FINAL REPORT

Managing Lab and Field Populations of Cherry Fruit Fly - Final Report
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The objectives of the project in 2001-2002 were to:
1. Develop a laboratory source of larval and adult flies available throughout the year for biological studies.
2. Manage a cherry orchard at the ARS Moxee Farm specifically to establish a population of cherry fruit flies for use in field studies.
3. Initiate trapping studies to determine degree day phenology of flies, to test attractants, to conduct behavioral studies and to determine dispersal distances.

Prior to 2001, work was already underway to establish a western cherry fruit fly colony to provide flies for research. In 2000, traps collected flies at Moxee for the first time. These presumably originated from infested fruit brought in from other areas. A transect indicated that some cherries from all trees were infested. Of 240 fruit collected (10 per tree), 103 pupae were collected. In the laboratory, over 1,600 field-collected flies were used in quarantine treatment studies, and 60 flies in attractant research. In addition, over 50% of eggs laid on artificial wax domes ultimately became pupae, which was the highest conversion rate achieved.

Results
Objectives 1, 2, and 3 were met during 2001, as follows.
Objective 1.
A laboratory colony of flies was successfully established at the Yakima Agricultural Research Laboratory. This colony allowed experiments to be conducted during fall, winter, and spring, periods when the flies are absent in the field. The colony originated from extensive field collecting of infested fruit from > 200 trees in Yakima, Benton, Chelan, Douglas, and Kittitas Counties. Larvae dropped from fruit into soil held in tubs, where they pupated. After 1-2 weeks at room temperature, pupae were transferred to a cold room held at 3 °C for 4-7 months. Emerged flies were allowed to lay eggs into fruit in the laboratory. The larvae and pupae were obtained, and then pupae were to adults in order to perpetuate the colony. Flies also were allowed to lay eggs onto artificial wax domes. Larvae were then placed in artificial diet, and then reared to adults. Rearing on cherries obtained from Chile and stored during the winter resulted in higher production of flies and will be the preferred rearing method in the future, whereas use of artificial diet (AliNiazee and Brown 1977) will serve as a backup method. Procedures for maintaining flies in the cold during diapause also were developed. Flies were found to emerge over a wide range of time, in agreement with previous studies (Van Kirk and AliNiazee 1981, Stark and AliNiazee 1982). Emergence of flies reached 80% in many cases. In some, only 20-30% emerged, and studies are planned to determine why emergence was low in these cases. Although some of the flies that emerged in the laboratory were used to perpetuate the colony, the majority were used in detailed biological studies, including a study on the effects of different sugar concentrations and cherry, sugar and yeast diets on fly feeding duration, longevity and fecundity. This study is near completion and data are summarized in Tables 1, 2, and 3. In addition to this study, a mating study (Table 4) and several studies on the effects of nematode (Tables 5 and 6)

and *Bacillus thuringiensis* exotoxin on fly mortality were conducted using flies from the established colony. Thus the establishment of the colony was invaluable in providing flies needed in many studies that will help in understanding fly biology and ultimately in fly management in cherry orchards.

Objective 2.

The cherry orchard at the Moxee Farm was successfully infested. Fruit collected in 2000 were infested with maggots, as they were in 2001. Visual inspection of trees confirmed fly presence and that flies were attacking the cherries. The flies in this orchard were used to initiate field studies (below).

Objective 3.

Temperature and humidity data were gathered from July through mid August. This allowed degree-day models (AliNiazee 1976, 1979) to be used in predicting fruit fly emergence. Because of its relatively high altitude, flies at Moxee emerged 1-2 weeks later than the surrounding areas (Tri-Cities, Zillah, and Yakima). One hundred yellow sticky traps were hung on trees during July to confirm infestation. A total of 428 flies was collected on ammonia-baited traps between 10-24 July, confirming high infestation. Numbers caught in these traps on 9 days (at 2 or 3 day intervals) were 176, 145, 22, 27, 13, 15, 12, 3, and 4. Because the orchard was isolated, it was unlikely these flies originated from outside the orchard. These data provided information on seasonal activity of resident flies at the orchard, and they should prove valuable in planning future work at this site. Approximately 200 flies from the orchard were also collected for a dispersal study, marked, released, and re-sighted or re-captured. Dispersal distances of flies in the presence and absence of high fruit loads in this study were determined (Table 7).

Discussion

The establishment of laboratory and maintenance of field populations of the western cherry fruit fly proved indispensable for research. We tested and modified techniques published before on cherry fruit fly colonization (AliNiazee and Brown 1977). Without the laboratory colony, research progress would have been slowed considerably, and would have been impossible during the winter. Research would have been possible only from May to August, when the fly is active in the field. Without the field population at Moxee, field research would have been and potentially will be greatly hindered. Although the research can still proceed because of homeowners who cooperate and allow us use of their infested trees, this cannot be considered a reliable resource in the future, whereas the Moxee orchard can be a reliable resource indefinitely. Because much of the research in fly management begins with preliminary, controlled laboratory studies or experiments, there remains a continual need for a laboratory colony of the western cherry fruit fly.

Literature Cited

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Stark, S. B. and M. T. AliNiazee. 1982. Model of postdiapause development in the western cherry fruit fly. Environ. Entomol. 11: 471-474.

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Tables 1-7: Studies resulting from establishment of laboratory and maintenance of field populations of western cherry fruit fly, *Rhagoletis indifferens*

Table 1. Mean feeding duration (min) and longevity (d) ± SE of female and male *Rhagoletis indifferens* fed single meals of cherry juice, sucrose of different concentrations, and dry sugar-yeast diet 1-2 days after emergence.

	Females			Males		
Treatment	*N*	Feeding Duration min ± SE	Longevity days ± SE	*N*	Feeding Duration min ± SE	Longevity days ± SE
Cherry Juice	7	7.80 ± 1.83	4.4 ± 0.2	3	3.04 ± 0.64	4.0 ± 0.0
No Food (water)	22	0.32 ± 0.08	4.0 ± 0.1	19	0.31 ± 0.10	4.3 ± 0.2
Sucrose (Wet Food)						
2%	6	1.08 ± 0.34	4.2 ± 0.3	6	1.90 ± 0.44	3.8 ± 0.5
10%	9	2.19 ± 3.05	4.6 ± 0.2	8	2.21 ± 0.41	4.0 ± 0.2
20%	9	4.25 ± 1.28	4.7 ± 0.3	8	3.34 ± 1.14	4.2 ± 0.3
40%	10	2.96 ± 0.17	6.1 ± 0.1	8	2.53 ± 0.39	5.5 ± 0.3
60%	11	4.56 ± 0.69	6.7 ± 0.3	9	4.38 ± 0.57	6.8 ± 0.2
80%	9	15.20 ± 1.72	7.2 ± 0.5	5	10.02 ± 1.90	6.5 ± 0.3
Sucrose (80%)-Yeast (20%) Food	4	129.37 ± 39.67	5.2 ± 0.5	------	-------	------

Table 2. Mean longevity and fecundity of female *Rhagoletis indifferens* exposed to sweet cherry and sugar and yeast dry and wet diets in the laboratory.

Treatment[a,b]	*N*	Longevity (d) Per Female + SE	No. Total Eggs Per Female + SE	% Eggs of Best Diet
Test 2 - 1 female and 1 male/cage				
(All with Cherries)				
1- Cherry only from start	11	37.6 ± 5.9a	86.1 ± 21.3a	24.2
2- + 88-12 throughout	9	63.1 ± 6.7b	356.2 ± 53.9b	-------
3- + 88-12 for 14 d	7	36.6 ± 6.1a	157.0 ± 55.4ab	44.1
4- + 47-6 throughout	3	49.0 ± 6.6ab	267.3 ± 60.0ab	75.0
5- + 47-6 for 14 d	4	31.0 ± 5.6a	135.5 ± 76.6ab	38.0
Test 3 - 3 females and 3 males/cage				
(All with Cherries except 4)				
1- + 80-20 throughout	7	60.6 ± 6.6 a	325.8 ± 62.2a	-------
2- + 80-20 for 14 d	10	34.0 ± 3.2b	133.0 ± 27.5b	40.8
3- + 80-20 for 8 d	7	35.3 ± 3.1b	171.3 ± 26.4ab	52.6
4-No cherry, 80-20 for 8 d only	6	10.1 ± 0.6c	0 ± 0c	0

[a]88-12: 88% sucrose and 12% yeast, dry diet. 47-6: 47% sucrose and 6% yeast, wet diet; 80-20: 80% sucrose and 20% yeast, dry diet.
[b]Except for test 1, treatment 1 and test 3, treatment 4, cherries in treatments were introduced on day 8.
Means followed by the same letter within columns are not significantly different ($P > 0.05$).

Table 3. Effects of cherries and male and female presence on longevity and fecundity of *Rhagoletis indifferens*.

Treatment	*N*	Longevity (d) ± SE Males	Females	No. Total Eggs per Female ± SE
(1) 6 males only + C	2	23.8 ± 3.8	-------	-------
(2) 6 females only + C	2	-------	46.5 ± 0.7	107.7 ± 11.9
(3) 3 males + 3 females + C	3	48.8 ± 1.9	41.9 ± 5.3	128.2 ± 12.1
(4) 6 males only + S	__	_____	-------	-------
(5) 6 females only + S	__	-------	_____	_____
(6) 3 males + 3 females + S	__	_____	_____	_____
(7) 3 males + 3 females No Food	3	3.5 ± 0.2	4.1 ± 0.1	0 ± 0

C = Cherry; S = Dry Sucrose Cubes.

Table 4. Mean number of matings/day and mean duration of matings (minutes) of *Rhagoletis indifferens* under laboratory conditions.

Treatment Ages (days) Male	Females	*N*	% of Pairs Mated	Mean No. Matings/Day ± SE	Mean Mating Duration ± SE	Matings
3-6	3-6	12	16.7	0.06 ± 0.04	5.64 ± 5.36	2
3-6	17-26	10	40.0	0.30 ± 0.15	72.51 ± 25.05	4
17-26	3-6	9	22.2	0.26 ± 0.19	61.56 ± 7.36	2
17-26	17-26	24	29.2	0.57 ± 0.37	31.39 ± 13.58	6
32-67	32-67	11	72.7	0.33 ± 0.11	10.02 ± 5.33	8

Table 5. Mean percent mortality ± SE and % pupation (in parentheses) of *Rhagoletis indifferens* larvae exposed to two concentrations of infective juveniles (IJ) in a soil mixture with 20% moisture at 27 °C.

			Test 1 (21 days after exposure)	
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*
0	5	52 ± 5 (60 + 7)	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (40 ± 4)	100 ± 0 (54 ± 5)
1,000,000 IJ/m^2	5	-------	100 ± 0 (30 ± 9)	100 ± 0 (48 ± 8)

			Test 2 (20 days after exposure)		
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*	*Steinernema intermedium*
0	5	6 ± 4 (94 ± 4)	-------	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (56 ± 11)	100 ± 0 (54 ± 10)	66 ± 12 (64 ± 8)
1,000,000 IJ/m^2	5	-------	100 ± 0 (58 ± 6)	100 ± 0 (58 ± 9)	54 ± 12 (56 ± 9)

			Test 3 (12 days after exposure)		
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*	*Steinernema intermedium*
0	5	22 ± 10 (78 ± 10)	-------	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (28 ± 8)	100 ± 0 (26 ± 12)	96 ± 4 (20 ± 8)
1,000,000 IJ/m^2	5	-------	100 ± 0 (20 ± 8)	100 ± 0 (26 ± 7)	92 ± 8 (20 ± 7)

Table 6. Mean percent mortality and % pupated (in parentheses) ± SE of *Rhagoletis indifferens* larvae exposed to water and placed directly into soil and exposed to 500,000 infective juveniles (IJ) in a soil mixture with 20% moisture at 27 °C after 7 days.

Treatment	*N*	In water for 24 hours	Directly in soil
Control	3	0 ± 0 (100 ± 0)	0 ± 0 (100 ± 0)
Steinernema feltiae	3	100 ± 0 (67 ± 9)	100 ± 0 (20 ± 20)
Steinernema carpocapsae	3	100 ± 0 (50 ± 6)	100 ± 0 (7 ± 3)

Table 7. Numbers of marked and released *Rhagoletis indifferens* sighted in 2-min/tree searches on 119 trees and collected from 100 trees, % seen or recaptured, and mean distances (m) ± SE seen from release trees at 1-23 days after release (DAR) in 2001 at Moxee, WA.

Numbers of Marked Flies Sighted (all males)

Date	DAR	Control	%	Mean Distance/Fly	Treatment	%	Mean Distance/Fly
3 July	1	12	2.2	34 ± 7	9	1.2	32 ± 8
5	3	6	1.1	55 ± 12	5	0.6	56 ± 10
9	7	2	0.4	48 ± 22	1	0.1	42
Totals seen		20	3.6	--------	15	1.9	--------

Numbers of Marked Flies Collected on Yellow Traps (all males, 1 female 10 July)

Date	DAR	Control	%	Mean Distance/Fly	Treatment	%	Mean Distance/Fly
10 July	10	13	2.3	49 ± 5	5	0.6	24 ± 4
12	11	10	1.8	34 ± 5	10	1.3	52 ± 9
13	12	1	0.2	87	1	0.1	79
16	15	0	0	-----	0	0	-----
18	17	2	0.4	38 ± 24	0	0	-----
20	19	3	0.5	54 ± 15	0	0	-----
23	22	0	0	-----	1	0.1	31
25	24	0	0	-----	-----	-----	-----
27	26	0	0	-----	-----	-----	-----
Totals		29	5.2	43 ± 4	17	2.2	44 ± 6