



## The Reemergence of an Old Pest, *Orchestes pallicornis* (Coleoptera: Curculionidae)

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**ABSTRACT.** Apple flea weevil, *Orchestes pallicornis* (Say) was a sporadic pest in the early 1900s and has reemerged as a severe pest of cultivated apple (*Malus domestica* Borkh.) in Michigan. Organic apple orchards in Michigan have had outbreak population levels of apple flea weevil since 2008 and damage has resulted in up to 90% losses. Apple flea weevil is a small, 2–3-mm black weevil with enlarged high legs for jumping. The adults feed on bud and leaf tissue and heavy pressure causes bud termination. Leaf tissue is removed in multiple small circles, with the net result of the large removal of photosynthetic material. Larvae are leaf miners, developing between the upper and lower leaf cuticles while migrating from the midrib to the leaf margin where pupation occurs. Pupae develop inside a blister, an air-filled space that turns brown. Low populations of apple flea weevil are missed easily or misdiagnosed as either frost damaged from bud feeding or sulfur burn from pupal cases. Apple flea weevil is likely secondarily managed by broad-spectrum insecticides used in conventional programs. However, there are currently no proven management options for use in organic production. As broad-spectrum materials are replaced by reduced-risk compounds, it is possible that apple flea weevil will become an important pest in apple production.

**Key Words:** organic, outbreak, management, population effects, reduced-risk insecticide

*Orchestes pallicornis* (Say) (formerly *Rhynchaneus pallicornis*) (Coleoptera: Curculionidae), the apple flea weevil, has rapidly become a serious pest in Michigan organic apple (*Malus domestica* Borkh.) orchards—with some growers experiencing >90% crop loss (Grieshop et al. 2010). Beginning in 2008, four growers, representing about half of total Michigan organic apple acreage—≈300 acres—experienced severe decreases in bloom, fruit set, or both. Observations of this damage continued to increase through 2011 (current). In each of these cases the organic acreage was in its first decade of certification—having been managed conventionally in years prior. Originally, growers attributed the loss to possible frost damage but damage was occurring in frost-free years as well. It was not attributed to apple flea weevil until 2010 by which time over half of the organic apple acreage in Michigan was reporting high damage and populations. Increasing populations also were noticed in reduced-input orchards relying primarily on mating disruption for Lepidopteran pests.

One hypothesis for the recent reemergence of this pest in relatively newly certified organic, but not conventional orchards, is that the recently organic orchards are now relying on *narrow spectrum* pesticides. Changes in insecticide use and application patterns recently have shown to have major impacts on insect pest complexes (Lu et al. 2010). In tree fruit production, growers are transitioning to reduced risk insecticides as the Environmental Protection Agency (EPA) phases out broad-spectrum organophosphates and carbamates. Although the broad-spectrum compounds may be effective at killing apple flea weevil adults, chemical-based integrated pest management (IPM) or organic management programs targeting specific pests may not overlap with peak apple flea weevil populations (Wise 2011).

**Description of Insect Stages.** Adult *O. pallicornis* are small black weevils, 2–3 mm in length, with enlarged hind femora used for jumping. The oval-shaped body is densely punctate and covered with short yellow-gray hairs. Elytra are also punctate and striated. Antennae and tarsi are reddish-brown with a lineated rostrum and curved snout (Fig. 1). Eggs are ≈0.7 mm long and pearly white. Larvae are creamy-white colored and dorso-ventrally flattened with sharply defined segments. Eggs, larvae, and pupae are located within the leaf and the larvae are miners (Flint et al. 1924). Currently there is no degree-day information for development or upper or lower developmental thresholds.

**Apple Flea Weevil Biology.** The apple flea weevil is oligophagous, feeding on Rosacea family plants, and has been deemed an economically important species (Anderson 1989). Extension bulletins from the early 20th century list larva collections from leaves of elm (*Ulmus alata* Michx., *U. americana* L.); alder (*Alnus* sp.); quince (*Cydonia oblonga* Mill.); choke cherry (*Prunus virginiana* L.); and hawthorns (*Crataegus mollis* (Torr. & A. Gray) Scheele) (Houser 1923). In addition, adults have been collected from *Amelanchier* sp., *A. alnifolia* Nutt., *Pyrus coronaria* L., *P. floribunda* Lindl., *P. malus* L., *Prunus* spp., *Pr. americana* Marsh., *Pr. carolineae*, *Pr. persica* (L.), and *Pr. serotina* Ehrh. Authors that described collecting apple flea weevil from non-Rosacea hosts (such as elm) may have confused the species with *Orchestes mixtus* Blatchley, which is found on elm. Apple flea weevil is the primary *Orchestes* sp. in apple (R. Anderson, personal communications) and appears to prefer cultivated apple to the uncultivated wild hosts (Houser 1923). It has been previously collected from apples in Alberta and Ontario, Canada; Arkansas; Connecticut; Georgia; Illinois; Louisiana; Maine; Michigan; Montana; New Hampshire; North Carolina; Ohio; Texas; Virginia; and Washington (Houser 1923, Flint et al. 1924, Anderson 1989).

**Biology.** *Orchestes pallicornis* adults begin emerging from their overwintering sites in the orchard floor early in the apple growing season. Houser (1923) found adults concentrated within the drip line of apples, and our Michigan surveys found them in the duff layer and minimally in the soil A-horizon (Table 1). They are one of the first insects active in the tree canopy in the spring, coinciding with the silver tip phenological stage of blossom development. These “spring adults” feed on developing leaf and bud tissue, and begin mating soon after emergence from diapause. Eggs are oviposited in the leaf midrib on the lower leaf surface. Flint et al. (1924) estimated that egg hatch occurs within 1 wk and larvae take 17 d to mature.

The larvae are miners that feed and develop within the leaf tissue, migrating toward the leaf margin (Fig. 2). Pupal cases are found at the leaf margin, in a “blister” separating the two tissue layers (Houser 1923). It is estimated that pupation lasts for ≈5–6 d and multiple larvae can develop within a single leaf. The larval mine and pupal blister turn brown after formation and are easily identifiable on the leaf. Spring adult activity in Michigan declines significantly at petal fall in apples (A.L.N, unpublished data). The “summer adults” emerge



Fig. 1. Adult *Orchestes pallicornis* (apple flea weevil).

**Table 1.** Fall 2010 surveys of leaf damage and mean apple flea weevil extracted from leaf litter at orchards in Michigan reporting damage

Site	Block	Percent leaf damage per tree				Leaf litter extraction
		Absent	Low	Medium	High	
Flushing		20.00	44.00	26.00	9.00	28.7 ± 10.0
	1	0.00	30.00	50.00	20.00	
Clarksville	2	40.00	58.00	2.00	0.00	60.9 ± 11.6
	1 <sup>a</sup>	0.00	1.00	28.00	71.00	
Charlotte	2 <sup>b</sup>	0.00	0.00	34.00	66.00	16.2 ± 3.6
	1	0.00	2.00	22.00	76.00	
Berrien Center	2	2.11	20.00	26.84	51.05	17.4 ± 2.8
	1	0.00	0.00	17.78	82.22	
	3	0.00	16.00	38.00	46.00	
Fennville	1	8.00	60.00	32.00	0.00	21.0 ± 8.1
	2	0.00	0.91	9.09	89.09	
Fennville	1	0.00	2.00	10.00	88.00	21.0 ± 8.1
	2	0.00	0.00	8.33	91.67	
Fennville	1	0.00	5.45	22.73	71.82	21.0 ± 8.1
	2	0.00	5.56	22.22	72.22	
Fennville	1	0.00	5.36	23.21	71.43	21.0 ± 8.1
	2	0.00	5.36	23.21	71.43	

<sup>a</sup> Grass mulch within drip line.

<sup>b</sup> Straw mulch within drip line.

beginning mid-June. In Michigan, our surveys indicate that apple flea weevil is univoltine with summer adults feeding for a short period before returning to the orchard floor in early July to overwinter (Houser 1923) (Figs. 1 and 2).

**Damage.** Damage by *O. pallicornis* occurs as soon as there is leaf tissue, but literature and our own experiences indicate that adult emergence varies with tree phenology (Houser 1936, Mundinger 1951). Once in the canopy, adults feed on the developing buds and/or foliage, removing leaf material in small circles or “shot holes” that expand as the leaf develops (Fig. 3). Early emergence of the beetles prompts heavy feeding on the bud tissue before the leaves develop, leading to situations of heightened damage and severe loss (Mundinger 1951). When adults feed on developing blossoms beginning at green tip through bloom economic losses occur, which causes termination of fruit development (Fig. 4). Heavy populations cause significant defoliation of leaf tissue, resembling a lace-like or birdshot pattern, which leads to decreased productivity and possible tree death after consecutive years of pressure (Fig. 5) (Houser 1923, Flint 1924, Mundinger 1951). Early literature and our observations suggest that apple flea weevil are slow to disperse within and between orchards and demonstrate highly aggregated populations (Houser 1923; Nielsen et al. unpublished). At low populations, damage is concentrated near the trunk of the tree and is often unnoticed because it is easily confused with frost damage—reduced bloom and abscessed flowers—sulfur phytotoxicity, or all of these—pupal cases (Fig. 6) (J. Koan and S. Tennes, personal communications). Thus, although apple flea weevil has not been widely reported in neighboring states, this may be because of grower, pest management scout, and extension personnel unfamiliarity with apple flea weevil damage.

#### Survey and Monitoring

**Initial Survey of Damage.** In September and October of 2010, five organic orchards in Michigan (Berrien Center, Flushing, Pottersville, Fennville, Clarksville) were surveyed to assess apple flea weevil damage. Damage was categorized by leaf feeding intensity—number of shotholes—and leaves that were severely damaged by Japanese beetle or other leaf feeding pests were excluded from the survey. At

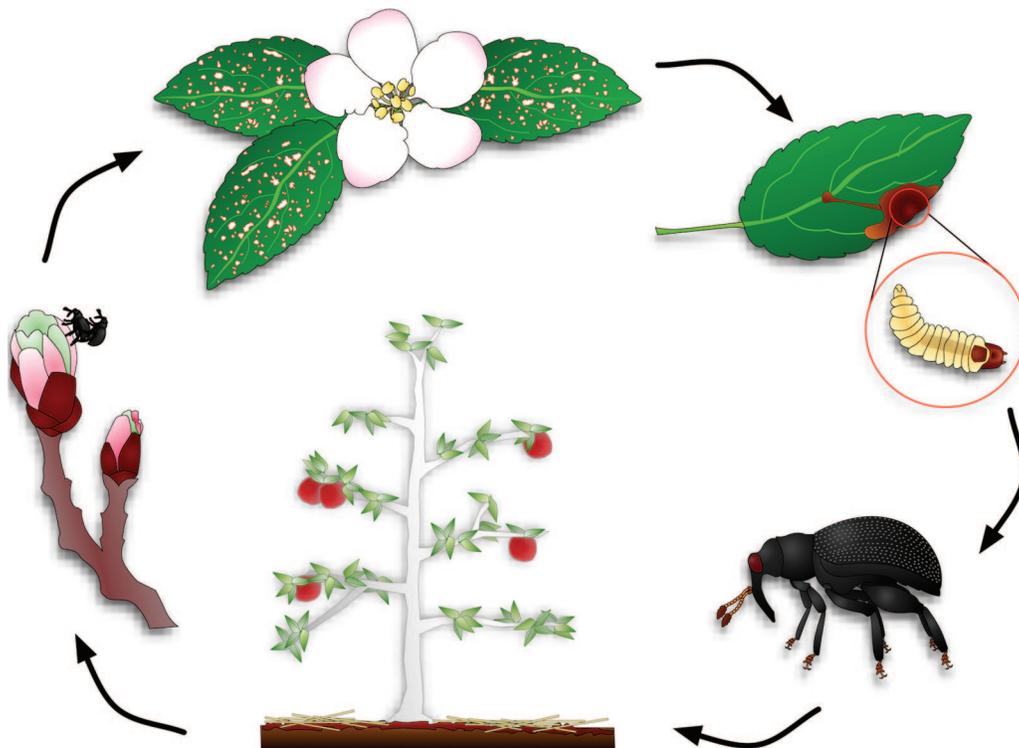


Fig. 2. Apple flea weevil life cycle.



**Fig. 3.** Leaf feeding damage by spring adults at tight cluster phenological stage of apple (May 5, 2011).



**Fig. 4.** Apple flea weevil damage to bud cluster. Note that feeding has terminated the flower buds (May 13, 2011).



**Fig. 5.** Heavy leaf damage from apple flea weevil feeding (October 2010).



**Fig. 6.** Apple leaves with larvae or pupae of apple flea weevils. Larval mines originate in the midrib of the leaf, turning brown as the larvae migrates towards the leaf margin to form the pupal blister, also brown (May 24, 2011).

each location 2–3 blocks were sampled, each containing five randomly selected tree rows. Within an orchard row, 10 trees were measured for severity of damage. Severity was categorized as absent, low, medium, and high for the whole tree by visual assessment of five randomly selected terminals. Trees where <20% of leaf area were damaged, with 3–5 feeding holes per leaf were considered low damage intensity. Medium intensity was denoted by 20–60% of leaf area had feeding damage, with leaves having 10 or greater feeding sites. Trees classified as “medium” may have regrowth on some terminals that were undamaged. At heavy damage levels, >60% of leaf area had damage and the leaves were severely damaged (Fig. 5). Location of each tree was recorded with a handheld GPS unit (eTrex Vista HCx, Garmin, Olathe, KS). Coordinates were uploaded into GoogleMaps and severity of damage was color coded (zero: green, low: yellow, medium: magenta, high: red). High leaf feeding damage was evident at all sites sampled in fall 2010 with over 80% of trees sampled falling into the medium or high leaf damage categories (Table 1; Fig. 7). From 2008 to 2010, few apples were on trees in these blocks, with no apples present in 2010 although spring frosts may have exacerbated blossom damage. Fewer than 4% of trees had no visible damage and these trees were primarily in a cultivated block at the Flushing, MI farm.

Leaf litter samples (1 gal) from within the tree drip line were taken at 10 random locations within each orchard. Samples were placed in a Berlese funnel (BioQuip, Santa Domingo, CA) for 7 d and the total number of adults collected were counted. Overwintering adults were extracted from the leaf litter but exhibited large levels of variation in population size (Table 1).

**Monitoring Methods.** Our experiences in Michigan demonstrated that at low population densities and early in the season, apple flea weevil often goes unnoticed. However, left unmanaged; populations

became a serious problem and damage to fruit bearing tissues occurred well in advance of pesticide applications targeting other pests. This is problematic because effective early season monitoring techniques have not been developed for this pest. Houser et al. (1924) measured tanglefoot bands surrounding the tree bark. Approximately equal numbers of adults were caught on the tanglefoot as in the canopy suggesting that adults just as readily flew up into the tree as walked. There were also relatively equal numbers of larval mines on trees without banding as those with.

Our observations indicate that apple flea weevil emergence coincides with Ida Red phenology, which is one of the earlier varieties grown in Michigan. Currently we lack a proven early season apple flea weevil monitoring program. There have been anecdotal reports of apple flea weevil in plum curculio, *Conotrachelus nenuphar* (Herbst) pyramid traps and on yellow sticky cards. Thus, either may serve as monitoring methods for where low population densities are expected. In addition, we have found adults are easily dislodged when limb jarring or beat sampling is used however this is a more labor-intensive sampling method.

**Past Management Tactics.** There have been six documented outbreaks of *O. pallicornis* in the past 100 yr in Ohio (1907, 1914, 1921, 1950); Illinois (1924); and now Michigan (2009–present) (Houser 1923, Flint et al. 1924, Houser and Neiswander 1936, Munding 1951, Grieshop et al. 2010). Previous experiences with apple flea weevil indicate that if left unmanaged, it can cause damage exceeding that of codling moth [*Cydia pomonella* (L.)] (Houser and Neiswander 1936). Unfortunately, because it has not been a common pest since the introduction of chlorinated hydrocarbon, organophosphate, carbam-



**Fig. 7.** Incidence of apple flea weevil damage at 2 organic orchards in Michigan. Severity of leaf damage was scored as low (yellow), medium (magenta), and high (red) in the fall.

ate, and pyrethroid insecticides, we know very little about the pest's biology and no control recommendations exist that are suitable by today's standards.

**Chemical Management.** Spray trials in the 1930s found fluorine to be decidedly toxic to adults in laboratory and field trials (Houser and Neiswander 1936). In 1951—the most recent publication on apple flea weevil management—Mundinger (1951) found that DDT and fluorine (especially cryolite) were consistently the most efficacious materials in the field. Pyrethrum and rotenone dusts also caused high field mortality after knock-down but efficacy was dependent direct application to individual apple flea weevil. Previous literature recommended two applications of materials timed at prepink (tight cluster stage) and one week later (Houser and Neiswander 1936, Mundinger 1951). Summer adults were successfully controlled by parathion, benzene hexachloride, and DDT (Mundinger 1951). Lime sulfur, commonly used in organic systems for scab, did not negatively impact apple flea weevil populations in Ohio (Houser and Neiswander 1936), which is consistent with our observations.

In current orchard management systems, apple flea weevil begins emerging and feeding on buds and leaves before first cover sprays for *Grapholita molesta* Busck and plum curculio. However, by then damage to reproductive buds has already occurred. Summer apple flea weevil populations may be secondarily controlled by cover sprays targeting summer generations of *Grapholita molesta* and codling moth. Laboratory bioassays (A.L.N., unpublished data) on overwintering apple flea weevil suggest that many compounds labeled for use in conventional orchards (e.g., Guthion, Danitol, Delegate) are highly effective. Reduced risk products like Avaunt were ineffective and many of the National Organic Program (NOP)-approved compounds—Pyganic, Neemix, and others—were ineffective. Only the NOP-approved Entrust (a spinosad) provided good efficacy for organic production. Although many of the conventional compounds are likely to provide field efficacy, it is not unreasonable to expect species such as *O. pallicornis* to increase in pest status in conventionally managed orchards considering the continuing loss of organophosphates because of Food Quality Protection Act (FQPA) regulations (FQPA 1996) and grower transition to reduced risk insecticides. Furthermore, as precision IPM targets specific species, the seasonality of apple flea weevil may not coincide with primary orchard pests, allowing population numbers to increase. Thus, there is a need for modern apple flea weevil management tactics.

**Other Management Considerations.** Nonchemical options provide the best long-term sustainable approach for apple flea weevil man-

agement of apple flea weevil. *Beauveria bassiana* is reported to cause mortality against the overwintering soil or ground-dwelling stage. Larval or pupal parasitoids—*Zatropis incertus* Ashm., *Trichomalus incitus* Walker (Hymenoptera: Pteromalidae), *Epius* sp., and *Chrysocharis pentheus* Walker (Hymenoptera: Eulophidae)—have been collected from leaves (Houser 1934). The impact of insecticides on parasitoid populations that may naturally keep apple flea weevil in check is unknown.

Cultural methods such as clean cultivation of the orchard floor and flaming may reduce overwintering populations (Houser 1923, Flint et al. 1924), whereas repeated years of sod culture are hypothesized to lead to population build-ups (Houser and Neiswander 1936). Maintenance of bare ground underneath the drop line because of cultivation or herbicide strips may eliminate overwintering habitat for apple flea weevil.

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