beetle**, *Tomicus piniperda* (L.) (Coleoptera: Curculionidae), a European species, was first found in the Niagara region in 1993 (Bright 1996). Parasitoids found in his study included *Coeloides pissodis* (Ashmead), *Spathius* sp. (Hymenoptera: Braconidae), *Dinotiscus dendroctoni* (Ashmead), *Rhopalicus tutela* (Walker), *Roptrocerus xylophagorum* (Ratzeburg) (Hymenoptera: Pteromalidae), *Eupelmus* sp. (Hymenoptera: Eupelmidae) and *Eurytoma* sp. (Hymenoptera: Eurytomidae). Predators included *Platysoma gracile* LeConte (Coleoptera: Histeridae), *Corticeus praetermissus* (Fall) (Coleoptera: Tenebrionidae), *Medetera signaticornis* (Loew) and *M. pinicola* Kowarz (Diptera: Dolichopodidae). Most of the species found are habitat-specific rather than host-specific, thus any bark beetle encountered under the bark may be a suitable host. A few parasitoid species, e.g., *Eupelmus* sp., may be hyperparasitoids. It was concluded that further investigation of the role of native natural enemies would provide evidence on whether or not there is a need to introduce exotic natural enemies.

**Potato Leafhopper**, *Empoasca fabae* Harris (Hemiptera: Cicadellidae), is a pest of a variety of field crops such as edible beans, potatoes, alfalfa, peanut and soybean (Appleton et al. 2004). They concluded that predators and parasitoids were not effective

regulators of potato leafhopper populations, despite egg parasitism up to 40% by *Anagrus armatus* (Ashmead) (Hymenoptera: Mymaridae). Although the fungus *Zoophthora radicans* (Brefeld) Batko (Entomophthoraceae) caused epizootics, the narrow environmental conditions required for this are rare in Ontario; thus it was not considered to be a reliable control.

**Redbanded Leafroller**, *Argyrotaenia velutinana* (Walker) (Lepidoptera: Tortricidae) is a native species that occurs on broad-leaved trees in eastern North America (Hikichi 1971). In response to increasing outbreaks in apple orchards in Ontario, Hikichi (1962) studied its mortality factors. *Trichogramma minutum* parasitized ~2% of the eggs collected, ~50% of larvae were infected by a granulovirus and another ~12% of larvae were parasitized by *Phytodietus vulgaris* Cresson (Hymenoptera: Ichneumonidae). The study concluded that disease and drought conditions that reduced foliage quality were the primary factors contributing to mortality of *A. velutinana*.

**Six-spotted Leafhopper**, *Macrosteles fascifrons* (Stål) (Hemiptera: Cicadellidae), is an important vector of aster-yellows virus (Miller and De Lyzer 1960). They conducted field surveys but only a single parasitoid species, *Epigonatopus plesius* Fenton (Hymenoptera: Dryinidae) was recovered from adults and levels of parasitism were not considered of economic importance.

**Soybean Aphid**, *Aphis glycines* Matsumura (Hemiptera: Aphididae), native to eastern Asia, was first reported in Ontario in 2001 (Ragsdale et al. 2004). Bahlai and Sears (2009) studied the population dynamics of soybean aphid and the predator *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) in vineyards in the Niagara region. They found that high populations of *H. axyridis* were correlated with substantial numbers of soybean aphid when aphids occurred early in the season. However, outbreaks of *H. axyridis* in vineyards were observed when the numbers of soybean aphid eggs were fewest on overwintering buckthorn, *Rhamnus* spp. (Rhamnaceae), plant hosts. The availability of high numbers of eggs, oviposited by soybean aphid late in the season on the winter host plant, served to divert *H. axyridis* from feeding on ripening grapes in vineyards. Thus Bahlai and Sears (2009) showed that high numbers of aphids in soybean did not result in high numbers of *H. axyridis* invading vineyards. They proposed a ‘kick start/distract’ model to explain these dynamics and provide a basis for integrated management.

**Spotted Tentiform Leafminer**, *Phyllonorycter blancaudella* (Fabricius) (Lepidoptera: Gracillariidae) an invasive alien pest from the Palaearctic is an important pest of apples in central Ontario as well as other parts of eastern Canada (Vincent et al. 2013). Johnson et al. (1977) studied the seasonal occurrence and natural enemies of this pest in Ontario apple orchards. They reported that the endoparasitic *Pholetesor ornigis* (Weed) (Hymenoptera: Braconidae) was the dominant parasitoid (up to 57% parasitism) and was well-synchronized with the 1<sup>st</sup> and 3<sup>rd</sup> host generations. *Sympiesis gordius* (Walker), *S. sericeicornis* (Nees), *Pnigalio minio* (Walker), *P. uroplatae* (Howard), *Chrysocaris nepereus* (Walker) and *Closterocerus* sp. (Hymenoptera: Eulophidae) impacted 1<sup>st</sup> and 2<sup>nd</sup> generation spotted tentiform leafminer, the first three species being most prevalent, although overall parasitism was at most 24%. Predation was not significant.

**Tarnished Plant Bug**, *Lygus lineolaris* (Palisot) (Hemiptera: Miridae) is a widespread and important pest of vegetable, fruit, greenhouse, and field crops, particularly those grown for seed (Broadbent et al. 2013). Broadbent et al. (1999) reared five parasitoid

species, including *Leiophron mellipes* (Cresson), *L. digoneutis* (Loan), *L. pseudopallipes* (Loan), *Leiophron lygivora* (Loan), and *L. rubricollis* (Thomson) (Hymenoptera: Braconidae). Mason et al. (2011) examined the effect of periodic cutting of alfalfa on parasitism of tarnished plant bug and alfalfa plant bug, *Adelphocoris lineolatus* (Goeze) (Hemiptera: Miridae) by *Leiophron* spp. Although populations of hosts and parasitoids declined in cut habitats, they did not go extinct and recolonization by adults sustained parasitoid populations.

**Trefoil Seed Chacid**, *Bruchophagus platyptera* (Walker) (Hymenoptera: Eurytomidae) is an important pest of alfalfa, clover and trefoil seed crops (Ellis and Nang'ayo 1992). These authors discovered two parasitoids, *Mesopolobus bruchophagi* (Gahan) and *Tetrastichus bruchophagi* Gahan (Hymenoptera: Pteromalidae) at levels of 8.2 and 11.0%, respectively. Parasitoids were not present in all fields and were more likely to occur in older fields. They noted that these same species occur elsewhere in North America where trefoil seed chacid is found.

**White Pine Weevil**, *Pissodis strobi* (Peck) (Coleoptera: Curculionidae), native to North America, is a major pest in pine plantations in most of Canada and the USA (Hulme and Kenis 2002). Wallace and Sullivan (1985) reviewed its biology, highlighting aspects that could be exploited to manage the pest. Among major larval and pupal mortality factors identified were the predator *Lonchaea corticis* Taylor (Diptera: Lonchaeidae) and the parasitoids *Eurytoma pissodes* Girault (Hymenoptera: Eurytomidae) and *Dolichotomitus terebrans nubilipennis* (Viereck) (Hymenoptera: Ichneumonidae).

**Willow Gall Fly**, *Rhabdopahaga strobilooides* Walsh (Diptera: Cecidomyiidae) was studied by Judd (1953). In addition to willow gall fly which induces the galls, the inquiline *Dasyneura albovittata* Walsh (Diptera: Cecidomyiidae) was reared from these galls, as was a single female sawfly, *Amauronematus* sp. (Hymenoptera: Tenthredinidae). Parasitoids reared from willow gall fly included *Copidosoma* sp., (Hymenoptera: Encyrtidae), *Tridymus* sp. (Hymenoptera: Pteromalidae), and *Torymus cecidomyiae* (Walker) (Hymenoptera: Torymidae). *Leptacis* sp. (Hymenoptera: Platygasteridae), *Ceraphron* sp. (Hymenoptera: Ceraphronidae), *Tetrastichus* sp. (Hymenoptera: Eulophidae) and *Torymus* sp. were reared from cocoons of *D.albovittata*. Among the remaining parasitoids reared were *Adialytus salicaphis* (Fitch) and *Aphidius matricariae* Haliday (Hymenoptera: Braconidae), known parasitoids of aphids, and *Microgaster hospes* Marshall (Hymenoptera: Braconidae) and *Pediobius* sp. (Hymenoptera: Eulophidae), parasitoids of Lepidoptera. The hyperparasitoids *Lygocerus* sp. (Hymenoptera: Cephronidae) and *Alloxysta* sp. (Hymenoptera: Alloxystidae) were reared, probably from *A. phorodontis*.

## 2. General Studies of Natural Enemy Communities

Natural enemy surveys that are not pest specific provide a broad perspective of the complexes present in different habitats. Several studies published in JESO documented natural enemies associated with particular pests or crop systems, often to evaluate the impacts of management systems or pesticides on these communities. Other studies appear to have been opportunistic and documented natural enemies associated with host species likely encountered fortuitously during field trips focusing on other topics.

**Field crop habitats.** Ben-Ze'ev and Jaques (1990) surveyed alfalfa fields in southwestern Ontario for entomopathogens. The invasive Alfalfa Weevil, *Hypera postica*

(Gyllenhal) (Coleoptera: Curculionidae) was infected by *Erynia phytonomi* (Arthur) Humber, Ben-Ze'ev and Kenneth, *Erynia* sp. (Entomophthoraceae) and *Beauveria bassiana* (Balsamo) Vuillemin (Moniliaceae). *Conidiobolus obscurus* (Hall and Dunn) Remaudière and Keller, *C. thromboides* Dreschler (Acylistaceae), *Entomophthora planchoniana* Cornu, *Erynia neoaphidis* Remaudière and Hennebert (Entomophthoraceae), and *Neozygites fresenii* (Thaxter) Remaudière and Keller (Neozygotaceae) were associated with a mixed population of Pea Aphid, *Acyrtosiphon pisum* (Harris), Black Bean Aphid, *Aphis fabae* Scopoli, and the Green Peach Aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). *Entomophthora muscae* (Cohn) Fresen (Entomophthoraceae) complex was associated with the Seedcorn Maggot, *Delia platura* (Meigen) (Diptera: Anthomyiidae). *Erynia echinospora* (Thaxter) Remaudière and Keller [or *E. dipterigena* (Thaxter) Remaudière and Keller] was associated with Lauxaniidae (Diptera). *Erynia petchii* (Ben-Ze'ev and Kenneth) was associated with the Meadow Spittlebug, *Philaenus spumarius* (L.) (Hemiptera: Cercopidae) and *Zoophthora radicans* (Brefeld) Batko was associated with the Potato Leafhopper, *Empoasca fabae* Harris (Hemiptera: Cicadellidae) and Aphididae. The study concluded that entomopathogens have a role in natural regulation of pest insects and there is potential for their introduction (e.g., *B. bassiana* and *Erynia* spp.) to supplement other biological control agents to manage *H. postica* populations.

**Orchard habitats.** Hagley (1979) studied the effects of insecticides on natural predator populations in apple, *Malus* spp. (Rosaceae), orchards. *Hippodamia tridecemlineata tibialis* (Say) and *Adalia bipunctata* (L.) (Coleoptera: Coccinellidae) were the most abundant predators collected. *Phytocoris* sp., *Deraeocoris fasciolus* Knight and *Plagiognathus obscurus* (Uhler) (Hemiptera: Miridae) were the main true bug species encountered, and *Chrysopa oculata* (Say) (Neuroptera: Chrysopidae), *Hemerobius humulinus* (L.) (Neuroptera: Hemerobiidae), *Epiodes americanus* Wiedemann, *Allograpta obliqua* (Say) (Diptera: Syrphidae), *Cantharis* sp. and *Podabrus* spp. (Coleoptera: Cantharidae) commonly occurred. Overall, predator populations were low and insecticide treatments (phosmet and azinphosmethyl) appeared to reduce eggs and immature stages of the predators. Most adult predators collected immigrated from outside of treated areas. Thus, numbers of predators in natural areas was insufficient to provide effective control of the major pests: codling moth, apple maggot, and Plum Curculio, *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae). Hagley (1979) concluded that augmentation of predator numbers is required when management practices use insecticides.

Woolhouse and Harmsen (1985) studied the population dynamics of the mite complex on foliage of a pesticide-free apple orchard. Over a 3-year period, population dynamics were highly variable but pest species did not reach economic thresholds. *Zetzellia mali* (Ewing) (Trombidiformes: Stigmeiidae) and Phytoseiidae species tracked changes in prey abundance. *Zetzellia mali* was more closely linked to eriophyid rust mites, *Aculus* sp., abundance while the Phytoseiidae were linked to tetranychid, i.e., Two-spotted Spider Mite and European Red Mite, abundance. *Zetzellia mali* and Phytoseiidae were more abundant on trees nearer the orchard edge suggesting the acaricide spray programs that focus on the central parts of an orchard could be less detrimental to predator populations. They concluded that pest populations tend to be lower, sometimes by an order of magnitude, on McIntosh and Golden Delicious varieties than on Red Delicious and Empire varieties in a predator-rich environment.

**Non-crop habitats.** Laing and Welch (1963) reported feeding by adults of the predaceous fly, *Dolichopus gratus* Loew (Diptera: Dolichopodidae), on larvae of *Culex restuans* Theobald (Diptera: Culicidae). Edwards and Pengelly (1966) reported parasitism of *Bombus fervidus* (Fabricius) (Hymenoptera: Apidae) by *Melittobia chalybii* Ashmead (Hymenoptera: Eulophidae). Loan (1973) reported the first occurrence of parasitism of adult *Notoxus anchora* Hentz (Coleoptera: Anthicidae) by *Centistes agilis* (Cresson) (Hymenoptera: Braconidae); the level of parasitism was 7%.

### 3. Natural Enemy Biology

Understanding the biology of natural enemies provides guidance for the development and conservation of agents to better manage key pests. Since 1952, five JESO studies described methods to improve rearing of natural enemies useful as biological control agents while another 18 studied performance of potential biological control agents. Four other studies described the basic biology of particular natural enemies to better understand development, behaviours or species interactions. Finally, four studies looked at how particular pesticides affected the biology of natural enemies.

**Rearing of natural enemies.** Maybee (1956) described a method for rearing the exotic parasitoid *Basalys tritomus* Thomson (Hymenoptera: Diapriidae) on *Drosophila melanogaster* Meigen (Diptera: Drosophilidae) in the laboratory. West and DeLong (1956) studied the biology of and developed a rearing method for *Zelus exsanguis* (Ståhl) (Hemiptera: Reduviidae), a generalist predator found in Ontario commonly found feeding on larvae of the forest tent caterpillar. They successfully reared three generations in the laboratory; cannibalism appeared to be an important consideration because it affects survival of newly hatched nymphs.

Corrigan et al. (1990) studied the pupal orientation and emergence success of *Horismenus puttleri* (Grissell) (Hymenoptera: Eulophidae), imported from Central America for biological control of Colorado Potato Beetle, *Leptinotarsa decemlineata* (Say) (Coleoptera: Chrysomelidae). Because *H. puttleri* is unable to overwinter in temperate North America, mass production for inundative releases was considered as the best option to use this agent. Location of host eggs on leaf surfaces influenced parasitoid pupal orientation and emergence. When egg masses faced down (i.e., underside of leaf) 98% of parasitoids pupated with their head down and 89% of adult *H. puttleri* emerged successfully. In contrast, when egg masses faced up (i.e., upper side of leaf) 63% of *H. puttleri* individuals faced down (head faced the leaf surface) and 66% of adult parasitoids emerged successfully.

Corrigan and Laing (1992) studied an improved method for producing small, consistent samples of hosts for presentation to the egg parasitoid, *Trichogramma minutum*. They described a new sampling strip to decrease preparation times and reduce damage to host *Ephestia kuehniella* Zeller eggs (Lepidoptera: Pyralidae). Corrigan et al. (1994) studied the feasibility of delaying emergence of *T. minutum* and subsequent effects on adult longevity and fecundity. Adult longevity of individuals reared at 16°C increased in direct proportion to the length of time they were held as pre-adults at this temperature, compared to 25°C. However, offspring production was reduced when reared at 16°C, although reproductive potential was not affected by length of time at 16°C or 12L:12D conditions. The results indicated that under the conditions studied emergence from *E. kuehniella* eggs

was not sufficiently delayed and rearing at lower temperatures (i.e., 16°C) adversely affected reproductive performance.

**Performance of biological control agents.** James (1959) studied egg development, hatching and prey consumption in several habitats by *Mantis religiosa* L. (Orthoptera: Mantidae), introduced from Europe in the early 1900s. Egg development differed among habitats but did not affect hatching. He found that prey abundance, primarily field crickets, influenced number of and size of egg masses indicating the importance of this prey for maintaining local populations of *M. religiosa*.

Loan (1964) studied the biology of *Centistes ater* (Nees) (Hymenoptera: Braconidae), an internal parasitoid of adult *Sitona* spp. (Coleoptera: Curculionidae), as a biological control agent of *S. lineellus* (Bonsdorff) in Canada. In the field, *C. excrucians* is well synchronized with the univoltine *S. lineellus*. The parasitoids overwintered as mature larvae in adult weevils, emerging the following spring in late April or May, depending on temperature, to pupate in the soil. Adult *C. ater* emerged in late June–early July when the summer-emerged adult *S. lineellus* were present.

Loan (1965) described the life cycle and development of *Leiophron mellipes* (Cresson) in five Miridae (Hemiptera) hosts in southern Ontario. Adults were present from May to September. Immature stages were found in *Labops hirtus* Knight (late May to mid-June, 20% parasitism), *Leptopterna dolabrata* (L.) (mid-May to end of June, 42% parasitism), *Adelphocoris lineolatus* (Goeze) and *A. rapidus* Say (June, 49% and 60%, respectively), and *Lygus lineolaris* (Hemiptera: Miridae) (June–July, 46% parasitism, and August–September, 12% parasitism). A single generation of *L. mellipes* occurred in each host species, although each of the two distinct generations of *L. lineolaris* were parasitized.

Griffiths (1972) studied the discrimination ability of the parasitoid *Pleolophus basizonus* (Gravenhorst) (Hymenoptera: Ichneumonidae) introduced from 1939–1949 for biological control of the invasive European Pine Sawfly, *Neodiprion sertifer* (Geoffroy) (Hymenoptera: Diprionidae). Although unable to detect hosts containing eggs of conspecifics, *P. basizonus* were able to detect hosts containing later developmental stages. *Pleolophus basizonus* was also recovered from two other introduced and seven native sawflies.

Reid and Harmsen (1975) studied the biology of *Trihabda borealis* Blake (Coleoptera: Chrysomelidae) on goldenrod, *Solidago canadensis* (Kirby) (Asteraceae). They determined *T. borealis* is of major importance as a phytophage on *S. canadensis* in southeastern Ontario, although serious defoliation was rare.

Ramey (1990) studied the host identification and oviposition behaviour of *Eurytoma obtusiventris* Gahan (Hymenoptera: Eurytomidae), a parasitoid of *Eurosta solidaginis* (Fitch) (Diptera: Tephritidae) that live in galls of goldenrod (*Solidago* spp.). Female *E. obtusiventris* preferred stems of *Solidago altissima* L. infested with *E. solidaginis* but also explored *S. altissima* stems without fly larvae, although females only oviposited in plants containing host larvae. He also showed that *E. obtusiventris* females prefer *S. altissima* infested plants over infested *S. canadensis* plants.

George (1979) studied the potential of *Dugesia tigrina* (Girard) (Tricladida: Duegesiidae) for control of mosquitoes in Ontario. Field tests showed that *D. tigrina* reduced populations of *Culex restuans* and *C. pipiens* L. (Diptera: Culicidae) by 17 times (4/dip versus 69/dip in control treatments). Low oxygen levels and toxins such as turpentine and paint were important mortality factors of *D. tigrina* in catch basins (George 1984).

Loan (1982) developed a field technique to study the interaction of the fungi *Zoophthora* spp. (Entomophthoraceae) and the parasitoid *Perilitus colesi* (Drea) (Hymenoptera: Braconidae) both of which attack larvae of the alfalfa weevil. Foliar applications of the fungicide captan protected weevil larvae from attack by *Zoophthora* spp. The study confirmed earlier findings that peak attack by *M. colesi* occurred after disease epizootics caused by *Zoophthora* spp. began to subside.

Bolter and Laing (1984) studied competitive interactions between *Diadegma insulare* and *Microplitis plutellae* for larvae of diamondback moth. Development of both parasitoids was synchronized with that of the host. At 23°C average fecundity was 814 eggs per female for *D. insulare* and 316 eggs per female for *M. plutellae*. Degree-day development from egg to adult was 282 above 6.6°C for *D. insulare* and 218 above 9.2°C for *M. plutellae*. *Diadegma insulare* avoided superparasitism and multiple parasitism of larvae already parasitized by *M. plutellae*. In contrast, *M. plutellae* avoided superparasitism but could not detect eggs of *D. insulare* for at least 12 h after they were oviposited in the host. When eggs of both species were oviposited at the same time, 1<sup>st</sup> instar *M. plutellae* was intrinsically superior to 1<sup>st</sup> instar *D. insulare*. However, 2<sup>nd</sup> and 3<sup>rd</sup> instar *D. insulare* were superior to 1<sup>st</sup> instar *M. plutellae*.

Clements (1989) studied the role of the stigmeid mite, *Z. mali* in orchards. *Zetzellia mali* fed on the European red mite and the Apple Rust Mite, *Aculus schlechtendali* (Nalepa) (Trombidiformes: Eriophyidae) but did not interfere with the phytoseiid mite *Typhlodromus caudiglans* (Schuster) (Mesostigmata: Phytoseiidae), either by intraguild predation or competition.

Whistlecraft and Lepard (1989) studied the effect of flooding on the survival of the Onion Maggot, *Delia antiqua* (Meigen) (Diptera: Anthomyiidae), and two of its parasitoids, *Aphaereta pallipes* (Say) (Hymenoptera: Braconidae) and *Aleochara bilineata* Gyllenhal (Coleoptera: Staphylinidae). Survival of *A. pallipes* was greater than or equal to that of its host while survival of *A. bilineata* was less, even at temperatures below the developmental threshold (1°C). This suggested that flooding of fields to control *D. antiqua* may lead to elimination of *A. bilineata* populations. Whitfield et al. (1981) developed a computer model to simulate the interaction between onion maggot and *A. pallipes*, a larval parasitoid. The model determined that *A. pallipes* reduced 2<sup>nd</sup> and 3<sup>rd</sup> generation maggot populations, resulting in a 70% profit gain. As well, the model provided guidance on when spray applications would least affect parasitoids.

Wang and Laing (1989) studied the reproductive biology of the introduced *Ageniaspis testaceipes* (Ratzeburg) (Hymenoptera: Encyrtidae), an egg-larval parasitoid, and its effect on the spotted tentiform leafminer. Potential fecundity of *H. testaceipes* was 25 eggs per female and an average of 9.1±3.4 broods were produced over an average lifespan of 7.5±2.7 days. Although newly oviposited host eggs were preferred, eggs up to 5 days old were successfully parasitized and parasitoid development took 35–37 days at 25°C. Development of parasitized *H. testaceipes* was delayed and these individuals were larger than unparasitized individuals. The longer feeding period and larger size of parasitized spotted tentiform leafminer larvae suggest that *H. testaceipes* may consume more foliage, however, this may also increase the size and/or number of parasitoids. They concluded that the attribute that female *H. testaceipes* may oviposit into host eggs of any age provides a

larger window of opportunity for oviposition, facilitating synchronization with its host and improve efforts to establish *H. testaceipes* in North America.

Song (1990) studied the potential for *Gelis tenellus*, a hyperparasitoid, to influence parasitism of gypsy moth by *Cotesia melanoscela* (Ratzeburg) (Hymenoptera: Braconidae). *Gelis tenellus* produced significantly more eggs when hosts were available on a daily basis versus every third day. Nealis and Bourchier (1995) compared the vulnerability to hyperparasitism of different European and Asian strains of *Cotesia melanoscela*, a biological control agent of gypsy moth. Rates of predation and hyperparasitism were not related to cocoon morphology but were dependent on length of time cocoons were exposed to hyperparasitism in the field. The nondiapause characteristics of the Asian strain decreased its exposure time and therefore reduced vulnerability to hyperparasitism. Thus, inundative releases of nondiapause strains early in the season were likely to minimize exposure of *C. melanoscela* to hyperparasitism, which currently is 95% over the summer. They also concluded that diapause of already established local strains of *C. melanoscela* could be manipulated by varying photoperiod during larval development, thus release of additional exotic strains would not be required.

Villaneuva and Harmsen (1996) studied the ecological interactions of tarsonemid mites in apple orchards. *Dendroptus* n. sp. near *suskii* Sharonov and Livshitz (Trombidiformes: Tarsonemidae) was identified as a predator of apple rust mite and contributed to the mid-summer decrease of this pest.

Jones et al. (2006) studied the influence of greenhouse microclimate on predation of Western Flower Thrips, *Franklinella occidentalis* (Pergande) (Thysanoptera: Thripidae) by *Neoseiulus cucumeris* (Oudemans) (Mesostigmata: Phytoseiidae). Leaf temperature was positively correlated with predation and oviposition by *N. cucumeris*, suggesting that seasonal adjustments in release of this biological control agent could be made.

**Development, behaviour and species interactions.** Vander Hoek (1971) described the larval instars of *Aphidius nigripes* Ashmead (Hymenoptera: Braconidae), a common parasitoid of the pea aphid, *Acyrthosiphon pisum* (Harris) (Hemiptera: Aphididae). Five instars were documented based on changes in cuticular structure observed at 24 h intervals.

Bennett (2004) studied the host location behaviour of *Pelecinus polyturator* (Drury) (Hymenoptera: Pelecinidae) a common endoparasitoid of june beetles, *Phyllophaga* spp. (Coleoptera: Scarabeidae). Host location consisted of wandering on the surface until the antennae ceased moving and the distal abdominal segments appeared to touch the surface. Then a series of movements would push the distal segment into the soil, penetrating up to 5 cm. The procedure lasted about 145 seconds.

Macfarlane and Pengelly (1978) studied *Brachioma* spp. (Diptera: Sarcophagidae), and the eulophid *Melittobia chalybii* Ashmead (Hymenoptera: Eulophidae), parasites of the brood of *Bombus* spp. in southern Ontario. They reported *Brachioma setosa* Coquillett as a parasite of *Bombus* for the first time and found that 2–3 generations occurred each season. As well, *M. chalybii* attacked both *Bombus* spp. and *B. setosa*. They found that these parasites attacked larvae of *Bombus* spp. and infested colonies had fewer workers and died out more quickly than unparasitized colonies.

Wright and Laing (1979) reported on the effects of temperature on development, adult longevity and fecundity of *Coleomegilla maculata lengi* Timberlake (Coleoptera:

Coccinellidae) and its parasitoid *Dinocampus coccinellae* (Shrank) (Hymenoptera: Braconidae). A total of 198.8 degree-days (above 13.8°C) were required for development of *C. maculata lengi* from egg to adult while 180.5 degree-days (above 11.2°C) were required for *D. coccinellae* development. *Coleomegilla maculata lengi* produced an average of 191.5 eggs per female and longevity averaged 82.3 days. *Dinocampus coccinellae* survived for 5 days when continuously exposed to hosts and produced an average of 66.8 eggs per female at 25°C. Earlier studies had estimated potential fecundity of *D. coccinellae* at 200–400 eggs per female, thus it appeared that realized fecundity was limited by the ability of females to find hosts. Wright (1979) observed the copulatory behaviour of *C. maculata lengi*. The male mounted females from behind and assumed the dorsal position as is normal for braconids. Copulation lasted for 18–20 min, considerably longer than the <1 min known for other braconids.

**Effects of pesticides on natural enemies.** Robinson (1953) described the biology of *Stethorus punctum* (LeConte) (Coleoptera: Carabidae) and determined that DDT and methoxychlor were lethal to adults, killing 47.1 and 60%, respectively, in laboratory experiments. Fisher (1988) reported on the effects of pesticides on *Pholetesor ornigis* (Weed) and *P. pedias* (Nixon) (Hymenoptera: Braconidae), parasitoids of the spotted tentiform leafminer. The number of days to 50% mortality (LT50) of *Pholetesor pedias* was higher than for *P. ornigis* when exposed to azinphosmethyl and permethrin.

Hagley and Laing (1989) studied the effect of pesticides on parasitism by *T. minutum* and *T. pretiosum* Riley (Hymenoptera: Trichogrammatidae) of eggs of codling moth. The insecticides azinphosmethyl, diflubenzuron, permethrin, and methomyl were toxic, as was the acaricide cyhexatin. Triflumuron, a lower rate of diflubenzuron (1/3 of recommended dose), and the fungicides captan, dodine and polyram did not affect parasitism.

Wang and Laing (1990) studied the toxicity of methomyl, permethrin, azinphosmethyl and phosmet to adult *Ageniaspis testaceipes*, an introduced egg-larval parasitoid of the spotted tentiform leafminer. At the time, these insecticides were used to control spotted tentiform leafminer, the plum curculio, codling moth and apple maggot in Ontario orchards. They concluded that understanding tolerance levels of *A. testaceipes* to pesticides used is essential for integrating this biological control agent into management programmes. For example, methomyl and permethrin residues caused higher mortality of *A. testaceipes* than azinphosmethyl and phosmet, although responses of individual females were highly variable to the latter two products.

#### 4. Classical Biological Control of Weeds

Studies on classical biological control of weeds reported in JESO have been few and none are comprehensive. A great deal of the work in this area relevant to Ontario has been published elsewhere (e.g., The Canadian Entomologist). In JESO there are publications on various aspects of exotic phytophagous-feeding insects introduced for biological control of five non-native weed species (Table 1). Three species are on the Noxious Weeds in Ontario list (Anonymous 2013) and all are treated in the *Ontario Weeds* guide (Alex, 1998). The publications summarized here report on the status, at the time of publication, of introduced species.

**Canada Thistle**, *Cirsium arvense* (L.) Scopoli (Asteraceae), is a noxious and widespread weed in Ontario, most abundant in southern areas (Moore, 1975). *Urophora*

*cardui* L. (Diptera: Tephritidae) was introduced for its biological control (Laing 1978). Three years after initial releases in 1975, 40% of host plants around the release site contained galls of *U. cardui* and the agent had spread to plants several hundred meters from the release site.

**Leafy Spurge**, *Euphorbia esula* L. (*Euphorbiaceae*), is a noxious and widespread weed in Ontario (Best et al. 1980). LeSage (1996a) reported that populations of the introduced biological control agent, *Aphthona nigriscutis* Foudras (Coleoptera: Chrysomelidae) increased significantly in 1994 and 1995 but did not damage leafy spurge. The survey also yielded specimens of *A. flava* Guillebeau, a related exotic species that had not been approved for release, suggesting that some individuals in the released population were misidentified.

**Nodding Thistle**, *Carduus nutans* L. (*Asteraceae*), is a noxious and widespread weed in Ontario where it is most abundant, although it occurs throughout Canada (Desrochers et al. 1988). Laing and Heels (1979) reported that three years after 1975 releases, *Rhinocyllus conicus* Frölich (Coleoptera: Curculionidae) was well established around Guelph. Infestation levels up to 95% (24–95%) were recorded. Thistle seed heads with 7+ pupal cells of *R. conicus* produced significantly reduced amounts of seed than those seed heads with 0–6 pupal cells.

**Purple Loosestrife**, *Lythrum salicaria* L. (*Lythraceae*), is highly abundant in the Great Lakes Basin and along the St. Lawrence River (Mal et al. 1992). Corrigan et al. (1998) conducted a study on potential non-target feeding by *Neogalerucella calmariensis* (L.) (Coleoptera: Chrysomelidae) introduced for biological control of this invasive plant. The study was initiated based on the field observations of *G. calmariensis* feeding on cuttings of Swamp Loosestrife, *Decodon verticillatus* (L.) Elliott, and egg masses on Winged Loosestrife, *Lythrum alatum* Pursh (*Lythraceae*), at the Ontario Royal Botanical Garden where large populations of *N. calmariensis* were present. Monitoring of all three plant species through two generations of the beetle revealed that *L. salicaria* plants sustained moderate to complete defoliation in all areas monitored. Several *D. verticillatus* and *L. alatum* plants were slightly damaged by *N. calmariensis* feeding and about 15 egg masses were found when several hundred of these non-target plants were examined. No late instar larvae were found on either *D. verticillatus* or *L. alatum*. The results suggested that the minimal feeding and few egg masses represent a ‘spill-over’ effect that occurred when large numbers of *N. calmariensis* were dispersing from locations where *L. salicaria* populations had been significantly reduced.

**St. John’s Wort**, *Hypericum perforatum* L. (*Hyperiaceae*) is found in the Great Lakes-St. Lawrence regions of Ontario (Crompton et al. 1988). LeSage (1996b) reported on the presence in the Gatineau area of Quebec of *Chrysolina hyperici* (Förster) (Coleoptera: Chrysomelidae), introduced for biological control of St. John’s wort. The agent had dispersed 145 km from the release site in Belleville, Ontario, at an estimated rate of 6 km per year.

## 5. Classical Biological Control of Arthropods

Introduction of exotic species for the biological control of arthropods has been reported in JESO for 15 invasive species (Table 2). All but one of these papers (Maxwell and Morgan 1952) treated pests of agriculture crops or trees in Ontario. The JESO studies summarized here for each target species report on the status of introduced biological

control agents, i.e., whether established or not, and document native natural enemy species associated with the targets at the time of publication.

**Alfalfa Blotch Leafminer**, *Agromyza frontella* (Rondani) (Diptera: Agromyzidae), invaded Ontario in the mid 1970s. Coote and Ellis (1987) studied the parasitoids of alfalfa blotch leafminer near Guelph in 1983–1984. Four parasitoids, *Diglyphus begini* (Ashmead), *D. intermedius* (Girault), *D. pulchripes* (Crawford) and *Pnigalio maculipes* (Crawford) (Hymenoptera: Eulophidae) were reared from larvae. *Cyrtogaster vulgaris* Walker (Hymenoptera: Pteromalidae) and *Chrysocharis giraulti* Yoshimoto (Hymenoptera: Eulophidae) were reared from pupae. Overall parasitism was low, averaging 3.4% due in part to poor synchrony of the parasitoids with the host. One additional species, *Diglyphus isaea* (Walker) (Hymenoptera: Eulophidae) was collected from alfalfa plants. Parasitoids emerged later in the spring than alfalfa blotch leafminer, thus parasitizing only 2<sup>nd</sup> and 3<sup>rd</sup> generation hosts. *Diglyphus intermedius* was the most abundant of the larval parasitoids and the three *Diglyphus* spp. accounted for 75% of the parasitoids reared from hosts. *Diglyphus isaea* and *C. vulgaris* are exotic parasitoids and were reported for the first time in Ontario and in association with alfalfa blotch leafminer. All but one of the pupal parasitoids was *C. vulgaris* and parasitism levels were low, averaging <1% but were highest at 3.3% in the 3<sup>rd</sup> generation, although sampling included only the few pupae on plants and not those in soil where alfalfa blotch leafminer normally pupates. It was concluded that the existing parasitoid complex was unlikely to maintain alfalfa blotch leafminer below economic thresholds and exotic species already established in the USA would be suitable for introduction. Harcourt et al. (1987) reported that the European larval-pupal endoparasitoid *Dacnusa dryas* (Nixon) (Hymenoptera: Braconidae), first released in 1979 near Ottawa, became well established in most counties of southern Ontario, with rates of attack averaging 84% (65–95%). Dispersal from nursery plots and natural spread from release sites and life table data indicated that alfalfa blotch leafminer populations declined less than three years after release of *D. dryas*.

**Alfalfa Weevil**, *Hypera postica* (Gyllenhal) (Coleoptera: Curculionidae), of European origin, was first reported in the Great Lakes region in the early 1960s. Abu and Ellis (1976) studied *Bathyplectes curculionis* (Thomson) (Hymenoptera: Ichneumonidae) a larval parasitoid of alfalfa weevil and found that although spring emergence of *B. curculionis* was synchronized with that of alfalfa weevil larvae, parasitism levels were low early in the season (6.3–33.3%) when host populations were highest, increasing later in the season (60–68%) when host populations were declining. High rates of diapause in 1<sup>st</sup> generation parasitoid larvae were thought to be responsible for the lower initial parasitism. Several hyperparasitoids, *Gelis* sp., *Trichomalopsis viridescens*, *Pteromalus* sp. and *Eupelmella vesicularis* (Retzius) (Hymenoptera: Eupelmidae) were reared from 24% of *B. cuculionis*. Harcourt et al. (1980) studied the distribution of the European exotic *Perilitus aethiops* Nees (Hymenoptera: Braconidae), a parasitoid that attacks adults of alfalfa weevil. First released in Ontario in 1970–1971, *P. aethiops* became widely established in southern Ontario by 1979, where parasitism levels of the spring generation of alfalfa weevil averaged 60% (13–92%). Harcourt et al. (1982) conducted a survey for *Perilitus colesei* (Drea), a larval parasitoid introduced in 1970 and found that *P. colesei* was present in 39 of 41 counties, with parasitism levels averaging 13% (1–52%). Although two fungal pathogens also attack alfalfa weevil larvae, *M. colesei* emerges from cocoons in late May or early June and attacks larger

host larvae, likely after epizootics have subsided and therefore it is able to coexist with the disease agents. The widespread distribution of *M. colesi* is probably the result of dispersal from the USA into southwestern Ontario and dispersal from the release site in Prince Edward County in eastern Ontario. Harcourt and Ellis (1992) determined that the larval parasitoid *Bathyplectes anurus* (Thomson) (Hymenoptera: Ichneumonidae), introduced in 1970, had become widespread in southern Ontario and had displaced *B. curculionis* as the main larval parasitoid of *H. postica*. Abundance of this parasitoid was influenced by the fungal pathogen *Zoophthora phytonomi* (Arthur) Batko (Entomophthoraceae), which dominated during wet periods while *B. anurus* increased during successive dry springs.

**Carrot Rust Fly**, *Psila rosae* (Fabricius) (Diptera: Psilidae) was introduced around 1885. Releases of *Chorebus posticus* (Haliday) (Hymenoptera: Braconidae), a larval parasitoid, and *Basalys tritoma*, a pupal parasitoid, were made from 1949–1953 in Ontario, British Columbia, and Prince Edward Island (Maybee 1954). Although recoveries were made in the year of release neither *C. posticus* nor *B. tritoma* were collected the following winter.

**Cereal Leaf Beetle**, *Oulema melanopus* (L.), (Coleoptera: Chrysomelidae), was first found in southwestern Ontario in 1965 and became established in 1967 (McClanahan et al. 1968; Bierne 1971). McClanahan et al. (1968) reported that while no natural enemies were present in southwestern Ontario during the study, predators, parasitoids and diseases had been reported elsewhere in parts of North America invaded by this European pest. Ellis et al. (1979) reported that *Tetrastichus julis* (Walker) (Hymenoptera: Eulophidae), introduced into southern Ontario in 1974 as a biological control agent for cereal leaf beetle, had by 1977 expanded its range into the area north of Lake Huron and parasitism levels from 19–90% were documented. In areas where *T. julis* had been established since 1976, parasitism averaged 65%, indicating that it can maintain populations even when host densities are low. This successful biological control continued until an outbreak occurred in the central tobacco growing area of Ontario (Ellis et al. 1989). In a 1987 survey they reared a single *Anaphes* sp. from eggs of cereal leaf beetle and parasitism by *T. julis* was nil, despite high levels (~75%) of parasitism in other parts of the province. It was concluded that tillage, which kills 95% of overwintering *T. julis*, probably accounted for the absence of this agent in areas where crop rotations were practiced.

**Codling Moth**, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae), of southeastern European origin, was present in Ontario by 1858–1860 and a major apple pest by 1868 (Putnam 1963). In a review of the status of *C. pomonella* Putnam (1963) included what was known at the time about natural enemies. *Trichogramma minutum* was the only egg parasitoid associated with *C. pomonella*, while larval parasitoids included *Scambus pterophori* Ashmead (Hymenoptera: Ichneumonidae), *Dibrachys microgastri* (Bouché) (Hymenoptera: Pteromalidae), *Hymenocharonia delicata* (Cresson), *Macrocentrus ancylivora* Rohwer, *M. instabilis* Muesebeck, *Phanerotoma fasciata* Provancher (Hymenoptera: Braconidae), *Mastrus carpocapsae* (Cushman), *Temelucha minor* (Cushman), *Cryptus albitalris* (Cresson), *Glypta* sp., *Aritranis* sp. (Hymenoptera: Ichneumonidae), and the adventive *Ascogaster quadridentata* Wesmael (Hymenoptera: Braconidae). *Dibrachys microgastri* was also found to be a hyperparasitoid of *A. quadridentata* as were *Perilampus fulvicornis* Ashmead, *P. tristis* Mayr and *Perilampus* sp. (Hymenoptera: Perilampidae), sometimes at levels of 72%. Pupal parasitism was negligible but included *D. microgastri*, *Eupelmus*

*cyaniceps* Ashmead (Hymenoptera: Eupelmidae), *Pimpla annulipes* Brullé, *Itoplectis conquisitor*, and *Eurytoma* sp. a hyperparasitoid. *Eupelmus cyaniceps* also parasitized the larval parasitoids *Macrocentrus* spp. and the pupal parasitoid *P. annulipes*. *Liotryphon caudatus* (Ratzeburg) and *Nippocryptus vittatorius* (Jurine) (Hymenoptera: Ichneumonidae) were introduced from France from 1941–1945 but failed to establish. *Elodia tragica* (Meigen) (Diptera: Tachinidae) and *Pristomerus vulnerator* (Panzer) (Hymenoptera: Ichneumonidae) were introduced from England in 1943–1944. *Ascogaster quadridentata*, *L. caudatus* and *N. vittatorius* were introduced into British Columbia but only *A. quadridentata* became established. The most important insect predators were the trogositid borer *Tenebrobroides corticalis* Melsheimer (Coleoptera: Trogossitidae), *Chrysopa carnea* (Stephens) and *C. rufilabris* Burmeister (Neuroptera: Chrysopidae), the egg feeding *Haplothrips faurei* Hood and *Leptothrips mali* (Fitch) (Thysanoptera: Phlaeothripidae), and the mite *Anystis agilis* Banks (Trombidiformes: Anystidae). Downy, *Dendrocosps pubescens* (L.), and hairy, *D. villosus* (L.) woodpeckers (Piciformes: Picidae) were important predators of codling moth. Several diseases have been isolated from codling moth, including *Bacillus cereus* from the Niagara Peninsula, *Beauveria bassiana* from Nova Scotia, and *Hirsutella subulata* Petch (Ophiocordycipitaceae) from the USA. *Mermis* sp. and *Neoaplectana* n. sp. (DD136) (Mermithidae) nematodes were also found infecting codling moth. Hagley (1970) studied codling moth to assess the importance of biotic and abiotic factors in regulating populations. He determined that disease (34.4–65.1%) and parasitism (31.9–80%) could be significant, although they were not uniform across orchards. Predation by birds was as high as 90%. Hagley (1987) surveyed the *Trichogramma* spp. in apple orchards in southern Ontario after inundative releases of *T. pretiosum* and *T. minutum*. Only *T. pretiosum* was recovered from sentinel codling moth eggs set out in 1982 and 1983. Parasitism ranged from 2.2–11.9% and parasitoids were recovered in both unsprayed and sprayed orchards. In 1984, *T. minutum* was the only species recovered in unsprayed orchards. The results indicated that *Trichogramma* spp. migrated into orchards from alternative hosts and occurred in low numbers early in the season. This and overall low natural parasitism suggested that augmentative releases and management of parasitoid populations could improve the success of biological control of coding moth.

**Cranberry Fruitworm**, *Acrobasis vaccinii* Riley (Lepidoptera: Pyralidae), in New Brunswick was the subject of a study showing that eggs were parasitized by *Phanerotoma franklini* Gahan (Hymenoptera: Braconidae) and that *Cryptus albitarsus albitarsus* (Cresson) (Hymenoptera: Ichneumonidae) emerged from overwintered larvae (Maxwell and Morgan 1952).

**European Pine Shoot Moth**, *Rhyacionia buoliana* (Denis and Schiffermüller) (Lepidoptera: Tortricidae), was introduced adventively from the USA into Ontario near Windsor in 1925 (Pointing and Green 1962). Coppel and Arthur (1954) provided an update on parasitoids introduced in Ontario to control it. From 1928–1953 nine species, including *Campoplex difformis* (Gmelin), *Sinophorus turionum* (Ratzeburg), *Temelucha interruptor* (Gravenhorst), *Exeristes ruficollis* (Gravenhorst), *Pimpla turionellae* (L.), an unidentified *Pimpla* sp. (Hymenoptera: Ichneumonidae), *Orgilus obscurator* (Nees) (Hymenoptera: Braconidae), *Copidosoma filicornis* (Dalmen) (Hymenoptera: Encyrtidae), and *Baryscapus turionum* (Hartig) (Hymenoptera: Eulophidae) were released. Among the species recovered during post-release surveys, *C. interruptor* and *O. obscurator* accounted for more than 2/3

of all parasitoids. Overall parasitism was 1.96–10.86% and the native species, *Campoplex* sp., *Itoplectis conqueritor*, *Itoplectis* sp., *Scambus hispae* (Harris) (Hymenoptera: Ichneumonidae), *Eurytoma appendigaster* (Swederus) (Hymenoptera: Eurytomidae), *Habrocytus* sp. (Hymenoptera: Pteromalidae), *Hyssopus thymus* Girault (Hymenoptera: Eulophidae), the tachinid *Exeristes comstockii*, and an undetermined species were reared from European pine shoot moth. Individuals of the introduced *T. turionum*, *C. difformis*, and *P. turionellae* were also reared; however, no recoveries of *C. geniculatum*, *C. rufifemur* and *E. ruficollis* were made during the survey. Pointing and Green (1962) determined that the 21 native and introduced parasitoids had negligible impact on the host and only four, *O. obscurator*, *T. interruptor*, *P. turionellae* and *B. turionum*, of the 13 species introduced had established. Among these, *O. obscurator* was the most abundant in Ontario and Quebec.

**Gypsy Moth**, *Lymantria dispar* (L.) (Lepidoptera: Erebidae), was first reported in Ontario on Wolf Island near Kingston in 1969, spreading to the mainland and throughout eastern Ontario by 1971 (Griffiths 1977). A survey in 1974–1975 by Griffiths (1977) reported that among the four parasitoid species recovered, *Cotesia melanoscela*, *Compsilura concinnata* and *Parasetigena agilis* (Robineau-Desvoidy) (Diptera: Tachinidae) are exotic introductions, none of which targeted gypsy moth, while *Pimpla pedalis* Cresson (Hymenoptera: Ichneumonidae) is native. Also reported was the native *Gelis tenellus* as a hyperparasitoid of *C. melanoscela*. *Cotesia melanoscela* was the most widely distributed while *C. concinnata* was the most abundant. Nealis and Quednau (1996) documented releases and overwintering survival of the European *Ceranthis samarensis* (Villeneuve) (Diptera: Tachinidae) introduced for biological control of gypsy moth. Releases of gravid female adults, parasitized larvae and parasitized pupae were made from 1991–1996. In each year of release, evidence of successful parasitism by field-released females was observed. All progeny retrieved were in diapause and overwintering studies indicated that survival of pharate adults was expected to be high. Because of the low fecundity of *C. samarensis* ongoing monitoring was recommended to determine if successful establishment had occurred.

**Imported Cabbageworm**, *Pieris rapae* (L.) (Lepidoptera: Pieridae), was first reported in eastern Ontario in 1871 and throughout southwestern Ontario by 1876 (Harcourt 1963). Parasitoids are important mortality factors of *P. rapae* (Harcourt 1963), principally *Cotesia glomerata* (L.) (Hymenoptera: Braconidae) which attacks larvae. Later instars are attacked by *Phryxe vulgaris* (Fallén) (Diptera: Tachinidae) and pupae are attacked by *Pteromalus puparum* (L.) (Hymenoptera: Pteromalidae). Generalist species associated with *P. rapae* include *C. concinnata*, *Helicobia rapax* (Walker) (Diptera: Sarcophagidae) and *Madremya saundersii* (Williston) (Diptera: Tachinidae). Although invertebrate predators and birds are present they did not have a significant impact, unlike granulosis virus which caused up to 94% mortality. Corrigan (1983) conducted a survey for *Cotesia rubecula* (Marshall) (Hymenoptera: Braconidae) introduced from British Columbia as a biological control agent. Recovery of *C. rubecula* near Ottawa 10 years after its release indicated that this agent had established in eastern Canada and was tolerant of winter conditions. Up to 1982, no progeny of *C. rubecula* released near Guelph and Harrow in 1978–1979 were recovered in the years after release and it was thought that *C. rubecula* had been negatively impacted by hyperparasitoids. Carter and Laing (1997) reported on recoveries of a Chinese strain of *C. rubecula* released in 1991–1992. Three years after releases *C. rubecula* was

found in the release area, although the hyperparasitoids *Catolaccus* sp. (Hymenoptera: Pteromalidae), *Mesochorus vittator* (Zetterstedt) (Hymenoptera: Ichneumonidae) and *Baryscapus galactopus* (Ratzeburg) (Hymenoptera: Eulophidae) were reared from *C. rubecula* cocoons. Parasitism levels ranged from 15–21%.

**Larch Casebearer**, *Coleophora laricella* (Hübner) (Lepidoptera: Coleophoridae), was introduced into Ontario from 1935–1941. Graham (1958) studied the effectiveness of parasitoids of larch casebearer and confirmed establishment of *Chrysocharis laricinellae* (Ratzeburg) (Hymenoptera: Eulophidae) and *Agathis pumila* (Ratzeburg) (Hymenoptera: Braconidae). Parasitism by the widely established *A. pumila* ranged from 41% south of 43° north latitude to 67% between 44–45° north and it was present in areas of low and discontinuous host populations. In contrast, *C. laricinellae* had spread only 42 miles from the release point and spread appeared to be dependent on high host populations.

**Oriental Fruit Moth**, *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae), was first reported in Ontario in 1925 (McLeod 1962). Boyce and Dustan (1954) compared parasitism of *G. molesta* in a young peach orchard and a mature orchard, before and after pesticides (DDT and parathion) came into use. The most prevalent parasitoids recovered were the introduced *Macrocentrus ancyllivora*, and the native *Hymenochoaonia delicata*, *Enytus oblitteratus* (Cresson), *Glypta rufiscutellaris* Cresson (Hymenoptera: Ichneumonidae) and *Temelucha minor*. Overall, *M. ancyllivora* populations increased since insecticide use began while those of *G. rufiscutellaris* and *H. oblitteratus* decreased. *Hymenochoaonia delicata* a common parasite of the ragweed borer, *Epiblema strenuana* (Walker) (Lepidoptera: Tortricidae), continued to be abundant. Dustan and Boyce (1966) assessed parasitism of *G. molesta* from 1956–1965 and found that average parasitism by *M. ancyllivora* was 43.2–64.5% in 1<sup>st</sup> and 2<sup>nd</sup> generations, respectively, in the Niagara region and 10.3 and 12.4% in the Essex county region. Parasitism of 2<sup>nd</sup> generation oriental fruit moth by *G. rufiscutellaris* was 1.4% in Niagara and 28.6% in Essex. Among the other parasitoids, *T. minor* was reared from larvae of the 1<sup>st</sup> and 2<sup>nd</sup> generations, and *Enytus oblitteratus* (Cresson) (Hymenoptera: Ichneumonidae) and *H. delicata* were reared from larvae of the 1<sup>st</sup> generation. The abundance of *M. ancyllivora* in the Niagara region was attributed to the presence of strawberry plantings which support populations of *Ancylis comptana* (Frölich) (Lepidoptera: Tortricidae), an alternate host of *M. ancyllivora*. Phillips (1969) found that *M. ancyllivora* was the most abundant of eight parasitoids reared from Oriental fruit moth in pear orchards. Between 40 and 50% of 1<sup>st</sup> and 2<sup>nd</sup> generation fruit moth larvae were parasitized from 1964–1966. In 1967, parasitism of 1<sup>st</sup> and 2<sup>nd</sup> generation fruit moth larvae increased to 61–74%, respectively, a positive response to increasing host numbers. Increased parasitism of 2<sup>nd</sup> generation larvae led to low adult emergence.

**Pea Aphid**, *Acyrthosiphon pisum* (Harris) (Hemiptera: Aphididae), an invasive species believed to be of Palaearctic-Oriental origin, was first reported in the Ottawa area about 1898 (Mackauer 1971). Mackauer and Bisdee (1965) reported on the status of *Aphidius smithi* Sharma and Subba Rao (Hymenoptera: Aphidiidae) introduced to control pea aphid. Their southern Ontario survey revealed *Praon pequodorum* Viereck and *Aphidius nigripes* Ashmead (Hymenoptera: Aphidiidae) to be the principal parasitoids of *A. pisum*, with *Praon* sp. and *Aphelinus semiflavus* Howard (Hymenoptera: Aphelinidae) of secondary importance. Although not released in Ontario, *A. smithii* was found in areas adjacent to

Lake Ontario and it was concluded that the populations present were the result of dispersal from releases made in the USA (New Jersey, Delaware, Pennsylvania) in the late 1950s.

**Pear Psylla**, *Cacopsylla pyricola* (Förster) (Hemiptera: Psyllidae), a European invader was first reported in Ontario in 1894 (McMullen 1971). Wilde (1965) studied the biology of *C. pyricola* and noted that the nymphal parasitoid *Trechnites insidiosus* (Crawford) (Hymenoptera: Encyrtidae) was abundant before the widespread use of insecticides came to dominate control strategies. However, the predators *Chrysopa* spp., *Hippodamia* sp., *Cycloneda* sp., *Ceratomegilla* sp., *Anthocoris* sp. and *Orius* sp. were abundant during the study period. *Anthocoris melanocerus* Reuter (Hemiptera: Anthocoridae) from British Columbia was released in southwestern Ontario (Wilde 1965). Philogene and Chang (1979) reported new records of parasitic chalcidoids of pear psylla in Ontario. *Trechnites insidiosus*, *Pachyneuron* sp. and *Coccidencyrtus* sp. were found for the first time parasitizing *C. pyricola*.

**Potato Stem Borer**, *Hydraecia micacea* (Esper) (Lepidoptera: Noctuidae), an invasive pest of European origin, established in southern Ontario in the 1960s, becoming a pest in eastern Ontario in 1968 (Deedat et al. 1983). West et al. (1984) studied the parasitoids of *H. micacea*, in southern Ontario and Europe. In Ontario, the tachinid *Lydella radicis* (Townsend) (Diptera: Tachinidae) was reared from 61% of the host larvae collected. Other parasitoids recovered were *Diadegma* sp., *Campoletis* sp., *Glypta* sp., and *Pterocormis* sp. and *Therion* sp. (Hymenoptera: Ichneumonidae), although parasitism levels were low (0.5–6%). European parasitoids imported into quarantine included *Lydella stabulans* (Meigen) (Diptera: Tachinidae), *Macrocentrus blandus* Eady and Clark (Hymenoptera: Braconidae), *Exephanes occupator* Gravenhorst (Hymenoptera: Ichneumonidae) and an unidentified mermithid nematode. Comparison of the biologies of *L. radicis* and *L. stabulans* suggested that these species may coexist in the field. *Lydella stabulans* has a lower developmental threshold (6.7°C) and develops faster (159 Degree days) than *L. radicis* (13.5 °C and 113 Degree days), suggesting that the latter species would attack overwintering potato stem borer larvae earlier in the season than the former species. Developmental studies of *M. blandus* suggested that it may require an alternate host in order to produce a 2<sup>nd</sup> generation in summer. Small numbers of *L. stabulans* and *M. blandus* were released near Guelph (43.7167°N 80.4000°W).

**Red Clover Casebearer**, *Coleophora deauratella* Lienig and Zeller (Lepidoptera: Coleophoridae), was discovered in Ontario in 1989 at New Liskard (Ellis and Bjornson 1996). This European native is a threat to red clover, *Trifolium pratense* L. (Fabaceae), seed crops. Ellis and Bjornson (1996) studied the biology and biological control of red clover casebearer. Based on a successful biological control program in New Zealand, individuals of the European native *Neochrysocharis formosus* (Westwood) (Hymenoptera: Eulophidae) were imported from the population established in New Zealand and released in Ontario. However, no recoveries of *N. formosa* were made, although several other parasitoids, including the native *Bracon pygmaeus* Provancher (Hymenoptera: Braconidae), were reared. There are some taxonomic issues relating to whether the New Zealand specimens released in Ontario were indeed *N. formosa*, known to be Holarctic, or a distinct more host-specific population of *N. formosa*, or the related European *N. trifolii* Erdös (Hymenoptera: Eulophidae).

## 6. Inundative Biological Control of Arthropods with Pathogens

Entomopathogens, like other natural enemies, are important agents for reducing populations of pest arthropods, particularly insects. Among these, *Bacillus thuringiensis* Berliner (Bacilliaceae) is the most studied and this is evident in the JESO publications summarized here. In addition, papers in JESO have evaluated several other entomopathogenic organisms for their potential for inundative biological of pest insects (Table 3).

Cameron (1952) conducted a review of diseases of insects to 1951. Included was information on the fungi, *Beauveria bassiana*, *Anisoplia australica* Herbst, *Metarrhizium anisopliae* (Metchnikoff) Sorokin (Clavicipitaceae), *Aspergillus flavus* Link (Trichocomaceae) and *Isaria larinosa* (Holmskiold) Fries (Moniliaceae), the bacteria *Enterobacter aerogenes* Hormaeche and Edwards, *Bacillus subtilis* (Ehrenberg), *B. proteus* (Bach), *B. thuringiensis*, and *Paenibacillus popilliae* Dutkey (Bacilliaceae), as well as polyhedroviruses and granuloviruses. The main conclusion was that better understanding of the biology and pathogenesis of the organisms should be a priority, before practical application as biopesticides could be considered. Later, Cameron (1969) reviewed the problems and prospects in the use of pathogens for insect control. He reported that *B. thuringiensis* and *B. papillae* were the most practical and most developed pathogens at the time. Other pathogens reported on in JESO include *Nosema* species (Microsporida), viruses, and pathogenic nematodes.

***Bacillus thuringiensis*.** Angus and Heimpel (1960) reviewed the potential of bacteria for insect control. Among the several species mentioned, strains of *Bacillus thuringiensis* Berliner (*Bt*) were considered to be promising and the authors concluded that bacterial pathogens can be used to advantage in certain situations but they will never entirely replace chemical insecticides.

Angus (1965) studied the post-larval mortality of *Bt* on forest tent caterpillar, the Grey Midget, *Nycteola cinereana* Neumoegen and Dyar (Lepidoptera: Nolidae), and the Mourning Cloak, *Nymphalis antiopa* (L.) (Lepidoptera: Nymphalidae). Results showed that while most larvae were killed by *Bt* in the larval stage, some individuals of each species pupated; however, these did not survive and they contained *Bt* cells. Stewart et al. (1992) studied the factors affecting the efficacy of *Bt* serovar. *San Diego* against larvae of the Colorado potato beetle. They determined that young larvae are most susceptible and should be targeted when using this agent. Morris (1980) isolated microbial pathogens from the Maize Weevil, *Sitophilus zeamais* Motchulsky (Coleoptera: Curculionidae), including a *Bacillus* sp. from adults and two *Pseudomonas* spp. from larvae and pupae.

Tripp (1972) reported on field trials of *Bt* applications to control Eastern Spruce Budworm, *Choristoneura fumiferana* (Clemens) (Lepidoptera: Tortricidae). Application rates of 3.6 and 4.0 billion International Units (BIU) / US gal / acre effected mortalities of 96–99% on balsam fir and 80–86% on white spruce 33 days after spraying, although the occurrence of frost shortly after spraying may have influenced mortality.

Cadogan et al. (1987) evaluated a formulation of *Bt* on Jack Pine Budworm, *Choristoneura pinus pinus* (Freeman) (Lepidoptera: Tortricidae). Futura®, a new *Bt* formulation effectively suppressed populations of *C. pinus pinus* and prevented serious defoliation of host tress when applied at a rate of 30 BIU/ha. Cadogan (1993) showed that

*C. pinus* larvae that survived *Bt* applied at 30 BIU weighed significantly less than controls and *Bt* applied at 20 BIU, suggesting that weights of surviving larvae could be used as an additional criterion for assessing efficacy of *Bt*.

**Nosema species** – Wilson (1978) determined that incidence of the microsporidian *Nosema fumiferanae* (Thompson) (Nosematidae) infections increased from 35.9–69.0% over a five-year period of outbreak of its host, eastern spruce budworm. Wilson (1981) looked at the effects of *N. fumiferanae* on rearing stock of this host. Synthetic diets allowed the host to cope better with infection by *N. fumiferana*. Wilson (1985a) studied transmission and effects of *N. fumiferanae* and *Pleistophora schubergi* Zwölfer (Pleistophoridae) on eastern spruce budworm. Males infected with either *N. fumiferanae* or *P. schubergi* did not transmit spores to uninfected females through mating. However, *P. schubergi* infection reduced pupal weight (about 30%) and adult longevity of females by 2.5 days. Wilson (1985b) studied dose mortality response of *P. schubergi* on eastern spruce budworm and found that a dose of  $5 \times 10^5$  spores/larva caused >80% mortality of larvae and a dose of  $5 \times 10^7$  spores/larva caused 100% mortality. Higher doses resulted in decreased survival times of infected larvae. Wilson (1987) found that *Vairimorpha necatrix* (Kramer) (Nosematidae) caused high mortality: a dose of  $5 \times 10^4$  spores/needle caused 100% mortality. Large doses caused mortality by gut damage and bacterial septicemia, whereas low doses caused death by microsporidiosis usually just before pupation.

Wilson and Burke (1979) documented the presence of three microsporidians, *Nosema cerasivoranus* Thomson (Nosematidae), *Pleistophora* sp. (Pleistophoridae) and *Thelohania* sp. (Thelohaniidae) from larvae of the Ugly Nest Caterpillar, *Archips cerasivoranus* (Fitch) (Lepidoptera: Tortricidae). Levels of parasitism varied between years and among species, *Pleistophora* sp. at 3–35.9% was the most prevalent, followed by *N. cerasivoranae* at 0–28%, and *Thelohania* at 0–2.3%. Wilson (1980) examined the effects of *Nosema disstriae* Thompson (Nosematidae) on the forest tent caterpillar, *M. disstria*, finding that this microsporidian adversely affected pupal weights, adult fecundity and longevity.

Laing and Jaques (1985) studied Microsporidia associated with the European Corn Borer, *Ostrinia nubilalis* (Hübner) (Lepidoptera: Pyralidae) over a 7-year period. Applications of *Nosema pyrausta* (Paillot) (Nosematidae), *V. necatrix*, *Bt* and *Autographa californica* nuclear polyhedrosis virus (ACNPV) (*Baculoviridae*) had little or no effect on reducing crop damage compared to insecticides. However, Microsporidia infection levels of field collected corn borer larvae (17–40%) and adults (10–24%) did not result in reduced damage to the current crop but these authors concluded that infection levels may, over the longer term, reduce viability of populations of the pest.

**Viruses** – Cunningham et al. (1987) found the nuclear polyhedrosis virus *Lecontivirus* (*Baculoviridae*) to be highly effective against the Redheaded Pine Sawfly, *Neodiprion lecontei* (Fitch) (Hymenoptera: Tenthredinidae). A dose of  $5 \times 10^9$  polyhedral inclusion bodies (PIB) per ha in spray volumes of 2.4–9.4 L/ha provided consistent control when applied to 1<sup>st</sup>–3<sup>rd</sup> instar larvae. The virus can be cheaply produced (50 infected larvae can produce enough concentrate for the  $5 \times 10^9$  PIB/ha dose) at about \$2.50/ha in 1985 dollars and applied using water alone. Evaluation of 100 trees, each with one redheaded pine sawfly colony and scoring colonies as healthy, diseased or dead, allowed reliable monitoring of epizootic progress. It was registered in Canada and was being used by Ontario.

Jaques (1971) studied the potential for use of viruses to control cabbage insect pests. Natural epizootics of the nuclear polyhedrosis viruses, *Tricoplusia ni NPV* (TnNPV) and *Pieris rapae GV* (PrGV) (*Baculoviridae*) contributed substantially to control of *T. ni* and *P. rapae* in the latter part of the season. Natural epizootics were the result of virus accumulations in the soil, TnNPV residues being found in 60% and *P. rapae* GV in 19% of samples taken. Application of the viruses to plants resulted in control as effective as or better than that provided by chemical pesticides.

Bird et al. (1973) studied the possible use of a *nuclear polyhedrosis virus* (NPV) and *entomopoxvirus* (EPV) (*Poxyviridae*) to control eastern spruce budworm. Both viruses were isolated from eastern spruce budworm and the Two-year-cycle Budworm, *Choristoneura biennis* Freeman (Lepidoptera: Tortricidae) from British Columbia. EPV was more effective on white spruce than on balsam fir in early season applications, while late spray of NPV was more effective. Virus carryover from 1971–1972 occurred.

Cunningham et al. (1996a) evaluated *Disparvirus*, nuclear polyhedrosis virus, and *Bt* serovar. *kurstaki* (*Btk*) applied as aerial sprays on mortality of gypsy moth. Average egg mass reductions from *Disparvirus* were 76% and 80% at rates of 5.0 and 2.5 L/ha, respectively, and 96% for *Btk* at 50 billion International Units (BIU) in 4.0 L/ha. Cunningham et al. (1996b) reported on impact of *Disparvirus* and *Btk* one year after application. Gypsy moth, larvae were 20.4% positive for NPV in plots treated with *Disparvirus* at 5.0 L/ha, 14.6% positive for NPV in plots treated at 2.5 L/ha, and 8.0% positive for NPV in plots treated with *Btk*, and 9.2% positive for NPV in control plots. Negligible foliage damage was reported and fall egg mass numbers were low indicating that in the treated area, the gypsy moth population had collapsed, suggesting that NPV was a contributing factor.

**Nematodes** – Welch (1962) reviewed the status of nematodes as agents for insect control. In nature, nematodes are generally not significant mortality factors, although under some conditions they may be significant regulatory factors. Mermithidae have the greatest potential as biological control agents because of their size and similarity to insect parasitoids. Neoaplectanidae also show potential because of their high rate of reproduction. Allantonematidae and Aphelenchoidea are best suited to environmental manipulation. Moisture, moderate temperatures and high host density are important factors for successful control.

Welch and Briand (1962) evaluated a neoplectanid nematode for control of Colorado potato beetle, cabbage root maggot, European corn borer and the imported cabbage worm. Use of the nematode was most promising for control of cabbage root maggot and European corn borer where the soil environment provides conditions suitable for nematode survival.

Briand (1960) reported the occurrence of the nematode *Howardula beninga* Cobb (Tylenchida: Allantonematidae) in the Striped Cucumber Beetle, *Diabrotica vittata* (Fabricius) (Coleoptera: Chrysomelidae). Parasitism was 7.6% and 2.5% in surveys conducted in 1958 and 1959, respectively. Parasitism was nil in the secondary host *D. undecimpunctata howardi* (Barber) even though this species was common in the southern Ontario study area.

Wright (1972) reported a new Canadian record for the adventive nematode *Heterotylenchus autumnalis* Nickle (Nematoda: Sphaerulariidae) as a parasite of the Face Fly, *Musca autumnalis* DeGeer (Diptera: Muscidae). *Heterotylenchus autumnalis* is widely distributed in Ontario but incidence was <2% and unlikely to contribute significantly to

natural control. Gregory and Wright (1973) released irradiated female face flies parasitized with *H. autumnalis* and found that doses of 1.0 and 2.5 krad did not sterilize the nematodes and parasitized face fly females produced progeny with high levels of parasitism. Release of sterile flies that were parasitized was considered better than the release of sterile flies alone.

Welch (1958) evaluated the nematode *Neaplectana chresima* Steiner (Rhabditida: Steinernematidae) for biological control of Colorado potato beetle. Application of ~20,000 cultured nematodes resulted in an approximate 14% reduction in beetle numbers although abiotic factors, i.e., significant rainfall, had an impact on the nematodes.

## 7. Natural Enemy Taxonomy

Taxonomy is essential to biological control and a few studies on groups relevant to biological control have been published in JESO. These studies, while clarifying taxonomic status, unfortunately also demonstrate just how poorly the biology of parasitoids is understood. Six taxonomic studies published in JESO that are relevant to biological control treat taxa within the Hymenoptera families Braconidae (2), Eucharitidae (1) and Mymaridae (3).

**Braconidae.** Loan (1970) described the new species, *Leiophron pseudopallipes* Loan and *Leiophron lygivora* (Loan) (Hymenoptera: Braconidae) reared from tarnished plant bug, *Lygus lineolaris*, in Ontario. *Leiophron pseudopallipes* is ecologically distinct, attacking 2<sup>nd</sup> generation *L. lineolaris*, from the related *L. mellipes* (Cresson) which attacks the 1<sup>st</sup> generation. *Leiophron lygivora* also attacks 2<sup>nd</sup> generation *L. lineolaris*. Loan and New (1972) reviewed the taxonomy of the Euphorine (Hymenoptera: Braconidae) genus *Leiophron*, subgenus *Euphoriella* Ashmead and redescribed *L. (E.) sommermannae* (Muesebeck), *L. (E.) incerta* (Ashmead), and *L. (E.) pacifica* (Muesebeck). *Leiophron (E.) nixoni* (Loan and New), *L. (E.) kaladarensis* (Loan and New), *L. (E.) solidaginis* (Loan and New), *L. (E.) foutsii* (Loan and New), *L. (E.) pallidifacia* (Loan and New), *L. (E.) hyalopsocidis* (Loan and New) and *L. (E.) criddlei* (Loan and New) were newly described. *Leiophron (E.) hyalopsocidis* was the only species associated with a host and it was reared from the psocid *Hyalopsocus striatus* (Walker) (Psocoptera: Psocidae).

Sharkey (2007) revised the Neotropical Braconidae (Hymenoptera) genus *Trachagathis* Viereck. Among the 3 species treated, *Trachagathis rubricincta* (Ashmead) is associated with the lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller) (Lepidoptera: Pyralidae), from sugarcane and the biologies of the other two species are unknown.

**Eucharitidae.** Heraty (1985) revised the Nearctic Eucharitinae (Hymenoptera: Eucharitidae), providing keys to the 5 genera and 16 species. Species of Eucharitidae are specialized ant parasitoids. Among the species treated, only the host of *Pseudometagea schwarzi* (Ashmead), the ant *Lasius neoniger* Emery (Hymenoptera: Formicidae), is known.

**Mymaridae.** Huber (1992) studied the subgenera and species groups of *Anaphes* (Hymenoptera: Mymaridae), and reviewed the described Nearctic species of the *fuscipennis* group of *Anaphes* s.s. and the described species of *Anaphes* (*Yungaburra*). *Anaphes* spp. are mostly parasitoids of Curculionidae and Chrysomelidae. Among the 9 species of the *Anaphes fuscipennis* group treated, hosts have been associated with *Anaphes fuscipennis* Haliday [*Sitona humeralis* Stephens, *Hypera postica* (Gyllenhal) and *H. punctata*

(Fabricius) (Coleoptera: Curculionidae)], *A. iole* Girault [*Lygus* spp. and *Pseudatomoscelis* sp. (Hemiptera: Miridae)], *A. byrrhidiphagus* Huber [*Lioon simplicipes* (Mannerheim) and *Lioligus nitidus* (Motschulsky) (Coleoptera: Byrridae)], and *Anaphes flavipes* (Förster) [*Oulema melanopus* (L.), *O. gallaeciana* (Heydon), *O. collaris* (Say), *Lema trilineata* Oliver, *L. trilineata trivittata* (Say), *L. lichenis* Voet. and *L. cyanella* (L.) (Coleoptera: Chrysomelidae)]. *Anaphes flavipes* was imported for biological control of *O. melanopus*. Hosts are unknown for the six species of the *Anaphes* (*Yungabura*) group.

Huber (2006) reviewed the described species of the *Anaphes crassicornis* group, important in biological control with the aim to improve identification of the species. Among the 13 species treated hosts are known for *Anaphes calendrae* (Gahan) [*Sphenophorus* spp. (Coleoptera: Curculionidae)], *A. conotrachelii* Girault [*Conotrachelus geminatus* (LeConte), *Hypera nigrirostris* (Fabricius) (Coleoptera: Curculionidae)], *A. cotei* Huber [*Listronotus oregonensis* (LeConte) (Coleoptera: Curculionidae)], *A. diana* (Girault) [*Sitona hispidulus* (Fabricius), *S. humeralis* Stephens, *S. lineatus* (L.) (Coleoptera: Curculionidae)], *A. gerrisophagus* (Doutt) [*Gerris* sp. (Hemiptera: Gerridae) and *Lestes* sp. (Odonata: Lestidae)], *A. listronoti* Huber [*L. oregonensis*], *A. luna* (Girault) [*Hypera* spp., and in North America, *H. postica* (Gyllenhal) and *H. eximia* (LeConte) (Coleoptera: Curculionidae)], *A. pallipes* (Ashmead) [*Cylindrocopturus adspersus* (LeConte) (Coleoptera: Curculionidae) and *Rhagoletis pomonella* Walsh (Diptera: Tephritidae)], *A. pullicrurus* (Girault) [*Chaetoctema denticulata* (Illiger) (Coleoptera: Chrysomelidae)], *A. sordidatus* [*Tyloderma foveolatum* (Say) (Coleoptera: Curculionidae)], and *A. victus* Huber [*L. oregonensis*]. *Anaphes luna* and *A. diana* were imported and released in the USA as biological control agents.

Huber (2012) revised the *Ooconus* spp. (Hymenoptera: Mymaridae) in the Nearctic region. Among the 15 species described, hosts are known for *O. aphrophorae* Milliron [on *Aphrophora saratogensis* (Fitch) (Hemiptera: Cercopidae)], and *O. vulgatus* Haliday [on *Philaenus spumarius* (L.) (Hemiptera: Cercopidae)]. Although white pine weevil was recorded as a potential host for *O. quadricarinatus* Girault the record is incorrect (J. Huber, personal communication).

## Conclusions

Over the years, the *Journal of the Entomological Society of Ontario* has been an important venue for dissemination of scientific results on biological control of pest arthropods and weeds in Ontario. Included are studies on natural enemy assemblages, biology of natural enemies, releases of exotic species as agents for biological control, entomopathogens for use in reduced risk management strategies, and taxonomy of groups important to biological control. In recent years, competition with an ever increasing number of specialized journals with high impact factors, many of which have no page charges, has led to a decline in submissions to JESO. However, there are unfilled niches for which JESO can provide a good opportunity to publish: documenting the status and distribution of natural enemies intentionally released as biological control agents, documenting associations among natural enemies and hosts, and assessing changes in natural enemy assemblages over time.

## Acknowledgements

Andrea Brauner assisted in the task of verifying taxonomic names and JESO editor, John Huber invited this review. Two reviewers provided constructive recommendations to improve the manuscript.

## References

- Abu, J. F. and Ellis, C. R. 1976. Biology of *Bathyplectes curculionis* (Thomson) (Hymenoptera: Ichneumonidae) a parasitoid of the alfalfa weevil in Ontario. *Proceedings of the Entomological Society of Ontario* **106**: 8–12.
- Alex, J. F. 1998. Ontario Weeds. Ontario weeds: descriptions, illustrations and keys to their identification. Ontario Ministry of Agriculture, Food and Rural Affairs Publication 505, Guelph, Ontario, Canada. Available from <http://www.omafra.gov.on.ca/english/crops/pub505/p505order.htm> [Accessed 1 November 2013].
- Angus, T. A. and Heimpel, A. M. 1960. The bacteriological control of insects. *Proceedings of the Entomological Society of Ontario* **90**: 13–21.
- Angus, T. A. 1965. Mortality due to *Bacillus thuringiensis* in post-larval stages of some Lepidoptera. *Proceedings of the Entomological Society of Ontario* **95**: 133–134.
- Anonymous. 2012. Noxious weeds in Ontario. Available at: [http://www.omafra.gov.on.ca/english/crops/facts/noxious\\_weeds.htm](http://www.omafra.gov.on.ca/english/crops/facts/noxious_weeds.htm) [Accessed 1 November 2013].
- Appleton, E. S. B., Gillard, C. and Schaafsma, A. W. 2004. Biology and management of the potato leafhopper, *Empoasca fabae* Harris (Homoptera: Cicadellidae) on field crops in Ontario. *Journal of the Entomological Society of Ontario* **134**: 3–17.
- Bahlai, C. A. and Sears, M. K. 2009 Population dynamics of *Harmonia axyridis* and *Aphis glycines* in Niagara peninsula soybean fields and vineyards. *Journal of the Entomological Society of Ontario* **140**: 27–39.
- Beirne, B. P. 1971. Pest insects of annual crop plants in Canada: Part I, Lepidoptera; II, Diptera; III, Coleoptera. *Memoirs of the Entomological Society of Canada* **103**, Supplement **S78**: 1–124.
- Bennett, A. M. R. 2004. Host location behaviour in *Pelecinus polyturator* (Hymenoptera: Pelecinidae). *Journal of the Entomological Society of Ontario* **135**: 131–134.
- Ben-Ze'ev, L. S. and Jaques, R. P. 1990. Entomopathogenic fungi in insects in alfalfa fields in southwestern Ontario. *Proceedings of the Entomological Society of Ontario* **121**: 71–78.
- Best, K. F., Bowes, G. G., Thomas, A. G. and Maw, M. G. 1980. The biology of Canadian weeds. 39. *Euphorbia esula* L. *Canadian Journal of Plant Science* **60**: 651–663.
- Bird, F. T., Cunningham, J. S. and Howse, G. M. 1973. The possible use of viruses in the control of spruce budworm. *Proceedings of the Entomological Society of Ontario* **102**: 69–75.
- Bolter, C. J. and Laing J. E. 1984. Competition between *Diadegma insulare* (Hymenoptera: Ichneumonidae) and *Microplitis plutellae* (Hymenoptera: Braconidae) for larvae of the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae). *Proceedings of the Entomological Society of Ontario* **114**: 1–10.
- Briand, L. J. 1960. The nematode *Howardula benigna* Cobb, 1921, parasite of the cucumber beetles in Ontario. *Proceedings of the Entomological Society of Ontario* **90**: 53.

- Bright, D. E. 1996. Notes on native parasitoids and predators of the larger pine shoot beetle, *Tomicus piniperda* (Linnaeus) in the Niagara region of Canada (Coleoptera: Scolytidae). *Proceedings of the Entomological Society of Ontario* **127**: 57–62.
- Broadbent, A. B., Goulet, H., Whistlecraft, J. W., Lachance, S. and Mason, P. G. 1999. First Canadian record of three parasitoid species (Hymenoptera: Braconidae: Euphorinae) of the tarnished plant bug, *Lygus lineolaris* (Hemiptera: Miridae). *Proceedings of the Entomological Society of Ontario* **130**: 109–111.
- Broadbent, A. B., Haye, T., Gariepy, T. D., Olfert, O. O. and Kuhlmann, U. 2013. *Lygus lineolaris* (Palisot), tarnished plant bug (Hemiptera: Miridae). Pp. 221–227 in Mason P. G. and Gillespie, D. R. (eds), *Biological Control Programmes in Canada 2001–2012*. CABI Publishing, Wallingford, Oxfordshire United Kingdom, 518 pp.
- Boyce, H. R. and Dustan, G. G. 1954. Parasitism of twig-infesting larvae of the oriental fruit moth, *Grapholita molesta* (Busck) (Lepidoptera: Olethreutidae), in Ontario, 1939–1953. *Annual Report of the Entomological Society of Ontario* **84**: 48–55.
- Cadogan, B. L. 1993. Field weights of jack pine budworm larvae (Lepidoptera: Tortricidae) surviving aerial applications of *Bacillus thuringiensis* and two chemical insecticides. *Proceedings of the Entomological Society of Ontario* **124**: 189–196.
- Cadogan, B. L. and Laing, J. E. 1982. A study of *Balaustium putnami* (Acarina: Erythraeidae) in apple orchards in southern Ontario. *Proceedings of the Entomological Society of Ontario* **112**: 13–21.
- Cadogan, B. L., Zylstra, B. F., Nystrom, C., Ebbling, P. M. and Pollock, L. B. 1987. Evaluation of a new *Futura*® formulation of *Bacillus thuringiensis* on populations of jack pine budworm, *Choristoneura pinus pinus* (Lepidoptera: Tortricidae). *Proceedings of the Entomological Society of Ontario* **117**: 59–64.
- Cameron, J. W. M. 1952. A survey of investigations on the diseases of insects. *Annual Report of the Entomological Society of Ontario* **83**: 7–14.
- Cameron, J. W. M. 1969. Problems and prospects in the use of pathogens in insect control. *Proceedings of the Entomological Society of Ontario* **99**: 73–81.
- Carter, N. J. and Laing, J. E. 1997. *Cotesia rubecula* (Marshall) (Hymenoptera: Braconidae) recovered three years after release in southern Ontario. *Proceedings of the Entomological Society of Ontario* **128**: 113–115.
- Chant, D. A. 1957. Biological control. *Annual Report of the Entomological Society of Ontario* **87**: 54–58.
- Clements, D. R. 1989. The role of stigmaeids (Acari) in the orchard acarine system. *Proceedings of the Entomological Society of Ontario* **120**: 74–75.
- Coote, L. D. and Ellis C. R. 1987. Parasites of the alfalfa blotch leafminer, *Agromyza frontella* (Diptera: Agromyzidae), near Guelph, Ontario. *Proceedings of the Entomological Society of Ontario* **117**: 21–27.
- Coote, L. D. and Ellis, C. R. 1987. *Diglyphus intermedius* (Hymenoptera: Eulophidae), an indigenous parasite of the alfalfa blotch leafminer, *Agromyza frontella* (Diptera: Agromyzidae). *Proceedings of the Entomological Society of Ontario* **117**: 83–85.
- Coppel, H. C. and Arthur, A. P. 1954. Notes on introduced parasites of the European pine shoot moth, *Rhyacionia buoliana* (Schiff.) (Lepidoptera: Tortricidae), in Ontario. *Annual Report of the Entomological Society of Ontario* **84**: 55–58.
- Corrigan, J. E. 1983. *Cotesia (Apanteles) rubecula* (Hymenoptera: Braconidae) recovered in Ottawa, Ontario ten years after its release. *Proceedings of the Entomological Society of Ontario* **113**: 71.

- Corrigan, J. E. and Laing, J. E. 1992. An improved method for producing small, consistent samples of hosts for presentation to the egg parasitoid, *Trichogramma minutum*. *Proceedings of the Entomological Society of Ontario* **122**: 103–104.
- Corrigan, J. E., Lashomb, J. H. and Kingsley, P. C. 1990. Pupal orientation and emergence success of the egg parasitoids *Edovum puttleri* (Hymenoptera: Eulophidae). *Proceedings of the Entomological Society of Ontario* **121**: 95–100.
- Corrigan, J. E., Laing, J. E. and Caddick, G. 1994. Feasibility of delaying emergence of *Trichogramma minutum* Riley (Hymenoptera: Trichogrammatidae) and subsequent effects on adult longevity and fecundity. *Proceedings of the Entomological Society of Ontario* **125**: 81–86.
- Corrigan, J. E., Mackenzie, D. L. and Simser, L. 1998. Field observations of non-target feeding by *Galerucella calmariensis* [Coleoptera: Chrysomelidae], an introduced biological control agent of purple loosestrife, *Lythrum salicaria* [Lythraceae]. *Proceedings of the Entomological Society of Ontario* **129**: 99–106.
- Crompton, C. W., Hall, I. V., Jensen, K. I. N. and Hildebrand, P. D. 1988. The biology of Canadian weeds. 83. *Hypericum perforatum* L. *Canadian Journal of Plant Science* **68**: 149–162.
- Cunningham, J. C., deGroot, P. and Kaup, W. J. 1987. A review of aerial spray trials with Lecontivirus for control of redhead pine sawfly, *Neodiprion lecontei* (Hymenoptera: Diprionidae), in Ontario. *Proceedings of the Entomological Society of Ontario* **117**: 65–72.
- Cunningham, J. C., Payne, N. J., Brown, K. W., Fleming, R. A., Burns, T., Mickle, R. E. and Scarr, T. 1996a. Aerial spray trials with nuclear polyhedrosis virus and *Bacillus thuringiensis* on gypsy moth (Lepidoptera: Lymantriidae) in 1994. I. Impact in the year of application. *Proceedings of the Entomological Society of Ontario* **127**: 21–35.
- Cunningham, J. C., Brown, K. W., Scarr, T., Fleming, R. A. and Burns, T. 1996b. Aerial spray trials with nuclear polyhedrosis virus and *Bacillus thuringiensis* on gypsy moth (Lepidoptera: Lymantriidae) in 1994. II. Impact one year after application. *Proceedings of the Entomological Society of Ontario* **127**: 37–43.
- Deedat, Y. D., Ellis, C. R. and West, R. J. 1983. Life History of the Potato Stem Borer (Lepidoptera: Noctuidae) in Ontario. *Journal of Economic Entomology* **76**: 1033–1037.
- Desrochers, A. M., Bain, J. F. and Warwick, S. I. 1988. The Biology of Canadian weeds. 89. *Carduus nutans* L. and *Carduus acanthoides* L. *Canadian Journal of Plant Science* **68**: 1053–1068.
- Dustan, G. G. and Boyce, H. R. 1966. Parasitism of the oriental fruit moth, *Grapholitha molesta* (Busck) (Lepidoptera: Tortricidae) in Ontario, 1956–1965. *Proceedings of the Entomological Society of Ontario* **96**: 100–102.
- Edwards, C. J. and Pengelly, D. H. 1966. *Melittobia chalybii* Ashmead (Hymenoptera: Eulophidae) parasitizing *Bombus fervidus* Fabricius (Hymenoptera Apidae). *Proceedings of the Entomological Society of Ontario* **96**: 98–99.
- Ellis, C. R., Harcourt, D. G. and Dubois-Martin, D. 1979. The current status in Ontario of *Tetrastichus julis* (Hymenoptera: Eulophidae), a parasitoid of the cereal leaf beetle. *Proceedings of the Entomological Society of Ontario* **109**: 23–26.
- Ellis, C. R., Kormos, B. and Guppy, J. C. 1989. Absence of parasitism in an outbreak of the cereal leaf beetle, *Oulema melanopus* (Coleoptera: Chrysomelidae), in the central tobacco growing area of Ontario. *Proceedings of the Entomological Society of Ontario* **119**: 43–46.

- Ellis, C. R. and Nang'ayo, F. L. O. 1992. The biology and control of the trefoil seed chalcid, *Bruchopagus platypterus* (Walker) (Hymenoptera: Eurytomidae), in Ontario. *Proceedings of the Entomological Society of Ontario* **123**: 111–122.
- Ellis, C. R. and Bjornson, S. 1996. The biology, importance, and biological control of *Coleophora deauratella* (Lepidoptera: Coleophoridae), a new pest of red clover in North America. *Proceedings of the Entomological Society of Ontario* **127**: 115–124.
- Fisher, P. 1988. The effect of pesticides on two species of parasitoids, *Pholetesor ornigis* and *Pholetesor pedias* (Hymenoptera: Braconidae). *Proceedings of the Entomological Society of Ontario* **118**: 171.
- Foot, W. H. 1974. Observations on Coccinellidae in corn fields in Essex County, Ontario. *Proceedings of the Entomological Society of Ontario* **104**: 16–21.
- George, J. A. 1979. The potential of a local planarian, *Dugesia tigrina* (Tricladida, Turbellaria), for the control of mosquitoes in Ontario. *Proceedings of the Entomological Society of Ontario* **109**: 23.
- George, J. A. 1984. Survival of the mosquito predator *Dugesia tigrina* (Tricladida: Turbellaria), over three years in catch basins. *Proceedings of the Entomological Society of Ontario* **114**: 83–85.
- Glen, R. 1962. Preface. Pp. ix–x in McLeod, J. S., McGugan, B. M. and Coppel, H. C. (eds), *A review of the biological control attempts against insects and weeds in Canada*. Technical Communication Commonwealth Institute of Biological Control 2, Franham Royal, Bucks, England, 216 pp.
- Glen, R. 1965. Entomology in Canada up to 1956. A review of developments and accomplishments. *The Canadian Entomologist* **58**: 290–371.
- Goble, H. W. 1965. The armyworm *Pseudaletia unipuncta* (Hawthorn) in Ontario in 1964. *Proceedings of the Entomological Society of Ontario* **95**: 11–14.
- Graham, A. R. 1958. Effectiveness of two introduced parasites of the larch casebearer, *Coleophora laricella* (Hbn.) (Lepidoptera: Coleophoridae), in Ontario. *Annual Report of the Entomological Society of Ontario* **88**: 37–41.
- Gregory, D. and Wright, R. E. 1973. Irradiation of the female face fly, *Musca autumnalis* DeGeer, parasitized by the nematode, *Heterotylenchus autumnalis* Nickle. *Proceedings of the Entomological Society of Ontario* **102**: 104–107.
- Griffiths, K. J. 1972. Discrimination between parasitized and unparasitized hosts by *Pleolophus basizonus* (Hymenoptera: Ichneumonidae). *Proceedings of the Entomological Society of Ontario* **102**: 83–91.
- Griffiths, K. J. 1977. A preliminary report on the gypsy moth and its parasites in southeastern Ontario. *Proceedings of the Entomological Society of Ontario* **107**: 79–84.
- Hagley, E. A. C. 1970. The distribution and survival of overwintering codling moth larvae in southern Ontario. *Proceedings of the Entomological Society of Ontario* **100**: 40–47.
- Hagley, E. A. C. 1979. Integrated pest management — insecticides and natural predator populations on apple. *Proceedings of the Entomological Society of Ontario* **109**: 9–21.
- Hagley, E. A. C. 1987. Occurrence of *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) in apple orchards in southern Ontario. *Proceedings of the Entomological Society of Ontario* **117**: 79–82.
- Hagley, E. A. C. and Barber, D. R. 1992. Foliage-feeding Lepidoptera and their parasites recovered from unmanaged apple orchards in southern Ontario. *Proceedings of the Entomological Society of Ontario* **122**: 1–7.

- Hagley, E. A. C. and Laing, J. E. 1989. Effect of pesticides on parasitism of artificially distributed eggs of the codling moth, *Cydia pomonella* (Lepidoptera: Tortricidae). *Proceedings of the Entomological Society of Ontario* **120**: 25–33.
- Harcourt, D. G. 1963. Biology of cabbage caterpillars in eastern Ontario. *Proceedings of the Entomological Society of Ontario* **93**: 61–75.
- Harcourt, D. G. and Ellis, C. R. 1992. Distribution in southern Ontario of *Bathyplectes anurus* (Hymenoptera: Ichneumonidae), a larval parasitoid of the alfalfa weevil. *Proceedings of the Entomological Society of Ontario* **122**: 41–45.
- Harcourt, D. G., Ellis, C. R. and Guppy, J. C. 1980. Distribution of *Microctonus aethiopoides*, a parasitoid of the alfalfa weevil (Coleoptera: Curculionidae) in Ontario. *Proceedings of the Entomological Society of Ontario* **110**: 35–39.
- Harcourt, D. G., Guppy, J. C. and Ellis, C. R. 1982. Distribution of *Microctonus colesi* (Hymenoptera: Braconidae), a new parasite of the alfalfa weevil in Ontario. *Proceedings of the Entomological Society of Ontario* **112**: 33–37.
- Harcourt, D. G., Guppy, J. C. and Ellis, C. R. 1987. Establishment and spread of *Dacnusa dryas* (Hymenoptera: Braconidae), an exotic parasite of the alfalfa blotch leafminer in Ontario. *Proceedings of the Entomological Society of Ontario* **117**: 29–33.
- Harmsen, R. and Rose, M. R. 1984. Habitat effects on larval mortality in the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae). *Proceedings of the Entomological Society of Ontario* **114**: 87–89.
- Heraty, J. M. 1985. A revision of the Nearctic Eucharitinae (Hymenoptera: Chalcidoidea: Eucharitidae). *Proceedings of the Entomological Society of Ontario* **116**: 61–103.
- Herbert, H. J. 1953. Progress report on predacious mite investigations in Nova Scotia (Acarina: Phytoseiidae). *Annual Report of the Entomological Society of Ontario* **84**: 27–29.
- Hikichi, A. 1962. Notes on mortality factors affecting the red-banded leaf roller, *Argyrotaenia velutinana* (Wlkr.), (Lepidoptera: Tortricidae) in an unsprayed apple orchard in Ontario. *Proceedings of the Entomological Society of Ontario* **92**: 180–182.
- Hikichi, A. 1971. 3. *Argyrotaenia velutinana* (Walker), red-banded leafroller (Lepidoptera: Tortricidae). Pp. 10–12 in Kelleher et al. (eds), *Biological control programmes against insects and weeds in Canada 1959–1968*. Technical Communication Commonwealth Institute of Biological Control 4, 266 pp.
- Hoffmeister T. S. 2002. *Rhagoletis pomonella* (Walsh), apple maggot (Diptera: Tephritidae). Pp. 238–241 in Mason, P. G. and Huber, J. T. (eds), *Biological Control Programmes in Canada 1981–2000*. CABI Publishing, Wallingford, Oxon, United Kingdom, 583 pp.
- Huber, J. T. 1992. The subgenera, species groups, and synonyms of *Anaphes* (Hymenoptera: Mymaridae) with a review of the described Nearctic species of the *fuscipennis* group of *Anaphes s.s.* and the described species of *Anaphes* (*Yungaburra*). *Proceedings of the Entomological Society of Ontario* **123**: 23–110.
- Huber, J. T. 2006. Review of the described Nearctic species of the *crassicornis* group of *Anaphes s.s.* (Hymenoptera: Mymaridae). *Journal of the Entomological Society of Ontario* **135**: 3–86.
- Huber, J. T. 2012. Revision of the genus *Ooconus* (Hymenoptera: Mymaridae) in the Nearctic region. *Journal of the Entomological Society of Ontario* **143**: 15–105.
- Hulme, M. A. and Kenis, M. 2002. *Pissodes strobe* (Peck), white pine weevil (Coleoptera: Curculionidae). Pp. 221–228 in Mason, P. G. and Huber, J. T. (eds), *Biological Control Programmes in Canada 1981–2002*. CABI Publishing, Wallingford, Oxon, United Kingdom, 583 pp.

- Jaques, R. P. 1971. Control of cabbage insects by viruses. *Proceedings of the Entomological Society of Ontario* **101**: 28–34.
- James, H. G. 1952. Natural control of Tabanidae (Diptera) in the region of Churchill, Manitoba. *Annual Report of the Entomological Society of Ontario* **83**: 70–74.
- James, H. G. 1959. Egg development, hatching, and prey taken by the European mantis, *Mantis religiosa* L., in several habitats. *Annual Report of the Entomological Society of Ontario* **89**: 50–55.
- Jones, T., Shipp, J. L., Scott-Dupree, C. D. and Harris, C. R. 2006. Influence of greenhouse microclimate on *Neoseiulus (Amblyseius) cucumeris* (Acari: Phytoseiidae) predation on *Frankliniella occidentalis* (Thysanoptera: Thripidae) and oviposition on greenhouse cucumber. *Journal of the Entomological Society of Ontario* **136**: 71–83.
- Johnson, E. F., Laing, J. E. and Trottier, R. 1977. The seasonal occurrence of *Lithocolletis blanchardella* (Gracillariidae), and its major natural enemies in Ontario apple orchards. *Proceedings of the Entomological Society of Ontario* **107**: 31–45.
- Judd, W. W. 1953. Diptera and Hymenoptera reared from pine cone willow galls caused by *Rhabdophaga strobiloides* (Diptera: Itonididae). *Annual Report of the Entomological Society of Ontario* **84**: 34–42.
- Kelleher, J. S. et al. 1971. *Biological control programmes against insects and weeds in Canada 1959–1968*. Technical Communication Commonwealth Institute of Biological Control 4, Franham Royal, Slough, England, 266 pp.
- Kelleher, J. S. and Hulme, M. A. (eds) 1984. *Biological Control Programmes against insects and weeds in Canada 1969–1980*. Commonwealth Agricultural Bureaux, Franham Royal, Slough, England, 410 pp.
- Laing, J. E. 1978. Establishment of *Urophora cardui* L. (Diptera: Tephritidae) on Canada thistles in southern Ontario. *Proceedings of the Entomological Society of Ontario* **108**: 2.
- Laing, D. R. and Jaques, R. P. 1985. Microsporidia of the European corn borer (Lepidoptera: Pyralidae) in southwestern Ontario: natural occurrence and effectiveness as microbial insecticides. *Proceedings of the Entomological Society of Ontario* **115**: 13–17.
- Laing, J. E. and Welch, H. E. 1963. A dolichopodid predaceous on larvae of *Culex restuans* Theob. *Proceedings of the Entomological Society of Ontario* **93**: 89–90.
- Laing, J. E. and Heraty, J. M. 1982. The parasite complex of the overwintering population of *Epiblema scudderiana* (Lepidoptera: Olethreutidae) in southern Ontario. *Proceedings of the Entomological Society of Ontario* **112**: 59–66.
- Laing, J. E. and Heels, P. R. 1979. Establishment of an introduced weevil, *Rhinocyllus conicus* (Coleoptera: Curculionidae) for the biological control of nodding thistle, *Carduus nutans* (Compositae) in southern Ontario. *Proceedings of the Entomological Society of Ontario* **109**: 3–8.
- LeSage, L. 1989. Survival of *Aphthona* species in Ontario. *Biocontrol News* **2**: 1.
- LeSage, L. 1996a. Suivi, pour les années 1994 et 1995, des altises de l'euphorbe (Coleoptera: Chrysomelidae: *Aphthona* spp.) relâchées à Marshall Bay (Ontario) contre l'euphorbe (*Euphorbia esula* L.). *Proceedings of the Entomological Society of Ontario* **127**: 125–126.
- LeSage, L. 1996b. Expansion de l'aire de répartition de *Chrysolina hyperici* (Forster) depuis son introduction en Ontario (Coleoptera: Chrysomelidae). *Proceedings of the Entomological Society of Ontario* **127**: 127–130.
- Li, S. Y. 2000. Larval susceptibility of balsam fir sawfly (Hymenoptera: Diprionidae) to neem. *Proceedings of the Entomological Society of Ontario* **110**: 139–143.

- Loan, C. C. 1964. Observations on the biology of *Centistes excrucians* Haliday (Hymenoptera: Braconidae). *Proceedings of the Entomological Society of Ontario* **94**: 56–61.
- Loan, C. C. 1965. Life cycle and development of *Leiophron pallipes* Curtis (Hymenoptera: Braconidae: Euphorinae) in five mired hosts in the Belleville district. *Proceedings of the Entomological Society of Ontario* **95**: 115–121.
- Loan, C. C. 1970. Two new parasites of the tarnished plant bug in Ontario: *Leiophron pseudopallipes* and *Euphoriana lygivora* (Hymenoptera: Braconidae, Euphorinae). *Proceedings of the Entomological Society of Ontario* **100**: 188–195.
- Loan, C. C. 1973. Parasitism of adult *Notoxus anchora* Henz. (Coleoptera: Anthicidae) by *Syrrhizus agilis* (Cresson) (Hymenoptera: Braconidae). *Proceedings of the Entomological Society of Ontario* **102**: 76.
- Loan, C. 1982. Suppression of the fungi *Zooththora* spp. by capitol: a technique to study interaction between disease and parasitism of the alfalfa weevil *Hyperica postica* (Coleoptera: Curculionidae). *Proceedings of the Entomological Society of Ontario* **112**: 81–82.
- Loan, C. C. and New T. R. 1972. An account of the North American species of *Eurphoriella* Ashmead with descriptions of seven new species (Hymenoptera: Braconidae, Euphorinae). *Proceedings of the Entomological Society of Ontario* **102**: 92–108.
- Lyons, D. B., Helson, B. V., Jones, G. C., MacFarlane, J. W. and Scarr, T. 1996. Systemic activity of neem seed extracts containing azadirachtin in pine foliage for control of the pine false webworm, *Acantholyda erythrocephala* (Hymenoptera: Pamphiliidae). *Proceedings of the Entomological Society of Ontario* **127**: 45–55.
- MacFarlane, R. P. and Pengelly, D. H. 1978. *Brachicoma* spp. (Sarcophagidae) and *Melittobia chalybii* (Eulophidae) as parasites of the brood of *Bombus* spp. (Apidae) in southern Ontario. *Proceedings of the Entomological Society of Ontario* **108**: 31–35.
- Mackauer, M. 1971. 2. *Acyrthosiphon pisum* (Harris), pea aphid (Homoptera: Aphididae). Pp. 3–10 in McLeod, J. S., McGugan, B. M. and Coppel, H. C. (eds), *Biological control programmes against insects and weeds in Canada 1959–1968*. Technical Communication Commonwealth Institute of Biological Control 4, 266 pp.
- Mackauer, M. J. P. and Bisdee, H. E. 1965. *Aphidius smithi* Sharma and Subba Rao (Hymenoptera: Aphidiidae) a parasitoid of the pea aphid new in southern Ontario. *Proceedings of the Entomological Society of Ontario* **95**: 121–124.
- Mal, T. K., Loverr-Doust, J., Lovett-Doust, L. and Mulligan, G. A. 1992. The biology of Canadian weeds. 100. *Lythrum salicaria*. *Canadian Journal of Plant Science* **72**: 1305–1330.
- Mason, P. G. and Huber, J. T. (eds) 2002. *Biological Control Programmes in Canada 1981–2000*. CABI Publishing, Wallingford, Oxon, United Kingdom, 583 pp.
- Mason P. G. and Gillespie, D. R. (eds) 2013. *Biological Control Programmes in Canada 2001–2012*. CABI Publishing, Wallingford, Oxfordshire, United Kingdom, 518 pp.
- Mason, P. G., Goulet, H. and Bostanian, N. 2011. Effect of harvest on Euphorine (Hymenoptera: Braconidae) parasitism of *Lygus lineolaris* and *Adelphocoris lineolatus* (Hemiptera: Miridae) in alfalfa. *Journal of the Entomological Society of Ontario* **142**: 3–10.
- Maybee, G. E. 1954. Introduction into Canada of parasites of the carrot rust fly, *Psila rosae* (F.) (Diptera: Psilidae). *Annual Report of the Entomological Society of Ontario* **84**: 58–62.
- Maybee, G. E. 1956. Observations, life-history, habits, immature stages, and rearing of *Loxotropa tritoma* (Thoms.) (Hymenoptera: Proctotrupoidea) a parasite of the carrot rust fly, *Psila rosae* (F.) (Diptera: Psilidae). *Annual Report of the Entomological Society of Ontario* **86**: 53–58.

- Maxwell, C. W. and Morgan, G. T. 1952. Life-history studies of the cranberry fruitworm, *Mineola vaccinii* (Riley), in New Brunswick (Lepidoptera: Pyralidae). *Annual Report of the Entomological Society of Ontario* **83**: 21–25.
- McClanahan, R. J., Boyce, H. R. and Code, W. R. 1968. The cereal leaf beetle – A new insect in Ontario. *Proceedings of the Entomological Society of Ontario* **98**: 21–26.
- McLeod, J. H. 1962. Part I – Biological control of pests of crops, fruit trees, ornamentals, and weeds in Canada up to 1959. Pp. 1–34 in McLeod, J. S., McGugan, B. M. and Coppel, H. C. (eds), *A review of the biological control attempts against insects and weeds in Canada*. Technical Communication Commonwealth Institute of Biological Control 2, Franham Royal, Bucks, England, 216 pp.
- McLeod, J. S., McGugan, B. M. and Coppel, H. C. (eds) 1962. *A review of the biological control attempts against insects and weeds in Canada*. Technical Communication Commonwealth Institute of Biological Control 2, Franham Royal, Bucks, England, 216pp.
- McMullen, R. D. 1971. 16. *Psylla pyricola* Förster, pear psylla (Hemiptera: Psyllidae). Pp. 33–38 in Kelleher, J. S. et al. (eds), *Biological control programmes against insects and weeds in Canada 1959–1968*. Technical Communication Commonwealth Institute of Biological Control 4, Franham Royal, Slough, England, 266 pp.
- Miller, L. A. and De Lyzer, A. J. 1960. A progress report on studies of biology and ecology of the six-spotted leafhopper, *Macrosteles fascifrons* (Stål), in southwestern Ontario. *Proceedings of the Entomological Society of Ontario* **90**: 7–13.
- Monteith, L. G. 1976. Laboratory feeding studies of potential predators of the apple maggot *Rhagoletis pomonella* (Diptera: Tephritidae) in Ontario. *Proceedings of the Entomological Society of Ontario* **106**: 28–33.
- Monteith, L. G. 1977. Field studies of potential predators of the apple maggot *Rhagoletis pomonella* (Diptera: Tephritidae) in Ontario. *Proceedings of the Entomological Society of Ontario* **107**: 23–30.
- Monteith, L. G. 1978. Additional records and the role of the parasites of the apple maggot *Rhagoletis pomonella* (Diptera: Tephritidae) in Ontario. *Proceedings of the Entomological Society of Ontario* **108**: 3–6.
- Moore, R. J. 1975. The biology of Canadian weeds. 13. *Cirsium arvense* (L.) Scop. *Canadian Journal of Plant Science* **55**: 1033–1048.
- Morris, G. W. 1980. Microbial isolations from *Sitophilus zeamais* (Coleoptera: Curculionidae). *Proceedings of the Entomological Society of Ontario* **110**: 93–96.
- Mulligan, G.A. and C. Frankton. 1954. The plumeless thistles (*Carduus* spp.) in Canada. *Canadian Field Naturalist* **68**: 31–36.
- Murillo, H., Hunt, D. W. A. and Vanlaerhoven, S. L. 2012. Larval parasitoids of the cabbage looper, *Trichoplusia ni* (Lepidoptera: Noctuidae), in field tomato crops in southwestern Ontario. *Journal of the Entomological Society of Ontario* **143**: 115–119.
- Nealis, V. G. and Bourchier, R. S. 1995. Reduced vulnerability to hyperparasitism in nondiapause strains of *Cotesia melanoscela* (Ratzeburg) (Hymenoptera: Braconidae). *Proceedings of the Entomological Society of Ontario* **126**: 29–35.
- Nealis, V. G. and Quednau, F. W. 1996. Canadian field releases and overwinter survival of *Ceranthis samarensis* (Villeneuve) (Diptera: Tachinidae) for biological control of the gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae). *Proceedings of the Entomological Society of Ontario* **127**: 11–20.

- Nystrom, K. L. and Evans, H. J. 1989. Biological notes on a birch leaf edgeminer, *Scolioneura betuleti* (Hymenoptera: Tenthredinidae), new to North America. *Proceedings of the Entomological Society of Ontario* **120**: 17–24.
- Pengelly, D. H. 1961. *Thymelicus lineola* (Ochs.) (Lepidoptera: Hesperiidae) a pest of hay and pasture grasses in southern Ontario. *Proceedings of the Entomological Society of Ontario* **91**: 189–197.
- Phillips, J. H. H. 1969. Parasitism of a population of the Oriental fruit moth, *Grapholitha molesta* Busck, in an unsprayed peach orchard. *Proceedings of the Entomological Society of Ontario* **99**: 81.
- Philogene, B. J. R. and Chang, J. F. 1979. New records of parasitic chalcidoids of pear psylla (Homoptera: Psyllidae) in Ontario, with observations on the current world status of its parasitoids and predators. *Proceedings of the Entomological Society of Ontario* **109**: 53–63.
- Poinar, G. O. Jr., Thomas, G. and Prokopy, R. J. 1978. Microorganisms associated with *Rhagoletis pomonella* (Diptera: Tephritidae) in Massachusetts. *Proceedings of the Entomological Society of Ontario* **108**: 19–22.
- Pointing, P. J. and Green, G. W. 1962. A review of the history and biology of the European pine shoot moth, *Rhyacionia buoliana* (Schiff.) (Lepidoptera: Olethreutidae) in Ontario. *Proceedings of the Entomological Society of Ontario* **92**: 58–69.
- Proverbs, M. D. 1962. Progress on the use of induced sexual sterility for the control of the codling moth *Carpocapsa pomonella* (L.) (Lepidoptera: Olethreutidae). *Proceedings of the Entomological Society of Ontario* **92**: 5–11.
- Putnam, W. L. 1963. The codling moth, *Carpocapsa pomonella* (L.) (Lepidoptera: Tortricidae): A review with special reference to Ontario. *Proceedings of the Entomological Society of Ontario* **93**: 22–60.
- Ragsdale, D. W., Voeglin, D. J. and O’Neil, R. J. 2004. Soybean aphid biology in North America. *Annals of the Entomological Society of America* **97**: 204–208.
- Ramey, C. A. 1990. Host identification and oviposition behaviour of a parasitic wasp, *Eurytoma obtusiventris* (Hymenoptera: Eurytomidae). *Proceedings of the Entomological Society of Ontario* **121**: 127.
- Reid, D. G. and Harmsen, R. 1975. *Trirhabda borealis* Blake (Coleoptera: Chrysomelidae) a major phytophagous species on *Solidago canadensis* L. (Asteraceae) in south-eastern Ontario. *Proceedings of the Entomological Society of Ontario* **105**: 44–47.
- Robinson, A. G. 1952. Annotated list of predators of tetranychid mites in Manitoba. *Annual Report of the Entomological Society of Ontario* **83**: 33–37.
- Robinson, A. G. 1953. Notes on *Stethocorus punctum* (LEC.) (Coleoptera: Coccinellidae), a predator of tetranychid mites in Manitoba. *Annual Report of the Entomological Society of Ontario* **84**: 24–26.
- Sharkey, M. 2007. Revision of the Neotropical genus *Trachagathis* Viereck (Hymenoptera: Braconidae: Agathidinae). *Journal of the Entomological Society of Ontario* **137**: 51–61.
- Song, S. 1990. The effect of host encounter rate on fecundity of *Gelis tenellus* (Hymenoptera: Ichneumonidae). *Proceedings of the Entomological Society of Ontario* **121**: 129.
- Stewart, J. G., Lund, J. E. and Thompson, L. S. 1992. Factors affecting the efficacy of *Bacillus thuringiensis* var San Diego against larvae of the Colorado potato beetle. *Proceedings of the Entomological Society of Ontario* **122**: 21–25.

- Thistlewood, H. M. A., Bostanian, N. J. and Hardman, J. M. 2013. *Panonychus ulmi* (Koch) European red mite (Trombidiformes: Tetranychidae). Pp. 238–243 in Mason, P. G. and Gillespie, D. R. (eds), *Biological Control Programmes in Canada 2001–2012*. CABI Publishing, Wallingford, Oxfordshire, United Kingdom, 518 pp.
- Tripp, H. A. 1972. Field trials to control spruce budworm, *Choristoneura fumiferana* (Clem.), through aerial application of *Bacillus thuringiensis*. *Proceedings of the Entomological Society of Ontario* **102**: 64–69.
- Tyler, B. M. J. and Ellis, C. R. 1980. Ground beetles in three tillage plots in Ontario and observations on their importance as predators of the northern corn rootworm, *Diabrotica longicornis* (Coleoptera: Chrysomelidae). *Proceedings of the Entomological Society of Ontario* **110**: 65–73.
- Vander Hoek, G. 1971. The larval instars of *Aphidius pulcher* Baker (Hymenoptera: Aphidiidae). *Proceedings of the Entomological Society of Ontario* **101**: 55–59.
- Van Whervin, L. W. and Wilde, W. H. A. 1970. An analysis of the possibilities of the sterile male release technique in the eradication of the sugarcane moth borer, *Diatraea saccharalis* (F.), in Barbados West Indies. *Proceedings of the Entomological Society of Ontario* **100**: 111–113.
- Villanueva, R. and Harmsen, R. 1996. Ecological interactions of tarsonemid mites in apple orchards: Predation of apple rust mite and use of *Phyllonorycter blancardella* mines. *Proceedings of the Entomological Society of Ontario* **127**: 99–106.
- Vincent, C., Huber, J. T., Gibson, G. A. P. and Goulet, H. 2013. *Phyllonorycter blancardella* (Fabricius), spotted tentiform leafminer (Lepidoptera: Gracillariidae). Pp. 244–247 in Mason, P. G. and Gillespie, D. R. (eds), *Biological Control Programmes in Canada 2001–2012*. CABI Publishing, Wallingford, Oxfordshire, United Kingdom, 518 pp.
- Wallace, D. R. and Sullivan, C. R. 1985. The white pine weevil, *Pissodes strobe* (Coleoptera: Curculionidae): a review emphasizing behavior and development in relation to physical factors. *Proceedings of the Entomological Society of Ontario* **116** Supplement: 39–62.
- Wang, T. and Laing, J. E. 1989. Reproductive biology of *Holcothorax testaceipes* (Hymenoptera: Encyrtidae) and its effect on development of the host, *Phyllonorycter blancardella* (Lepidoptera: Gracillariidae). *Proceedings of the Entomological Society of Ontario* **120**: 35–41.
- Wang, T. and Laing, J. E. 1990. Toxicity of selected insecticides to adult *Holcothorax testaceipes* (Hymenoptera: Encyrtidae), an imported parasitoid of *Phyllonorycter blancardella* (Lepidoptera: Gracillariidae). *Proceedings of the Entomological Society of Ontario* **121**: 119–122.
- Welch, H. E. 1958. Test of a nematode and its associated bacterium for control of the Colorado potato beetle *Leptinotarsa decemlineata* (Say). *Annual Report of the Entomological Society of Ontario* **88**: 53–54.
- Welch, H. E. 1962. Nematodes as agents for insect control. *Proceedings of the Entomological Society of Ontario* **92**: 11–19.
- Welch, H. E. and Briand, L. J. 1961. Field experiment on the use of a nematode for the control of vegetable crop insects. *Proceedings of the Entomological Society of Ontario* **91**: 197–202.
- West, A. S. and DeLong, B. 1956. Notes on the biology and laboratory rearing of a predatory insect, *Zelus exsanguis* (Stahl) (Hemiptera: Reduviidae). *Annual Report of the Entomological Society of Ontario* **86**: 97–101.

- West, R. J. 1992. Notes on the biology and control of black army cutworm, *Actebia fennica* (Lepidoptera: Noctuidae), in black spruce plantations. *Proceedings of the Entomological Society of Ontario* **122**: 53–63.
- West, R. J., Laing, J. E. and Marshall, S. A. 1984. Parasitoids of the potato stem borer, *Hydraecia micacea* (Lepidoptera: Noctuidae). *Proceedings of the Entomological Society of Ontario* **114**: 69–82.
- Whistlecraft, J. W. and Lepard, I. J. M. 1989. Effect of flooding on survival of the onion fly *Delia antiqua* (Diptera: Anthomyiidae) and two parasitoids, *Aphaereta pallipes* (Hymenoptera: Braconidae) and *Aleochara bilineata* (Coleoptera: Staphylinidae). *Proceedings of the Entomological Society of Ontario* **120**: 43–47.
- Whitfield, G. H., Drummond, F. A. and Haynes, D. L. 1981. A simulation model for the survival and development of the onion maggot *Hylemya antiqua* (Diptera: Anthomyiidae). *Proceedings of the Entomological Society of Ontario* **111**: 39–55.
- Wilde W. H. A. 1965. The pear psylla, *Psylla pyricola* Foerster, in Ontario (Homoptera: Chermidae). *Proceedings of the Entomological Society of Ontario* **95**: 5–10.
- Wilson, G. G. 1978. Observations on the incidence rates of *Nosema fumiferanae* (Microsporidia) in a spruce budworm, *Choristoneura fumiferana*, (Lepidoptera: Tortricidae) population. *Proceedings of the Entomological Society of Ontario* **108**: 144–145.
- Wilson, G. G. 1980. Effects of *Nosema disstriae* (Microsporida) on the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae). *Proceedings of the Entomological Society of Ontario* **110**: 97–99.
- Wilson, G. G. 1981. Effects of *Nosema fumiferanae* (Microsporida) on rearing stock of spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae). *Proceedings of the Entomological Society of Ontario* **111**: 115–116.
- Wilson, G. G. 1985a. The transmission and effects of *Nosema fumiferanae* and *Pleistophora schubergi* (Microsporida) on *Choristoneura fumiferana* (Lepidoptera: Tortricidae). *Proceedings of the Entomological Society of Ontario* **115**: 71–75.
- Wilson, G. G. 1985b. Dose-mortality response of *Choristoneura fumiferana* (Lepidoptera: Tortricidae) to a microsporidium, *Pleistophora schubergi*. *Proceedings of the Entomological Society of Ontario* **115**: 93–94.
- Wilson, G. G. 1987. The effects of *Vairimorpha necatris* (Microsporida) on the spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae). *Proceedings of the Entomological Society of Ontario* **117**: 91–93.
- Wilson, G. G. and Burke, J. M. 1979. Microsporidian parasites of *Archips cerasivoranus* (Fitch) in the district of Algoma, Ontario. *Proceedings of the Entomological Society of Ontario* **109**: 84–85.
- Woolhouse, M. E. J. and Harmsen, R. 1985. The mite complex on the foliage of a pesticide-free apple orchard: population dynamics and habitat associations. *Proceedings of the Entomological Society of Ontario* **115**: 1–11.
- Wright, E. J. 1979. Observations on the copulatory behaviour of *Perilitus coccinellae* (Hymenoptera: Braconidae). *Proceedings of the Entomological Society of Ontario* **109**: 22.
- Wright, E. J. and Laing, J. E. 1979. The effects of temperature on development, adult longevity and fecundity of *Coleomegilla maculata lengi* and its parasite *Perilitus coccinellae*. *Proceedings of the Entomological Society of Ontario* **109**: 33–47.
- Wright, R. E. 1972. Nematode parasite of the face fly in Ontario. *Proceedings of the Entomological Society of Ontario* **102**: 168–175.

TABLE 1. Natural enemies introduced as classical biological control agents of invasive alien weeds in Ontario, 1952–2012.

Scientific name	Common name	Year first reported	Biological control agent	Year introduced	Reference
<i>Carduus nutans</i> L. (Asteraceae)	Nodding Thistle	1920 <sup>1</sup>	<i>Rhinocylmus conicus</i> Froelich (Coleoptera: Cucujionidae)	1968	Laing & Heels (1979)
<i>Cirsium arvense</i> (L.) Scopoli (Asteraceae)	Canada Thistle	17th century <sup>2</sup>	<i>Urophora cardui</i> L. (Diptera: Tephritidae)	1975	Laing (1978)
<i>Euphorbia esula</i> L. (Euphorbiaceae)	Leafy Spurge	1889 <sup>3</sup>	<i>Aphthona nigricutis</i> Fouadras (Coleoptera: Curculionidae) <i>Aphthona flava</i> Guillebeau (Coleoptera: Curculionidae)	1988	LeSage (1989)
<i>Hypericum perforatum</i> L. (Hyperiacae)	St. John's Wort	1800s <sup>4</sup>	<i>Chrysotina hyperici</i> (Fürster) (Coleoptera: Chrysomelidae)	1969	LeSage (1996b)
<i>Lythrum salicaria</i> L. (Lythraceae)	Purple Loosestrife	Early 19 <sup>th</sup> century	<i>Neogalerucella calmariensis</i> (L.) [= <i>Galerucella calmariensis</i> L.] (Coleoptera: Curculionidae)	1992	Corrigan et al. (1998)

<sup>1</sup>Mulligan and Frankton (1954), <sup>2</sup>Moore (1975), <sup>3</sup>Best et al. (1980), <sup>4</sup>Crompton et al. (1988).

TABLE 2. Natural enemies introduced as classical biological control agents of invasive alien arthropods in Ontario, 1952–2012.

Scientific name	Common name	Year first reported	Biological control agent	Year introduced	Reference
<i>Acyrtosiphon pisum</i> (Harris) (Hemiptera: Aphididae)	Pea Aphid	1890s <sup>1</sup>	<i>Aphydium smithi</i> Sharma and Subba Rao (Hymenoptera: Aphidiidae)	1950s in USA	Mackauer & Bisdee (1965)
<i>Agromyzafrontella</i> (Rondell) (Diptera: Agromyzidae)	Alfalfa Leaf Blotch Miner	Mid-1970s	<i>Dacusuta dryas</i> (Nixon) (Hymenoptera: Braconidae) <i>Diglyphus isaea</i> (Walker) (Hymenoptera: Eulophidae) <i>Cyrtogaster vulgaris</i> Walker (Hymenoptera: Pteromalidae)	1979 1975 (northeastern USA) 1976 (northeastern USA)	Harcourt et al. (1987) Cooté & Ellis (1987) Cooté & Ellis (1987)
<i>Coleophora deauratella</i> Lienig & Zeller (Lepidoptera: Coleophoridae)	Red Clover Case-bearer	1989	<i>Neochrysotacharis formosa</i> (Westwood) (Hymenoptera: Eulophidae)	1993 <sup>2</sup> , 1995 <sup>2</sup>	Ellis and Bjornson (1996)
<i>Coleophora laricella</i> (Hübner) (Lepidoptera: Coleophoridae)	Larch Casebearer	1935–1941	<i>Chrysotacharis laricinaella</i> (Ratzeburg) (Hymenoptera: Eulophidae) <i>Agathis piniilius</i> (Ratzeburg) (Hymenoptera: Braconidae)	1935–1941 1935–1941	Graham (1958) Graham (1958)
<i>Cydia pomonella</i> (L.) (Lepidoptera: Tortricidae)	Codling Moth	1958–1960	<i>Lioryphon caudatus</i> (Ratzeburg) [= <i>Apistephilides caudata</i> (Ratzeburg)] (Hymenoptera: Ichneumonidae) <i>Nippocryptus vitatorius</i> (Jurine) [= <i>Crypsus sexannulatus</i> Gravenhorst] (Hymenoptera: Ichneumonidae) <i>Elodia tragicula</i> (Meigen) (Diptera: Tachinidae) <i>Pristomerus vulnerator</i> Panzer (Hymenoptera: Ichneumonidae)	1941–1945 1941–1945 1943–1944 1943–1944	Putnam (1963) Putnam (1963) Putnam (1963) Putnam (1963)
<i>Hydractinia micacea</i> (Esper) (Lepidoptera: Noctuidae)	Potato Stem Borer	1968	<i>Lydella stabulans</i> Fallén (Diptera : Tachnidae)	1983	West et al. (1984)

TABLE 2 continued...

Scientific name	Common name	Year first reported	Biological control agent	Year introduced	Reference
<i>Hydraelia micacea</i> (Esper) (Lepidoptera: Noctuidae)	Potato Stem Borer		<i>Macrocentrus blandus</i> Eady and Clark (Hymenoptera: Braconidae)	1983	West et al. (1984)
<i>Hypera postica</i> (Gyllenhal) (Coleoptera: Curculionidae)	Alfalfa Weevil	1960	<i>Bathyplectes anurus</i> (Thomson) (Hymenoptera: Ichneumonidae) <i>Perilissus aethiopoides</i> Nees [= <i>Microctonus aethiopoides</i> Loan] (Hymenoptera: Braconidae)	1970 1970–1971	Harcourt & Ellis (1992) Harcourt et al. (1980)
			<i>Perilissus colsei</i> (Drea) [= <i>Microctonus colesii</i> Drea] (Hymenoptera: Braconidae) <i>Zoophthora phytonomi</i> (Arthur) Balko (Entomophthoraceae)	1970	Harcourt et al. (1982) Harcourt & Ellis (1992)
<i>Lymantria dispar</i> (L.) (Lepidoptera: Erebidae)	Gypsy Moth	1969	<i>Cotesia melanoscela</i> (Raizeburg) [= <i>Apaneles melanoscelus</i> (Raizeburg)] (Hymenoptera: Braconidae) <i>Compsilura concinna</i> (Meigen) (Diptera: Tachinidae) <i>Parasentrena agilis</i> Robineau-Desvoidy (Diptera: Tachinidae) <i>Ceranthis samarensis</i> (Villeneuve) (Diptera: Tachinidae)	Not introduced into Ontario 1916 Not introduced into Ontario 1991–1996	Griffiths (1977) Griffiths (1977) Griffiths (1977) Nealis and Quednau (1996)
<i>Oulema melanopus</i> (L.) (Coleoptera: Chrysomelidae)	Cereal Leaf Beetle	1965	<i>Tetrastichus julis</i> (Walker) (Hymenoptera: Encyrtidae)	1974	Ellis et al. (1979)
<i>Pieris rapae</i> (L.) (Lepidoptera: Pieridae)	Imported Cabbageworm	1871	<i>Cotesia rubecula</i> (Marshall) (Hymenoptera: Braconidae)	1991–1992	Carter & Laing (1997)
<i>Psila rosae</i> (Fabricius) (Diptera: Psilidae)	Carrot Rust Fly	1885	<i>Dacnusa gracilis</i> (Nees) (Hymenoptera: Braconidae) <i>Loxoropa tritoma</i> (Thomson) (Hymenoptera: Proctotrupidae)	1949–1953 1949–1953	Maybee (1954) Maybee (1954)

TABLE 2 continued...

Scientific name	Common name	Year first reported	Biological control agent	Year introduced	Reference
<i>Rhyacionia buoliana</i> (Schiffermüller) (Lepidoptera: Tortricidae)	European Pine Shoot Moth	1925	<i>Campoplex difformis</i> (Gmelin) [= <i>Campoplex mutabilis</i> (Holmgren)] (Hymenoptera: Ichneumonidae)	1928–1953	Coppel & Arthur (1954)
			<i>Sinophorus turionum</i> (Ratzeburg) [= <i>Campoplex rufifemur</i> (Thomson)] (Hymenoptera: Ichneumonidae)	1928–1953	Coppel & Arthur (1954)
			<i>Copidosoma filicorne</i> (Balman) [= <i>Copidosoma geniculatum</i> (Balman)] (Hymenoptera: Encyrtidae)	1928–1953	Coppel & Arthur (1954)
			<i>Temeleua interruptor</i> (Gravenhorst) [= <i>Cremastus interruptor</i> (Gravenhorst)] (Hymenoptera: Ichneumonidae)	1928–1953	Coppel & Arthur (1954)
			<i>Exeristes ruficollis</i> (Gravenhorst) [= <i>Ephialtes ruficollis</i> (Gravenhorst)] (Hymenoptera: Ichneumonidae)	1928–1953	Coppel & Arthur (1954)
			<i>Orgilus obscurator</i> (Nees) (Hymenoptera: Braconidae)	1928–1953	Coppel & Arthur (1954)
			<i>Pimpla turionella</i> (L.) (Hymenoptera: Ichneumonidae)	1928–1953	Coppel & Arthur (1954)
			<i>Pimpla</i> sp. (Hymenoptera: Ichneumonidae)	1928–1953	Coppel & Arthur (1954)
			<i>Baryscapus turionum</i> (Hertig) [= <i>Tetrastichus turionum</i> (Hertig)] (Hymenoptera: Encyrtidae)	1928–1953	Coppel & Arthur (1954)

<sup>1</sup> Mackauer, M. 1971. 2. *Acyrtosiphon pisum* (Harris), pea aphid (Homoptera: Aphididae). In: *Biological control programmes against insects and weeds in Canada 1959–1968*. Technical Communication Commonwealth Institute of Biological Control 4: 3–10.

<sup>2</sup> Some uncertainty whether populations released were *N. formosa* or *N. trifolii* (see text).

TABLE 3. Pathogens evaluated as inundative biological control agents of pest insects in Ontario, 1952–2012.

Scientific name	Common name	Biological control agent	Reference
<i>Choristoneura fumiferana</i> (Clemens) (Lepidoptera: Tortricidae)	Spruce Budworm	<i>Bacillus thuringiensis</i> Berliner (Bacilliaceae)	Tripp (1972)
		<i>Entomopox virus</i> (EPV) ( <i>Baculoviridae</i> )	Bird et al. (1973)
		<i>Nosema fumiferanae</i> (Thompson) (Nosematidae)	Wilson (1978; 1981; 1985a)
		nuclear polyhedrosis virus (NPV) ( <i>Baculoviridae</i> )	Bird et al. (1973)
		<i>Plestophora schubergi</i> Zwölfer (Pleistophoridae)	Wilson (1985a, b)
		<i>Vairimorpha necatrix</i> (Kramer) (Nosematidae)	Wilson (1987)
<i>Choristoneura pinus pinus</i> (Freeman) (Lepidoptera: Tortricidae)	Jack Pine Budworm	<i>Bacillus thuringiensis</i> Berliner (Bacilliaceae)	Cadogan et al. (1987); Cadogan (1993)
<i>Leptinotarsa decemlineata</i> (Say) (Coleoptera: Chrysomelidae)	Colorado Potato Beetle	<i>Bacillus thuringiensis</i> Berliner serovar. <i>San Diego</i> (Bacilliaceae)	Stewart et al. (1992)
		<i>Neaplectana chresima</i> Steiner (Nematoda: Steinernematidae)	Welch (1958)
<i>Lymantria dispar</i> (L.) (Lepidoptera: Erebidae)	Gypsy Moth	<i>Bacillus thuringiensis</i> Berliner serovar. <i>kurstaki</i> (Bacilliaceae)	Cunningham et al. (1996a, b)
		nuclear polyhedrosis virus (NPV) ( <i>Baculoviridae</i> )	Cunningham et al. (1996a, b)
<i>Malacosoma disstria</i> Hübner (Lepidoptera: Lasiocampidae)	Forest Tent Caterpillar	<i>Bacillus thuringiensis</i> Berliner (Bacilliaceae)	Angus (1965)
		<i>Lecontivirus</i> ( <i>Baculoviridae</i> )	Cunningham et al. (1987)
<i>Nedipriion lecontei</i> (Fitch) (Hymenoptera: Tenthredinidae)	Redheaded Pine Sawfly		
<i>Ostrinia nubilalis</i> (Hübner) (Lepidoptera: Pyralidae)	European corn borer	<i>Autographa californica nuclear polyhedrosis virus</i> (ACNPV) ( <i>Baculoviridae</i> )	Laing & Jaques (1985)
		<i>Bacillus thuringiensis</i> Berliner (Bacilliaceae)	Laing & Jaques (1985)
		<i>Nosema pyrausta</i> (Paillot) (Nosematidae)	Laing & Jaques (1985)
		<i>Vairimorpha necatrix</i> (Kramer) (Nosematidae)	Laing & Jaques (1985)
<i>Pteris rapae</i> (L.) (Lepidoptera: Pieridae)	Imported cabbageworm	<i>Pteris rapae GV</i> ( <i>Baculoviridae</i> )	Jaques (1971)
<i>Tricophusia ni</i> (Hübner) (Lepidoptera: Noctuidae)	Cabbage looper	<i>Tricophusia ni GV</i> ( <i>Baculoviridae</i> )	Jaques (1971)

**APPENDIX A.** Natural Enemies of insects and weeds reported in JESO (1952–2012). Correct name is first, followed by names as spelled in JESO in brackets, if they are different.

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Actebia femina</i> (Tauscher) (Lepidoptera: Noctuidae)	<i>Areneta rufipes</i> Cresson	Hymenoptera	Ichneumonidae	parasitoid	West (1992)
<i>Campaletis</i> sp.		Hymenoptera	Ichneumonidae	parasitoid	West (1992)
<i>Enicospilus</i> sp.		Hymenoptera	Ichneumonidae	parasitoid	West (1992)
<i>Gonia</i> sp.		Diptera	Tachinidae	parasitoid	West (1992)
<i>Ichneumon creperus</i> Cresson		Hymenoptera	Ichneumonidae	parasitoid	West (1992)
<i>Steinernema feltiae</i> (Filipjev)		Rhabditida	Steinernematidae	parasite	West (1992)
<i>Tachinomyia panaeitus</i> (Walker)		Diptera	Tachinidae	parasitoid	West (1992)
<i>Apanteles cacoeciae</i> Riley [=Dolichogenidea cacoeciae Riley]		Hymenoptera	Braconiidae	parasitoid	Laing & Heraty (1982)
<i>Acrobasis</i> sp. (Lepidoptera: Pyralidae)		Hymenoptera	Braconiidae	parasitoid	Maxwell & Morgan (1952)
<i>Acrobasis vaccinii</i> Riley					
<i>Acrobasis vaccinii</i> (Riley) [=Mineola vaccinii (Riley)]					
<i>Pyralidae</i> (Lepidoptera: Pyralidae)					
<i>Cryptus albifarsis</i> (Cresson)		Hymenoptera	Ichneumonidae	parasitoid	Maxwell & Morgan (1952)
<i>Balanusium pumani</i> Smiley		Trombidiformes	Erythraeidae	predator	Cadogan & Laing (1982)
<i>Dendropus</i> n. sp. near <i>suskii</i> Sharov and Livshitz [=Dendropus <i>forestae</i> Lindquist] Phytocoris sp.		Trombidiformes	Tarsonemidae	predator	Villanueva & Harmsen (1996)
<i>Aculus schlechtendali</i> (Nalepa) (Trombidiformes: Eriophyidae)		Hemiptera	Miridae	predator	Heraty (1979)
<i>Zerzellia mali</i> (Ewing)		Trombidiformes	Stigmataidae	predator	Clemens (1989)
<i>Aphelinus howardi</i> (Ashmead) [=Aphelinus howardii Dalla Torre]		Hymenoptera	Aphelinidae	parasitoid	Mackauer & Bisdee (1965)
<i>Aphelinus semiflavus</i> Howard		Hymenoptera	Aphelinidae	parasitoid	Mackauer & Bisdee (1965)
<i>Aphelinus colemani</i> Viereck [=Aphidius plautensis Brethes] [=Aphelinus ervi Haliday]		Hymenoptera	Aphidiidae	parasitoid	Vander Hoek (1971)
<i>Aphidius nigripes</i> Ashmead [=Aphidius pulcher Baker]		Hymenoptera	Aphidiidae	parasitoid	Vander Hoek (1971)
<i>Aphidius smithi</i> Sharma & Subba Rao		Hymenoptera	Aphidiidae	parasitoid	Mackauer & Bisdee (1965)
<i>Diaeretiella rapae</i> (McIntosh) [=Dtaeretus rapae (Curtis)]		Hymenoptera	Braconiidae	parasitoid	Vander Hoek (1971)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Ephedrus californicus</i> Baker	Hymenoptera	Aphidiidae	parasitoid	Mackauer & Bisdee (1965)	
<i>Erynia neocaphidis</i> Remaudière & Hennebert	Hymenoptera	Entomophthoraceae	pathogen	Ben-Zeev & Jaques (1990)	
<i>Monocionus crepidis</i> (Haliday) [= <i>Monocionus pallidum</i> Marshall] <i>Monocionus nervosus</i> (Haliday) [= <i>Monocionus paulensis</i> (Ashmead)]	Hymenoptera	Braconidae	parasitoid	Vander Hoek (1971)	
<i>Praon pequodorum</i> Viereck <i>Praon</i> sp.	Hymenoptera	Braconidae	parasitoid	Mackauer & Bisdee (1965)	
<i>Leiophron dayi</i> (Goulet) [= <i>Peristenus dayi</i> Hymenoptera Goulet]	Hymenoptera	Aphidiidae	parasitoid	Mackauer & Bisdee (1965)	
<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis)= <i>Leiophron pallipes</i> Curtis]	Hymenoptera	Aphidiidae	parasitoid	Mackauer & Bisdee (1965)	
<i>Leiophron rubricollis</i> (Thomson) [= <i>Peristenus rubricollis</i> (Thomson)]	Hymenoptera	Braconidae	parasitoid	Mackauer & Bisdee (1965)	
<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis)= <i>Leiophron pallipes</i> Curtis]	Hymenoptera	Braconidae	parasitoid	Mackauer & Bisdee (1965)	
<i>Neoplectana</i> n. sp. (DD136)	Rhabditida	Steinernematidae	parasite	Welch (1962)	
<i>Aedes aegypti</i> (L.) (Diptera: Culicidae)	Hymenoptera	Pteromalidae	parasitoid	Coote & Ellis (1987a)	
<i>Agromyza frontella</i> (Rondani) (Diptera: Agromyzidae)	<i>Asaphes vulgaris</i> Walker	Eulophidae	parasitoid	Coote & Ellis (1987a)	
<i>Baryscapus racemariae</i> (Ashmead) [= <i>Tetrasichus centricolae</i> (Ashmead)]	Hymenoptera	Eulophidae	parasitoid	Coote & Ellis (1987a)	
<i>Chrysotcharis giraulti</i> Yoshimoto [= <i>Chrysotcharis lirionyzae</i> Delucchi] [= <i>Chrysotcharis punctifacies</i> Delucchi]	Hymenoptera	Eulophidae	parasitoid	Coote & Ellis (1987a)	
<i>Closterocerus cinctipennis</i> Ashmead <i>Closterocerus trifasciatus</i> Westwood [= <i>Closterocerus tricinctus</i> (Ashmead)]	Hymenoptera	Eulophidae	parasitoid	Coote & Ellis (1987a)	
<i>Cyrtogaster vulgaris</i> Walker	Hymenoptera	Pteromalidae	parasitoid	Coote & Ellis (1987a)	

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Dacnusa dryas</i> (Nixon)	Hymenoptera	Braconidae	parasitoid	Cooe & Ellis (1987a); Harcourt et al. (1987)	
<i>Diaulonopsis albiscapus</i> (Girault)	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Diaulonopsis callichroma</i> Crawford	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Diglyptus begini</i> (Ashmead)	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Diglyptus intermedius</i> (Girault)	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Diglyptus isaea</i> (Walker)	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Diglyptus pulchripes</i> (Crawford)	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Eunotus</i> sp.	Hymenoptera	Pteromalidae	parasitoid	Cooe & Ellis (1987a)	
<i>Hemiptarsenus ainstiei</i> (Crawford) [= <i>Nonanisomorpha ainstiei</i> Crawford]	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Misogaster horrensis</i> Walker	Hymenoptera	Pteromalidae	parasitoid	Cooe & Ellis (1987a)	
<i>Necremius</i> sp.	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Pnigalio maculipes</i> (Crawford)	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Pnigalio uroplatae</i> (Howard)	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Sympiesis ancylae</i> Girault	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Sympiesis enargiae</i> Miller	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Sympiesis sericeicornis</i> (Nees) [= <i>Sympiesis conica</i> (Provancher)]	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Sympiesis</i> sp.	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Sympiesis viridula</i> (Thomson)	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Tetrastichus</i> n. sp.	Hymenoptera	Eulophidae	parasitoid	Cooe & Ellis (1987a)	
<i>Tetrastichus cincinnatus</i> (Girault) [= <i>Aprostocetus cincinnatus</i> (Girault)]	Hymenoptera	Braconidae	parasitoid	Dustan & Boyce (1966)	
<i>Macrocenurus aencylivora</i> Rohwer	Hymenoptera	Braconidae	parasitoid	Dustan & Boyce (1966)	
<i>Ancylis comptana</i> (Frölich) [= <i>Ancylis comptana fragariae</i> (Walsh & Riley)] (Lepidoptera: Tortricidae)		Clavicipitaceae	pathogen	Cameron (1969)	
<i>Anisoplia austriaca</i> (Herbst) (Coleoptera: Scarabaeidae)					
<i>Metarrhizium anisopliae</i> (Metchnikoff) Sorokin					

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
aphids (Hemiptera: Aphididae)	<i>Adiaphytus salicaphis</i> (Fitch) [= <i>Diaeretus salicaphis</i> (Fitch)]	Hymenoptera	Braconidae	parasitoid	Judd (1953)
	<i>Aphidiinus matricariae</i> Haliday [= <i>Aphidiinus phorodonitis</i> Ashmead]	Hymenoptera	Aphidiidae	parasitoid	Judd (1953)
	<i>Asaphes suspensus</i> (Nees) [= <i>Asaphes rufipes</i> Brues]	Hymenoptera	Pteromalidae	parasitoid	Judd (1953)
	<i>Lygoceurus</i> sp.	Hymenoptera	Ceraphronidae	hyperparasitoid	Judd (1953)
<i>Aphidiinus phorodonitis</i> Ashmead (Hymenoptera: Braconidae)	<i>Alloxysta</i> sp. [= <i>Charipes</i> sp.]	Hymenoptera	Alyoxystidae	hyperparasitoid	Bahlai et al. (2009)
	<i>Harmonia axyridis</i> (Pallas)	Coccoptera	Coccinellidae	predator	Hagley (1979)
<i>Aphis glycines</i> Matsumura (Hemiptera: Aphididae)		Hemiptera	Miridae	predator	Hagley (1979)
<i>Aphis pomi</i> DeGeer (Hemiptera: Aphididae)	<i>Deraeocoris fasciatus</i> Knight	Hemiptera	Myrmidae	parasitoid	Huber (2012)
<i>Aphis sartoriensis</i> (Fitch) (Hemiptera: Cicadellidae)	<i>Ooconus aphrophorae</i> Milliron	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
<i>Schizocerella pilicornis</i> (Holmgren) [= <i>Aplosthena zahriskei</i> Webster & Malley] (Hymenoptera: Argidae)	<i>Anaphes conotracheli</i> Girault	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
<i>Archips cerasivorana</i> (Fitch) (Lepidoptera: Tortricidae)	<i>Nosema scerashvoranus</i> Thomson	Nosemidae		pathogen	Wilson & Burke (1979)
	<i>Pleistophora</i> sp.	Pleistophoridae		pathogen	Wilson & Burke (1979)
	<i>Thelobanina</i> sp.	Thelobanidae		pathogen	Wilson & Burke (1979)
<i>Archips purpuranus</i> Clemens (Lepidoptera: Tortricidae)	<i>Macrocentrus nigridorsis</i> Viereck	Hymenoptera	Braconidae	parasitoid	Hagley & Barber (1992)
	<i>Microgaster canadensis</i> Muesebeck [= <i>Microgaster canadensis</i> Muesebeck] <i>Oncophanes americanus</i> (Weed) [= <i>Oncophanes atriceps</i> (Ashmead)]	Hymenoptera	Braconidae	parasitoid	Hagley & Barber (1992)
	<i>Oncophanes canadensis</i> (Muesebeck) [= <i>Zenilla caesar</i> (Aldrich)]	Diptera	Tachinidae	parasitoid	Hagley & Barber (1992)
<i>Archips rosana</i> (L.) (Lepidoptera: Tortricidae)	<i>Euema caesar</i> (Aldrich) [= <i>Zenilla caesar</i> Aldrich]	Hymenoptera	Braconidae	parasitoid	Hagley & Barber (1992)
	<i>Microgaster canadensis</i> Muesebeck	Diptera	Tachinidae	parasitoid	Hagley & Barber (1992)
	<i>Phorocera erecta</i> Coquillett				

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Archips</i> spp. (Lepidoptera: Tortricidae)	<i>Apanthes cacoeciae</i> Riley [= <i>Dolichogenidea cacoeciae</i> Riley] <i>Phytoptenus vulgaris</i> Cresson	Hymenoptera	Braconidae	parasitoid	Laing & Heraty (1982)
<i>Argyrotaenia velutinana</i> (Walker) (Lepidoptera: Tortricidae)	<i>Phytodietus annulatus</i> (Provancher) [= <i>Trichogramma minutum</i> Riley]	Hymenoptera	Ichneumonidae	parasitoid	Hikichi (1962); Hagley & Barber (1992)
<i>Ascogaster quadridentata</i> Westmael (Hymenoptera: Braconidae)	<i>Dibrachys microgasteri</i> (Bouché) [= <i>Dibrachys cavus</i> (Walker)]	Hymenoptera	Trichogrammaidae	parasitoid	Hikichi (1962); Hagley & Barber (1992)
<i>Perilampus fulvicornis</i> Ashmead		Hymenoptera	Pteromalidae	hyperparasitoid	Putnam (1963)
<i>Perilampus</i> sp.		Hymenoptera	Perilampidae	hyperparasitoid	Putnam (1963)
<i>Perilampus tristis</i> Mayr		Hymenoptera	Perilampidae	hyperparasitoid	Putnam (1963)
<i>Autographa californica</i> (Speyer) (Lepidoptera: Noctuidae)	<i>Cotesia yakutensis</i> (Ashmead) [= <i>Apaneles yakutensis</i> (Ashmead)]	Hymenoptera	Braconidae	parasitoid	West et al. (1984)
<i>Bathyplectes curculionis</i> (Thomson) (Hymenoptera: Ichneumonidae)	<i>Agrothereutes abbreviator</i> (Cresson) [= <i>Agrothereutes abbreviator</i> <i>similaris</i> (Provancher)]	Hymenoptera	Ichneumonidae	hyperparasitoid	Abu & Ellis (1976)
<i>Agrothereutes</i> sp.		Hymenoptera	Chalcidae	hyperparasitoid	Abu & Ellis (1976)
<i>Conura albifrons</i> (Walsh) [= <i>Spilochohalcis</i> <i>albifrons</i> (Walsh)]		Hymenoptera	Chalcidae	hyperparasitoid	Abu & Ellis (1976)
<i>Eupelmella vesticulans</i> (Retzius)		Hymenoptera	Eupelmidae	hyperparasitoid	Abu & Ellis (1976)
<i>Eupelmus</i> sp.		Hymenoptera	Eupelmidae	hyperparasitoid	Abu & Ellis (1976)
<i>Gelis</i> sp.		Hymenoptera	Ichneumonidae	hyperparasitoid	Abu & Ellis (1976)
<i>Habrocytus</i> sp.		Hymenoptera	Pteromalidae	hyperparasitoid	Abu & Ellis (1976)
<i>Itoplexis conqueritor</i> (Say)		Hymenoptera	Ichneumonidae	hyperparasitoid	Abu & Ellis (1976)
<i>Pteromalus</i> sp.		Hymenoptera	Pteromalidae	hyperparasitoid	Abu & Ellis (1976)
<i>Trichomalopsis viridescens</i> (Walsh) [= <i>Eupteromalus viridescens</i> (Walsh)]		Hymenoptera	Pteromalidae	hyperparasitoid	Abu & Ellis (1976)
<i>Bombus fervidus</i> (Fabricius) (Hymenoptera: Apidae)		Diptera	Sarcophagidae	parasitoid	MacFarlane & Pengelly (1978)

## APPENDIX A continued..

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Bombus impatiens</i> Cresson (Hymenoptera: Apidae)	<i>Melittobia chalybii</i> Ashmead	Hymenoptera	Eulophidae	parasitoid	Edwards & Pengelly (1966); MacFarlane & Pengelly (1978)
<i>Bombus laboriosus</i> (Fabricius) [= <i>Pstithrus laboriosus</i> (Fabricius)] (Hymenoptera: Apidae)	<i>Brachicoma setosata</i> Coquillett	Diptera	Sarcophagidae	parasitoid	MacFarlane & Pengelly (1978)
<i>Bombus vagans</i> Smith (Hymenoptera: Apidae)	<i>Melittobia chalybii</i> Ashmead	Hymenoptera	Eulophidae	parasitoid	MacFarlane & Pengelly (1978)
<i>Bombyx mori</i> (L.) (Lepidoptera: Bombycidae)	<i>Melittobia chalybii</i> Ashmead	Hymenoptera	Eulophidae	parasitoid	MacFarlane & Pengelly (1978)
<i>Bruchophagus platyptera</i> (Walker) [= <i>Bruchophagus</i> <i>platypterus</i> (Walker)] (Hymenoptera: Eurytomidae)	<i>Bacillus thuringiensis</i> Berliner serovar. <i>sotto</i> Aoki & Chigasaki <i>Tetrastichus bruchophagi</i> Gahan	Hymenoptera	Bacillaceae	pathogen	Angus & Heimpel (1960)
<i>Cacopsylla pynicola</i> (Förster) [= <i>Psylla pynicola</i> Förster] (Hemiptera: Psyllidae)	<i>Mesopolobus bruchophagi</i> (Gahan) <i>Adalia bipunctata</i> (L.)	Hymenoptera Coleoptera	Pteromalidae Coccinellidae	parasitoid predator	Ellis & Nang'ayo (1992); Philogene & Chang (1979)
<i>Adalia bipunctata frigida</i> Schneider [= <i>Adalia frigida</i> Schneider]	<i>Adalia bipunctata</i> (L.)	Coleoptera	Coccinellidae	predator	Philogene & Chang (1979)
<i>Aguila</i> sp.					Philogene & Chang (1979)
<i>Anthocoris antevolens</i> White					Philogene & Chang (1979)
<i>Anthocoris melanocerus</i> Reuter					Wilde (1965); Philogene & Chang (1979)
<i>Anthocoris musculus</i> Say					Philogene & Chang (1979)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
	<i>Anthocoris nemoralis</i> (Fabricius)	Hemiptera	Anthocoridae	predator	Philogene & Chang (1979)
	<i>Anthocoris nemorum</i> L.	Hemiptera	Anthocoridae	predator	Philogene & Chang (1979)
	<i>Anthocoris pilosus</i> (Jakovlev)	Hemiptera	Anthocoridae	predator	Philogene & Chang (1979)
	<i>Anthocoris sp.</i>	Hemiptera	Anthocoridae	predator	Wilde (1965)
	<i>Anthocoris whitei</i> Reuter	Hemiptera	Anthocoridae	predator	Philogene & Chang (1979)
	<i>Asaphes vulgaris</i> Walker	Hymenoptera	Pteromalidae	parasitoid/ hyperparasitoid	Philogene & Chang (1979)
	<i>Atracotomus mali</i> Meyer	Neuroptera	Chrysopidae	predator	Philogene & Chang (1984)
	<i>Cahvia quatuordecimguttata</i> (L.) [= <i>Anisocloavia quatuordecimguttata</i> L.]	Coleoptera	Coccinellidae	predator	Philogene & Chang (1979)
	<i>Cathria thodeimmaculata</i> Gebler [= <i>Campylomma verbasci</i> (Meyer-Dür)]	Hemiptera	Miridae	predator	Philogene & Chang (1979)
	<i>Ceratomegilla</i> sp.	Coleoptera	Coccinellidae	predator	Philogene & Chang (1979); Wilde (1965)
	<i>Chrysopa carnea</i> Stephens	Neuroptera	Chrysopidae	predator	Philogene & Chang (1985)
	<i>Chrysopa oculata</i> Say	Neuroptera	Chrysopidae	predator	Philogene & Chang (1986)
	<i>Chrysopa ploribunda</i> Fitch	Neuroptera	Chrysopidae	predator	Philogene & Chang (1987)
	<i>Chrysopa</i> sp.	Neuroptera	Chrysopidae	predator	Wilde (1965); Philogene & Chang (1979)
	<i>Coccidencyrtus</i> sp.	Hymenoptera	Pteromalidae	parasitoid	Philogene & Chang (1980; 1981)
	<i>Coccinella transversoguttata richarsoni</i> Brown [= <i>Coccinella transversoguttata</i> Faldeman]	Coleoptera	Coccinellidae	predator	Philogene & Chang (1979)
	<i>Coleomegilla maculata fuscilabris</i> (Mulsant) [= <i>Magilla fuscilabris</i> Mulsant]	Coleoptera	Coccinellidae	predator	Philogene & Chang (1979)
	<i>Cycloneura polita</i> Casey	Coleoptera	Coccinellidae	predator	Wilde (1965)
	<i>Cycloneura</i> sp.	Coleoptera	Coccinellidae	parasitoid	Philogene & Chang (1979)
	<i>Dendrocerus floridanus</i> (Ashmead) [= <i>Lygoconus seminodosus</i> Kieffer]	Hymenoptera	Ceraphronidae		
	<i>Deraeocoris brevispicatus</i> Knight [= <i>Deraeocoris brevispicatus</i> Knight]	Hemiptera	Miridae	predator	Philogene & Chang (1979)

## APPENDIX A continued..

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Deraeocoris fasciatus</i> Knight [= <i>Dereocoris fasciatus</i> Knight] <i>Diaphorinocoris provancheri</i> (Burque)	Hemiptera	Miridae		predator	Philogene & Chang (1979)
<i>Encyrtus</i> sp.	Hymenoptera	Encyrtidae		predator	Philogene & Chang (1979)
<i>Endopsylla agilis</i> de Mejere	Diptera	Cecidomyiidae		parasitoid	Philogene & Chang (1979)
<i>Endopsylla</i> sp.	Diptera	Cecidomyiidae		parasitoid	Philogene & Chang (1979)
<i>Hemerobius pacificus</i> Banks	Neuroptera	Hemerobiidae		predator	Philogene & Chang (1979)
<i>Hemerobius angustus</i> Banks	Neuroptera	Hemerobiidae		predator	Philogene & Chang (1979)
<i>Hemerobius</i> sp.	Neuroptera	Hemerobiidae		predator	Philogene & Chang (1979)
<i>Hippodamia convergens</i> Guérin-Ménville [= <i>Hippodamia convergens</i> Guérin-Ménerville]	Coleoptera	Coccinellidae		predator	Philogene & Chang (1979)
<i>Hippodamia quinquesignata</i> (Kirby) [= <i>Hippodamia quinquesignata</i> (Kirby)]	Coleoptera	Coccinellidae		predator	Wilde (1965)
<i>Hippodamia</i> sp.	Coleoptera	Coccinellidae		predator	Philogene & Chang (1979)
<i>Hippodamia tredecimpunctata tibialis</i> (Say) [= <i>Hippodamia tredecimpunctata</i> tibialis (Say)]					
<i>Lastius pallitarsi</i> (Provancher) [= <i>Lastius sitkaensis</i> Pergande]	Hymenoptera	Formicidae		predator	Philogene & Chang (1979)
<i>Lygocherus</i> sp.	Hymenoptera	Ceraphronidae		parasitoid	Philogene & Chang (1979)
<i>Olla v-nigrum</i> (Mulsant) [= <i>Olla abdominalis</i> Say]	Coleoptera	Coccinellidae		predator	Philogene & Chang (1979)
<i>Orius</i> sp.	Hemiptera	Anthocoridae		predator	Philogene & Chang (1979)
<i>Orius tristicolor</i> (White)	Hemiptera	Anthocoridae		predator	Philogene & Chang (1979)
<i>Pachyneuron californicum</i> Girault	Hymenoptera	Pteromalidae		parasitoid/ hyperparasitoid	Philogene & Chang (1982)
<i>Pachyneuron</i> sp.	Hymenoptera	Pteromalidae		parasitoid	Philogene & Chang (1983)
<i>Platypalpus</i> sp.	Diptera	Hybotidae		predator	Philogene & Chang (1979)
<i>Prionomitus mitratus</i> (Dalman)	Hymenoptera	Encyrtidae		parasitoid	Philogene & Chang (1979)
<i>Psyllaphagus</i> sp.	Hymenoptera	Encyrtidae		parasitoid	Philogene & Chang (1979)

## APPENDIX A continued...

<u>Host</u>	<u>Natural enemy</u>	<u>Order</u>	<u>Family</u>	<u>Feeding niche</u>	<u>Reference</u>
<i>Carduus acanthoides</i> L. (Asteraceae)	<i>Scymnus marginicollis</i> Mannerham [= <i>Scymnus marginicollis</i> Mannerham] <i>Spanosiphonia</i> sp.	Coleoptera	Coccinellidae	predator	Philogene & Chang (1979)
<i>Carduus nutans</i> L. (Asteraceae)	<i>Stethorus punctum pictipes</i> Casey [= <i>Stethocrus pictipes</i> Casey] <i>Trechonites insidiosus</i> (Crawford) [= <i>Trechonites psyllae</i> (Ruschka)] <i>Rhinoceylus conicus</i> Frölich	Diptera Coleoptera Hymenoptera Coleoptera	Syphidae Coccinellidae Encyrtidae Curculionidae	predator predator parasitoid phytophage	Philogene & Chang (1979) Philogene & Chang (1979) Wilde (1965); Philogene & Chang (1979) Laing & Heels (1979)
<i>Chaetocnema denticallata</i> (Illiger) (Coleoptera: Chrysomelidae)	<i>Papaipema nebris</i> Guenée [= <i>Papaipema negris</i> Guenée] <i>Platyphila carduidactyla</i> (Riley)	Lepidoptera	Noctuidae	phytophage	Laing & Heels (1979)
<i>Chlamydatus</i> sp. (Hemiptera: Miridae)	<i>Rhinoceylus conicus</i> Frölich <i>Anaphes pullicurus</i> (Girault)	Lepidoptera Coleoptera Hymenoptera	Pterophoridae Curculionidae Mymaridae	phytophage phytophage parasitoid	Laing & Heels (1979) Laing & Heels (1979) Huber (2006)
<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis) = <i>Leiophron pallipes</i> Curtis]	<i>Telenomus utahensis</i> Ashmead	Hymenoptera	Scelionidae	parasitoid	Loan (1965)
<i>Chlorochroa sayi</i> Stål (Hemiptera: Pentatomidae)	<i>Telenomus utahensis</i> Ashmead	Hymenoptera	Scelionidae	parasitoid	Wang & Laing (1989)
<i>Chlorochroa uhleri</i> Stål (Hemiptera: Pentatomidae)	<i>entomopoxvirus EPV</i>		<i>Poxviridae</i>	pathogen	Wang & Laing (1989)
<i>Choristoneura biennis</i> Freeman (Lepidoptera: Tortricidae)	<i>Bacillus thuringiensis</i> Berliner		Bacillaceae	pathogen	Bird et al. (1973)
<i>Choristoneura fumiferana</i> (Clemens) (Lepidoptera: Tortricidae)	<i>entomopoxvirus EPV</i> <i>Nosema fumiferanae</i> (Thomson) <i>Nosema fumiferanae</i> (Thomson) <i>Pleistophora schubergi</i> Zwölfer		<i>Poxviridae</i> Nosematidae Nosematidae Pleistophoridae	pathogen pathogen pathogen pathogen	Bird et al. (1973) Wilson (1978, 1985a; 1987) Wilson (1981) Wilson & Burke (1979); Wilson (1985a, b)

## APPENDIX A continued..

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Pleistophora</i> sp.	Pleistophoridae			pathogen	Wilson & Burke (1979)
<i>polyhedrosis virus NPV</i>	<i>Baculoviridae</i>			pathogen	Bird et al. (1973)
<i>Thelophania</i> sp.	Nosematidae			pathogen	Wilson (1987)
<i>Thelophania</i> sp.	Thelophaniidae			pathogen	Wilson & Burke (1979)
<i>Trichogramma minutum</i> Riley	Hymenoptera		Trichogrammatidae	parasitoid	Corrigan et al. (1994)
<i>Vairimorpha necatrix</i> (Kramer)	Dissociodiaphlop-		Nosematidae	pathogen	Wilson (1987)
<i>Choristoneura pinus pini</i> (Freeman) (Lepidoptera: Tortricidae)	<i>Bacillus thuringiensis</i> Berliner serovar. <i>kurstaki</i>		Bacillaceae	pathogen	Cadogan et al. (1987); Cadogan (1993)
<i>Choristoneura rosaceana</i> (Harris) (Lepidoptera: Tortricidae)	<i>Acropimpla albioricta</i> (Cresson)	Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Actia interrupta</i> Curran	Diptera	Tachinidae		parasitoid	Hagley & Barber (1992)
<i>Agyron</i> sp.	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Apophua simplicipes</i> (Cresson)	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Colpoctypeus florus</i> (Walker)	Hymenoptera	Eulophidae		parasitoid	Hagley & Barber (1992)
<i>Elachertus</i> sp.	Hymenoptera	Eulophidae		parasitoid	Hagley & Barber (1992)
<i>Glypta fumiferanae</i> (Viereck)	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Glypta</i> sp.	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Itolectus conquistor</i> (Say)	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Macrocentrus linearis</i> (Nees)	Hymenoptera	Braconidae		parasitoid	Hagley & Barber (1992)
[= <i>Macrocentrus iridescens</i> (French)]					
<i>Nilea erecta</i> (Coquillet)	Diptera	Tachinidae		parasitoid	Hagley & Barber (1992)
<i>Phytodietus</i> sp.	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Phytodietus vulgaris</i> Cresson	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Pimpia aequalis</i> Provancher	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Scambus versicolorius</i> Ratzburg	Hymenoptera	Ichneumonidae		parasitoid	Hagley & Barber (1992)
<i>Trichogramma minutum</i> Riley	Hymenoptera	Trichogrammatidae		parasitoid	Hagley & Barber (1992)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Chrysops frigidus</i> Osten-Sacken [= <i>Chrysops frigida</i> Osten-Sacken] (Diptera: Tabanidae)	<i>Diglochis occidentalis</i> (Ashmead) <i>Diglochis occidentalis</i> (Ashmead)	Hymenoptera	Pteromalidae	parasitoid	James (1952)
<i>Chrysops fuscatus</i> Walker [= <i>Chrysops furcata</i> Walker] (Diptera: Tabanidae)					James (1952)
<i>Chrysops</i> spp. (Diptera: Tabanidae)	<i>Diglochis occidentalis</i> (Ashmead)	Hymenoptera	Pteromalidae	parasitoid	James (1952)
<i>Cirsium arvense</i> (L.) Scopoli (Asteraceae)	<i>Prionocera dimitidata</i> (Loew) <i>Urophora cardui</i> L.	Hymenoptera Diptera	Tipulidae Tephritidae	predator phytophage	James (1952) Laing (1978)
<i>Cirsium vulgare</i> (Savi) Tenore (Asteraceae)	<i>Rhinoceyllus conicus</i> Frölich	Coleoptera	Curculionidae		Laing & Heels (1979)
<i>Costerotomus norvegicus</i> (Gmelin) [= <i>Calocoris norvegicus</i> Reuters] (Hemiptera: Miridae)	<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis) = <i>Leiophron</i> pallipes Curtis <i>Dinocampus coccinellae</i> (Schrank) [= <i>Perilissus coccinellae</i> (Shrank)]	Hymenoptera	Braconidae	parasitoid	Loan (1965)
<i>Coleomegilla maculata</i> lengi Timberlake (Coleoptera: Coccinellidae)					Wright (1979); Wright & Laing (1979)
<i>Coleophora aleyroprivella</i> (Kollar) (Lepidoptera: Coleophoridae)	<i>Neochrysocharis formosus</i> (Westwood) [= <i>Neochrysocharis formosa</i> (Westwood)]	Hymenoptera	Eulophidae	parasitoid	Ellis & Björnson (1996)
<i>Coleophora deauratella</i> Lienig & Zeller (Lepidoptera: Coleophoridae)	<i>Bracon pygmaeus</i> Provancher	Hymenoptera	Braconidae	parasitoid	Ellis & Björnson (1996)
	<i>Neochrysocharis formosus</i> (Westwood) [= <i>Neochrysocharis formosa</i> (Westwood)]	Hymenoptera	Eulophidae	parasitoid	Ellis & Björnson (1996)
	<i>Neochrysocharis trifolii</i> Erdős [= <i>Chrysotonomyia trifolii</i> (Erdős)] <i>Agathis pumila</i> (Ratzeburg)	Hymenoptera	Eulophidae	parasitoid	Ellis & Björnson (1996)
<i>Coleophora laniella</i> (Hubner) (Lepidoptera: Coleophoridae)					Graham (1958)
<i>Coleophora mayrella</i> (Hubner) (Lepidoptera: Coleophoridae)	<i>Chrysocharis laricinella</i> (Ratzeburg) <i>Neochrysocharis formosus</i> (Westwood) [= <i>Neochrysocharis formosa</i> (Westwood)]	Hymenoptera	Eulophidae Eulophidae	parasitoid parasitoid	Graham (1958) Ellis & Björnson (1996)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Coleophora pruniella</i> (Clemens) (Lepidoptera: Coleophoridae)	<i>Orgilus scaber</i> Muesebeck [= <i>Orgilus scabriculus</i> Nees]	Hymenoptera	Braconidae	parasitoid	Hagley & Barber (1992)
<i>Coleophora tiliaefoliella</i> Clemens (Lepidoptera: Coleophoridae)	<i>Gelis</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Scambus decorus</i> Walley		Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Scambus</i> sp.		Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Anaphes conotrachelii</i> Girault		Hymenoptera	Mymaridae	parasitoid	Huber (2006)
<i>Conotrachelus geminatus</i> LeConte (Coleoptera: Curculionidae)		Coleoptera	Coccinellidae	predator	Hagley (1979)
<i>Conotrachelus nemophar</i> (Herbst) (Coleoptera: Curculionidae)	<i>Hippodamia tredecimpunctata tibialis</i> (Say)	Hymenoptera	Ichneumonidae	hyperparasitoid	Griffiths (1980); Song (1990)
<i>Coresia melanoscela</i> (Raizeburg) [= <i>Apanteles melanoscelus</i> (Raizeburg)] (Hymenoptera: Braconidae)	<i>Baryscapus galactopus</i> (Raizeburg)	Hymenoptera	Eulophidae	hyperparasitoid	Carter & Laing (1997)
<i>Coresia rubecula</i> (Marshall) (Hymenoptera: Braconidae)	<i>Catolaccus</i> sp.	Hymenoptera	Pteromalidae	hyperparasitoid	Carter & Laing (1997)
<i>Craponius inaequalis</i> (Say) (Coleoptera: Curculionidae)	<i>Mesochorus vitator</i> (Zetterstedt)	Hymenoptera	Ichneumonidae	hyperparasitoid	Carter & Laing (1997)
<i>Culex annulirostris</i> Skuse (Diptera: Culicidae)	<i>Anaphes conotrachelii</i> Girault	Hymenoptera	Mymaridae	parasitoid	Huber (2006)
<i>Culex pipiens</i> L. (Diptera: Culicidae)	<i>Paraclelius germanus</i> Parent	Diptera	Dolichopodidae	predator	Laing & Welch (1963)
<i>Culex quinquefasciatus</i> Say (Diptera: Culicidae)	<i>Dugesia tigrina</i> (Girard)	Trichladida	Duegesiidae	predator	George (1979, 1984)
<i>Culex restuans</i> Theobald (Diptera: Culicidae)	<i>Paraclelius germanus</i> Parent	Diptera	Dolichopodidae	predator	Laing & Welch (1963)
<i>Cydia pomonella</i> (L.) [= <i>Carpocapsa pomonella</i> (L..)] (Lepidoptera: Tortricidae)	<i>Dugesia tigrina</i> (Girard)	Diptera	Dolichopodidae	predator	Laing & Welch (1963)
	<i>Agelema nivevia</i> Walkenaer	Trichladida	Duegesiidae	predator	George (1979, 1984)
		Araneae	Agelenidae	predator	Putnam (1963)
	<i>Anystis agilis</i> Banks	Trombidiformes	Anystidae	predator	Putnam (1963)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Ascochaster quadridentata</i> Wesmael [= <i>Ascochaster carpopcae</i> (Viereck)] <i>Bacillus cereus</i> Frankland & Frankland	Hymenoptera	Braconidae	parasitoid	Putnam (1963)	
<i>Beauniera bassiana</i> (Balsamo) Vuillemin		Bacillaceae	pathogen	Angus & Heimpel (1960); Putnam (1963)	
<i>Chrysopa carnea</i> Stephens [= <i>Chrysops plurabunda</i> Fitch]	Neuroptera	Moniliaceae	pathogen	Putnam (1963)	
<i>Chrysopa rufilabris</i> Burmeister		Chrysopidae	predator	Putnam (1963)	
<i>Crypsis albifarsis</i> (Cresson)	Neuroptera	Chrysopidae	predator	Putnam (1963)	
<i>Dendrocops pubescens</i> (L.)	Hymenoptera	Ichneumonidae	parasitoid	Putnam (1963)	
<i>Dendrocops villosus</i> (L.)	Piciformes	Picidae	predator	Putnam (1963)	
<i>Dibrachys microgaster</i> (Bouché) [= <i>Dibrachys cavus</i> (Walker) = <i>Dibrachys boucheanus</i> (Ratzeburg)]	Hymenoptera	Pteromalidae	parasitoid	Putnam (1963)	
<i>Elodina trigrica</i> (Meigen)	Diptera	Tachinidae	parasitoid	Putnam (1963)	
<i>Eupelmus cyaniceps</i> Ashmead	Hymenoptera	Eupelmidae	parasitoid	Putnam (1963)	
<i>Eurytoma</i> sp.	Hymenoptera	Eurytomidae	parasitoid	Putnam (1963)	
<i>Glypta</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Putnam (1963)	
<i>Haplothrips faurei</i> Hood	Thysanoptera	Phaenothripidae	predator	Putnam (1963)	
<i>Hirsutella strobilata</i> Petch		Ophiocordyphaceae	pathogen	Putnam (1963)	
<i>Hoplacryptus</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Putnam (1963)	
<i>Hyaliodes vitripennis</i> (Say)	Hemiptera	Miridae	predator	Putnam (1963)	
<i>Hymenochaonia delicata</i> (Cresson) [= <i>Macrocentrus delicatus</i> Cresson]	Hymenoptera	Braconidae	parasitoid	Putnam (1963)	
<i>Ioplectis conqueritor</i> (Say)	Hymenoptera				
<i>Leptothrips malii</i> (Fitch)	Thysanoptera	Phaenothripidae	parasitoid	Putnam (1963)	
<i>Liotryphon caudatus</i> (Ratzeburg) [= <i>Apistephiathes caudatus</i> (Ratzeburg)]	Hymenoptera	Ichneumonidae	parasitoid	Putnam (1963)	
<i>Macrocentrus ancylivora</i> Rohwer	Hymenoptera	Braconidae	parasitoid	Putnam (1963)	
<i>Macrocentrus instabilis</i> Muesebeck	Hymenoptera	Braconidae	parasitoid	Putnam (1963)	

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Mastrius carpopcae</i> (Cushman) [= <i>Aenophlex carpopcae</i> Cushman] <i>Mermis</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Putnam (1963)	
<i>Neoaplectana</i> n. sp. <i>Nippocryptius vittatorius</i> (Jurine) [= <i>Cryptus sexannulatus</i> Gravenhorst] <i>Nosema destructor</i> Steinhaus & Hughes	Mermithida Rhabditida Hymenoptera	Mermithidae Steinernematidae Ichneumonidae	parasite parasite parasitoid	Putnam (1963) Putnam (1963) Putnam (1963)	
<i>Panonychus ulmi</i> Koch <i>Phanerotoma fasciata</i> Provancher <i>Pimpla annulipes</i> Brullé [= <i>Pimpla inflata</i> Townes] <i>Plisiophora californica</i> Steinhaus & Hughes <i>Pristomerus vulnerator</i> (Panzer)	Trombidiformes Hymenoptera Hymenoptera	Tetranychidae Braconidae Ichneumonidae	pathogen predator parasitoid	Putnam (1963) Hagley (1979) Putnam (1963) Putnam (1963)	
<i>Scambus pterophori</i> Ashmead [= <i>Pimpla pierella</i> Auctorum] <i>Solenopsis molesta</i> (Say) <i>Temelucha minor</i> (Cushman) <i>Tenebroides corticalis</i> Melsheimer	Hymenoptera Hymenoptera Coleoptera	Ichneumonidae Ichneumonidae	parasitoid parasitoid	Putnam (1963) Putnam (1963)	
<i>Trichogramma minutum</i> Riley [= <i>Trichogramma emryophagum</i> Hertig] <i>Trichogramma pretiosum</i> Riley	Hymenoptera	Trogositidae Trichogrammatidae	predator parasitoid	Putnam (1963)	
<i>Trichogramma</i> sp. <i>Anaphes pallipes</i> (Ashmead)	Hymenoptera Hymenoptera	Trichogrammatidae Mymaridae	parasitoid parasitoid	Hagley (1987); Hagley & Laing (1989) Putnam (1963) Huber (2006)	
<i>Cylindrocopturus adspersus</i> (LeConte) (Coleoptera: Curculionidae)					

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Cylindrocypturus furnissi</i> Buchanan (Coleoptera: Curculionidae)	<i>Dinotiscus dendroctoni</i> (Ashmead)	Hymenoptera	Pteromalidae	parasitoid	Bright (1996)
<i>Dasyneura albiorbitata</i> Walsh (Diptera: Cecidomyiidae)	<i>Ceraphron</i> sp.	Hymenoptera	Ceraphronidae	parasitoid	Judd (1953)
	<i>Lepiacts</i> sp.	Hymenoptera	Platygastridae	parasitoid	Judd (1953)
	<i>Tetrastichus</i> sp.	Hymenoptera	Eulophidae	parasitoid	Judd (1953)
	<i>Torymus</i> sp.	Hymenoptera	Torymidae	parasitoid	Judd (1953)
<i>Delta antiqua</i> (Meigen) [= <i>Hylemya antiqua</i> Meigen] (Diptera: Anthomyiidae)	<i>Aleochara bilineata</i> Gyllenhal	Coleoptera	Staphylinidae	parasitoid	Whistlecraft & Lepard (1989)
	<i>Aphaereta pallipes</i> (Say)	Hymenoptera	Braconidae	parasitoid	Whitfield et al. (1981); Whistlecraft & Lepard (1989)
<i>Delta radicum</i> (L.) [= <i>Hylemya</i> <i>bassicae</i> L.] (Diptera: Anthomyiidae)	<i>Entomophthora muscae</i> (Cohn) Fresen <i>Heteromyzzenthus</i> sp.	Nematoda	Entomophthoraceae	pathogen	Ben-Zeev & Jaques (1990)
			Sphaerulariidae	parasite	Wright (1972)
	<i>Neaplectana</i> n. sp. (DD136)	Rhabditida	Steinernematidae	parasite	Welch & Briand (1961); Welch (1962)
<i>Delia</i> spp. [= <i>Hylemya</i> spp.] (Diptera: Anthomyiidae)	<i>Phygadeuon trichops</i> Thomson	Hymenoptera	Ichneumonidae	parasitoid	Maybee (1956)
	<i>Coeloides piassodis</i> (Ashmead)	Hymenoptera	Braconidae	parasitoid	Bright (1996)
<i>Dendroctonus frontalis</i> Zimmermann (Coleoptera: Curculionidae)	<i>Dinotiscus dendroctoni</i> (Ashmead)	Hymenoptera	Pteromalidae	parasitoid	Bright (1996)
<i>Dendroctonus</i> spp. (Coleoptera: Curculionidae)	<i>Agonum muelleri</i> (Herbst)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)
<i>Diabrotica barberi</i> R.F. Smith & Lawrence [= <i>Diabrotica</i> <i>longicornis</i> (Say)] (Coleoptera: Chrysomelidae)					
	<i>Amara arida</i> Say	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)
	<i>Amara</i> sp.	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)
	<i>Anisodactylus rusticus</i> (Say)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Anisodactylus sanctaecrucis</i> (Fabricius)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Bembidion quadrimaculatum opositum</i> Say	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Bembidion tetracolum</i> Say	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Bembidion versicolor</i> (LeConte)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Blethis discus</i> (Fabricius) [= <i>Lasiotrechus discus</i> Fabricius]	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Carabus nemoralis</i> Müller	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Chlytina fossor</i> (L.)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Colluris pensylvanica</i> L.	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Dyschirius</i> sp.	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Harpalus affinis</i> (Schrank)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Harpalus pensylvanicus</i> (DeGeer)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Harpalus pleuriticus</i> Kirby	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Notiophilus aquaticus</i> (L.)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Patrobus longicornis</i> (Say)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Poecilius lucublandus</i> (Say) [= <i>Pterostichus lucublandus</i> Say]	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Pterostichus melanarius</i> (Illiger)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Stenolophus comma</i> (Fabricius)	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Tachys</i> sp.	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Trechus apicalis</i> Motschulsky	Coleoptera	Carabidae	predator	Tyler & Ellis (1980)	
<i>Trechus melanarius</i> (Illiger)	Tylenchida	Allantonetomatidae	parasite	Briand (1960)	
<i>Diabrotica trifolia</i> (Mannerheim)	<i>Howardula beringia</i> Cobb	Hymenoptera	Mymaridae	Huber (1992)	
(Coleoptera: Chrysomelidae)					
<i>Dibolia borealis</i> Chevrolat					
(Coleoptera: Chrysomelidae)					
<i>Diprion hercyniae</i> (Hartig)					
(Hymenoptera: Diprionidae)					
<i>Drosophila melanogaster</i> Meigen	<i>Basalyss tritomus</i> Thomson [= <i>Loxotropa trioma</i> (Thomson)]	Hymenoptera	Diapriidae	Maybee (1956)	
(Diptera: Drosophilidae)					
<i>Zelus exsanguis</i> (Sahl)		Orthoptera	Mantidae	West & DeLong (1956)	

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Drosophila subobscura</i> Collin (Diptera: Drosophilidae)	<i>Parastylelachus diploegenus</i> Welch	Tylenchida	Allantonetematidae	parasite	Welch (1962)
<i>Elasmostylus lingosellus</i> (Zeller) (Lepidoptera: Pyralidae)	<i>Trachagathis rubricincta</i> (Ashmead)	Hymenoptera	Braconidae	parasitoid	Sharkey (2007)
<i>Empoasca fabae</i> Harris (Hemiptera: Cicadellidae)	<i>Anagrus armatus</i> (Ashmead)	Hymenoptera	Mymaridae	parasitoid	Appleton et al. (2004)
<i>Zoophthora radicans</i> (Brefeld) [= <i>Erynia radicans</i> (Brefeld)] Humber, Ben-Ze'ev & Kenneth	<i>Zoophthora radicans</i> (Brefeld) Batko [= <i>Erynia radicans</i> (Brefeld)]	Hymenoptera	Entomophthoraceae	pathogen	Ben-Ze'ev & Jaques (1990)
<i>Ephestia kuhniella</i> Zeller [= <i>Anagasta kuhniella</i> (Zeller)] (Lepidoptera: Pyralidae)	<i>Bacillus thuringiensis</i> Berliner serovar. <i>thuringiensis</i>	Hymenoptera	Bacillaceae	pathogen	Angus & Heimpel (1960)
<i>Trichogramma minutum</i> Riley	<i>Trichogramma</i> Riley	Hymenoptera	Trichogrammatidae	parasitoid	Hagley & Laing (1939); Corrigan & Laing (1992); Corrigan et al. (1994)
<i>Epiblema scudderiana</i> (Clemens) (Lepidoptera: Tortricidae)	<i>Apanteles cacoeciae</i> Riley [= <i>Dolichogenidea cacoeciae</i> Riley] <i>Bassus binominatus</i> (Muesebeck) [= <i>Agathis binominata</i> Muesebeck]	Hymenoptera	Trichogrammaidae	parasitoid	Hagley & Laing (1989)
<i>Macrocentrus pallisteri</i> DeGant	<i>Macrocentrus pallisteri</i> DeGant	Hymenoptera	Braconidae	parasitoid	Laing & Heraty (1982)
<i>Perilampus fulvicornis</i> Ashmead	<i>Perilampus fulvicornis</i> Ashmead	Hymenoptera	Perilampidae	hyperparasitoid	Laing & Heraty (1982)
<i>Scambus pierophori</i> Asmead	<i>Scambus pierophori</i> Asmead	Hymenoptera	Ichnionomidae	parasitoid	Laing & Heraty (1982)
<i>Glypta rufiscutellaris</i> Cresson	<i>Glypta rufiscutellaris</i> Cresson	Hymenoptera	Ichnionomidae	parasitoid	Boyce & Dustan (1954)
<i>Epiblema strenuana</i> (Walker) (Lepidoptera: Tortricidae)	<i>Apanteles cacoeciae</i> Riley [= <i>Dolichogenidea cacoeciae</i> Riley]	Hymenoptera	Braconidae	parasitoid	Laing & Heraty (1982)
<i>Epinotia</i> sp. (Lepidoptera: Tortricidae)	<i>Apanteles cacoeciae</i> Riley [= <i>Dolichogenidea cacoeciae</i> Riley]	Hymenoptera	Aphelinidae	parasitoid	Hagley & Laing (1989)
<i>Erioxoma lanigerum</i> (Haussmann) (Hemiptera: Aphididae)	<i>Aphelinus mali</i> Haldeman	Hymenoptera	Coccoptidae	phytophage	LeSage (1996a)
<i>Euphorbia esula</i> L. (Euphorbiaceae)	<i>Aphthona czwalinae</i> Weisse	Coleoptera	Chrysomelidae	phytophage	LeSage (1996a)
	<i>Aphthona flava</i> Guillebeau	Coleoptera	Chrysomelidae	phytophage	LeSage (1996a)

## APPENDIX A continued...

<b>Host</b>	<b>Natural enemy</b>	<b>Order</b>	<b>Family</b>	<b>Feeding niche</b>	<b>Reference</b>
<i>Eurosta solidaginis</i> (Fitch) (Diptera: Tephritidae)	<i>Aphthona nigricutis</i> Foudras <i>Eurytoma obtusiventris</i> Gahan	Coleoptera Hymenoptera	Chrysomelidae Eurytomidae	phytophage parasitoid	LeSage (1996a) Ramey (1990)
<i>Exaireta</i> sp. (Lepidoptera: Tortricidae)	<i>Apaneles cacoeciae</i> Riley [= <i>Dolichogenidea cacoeciae</i> Riley] <i>Trichomalopsis viridescens</i> (Walsh)	Hymenoptera	Braconidae	parasitoid	Laing & Heraty (1982)
<i>Exeristes constockii</i> (Cresson) (Diptera: Tachinidae)		Hymenoptera	Pteromalidae	parasitoid	Murillo et al. (2012)
<i>Frankliniella occidentalis</i> (Pergande) (Thysanoptera: Thripidae)	<i>Neoseiulus cucumeris</i> (Oudemans) [= <i>Amblyseius cucumeris</i> (Oudemans)]	Mesostigmata	Phytoseiidae	predator	Jones et al. (2006)
<i>Gerris</i> sp. (Hemiptera: Gerridae)	<i>Anaphes gerrisophaga</i> (Doutt)	Hymenoptera	Mymaridae	parasitoid	Huber (2006)
<i>Gnorimoschema gallaesolidaginis</i> (Riley) (Lepidoptera: Gelechiidae)	<i>Apaneles cacoeciae</i> Riley [= <i>Dolichogenidea cacoeciae</i> Riley]	Hymenoptera	Braconidae	parasitoid	Laing & Heraty (1982)
<i>Gorytes costalis</i> Cresson [= <i>Psammeictus costalis</i> (Cresson)] (Hymenoptera: Crabronidae)	<i>Elampus viridicyaneus</i> Norton	Hymenoptera	Chrysidae	parasitoid	Huber & Pengelly (1977)
<i>Grapholita molesta</i> (Busck) [= <i>Grapholita molesta</i> (Busck)] (Lepidoptera: Tortricidae)	<i>Enyptis obliteratus</i> (Cresson) [= <i>Diadegma</i> <i>obliteratum</i> (Cresson)]	Hymenoptera	Ichneumonidae	parasitoid	Boyce & Dunstan (1954); Dunstan & Boyce (1966)
<i>Hymenochaonia delicata</i> (Cresson) [= <i>Macrocentrus delicatus</i> Cresson]	<i>Glypta rufiscutellaris</i> Cresson	Hymenoptera	Ichneumonidae	parasitoid	Boyce & Dunstan (1954); Dustan & Boyce (1966)
<i>Macrocentrus ancylivora</i> Rohwer		Hymenoptera	Braconidae	parasitoid	Boyce & Dunstan (1954); Dustan & Boyce (1966)
grasshoppers (Orthoptera: Acridae)	<i>Temelucha minor</i> (Cushman) [= <i>Cremastus</i> <i>minor</i> Cushman] <i>Trichogramma minutum</i> Riley <i>Pseudaomonas aeruginosa</i> (Schroeter) Migula	Hymenoptera	Ichneumonidae Trichogrammatidae Bacillaceae	parasitoid parasitoid pathogen	Philips (1969); Boyce & Dunstan (1954); Dustan & Boyce (1966); Hagley (1987) Angus & Heimpel (1960)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Hedya chionosoma</i> (Zeller) (Lepidoptera: Tortricidae)	<i>Macrocentrus nigridorsis</i> Viebeck	Hymenoptera	Braconidae	parasitoid	Hagley & Barber (1992)
<i>Hedya nubiferana</i> (Haworth) (Lepidoptera: Tortricidae)	<i>Cotesia acanda</i> (Provancher) [= <i>Cotesia acaudus</i> Provancher]	Hymenoptera	Braconidae	parasitoid	Hagley & Barber (1992)
<i>Heliothis</i> spp. (Lepidoptera: Noctuidae)	<i>Trichogramma pretiosum</i> Riley	Hymenoptera	Trichogrammatidae	parasitoid	Hagley & Laing (1989)
<i>Helioverpa virescens</i> (Fabricius) [= <i>Heliothis virescens</i> (Fabricius)]	<i>Neoaplectana</i> n. sp. (DD136)	Rhabditida	Steinernematidae	parasite	Welch (1962)
<i>Hyalopsocus striatus</i> (Walker) (Psocoptera: Psocidae)	<i>Leiophron</i> ( <i>Euphorriella</i> ) <i>criddlei</i> (Loan & New) [= <i>Euphorriella criddlei</i> Loan & New]	Hymenoptera	Braconidae	parasitoid	Loan & New (1972)
<i>Leiophron fousi</i> (Loan & New) [= <i>Euphorriella fousi</i> Loan & New]	<i>Leiophron</i> ( <i>Euphorriella</i> ) <i>hyalopsocidis</i> (Loan & New)	Hymenoptera	Braconidae	parasitoid	Loan & New (1972)
<i>Leiophron incerta</i> (Ashmead) [= <i>Euphorriella incerta</i> Ashmead]	<i>Leiophron</i> ( <i>Euphorriella</i> ) <i>kaladarensis</i> (Loan & New)	Hymenoptera	Braconidae	parasitoid	Loan & New (1972)
<i>Leiophron nixoni</i> (Loan & New) [= <i>Euphorriella nixoni</i> Loan & New]	<i>Leiophron</i> ( <i>Euphorriella</i> ) <i>pacificica</i> (Muesebeck)	Hymenoptera	Braconidae	parasitoid	Loan & New (1972)
<i>Leiophron pallidifacia</i> (Loan & New) [= <i>Euphorriella pallidifacia</i> Loan & New]	<i>Leiophron</i> ( <i>Euphorriella</i> ) <i>solidaginis</i> (Loan & New)	Hymenoptera	Braconidae	parasitoid	Loan & New (1972)
<i>Leiophron sommermannae</i> (Muesebeck) [= <i>Euphorriella sommermannae</i> Muesebeck]	<i>Camptoleitis</i> sp.	Hymenoptera	Braconidae	parasitoid	West et al. (1984)
<i>Hydractcia micacea</i> (Esper) (Lepidoptera: Noctuidae)	<i>Centrodora</i> near <i>locustrum</i> Girault <i>Diadegma</i> sp.	Hymenoptera	Aphelinidae	parasitoid	West et al. (1984)
		Hymenoptera	Ichnaeumonidae	parasitoid	West et al. (1984)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Epirus</i> sp.	Hymenoptera		Ichneumonidae	parasitoid	West et al. (1984)
<i>Exephanes occupator</i> Gravenhorst	Hymenoptera		Ichneumonidae	parasitoid	West et al. (1984)
<i>Glypta</i> sp.	Hymenoptera		Ichneumonidae	parasitoid	West et al. (1984)
<i>Lydella radicis</i> (Townsend)	Diptera	Tachinidae	parasitoid	West et al. (1984)	
<i>Lydella stabulans</i> (Meigen)	Diptera	Tachinidae	parasitoid	West et al. (1984)	
<i>Macrocentrus blandus</i> Eady & Clark	Hymenoptera	Braconidae	parasitoid	West et al. (1984)	
<i>Macrocentrus infirmus</i> (Nees)	Hymenoptera	Braconidae	parasitoid	West et al. (1984)	
<i>Pterocormus</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	West et al. (1984)	
<i>Telenomus</i> sp.	Hymenoptera	Scionidae	parasitoid	West et al. (1984)	
<i>Therion</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	West et al. (1984)	
<i>Trichogramma retorridum</i> (Girault)	Hymenoptera	Trichogrammaidae	parasitoid	West et al. (1984)	
<i>Hypera brunneipennis</i> (Bohemian)	<i>Anaphes luna</i> (Girault)	Hymenoptera	Myrmariidae	parasitoid	Huber (2006)
(Coleoptera: Curculionidae)					
<i>Hypera compta</i> (Say)	<i>Anaphes nigrellus</i> Girault	Hymenoptera	Myrmariidae	parasitoid	Huber (1992)
(Coleoptera: Curculionidae)					
<i>Hypera crinitus</i> (Bohemian)	<i>Anaphes luna</i> (Girault)	Hymenoptera	Myrmariidae	parasitoid	Huber (2006)
[= <i>Donus crinitus</i> Bochman]					
(Coleoptera: Curculionidae)					
<i>Hypera extimia</i> (LeConte)	<i>Anaphes luna</i> (Girault)	Hymenoptera	Myrmariidae	parasitoid	Huber (2006)
(Coleoptera: Curculionidae)					
<i>Hypera nigrirostris</i> (Fabricius)	<i>Anaphes nigrellus</i> Girault	Hymenoptera	Myrmariidae	parasitoid	Huber (1992)
(Coleoptera: Curculionidae)					
<i>Hypera palpaticola</i> Warner	<i>Anaphes conotrachelii</i> Girault	Hymenoptera	Myrmariidae	parasitoid	Huber (2006)
(Coleoptera: Curculionidae)					
<i>Hypera postica</i> (Gyllenahl)	<i>Anaphes nigrellus</i> Girault	Hymenoptera	Myrmariidae	parasitoid	Huber (1992)
(Coleoptera: Curculionidae)					
<i>Anaphes fuscipennis</i> Haliday	Hymenoptera	Myrmariidae	parasitoid	Huber (1992)	
<i>Anaphes luna</i> (Girault)	Hymenoptera	Myrmariidae	parasitoid	Huber (2006)	
<i>Anaphes nigrellus</i> Girault	Hymenoptera	Myrmariidae	parasitoid	Huber (1992)	
<i>Bathyplectes anurus</i> (Thomson)	Hymenoptera	Ichneumonidae	parasitoid	Harcourt & Ellis (1992)	
<i>Bathyplectes curculionis</i> (Thomson)	Hymenoptera	Ichneumonidae	parasitoid	Abu & Ellis (1976); Harcourt & Ellis (1992)	

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Hypera punctata</i> (Fabricius) (Coleoptera: Curculionidae)	<i>Beauveria bassiana</i> (Balsamo) Vuillemin	Moniliaceae	pathogen	Ben-Zeev & Jaques (1990)	
<i>Entomophthora</i> ( <i>Tarichium</i> ) <i>punctata</i> Garbowksi		Entomophthoraceae	pathogen	Ben-Zeev & Jaques (1990)	
<i>Entomophthora phytonomi</i> Arthur		Entomophthoraceae	pathogen	Harcourt et al. (1980)	
<i>Erynia phytonomi</i> (Arthur) Humber, Ben-Zeev & Kenneth		Entomophthoraceae	pathogen	Ben-Zeev & Jaques (1990)	
<i>Erynia</i> sp.		Entomophthoraceae	pathogen	Ben-Zeev & Jaques (1990)	
<i>Perilissus aethiops</i> Nees [= <i>Microctonus</i> <i>aethiopoides</i> ] Loan	Hymenoptera	Braconidae	parasitoid	Harcourt et al. (1980; 1982); Loan (1982)	
<i>Perilissus colesi</i> (Drea) [= <i>Microctonus</i> <i>colesi</i> ] Drea	Hymenoptera	Braconidae	parasitoid	Harcourt et al. (1982); Loan (1982)	
<i>Tarichium phytonomi</i> Jacewski		Entomophthoraceae	pathogen	Ben-Zeev & Jaques (1990)	
<i>Zoophthora phytonomi</i> (Arthur) Batko		Entomophthoraceae	pathogen	Harcourt & Ellis (1992)	
<i>Zoophthora</i> spp.		Entomophthoraceae	pathogen	Loan (1982)	
<i>Anaphes fuscipennis</i> Haliday	Hymenoptera	Myrmidae	parasitoid	Huber (1992)	
<i>Anaphes luna</i> Girault	Hymenoptera	Myrmidae	parasitoid	Huber (2006)	
<i>Anaphes luna</i> Girault	Hymenoptera	Myrmidae	parasitoid	Huber (2006)	
<i>Hypera trilineata</i> Marsham (Coleoptera: Curculionidae)	<i>Anaphes luna</i> (Girault)	Myrmidae	parasitoid	Huber (2006)	
<i>Hypera variabilis</i> Herbst (Coleoptera: Curculionidae)	<i>Anaphes luna</i> (Girault)	Myrmidae	parasitoid	Huber (2006)	
<i>Hypera zoilii</i> Scopoli (Coleoptera: Curculionidae)	<i>Anaphes luna</i> (Girault)	Myrmidae	parasitoid	Huber (2006)	
<i>Hypericum perforatum</i> L. ( <i>Hypericaceae</i> )	<i>Chrysotina hyperici</i> (Förster)	Chrysomelidae	phytophage	LeSage (1996b)	
<i>Hyraecia petasitis</i> Doubleday (Lepidoptera: Noctuidae)	<i>Macrocentrus blandus</i> Eady & Clark	Braconidae	parasitoid	West et al. (1984)	
<i>Ips calligraphis</i> (Germar) (Coleoptera: Curculionidae)	<i>Coeloides pissodis</i> (Ashmead)	Braconidae	parasitoid	Bright (1996)	
<i>Ips grandicollis</i> (Eichhoff) (Coleoptera: Curculionidae)	<i>Coeloides pissodis</i> (Ashmead)	Braconidae	parasitoid	Bright (1996)	
<i>Ips pini</i> (Say) (Coleoptera: Curculionidae)	<i>Rhopalicus tutela</i> (Walker)	Hymenoptera	Pteromalidae	Bright (1996)	

## APPENDIX A continued..

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Ips</i> spp. (Coleoptera: Curculionidae)	<i>Dinotiscus dendroconii</i> (Ashmead)	Hymenoptera	Pteromalidae	parasitoid	Bright (1996)
<i>Labops hirtus</i> Knight (Hemiptera: Miridae)	<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis) – <i>Leiophron pallipes</i> Curtis]	Hymenoptera	Braconidae	parasitoid	Loan (1965)
<i>Lasius neoniger</i> Emery (Hymeoptera: Formicidae)	<i>Pseudometagea schwarzii</i> (Ashmead)	Hymenoptera	Eucharitidae	parasitoid	Heraty (1985)
<i>Lasius</i> sp. (Hymenoptera: Formicidae)	<i>Pseudometagea schwarzii</i> (Ashmead)	Hymenoptera	Eucharitidae	parasitoid	Heraty (1985)
<i>Lebia vittata</i> (Fabricius) [= <i>Diabrotica vittata</i> (Fabricius)] (Coleoptera: Chrysomelidae)	<i>Howardula benning Cobb</i>	Tylenchida	Allantonematidae	parasite	Briand (1960)
<i>Lema cyanella</i> (L.) (Coleoptera: Chrysomelidae)	<i>Anaphes flavipes</i> (Forster)	Hymenoptera	Mymaridae	parasitoid	Huber (1992)
<i>Lema lichenis</i> Voet (Coleoptera: Chrysomelidae)	<i>Anaphes flavipes</i> (Forster)	Hymenoptera	Mymaridae	parasitoid	Huber (1992)
<i>Lema trilineata</i> (Olivier) (Coleoptera: Chrysomelidae)	<i>Anaphes flavipes</i> (Forster)	Hymenoptera	Mymaridae	parasitoid	Huber (1993)
<i>Lema trivittata trivittata</i> (Say) [= <i>Lema trilineata trivittata</i> (Say)] (Coleoptera: Chrysomelidae)	<i>Anaphes flavipes</i> (Forster)	Hymenoptera	Mymaridae	parasitoid	Huber (1994)
<i>Lepinotarsa decemlineata</i> (Say) (Coleoptera: Chrysomelidae)	<i>Bacillus thuringiensis</i> Berliner	Bacillaceae	pathogen	Stewart et al. (1992)	
<i>Horismenus putteri</i> (Grissell) [= <i>Edovum putteri</i> Grissell]	<i>Horismenus putteri</i> (Grissell) [= <i>Edovum putteri</i> Grissell]	Hymenoptera	Eulophidae	parasitoid	Corrigan et al. (1990)
<i>Neoplectana chresima</i> Steiner		Rhabditida	Steinernematidae	parasite	Welch (1958)
<i>Neoplectana</i> n. sp. (DD136)		Rhabditida	Steinernematidae	parasite	Welch & Briand (1961); Welch (1962)
<i>Leptopterna dolabrata</i> (L.) (Hemiptera: Miridae)	<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis) = <i>Leiophron pallipes</i> Curtis]	Hymenoptera	Braconidae	parasitoid	Loan (1965)
<i>Leptopterna dolabrata</i> (L.) (Hemiptera: Miridae)	<i>Anaphes gerrisophaga</i> (Doutt)	Hymenoptera	Mymaridae	parasitoid	Huber (2006)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Lioleius nitidus</i> (Motschulsky) (Coleoptera: Byrridae)	<i>Anaphes byrrhidiphagus</i> Huber	Hymenoptera	Mymaridae	parasitoid	Huber (1992)
<i>Lioon simplicipes</i> (Mannheim) (Coleoptera: Byrridae)	<i>Anaphes byrrhidiphagus</i> Huber	Hymenoptera	Mymaridae	parasitoid	Huber (1992)
<i>Liriomyza sativae</i> Blanchard (Diptera: Agromyzidae)	<i>Diglyphus intermedius</i> (Girault)	Hymenoptera	Eulophidae	parasitoid	Coote & Ellis (1987b)
<i>Liriomyza trifoliaeum</i> Spencer [= <i>Liriomyza trifolium</i> Spencer] (Diptera: Agromyzidae)	<i>Diglyphus intermedius</i> (Girault)	Hymenoptera	Eulophidae	parasitoid	Coote & Ellis (1987b)
<i>Listronotus oreensis</i> (LeConte) (Coleoptera: Curculionidae)	<i>Anaphes conotrachelii</i> Girault	Hymenoptera	Mymaridae	parasitoid	Huber (2006)
<i>Lycus hepenus</i> Knight (Hemiptera: Miridae)	<i>Geocoris pallens</i> Ståhl	Hemiptera	Geocoridae	predator	Mason et al. (2011)
<i>Geocoris punctipes</i> (Say)	<i>Geocoris punctipes</i> (Say)	Hemiptera	Geocoridae	predator	Mason et al. (2011)
<i>Nabis alternans</i> Parshley	<i>Nabis alternans</i> Parshley	Hemiptera	Nabidae	predator	Mason et al. (2011)
<i>Nabis americoferus</i> (Carayon)	<i>Nabis americoferus</i> (Carayon)	Hemiptera	Nabidae	predator	Mason et al. (2011)
<i>Orius tristiscolor</i> (White)	<i>Orius tristiscolor</i> (White)	Hemiptera	Anthocoridae	predator	Mason et al. (2011)
<i>Leiophron pseudopalipes</i> Loan [= <i>Peristenus pseudopalipes</i> Loan]	<i>Leiophron pseudopalipes</i> (Loan)	Hymenoptera	Braconidae	parasitoid	Broadbent et al. (1999); Mason et al. (2011)
<i>Leiophron dayi</i> (Goulet) [= <i>Peristenus dayi</i> Hymenoptera Goulet]	<i>Leiophron dayi</i> (Goulet) [= <i>Peristenus dayi</i> Hymenoptera Goulet]	Hymenoptera	Braconidae	parasitoid	Broadbent et al. (1999); Mason et al. (2011)
<i>Leiophron digoneutis</i> (Loan) [= <i>Peristenus digoneutis</i> Loan]	<i>Leiophron digoneutis</i> (Loan) [= <i>Peristenus digoneutis</i> Loan]	Hymenoptera	Braconidae	parasitoid	Broadbent et al. (1999); Mason et al. (2011)
<i>Leiophron hygivora</i> (Loan)	<i>Leiophron hygivora</i> (Loan)	Hymenoptera	Braconidae	parasitoid	Loan (1965); Broadbent et al. (1999); Mason et al. (2011)
<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis)]	<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis)]	Hymenoptera	Braconidae	parasitoid	Broadbent et al. (1999); Mason et al. (2011)
<i>Leiophron rubricollis</i> (Thomson) [= <i>Peristenus rubricollis</i> (Thomson)]	<i>Leiophron rubricollis</i> (Thomson) [= <i>Peristenus rubricollis</i> (Thomson)]	Hymenoptera	Braconidae	parasitoid	Broadbent et al. (1999)
<i>Peristenus conradi</i> Marsh					
<i>Leiophron uniformis</i> (Gahan)					

APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Lygus</i> spp. (Hemiptera: Miridae)	<i>Anaphes iole</i> Girault	Hymenoptera	Mymaridae	parasitoid	Huber (1992)
	<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>Peristenus pallipes</i> (Curtis) = <i>Leiophron</i> <i>pallipes</i> Curtis]	Hymenoptera	Bracidae	parasitoid	Loan (1965)
	<i>Bacillus thuringiensis</i> Berliner serovar. <i>kurstaki</i>	Bacillaceae		pathogen	Cunningham et al. (1996a; b)
<i>Lymantria dispar</i> (L.) [= <i>Porteria dispar</i> L.]	<i>Ceranthis samarensis</i> (Villeneuve) <i>Compsilura concinna</i> (Meigen) <i>Coesia melanoscela</i> (Ratzeburg) <i>Coesia melanoscela</i> (Ratzeburg) [= <i>Apanteles melanoscelus</i> (Ratzeburg)] <i>Ooencyrtus kuvanae</i> (Howard) <i>Parasetigena agilis</i> (Robineau-Desvoidy) <i>Pimpla pedalis</i> Cresson <i>Pleistophora schubergi</i> Zwölfer <i>Lythrum salicaria</i> L. ( <i>Iythraceae</i> ) [= <i>Galerucella calmariensis</i> (L.)] [= <i>Galerucella calmariensis</i> (L.)] <i>Macrocentrus</i> spp. (Hymenoptera: Eupelmidae)	Diptera Diptera Hymenoptera Hymenoptera Hymenoptera Hymenoptera Diptera Hymenoptera Coleoptera Hymenoptera	Tachinidae Tachinidae Bracidae Bracidae Eurytidae Tachinidae Ichneumonidae Pleistophoridae Chrysomelidae Eupelmidae	parasitoid parasitoid parasitoid parasitoid parasitoid parasitoid parasitoid parasitoid pathogen hyperparasitoid	Neal & Quendau (1996) Griffiths (1977) Neals & Bourchier (1995) Griffiths (1976) Hagley & Laing (1989) Griffiths (1978) Griffiths (1979) Wilson (1985a) Corrigan et al. (1998) Putnam (1963)
(Lepidoptera: Erebidae)	<i>Epigonotopus plexius</i> Fenton	Hymenoptera	Dryinidae	parasitoid	Miller & De Lyzer (1960)
	<i>Aletiodes malacosomatus</i> (Mason) [= <i>Rogas malacosomatos</i> Mason] <i>Bacillus thuringiensis</i> Berliner	Hymenoptera	Bracidae	parasitoid	Harmsen & Rose (1984)
	<i>Noctema dissiriae</i> Thompson	Hymenoptera	Nosematidae	pathogen	Angus (1965)
	<i>Phobocampe clisiocampae</i> (Weed)		Ichneumonidae	pathogen	Wilson (1980)
	<i>Vairimorpha necatrix</i> (Kramer)		Dissociodiaphlo- phasida	parasitoid	Harmsen & Rose (1984)
	<i>Zelus exsanguis</i> (Stål)		Orthoptera	pathogen	Wilson (1987)
					predator
					Mantidae

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Marmara fraxinicola</i> Braun (Lepidoptera: Gracillariidae)	<i>Ageniaspis bicoloripes</i> (Girault) [= <i>Paraleurocerus bicoloripes</i> Girault]	Hymenoptera	Encyrtidae	parasitoid	Wang & Laing (1989)
<i>Melolontha</i> spp. (Coleoptera: Scarabaeidae)	nematoide	Nematoda		parasite	Welch (1962)
<i>Meteorus hyphantriae</i> Riley [= <i>Meteorus hyphantriae</i> Riley] (Hymenoptera: Ichneumonidae)	<i>Gelis</i> sp.	Hymenoptera	Ichneumonidae	hyperparasitoid	Pengelly (1961)
<i>Morellia horrorum</i> (Fallen) (Diptera: Muscidae)	<i>Heterotylencus</i> sp.	Nematoda	Sphaerulariidae	parasite	Wright (1972)
<i>Musca autumnalis</i> DeGeer (Diptera: Muscidae)	<i>Heterotylencus autumnalis</i> Nickle	Nematoda	Sphaerulariidae	parasite	Gregory & Wright (1973); Wright (1972)
<i>Musca velutissima</i> Walker (Diptera: Muscidae)	<i>Entomophthora</i> sp.	Nematoda	Entomophthoraceae	pathogen	Gregory & Wright (1973)
<i>Mythima unipuncta</i> (Haworth) [= <i>Pseudaleitia unipuncta</i> (Haworth)] (Lepidoptera: Noctuidae)	<i>Heterotylencus</i> sp. <i>Apanteles</i> sp.	Hymenoptera	Sphaerulariidae	parasite	Wright (1972)
<i>Myzus persicae</i> (Sulzer) (Homoptera: Aphididae)			Braconidae	parasitoid	Goble (1965)
<i>Nabis capsiformis</i> Germar [= <i>Reduviulus capsiformis</i> (German); <i>Reduviulus blackburni</i> (Kirikaldy)] (Hemiptera: Nabidae)	<i>Stephanodes reduviioli</i> (Perkins)	Hymenoptera	Baculoviridae	disease	Goble (1965)
<i>Neodiprion lecontei</i> (Fitch) (Hymenoptera: Diprionidae)		Diptera	Tachinidae	parasitoid	Goble (1965)
<i>Neodiprion pratti banksianae</i> Rohwer [= <i>Neodiprion banksiana</i> (Hymenoptera: Diprionidae)]			Entomophthoraceae	pathogen	Ben-Ze'ev & Jaques (1990)
<i>Neodiprion sertifer</i> (Geoffroy) (Hymenoptera: Diprionidae)			Mymaridae	parasitoid	Huber & Fildago (1997)
<i>Lecontivirus (redheaded pine sawfly, NPV)</i>					Cunningham et al. (1987)
<i>polyhedrosis virus</i>					
<i>Pleolophus basizonus</i> (Gravenhorst) <i>polyhedrosis virus</i>		Hymenoptera	Baculoviridae	pathogen	Griffiths (1972)
					Cameron (1969)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Notoxus anchora</i> Hentz (Coleoptera: Anthicidae)	<i>polyhedrosis virus NPV</i> <i>Cenitites agilis</i> (Cresson) [= <i>Syrrhizus agilis</i> (Cresson)]	Hymenoptera	<i>Baculoviridae</i> Braconidae	pathogen parasitoid	Bird et al. (1973) Loan (1973)
<i>Nycteola cinereana</i> Neumoegen & Dyar [= <i>Sarrorthripus cinereana</i> Neumoegen & Dyar]	<i>Bacillus thuringiensis</i> Berliner	Bacillaceae		pathogen	Angus (1965)
(Lepidoptera: Nolidae)					
<i>Nymphalis antiopa</i> (L.)	<i>Bacillus thuringiensis</i> Berliner	Bacillaceae		pathogen	Angus (1965)
(Lepidoptera: Nymphalidae)					
<i>Orocrambus simplex</i> Butler	<i>Neoaplectana leucaniae</i> Hoy	Rhabditida	Steinernematidae	parasite	Welch (1962)
[= <i>Crambus simplex</i> Butler]					
(Lepidoptera: Crambidae)					
<i>Oryctes rhinoceros</i> (L.)	<i>Neoaplectana glaseri</i> Steiner	Rhabditida	Steinernematidae	parasite	Welch (1962)
(Coleoptera: Scarabaeidae)					
<i>Oscinella frut</i> (L.) (Diptera: Chloropidae)	<i>Basalia tritomus</i> (Thomson) [= <i>Loxotropa tritoma</i> (Thomson)]	Hymenoptera	Dipriidae	parasitoid	Maybee (1956)
<i>Ostrinia nubilalis</i> (Hübner)	<i>Autographa californica NPV</i> (ACNPV)		<i>Baculoviridae</i>	pathogen	Laing & Jacques (1985)
(Lepidoptera: Crambidae)					
<i>Bacillus thuringiensis</i> Berliner		Bacillaceae		pathogen	Laing & Jacques (1985)
<i>Neoaplectana</i> n. sp. (DD136)	Rhabditida	Steinernematidae	parasite	Welch & Briand (1961); Welch (1962); Wilson (1985a)	
<i>Nosema heliothisidis</i> Lutz & Splendor		Nosematidae		pathogen	Laing & Jacques (1985)
<i>Nosema pyrausta</i> (Paillot)		Nosematidae		pathogen	Laing & Jacques (1985)
<i>Vairimorpha necatrix</i> (Kramer)		Nosematidae		pathogen	Laing & Jacques (1985)
<i>Anaphes flavipes</i> (Forster)	Hymenoptera	Mymaridae		parasitoid	Huber (1992)
<i>Oulema collaris</i> (Say)		Mymaridae		parasitoid	Huber (1992)
(Coleoptera: Chrysomelidae)					
<i>Oulema galloaeciana</i> (Heydon)	<i>Anaphes flavipes</i> (Forster)	Hymenoptera			
(Coleoptera: Chrysomelidae)					
<i>Oulema melanopus</i> (L.)	<i>Anaphes flavipes</i> (Forster)	Hymenoptera	Mymaridae	parasitoid	Ellis et al. (1989); Huber (1992)
(Coleoptera: Chrysomelidae)					
<i>Pandemis</i> sp. (Lepidoptera: Tortricidae)	<i>Tetrastichus julis</i> (Walker)	Hymenoptera	Eulophidae	parasitoid	Ellis et al. (1979; 1989)
	<i>Triclistus</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
		Coleoptera	Coccinellidae		Hagley (1979)
<i>Panonychus ulmi</i> (Koch) [= <i>Metatetranychus ulmi</i> (Koch)] (Trombidiformes: Tetranychidae)	<i>Adalia bipunctata</i> (L.)				
<i>Amblyseius</i> spp.		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Balaustium putnami</i> Smiley		Trombidiformes	Erythraeidae	predator	Cadogan & Laing (1982)
<i>Balaustium</i> sp.		Trombidiformes	Erythraeidae	predator	Woolhouse & Hammes (1985)
<i>Neoseiulus cucumeris</i> (Oudemans) [= <i>Typhlodromus cucumeris</i> Oudemans]		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Neoseiulus fallacis</i> (Garman) [= <i>Typhlodromus fallacis</i> (Garman)]		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Phyoseiulus macropilis</i> (Banks)		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus bakeri</i> (Garman) [= <i>Typhlodromus (Neoseiulus) bakeri</i> (Garman)]		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus caudiglans</i> (Schuster)		Mesostigmata	Phytoseiidae	predator	Clements (1989)
<i>Typhlodromus conspicuus</i> (Garman)		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus conspicuus</i> var. <i>herbertae</i> Nesbitt		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus finlandicus</i> (Oudemans) [= <i>Typhlodromus finlandicus</i> Oudemans]		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus longipilus</i> Nesbitt		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus maseei</i> (Nesbitt) [= <i>Typhlodromus maseei</i> (Nesbitt)]		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus pomii</i> (Parrott, Hodges & Shoene) [= <i>Typhlodromus pomii</i> (Parrott) Garman]		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus rhenanus</i> (Oudemans) [= <i>Typhlodromus (Neoseiulus) rhenanus</i> Oudemans]		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus tiliae</i> Oudemans		Mesostigmata	Phytoseiidae	predator	Herbert (1953)
<i>Typhlodromus tiliarum</i> (Garman)		Trombidiformes	Sigmaidae	predator	Clements (1989)
<i>Zeuzella mali</i> (Ewing)					

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Pentiplaneta americana</i> (L.) (Orthoptera: Blattidae)	<i>Melitobia chalybeii</i> Ashmead	Hymenoptera	Eulophidae	parasitoid	Edwards & Pengelly (1966)
<i>Philaenus spumarius</i> (L.) (Hemiptera: Cercopidae)	<i>Erynia petchii</i> (Ben-Ze'ev & Kenneth)		Entomophthoraceae	pathogen	Ben-Ze'ev & Jaques (1990)
<i>Phthorimaea operculella</i> (Zeller) (Lepidoptera: Gelechiidae)	<i>Ooconus vulgaris</i> Haliday	Hymenoptera	Myrmidae	parasitoid	Huber (2012)
<i>Phthorimaea operculella</i> (Zeller) (Lepidoptera: Gelechiidae)	<i>Chelonus kelleiae</i> Marsh	Hymenoptera	Braconidae	parasitoid	Wang & Laing (1989)
<i>Phyllonorycter blancardella</i> (Fabricius) [= <i>Lithocollotis</i> <i>blancardella</i> Fabricius] (Lepidoptera: Gracillariidae)	<i>Chelonus phthorimaeae</i> Gahan	Hymenoptera	Braconidae	parasitoid	Wang & Laing (1989)
<i>Phyllonorycter blancardella</i> (Fabricius) [= <i>Lithocollotis</i> <i>blancardella</i> Fabricius] (Lepidoptera: Gracillariidae)	<i>Achrysocharoides</i> sp. [= <i>Enayema</i> sp.]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)
<i>Ageniaspis testaceipes</i> (Ratzeburg) [= <i>Holcothorax testaceipes</i> (Ratzeburg)]	Hymenoptera	Encyrtidae	parasitoid	Wang & Laing (1989)	
<i>Baryscapus nigroviolescens</i> (Nees) [= <i>Tetrasichus amethystinus</i> (Ratzeburg)]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Chrysoscharis nepterus</i> (Walker) [= <i>Chrysoscharis cupidogaster</i> Yoshimoto]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Chrysoscharis pubens</i> Delucchi	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Cirrospilus elegantissimus</i> Westwood	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Cirrospilus lynceus</i> Walker [= <i>Atoposomaidea lynceus</i> Walker]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Cirrospilus lynceus</i> Walker [= <i>Atoposomaidea unifasciata</i> (Förster)]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Closterocerus</i> sp.		Encyrtidae	parasitoid	Wang & Laing (1989)	
<i>Copidosoma truncatellum</i> (Dalmann)	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Minoterasichus frontalis</i> (Nees) [= <i>Tetrasichus cyclogaster</i> (Ratzeburg)]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Minoterasichus frontalis</i> (Nees) [= <i>Tetrasichus xanthops</i> (Ratzeburg)]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Minoterasichus plataneilus</i> (Mercet) [= <i>Tetrasichus plataneilus</i> (Mercet)]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Neochrysocharis formosana</i> (Westwood) [= <i>Achrysocharilla formosa</i> (Westwood)]	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	
<i>Pediobius stalius</i> (Walker)	Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)	

APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Pholetesor circumscriptus</i> (Nees) [=Apanteles blanchardellae Bouché] <i>Pholetesor circumscriptus</i> (Nees) [=Apanteles flavolinimbatus Ratz] <i>Pholetesor circumscriptus</i> (Nees) [=Apanteles laetellus Marsh] <i>Pholetesor circumscriptus</i> Nees [=Apanteles circumscriptus Nees] <i>Pholetesor ornigis</i> (Weed) <i>Pholetesor ornigis</i> (Weed) [=Apanteles ornigis Weed] <i>Pholetesor pedias</i> (Nixon) <i>Pholetesor pedias</i> (Nixon) [=Apanteles bicolor Nees] <i>Pnigalio minio</i> (Walker) [=Pnigalio flavipes (Ashmead)] <i>Pnigalio uruplatae</i> (Howard) <i>Sympiesis dolicogaster</i> Ashmead <i>Sympiesis gordius</i> (Walker) [=Sympiesis marylandensis Girault] <i>Sympiesis gordius</i> Walker <i>Sympiesis servicornis</i> (Nees) <i>Ageniaspis testaceipes</i> (Ratzeburg) [=Holcothorax testaceipes (Ratzeburg)] <i>Phyllonorycter ringonella</i> Matsumura (Lepidoptera: Gracillariidae) <i>Phyllophaga</i> spp. (Coleoptera: Scarabaeidae) <i>Pieris rapae</i> (L.) (Lepidoptera: Pieridae)	Hymenoptera	Braconidae	parasitoid	Johnson et al. (1977)	
		Hymenoptera	Braconidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Braconidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Braconidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Braconidae	parasitoid	Fisher (1988)
		Hymenoptera	Braconidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Braconidae	parasitoid	Fisher (1988)
		Hymenoptera	Braconidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Braconidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Eulophidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Encyrtidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Encyrtidae	parasitoid	Johnson et al. (1977)
		Hymenoptera	Peleciniidae	parasitoid	Bennett (2004)
		Bacillus thuringiensis Berliner	Bacillaceae	pathogen	Jaques (1971)
		Compsilura concinnata (Meigen)	Diptera	Tachinidae	Harcourt (1963)
		<i>Coesia glomerata</i> (L.) [=Apanteles glomeratus (L.)]	Hymenoptera	Braconidae	Harcourt (1963); West et al. (1984); Wang & Laing (1989)
		<i>Coesia rubecula</i> (Marsh) [=Apanteles rubecula Marsh]	Hymenoptera	Braconidae	Wang & Laing (1989)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Cotesia rubecula</i> (Marshall)	Hymenoptera	Braconidae	parasitoid	Corrigan (1983); Carter & Laing (1997)	
<i>Helicobia rapax</i> (Walker) [= <i>Helocobia rapax</i> Walker]	Diptera	Sarcophagidae	parasitoid	Harcourt (1963)	
<i>Madrenzia staudtii</i> (Williston)	Diptera	Tachinidae	parasitoid	Harcourt (1963)	
<i>Neoaplectana</i> n. sp. (DDI136)	Rhabditida	Steinernematidae	parasite	Welch & Briand (1961); Welch (1962)	
<i>Phryxe vulgaris</i> (Fallén)	Diptera	Tachinidae	parasitoid	Harcourt (1963)	
<i>Pieris rapae</i> GVV [= <i>P. rapae</i> GVV] (PrGV)		<i>Baculoviridae</i>	pathogen	Jaques (1971)	
<i>Pieromalus puparum</i> (L.)	Hymenoptera	Peromalidae	parasitoid	Harcourt (1963)	
<i>Tetrastichus</i> sp.	Hymenoptera	Eulophidae	parasitoid	Corrigan (1983)	
<i>Eupelmus cyaniceps</i> Ashmead	Hymenoptera	Eupelmidae	hyperparasitoid	Putnam (1963)	
<i>Pimpla annulipes</i> Brullé (Hymenoptera: Ichneumonidae)	Hymenoptera	Braconidae	parasitoid	Bright (1996)	
<i>Pissodes approximatus</i> Hopkins (Coleoptera: Curculionidae)	<i>Coeloides pissodis</i> (Ashmead)	Hymenoptera	Braconidae	Bright (1996)	
<i>Pissodes nemorensis</i> Germar (Coleoptera: Curculionidae)	<i>Coeloides pissodis</i> (Ashmead)	Hymenoptera	Braconidae	Bright (1996)	
<i>Pissodes strobi</i> (Peck) (Coleoptera: Curculionidae)	<i>Coeloides pissodis</i> (Ashmead)	Hymenoptera	Braconidae	Bright (1996)	
<i>Dolichomitus terbraensis nubilipennis</i> (Viereck) [= <i>Dolichomitus terbraensis</i> <i>nubilipennis</i> (Viereck)]	Hymenoptera	Ichneumonidae	parasitoid	Wallace & Sullivan (1985)	
<i>Eurytoma pissodis</i> Girault	Hymenoptera	Eurytomidae	parasitoid	Wallace & Sullivan (1985)	
<i>Lonchaea corticis</i> Taylor	Diptera	Lonchaeidae	predator	Wallace & Sullivan (1985)	
<i>Ocottomus quadricarinatus</i> Girault	Hymenoptera	Myrmidae	parasitoid	Huber (2012)	
<i>Rhopalicus tuella</i> (Walker)	Hymenoptera	Peromalidae	parasitoid	Bright (1996)	
<i>Leiophron mellipes</i> (Cresson) [= <i>Peristenus mellipes</i> (Cresson); not <i>pallipes</i> Curtis]	Hymenoptera	Braconidae	parasitoid	Loan (1965)	
<i>Plagiognathus bruneus</i> (Provancher) [= <i>Plagiognathus medicagus</i> Arrand] (Hemiptera: Miridae)	[= <i>Peristenus pallipes</i> (Curtis) = <i>Leiophron pallipes</i> Curtis]	Nosemaidae	pathogen	Wilson (1985a)	
<i>Podia interpunctella</i> (Hübner) (Lepidoptera: Pyralidae)					

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Plutella xylostella</i> (L.) [= <i>Plutella</i> <i>Campolepis</i> sp.]		Hymenoptera	Ichneumonidae	parasitoid	Harcourt (1963)
<i>maculipennis</i> (Curtis)] (Lepidoptera: Plutellidae)					
<i>Conura albifrons</i> (Walsh) [= <i>Spi洛chalcis</i> <i>albifrons</i> (Walsh)]	Hymenoptera	Chalcidae	parasitoid	Harcourt (1963)	
<i>Diadegma insulare</i> (Cresson)	Hymenoptera	Ichneumonidae	parasitoid	Bolter & Laing (1984)	
<i>Diadegma insulare</i> (Cresson) [= <i>Horogenes insularis</i> (Cresson)]	Hymenoptera	Ichneumonidae	parasitoid	Harcourt (1963)	
<i>Diadromus subtilicornis</i> (Gravenhorst)	Hymenoptera	Ichneumonidae	parasitoid	Bolter & Laing (1984)	
<i>Diadromus subtilicornis</i> (Gravenhorst) [= <i>Diadromus phletuae</i> (Ashmead)]	Hymenoptera	Ichneumonidae	parasitoid	Harcourt (1963)	
<i>Dibracys microgaster</i> (Bouché) [= <i>Dibrachys cavaus</i> (Walker)]	Hymenoptera	Pteromalidae	parasitoid	Harcourt (1963)	
<i>Gelis tenellus</i> (Say)	Hymenoptera	Ichneumonidae	parasitoid	Harcourt (1963)	
<i>Microplitis plutellae</i> Muesbeck	Hymenoptera	Braconidae	parasitoid	Harcourt (1963); Bolter & Laing (1984)	
<i>Oomyzus sokolovskii</i> (Kurdjumov) [= <i>Tetrastichus sokolovskii</i> Kurdjumov]	Hymenoptera	Eulophidae	parasitoid	Harcourt (1963)	
<i>Pteromalus</i> sp. near <i>phycidis</i> Ashmead [= <i>Habrocytus</i> sp. near <i>phycidis</i> Ashmead]	Hymenoptera	Pteromalidae	parasitoid	Harcourt (1963)	
<i>Dinotiscus denaroceni</i> (Ashmead)	Hymenoptera	Pteromalidae	parasitoid	Bright (1996)	
<i>Polygraphus</i> spp. (Coleoptera: Curculionidae)	<i>Bacillus lentimorbus</i> Dutky	Bacillaceae	pathogen	Angus & Heimpel (1960)	
<i>Popillia japonica</i> Newman (Coleoptera: Scarabaeidae)	<i>Bacillus popilliae</i> Dutky	Rhabditida	Steinernematidae	Angus & Heimpel (1960)	
<i>Pristiphora erichsonii</i> (Hartig) (Hymenoptera: Tenthredinidae)	<i>Neoaplectana glaseri</i> Steiner	Bacillaceae	pathogen	Welch (1962)	
<i>Pseudalepta unipuncta</i> (Haworth) (Lepidoptera: Noctuidae)	<i>Bacillus cereus</i> Frankland & Frankland	Dissociodihaplophasida	pathogen	Angus & Heimpel (1960)	
<i>Pseudatomoscelis</i> sp. (Hemiptera: Miridae)	<i>Vairimorpha necatrix</i> (Kramer)	Hymenoptera	Myrmidae	Wilson (1987)	
<i>Pseudexentera malii</i> Freeman (Lepidoptera: Tortricidae)	<i>Diadegma</i> sp.	Hymenoptera	Ichneumonidae	Huber (1992)	
					Hagley & Barber (1992)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Pseudosciaphila</i> sp. [=Sciaphila sp.] (Lepidoptera: Olethreutidae)	<i>Hoplectis conquisitor</i> (Say)	Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Psilota rosae</i> (Fabricius) (Diptera: Psilidae)	<i>Apantheles cacoeciae</i> Riley [=Dolichogenidea cacoeciae Riley] <i>Aleochara sparsa</i> Heer	Hymenoptera Coleoptera	Braconidae Staphylinidae	parasitoid	Laing & Heraty (1982) Maybee (1954)
<i>Rhabdophaga strobioides</i> Walsh (Diptera: Cecidomyiidae)	<i>Basalyt tritonus</i> Thomson [=Loxotropa tritoma] (Thomson) <i>Chorebus posticus</i> (Haliday) [=Dacnusa gracilis] (Nees) <i>Kleidotoma</i> sp. <i>Copidosoma</i> sp.	Hymenoptera	Diapriidae	parasitoid	Maybee (1954; 1956)
<i>Rhagoletis pomonella</i> (Walsh) (Diptera: Tephritidae)	<i>Torymus cecidomyiae</i> (Walker) [=Torymus strobioides] (Huber) <i>Triatynus</i> sp.	Hymenoptera	Braconidae	parasitoid	Maybee (1954) Judd (1953)
<i>Rhagoletis pomonella</i> (Walsh) (Diptera: Tephritidae)	<i>Xenorhabdus nematophilus</i> (Poinar & Thomas) [=Achromobacter nematophilus]	Hymenoptera	Torymidae	parasitoid	Judd (1953)
<i>Allonemobius fasciatus</i> (DeGeer)	Orthoptera	Gryllidae	predator	Monteith (1976)	
<i>Amblyseius fallacis</i> Garman	Mesostigmata	Phytoseiidae	predator	Hagley (1979)	
<i>Anaphes conotrachelii</i> Girault	Hymenoptera	Mymaridae	parasitoid	Huber (2006)	
<i>Anaphes pallipes</i> (Ashmead)	Hymenoptera	Mymaridae	parasitoid	Huber (2006)	
<i>Bacillus cereus</i> Frankland & Frankland		Bacillaceae	pathogen	Poinar et al. (1977)	
<i>Calosoma calidum</i> (Fabricius)	Coleoptera	Carabidae	predator	Monteith (1976; 1977)	
<i>Diachasma alloeum</i> (Muesebeck) [= <i>Opius</i> <i>Hymenoptera alloensis</i> Muesebeck]	Braconidae	Braconidae	parasitoid	Monteith (1978)	
<i>Diachasma ferrugineum</i> (Gahan) [= <i>Opius ferrugineus</i> Gahan]	Hymenoptera	Braconidae	parasitoid	Monteith (1978)	
<i>Diachasmimorpha mellea</i> (Gahan) [= <i>Opius melleus</i> Gahan] <i>Enterobacter</i> sp.		Enterobacteriaceae	pathogen	Poinar et al. (1977)	
<i>Escherichia coli</i> (Migula)		Enterobacteriaceae	pathogen	Poinar et al. (1977)	
Castellani and Chalmers					

APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Forficula auricularia</i> L.	Dermoptera	Forficulidae	predator	Monteith (1976; 1977)	
<i>Geotrichium</i> sp.		Endomycetaceae	pathogen	Poinar et al. (1977)	
<i>Gryllus pennsylvanicus</i> Burmeister	Orthoptera	Grylliidae	predator	Monteith (1976)	
<i>Harpalus pensylvanicus</i> (DeGeer)	Coleoptera	Carabidae	predator	Monteith (1976; 1977)	
<i>Lithobius forficatus</i> (L.)	Lithobiomorpha	Lithobiidae	predator	Monteith (1976; 1977)	
<i>Neopallectana</i> sp.	Rhabditida	Steinernematidae	parasite	Poinar et al. (1977)	
<i>Oniscus laevis</i> (Koch)	Isopoda	Oniscidae	predator	Monteith (1976)	
<i>Oxidus rathkei</i> (Koch)	Polydesmida	Paradoxosomatidae	predator	Monteith (1976)	
<i>Porcellio laevis</i> Latreille [= <i>Oniscus laevis</i> Isopoda (Koch)]	Isopoda	Oniscidae	predator	Monteith (1977)	
<i>Pseudomonas aeruginosa</i> (Schroeter)		Bacillaceae	pathogen	Poinar et al. (1977)	
Migula					
<i>Staphylinus badipes</i> (LeConte)	Coleoptera	Staphylinidae	predator	Monteith (1976; 1977)	
<i>Stereococcus</i> sp.		Stereococcaceae	pathogen	Poinar et al. (1977)	
<i>Thachelipus rathkei</i> (Koch) [= <i>Oxidus rathkei</i> (Koch)]	Polydesmida	Paradoxosomatidae	predator	Monteith (1977)	
<i>Uteles canaliculatus</i> (Gahan) [= <i>Opisus lectus</i> Gahan]	Hymenoptera	Braconidae	parasitoid	Monteith (1978)	
<i>Uteles lectoides</i> (Gahan) [= <i>Opisus lectoides</i> Gahan]	Hymenoptera	Braconidae	parasitoid	Monteith (1978)	
<i>Adalia bipunctata</i> (L.)	Coleoptera	Coccinellidae	predator	Foott (1974)	
<i>Rhopalosiphum maidis</i> (Fitch) (Hemiptera: Aphididae)					
<i>Coccinella novemnotata</i> Herbst	Coleoptera	Coccinellidae	predator	Foott (1974)	
<i>Coccinella transversoguttata</i> Faldermann	Coleoptera	Coccinellidae	predator	Foott (1974)	
<i>Coccinella trifasciata perplexa</i> Mulsant	Coleoptera	Coccinellidae	predator	Foott (1974)	
<i>Coleomegilla maculata lengi</i> Timberlake	Coleoptera	Coccinellidae	predator	Foott (1974)	
<i>Cyclonedda sanguinea</i> (L.)	Coleoptera	Coccinellidae	predator	Foott (1974)	
<i>Hippodamia convergens</i> Guérin-Ménville	Coleoptera	Coccinellidae	predator	Foott (1974)	
<i>Hippodamia parenthesis</i> (Say)	Coleoptera	Coccinellidae	predator	Foott (1974)	
<i>Hippodamia tridecemlineata tibialis</i> (Say)	Coleoptera	Coccinellidae	predator	Foott (1974)	

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Rhopalosiphum padi</i> (L.) (Hemiptera: Aphididae)	<i>Entomophthora planchoniana</i> Cornu		Entomophthoraceae	pathogen	Ben-Zeev & Jaques (1990)
<i>Rhyacionia buoliana</i> Denis & Schiffermüller (Lepidoptera: Tortricidae)	<i>Bacillus thuringiensis</i> Berliner	Bacillaceae	parasitoid		Pointing & Green (1962)
	<i>Baryscapus turionum</i> (Hartig) [= <i>Tetrasiphus turionum</i> (Hartig)]	Hymenoptera	Eulophidae	parasitoid	Coppel & Arthur (1954); Pointing & Green (1962)
	<i>Campoplex difformis</i> (Gmelin) [= <i>Campoplex mutabilis</i> (Holmgren)]	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Campoplex</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Copidosoma filicornis</i> (Dalmann) [= <i>Copidosoma geniculatum</i> (Dalmann)]	Hymenoptera	Encyrtidae	parasitoid	Coppel & Arthur (1954)
	<i>Eurytoma appendigaster</i> (Swederus)	Hymenoptera	Eurytomidae	parasitoid	Coppel & Arthur (1954)
	<i>Exeristes comstockii</i> (Cresson) [= <i>Callilepihalles comstockii</i> (Cresson)]	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Exeristes ruficollis</i> (Gravenhorst) [= <i>Ephialtes ruficollis</i> (Gravenhorst)]	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Habrocytus</i> sp.	Hymenoptera	Pteromalidae	parasitoid	Coppel & Arthur (1954)
	<i>Hyssopus thymus</i> Girault	Hymenoptera	Eulophidae	parasitoid	Coppel & Arthur (1954)
	<i>Itolectis conquistior</i> (Say)	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Itolectis</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Orgilus obscurator</i> (Nees)	Hymenoptera	Braconidae	parasitoid	Coppel & Arthur (1954); Pointing & Green (1962)
	<i>Pimpla</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Pimpla turionella</i> (L.)	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954); Pointing & Green (1962)
	<i>Scambus hispae</i> (Harris)	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Sinophorus turionum</i> (Ratzeburg) [= <i>Campoplex rufifemur</i> (Thomson)]	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954)
	<i>Temeucha interrupta</i> (Gravenhorst) [= <i>Cremastus interruptor</i> (Gravenhorst)]	Hymenoptera	Ichneumonidae	parasitoid	Coppel & Arthur (1954); Pointing & Green (1962)
	<i>Melittobia chalybitii</i> Ashmead (Coleoptera: Cerambycidae)	Hymenoptera	Eulophidae	parasitoid	Edwards & Pengelly (1966)
<i>Saperda candida</i> Fabricius					

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Schistocerca</i> spp. (Orthoptera: Acridae)	<i>Coccobacillus acridiorum</i> d'Herelle	Bacillidae	pathogen	Angus & Heimpel (1960)	
<i>Scelioneura betuleti</i> (Klug) (Hymenoptera: Tenthredinidae)	<i>Chrysocharis laricinella</i> (Ratzburg)	Hymenoptera	Eulophidae	parasitoid	Nystrom & Evans (1989)
<i>Scolytus multistriatus</i> (Marsham) (Coleoptera: Curculionidae)	<i>Pnigalio minio</i> (Walker)	Hymenoptera	Eulophidae	parasitoid	Nystrom & Evans (1989)
<i>Scolytus multistriatus</i> (Marsham) (Coleoptera: Curculionidae)	<i>Zagranmosoma multilineatum</i> (Ashmead)	Hymenoptera	Eulophidae	parasitoid	Nystrom & Evans (1989)
<i>Scolytus multistriatus</i> (Marsham) (Coleoptera: Curculionidae)	<i>Parasitaphelenchus oldhami</i> Rühm	Nematoda	Aphelenchoidae	parasite	Welch (1962)
<i>Sitona cylindricollis</i> Fähreus (Coleoptera: Curculionidae)	<i>Anaphes diana</i> (Girault)	Hymenoptera	Mymaridae	parasitoid	Huber (2006)
<i>Sitona hispidulus</i> (Fabricius) (Coleoptera: Curculionidae)	<i>Anaphes diana</i> (Girault)	Hymenoptera	Mymaridae	parasitoid	Huber (2006)
<i>Sitona humeralis</i> Stephens (Coleoptera: Curculionidae)	<i>Anaphes diana</i> (Girault)	Hymenoptera	Mymaridae	parasitoid	Huber (2006)
<i>Sitona lineatus</i> (L.) (Coleoptera: Curculionidae)	<i>Anaphes fuscipennis</i> Haliday	Hymenoptera	Mymaridae	parasitoid	Huber (1992)
<i>Sitona lineatus</i> (L.) (Coleoptera: Curculionidae)	<i>Anaphes diana</i> (Girault)	Hymenoptera	Mymaridae	parasitoid	Huber (2006)
<i>Sitona lineellus</i> (Borsdorf) [= <i>Sitona scissifrons</i> Say] (Coleoptera: Curculionidae)	<i>Cenistes ater</i> (Nees) [= <i>Centistes excrucians</i> Haliday]	Hymenoptera	Braconidae	parasitoid	Loan (1964)
<i>Sitophilus granarius</i> (L.) (Coleoptera: Curculionidae)	<i>Perilissus sitonae</i> (Mason) [= <i>Microctonus sitonae</i> Mason]	Hymenoptera	Braconidae	parasitoid	Loan (1964)
<i>Sitophilus zeamais</i> Motschulsky (Coleoptera: Curculionidae)	<i>Pygostolus falcatus</i> (Nees)	Hymenoptera	Braconidae	parasitoid	Loan (1964)
<i>Sitophilus zeamais</i> Motschulsky (Coleoptera: Curculionidae)	<i>Bacillus</i> sp.		Bacillidae	pathogen	Morris (1980)
<i>Sitotroga cerealella</i> (Olivier) (Lepidoptera: Gelechiidae)	<i>Pseudomonas</i> sp.		Bacillidae	pathogen	Morris (1980)
<i>Solidago canadensis</i> L. (Asteraceae)	<i>Trichogramma minutum</i> Riley	Hymenoptera	Pseudomonadaceae	pathogen	Corrigan et al. (1994)
<i>Solidago canadensis</i> L. (Asteraceae)	<i>Trichogramma pretiosum</i> Riley	Hymenoptera	Trichogrammatidae	parasitoid	Hagley & Laing (1989)
<i>Solidago canadensis</i> L. (Asteraceae)	<i>Trihabda borealis</i> Blake	Coleoptera	Chrysomelidae	phytophage	Reid & Harmsen (1975)
<i>Solidago canadensis</i> (Kirby)		Coleoptera	Chrysomelidae	phytophage	Reid & Harmsen (1975)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
		Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Sparaganophis distincta</i> (Walshingham) (Lepidoptera: Tortricidae)	<i>Enytus</i> sp.	Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Triclistus</i> sp.		Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Sparaganophis reticulatana</i> (Clemens) (Lepidoptera: Tortricidae)	<i>Triclistus crassus</i> Townes & Townes	Hymenoptera	Ichneumonidae	parasitoid	Hagley & Barber (1992)
<i>Sphenophorus australis</i>	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
Chittenden (Coleoptera: Curculionidae)					
<i>Sphenophorus callosus</i> (Olivier) (Coleoptera: Curculionidae)	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
<i>Sphenophorus costipennis</i> Horn (Coleoptera: Curculionidae)	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
<i>Sphenophorus destructor</i>	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
Chittenden (Coleoptera: Curculionidae)					
<i>Sphenophorus maidis</i> Chittenden (Coleoptera: Curculionidae)	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
<i>Sphenophorus minimus</i> Hart. (Coleoptera: Curculionidae)	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
<i>Sphenophorus necydaloides</i> (Fabricius) [= <i>Sphenophorus</i> <i>necydaloides</i> Chittenden] (Coleoptera: Curculionidae)	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
<i>Sphenophorus parvulus</i> Gyllenhal					
<i>Sphenophorus venatus</i> (Say) (Coleoptera: Curculionidae)	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
<i>Sphenophorus venatus vestitus</i>	<i>Anaphes calandrae</i> (Gahan)	Hymenoptera	Myrmidae	parasitoid	Huber (2006)
Chittenden (Coleoptera: Curculionidae)					
<i>Spilonota ocellana</i> (Denis & Schiffermüller) (Lepidoptera: Tortricidae)	<i>Bassus dimidiator</i> (Nees)	Hymenoptera	Braconidae	parasitoid	Hagley & Barber (1992)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
<i>Stenhorus punctum</i> (LeConte) (Coleoptera: Coccinellidae)	<i>Colpochyleus florus</i> (Walker) <i>Triclistus crassus</i> Townes & Townes <i>Trichogramma minutum</i> Riley <i>Anthocoris musculus</i> (Say)	Hymenoptera Hymenoptera Hymenoptera Hemiptera	Eulophidae Ichneumonidae Trichogrammatidae Anthocoridae	parasitoid parasitoid parasitoid predator	Hagley & Barber (1992) Hagley & Barber (1992) Hagley & Barber (1992) Robinson (1952)
<i>Tabanus affinis</i> Kirby (Diptera: Tabanidae)	<i>Chrysopa</i> spp. <i>Orius insidiosus</i> (Say)	Neuroptera Hemiptera	Chrysopidae Anthocoridae	predator predator	Robinson (1952) Robinson (1952)
<i>Tabanus frontalis-septentrionalis</i> complex (Diptera: Tabanidae)	<i>Diglochis occidentalis</i> (Ashmead) <i>Diglochis occidentalis</i> (Ashmead) <i>Diglochis occidentalis</i> (Ashmead)	Hymenoptera	Pteromalidae	parasitoid	James (1952)
<i>Tabanus</i> sp. (Diptera: Tabanidae)	<i>Mermis</i> sp.	Hymenoptera	Pteromalidae	parasitoid	James (1952)
<i>Tarsonomus confusus</i> Ewing (Trombidiformes: Tarsonomidae)	<i>Amblyseus fallacis</i> Garman	Megastigmata	Mermithidae	parasite	James (1952)
<i>Tetranychus medani</i> McGregor [= <i>Eotetranychus medani</i> McGregor]	<i>Adalia bipunctata</i> (L.)	Coleoptera	Phytoseiidae	predator	Villanueva & Harnsen (1996)
Tetranychidae			Coccinellidae	predator	Robinson (1952)
<i>Aeolothrips melaleucus</i> Haliday		Thysanoptera	Aelothripidae	predator	Robinson (1952)
<i>Anthocoris musculus</i> (Say)		Hemiptera	Anthocoridae	predator	Robinson (1952)
<i>Anystis agilis</i> Banks		Trombidiformes	Anystidae	predator	Robinson (1952)
<i>Chrysopa chi</i> Fitch		Diptera	Chrysopidae	predator	Robinson (1952)
<i>Chrysoperla carnea</i> (Stephens) [= <i>Chrysopa harrisi</i> var. <i>externa</i> Hagen]		Diptera	Chrysopidae	predator	Robinson (1952)
<i>Chrysoperla carnea</i> (Stephens) [= <i>Chrysopa plorabunda</i> var. <i>californica</i> Coquillett]		Diptera	Chrysopidae	predator	Robinson (1952)
<i>Diaphorina pellucida</i> Uhler		Hemiptera	Miridae	predator	Robinson (1952)
<i>Feltiella</i> sp.		Diptera	Cecidomyiidae	predator	Robinson (1952)
<i>Haplothrips faurei</i> Hood		Thysanoptera	Phlaeothripidae	predator	Robinson (1952)
<i>Hemerobius simulans</i> Walker		Neuroptera	Hemerobiidae	predator	Robinson (1952)

## APPENDIX A continued...

<b>Host</b>	<b>Natural enemy</b>	<b>Order</b>	<b>Family</b>	<b>Feeding niche</b>	<b>Reference</b>
<i>Tetranychus pacificus</i> McGregor [=Eotetranychus pacificus] (McGregor) (Trombidiformes: Tetranychidae)	<i>Hemerobius stigmaterus</i> Fitch <i>Hyaliodes virripennis</i> (Say) <i>Hyaliodes harri</i> Knight <i>Nabis fenus</i> (L.) <i>Orius insidiosus</i> (Say) <i>Plagiognathus obscurus</i> (Uhler) <i>Scolothrips sexmaculatus</i> (Pergande) <i>Stethorus punctum punctum</i> (LeConte) <i>Stilbus probatus</i> Casey <i>Toxomerus geminatus</i> (Say) <i>Typhlodromus fallacis</i> (Garman) <i>Typhlodromus longipilus</i> Nesbit <i>Tetranychus pacificus</i> McGregor [=Eotetranychus pacificus] (McGregor) (Trombidiformes: Tetranychidae)	Neuroptera Hemiptera Hemiptera Hemiptera Hemiptera Hemiptera Thysanoptera Coleoptera Coleoptera Diptera Mesostigmata Mesostigmata Coleoptera	Hemerobiidae Miridae Miridae Nabidae Anthocoridae Miridae Thripidae Coccinellidae Phalacrididae Syrphidae Phytoseiidae Phytoseiidae Coccinellidae	predator predator predator predator predator predator predator predator predator predator predator predator	Robinson (1952) Robinson (1952)
<i>Tetranychus urticae</i> Koch (Trombidiformes: Tetranychidae)	<i>Balaustium putnami</i> Smiley	Trombidiformes	Erythraeidae	predator	Cadogan & Laing (1982)
<i>Zeitelia mali</i> (Ewing)	<i>Phyoseiulus persimilis</i> Athias-Henriot	Mesostigmata	Phytoseiidae	predator	Jones et al. (2006)
<i>Thymelicus lineola</i> (Odhner) (Lepidoptera: Hesperiidae)	<i>Camposcopus</i> sp. [=Labryrchus sp.]	Hymenoptera	Stigmaeidae	predator	Woolhouse & Harmsen (1985)
	<i>Casinaria</i> sp. A [=Horogenes sp. A] <i>Ioplectis conqueritor</i> (Say) <i>Meteorus hyphantriae</i> Riley <i>Pimpla pedalis</i> Cresson <i>Rogas</i> sp. <i>Coeloides pissodis</i> (Ashmead) <i>Tomicus piniperda</i> (L.) (Coleoptera: Curculionidae)	Hymenoptera Hymenoptera Hymenoptera Hymenoptera Hymenoptera Hymenoptera	Ichneumonidae Ichneumonidae Braconidae Ichneumonidae Braconidae Braconidae	parasitoid parasitoid parasitoid parasitoid parasitoid parasitoid	Pengelly (1961) Pengelly (1961) Pengelly (1961) Pengelly (1961) Pengelly (1961) Bright (1996)
106	<i>Corticinus praetermissus</i> (Fall)	Coleoptera	Tenebrionidae	predator	Bright (1996)

## APPENDIX A continued...

<u>Host</u>	<u>Natural enemy</u>	<u>Order</u>	<u>Family</u>	<u>Feeding niche</u>	<u>Reference</u>
	<i>Dinotiscus dentroctoni</i> (Ashmead)	Hymenoptera	Pteromalidae	parasitoid	Bright (1996)
	<i>Eupelmus</i> sp.	Hymenoptera	Eupelmidae	parasitoid	Bright (1996)
	<i>Eurytoma</i> sp.	Hymenoptera	Eurytomidae	parasitoid	Bright (1996)
	<i>Medetera pinicola</i> Kowarz	Diptera	Dolichopodidae	predator	Bright (1996)
	<i>Medetera signaticornis</i> (Loew)	Diptera	Dolichopodidae	predator	Bright (1996)
	<i>Planysoma gracile</i> LeConte [= <i>Cyllostix gracilis</i> (LeConte)]	Coleoptera	Histeridae	predator	Bright (1996)
	<i>Rhopalicus tuvela</i> (Walker)	Hymenoptera	Pteromalidae	parasitoid	Bright (1996)
	<i>Ropicaerus xylophagorum</i> (Ratzeburg)	Hymenoptera	Pteromalidae	parasitoid	Bright (1996)
	<i>Spathius</i> sp.	Hymenoptera	Braconidae	parasitoid	Bright (1996)
	<i>Apanthes cacoeciae</i> Riley [= <i>Dolichogenidea cacoeciae</i> Riley]	Hymenoptera	Braconidae	parasitoid	Laing & Heraut (1982)
	<i>Bacillus thuringiensis</i> Berliner		Bacillaceae	pathogen	Jaques (1971)
	<i>Bacillus thuringiensis</i> Berliner serovar. <i>alestii</i>		Bacillaceae	pathogen	Angus & Heimpel (1960)
	<i>Compsilura concinna</i> (Meigen)	Diptera	Tachinidae	parasitoid	Harcourt (1963)
	<i>Copidosoma floridanum</i> (Ashmead)	Hymenoptera	Encyrtidae	parasitoid	Murillo et al. (2012)
	<i>Copidosoma truncatellum</i> (Dalman)	Hymenoptera	Encyrtidae	parasitoid	Harcourt (1963)
	<i>Cotesia marginiventris</i> (Cresson)	Hymenoptera	Braconidae	parasitoid	Murillo et al. (2012)
	<i>Cotesia plathypenae</i> (Muesebeck)	Hymenoptera	Braconidae	parasitoid	Murillo et al. (2012)
	<i>Euplectrus</i> sp.	Hymenoptera	Eulophidae	parasitoid	Murillo et al. (2012)
	<i>Exeristes comstockii</i> (Cresson) [= <i>Camptolepis sonorensis</i> (Cameron)]	Hymenoptera	Ichneumonidae	parasitoid	Murillo et al. (2012)
	<i>Itoplectis conqueror</i> (Say)	Hymenoptera	Braconidae	parasitoid	Harcourt (1963)
	<i>Meteorus</i> sp.	Hymenoptera	Braconidae	parasitoid	Murillo et al. (2012)
	<i>Micropeltis alaskensis</i> (Ashmead)	Rhabditida	Steinemematidae	parasite	Murillo et al. (2012)
	<i>Neoplectana</i> n. sp. (DD136) <i>polyhedrosis virus</i>		<i>Baculoviridae</i>	pathogen	Welch & Briand (1961)
	sp.	Hymenoptera	Braconidae	parasitoid	Cameron (1969)
	sp.	Hymenoptera	Tachinidae	parasitoid	Murillo et al. (2012)
					Murillo et al. (2012)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
	<i>Stenichneumon culpator cincticornis</i> (Cresson)	Hymenoptera	Ichneumonidae	parasitoid	Harcourt (1963)
	<i>Trichomalopsis viridiscaens</i> (Walsh) [= <i>Eupieromalus viridescaens</i> (Walsh)]	Hymenoptera	Pteromalidae	parasitoid	Harcourt (1963)
	<i>Trichophusia ni</i> NPV (TnNPV)		<i>Baculoviridae</i>	pathogen	Jaques (1971)
host species not specified (Diptera: Culicidae)	<i>Dolichopus appendiculatus</i> Van Duzee	Diptera	Dolicopodidae	predator	Laing & Welch (1963)
	<i>Dolichopus nigricauda</i> Van Duzee	Diptera	Dolicopodidae	predator	Laing & Welch (1963)
	<i>Dolichopus rendescens</i> Melander & Brues	Diptera	Dolicopodidae	predator	Laing & Welch (1963)
	<i>Dolichopus walkeri</i> Van Duzee	Diptera	Dolicopodidae	predator	Laing & Welch (1963)
	<i>Dugesia dorotocephala</i> (Woodworth)	Trichladida	Dugesidiidae	predator	George (1979; 1984)
	<i>Erynia dipterigena</i> (Thaxter) Remaudière & Keller		Entomophthoraceae	pathogen	Ben-Ze'ev & Jaques (1990)
	<i>Pelastoneurus</i> sp.	Diptera	Dolicopodidae	predator	Laing & Welch (1963)
	<i>Thinophilus</i> sp.	Diptera	Dolicopodidae	predator	Laing & Welch (1963)
	<i>Erynia echinospora</i> (Thaxter) Remaudière & Keller		Entomophthoraceae	pathogen	Ben-Ze'ev & Jaques (1990)
host species not specified (Diptera: Lauxaniidae)	<i>Conidiobolus obscurus</i> (Hall & Dunn)		Ancylistaceae	pathogen	Ben-Ze'ev & Jaques (1990)
host species not specified (Hemiptera: Aphididae)	<i>Conidiobolus thrombooides</i> Dreschler		Ancylistaceae	pathogen	Ben-Ze'ev & Jaques (1990)
	<i>Neozygites freseñii</i> (Thaxter) Remaudière & Keller		Neozygitiaceae	pathogen	Ben-Ze'ev & Jaques (1990)
	<i>Pediobius</i> sp. [= <i>Pleurotropis</i> sp.]	Hymenoptera	Eulophidae	parasitoid	Judd (1953)
host species not identified (Lepidoptera:Diptera)	<i>Microgaster hospes</i> Marshall [= <i>Microgaster comptanae</i> Viereck acridorum D'Herelle]	Hymenoptera	Braconidae	parasitoid	Judd (1953)
host species not specified (Lepidoptera)	<i>Aerobacter aerogenes</i> [= <i>Coccobacillus</i> <i>Acholla multispinosa</i> (DeGeer)]		Enterobacteriaceae	pathogen	Cameron (1969)
host species not specified (Orthoptera: Acrididae)	<i>Allograpta obliqua</i> (Say)	Hemiptera	Reduviidae	predator	Hagley (1979)
host species not specified (Orthoptera: Acrididae)	<i>Anaphe alaskae</i> Annecke & Doutt	Diptera	Syphidae	predator	Hagley (1979)
	<i>Anaphe amplipennis</i> Ogloblin	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
		Hymenoptera	Myrmidae	parasitoid	Huber (1992)

## APPENDIX A continued...

Host	Natural enemy	Order	Family	Feeding niche	Reference
	<i>Anaphes fabrius</i> (Rondani)	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes hercules</i> Girault	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes hundsheimensis</i> (Soyka)	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes inexpectatus</i> Huber & Prinsloo	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes intermedius</i> (Soyka)	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes medius</i> (Soyka)	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes nitens</i> (Girault)	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes nunezi</i> Ogloblin	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes pectoralis</i> (Soyka)	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes pucarobius</i> Ogloblin	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes simpennis</i> Girault	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes stubaensis</i> (Soyka)	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes superadditus</i> (Soyka)	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes tasmaniæ</i> Huber & Prinsloo	Hymenoptera	Myrmidae	parasitoid	Huber (1992)
	<i>Anaphes wolfsthalii</i> (Soyka)	Hymenoptera	Coccinellidae	parasitoid	Huber (1992)
	<i>Anatis labiculata</i> (Say) [= <i>Anatis quindecimpunctata</i> Olivier]	Coleoptera	Clavicipitaceae	predator	Hagley (1979)
	<i>Anisoplia austriaca</i> Herbst	Hemiptera	Anthocoridae	pathogen	Cameron (1953)
	<i>Anthocoris nemoralis</i> (Fabricius)	Hemiptera	Trichocomaceae	predator	Hagley (1979)
	<i>Aspergillus flavus</i> Link		Bacillaceae	pathogen	Cameron (1952)
	<i>Bacillus anthracis</i> Cohn		Bacillaceae	pathogen	Cameron (1969)
	<i>Bacillus cereus</i> Frankland & Frankland		Bacillaceae	pathogen	Cameron (1952; 1969)
	<i>Bacillus proteus</i> (Bach)		Bacillaceae	pathogen	Cameron (1952)
	<i>Bacillus subtilis</i> (Ehrenberg)		Bacillaceae	pathogen	Cameron (1952)
	<i>Bacillus thuringiensis</i> Berliner		Bacillaceae	pathogen	Cameron (1952; 1969)
	<i>Beauveria bassiana</i> (Balsamo) Vuillemin [= <i>Borytis bassiana</i> Balsamo]		Moniliaceae	pathogen	Cameron (1952)
	<i>Beauveria</i> spp.		Clavicipitaceae	pathogen	Cameron (1969)
	<i>Campylomma verbasci</i> (Meyer-Dür)	Hemiptera	Miridae	predator	Hagley (1979)

## APPENDIX A continued...

<u>Host</u>	<u>Natural enemy</u>	<u>Order</u>	<u>Family</u>	<u>Feeding niche</u>	<u>Reference</u>
	<i>Cantharis</i> sp.	Coleoptera	Cantharidae	predator	Hagley (1979)
	<i>Chilocorus stigma</i> (Say) [= <i>Chilocoris bivulneratus</i> Mulsant]	Coleoptera	Coccinellidae	predator	Hagley (1979)
	<i>Chrysopa oculata</i> (Say)	Neuroptera	Chrysopidae	predator	Hagley (1979)
	<i>Coccinella novemnotata</i> Herbst	Coleoptera	Coccinellidae	predator	Hagley (1979)
Brown	<i>Coccinella transversoguttata richarsoni</i>	Coleoptera	Coccinellidae	predator	Hagley (1979)
	<i>Coccinella undecimpunctata</i> L.	Coleoptera	Coccinellidae	predator	Hagley (1979)
	<i>Coelomegilla maculata lengi</i> Timberlake	Coleoptera	Coccinellidae	predator	Hagley (1979)
	<i>Cycloneura munda</i> (Say)	Coleoptera	Coccinellidae	predator	Hagley (1979)
	<i>Enterobacter aerogenes</i> Hormaeche & Edwards [= <i>Aerobacter acridiorum</i> d'Herelle]		Enterobacteriaceae	pathogen	Cameron (1952)
	<i>Entomophthora</i> spp.	Diptera	Syphidae	pathogen	Cameron (1969)
	<i>Eupiodes americanus</i> Wiedemann [= <i>Metasyrphus americanus</i> (Wiedemann)]			predator	Hagley (1979)
	<i>Haplothrips faurei</i> Hood	Thysanoptera	Phlaeothripidae	predator	Hagley (1979)
	<i>Haplothrips subtilissimus</i> (Haliday)	Thysanoptera	Phlaeothripidae	predator	Hagley (1979)
	<i>Hemerobius humulinus</i> (L.)	Neuroptera	Hemerobiidae	predator	Hagley (1979)
	<i>Hemerobius</i> sp.	Neuroptera	Hemerobiidae	predator	Hagley (1979)
	<i>Hyalioides vitripennis</i> (Say)	Hemiptera	Miridae	predator	Hagley (1979)
	<i>Hyperaspis undulata</i> (Say)	Coleoptera	Coccinellidae	predator	Hagley (1979)
	<i>Isaria larinosa</i> (Holmskold) Fries [= <i>Spicaria larinosa</i> (Holmskold)]		Moniliaceae	pathogen	Cameron (1952)
	<i>Mantis religiosa</i> L.	Orthoptera	Mantidae	predator	James (1959)
	<i>Metarrhizium anisopliae</i> (Metchnikoff)		Clavicipitaceae	pathogen	Cameron (1952)
Sorokin	<i>Myzus</i> sp. [= <i>Neomyzus</i> sp.]	Coleoptera	Coccinellidae	predator	Hagley (1979)
	<i>Nabis subcoleoptratus</i> (Kirby)	Hemiptera	Nabidae	predator	Pengelly (1961)
	<i>Paenibacillus popilliae</i> Dutkey [= <i>Bacillus popilliae</i> Dutkey]		Paenibacillaceae	pathogen	Cameron (1952; 1969)

## APPENDIX A continued..

Host	Natural enemy	Order	Family	Feeding niche	Reference
	<i>Pilophorus perplexus</i> Dove & Scott	Hemiptera	Miridae	predator	Hagley (1979)
	<i>Plagiognathus obscurus</i> Uhler	Hemiptera	Miridae	predator	Hagley (1979)
	<i>Podabrus</i> sp.	Coleoptera	Cantharidae	predator	Hagley (1979)
	<i>Podisus</i> sp.	Hemiptera	Pentatomidae	predator	Hagley (1979)
	<i>Polyhedral virus</i>		<i>Baculoviridae</i>	pathogen	Cameron (1952)
	<i>Reduvius personatus</i> (L.)	Hemiptera	Reduviidae	predator	Hagley (1979)
	<i>Thrips calcaratus</i> Uzae	Tlysanoptera	Thripidae	predator	Hagley (1979)
	<i>Trichogramma evanescens</i> Westwood	Hymenoptera	Trichogrammatidae	parasitoid	Griffiths (1972)