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The Common Asparagus Beetle and Spotted Asparagus Beetle (Coleoptera: Chrysomelidae): Identification, Ecology, and Management

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ABSTRACT. The common and spotted asparagus beetles (*Crioceris asparagi* (L.) and *Crioceris duodecimpunctata* (L.), respectively) are host-specific pests of asparagus, and frequently occur wherever asparagus is grown. The common asparagus beetle is the more serious of the two pests. It emerges earlier in the season, and both adults and larvae can cause damage to the asparagus crop by chewing spears and removing fern. This article describes morphological features of both asparagus beetles, discusses aspects of their life cycle and ecology, and addresses management strategies such as pesticides, biological, and cultural controls.

Key Words: integrated pest management, vegetable, crop protection, *Asparagus officinalis*, biological control

The common (*Crioceris asparagi* (L.) (Coleoptera: Chrysomelidae)) and spotted (*Crioceris duodecimpunctata* (L.)) asparagus beetles are major, host-specific pests of asparagus in most asparagus producing regions (LeSage et al. 2008), including the major production regions of the United States (except California) and Canada. They frequently undergo three generations per year in most temperate areas (Capinera and Lilly 1975, Taylor and Harcourt 1975, Taylor and Harcourt 1978), though they sometimes only undergo two generations, as in Germany (Dingler 1934). The common asparagus beetle emerges earlier in the season, and is often the more damaging of the two beetle species. In large outbreaks, the common asparagus beetle may cause widespread defoliation, either reducing the vigor of asparagus plants or causing stem death (Chittenden 1917). Infestations early in the season result in loss of marketable yield of spears (Delahout 2005). As an example of the economic impact of the common asparagus beetle, in three states of the United States alone (Washington, Michigan, and Illinois), the loss to beetle feeding damage, resultant market culling and the cost of partially effective insecticides has been estimated between US$1.4 and US$1.6 million per year (Hendrickson et al. 1991). This pest profile discusses morphological features of these two pests, their damage, life cycle, and biology. Finally, we conclude with options for management and explore possible directions for research in the future.

Identification

The common and spotted asparagus beetle belong to the family of leaf beetles. Both the spotted and common asparagus beetle exhibit warning coloration patterns often indicative of being noxious, and in the case of the spotted asparagus beetle, this results in a low acceptability as a food source to birds (Jones 1932). The chemical cause for this has not been studied. Adult common asparagus beetles can be recognized by a variable number of black spots on a red thorax, and patchy yellow coloration interspersed with black on the abdomen with a maroon border around the edges of the elytra (Fig. 1F–H). Adult common asparagus beetles are usually ≈6.4 mm (0.25 inch) in size, with a hardened front pair of wings (Chittenden 1917). In contrast, the spotted asparagus beetle is colored bright orange to red with six spots on each wing cover (Fig. 1I–K), but is similarly sized to the common asparagus beetle. Overall, the common asparagus beetle tends to be somewhat more elongate, while the spotted asparagus beetle is stockier (Fink 1913, Drake and Harris 1932). Larvae of both species have miniscule black heads (compared with the adults), thin thoraxes, three pairs of stout, light brown legs, and abdomens that bulge away from the head reminiscent of a comma. The difference between the two species in the larvae is primarily coloration: the larvae of the common asparagus beetle are dark gray to whitish, while those of the spotted asparagus beetle are first orange-like then more variable at later instars (ranging from grayish yellow to light orange). The larvae of both species may have black spots on the abdomen, and are similarly sized to adults in the last instar (Fig. 1C–E). Eggs of both species are 1–2 mm, oval, and black to greenish brown. For the common asparagus beetle, the eggs may occur in neat rows (Fig. 1A and B) with 3–10 per cluster and usually point perpendicularly to the branch or cladophyll on which it has been glued by the beetle (Voigt and Gorb 2010). The spotted asparagus beetle, however, lays its eggs singly on their sides instead of perpendicularly to the branches (Drake and Harris 1932).

Biogeography

The common and spotted asparagus beetles were originally Palearctic in distribution, mirroring that of *Asparagus officinalis* L. in the old world (Drake and Harris 1932), mostly around the Mediterranean Sea region (FGP Consortium 2014). There are also records of the common asparagus beetle from Russia (Krainsky 1914), Argentina (Miatello 1914, c.f. Dingler 1934), and parts of Burundi, Rwanda, and Tanganyika (former German Ostafrika: Heinze 1929). However, the common asparagus beetle was eventually introduced to North America in New York, NY, in 1860 from Europe, while the spotted asparagus beetle was first detected in the United States in 1881 near Baltimore, MD (Chittenden 1917). Subsequently, the beetles spread northward into Canada and westward across the United States and Canada (LeSage et al. 2008). The first detected specimens in Canada were found in 1899 in Queenston, ON (LeSage et al. 2008). Both asparagus beetles can now be found wherever asparagus is commonly grown, but tend to be less abundant in hotter climates such as southern California (Capinera 2001). They are able to coexist because of resource and temporal niche differentiation, with spotted asparagus beetle larvae feeding on berries instead of the fern, and developing later than the common asparagus beetle by ≈1 mo.

Life Cycle and Biology

Both the common and spotted asparagus beetle feed solely on *A. officinalis* in North America (Fink 1913, Drake and Harris 1932). In some rare circumstances, the species have been recorded as feeding from hosts other than garden asparagus in other regions of the world. For example, both the common and spotted asparagus beetle was recorded as feeding on *Asparagus filifolius* Bertoloni in Iran (Berti and Rapilly 1976). In laboratory experiments, the common asparagus beetle refused to feed on *Asparagus densiflorus* (Kunth) (cultivar Meyeri), and *Asparagus verticillatus* L., while the spotted asparagus

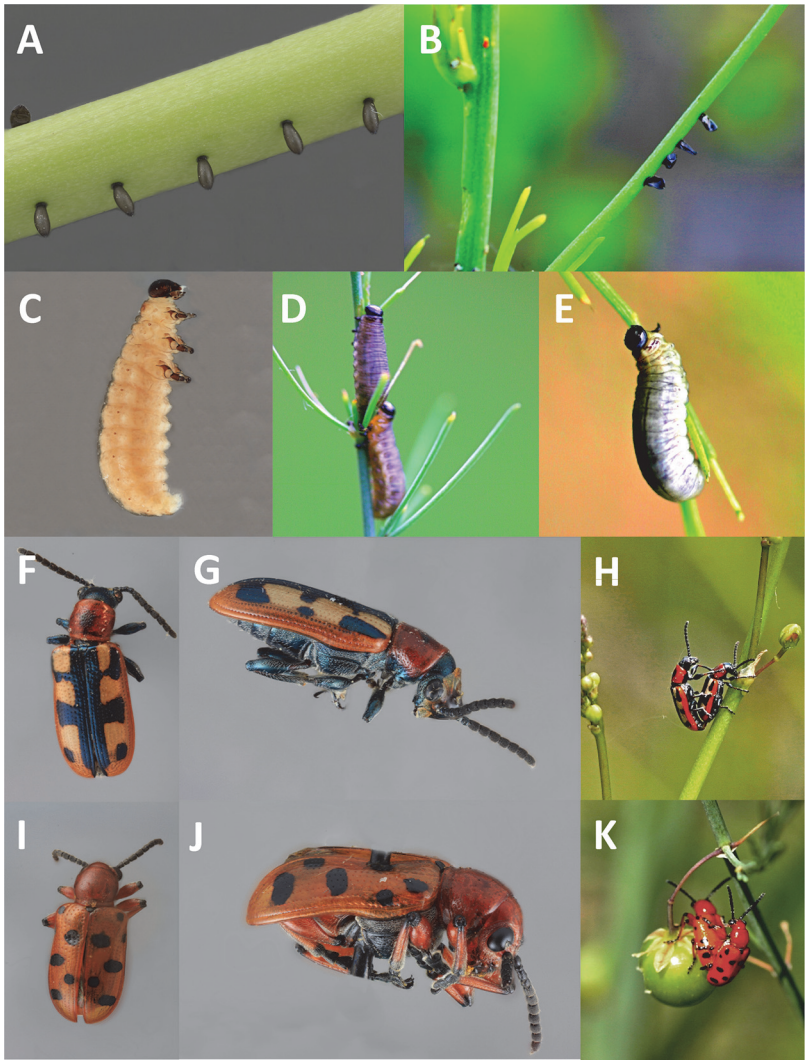

Fig. 1. Life stages of the common asparagus beetle and spotted asparagus beetle. (A) Healthy common asparagus beetle eggs, (B) common asparagus beetle eggs parasitized or fed on by natural enemies, (C–E) common asparagus beetle larvae, (F) adult common asparagus beetles seen dorsally, (G) from the side, or (H) in copula; adult spotted asparagus beetles seen (I) dorsally, (J) from the side, or (K) in copula. (Photos by W. R. Morrison, III.)

beetle fed on *A. verticillatus*, but to a lesser extent than *Asparagus officinalis* (Schmitt 1988).

The common asparagus beetle is more abundant, emerges earlier in the season, and causes more damage than the sympatric spotted asparagus beetle (Capinera 2001). When both asparagus beetles are present in a field, the common asparagus beetle outnumbers the spotted by ≈13:1 (Dingler 1934). Adult common asparagus beetles overwinter as adults (Fig. 2) in hollow asparagus stems, under debris in the field, and under the loose bark of trees (Chittenden 1917). On emergence during spring in early May (Wold-Burkness et al. 2006), common asparagus beetle adults begin to feed on spears, causing affected spears to exhibit pock marks and lose commercial value (Fig. 3). In addition, adults will mate and females then deposit their eggs with proteinaceous glue on developing spears, as well as any asparagus that is in fern. This sticky glue is usually secreted from the epithelium of the pedicel in the female asparagus beetle (Gupta and Riley 1967). Oviposition on spears poses a serious risk to their marketability because they cannot be washed off with water. The force required to remove asparagus beetle eggs from the plant is >8,600 times the weight of the egg (Voigt and Gorb 2010).

Eggs may start developing at lower temperatures than larvae or pupae, and degree–day (DD) calculations for the common asparagus beetle have worked best with a lower developmental threshold of 10°C (Taylor and Harcourt 1978). Eggs can appear as early as 120 DD in the season, which is about the time when asparagus spears start emerging (≈90 DD) along with other asparagus pests, such as the asparagus miner, which also become active in early spring (Morrison et al. 2014). Adult common asparagus beetles prefer to lay their eggs in neat rows on the cladophylls (or "needles") and flowers of the asparagus plant (Szwejda 2002). It takes eggs 3–10 d to hatch if the temperature is between 14 and 30°C. In the laboratory, eggs tolerated temperatures between 8 and 34°C. The eggs, larvae, and pupae take, on average, 58, 167, and 92 DD to complete development, respectively. Once spear harvesting stops, asparagus beetle populations may build up in a field, with both larvae and adults feeding on the plant (Watts 1938). Larvae or "grubs" typically feed for between 10 and 15 d, depending on the temperature (Drake and Harris 1932). Larvae and pupae can tolerate temperatures between 10 and 34°C in the laboratory (Taylor and Harcourt 1978). As the larvae feed, they secrete a blackish fluid, consisting of fecal material, which may contaminate spears (Drake and Harris 1932). Common asparagus beetle larvae undergo four successive instars during their development. Both adult and larval feeding reduces the photosynthetic capability of the plant (Grafius and Hutchison 1995), translating to fewer

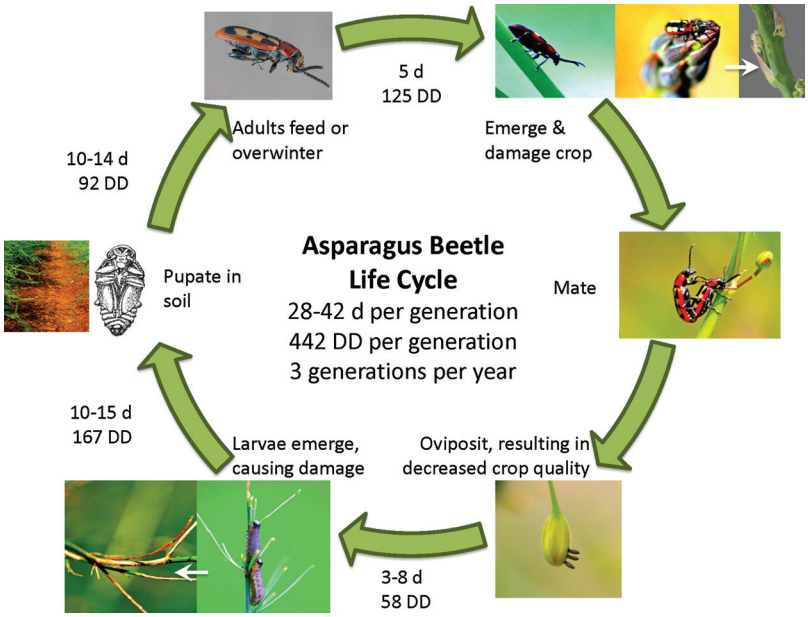

Fig. 2. Asparagus beetle life cycle, with a whole generation lasting between 23 and 37 d and a total of three generations per year in most temperate areas. Pupa drawn by Bernice DeMarco, Michigan State University.

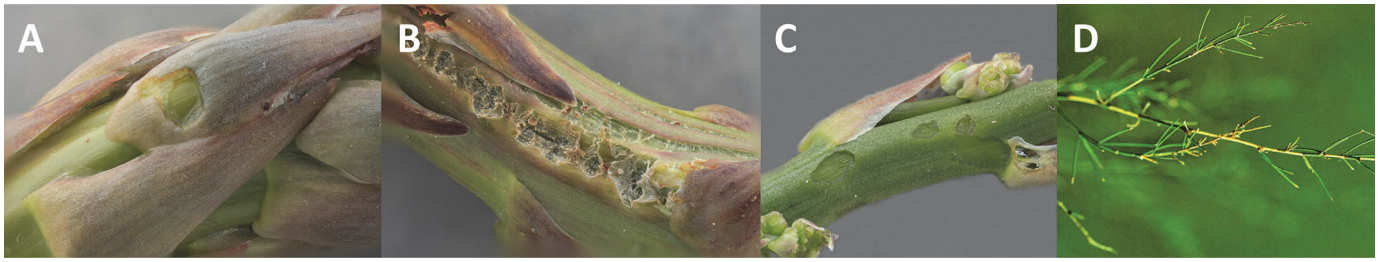

Fig. 3. Asparagus beetle damage on the (A) spear, on the(B and C) stem, and (D) widespread on *A. officinalis* plants in the field in Oceana County, MI, during the 2013 growing season. (Photos by W. R. Morrison, III.)

carbohydrates stored in the crown for subsequent harvests (Capinera 2001). Mature larvae fall off the plant and burrow into the ground, where they pupate just beneath the soil surface (Taylor and Harcourt 1975). After 10 to 14 d, adults eclose in temperate regions of North America and repeat the cycle (Capinera and Lilly 1975b). On average, a single generation for the asparagus beetle takes 30 d in the summer, depending on specific climatic conditions. The common asparagus beetle has three peak oviposition periods during the year: in early June, July, and August in Canada (Taylor and Harcourt 1975).

The life cycle of the spotted asparagus beetle is similar to that of the common asparagus beetle, except that it emerges later in the season, and only the adults are injurious to asparagus. Eggs are inconspicuously deposited singly among the thin branches of the asparagus plant, and the eggs often take on the color of the substrate (Fink 1913), allowing them to blend in with their surroundings. Larvae hatch and then seek out asparagus berries, in which they feed and complete their development (Fink 1913). Spotted asparagus beetle larvae typically require 2–5 asparagus berries to fully mature (Fink 1913, Dingler, 1934). This is not damaging to commercial asparagus production because the berries are not necessary for harvesting asparagus spears (although this is not the case for breeders and seed producers). The majority of the asparagus plants are male in a commercial field because these have higher yields than female plants, thus there are few locations where berries can be found for female spotted asparagus beetles to lay their eggs. Finally, the adults of the spotted asparagus beetle are thought to be better at dispersal than the common asparagus beetle, especially when there is a large amount of mechanical or anthropogenic disturbance (Capinera 1976).

The common asparagus beetle has three primary defenses when disturbed. It either dodges around the asparagus stem evasively, drops to the ground and feigns death (Capinera 1976), or uses its defensive glands located laterally on its pronotum (Deroe and Pasteels 1982). The spotted asparagus beetle, however, usually takes flight (Capinera 1976). Both the common and spotted asparagus beetles have the ability to stridulate in response to disturbance (Drake and Harris 1932, Capinera 1976).

Management Options

The primary method of control for asparagus beetles by most commercial asparagus growers involves the use of broad spectrum insecticides applied foliarly (McClanahan 1975) based on thresholds (see next paragraph). The most commonly used insecticides are carbamates (U.S. Department of Agriculture [USDA] 2007) and pyrethroids, but newer chemistries labeled for use in asparagus, containing spinetoram and spinosad, are also available and have lower impact and are environmentally safer options for growers. There is continuing work investigating the use of reduced-risk chemistries (Kuhar et al. 2006) such as Bt formulations (Gao et al. 2011). More reduced-risk insecticide options, which have a short preharvest interval, are needed to protect plants from adult beetle feeding and egg laying during harvest.

Economic thresholds have been developed for the asparagus beetles, which can guide growers in determining when to spray. Scouting usually begins in early spring, before 120 DD have accumulated (biofix 1 January, base 10°C) and continues throughout the season (Wold-Burkness et al. 2006). Twenty plants are typically checked at

random in five different locations in the field ($N = 100$ plants in total) when scouting, regardless of field size because asparagus fields are planted on smaller acreages than row crops. Sampling usually occurs in the afternoon, as this is when adult asparagus beetles are most active (Wold-Burkness et al. 2006). It is likely that asparagus beetles hide in the leaf litter or the soil during the night and early morning until air temperatures increase sufficiently for flight. Sampling for larvae is not contingent on time of day because larvae are relatively immobile compared with the adults. During the harvest season, an insecticide may be considered if >2% of the spears have eggs or >5% of the plants are infested with asparagus beetle adults (Wold-Burkness and Hahn 2007). After the harvest season, an insecticide may be applied if 10% of the plants are infested with adults, 2% of plants are egg infested, 50–75% of plants have larvae, or if plants have at least 10% defoliation. (Delahout 2005, Van Wychen-Bennett et al. 2013).

There are several natural enemies that feed on the asparagus beetle. The primary egg–larval parasitoid is *Tetrastichus coeruleus* (Nees) (Hymenoptera: Eulophidae; Fig. 4A and B), occurring mainly in the United States and Europe, which can cause up to 71% mortality in the field (Capinera and Lilly 1975a, Poll et al. 1998). This is a host-specific parasitoid of the common asparagus beetle. *T. coeruleus* was originally described as *Tetrastichus asparagi* Crawford (Noyes 2014), thus most of the literature regarding this species has been published under this junior synonym. This parasitoid is a gregarious koinobiont (Fernald 1909, Johnston, 1915), with young living inside the egg and feeding on the developing asparagus beetle embryo until it is ready to hatch. Parasitized eggs appear unaffected, and when the asparagus beetle larva emerges from the eggs, the parasitoid continues to feed on the larva until it drops to the soil to pupate (LeSage et al. 2008). The parasitoid emerges in place of the asparagus beetle adult from the pupal cell. Adult *T. coeruleus* prefers to host feed on eggs earlier in their development, while sparing more developed eggs for oviposition (Capinera and Lilly 1975b). Whereas beetle eggs with internal larval *T. coeruleus* feeding show no outwards signs of parasitism, eggs with *T. coeruleus* adult feeding show a distinct vacuum-sealed appearance (Fig. 1B). Parasitoids may destroy more eggs by adult feeding than through parasitization (Johnston 1915). On average, ≈4.75 *T. coeruleus* adults emerge per larva, though this ranges between 2 and 13 individuals per larva (Capinera and Lilly 1975b). In addition, the parasitoid and common asparagus beetle have fairly synchronous life cycles, disjunct by no more than 2–5 d (Capinera and Lilly 1975b). *T. coeruleus* overwinters as a larva in the pupal cells created by the asparagus beetle larva (Johnston 1915). Though *T. coeruleus* is capable of both parthenogenetically and sexually reproducing, it primarily does the latter in asparagus fields (Reumer et al. 2010). There has been some success in augmentatively releasing *T. coeruleus* in the field and greenhouse to control asparagus beetle infestations in Europe (Poll et al. 1998). In other cases, there is a lack of successful parasitization where *T. coeruleus* has been released (≈0.5% parasitization rate: Hendrickson et al. 1991). This may not be typical, however, as other studies have repeatedly found high rates of parasitization and effectiveness of *T. coeruleus* (e.g., ≈40% parasitization rate: Capinera and

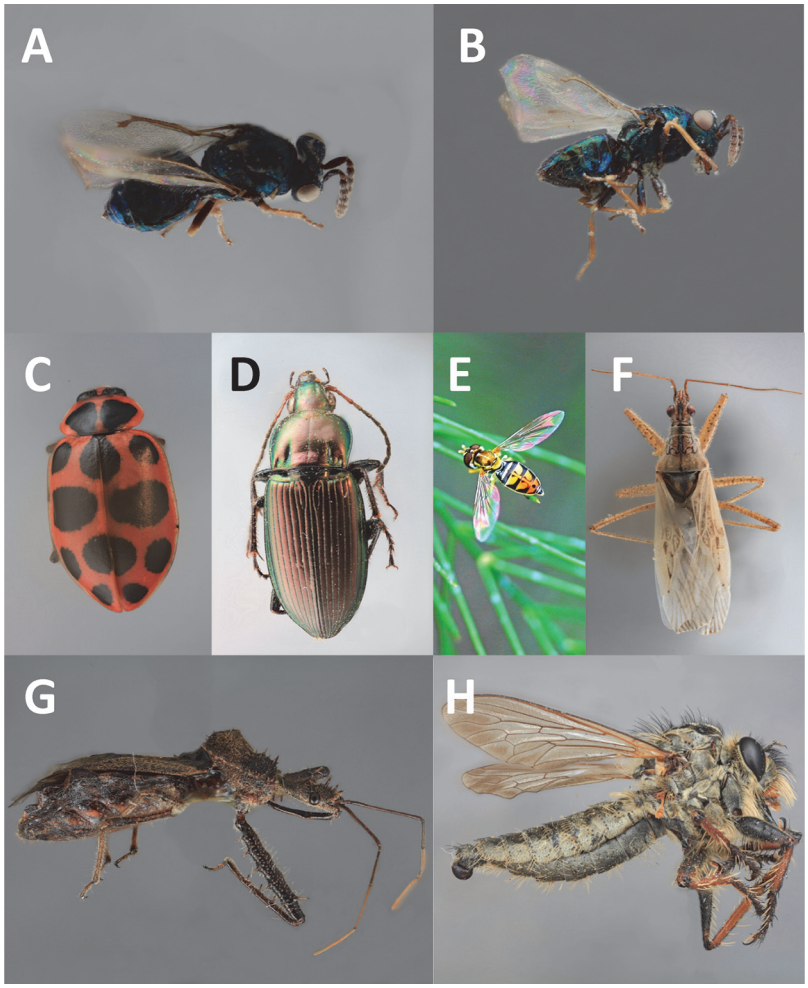

Fig. 4. Natural enemies found in asparagus agroecosystems. (A and B) *T. coeruleus*, a primary parasitoid of the asparagus beetles in the northern United States, (C) *C. maculata*, the most efficient lady beetle predator of the asparagus beetle, potential predator taxa (D) carabid, (E) syrphid, (F) nabid, (G) assassin bug, and (H) robber fly. (Photos by W. R. Morrison, III.)

Lilly 1975b; also see Johnston 1915, Poll et al. 1998, Capinera 2001). In the southern United States, there is a primary larval parasitoid of the common asparagus beetle, *Paralispe infernalis* (Townsend) (Diptera: Tachinidae), which has a documented parasitism range between 2.11 and 26.39% of the beetle larvae killed in South Carolina (Watts 1938). This tachinid is found in low abundance in northern parts of North America (Hendrickson et al. 1991).

Additional parasitoids described from Europe for the asparagus beetle and their rates of parasitization in the field are: *Meigenia mutabilis* (Fallen) (Diptera: Tachinidae) (16.1%), *Lemophagus crioceritor* Aubert (Hymenoptera: Ichneumonidae) (7.9%), *Diaparsis truncatus* (Gravenhorst) (Hymenoptera: Ichneumonidae) (20%), and *Tetrastichus crioceridis* Graham (Hymenoptera: Eulophidae) (17.8%) (Hendrickson et al. 1991). These parasitoids were introduced into the United States; however, all of them failed to establish at appreciable levels in the mid-Atlantic states (Hendrickson et al. 1991). Nonetheless, significant amounts of *L. crioceritor* were recovered from asparagus fields in Quebec (8.9% parasitization rate) and Ontario (15.7%) in Canada.

Common predators of the asparagus beetles include lady beetles, such as *Hippodamia convergens* Guérin-Méneville and *Coleomegilla maculata* De Geer (Fig. 4C) (Coleoptera: Coccinellidae), as well as carabids (Coleoptera: Carabidae) (Fig. 4D), predatory pentatomids (Hemiptera: Pentatomidae), assassin bugs (Hemiptera: Reduviidae) (Fig. 4G), and nabids (Hemiptera: Nabidae) (Fig. 4F), which consume beetle eggs and larvae (Watts 1938, Capinera and Lilly 1975a). Lady beetle species, including *C. maculata*, were the drivers for the 50% mortality of asparagus beetles in the second generation in Massachusetts in July (Capinera and Lilly 1975a). The spined soldier bug (*Podisus maculiventris* Say) has been documented feeding on the adult asparagus beetle (Drake and Harris 1932), and has been commonly observed feeding on asparagus beetle larvae in the field in Massachusetts (Capinera and Lilly 1975a). All of these groups are predacious in both the adult and immature stages. Certain entomopathogenic nematodes kill asparagus beetle larvae, including *Steinernema feltiae*, which caused up to 96% mortality in a greenhouse setting (van Schelt and Hoogerbrugge 2008). Results from this study indicate that the optimal rate of nematode application to asparagus is 1,250 nematodes per ml H_2O applied at 250 ml per asparagus plant to obtain maximum mortality of asparagus beetle larvae. The same study recommended that field trials with the nematodes be conducted, but there is no record in the literature of field trials having been performed, despite the fact that this seems like a promising avenue of control, especially for organic asparagus production. Other common predators in asparagus agroecosystems include soldier beetles (Coleoptera: Cantharidae), robber flies (Diptera: Asilidae), and syrphids (Diptera: Syrphidae) (W.R.M., unpublished data).

The only pathogen found to kill either asparagus beetle species is *Impudentia crioceris* Vujanovic, which is a naturally occurring dematiacious hyphomycetous fungus found within asparagus fields in Quebec, Canada (Vujanovic et al. 2003). The Cry3Aa toxin from *Bacillus thuringiensis tenebrionis* has been used with some success in combination with *Beauveria bassiana* to control a closely related, morphologically similar asparagus beetle species, *Crioceris quatuordecimpunctata* Scopoli in China (Gao et al. 2012). However, there is no evidence that anything similar has been tested for the asparagus beetles highlighted in this profile.

There are some common cultural controls that growers can implement to reduce outbreaks of asparagus beetles. Sanitation of the area around the asparagus fields is important. Volunteer asparagus is usually killed with herbicides or removed mechanically to eliminate additional food resources. In addition, before the beginning of the next growing season, plant residue is typically cleared from the field and ideally burned to avoid enabling overwintering adults from recolonizing asparagus fields (Delahout 2005).

There is some evidence that certain asparagus cultivars have greater resistance to feeding by asparagus beetles (Lamparski et al. 2010). For example, the German cultivar Rapsody had significantly fewer spotted and common asparagus beetles feeding on it compared with 10 other cultivars, whereas the Dutch variety Backlim seemed to be the most susceptible (Lamparski et al. 2010). The same study also found that drip irrigation often increased the number of asparagus beetle adults feeding on summer stalks (Lamparski et al. 2010). While asparagus plant breeding programs aimed at increased yield and increased pathogen resistance have been extensive (e.g., Stephens et al. 1989, Ellison et al. 1990, Dan and Stephens 1995, Pontaroli and Camadro 2001, Motoki et al. 2005), trying to increase the resistance of asparagus to insect pests has been largely lacking. This is an unexplored area that merits further attention by researchers both for the asparagus beetles (especially *C. asparagi*) and the other major insect pest of asparagus, the asparagus miner (Morrison et al. 2011).

Conclusions

Asparagus beetles are wide-spread pests of commercially grown asparagus and can be managed through a combination of scouting, insecticide application, and biological and cultural controls in an integrated pest management program. As a result of consistent monitoring throughout the season and spraying insecticides as needed, asparagus growers are able to keep the asparagus beetles from significantly impacting production. Short-term needs for the asparagus growers in controlling the asparagus beetle involve the registration of insecticides that have short reentry interval and can be used in periods between harvesting bouts. However, ideally management approaches involving minimizing insecticides should be pursued. There are several long-term needs for research on the asparagus beetles (primarily with the common asparagus beetle) that need to be explored. One of these is elucidating the chemical ecology of the asparagus beetle to understand the cues that are used by the species to locate its host crop, and those of parasitoids to locate the pest. Another priority should be investigating the use of promising nematodes and other pathogens to induce mortality in the asparagus beetle in the field. Finally, a key long-term need involves the improvement of biological control of asparagus beetles, perhaps by altering the surrounding landscape to favor the natural enemies and incorporating this into current management programs.

Acknowledgments

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