

Final Report
San Diego County Eye Gnat Research and
Education Project 2017-18
Escondido, CA

Biology and Control of the Eye Gnat
Liohippелates collusor

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RESEARCH PROJECT GOALS 2017-18

- Continue laboratory /greenhouse trials on the biology and control of eye gnats.
 - Continue studies on methods of control for eye gnat larvae and adults.
 - Continue studies on the ability of eye gnat eggs to survive and develop in response to dehydration and rehydration.
 - Study the effects of various compost compositions on eye gnat larval development and survival.
- Continue grid trapping to document eye gnat population dynamics.
 - Continue area-wide trapping on a grid system to determine annual abundance and the population dynamics of eye gnats over time.
 - Conduct critical mitigation trapping in one canyon between Inspiration Lane, Beethoven Drive, Huckleberry Lane, and Sierra Linda Drive in South Escondido
- Conduct studies on the effect of wind direction and intensity has on the migration of eye gnats into local canyons and residential areas
- Conduct emergence trap studies
 - Investigate potential eye gnat reproductive sources in the Lake Hodges vicinity, agricultural areas, and surrounding community areas (turf and landscape).
- Extend and educate the public on eye gnats and their control.
- Provide additional services as needed on eye gnat related issues.

BACKGROUND

Eye gnats are prevalent in the Southern United States, primarily in parts of California and Arizona. In San Diego County, especially in the Jacumba and Escondido areas, they have been a problem for many years and are the source of numerous citizen complaints to Departments of Environmental Health - Vector Control, and Agriculture Weights and Measures. Research has determined that local agriculture is the source of the problem, and the community residents are looking to the County for a solution. Eye gnats are problems in other agricultural areas in Southern California and have been extensively studied for more than a century. These nuisance problems have been successfully addressed by identifying the source, altering land management practices, implementing integrated pest management (IPM), and conducting a sound public outreach and education program.

Benefit to the County

In utilizing our technical and expert resources with UCCE, we can more efficiently offer the County's residents easier access to current and applicable information and educational opportunities to understand and manage the eye gnat problem. Increased awareness of this problem, its causes and possible solutions will assist county departments in dealing with citizen complaints.

Introduction

The eye gnat (*Liohippелates* and *Hippelates* spp.) has been a nuisance pest since the turn of the 20th century. *Liohippелates collusor* (Townsend), formerly known as *Hippelates collusor* in the scientific literature is the primary species in southern California and was implicated in an epidemic of bacterial conjunctivitis (pinkeye) in the Coachella Valley California and in the southern U.S. (Anonymous 1929, Buehler et al. 1983). There is no scientific evidence, however, to substantiate the inference. Eye gnats created problems in other cultivated areas such as the Imperial and San Joaquin valleys of California. In addition, they are present in many desert areas of California, such as the Mojave Desert, and could create problems if and when such areas are intensively cultivated and irrigated.

Problems are heightened when irrigated agriculture is in close proximity to urban areas. Research has shown that irrigated agriculture provides good reproductive potential for eye gnat production (Mulla 1963). However, female gnats need a protein food source (mucus, blood, scabs, etc.) in order to produce their young and that protein source is largely unavailable in agriculture. Therefore, since eye gnats can disperse approximately 4 miles both upwind and downwind, humans and domesticated animals living in close proximity to eye gnat producing areas can become a food source.

EXECUTIVE SUMMARY

Introduction

Trials were completed with the help of the City of San Diego, San Dieguito River Park, Kit Carson Park and the Center for Applied Horticultural Research in Vista, CA.

OBJECTIVE #1 – Laboratory and Greenhouse Studies.

- A trial was designed to test if eye gnat larvae can develop into adults exclusively on groundcover plants. Three common types of groundcover were planted in plastic totes with a soilless media. Eye gnats eggs were added to each tote and the number of adults counted upon emergence. Due to poor viability of the eye gnat eggs, results were inconclusive.

OBJECTIVE #2 – Annual Adult Eye Gnat Collar Trapping

- Adult eye gnats were collected for four consecutive days during the months of July, August, September and October. Traps were placed in the same locations as in previous years. During the 2017 trapping season, an average of 17.76 gnats/trap/day were caught. This is up from 12.84 gnats/trap/day collected the previous year. Historical data has not indicated a clear, monthly population peak throughout the typical eye gnat season (July-Oct) suggesting that an overall seasonal average of eye gnats per trap per day was the best indicator of local or regional population trends. The lack of a peak during any one month of data is likely due to changing environmental conditions (temperature, rainfall events, wind, etc.) during shorter intervals such as weeks or specific groups of days.

OBJECTIVE #3 – Potential Effects of Wind Direction and Intensity on Migration of Adult Eye Gnats

- No studies on wind were conducted during this time period

OBJECTIVE #4 – Emergence Trapping

- Eight soil samples were taken from three different locations along Sonata neighborhood hillsides with groundcover to be observed for eye gnat emergence. Two gnats emerged from one of the samples.

OBJECTIVE #5 – Extend and Educate the Public on Eye Gnats and Their Control

- Meetings were attended and data shared to community leaders, the farm, and the county. Information was made available on the Internet.

OBJECTIVE #6 – Provide Additional Services as Needed on Eye Gnat Related Issues

- No studies were conducted during this time period

OBJECTIVE #1 – Laboratory and Greenhouse Studies

INVESTIGATION OF LANDSCAPE GROUNDCOVER AS A POTENTIAL EYE GNAT LARVAL FOOD SOURCE

Objective

The intention of the following study was to determine if eye gnat larvae could fully develop with only landscape plant material as a food source. This is to confirm the previous year data where adult eye gnats were caught in emergence cages placed in hillside landscape groundcover. By removing the organic matter by using a soilless planting media, we can determine if eye gnats are feeding on the plants or a substance in the soil.

Materials and Methods

A mixture of vermiculite and perlite (2:1) was placed in a twenty gallon translucent plastic tub (Figure 1). Circular holes were on each side and on the bottom to allow for water drainage and air circulation. The holes were covered with a fine mesh using industrial tape. Cuttings were obtained from local sources and allowed to root and establish within the totes (Figure 2). Eye gnat eggs were obtained from a laboratory reared colony and added to each tote. Double sided sticky tape was added to the interior upper edge of the totes and sealed with the lid. About a month later, the sticky tape was removed and examined for the presence of eye gnats. Treatments were: 1) only soilless media, 2) soilless media with 2/3 cup ground rabbit food/pellets (to simulate materials used in eye gnat colony production), 3) rosemary *Rosmarinus officinalis*, 4) ice plant *Deloperma spp.* and 5) 'red apple' *Aptenia cordifolia*.

Results

Viability of the eye gnat eggs revealed that only 6% of the eggs produced larvae thus severely hindering results of this study. Only one of the totes produced any eye gnats. One tote containing the ground rabbit pellet food produced two gnats. The trial will be repeated in 2018.

Objective #2 – Annual Adult Eye Gnat Collar Trapping

ADULT EYE GNAT POPULATION DENSITY STUDY IN SOUTH ESCONDIDO

Objective

This study documents the annual eye gnat population dynamics (changes in size and dispersion) in the general area of south Escondido.

Materials and Methods

Experimental Unit- UCCE based 4-hole collar traps were used for monitoring. The lower portions of the trap are painted flat black and the top portion is clear plastic (Figure 3 & 4). Traps were attached to 3' wooden stakes using electrical tape. Putrefied egg was added as standard eye gnat bait to the lower PVC container.

Experimental Design- Twenty-three collar traps were placed on a 5-trap by 5-trap grid pattern approximately one-half mile apart (Figure 5) in south Escondido. Trap numbers in Table 2 correspond to the numbers on the pins in Figure 5. Trap UC#7 is not present in the study because Lake Hodges precluded its placement. Trap UC#16 was discontinued after 2011 because of its difficult accessibility within a gated community. Trap UC#5 was discontinued in 2017 due to addition of a gate to the property.

Sampling- Trap tops containing captured adult eye gnats collected over a four consecutive day period in the months of July-October. Trap tops were removed and replaced by a clean trap top. The trap tops with the eye gnats were placed in a Ziploc bag to prevent any gnats from escaping, brought back to the laboratory, and placed in the oven overnight to kill the gnats. Eye gnats were separated from other fly species, counted and recorded.

Analysis – Data were analyzed using descriptive statistics. Selected data sets were pooled in search of trends.

Results

Table 1 lists the annual mean number of adult eye gnats captured/trap/day in traps located a half mile apart on a grid delineated by GPS coordinates first established in 2011 (Figure 5). The percent change from the initial trapping of adult eye gnats in 2011 is represented in Table 2. The means from Table 3 are graphed below and an additional figure shows data only for the month of October 2011-2017. Overall population in 2017 was up compared to the preceding year. The main difference in 2017 was that traps UC#8, UC#15, UC#18, and UC#18 showed a significant increase of the number of gnats/trap/day compared to previous years. Two of these traps are located adjacent to the farm which could indicate increased farming activity near these traps.

Eye gnats are concentrated adjacent to a local organic farm (Table 4) with over three times as many gnats as those traps within one half mile of the farm (44.35 gnats/trap/day vs. 13.65 gnats/trap/day). Traps within residential areas recorded an average of 9.55 adult eye gnats/trap/day.

Traps counts in 2017, showed an overall decrease of 93.5% in the number of adult gnats caught compared to 2011.

Table 1. Mean number of eye gnat adults/trap/day from 23 traps throughout south Escondido. Traps were located a half-mile apart on a grid delineated by GPS coordinates (Figure 5) first established in 2011. Data were collected on four consecutive days from June through October.

Trap UC#	2011*	2012	2013	2014	2015	2016	2017
1	86.50	2.24	0.75	2.44	3.64	3.67	0.72
2	25.00	11.13	3.00	0.56	2.28	0.44	3.44
3	183.25	47.13	5.13	12.43	62.19	25.73	16.53
4	417.00	14.05	31.88	59.69	90.80	5.65	8.40
5	50.00	3.80	0.88	3.96	11.67	0.22	n/a
6	15.00	1.38	0.63	6.27	6.31	2.65	0.75
8	130.50	100.18	9.35	15.44	45.39	10.93	98.13
9	44.00	21.50	15.25	7.56	51.67	8.83	8.17
10	283.00	3.40	18.88	18.25	41.47	5.71	2.83
11	289.75	14.18	3.38	11.67	6.53	3.75	0.88
12	63.00	5.64	0.63	5.25	6.31	0.58	3.82
13	317.25	8.18	10.63	9.68	10.69	4.27	6.82
14	271.67	5.46	2.63	4.21	7.00	2.31	4.65
15	354.00	37.00	16.25	49.43	40.75	16.28	33.8
16	4.25	n/a	n/a	n/a	n/a	n/a	n/a
17	167.75	0.95	3.25	5.08	8.44	1.40	0.35
18	763.25	16.38	73.13	32.49	99.89	11.21	61.40
19	1050.00	70.98	10.9	31.69	98.36	60.03	44.57
20	386.00	110.05	19.13	132.06	260.36	77.16	78.82
21	8.67	3.63	0.25	6.67	1.69	0.79	0.90
22	1083.00	13.33	3.88	34.73	144.86	35.49	43.38
23	119.25	5.30	1.38	9.69	1.53	3.27	1.99
24	384.00	14.05	2.88	12.13	30.89	13.98	8.17
25	81.00	8.75	0.75	12.58	8.81	0.88	0.94
Mean	274.06	22.9	10.2	17.75	45.28	12.84	17.76

* Data collected only in month of October 2011

Table 2. Graphic representation of annual mean from Table 1. Percentages represent change from 2011 baseline.

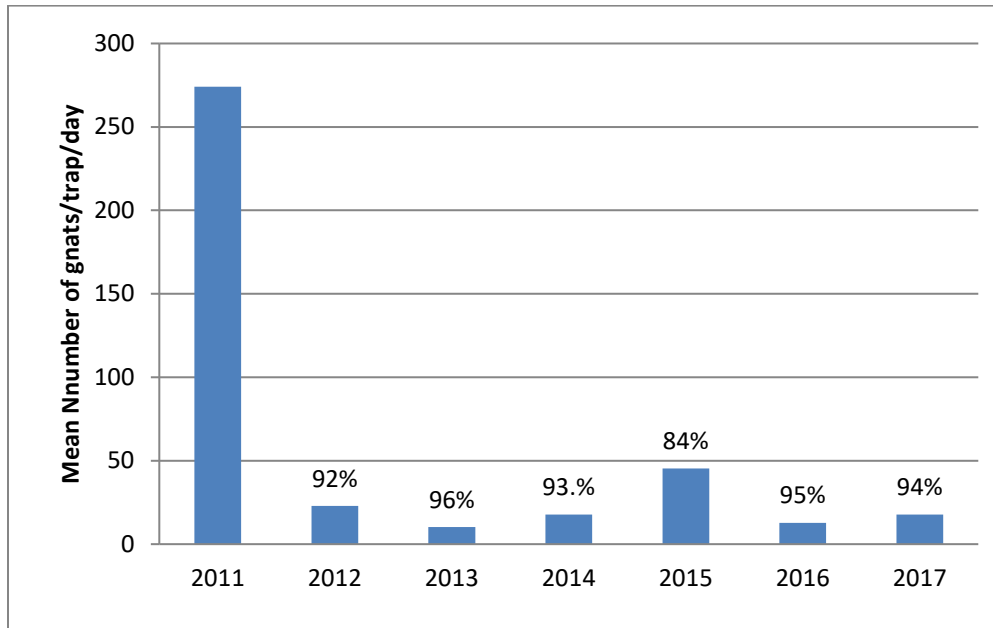


Table 3. Mean number of captured adult eye gnats/trap/day during a one-week period in the month of October for each year of data collected. Gnats were collected using UCCE collar traps as part of the historical grid sampling in south Escondido, CA.

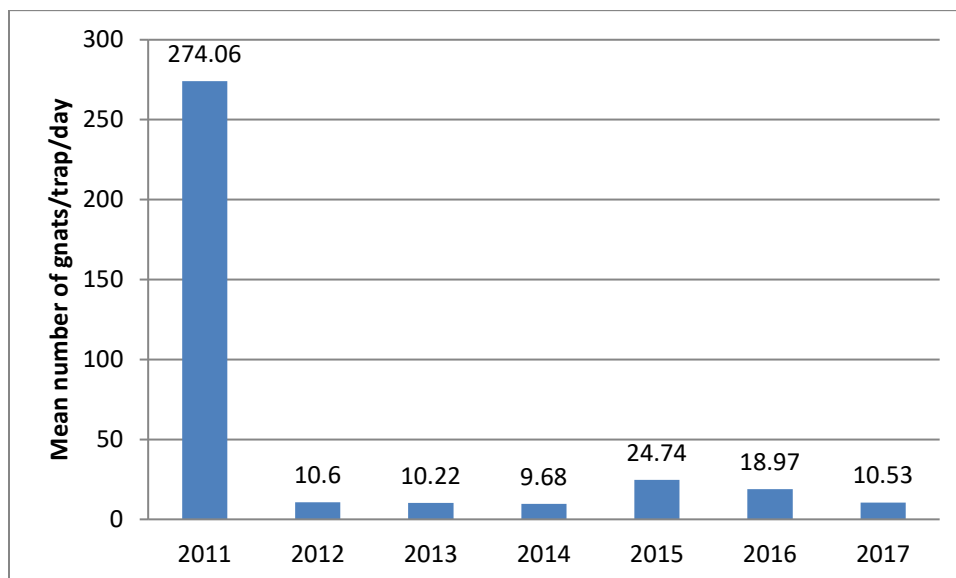


Table 4. Grouping of selected UC traps into areas of interest in 2017. Gnats were collected using UCCE collar traps as part of the historical grid sampling in south Escondido, CA.

Description of Area	UC Trap Numbers	# of Traps	Mean Gnats/Trap/Day	Importance
Proximity to Organic Farm	8, 9, 10, 15, 20	5	44.35	Population potential near the farm
South of farm (Highland Valley Rd)	2, 3, 4	3	9.46	Proximity to the farm but across open space
West of I-15	1, 6, 11, 21	4	0.81	Furthest from the farm, across freeway
Traps within a half mile of the farm	3, 4, 13, 14, 19, 25	6	13.65	Half mile proximity to farm
Traps greater than a mile of the farm	1, 17, 21, 22, 23	5	9.47	Mile proximity to farm
Traps in open areas	2, 3, 4, 6, 12, 22	6	12.72	Natural environment
Traps within residential areas	11, 13, 14, 19, 21, 24, 25	7	9.55	Residential landscaping

**Objective #3 – Potential Effects of Wind Direction and Intensity on
Migration of Adult Eye Gnats**

No experiments conducted for this objective

Objective #4 – Emergence Trapping

STUDY OF LANDSCAPE GROUNDCOVER AS POTENTIAL BREEDING SITE OF EYE GNATS

Objective

The purpose of this study was to determine if landscape groundcover in the local community of south Escondido is a potential breeding site for eye gnat development and a contributing source of eye gnats.

Materials and Methods

Sampling: Eight separate soil samples were taken from three different locations and depths consistent with emergence trap finds. Samples were taken to the laboratory and placed in cages and observed for eye gnat adult emergence. Soil was held in cages for at least one eye gnat life cycle to make sure any eye gnat eggs laid in the soil would develop to an adult during the study period (approx. 30 days).

Cage type: Soil was placed in a fourteen-quart translucent plastic tub (Figure 6). A circular hole was cut in the top of the tub and a funnel inverted and glued over the hole. A hole was cut in the lid of a 40-dram plastic vial, which was inverted and placed over the narrow end of the funnel. The light from above attracts adult eye gnats through the funnel opening and into the 40-dram vial.

The areas sampled include: 1) Beethoven Drive, just north of the natural area between Inspiration and Huckleberry Lanes. The area is a hillside planted in red apple. 2) Corner of Beethoven and Alton Way with the area planted in red apple. 3) On the northeast corner of Sierra Linda and Calle Montera planted with red apple.

Results

One gnat emerged from a sample taken at the Beethoven/Huckleberry site. Of the two years conducting this type of sampling method, 25 samples have been taken with only one confirmed eye gnat. This method proves ineffective and will be discontinued.

OBJECTIVE #5 – Extend and Educate the Public on Eye Gnats and Their Control

Information is available on the Internet for review by the public at:

<http://ucanr.org/eyegnats>

**Objective #6 – Provide Additional Services as Needed on Eye Gnat
Related Issues**

No studies were conducted in this objective

Extension Activity

ADDITIONS TO THE SAN DIEGO EYE GNAT RESEARCH AND EDUCATION PROJECT
WEB SITE (<http://ucanr.org/eyegnats>)

County Eye Gnat Report Research Report, 2011-15

Eye Gnat Research and Education Symposium, 2012

EYE GNAT PRESENTATIONS AND PUBLICATIONS

Bethke, J. A., Vander Mey, B., and I. DeBonis. Final Report: San Diego County Eye Gnat Research and Education Project 2011. In fulfillment of San Diego County Contract #532716. 36pgs. Available online: <http://ucanr.org/eyegnats>

Bethke, J. A., Vander Mey, B., and S. Zambrano. Final Report: San Diego County Eye Gnat Research and Education Project 2012. In fulfillment of San Diego County Contract #532716. 29pgs. Available online: <http://ucanr.org/eyegnats>

Bethke, J. A., Vander Mey, B., and S. Zambrano. Final Report: San Diego County Eye Gnat Research and Education Project 2013. In fulfillment of San Diego County Contract #532716. 21pgs. Available online: <http://ucanr.org/eyegnats>

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Available online: <http://ucanr.org/eyegnats>

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Gerhardt, R.R. and Axtell R. C. 1972. Flight of the eye gnat, *Hippelates pussio* (Diptera:Chloropidea): Effect of temperature, light, moisture and wind velocity. *J. Med. Ent.* 9(5):425-8.

Mulla, M. S. 1963. An ecological basis for suppression of *Hippelates* eye gnats. *Journal of Economic Entomology*. 56(6): 768

APPENDIX I

Photos and Figures

Figure 1. 20 gallon plastic tote used to conduct landscape groundcover study.

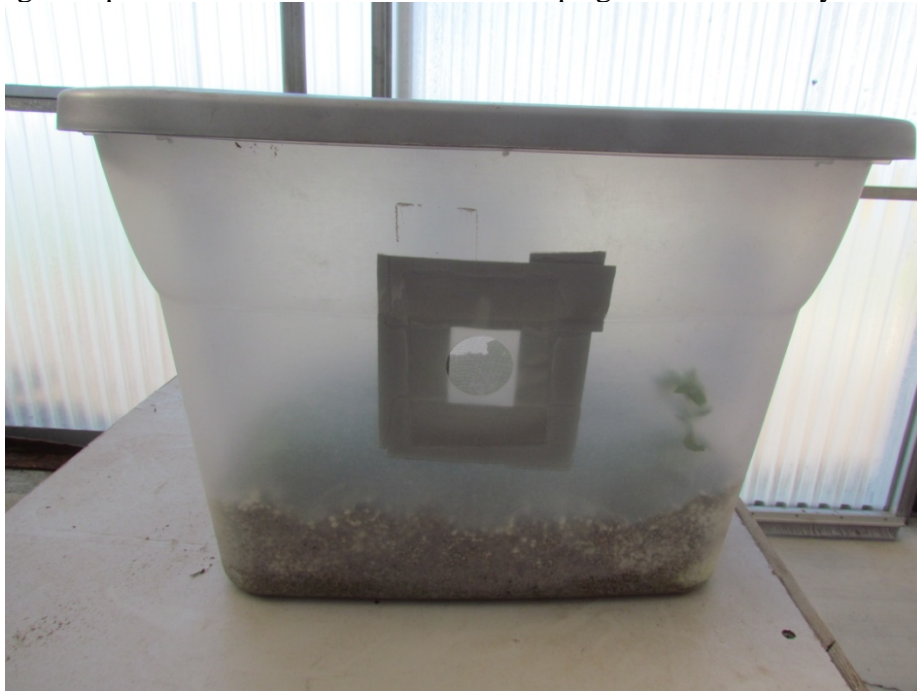


Figure 2. Inside the tote showing the vermiculite/perlite mix and red apple groundcover.



Figure 3. Components used to make UCCE collar traps. Bait jar (3-inch drainage pipe with cemented cap), 3-inch PVC collar with $\frac{3}{4}$ inch holes, plastic champagne glass, 3-inch drainage pipe used to connect 32-ounce pinch grip plastic container. Painted flat black to attract more gnats.



Figure 4. Assemble UCCE trap



Figure 5. Location of UCCE eye gnat collar traps used for yearly monitoring of adult populations. Grid uses traps placed approximately half mile equidistant. Numbers are those assigned to trap and correspond to the number of gnats caught in Table 1.

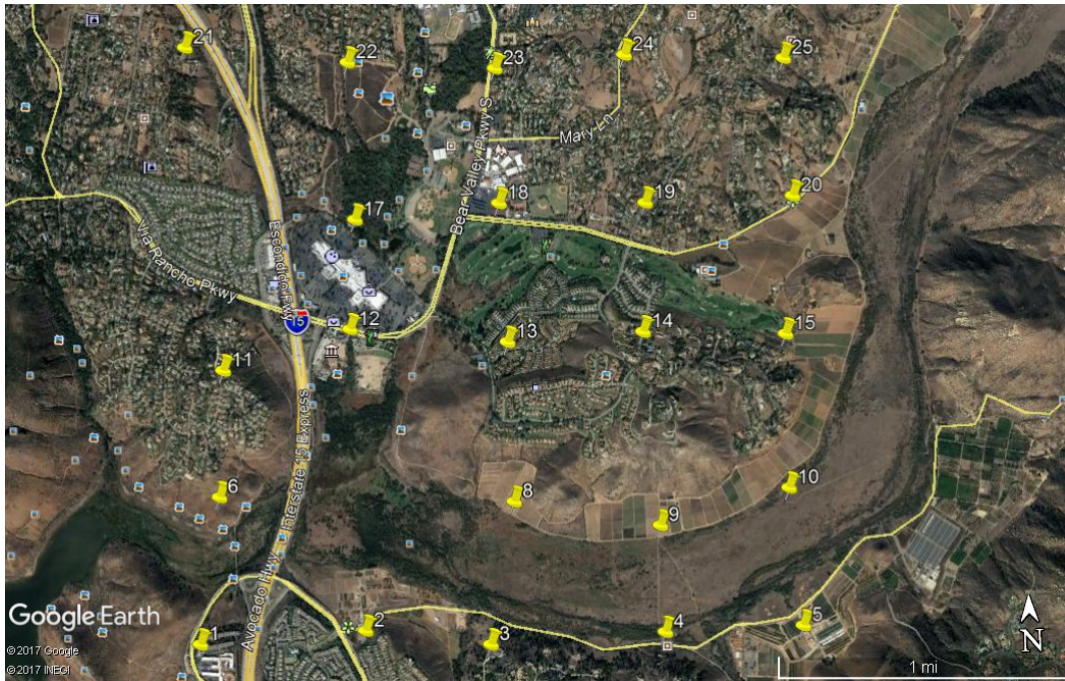


Figure 6. Fourteen-quart clear plastic tub used for monitoring emergence of eye gnats from soil samples. A hole was cut on the lid with an inverted funnel glued to the top. A 40-dram vial is attached to the spout of the funnel to collect emerged adult gnats.



APPENDIX II

Weather Data

California Irrigation Management Information System (CIMIS)

CIMIS Daily Report

Rendered in ENGLISH Units.

Thursday, June 1, 2017 - Tuesday, October 31, 2017

Escondido SPV - South Coast Valleys - Station 153

Date	ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Point (°F)	Avg Wind Speed (mph)	Wind Run (miles)	Avg Soil Temp (°F)
6/1/2017	0.10 R	0.00	355	16.8	75.2	57.9	64.1	100	63	82	58.5	2.1 Y	51.6 Y	69.8
6/2/2017	0.21	0.00	580	17.3	86.8	56.2	68.4	97	46	73	59.4	3.1	73.4	70.7
6/3/2017	0.21	0.00	605	17.5	84.3	56.7	67.9	97	50	75	59.8	3.2	77.7	77.4 Y
6/4/2017	0.20 R	0.00	557	17.5	82.2	56.8	67.5	97	52	76	59.8	3.1	75.2	-- S
6/5/2017	0.20	0.00	567	17.1	81.5	58.8	66.9	95	54	76	59.0	4.0	95.0	-- S
6/6/2017	0.15 R	0.00	440	16.9	73.9	62.0	66.0	85	66	77	58.7	3.9	94.1	-- S
6/7/2017	0.13	0.00	431	16.7	76.0	52.0	63.1	99	64	84	58.3	3.8	90.5	-- S
6/8/2017	0.19 R	0.00	572	16.0	78.9	52.0	62.8	99	56	82	57.1	3.7	87.8	-- S
6/9/2017	0.21 R	0.00	712	16.6	78.8	-- S	70.3	88	53	66	58.2	5.3	128.2	-- S
6/10/2017	0.19	0.00	561	16.2	72.9	57.3	64.8	92	59	77	57.5	4.9	117.0	-- S
6/11/2017	0.15 R	0.00	434	13.8	71.2	54.8	62.3	85	55	72	53.2	4.8	114.3	-- S
6/12/2017	0.22	0.00	662	12.7	73.5	49.2	62.0	93	45	67	51.0	3.3	79.5	-- S
6/13/2017	0.23 R	0.00	664	12.7	80.7	46.2	64.8	95	38	60	50.8	2.8 Y	66.7 Y	-- S
6/14/2017	0.24 R	0.00	664	14.5	84.9	47.5	67.1	97	43	64	54.5	2.8 Y	66.1 Y	-- S
6/15/2017	0.24 R	0.00	667	15.0	88.0	48.3	69.0	98	37	62	55.4	2.5 Y	59.2 Y	-- S
6/16/2017	0.25 R	0.00	666	15.1	92.1	49.1	71.3	94	31	58	55.6	2.5 Y	59.4 Y	-- S
6/17/2017	0.24 R	0.00	657	16.1	91.7	50.6	70.4	99	35	63	57.3	2.5 Y	59.8 Y	-- S
6/18/2017	0.24 R	0.00	654	16.9	88.6	51.1	70.8	97	43	66	58.8	2.5 Y	60.7 Y	-- S
6/19/2017	0.23 R	0.00	648	18.9	91.1	54.3	70.4	99	44	75	61.9	2.5 Y	61.0 Y	-- S
6/20/2017	0.23 R	0.00	636	19.7 Y	93.3	53.1	72.5	99	46	72 Y	63.1 Y	2.1 Y	49.3 Y	-- S
6/21/2017	0.23 R	0.00	617	19.8 Y	89.6	56.1	71.5	99	51	75 Y	63.2 Y	2.9	70.2	-- S
6/22/2017	0.18 R	0.00	532	19.3	83.4	59.1	68.1	100	58	82	62.5	3.5	83.1	-- S
6/23/2017	0.20	0.00	600	19.4	80.5	57.7	68.7	99	64	81	62.6	3.2	77.2	-- S
6/24/2017	0.19	0.00	552	19.5	84.1	58.7	69.8	100	56	79	62.8	2.2 Y	53.3 Y	-- S
6/25/2017	0.23 R	0.00	631	20.6 Y	93.0	56.7	74.9	99	47	70 Y	64.3 Y	2.5 Y	58.8 Y	-- S
6/26/2017	0.26 R	0.00	643	16.3	99.1 Y	57.0	78.5 Y	100	22	49 Y	57.8 Y	2.4 Y	58.3 Y	-- S
6/27/2017	0.28 R	0.00	671	13.3	97.6	54.0	74.7	91	14	45	52.2	4.0	94.8	-- S
6/28/2017	0.24	0.00	627	16.2	85.6	54.3	67.4	100	41	71	57.6	4.3	103.1	-- S
6/29/2017	0.22 R	0.00	605	16.1	81.1	58.9	67.7	88	48	70	57.3	4.6	111.1	78.7

Date	ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Point (°F)	Avg Wind Speed (mph)	Wind Run (miles)	Avg Soil Temp (°F)
6/30/2017	0.22	0.00	612	16.8	82.2	58.6	68.9	90	48	70	58.5	4.3	104.3	78.9
Tots/Avgs	6.31	0.00	594	16.7	84.1	54.7	68.4	96	48	71	58.2	3.3	79.4	75.1

Escondido SPV - South Coast Valleys - Station 153

Date	ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Point (°F)	Avg Wind Speed (mph)	Wind Run (miles)	Avg Soil Temp (°F)
7/1/2017	0.20	0.00	561	17.4	82.2	57.0	67.5	96	52	75	59.5	4.3	102.3	77.4
7/2/2017	0.23 R	0.00	635	17.1	84.0	57.9	70.2	91	47	68	59.1	3.6	85.4	77.6
7/3/2017	0.23 R	0.00	620	16.0	91.4	55.0	71.7	97	31	60	57.2	2.6 Y	63.1 Y	77.7
7/4/2017	0.23 R	0.00	612	17.9	92.8	54.9	72.2	95	37	66	60.3	2.7 Y	65.8 Y	78.2
7/5/2017	0.20	0.00	561	19.1	88.1	53.8	69.3	99	51	78	62.2	3.3	78.3	78.6
7/6/2017	0.21 R	0.00	558	18.8	93.1	52.5	71.6	99	46	71	61.8	2.7 Y	64.0 Y	77.0
7/7/2017	0.22 R	0.00	568	20.8	93.5	61.1	77.5 Y	96	44	64 Y	64.6 Y	2.7 Y	64.5 Y	78.9
7/8/2017	0.20 R	0.00	511	22.3 Y	94.6	63.1	77.4	94	51	70 Y	66.7 Y	3.2	76.1	79.9
7/9/2017	0.16 R	0.00	430	22.1 Y	88.8	66.5 Y	77.0	93	52	70 Y	66.4 Y	2.5 Y	60.6 Y	79.9
7/10/2017	0.22 R	0.00	590	21.0	90.6	62.6	76.0	96	46	69	64.9	3.1	74.5	79.9
7/11/2017	0.22 R	0.00	589	21.1	87.6	58.9	73.3	99	49	75	65.0	3.2	76.7	78.8
7/12/2017	0.21 R	0.00	583	21.6	86.2	62.2	74.0	99	54	75	65.7	2.8 Y	66.1 Y	78.9
7/13/2017	0.19	0.00	595	23.0 Y	82.8	64.0	71.5	100	64	87 Y	67.5 Y	2.3 Y	54.8 Y	78.1
7/14/2017	0.20 R	0.00	569	20.8	85.9	63.2	73.6	96	49	74	64.7	2.7 Y	64.9 Y	79.3
7/15/2017	0.20 R	0.00	552	21.3	87.8	61.6	73.5	95	57	75	65.3	3.2	77.0	78.8
7/16/2017	0.19 R	0.00	528	21.2	86.5	61.3	72.4	96	56	78	65.2	3.3	78.4	78.3
7/17/2017	0.20 R	0.00	559	21.5	84.9	61.0	72.8	98	59	78	65.6	3.4	81.5	77.9
7/18/2017	0.20 R	0.00	554	20.5	86.4	61.2	73.5	96	52	73	64.1	3.2	75.8	77.7
7/19/2017	0.16 R	0.00	447	21.5	89.6	65.9	75.6	89	48	71	65.6	3.5	84.7	78.1
7/20/2017	0.21 R	0.00	541	20.3	90.2	63.6	74.5	95	38	70	63.9	3.9	94.8	78.2
7/21/2017	0.22 R	0.00	587	19.9	89.4	61.2	74.1	93	43	69	63.3	3.5	83.5	78.8
7/22/2017	0.21 R	0.00	557	20.3	88.2	62.6	73.8	94	49	71	64.0	3.8	91.9	79.0
7/23/2017	0.21 R	0.00	552	20.3	89.8	63.0	74.5	93	43	70	63.9	4.1	97.2	79.2
7/24/2017	0.15 R	0.20	444	21.2	83.7	64.9	71.6	91	61	80	65.1	3.0	72.4	78.8
7/25/2017	0.15	0.00	467	21.4	81.8	57.7	69.4	100	65	87	65.4	3.7	88.5	77.2
7/26/2017	0.20	0.00	569	20.5	86.1	57.3	69.5	99	62	83	64.2	4.9	118.4	77.3
7/27/2017	0.22	0.00	599	20.7	88.0	58.7	71.5	98	52	79	64.4	4.8	114.5	77.5
7/28/2017	0.21	0.00	573	21.4	83.8	62.4	71.1	99	63	82	65.5	5.3	127.6	78.6
7/29/2017	0.21	0.00	573	20.3	84.6	59.3	70.6	100	60	79	64.0	4.9	117.0	78.0
7/30/2017	0.21	0.00	587	20.5	85.8	58.8	71.3	100	57	78	64.1	4.5	107.4	77.6
7/31/2017	0.21	0.00	565	21.6	87.4	65.6	74.2	92	57	75	65.7	4.2	100.3	78.0
Tots/Avgs	6.28	0.20	556	20.4	87.6	60.6	72.8	96	51	74	64.0	3.5	84.1	78.4

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Date	ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Point (°F)	Avg Wind Speed (mph)	Wind Run (miles)	Avg Soil Temp (°F)
8/1/2017	0.13	0.00	374	23.7	92.8	65.8	76.5	96	51	76	68.4	3.1	75.1	78.4
8/2/2017	0.10	0.00	293	24.5	90.3	68.5	77.9	95	60	75	69.4	3.0	70.9	78.8
8/3/2017	0.23	0.00	570	24.6	92.4	68.7	78.7	95	54	74	69.5	4.9	117.3	79.1
8/4/2017	0.22	0.00	581	22.9	90.6	63.9	75.3	99	53	76	67.4	4.3	103.7	79.1
8/5/2017	0.21	0.00	554	21.3	86.9	63.9	73.3	97	52	76	65.3	4.6	110.1	78.9
8/6/2017	0.20	0.00	542	20.3	85.7	61.4	72.3	96	53	75	64.0	4.2	101.6	78.4
8/7/2017	0.21	0.00	548	21.0	88.6	60.1	73.5	99	50	75	64.9	3.7	88.9	78.3
8/8/2017	0.22	0.00	565	20.5	92.1	61.3	74.3	98	43	71	64.3	3.8	90.5	78.5
8/9/2017	0.23	0.00	592	18.6	91.2	57.4	72.6	100	39	68	61.5	4.3	103.6	78.3
8/10/2017	0.23	0.00	563	18.7	90.8	56.8	72.2	100	41	69	61.6	4.6	110.0	78.2
8/11/2017	0.23	0.00	565	19.4	91.9	59.8	73.6	99	40	69	62.7	4.5	108.5	78.1
8/12/2017	0.21	0.00	538	18.7	90.4	57.0	69.5	99	44	76	61.5	5.1	122.4	76.8
8/13/2017	0.22	0.00	564	18.5	90.2	56.6	70.7	99	42	72	61.2	5.0	119.5	77.3
8/14/2017	0.22	0.00	574	18.3	86.5	59.2	69.7	95	46	74	60.9	5.7	137.1	77.1
8/15/2017	0.18	0.00	535	17.9	76.6	61.1	67.2	89	67	79	60.4	5.4	129.1	76.7
8/16/2017	0.19	0.00	551	17.2	81.1	53.7	65.5	100	50	80	59.2	4.4	106.6	75.6
8/17/2017	0.20	0.00	564	16.7	82.4	50.6	66.1	99	47	76	58.4	4.4	105.4	74.9
8/18/2017	0.19	0.00	529	18.4	83.6	57.4	69.1	96	50	76	61.2	4.5	108.3	75.3
8/19/2017	0.18	0.00	502	19.2	84.0	61.2	69.5	95	57	78	62.4	4.7	112.4	76.2
8/20/2017	0.18	0.00	509	18.2	83.3	61.9	68.7	89	53	76	60.9	5.0	121.2	76.8
8/21/2017	0.18	0.00	495	18.4	83.6	59.2	70.1	93	53	73	61.2	3.9	93.7	76.9
8/22/2017	0.19	0.00	531	19.7	85.0	55.9	69.7	99	56	79	63.0	4.1	99.0	77.3
8/23/2017	0.14	0.00	444	19.6	75.5	56.2	66.3	99	77	89	63.0	4.7	113.4	77.6
8/24/2017	0.10	0.00	352	18.3	76.3	55.1	64.3	99	71	89	60.9	4.3	102.5	76.7
8/25/2017	0.16	0.00	474	19.8	81.3	60.0	69.9	95	63	79	63.3	4.0	96.0	77.5
8/26/2017	0.20	0.00	535	20.2	90.2	54.9	71.3	100	50	77	63.8	3.5	84.5	78.0
8/27/2017	0.19	0.00	524	20.6	90.1	58.8	73.3	100	46	74	64.3	3.5	83.4	79.0
8/28/2017	0.20	0.00	529	21.8	95.5	60.3	77.0	99	44	69	66.0	3.3	80.3	79.9
8/29/2017	0.21	0.00	500	21.0	100.4	60.9	79.0	100	28	62	64.8	3.4	81.8	80.7
8/30/2017	0.22	0.00	512	21.4	100.5	62.5	80.4	98	33	61	65.5	3.5	84.3	81.5
8/31/2017	0.21	0.00	468	21.5	106.1	65.4	81.8	95	28	58	65.6	4.1	98.7	82.1
Tots/Avg	5.98	0.00	515	20.0	88.3	59.9	72.2	97	50	74	63.4	4.2	101.9	78.0

Escondido SPV - South Coast Valleys - Station 153

Date	ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Point (°F)	Avg Wind Speed (mph)	Wind Run (miles)	Avg Soil Temp (°F)
9/1/2017	0.24	0.0 0	506	18.7	106.3 Y	63.9	83.8 Y	96	22	47 Y	61.6 Y	4.2	100.3	82.7
9/2/2017	0.24	0.0 0	494	20.0	104.1	67.2	86.9 R	80 H	27 H	-- R	-- I	5.7 Y	137.2 Y	83.3 Y
9/3/2017	0.1 2 R	0.0 0	227	21.6	96.0	65.3	82.4 Y	99 H	33 H	57 Y	65.7 Y	8.1 R	193.4 R	82.6
9/4/2017	0.11	0.0 0	350	21.9	80.6	62.5	70.4	99	66	86	66.1	4.1	99.0	80.1
9/5/2017	0.18	0.0 0	487	22.3	86.2	61.0	73.2	100	60	80	66.7	4.4	105.3	80.2
9/6/2017	0.18	0.0 0	491	21.9	88.4	65.2	74.0	97	52	76	66.0	4.6	110.0	81.0
9/7/2017	0.19	0.0 0	492	19.9	88.9	60.0	72.9	99	45	72	63.4	3.9	92.6	80.7
9/8/2017	0.12	0.0 0	360	20.4	86.1	61.7	70.9	97	57	79	64.1	4.4	106.6	80.1
9/9/2017	0.15	0.0 0	398	20.0	86.5	64.9	73.3	89	42	71	63.4	3.9	93.6	80.0
9/10/2017	0.18	0.0 0	479	20.7	90.2	61.2	74.4	99	47	71	64.4	3.9	93.7	80.4
9/11/2017	0.19	0.0 0	480	21.6	94.5	65.7	75.8	93	46	71	65.8	4.3	104.4	81.2 Y
9/12/2017	0.14	0.0 0	408	21.6	86.1	62.0	72.4	98	60	80	65.7	3.9	93.3	81.3 Y
9/13/2017	0.10	0.0 0	310	19.6	80.1	60.4	69.3	93	62	80	62.9	3.8	91.8	80.3
9/14/2017	0.07	0.0 0	241	17.2	75.2	60.3	66.3	91	61	78	59.3	3.4	80.5	78.4
9/15/2017	0.11	0.0 0	360	18.5	77.0	59.9	66.1	99	61	85	61.3	3.6	87.4	77.4
9/16/2017	0.09	0.0 0	301	18.3	76.4	58.7	65.4	99	64	86	61.0	3.9	92.5	75.8
9/17/2017	0.11	0.0 0	344	18.7	77.3	63.1	67.9	94	63	80	61.5	3.7	88.2	77.1
9/18/2017	0.14	0.0 0	418	18.5	78.8	58.9	67.8	96	63	80	61.3	3.5	84.0	78.2
9/19/2017	0.14	0.0 0	427	17.6	78.9	60.8	67.7	93	57	76	59.9	4.0	94.9	78.2
9/20/2017	0.13	0.0 0	390	17.7	77.9	59.9	67.9	89	60	76	60.0	4.1	97.4	77.9
9/21/2017	0.06	0.0 0	219	15.9	71.6	53.2	63.4	90	66	80	57.0	4.4	105.3	76.7
9/22/2017	0.14	0.0 0	422	13.8	75.0	52.3	62.1	92	50	73	53.2	4.3	103.0	75.2
9/23/2017	0.14	0.0 0	441	13.9	73.6	50.9	61.4	94	52	75	53.3	4.1	97.3	74.7
9/24/2017	0.18	0.0 0	469	10.8	83.7	46.0	64.2	96	24	53	46.6	4.2	99.9	74.2

Date	ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Point (°F)	Avg Wind Speed (mph)	Wind Run (miles)	Avg Soil Temp (°F)
9/25/2017	0.19	0.00	454	8.1 Y	86.2	42.1	64.3	90	17	40 Y	39.2 Y	4.2	100.3	73.8
9/26/2017	0.19	0.00	454	9.2 Y	86.5	44.9	64.5	81	19	44 Y	42.2 Y	4.1	99.4	73.6
9/27/2017	0.18	0.00	455	10.9	87.0	44.1	65.0	88	26	52	46.8	3.8	90.5	73.7
9/28/2017	0.15	0.00	453	13.6	86.6	44.7	61.6	99	33	73	52.7	3.5	84.1	73.2
9/29/2017	0.17 R	0.00	447	13.3	89.2	42.9	64.7	99	29	64	52.2	3.9	94.6	72.8
9/30/2017	0.15	0.00	436	15.7	83.9	46.2	64.2	97	48	76	56.6	4.6	109.4	73.1
Tots/Avg s	4.48	0.00	407	17.4	84.6	57.0	69.5	94	47	71	58.6	4.2	101.0	77.9

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Date	ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Point (°F)	Avg Wind Speed (mph)	Wind Run (miles)	Avg Soil Temp (°F)
10/1/2017	0.14	0.00	407	16.7	77.3	58.9	66.1	94	56	76	58.4	5.1	121.6	73.7
10/2/2017	0.14	0.00	407	16.2	76.3	55.9	66.3	91	58	73	57.6	4.0	97.2	74.6
10/3/2017	0.11	0.00	327	15.2	74.5	55.3	63.8	92	52	75	55.9	5.1	121.4	73.9
10/4/2017	0.15	0.00	441	14.0	83.9	50.5	64.6	93	30	67	53.5	4.0	96.6	73.6
10/5/2017	0.16	0.00	441	13.2	86.4	46.0	63.8	99	36	65	51.9	3.3	79.1	73.4
10/6/2017	0.16	0.00	437	11.6	92.1	44.6	65.6	95	26	54	48.5	2.9	70.2	73.1
10/7/2017	0.18	0.00	440	9.4	93.1	41.7	65.9	90	20	43	42.8	3.4	81.4	73.0
10/8/2017	0.14	0.00	417	13.7	78.0	41.2	61.6	86	54	73	52.9	4.0	94.9	72.5
10/9/2017	0.18	0.00	414	11.6	87.0	45.3	65.4	99	8	54	48.4	4.7	113.9	73.0
10/10/2017	0.15	0.00	422	11.5	83.9	37.5	59.1	100	30	67	48.2	3.7	88.7	68.9
10/11/2017	0.13	0.00	405	14.6	77.5	45.5	61.8	94	52	77	54.7	3.7	89.5	69.4
10/12/2017	0.12	0.00	398	16.0	76.0	54.7	64.3	96	58	78	57.2	4.4	106.5	71.2
10/13/2017	0.11	0.00	367	15.8	78.4	50.7	62.0	97	59	83	56.9	3.8	90.7	71.5
10/14/2017	0.13	0.00	395	14.0	85.3	45.8	62.9	99	40	71	53.5	3.0	72.0	71.3
10/15/2017	0.16	0.00	400	10.8	95.2	40.5	66.0	99	22	49	46.5	3.2	77.0	71.1

Date	ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Point (°F)	Avg Wind Speed (mph)	Wind Run (miles)	Avg Soil Temp (°F)
10/16/2017	0.16	0.00	390	10.7	94.1	47.9	68.3	84	21	45	46.3	3.3	79.6	71.7
10/17/2017	0.14	0.00	358	12.1	90.9	49.9	67.9	79	24	52	49.6	3.3	78.6	72.0
10/18/2017	0.13	0.00	361	15.5	84.9	51.9	66.3	97	39	70	56.4	4.0	95.2	72.4
10/19/2017	0.08	0.00	272	16.9	75.3	53.8	63.7	98	65	84	58.8	3.2	76.7	72.2
10/20/2017	0.05	0.00	178	16.4	70.2	56.6	62.4	99	72	85	57.8	4.9	118.4	71.6
10/21/2017	0.11	0.00	360	13.5	78.8	48.7	61.4	93	46	73	52.6	3.2	76.0	70.9
10/22/2017	0.13	0.00	374	10.5	92.3	42.1	63.5	95	20	52	45.7	2.8	67.4	70.6
10/23/2017	0.15	0.00	374	10.4	101.3 Y	43.6	68.5	91	12	44	45.6	2.9	68.8	71.0
10/24/2017	0.20 R	0.00	367	9.0	99.5 Y	49.4	76.7 R	84 H	13 H	-- R	-- I	5.3	128.0	71.8 Y
10/25/2017	0.18 R	0.00	367	8.2	102.2 Y	54.3	77.6 R	62 H	11 H	-- R	-- I	4.0	96.2	73.0 Y
10/26/2017	0.16	0.00	358	8.8	94.1	48.5	68.3	74	15	37	41.3	3.7	89.2	72.7 Y
10/27/2017	0.13	0.00	354	10.1	88.7	44.9	64.2	82	19	49	44.7	2.9	70.0	71.9 Y
10/28/2017	0.12	0.00	352	12.8	87.1	41.7	62.4	96	29	67	51.2	3.4	81.2	71.3 Y
10/29/2017	0.08	0.00	280	16.0	77.2	53.1	63.4	93	58	80	57.2	4.4	106.8	71.7 Y
10/30/2017	0.03	0.00	114	14.7	66.9	60.3 Y	62.7	85	62	76	55.0	3.8	91.4	71.5 Y
10/31/2017	0.02	0.00	102	15.0	66.3	53.0	59.9	99	67	85	55.4	2.7	63.7	70.3 Y
Tots/Avg	4.03	0.00	357	13.1	84.3	48.8	65.0	91	38	66	51.9	3.7	89.9	72.0

Flag Legend		
A - Historical Average	I - Ignore	R - Far out of normal range
C or N - Not Collected	M - Missing Data	S - Not in service
H - Hourly Missing or Flagged Data	Q - Related Sensor Missing	Y - Moderately out of range
Conversion Factors		
Ly/day/2.065=W/sq.m	inches * 25.4 = mm	(F-32) * 5/9 = c
mph * 0.447 = m/s	mBars * 0.1 = kPa	miles * 1.60934 = km