FINAL REPORT **DURATION**: 1 YEAR

Project Title: Apple maggot host attractants

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Budget 1:

Organization: USDA-ARS		**Contract Administrator: Bobbie Bobango**	
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Item	**Year 1: 2007**	**Year 2:**	**Year 3:**
Salaries	0	0	0
Benefits	0	0	0
Wages	$11,000[1]	0	0
Benefits	$1,100	0	0
Equipment	0	0	0
Supplies	$1,500[2]	0	0
Travel	$1,400[3]	0	0
Miscellaneous	0	0	0
Total	$15,000	0	0

[1] One GS-5 technician; [2]Traps and components for lures; [3]Fuel for 2 personal car for travel to field sites to collect fruit/pupae and to conduct trapping experiments.

Budget note: $26,130 was also approved from the Washington State Commission on Pesticide Registration to support this work.

Budget 2: (*Complete only if funding is split between organizations***)**

Organization: Cornell University		**Contract Administrator: Donna Loeb**	
Telephone: 315-787-2325		**Email: drr2@cornell.edu**	
Item	**Year 1: 2007**	**Year 2:**	**Year 3:**
Salaries	$9,916	0	0
Benefits	$5,084	0	0
Wages	0	0	0
Benefits	0	0	0
Equipment	0	0	0
Supplies	0	0	0
Travel	0	0	0
Miscellaneous	0	0	0
Total	$15,000	0	0

Objectives: The project objectives were to develop an effective lure for Washington apple maggot flies based on discrimination of host fruit odors.

1. We will collect flies for flight tunnel tests and will use traps baited with hawthorn and apple volatile blends in central and western Washington.
2. We will do a preliminary comparison of the behavioral responses, in a flight tunnel, of apple maggot from Washington and New York to odorants already identified from apple and eastern hawthorn fruits.

Proposed Schedule of Accomplishments

Time Line	Objective 1: Field tests of odorants	Objective 2: Wind tunnel tests
2007	Test identified eastern fruit volatiles in western and central WA	Preliminary tests of eastern fruit volatiles with WA flies

Significant Findings:

● In the field, apple fruit volatiles were attractive to Washington *Rhagoletis* flies, although traps baited with ammonia overall caught slightly more flies than those baited with apple fruit volatiles.

● In the field, eastern hawthorn fruit volatiles were usually not attractive to Washington *Rhagoletis*, but occasionally were attractive to flies in apple trees.

● Effects of fruit volatiles appeared to depend on whether the host tree was apple or hawthorn, with overall responses to the apple volatiles higher in apple than ornamental hawthorn trees.

● In flight tunnel tests, apple origin flies from Washington were more attracted to apple than eastern hawthorn volatiles.

● In flight tunnel tests, black hawthorn origin flies from Washington were highly active, but did not show high responses to either apple or eastern hawthorn volatiles.

● In flight tunnel tests, ornamental hawthorn origin flies from Washington also did not show high responses to either apple or eastern hawthorn volatiles.

Results and Discussion:

1. We will collect flies for flight tunnel tests and will use traps baited with hawthorn and apple volatile blends in central and western Washington.

Flies for future flight tunnel tests were collected in central Washington and western Washington in 2007. A total of 58 pupae was collected from black hawthorn fruit in central Washington, and a total of >2,000 pupae was collected from apple and a similar number from black hawthorn and ornamental hawthorn in western Washington. Sticky red sphere traps baited with apple volatiles, eastern hawthorn volatiles, and ammonium carbonate were deployed in central and western Washington to capture apple maggots. The following areas and host trees were trapped using these treatments:

Central Washington: Wenas Wildlife Area, Yakima County
1) Host: Black Hawthorn (BH)

Western Washington: Saint Cloud Ranch, Skamania County
1) Host: Apple
2) Host: Black Hawthorn (BH)
3) Host: Ornamental Hawthorn (OH)

Western Washington: Washington State University (WSU), Clark County
1) Host: Apple
2) Host: Black Hawthorn (BH)
3) Host: Ornamental Hawthorn (OH)

Western Washington: Puyallup, Pierce County
1) Host: Apple, site 1 (Fruitland orchard)
2) Host: Apple, site 2 (Fourth street)
3) Host: Ornamental Hawthorn (OH)

For each of the 10 site/host tree combinations, there were 3 or 5 replicates, arranged in a randomized block design. Traps were rotated among trees once or twice a week over 2 to 3 months. The numbers of flies caught on traps when grouped by host trees on which traps were hung are shown in Figs. 1-3.

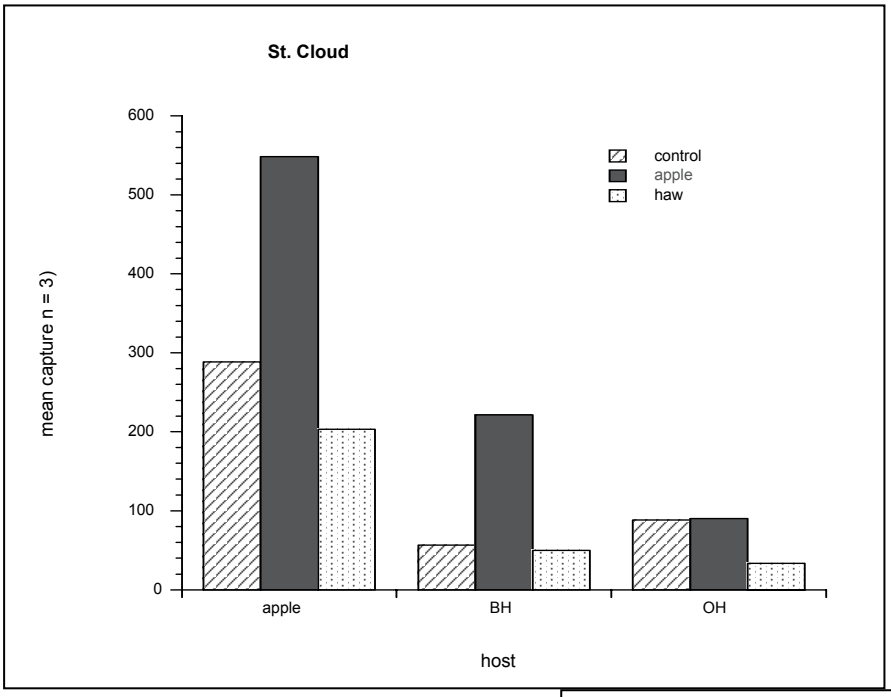

Fig. 1. Numbers of apple maggot flies caught on red spheres baited with fruit volatiles at St. Cloud Ranch, WA, 2007

At St. Cloud (Fig, 1), the apple volatile-baited treatment caught more flies than the control on apple, but not statistically different numbers on black and ornamental hawthorn trees. The hawthorn volatile-baited treatment did not catch more flies than in the control.

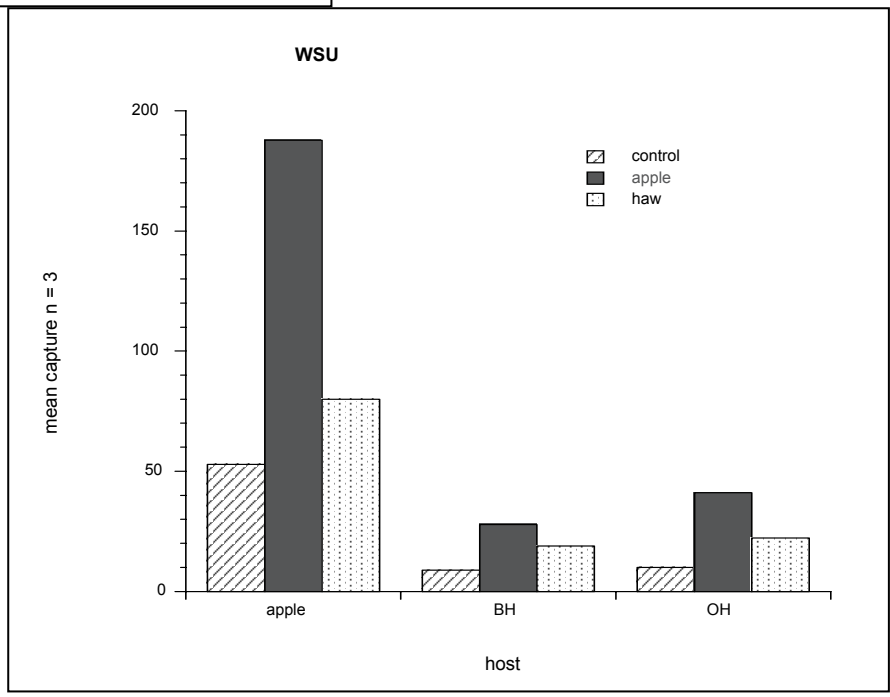

Fig. 2. Numbers of apple maggot flies caught on red spheres baited with fruit volatiles at WSU, 2007.

At WSU (Fig. 2), the apple volatile-baited treatment caught more flies than the control on apple and on black hawthorn, but not statisticallydifferent numbers on ornamental hawthorn.

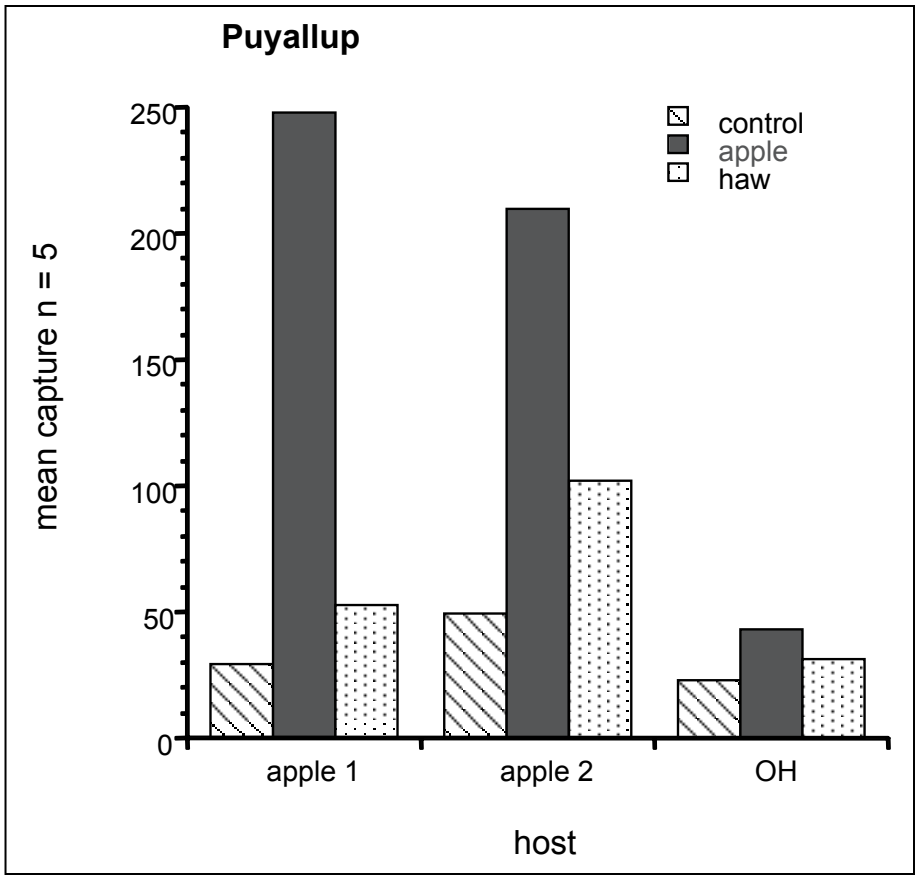

Fig. 3. Numbers of apple maggot flies caught on red spheres baited with fruit volatiles in Puyallup, WA, 2007.

In Puyallup (Fig. 3), the apple volatile-baited treatment caught more flies than the control on apple, although not on ornamental hawthorn. The hawthorn volatile-baited treatment caught more flies than the control on apple, but not on ornamental hawthorn. The apple volatile-baited treatment caught significantly more flies than the hawthorn volatile-baited treatment on apple.

Overall, the ammonia treatment caught more flies than the control at 3 of 4 sites, and more than the apple lure treatment at 1 of the sites. The apple lure treatment also caught more flies than the control at 3 of 4 sites, and more than the ammonia treatment at 1 site. The hawthorn lure treatment caught more flies than the control at 2 of 4 sites (both in Puyallup), but not more than the ammonia and apple lure treatments at any site.

2. We will do a preliminary comparison of the behavioral responses, in a flight tunnel, of apple maggot from Washington and New York to odorants already identified from apple and eastern hawthorn fruits.

We conducted wind tunnel tests in 2007 using flies that were reared from apple, black hawthorn, and ornamental hawthorn (apple, black hawthorn, and ornamental hawthorn origin flies) in 2006 or from the field in early summer 2007 (these were not the flies noted above that were collected in 2007 for future flight tunnel tests). Apple origin flies (Fig. 4) took flight more frequently in the presence of the apple than haw lure, and landed more frequently on apple- than haw-baited spheres, at about 20-40% versus about 0-20%. Black hawthorn origin flies (Fig. 5) took flight at high frequencies in the presence of either haw or apple lures, but the percent upwind flights over a 1 m distance and landing on the source by these flies on haw and apple lure-baited spheres was lower, at <15%. The percentages that took flight were higher than in apple origin flies. Ornamental hawthorn origin flies took flight at similar frequencies in the presence of the haw or apple lure, and the percent landings on haw and apple lure-baited spheres were low, at <20% (Fig. 6).

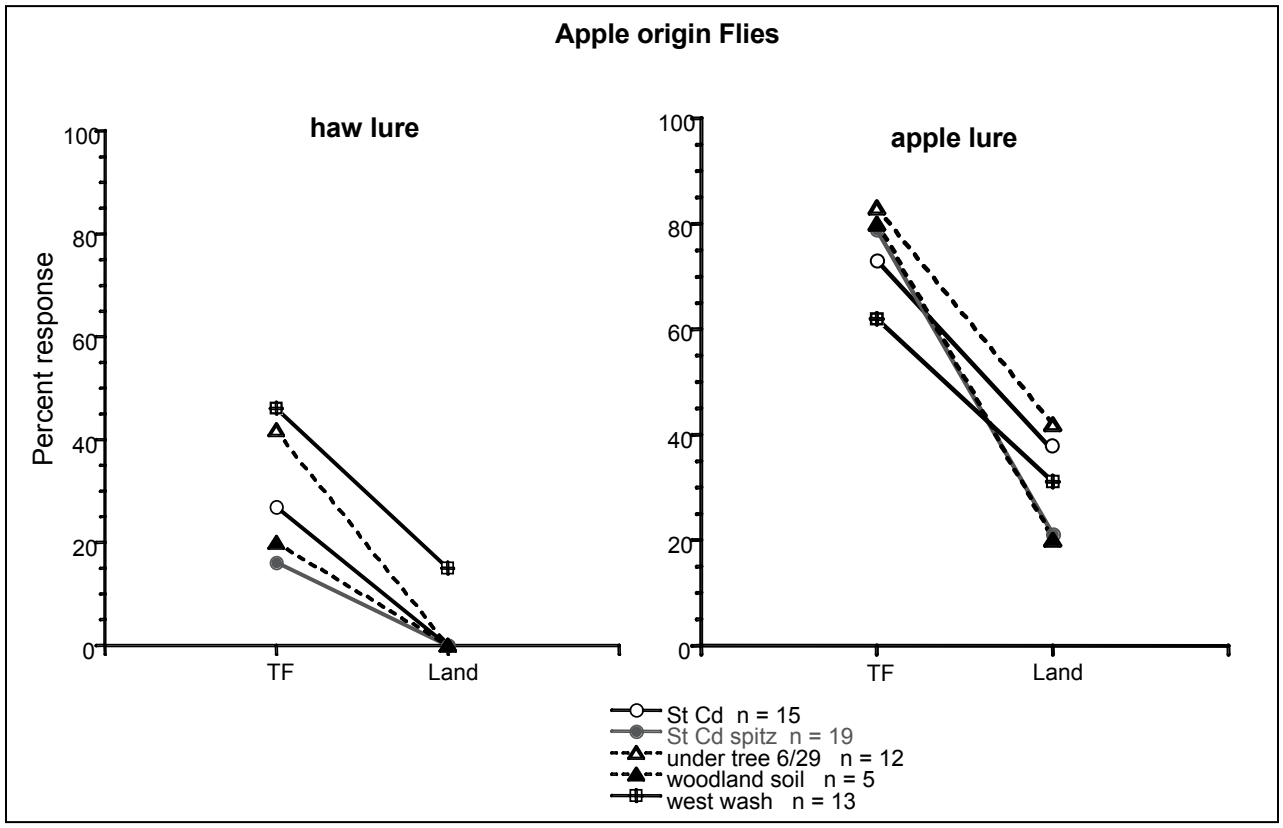

Fig. 4. Responses of apple origin flies collected in Washington to haw and apple lures on red spheres inside a flight tunnel. TF = take flight. Land = land on baited red sphere.

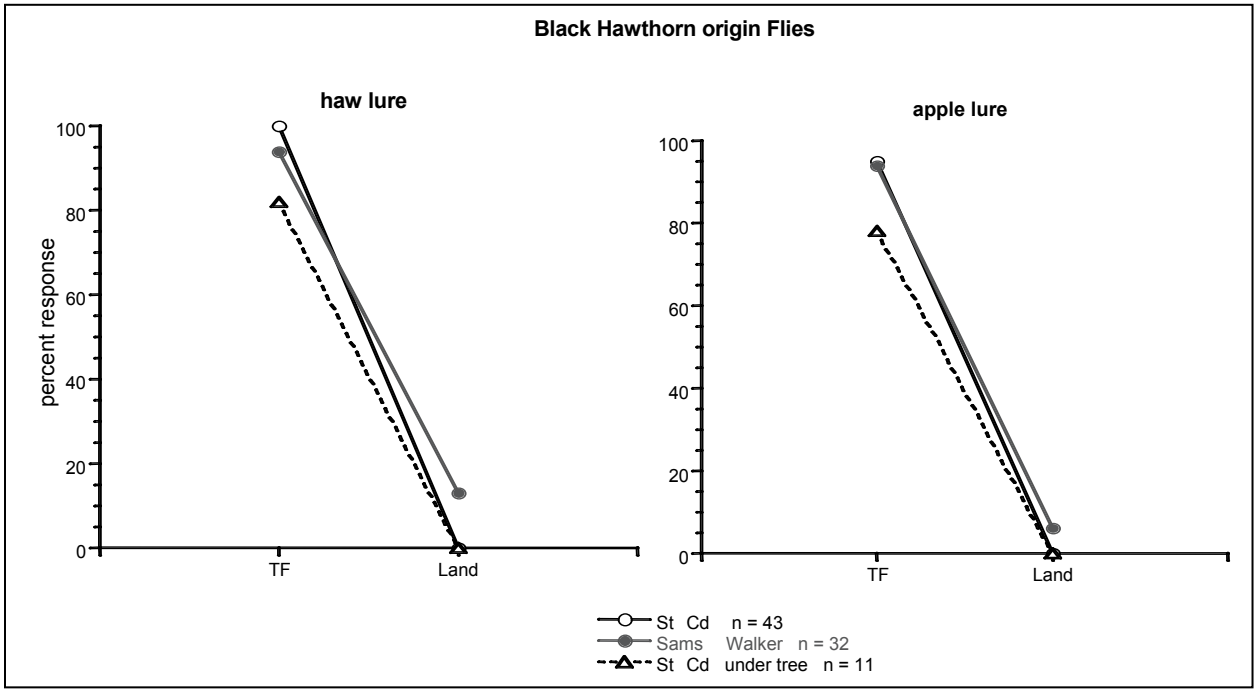

Fig. 5. Responses of black hawthorn origin flies collected in Washington to haw and apple lures on red spheres inside a flight tunnel. TF = take flight. Land = land on baited red sphere.

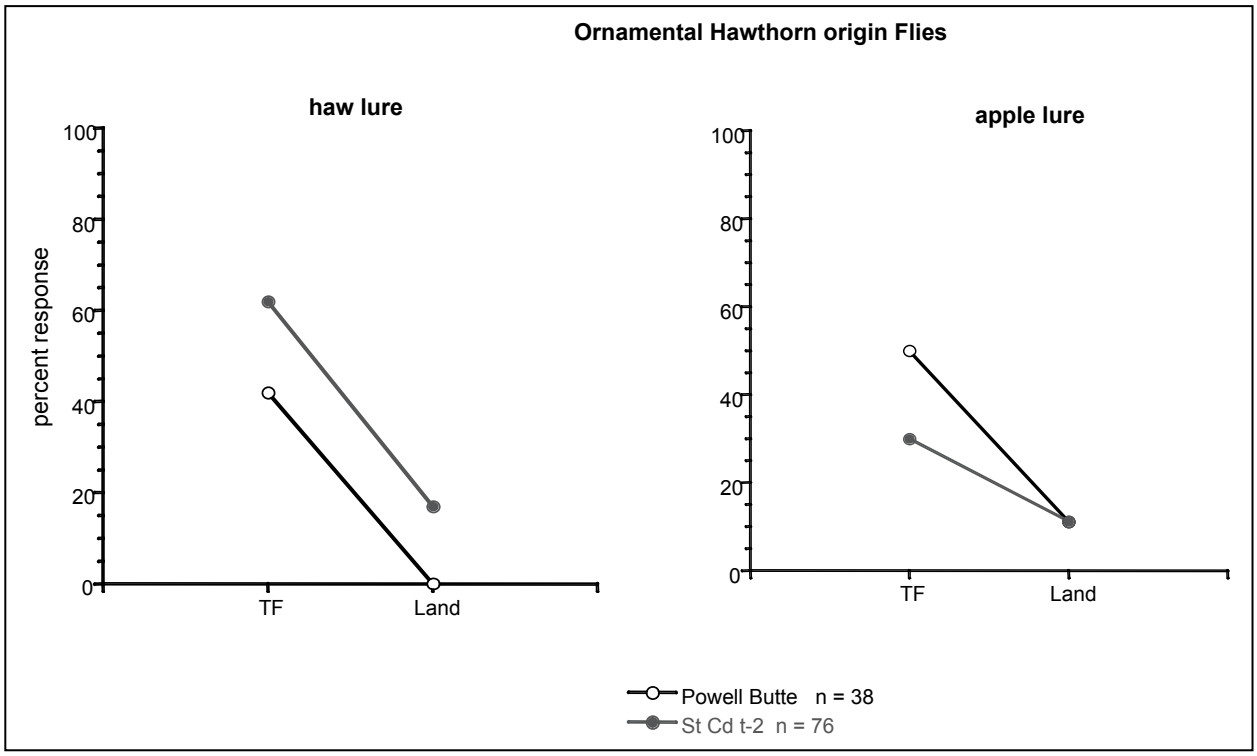

Fig. 6. Responses of ornamental hawthorn origin flies collected in Washington to haw and apple lures on red spheres inside a flight tunnel. TF = take flight. Land = land on baited red sphere.

Discussion

1. We will collect flies for flight tunnel tests and will use traps baited with hawthorn and apple volatile blends in central and western Washington.

Our results show that fruit volatile blends are attractive to *Rhagoletis* flies in Washington state. In particular, the apple volatiles attracted nearly as many flies as the ammonium carbonate lure. The eastern hawthorn volatile lure was usually not attractive, except in one instance where it was more attractive than controls on apple in Puyallup.

In the apple maggot survey and detection program conducted by the Washington State Department of Agriculture (WSDA), traps are placed in non-commercial apple, black hawthorn, and ornamental hawthorn trees for monitoring apple maggot, so our results have relevance to the program. In particular, we found that apple volatiles appeared to work best in apple trees. However, whether this was because apple volatiles in hawthorn trees resulted in apple-hawthorn volatile antagonism is unclear, because hawthorn volatiles in apple trees in Puyallup also were somewhat attractive.

In Wenas, in central Washington, numbers of flies caught on traps baited with apple lures in black hawthorn did not catch significantly more flies than the control or hawthorn lure. Whether a lure containing components of black and not eastern hawthorn odor would have attracted more flies in these hawthorn trees needs to be examined. We need to survey these low population areas and develop a black hawthorn specific lure to compare with apple and ammonia.

Host effects may also be caused by different seasonal phenologies of the hosts' fruit development and the interaction of their odors when the plants are near one another. Apples and black hawthorn fruit

generally ripened earlier than ornamental hawthorn fruit, but different apple varieties used in tests ripened at different times and there appeared to be much overlap in ripening times of apple and black hawthorn. Possibly the mix of odors from different hosts when hosts occurred together or the lack of some odors when hosts were more isolated affected the attractiveness of the apple or hawthorn lure.

A major benefit in using fruit volatiles rather than ammonia is that snowberry maggot flies were not attracted to the apple fruit volatiles, whereas they were attracted to ammonia. Snowberry maggot flies look nearly identical to apple maggot flies and are abundant in central Washington. They were commonly caught on red spheres baited with ammonia, but not with apple volatiles, hung in hawthorn trees. Because the two flies are so similar in appearance, in regulatory work it is necessary to look at each fly under a microscope to examine it for morphological differences. This is a time consuming process. The ideal attractant blend for apple maggot, therefore, is one that is highly attractive but yet does not attract too many non-target flies and snowberry maggot flies. One possibility is an attractant blend based on volatiles from black and not eastern hawthorn fruit.

Our results with the eastern hawthorn fruit volatile lure showed it was not or only slightly attractive in some cases to Washington apple maggot flies. Why they were only occasionally attractive is unknown. Possibly this was because flies in particular areas were broadly responsive. In the eastern U.S., the hawthorn volatiles tested attracted many flies on hawthorn, suggesting there are genetic differences between western flies on apple and hawthorn and eastern fly populations on hawthorn.

2. We will do a preliminary comparison of the behavioral responses, in a flight tunnel, of apple maggot from Washington and New York to odorants already identified from apple and eastern hawthorn fruits.

The behavioral responses of flies reared from apple and from black and ornamental hawthorn toward haw and apple lure odors differed. Apple origin flies (Fig. 4) responded more to apple than haw lures, consistent with field trapping results showing there are attractive components in the apple lure. However, while high percentages of black hawthorn origin flies took flight and were therefore very active flies, few of these flies were attracted to either haw or apple lures (Fig. 5). Taken together with results with apple origin flies, it appears there might be a host effect on responses to fruit odors. Although the percentages of ornamental hawthorn origin flies that took flight were lower than of black hawthorn origin flies, these flies also did not appear to respond to haw and apple odors (Fig. 6).

Future work should (1) confirm if there are true differential responses of flies to the apple lure among apple and different hawthorn trees; determine (2) whether the apple lure is effective with traps in central and western Washington if traps are replaced only once or twice during the season; (3) whether volatiles from black hawthorn in Washington are attractive to flies reared from black hawthorn; and (4) whether a lure with volatiles from black hawthorn fruit would be effective and more selective for apple maggots in Washington than the apple lure, when used in apple and black and ornamental hawthorn trees.