Rhagoletis cerasi

Scientific Name
Rhagoletis cerasi (Linnaeus, 1758)

Synonyms:
Musca cerasi Linnaeus,
Rhagoletis cerasi f. obsoleta Hering,
Rhagoletis cerasi ssp. *fasciata*, Rohdendorf,
Rhagoletis cerasi obsoleta Hering,
Rhagoletis obsoleta Hering,
Spilographa cerasi,
Tephritis cerasi,
Trupanea cerasi,
Trypeta signata Meigen,
Urophora cerasorum Dufour,
Urophora liturata Robineau-Desvoidy

Figure 1. Female *Rhagoletis cerasi* on cherry (Photo © OPIE/Rémi Coutin)

Common Name(s)
European cherry fruit fly, cherry fruit fly, cherry maggot

Type of Pest
Fruit fly

Taxonomic Position
Class: Insecta, **Order:** Diptera, **Family:** Tephritidae

Reason for Inclusion
PPQ Pest of Concern (New Pest Advisory Group)

Pest Description
Eggs: The eggs are 0.75 mm (approx. $^{1}/_{32}$ in.) long and 0.25 mm in diameter, ovoid, and white. A single egg is oviposited below the skin of fruit that has recently turned from green to yellow (Daniel and Grunder, 2012).

Larvae: Three instars, with the final instar measuring 5 to 6 mm (approx. $^{3}/_{16}$ to $^{1}/_{4}$ in.) long (Katsoyannos, 2008). The body is whitish and translucent (Alford, 2007).

Pupae: Pupae are 3 to 4 mm (approx. $^{1}/_{8}$ to $^{3}/_{16}$ in.) long and 2 mm (approx. $^{1}/_{16}$ in.) in diameter; pale yellowish brown (Alford, 2007; Daniel and Grunder, 2012). The larvae pupate 2 to 5 cm ($^{13}/_{16}$ to 2 in.) deep in the soil under the host plant (Daniel and Grunder, 2012).

Adults: “Average length of female 4.6 mm (approx. $^{3}/_{16}$ in.), of male 3.4 mm (approx. $^{1}/_{8}$ in.). Mostly black. Head yellowish except posteriorly. Apex of antenna sharply pointed dorsally. Thorax mostly black, postpronotum (= humeral callus) and notopleural stripes whitish. Scutellum mostly whitish except base of sides, with 2 pairs of marginal bristles. Postnotum black. Legs with femora black, tibiae and tarsi yellowish. Wing slightly longer than body, about 4.8 mm (approx.$^{3}/_{16}$ in.) in female, about 4.0 mm (approx.$^{3}/_{16}$ in.) in male. Wing crossed by 4 large and 1 small (intercalary) dark, distinct bands, the apical and subapical bands fused anteriorly, and the medial band isolated. Abdomen blackish, hind margin of segments yellowish. Female with tubular ovipositor sheath and thin elongate, piercing ovipositor apically. Male with tiny genital complex, coiled aedeagus (Hendel 1927)” (USDA, 1983).

Biology and Ecology

Rhagoletis cerasi is univoltine (Alford, 2007). Adults emerge late May to early July and are active in sunny, hot, dry conditions (Alford, 2007). Adults must feed to mature sexually (Boller and Prokopy, 1976) and can be found feeding on aphid honeydew and other sugary excretions from plants (Alford, 2007; Katsoyannos, 2008). Upon emerging, males establish territories on fruit and begin emitting a volatile sex pheromone to attract virgin females (Boller and Prokopy, 1976; Katsoyannos, 2008). Females begin mating approximately 4 days after emerging (Katsoyannos, 1982) and begin ovipositing in 7 to 13 days, mainly on mid and late ripening fruit varieties (Katsoyannos, 2008). Females prefer to oviposit into fruits that are in full sun, so flies often aggregate in the sunniest parts of the tree (Daniel and Grunder, 2012). Females begin laying eggs in mid-June and insert them individually beneath the skin of ripening fruit (Alford, 2007). Females can lay 30 to 200 eggs; usually one per fruit (Daniel and Grunder, 2012). Once a female has laid eggs, she will rub her ovipositor over the fruit surface depositing pheromones on the fruit; the pheromones deter other females from ovipositing on the same fruit (Katsoyannos, 1975). The average life span of *Rhagoletis cerasi* is four to seven weeks, with adults living two to four weeks (Bush, 1992; Daniel and Grunder, 2012).

Eggs hatch in one to two weeks (Alford, 2007). Larvae feed on pulp around the pit for approximately four weeks (USDA, 1983; Alford, 2007). Larvae then move to the soil where they pupate up to 5 cm (2 in.) deep in the soil (Alford, 2007; Daniel and Grunder, 2012) underneath the host plant (Fletcher, 1989). *Rhagoletis cerasi* overwinter as pupae in an obligate diapause for one year (Moraiti et al., 2014). Adult emergence is determined by the fruiting period of the host and the soil temperature during winter diapause (Fletcher, 1989; Stamenkovic et al., 2012). The dormancy period may extend into a facultative diapause for up to three winters if the chilling period is insufficient (not reaching degree day requirement or temperatures are too warm) or duration of cold temperatures extend past the degree day requirement (Moraiti et al., 2014). Temperature requirements vary depending on the geographic origin of the population, ranging from 0 to 10°C (32 to 50°F) (Leski, 1963; Moraiti et al., 2014). A study conducted by Moraiti et al. (2014) compared the chilling period requirements of populations collected from Germany and Greece and found that, while all populations could successfully terminate diapause when exposed to 8°C (46.4°F), populations collected from warmer regions had higher success rates and emerged earlier (~1

month) than populations collected from colder regions when exposed to temperatures ranging from 5 to 10°C (41 to 50°F). The difference in diapause intensity was found to be in line with the phenology patterns of the local host cultivars (early vs. late-flowering sweet cherry cultivars) in each area, further demonstrating that *R. cerasi* adjusts diapause to the fruiting periods of the hosts they emerge from (Moraiti et al., 2014).

Dispersal flights may occur when all suitable fruits are either destroyed, harvested, or marked by another female. Females typically disperse first and are followed by the males. Experimentally, dispersal distance is between 100 and 500 m (approx. 328 and 1640 ft), but laboratory studies have demonstrated that the flies can cover up to 3 km (approx. 1.9 miles) in 24 hours if there is no place to land (Daniel and Grunder, 2012).

Rhagoletis cerasi was thought to comprise two geographic races due to differences in host fidelity and unidirectional sterility between the races (Boller, 1989). Population genetic studies have since found that there is no genetic differences between the 'races' (Schwarz et al., 2003) and that the unidirectional sterility is actually cytoplasmic incompatibility caused by differences in *Wolbachia* strains (Arthofer et al., 2009; Riegler and Stauffer, 2002). Cytoplasmic incompatibility results in arrested embryonic development when the eggs of an uninfected or differently-infected female are fertilized by an infected male's sperm (Arthofer et al., 2009; Riegler and Stauffer, 2002). Northern, western, and eastern European populations are infected by the *w*Cer1 strain and central and southern European populations are superinfected by strains *w*Cer1 and *w*Cer2 (*w*Cer1+2) (Riegler and Stauffer, 2002). Unidirectional sterility commonly occurs between southern and central European males and northern, western, and eastern European females, indicating that the presence of *w*Cer2 causes cytoplasmic incompatibility (Riegler and Stauffer, 2002).

The species is now not considered as having races, based on geography or host preference. Host fidelity has not been found to be dictated by differences in infection or geographic distribution but is likely a result of phenological and behavioral differences in *R. cerasi* that emerge from *Lonicera* and *Prunus* (Riegler and Stauffer, 2002).

Damage

Fruit damaged by the larvae of *R. cerasi* often rots; heavy infestations can reduce marketable yields (Alford, 2007). Damaged cherries darken and commonly fall off of the tree (Daniel and Grunder, 2012). Mature fruit may have soft spots or an off-color, wilted, or shriveled appearance (USDA, 1983). Exit holes left by mature larvae are visible (Fig. 2) (USDA, 1983). Fruit processors may reject consignments of infested harvested cherries (Alford, 2007).

Figure 2. Damage on cherry caused by larval exit holes of *R. cerasi* (Photo © OPIE/Rémi Coutin).

Pest Importance

Rhagoletis cerasi is considered a serious pest of sweet cherry in Europe (Alford, 2007; Daniel and Grunder, 2012). Ripening cherries can be destroyed by this species shortly before harvest (USDA, 1983); and without proper control, infestation can reach 100% (Daniel and Grunder, 2012). From 1983 to 1992, the susceptibility of some sweet cherry cultivars was accessed in Cacak (western Serbia); this species was observed “causing more damage in mid-early and late sweet cherry cultivars” (Stamenkovic et al., 1996). Sour cherries are also infested to a lesser degree; without proper control, infestation reaches 30% (Olszak and Maciesiak, 2004).

If infestations are above 4% for table and canning cherries, they may be used for distillation which can tolerate higher limits of infestation (USDA, 1983). However, this can reduce the market prices by up to 50% (USDA, 1983).

If *Rhagoletis cerasi* becomes established in the United States it may seriously affect external markets such as New Zealand and Australia. The resulting quarantines might cause lower prices and economic losses for growers (W. Gould, personal communication, 2016).

Blueberry maggots (*Rhagoletis mendax*) have caused problems for canned blueberries because the larvae float to the top of the syrup in the cans, causing consumer rejections (Lathrop and McAlister, 1931, Lathrop and Nickels 1931, 1932). Canned cherries may have a similar problem. Blueberry growers in the eastern United States use a number of control methods including pesticides to lower populations (Lathrop and McAlister, 1931, Lathrop and Nickels 1931, 1932).

Known Hosts

This species has a narrow host range, comprised of cherry (*Prunus* spp.) and honeysuckle (*Lonicera* spp.). Host fidelity is likely a result of phenological and

behavioral differences in *R. cerasi* that emerge from *Lonicera* and *Prunus* (Riegler and Stauffer, 2002). Adult emergence "is closely synchronized with the fruiting period of their hosts" (Fletcher, 1989), and adult flies demonstrate a strong preference to oviposit into the host from which they emerged. *Rhagoletis cerasi* overwinter as pupae in the soil below their host plant (Alford, 2007) and emerge as the host's fruit begin to ripen. Adults do not typically disperse, but dispersal flights may occur when all suitable fruits are either destroyed, harvested, or marked by another female (Daniel and Grunder, 2012). If the preferred host is unavailable and the alternate host's fruit is becoming ripe, it is possible for flies to switch hosts. Host shifts have occurred; in Switzerland, *Rhagoletis cerasi* that emerged from *Prunus* oviposited into *Lonicera* when cherries were no longer available (Katsoyannos et al., 1986).

Major hosts
Lonicera alpigena (alpine honeysuckle), *L. tatarica* (Tatarian honeysuckle), *L. xylosteum* (dwarf honeysuckle), *Lonicera* spp. (honeysuckle), *Prunus avium* (sweet cherry), *P. cerasus* (sour cherry), *P. mahaleb* (mahaleb cherry), and *P. serotina* (black cherry) (Boller and Prokopy, 1976; White and Elson-Harris, 1994; Boller et al., 1998; Jaastad, 1998; Kovanci and Kovanci, 2006; Daniel and Grunder, 2012).

Minor hosts
Prunus padus (European bird cherry) and *Symphoricarpos albus* (snowberry) (Kotte, 1958).

Pathogens or Associated Organisms Vectored
This pest is not currently known to vector any pathogens or other associated organisms.

Known Distribution
Asia: Armenia, Azerbaijan, Georgia (Republic of), Iran, Kazakhstan, Kyrgyzstan, Tajikistan, Turkey, Turkmenistan, and Uzbekistan; **Europe:** Andora, Austria, Belgium, Britain, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece (including Crete), Hungary, Italy, Latvia, Lithuania, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, and Ukraine; **North America:** Canada (Boller et al., 1976; Neuenschwander et al., 1982; USDA, 1983; White and Elson-Harris, 1992; Jaastad, 1994, 1998; Kovanci and Kovanci, 2006; Barić et al., 2007; Stamenković et al., 2012; CABI, 2015).

Situation in Canada (as of October 2016)
"In February 2016, an amateur entomologist submitted a photograph of a non-indigenous *Rhagoletis* spp. to the Canadian Food Inspection Agency (CFIA). The photograph was taken in an urban park in Mississauga, Ontario in July 2015. In May 2016, the CFIA initiated a detection survey in the park and on June 27, 2016, the CFIA confirmed the detection of *R. cerasi*, the European cherry fruit fly, in association with invasive honeysuckle (*Lonicera morrowii*, *L. tatarica*, and *Lonicera* × *bella* Zabel [*morrowii* × *tatarica*]) in this park.

Rhagoletis cerasi is a regulated pest to Canada, and is previously unknown from North America. *R. cerasi* is subject to official control in Canada. The CFIA is carrying out additional surveillance to delimit the distribution of this pest" (NAPPO, 2016; E. Bullas-Appleton, personal communication, 2016).

Pathway

The United States does not allow cherry (*Prunus avium*) from areas where this species is known to occur (FAVIR, 2016). Sweet cherry (*Prunus avium*) fruits may be imported into all U.S. ports from Argentina, Australia (including Tasmania), Canada, Chile, and New Zealand (FAVIR, 2016). South Africa may export to ports within the continental United States (FAVIR, 2016). The Republic of Korea and Japan (except for Amami, Bonin, Ryukyu, Tokara, and Volcano Islands) may export to Guam and the Northern Mariana Islands (FAVIR, 2016). Cherries from Mexico have specific import requirements: cherries grown in fruit fly free areas of Mexico may be exported to all U.S. ports; if grown outside of fruit fly free areas may export to North Atlantic ports only, with cold treatment (FAVIR, 2016).

This species has been intercepted 115 times at U.S. ports of entry since 1988, with 58 of the interceptions occurring since 2000 (AQAS, 2016). All interceptions occurred at airports on *Prunus* spp. fruit found in passenger baggage (AQAS, 2016). The most common interceptions originated from material carried from France (19), Germany (15), Italy (13), Poland (9), and Romania (8) with the most common destinations being California (12), Florida (12), Georgia (7), Illinois (23), and Texas (10) (AQAS, 2016).

Its introduction into Crete was believed to have occurred through the importation of infested cherries. It may have been further dispersed in Crete through the transport of pupae in used crates to cherry growing areas in the mountains (Neuenschwander et al., 1982).

Potential Distribution within the United States

This genus is found throughout the Holarctic Region and in temperate parts of the Neotropical Region (Fletcher, 1989). *Rhagoletis cerasi* is not known to be present in the United States (USDA CPHST, 2016b). The predicted range for *Rhagoletis cerasi*, based on known global distribution, includes 9 USDA plant hardiness zones (2-10).

Sweet and tart cherry is found in the highest density towards the Pacific Coast (California, Oregon, and Washington), the northeastern United States (Maryland, New York, and Pennsylvania), and other states such as Colorado, Michigan, New Mexico, and Utah (USDA CPHST, 2016a). A recent combined host density map for *Rhagoletis cerasi* developed by USDA-APHIS-PPQ-CPHST (Fig. 3) identifies areas of high host acreage based on the combined acreage of sweet cherry and tart cherry.

The map included in the 2016 version of the datasheet was based on bearing acreage of the host from the National Agricultural Statistics Service (NASS). Bearing acreage includes: 1) acres of trees or vines that produced a fruit or nut crop for the NASS census year or in previous years, and 2) acreage where fruit was present but was not

harvested (e.g., market issues, damaged fruit). The present map has been updated with total acreage data, which includes bearing and non-bearing acreage. For non-bearing acreage, the host was not at the proper age or maturity to produce fruit when the data was collected. Please note, maps are created using the most current NASS point data available. Actual acreage may have changed since the point data was collected.

There are 19 native and 19 introduced species of *Lonicera* known to occur in the United States, including Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands (NGRP, 2016). Recent detections in Canada have all been associated with *Lonicera*, indicating that it should be included as a sentinel plant in host surveys in future detection efforts (K. Bloem, personal communication, 2016).

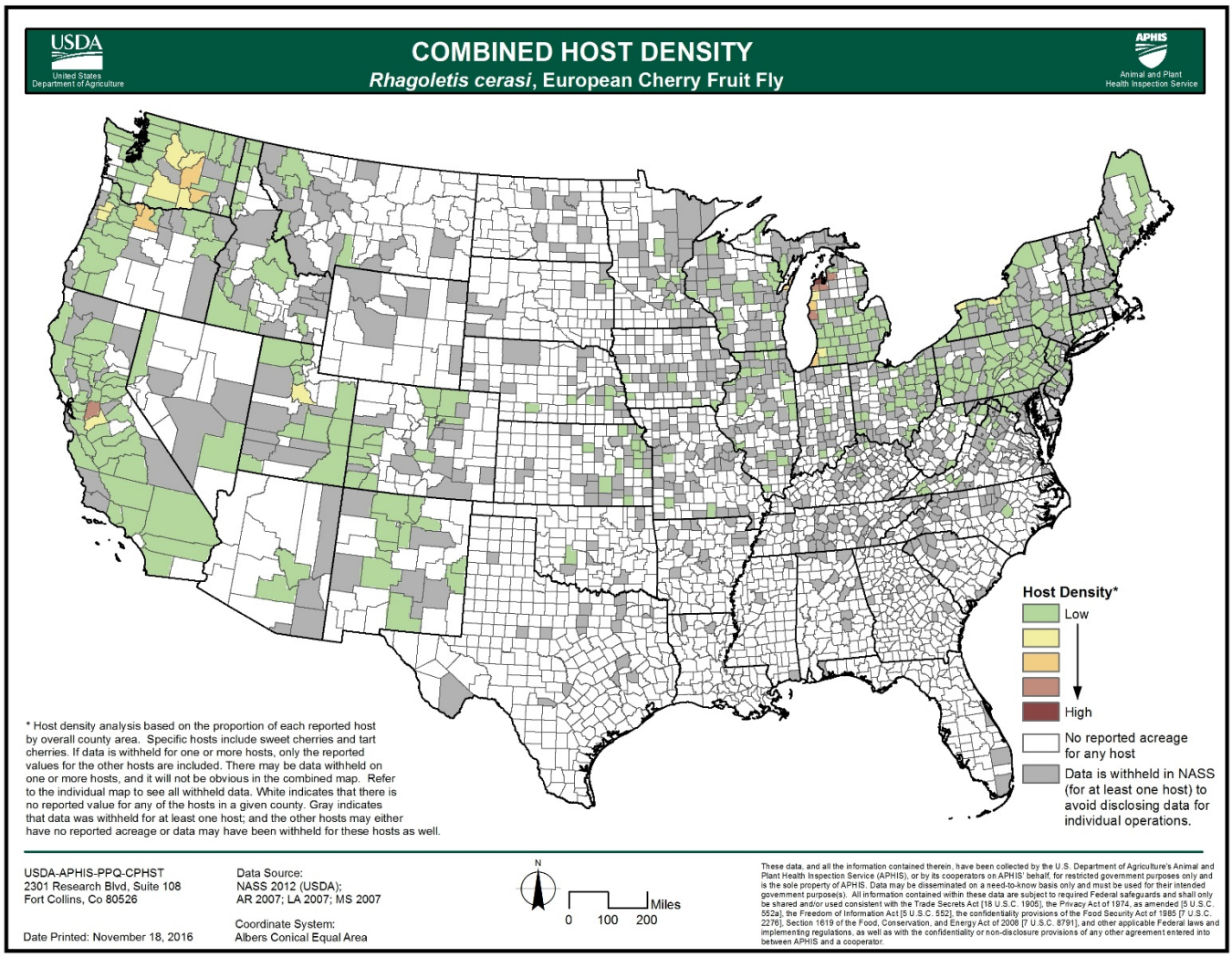

Figure 3. Combined Host Density Map for *Rhagoletis cerasi* within the continental United States. Values represent combined host acreage low to high (sweet cherry and tart cherry). Map courtesy of USDA-APHIS-PPQ-CPHST.

Survey

Approved Methods for Pest Surveillance*:

The CAPS-approved method is a trap and lure combination. The trap is a yellow sticky card with protein hydrolysate casein embedded in the adhesive, which serves as a bait. As there are also un-baited sticky cards, be sure to order the product “Sticky Card, Yellow, Baited” available through the IPHIS Survey Supply Ordering System. Note: this trap does not contain ammonium acetate, a synthetic food attractant. A separate ammonium acetate lure is required.

In 2016, the ammonium acetate lure was available in a patch form. This form is no longer being manufactured. For 2017 surveys and beyond, the ammonium acetate lure is in a polycon dispenser, and the product name is “Ammonium Acetate Lure, Bait Enhancer.” This lure is effective for 14 days (note that this is shorter than the length of effectiveness for the patch form). The polycon dispenser should be hung just above the trap by affixing it to the trap’s wire using the provided tie strap.

Figure 4. Ammonium acetate lure in preloaded polycon dispenser.

IPHIS Survey Supply Ordering System Product Names:

1) Sticky Card, Yellow, Baited
2) Ammonium Acetate Lure, Bait Enhancer

Time of year to survey

Traps should be in place before the end of May, and trapping should continue for three months.

Trap and lure placement

Traps should be placed around the perimeter of sweet cherry orchards. Traps should be placed in the middle section of the tree canopy on the outside edge of the tree with the yellow surface of the trap facing outward.

In addition, traps may be placed in honeysuckle, another significant host of *R. cerasi*. If the plant is large enough, the trap can be hung from the main stem. If the plant is unable to support the trap, hang it from a metal or wooden stake placed in close proximity to the plant, making sure the trap is level with the crown of the plant.

Trap servicing

Traps should be inspected weekly, if possible, but at least every two weeks. The lure should be replaced every two weeks, and the trap should be replaced every 4 weeks. Once the ammonium acetate dispenser has been expelled, the polycon should be discarded and replaced with a new pre-loaded polycon. The polycon dispensers are refillable; however, the Pest Detection program has decided to use pre-loaded, single-

use devices for ease of use. Therefore, do not attempt to re-load the dispensers and order enough product for single use application.

Yellow sticky cards capture many kinds of non-target insects; therefore, the traps need to be inspected and cleaned regularly, particularly in windy or dusty areas. If traps become too covered in dust, the traps will not be as effective.

Optional survey method
In addition to traps, sweep netting is an approved sampling technique for surveys in cherry and honeysuckle. Sweep netting around *Lonicera* has been found to be an effective method for detection of adult flies in Canada.

Use of ammonium carbonate lures
Ammonium carbonate lures have also been shown to be effective for *Rhagoletis cerasi*. However, in order to standardize data and survey supply procurement, it is preferable that states use the ammonium acetate lures available through the Survey Supply Ordering Database. Negative data may be reported if states conduct trapping for other target fruit flies using ammonium carbonate lures. However, it is imperative that traps must be placed in one of the two *Rhagoletis cerasi* hosts: cherry or *Lonicera* (honeysuckle). Negative data may not be reported from trapping conducted in other fruit fly hosts. Ammonium carbonate lures will not be available through the Survey Supply Ordering Database. The length of effectiveness of this lure and dispenser varies depending on the manufacturer. Consult the manufacturer's instructions for the lure.

Before planning a *R. cerasi* survey, it is IMPERATIVE that you work with the PPQ National Operations Managers for CAPS and Fruit Flies for guidance in planning your survey (see contact information below).

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Currently vacant
PPQ National Operations Manager, CAPS

IMPORTANT: Do not place lures for two or more target species in a trap unless otherwise recommended.

*For the most up-to-date methods for survey and identification, see Approved Methods for Pest Surveillance on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/approved-methods.

Literature-Based Methods:
Trapping: The International Atomic Energy Agency (IAEA) Trapping Guidelines for Area-wide Fruit Fly Programmes (2003) recommends trapping male and female *R.*

cerasi by using ammonium salts in 1 of 3 different traps, yellow panel, Rebell ® Yellow Traps, or red spheres. Trap density per km^2 is given and depends on both type of area (production area, marginal, urban, or points of entry) and scenario (monitoring or detection) (IAEA, 2003).

Katsoyannos et al. (2000) found that the Rebell ® Yellow Traps with a slow release formulation of ammonium acetate attached to the lower part of the trap was the most effective of all treatments tested, including the McPhail trap. The Rebell trap is a patented trap that "consists of two yellow plastic, sticky-coated rectangles (15 by 20 cm) that cross each other to form a two dimensional trap" (Katsoyannos et al., 2000).

Key Diagnostics/Identification

Approved Methods for Pest Surveillance*:

Morphological. *Rhagoletis cerasi* can be distinguished from the *Rhagoletis* species present in North America by the combination of its predominantly blackish body and its wing pattern, which includes an intercalary band, a small band on the anterior margin near the midlength, and a complete, unforked apical band. The native cherry-infesting species, including *R. cingulata* (cherry fruit fly), *R. indifferens* (western cherry fruit fly), and *R. fausta* (black cherry fruit fly), lack the intercalary band and have the apical band forked or broken into a posterior branch and an apical spot (Fig. 5) (USDA, 1983; White & Elson-Harris, 1992; Foote et al., 1993).

Any suspect positive samples should be sent to an expert in the family Tephritidae for definitive identification.

For additional guidance, see the keys in Foote, Blanc and Norrbom (1993).

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Easily Confused Species

Rhagoletis cerasi is similar to *R. berberidis*, which is currently not found in the United States; keys to differentiate adults of *R. cerasi* and *R. berberidis* and other Eurasian species can be found in Merz (1994), Korneyev and Merz (1997), and Kutuk and Ozaslan (2006). There are three *Rhagoletis* species found in North America that infest cherries: *R. cingulata* (cherry fruit fly), *R. indifferens* (western cherry fruit fly), and *R. fausta* (black cherry fruit fly) (USDA, 1983). *Rhagoletis cerasi* adults can be distinguished from these other species by their wing patterns (Fig. 5); the three species of *Rhagoletis* present in the United States that attack cherries lack the intercalary band and have a forked apical band or an apical spot (USDA, 1983; White & Elson-Harris, 1992; Foote et al., 1993). There are two species of *Rhagoletis* in the United States that have intercalary bands, *R. basiola* and *R. meigenii*; however, these species do not look very similar to *R. cerasi* (Lathrop and McAlister, 1931, Lathrop and Nickels 1931, 1932).

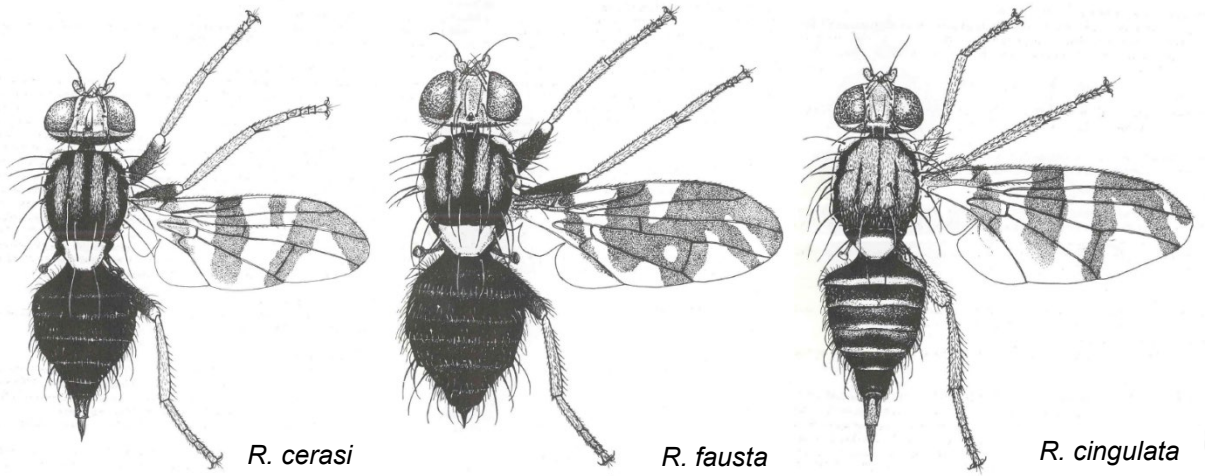

Figure 5. Body and wing pattern of adult female European cherry fruit fly (*R. cerasi*), black cherry fruit fly (*R. fausta*), and cherry fruit fly (*R. cingulata*) (White & Elson-Harris, 1992)

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May 2016: Complete update performed. 2016 Version posted to CAPS website.
July 2011: Final datasheet posted to CAPS website.

Revisions

May 2016

1) Revised the **Pest Description** section.
2) Revised the **Biology and Ecology** section. Added current research and explanation for unidirectional cytoplasmic incompatibility
3) Revised the **Pest Importance** section.
4) Revised the **Damage** section.
5) Revised the **Known Hosts** section.
6) Revised the **Known Distribution** section.
7) Added the **Pathway** section.
8) Revised the **Potential Distribution within the United States** section. Added a newly created map for the “Combined Host Density Map for *Rhagoletis cerasi* within the continental United States.”

9) Revised the **Survey** section. Added new trap and lure combinations in coordination with the PPQ Fruit Fly Cross Functional Working Group.
10) Revised the **Key Diagnostics/Identification** section. Section reviewed by subject matter experts.
11) Added photos to **Easily Confused Species** section. Section reviewed by subject matter experts.

October 2016

1) Revised the **Biology and Ecology** section. Provided additional clarification of unidirectional cytoplasmic incompatibility and the basis of host fidelity.
2) Revised **Known Hosts** section.
3) Added situation update on Canada in **Known Distribution** section.
4) Revised the **Potential Distribution within the United States** section. Added a new map using both bearing and non-bearing host acreage. Added information about U.S. distribution of *Lonicera*.
5) Revised the **Survey** section. Added new trap and lure combination. Previously approved lure no longer manufactured.
6) Added optional survey method of sweep net sampling in *Lonicera* in **Survey** section.
7) Added option of trapping in *Lonicera* in **Survey** section.
8) Added approval of negative data reporting from ammonium carbonate lures in **Survey** section.

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