FINAL REPORT
Project # CH-01-13

Project title: Host and Feeding Preference of Cherry Fruit Fly
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Objectives:
2001
- Determine cherry fruit fly activity within days and during the season.
- Relate fly abundance to larval infestation of fruit.
- Determine distances flown by the flies.

2002
- Determine host use patterns by flies in eastern and western Washington.
- Determine the preference of flies for different varieties of sweet and sour cherries and native hosts in the laboratory, and ...
- Developmental rates of flies in these different hosts.

2003
- Continue to monitor fly populations on sour and sweet cherries in eastern and western Washington and identify new hosts.
- Identify food sources of flies on different cherry hosts over the season in eastern and western Washington.
- Evaluate the food sources and preferences in the laboratory, with goal of incorporating foods in baits for control.

Significant findings:
2001
- Males were found mostly on fruit, but females were found equally on fruit and leaves; flies were most during active midday.
- There was a poor relationship between flies detected using unbaited yellow panels and larval infestation of fruit.
- Flies dispersed from host trees, whether they had fruit or not, averaging 50 m after 2 weeks.

2002-2003
- Sour cherries had many more adult flies than sweet cherries in eastern Washington. This pattern may have been caused by a loss of sweet cherries due to birds and not a preference by the flies for fruit. Numbers on the two hosts were similar in western Washington.
- Flies preferred to lay eggs into sour over sweet cherries, but the differences were not large. Host preference may play a role, with one factor being fruit color or visibility.
- New hosts of the cherry fruit fly were English laurel, *Prunus laurocerasus*, a hedgerow plant, and possibly black hawthorn, *Crataegus douglasii* (pending emergence of adults in winter) in western but not in eastern Washington (preference for these hosts not determined).
- Bitter cherry appeared to be preferred over cascara, and choke cherry was not preferred.
- Bitter cherries with high fly populations were seen from July into September in the Nile Valley, a ponderosa pine ecosystem, near the commercial growing areas.
- Cultivated cherries appear to be preferred over bitter cherries and cascara.
- Flies apparently cannot survive on leaves alone, suggesting the amounts of leaves the flies need to obtain enough food is substantial.
- Leaves had sugars on the surface, but the minute amounts were unable to sustain the flies. Fruit (at least when opened) and aphid honeydew thus far appear to be the main or certainly the most concentrated sugar sources for flies.
- Flies seemed to preferred concentrated sugars over diluted sugars, and sugars over protein foods.

- Flies are probably highly attracted to concentrated food baits because foods in nature appear to be in diluted and scattered.

Methods (2003):

1. Fly numbers on 4-6 pairs of sour and sweet cherries in 2003 were determined throughout the season, as in 2002. Fruit samples were collected at bi-weekly basis from trees to determine larval infestations of fruit. Adult and larval numbers on bitter cherry and cascara in western Washington were determined weekly or bi-weekly to document their possible role in contributing to fly populations on cultivated cherries.
2. Choice experiments using whole branches with fruit from sour and sweet cherry trees that had been held inside sleeves were conducted.
3. To determine if substances on leaves and fruit can sustain longevity and fecundity and whether possible nutrients on them change over the season, branches with intact and damaged leaves and fruit were removed from cultivated and native host trees throughout the season and brought into the laboratory, placed in containers with water (to keep them fresh) inside cages, and exposed to flies. Five groups of 10 field-collected male and female flies were exposed to substrates. Observations were made to determine if a preference for fruit or leaves existed.
4. Substances from leaves were washed and the concentrates dried on plastic. Groups of 3-5 females and males were exposed to the fruit and leaf concentrates and also to whole fruit and leaves to determine if a preference in foods and their form exists.

Results and Discussion:

<u>2001</u>

Male and female flies differed in their activity on leaves and fruit. Males spent the majority of their day on fruit, whereas females spent equal time on fruit and leaves. Both were most active midday. This suggests that short-lived insecticides on leaves will be especially effective and immediate against females that feed on leaves.

There was a poor relationship between flies detected using unbaited yellow panel traps and larval infestation of fruit. This indicates the traps used were not attracting large percentages of flies in the population, and that better attractants are needed. However, for detection purposes, traps will detect at least some flies if populations are large.

Flies dispersed readily from host trees, averaging 50 m after 2 weeks. This seems to occur regardless of whether fruit are present or absent in trees. This apparent instinct to disperse is important because flies dispersing from infested backyard trees seem to be the major threat to commercial orchards. Factors that cause large numbers to disperse are especially important and need to be studied.

<u>2002-2003</u>

Sour cherries had more adult flies than sweet cherries in eastern Washington in 2002 and 2003 (Fig. 1). This pattern was apparently caused in part by the loss of sweet cherries due to birds and not a clear preference by the flies for sour cherry fruit (Table 1), or to greater development on sour cherries, as size and survivorship of pupae from the two hosts were similar. This does not preclude an actual preference, as color and visibility of sour cherries may be greater than sweet cherries, especially when both are ripe. When both fruit are on the trees, infestation rates between sour and sweet fruit are similar (Fig. 2). This suggests that the greater adult numbers seen on sour trees are a result of fruit loss. The fact that sour trees retain fruit longer indicates they are greater producers of flies and thus a greater threat to commercial orchards in the Yakima Valley. This is apparently not the case in western Washington, where infestations on the two are nearly equal.

New hosts of the cherry fruit fly were discovered. These were native cascara, *Rhamnus purshiana*, introduced English laurel, *Prunus laurocerasus*, a hedgerow plant, and possibly native black hawthorn, *Crataegus douglasii* (pending emergence of adults in winter). Six English laurels were sampled in 2003. From these, 140 pupae were obtained from 1,672 fruit (0.084 larvae/fruit). These are hosts in western Washington, but apparently not in eastern Washington.

Native trees and cultivated cherries were attacked by cherry fruit flies across the state. Cascara, bitter cherry, and black hawthorn were hosts in some form in the coast forest ecosystem in western Washington (Fig. 3), but cultivated sweet and sour cherries seemed to be more preferred than any of these native hosts (Table 2). Bitter cherries but not chokecherries or black hawthorn were infested with high fly numbers in the ponderosa pine ecosystem of the Nile Valley (Fig. 4). This population is important because it is fairly close to commercial plantings. Similar populations probably exist near the canyons in Wenatchee. Flies from these may be a source of flies in commercial plantings. Cultivated cherries in backyards or urban settings appear to be the only cherry fruit fly host in the sagebrush-bunchgrass ecosystem of the Yakima Valley (Fig. 5). This is important because in this area these trees can be specifically targeted for control of flies. However, flies on native hosts in the other ecosystems need to be monitored as they represent continual threats to the industry.

Flies apparently cannot survive on leaves alone (Table 3), suggesting the amounts of leaves the flies need to obtain enough food is substantial. Gas chromatography analyses indicated leaves had sugars on the surface, but the minute amounts were unable to sustain the flies. Flies placed in beakers with leaf and fruit concentrates died within 3 days, same as controls. Surprisingly, even intact fruit failed to sustain the flies. Fruit and aphid honeydew thus far appear to be the main or certainly the most concentrated sugar sources for flies (especially if ripe fruit are opened by birds). The results suggest food is scarce in the environment or at least is difficult to find in concentrated form. Laboratory results indicated flies fed on large amounts of 20%-60% sucrose, but only on small amounts of 2% sucrose. In addition, flies did not feed on protein sources alone without a sugar stimulant, indicating a preference for sugar over protein foods.

Conclusions

The threat of cherry fruit flies to the commercial cherry industry is continual because of the presence of high fly numbers on cultivated sour and sweet cherry trees in abandoned lots and residential yards and on native hosts. No clear factor as yet explains fly predominance on some seemingly preferred hosts. Flies are clearly able to sustain themselves by feeding on sugars and proteins within trees, but food sources have been difficult to identify. Once fly populations are established on hosts, substantial efforts are needed to remove the populations, as the flies do not require outside vegetation for sustenance. The knowledge gained in this project lays the foundation for future work on how to control the flies on a variety of native hosts and cherries using food-based sprays.

Table 1. Preference of cherry fruit fly for sour and sweet cherry fruit on paired branches, 2003.

	Sour Cherry (Mean ± SE)	Sweet Cherry (Mean ± SE)	t	*P*
Preference Parameter				
Males on Fruit[a]	0.80 ± 0.19	0.18 ± 0.14	2.820	0.0667
Females on Fruit[a]	0.20 ± 0.08	0.12 ± 0.12	0.475	0.6645
Males on Leaves[a]	0.22 ± 0.06	0.60 ± 0.29	-1.367	0.2651
Females on Leaves[a]	0	0	------	------
Eggs per Fruit	0.50 ± 0.18	0.03 ± 0.02	2.687	0.0746
% Fruit with eggs	24.8 ± 7.8	2.2 ± 1.3	3.596	0.0369
Fruit Characteristics				
Diameter (cm)	1.97 ± 0.04	2.60 ± 0.06	7.667	0.0046
Weight (g)	4.23 ± 0.21	9.06 ± 0.48	8.025	0.0040
Hardness (durometers)	34.4 ± 1.7	56.0 ± 4.6	5.896	0.0097
% Sugar	14.2 ± 0.4	27.8 ± 1.0	11.030	0.0016

Five or 6 females and 29 males released per cage
[a]Per 1.5-2 min observations

Table 2. Adult *Rhagoletis indifferens* presence and larval infestation of native trees and cultivated cherries in representative sites within three ecosystems in WA, 2001-2003.

Coast Forest Ecosystem (Vancouver and vicinity)							
			2001				
Tree Species	No. Trees Trapped	Pct. with Flies	No. Trees Fruit Picked	% Trees Infested	Total Fruit	Total Pupae[a]	Pupae/fruit/ Tree ± SE
Cascara	3	100.0	3	-------	------	7	-----[b]
Black Hawthorn	14	64.3	-------	-------	------	-----[b]	-----[b]
			2002				
Cascara	7	57.1	8	75.0	3,885	94	0.024 ± 0.010
Bitter Cherry	8	75.0	13	92.3	6,059	615	0.125 ± 0.029
Black Hawthorn	20	90.0	6	------[b]	2,095	------[b]	------[b]
Cultivated Cherry	51	31.4	6	83.3	808	26	0.030 ± 0.009
			2003				
Cascara	16	37.4	18	33.3	3,922	21	0.004 ± 0.002
Bitter Cherry	27	51.8	29	89.5	8,761	1,021	0.139 ± 0.024
Black Hawthorn	26	55.6	18	-------[b]	4,465+[b]	375+[b]	--------[b]
Cultivated Cherry	42	64.3	39	82.1	1,260	539	0.417 ± 0.061

Ponderosa Pine Ecosystem (Nile Valley)							
			2003				
Tree Species	No. Trees Trapped	Pct. with Flies	No. Trees Fruit Picked	% Trees Infested	Total Fruit	Total Pupae[a]	Pupae/fruit/ Tree ± SE
Bitter Cherry	30	96.7	26	73.3	9,880	346	0.107 ± 0.022

Table 2, continued

Choke Cherry	24	8.3	22	0	7,516	0	0
Black Hawthorn	12	8.3	11	0	6,106	0	0

Sagebrush-Bunchgrass Ecosystem (Yakima Valley)

Tree Species	No. Trees Trapped	Pct. with Flies	No. Trees Fruit Picked	% Trees Infested	Total Fruit	Total Pupae[a]	Pupae/fruit/ Tree ± SE
			2001				
Choke Cherry	14	0	-------	------	------	------	------
Cultivated Cherry	40	92.3	40	92.5	20,918	5,561	0.337 ± 0.05
			2002				
Choke Cherry	26	15.4	3	0	596	0	0
Cultivated Cherry	32	53.1	32	71.9	6,026	1,694	0.278 ± 0.053
			2003				
Choke Cherry	44	2.3	44	0	27,354	0	0
Black Hawthorn	17	0	8	0	3,248	0	0
Cultivated Cherry	37	94.6	28	96.4	4,875	3,650	0.745 ± 0.210

---------, data not collected.

[a]Fly identification confirmed by rearing to the adult stage.

[b]2001, 2002, not reared to determine if *R. indifferens*; 2003, currently being reared to determine if *R. indifferens* or apple maggot, *R. pomonella*.

Table 3. Percent survival ± SE of cherry fruit flies exposed to different substrates in the field and laboratory, 2003. Four replicates each.

Treatment	Field (23 flies/rep)	Laboratory (8-11 flies/rep)
Control	0.0 ± 0.0a	11.1 ± 11.1a
Leaves Only	43.5 ± 20.7bc	2.8 ± 2.8a
Fruit Only	5.4 ± 4.1ab	48.9 ± 3.2b
Leaves + Fruit	54.3 ± 13.8c	43.9 ± 13.9b
Leaves + Fruit + Aphids	71.7 ± 5.8c	65.8 ± 6.1b

Means with the same letters within columns are not significantly different ($P > 0.05$).

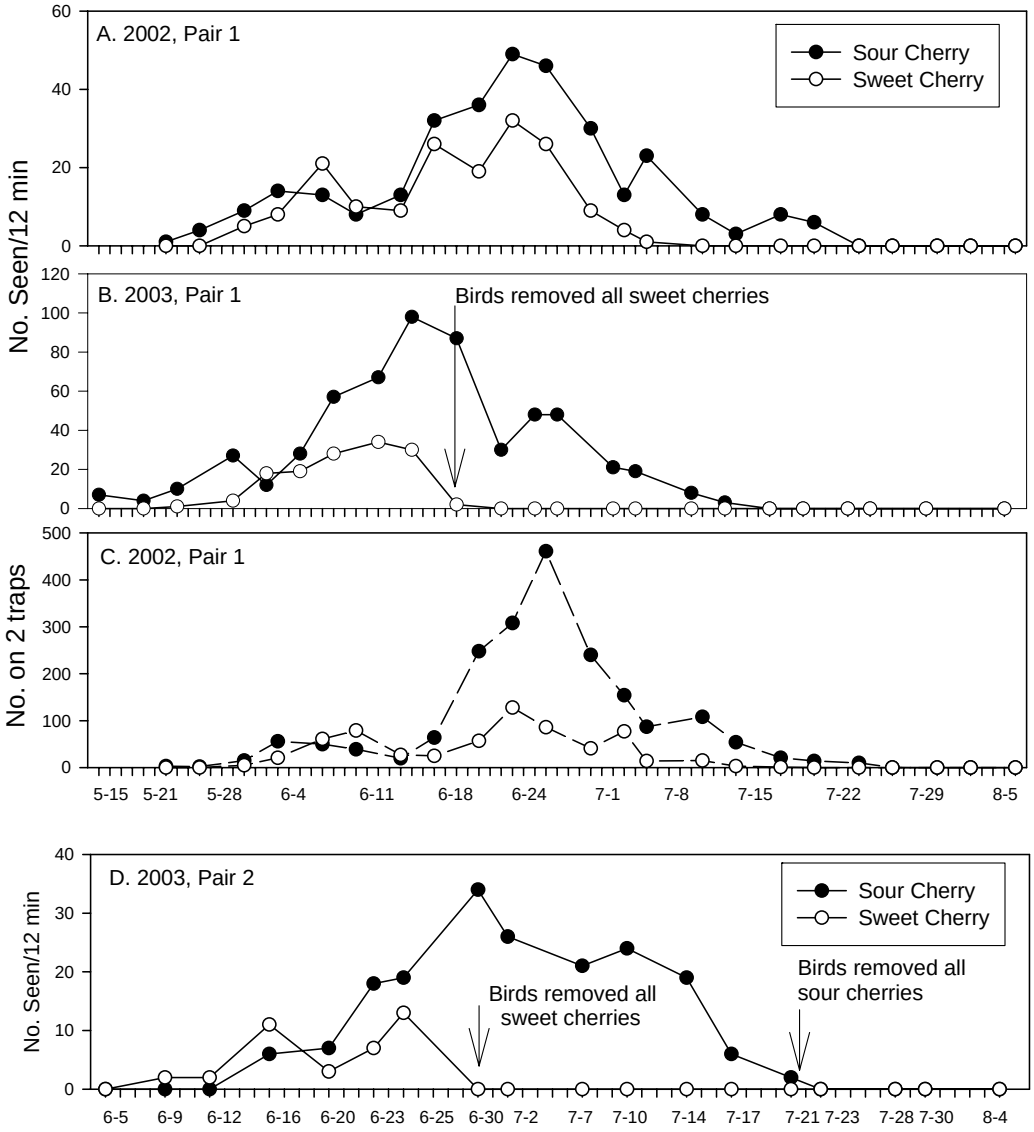

Fig. 1. Cherry fruit fly abundance on representative sour and sweet cherries in the Yakima Valley, 2002-2003.

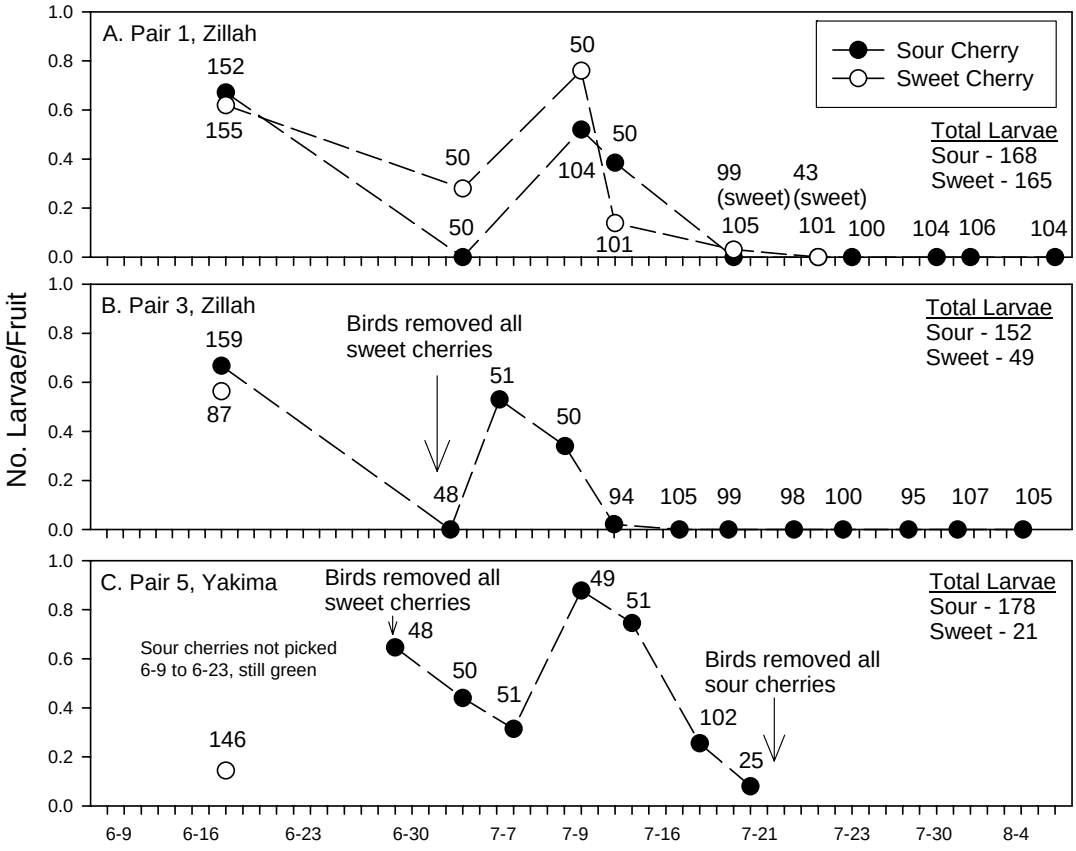

Fig. 2. Infestation of sour and sweet cherry fruit by cherry fruit flies in the Yakima Valley, 2002.

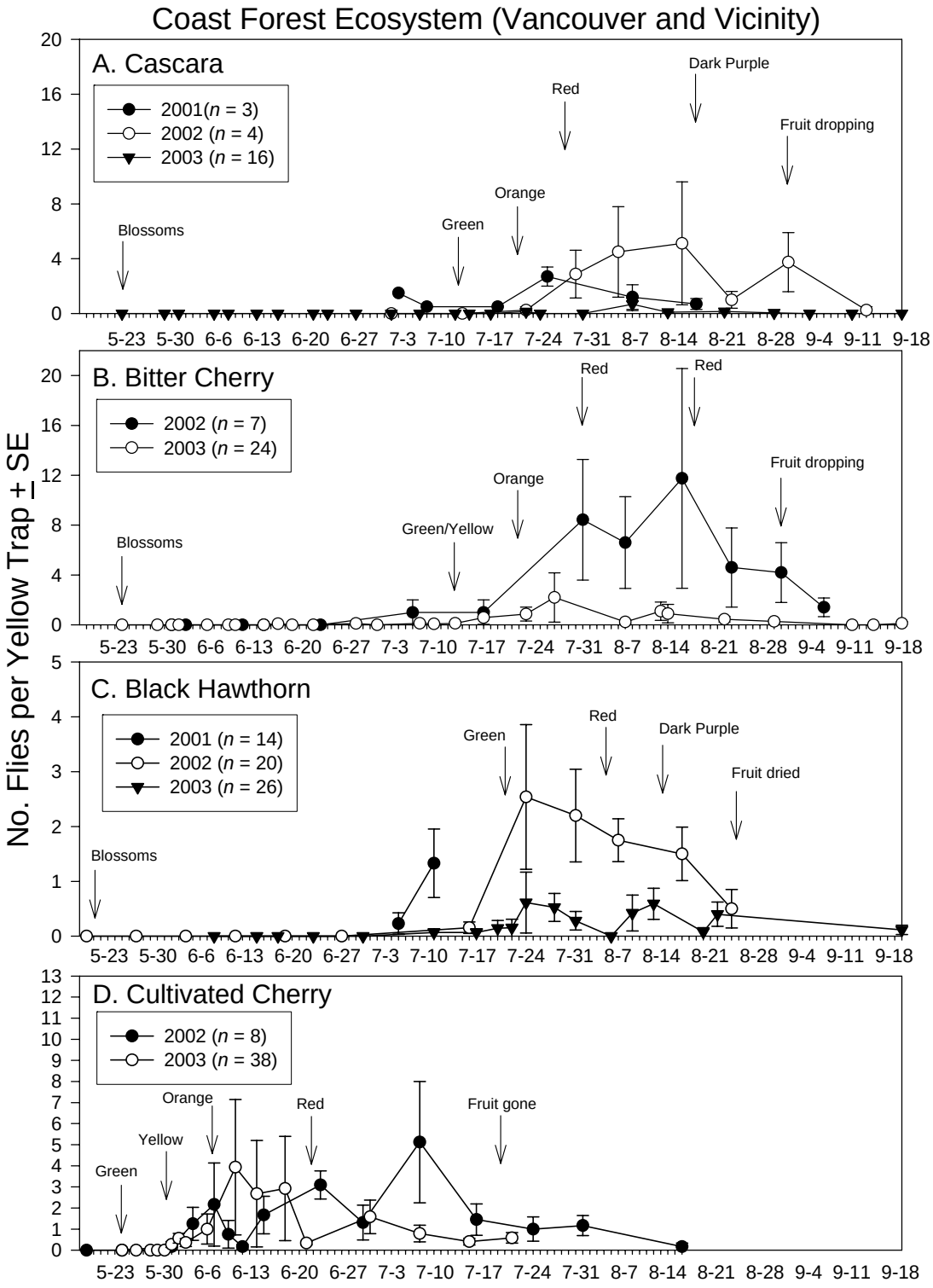

Fig. 3. Use of native trees and cultivated cherries by cherry fruit flies in the coast forest ecosystem.

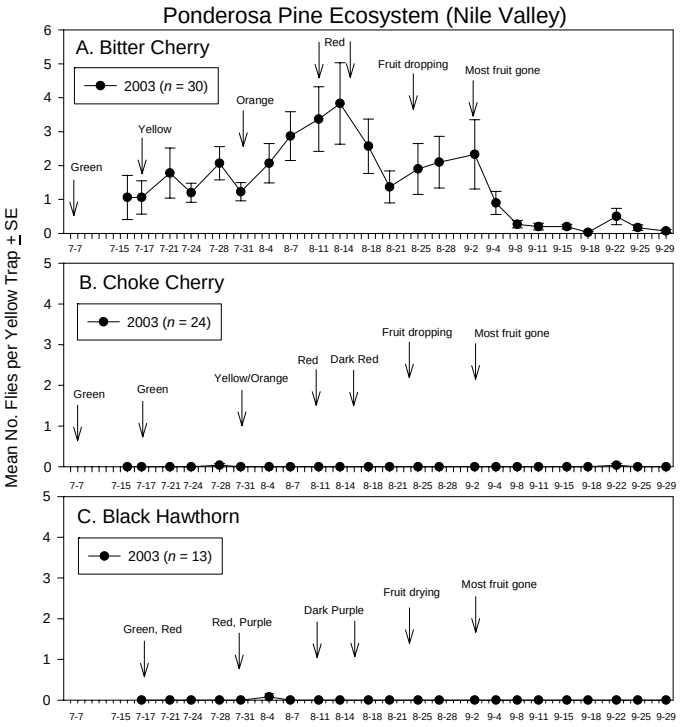

Fig. 4. Use of native trees by cherry fruit flies in the ponderosa pine ecosystem.

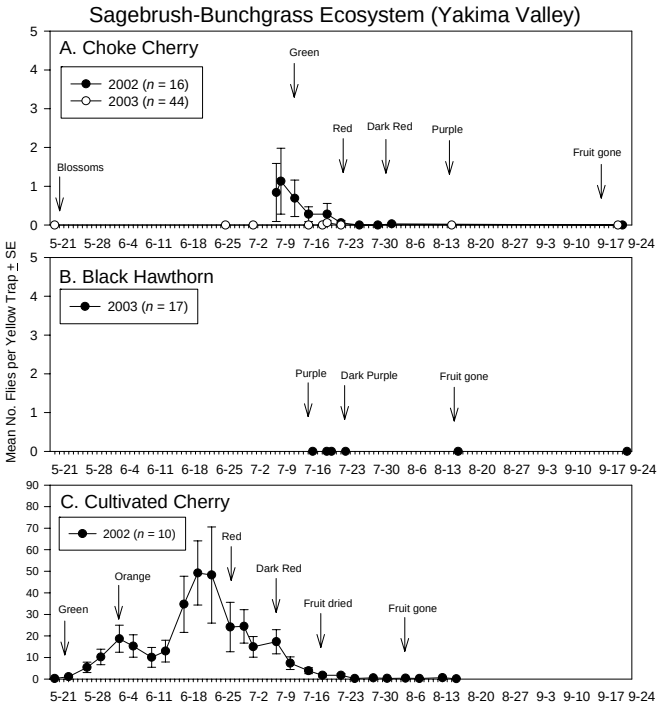

Fig. 5. Use of native trees and cultivated cherries by cherry fruit flies in the sagebrush-bunchgrass ecosystem.

Budget:
Project title: Host and Feeding Preference of Cherry Fruit Fly
PI: Wee Yee
Project duration: 2001-2003
Current year: 2003
Project total (3 years): **$54,477.60**
Current year requested: **$21,977.60**

Year	Year 1 (2001)	Year 2 (2002)	Year 3 (2003)
Total	14,000	18, 500	21,977.60

Current year breakdown

Item	Year 1(2001)	Year 2 (2002)	**Year 3 (2003)**
Salaries	11,000	16,000	**18,616.00**[1]
Benefits (%)			**1,861.60**
Wages			
Benefits (%)			
Equipment	2,500	1,000	
Supplies			
Travel	750	1,500	**1,500**[2]
Miscellaneous			
Total	14,000	18,500	**21,977.60**

[1]GS-6 ($13.19/h), full time, 6 months, and 1 GS-3 ($9.42), full time, 3 months; [2]To field sites.