Final Report
San Diego County Eye Gnat Research and Education Project 2018
Escondido, CA

Biology and Control of the Eye Gnat
Liohippelates collusor

Bryan Vander Mey, James A. Bethke and Laurent Ahiablame
University of California Cooperative Extension, San Diego
9335 Hazard Way, Suite 201
San Diego, CA 92123

CONTENTS

PROJECT LEADERS:

James A. Bethke, Floriculture and Nursery Farm Advisor (emeritus), UCCE San Diego
Laurent Ahiablame, County Director, San Diego
Bryan Vander Mey, Staff Research Associate, UCCE San Diego

RESEARCH PROJECT GOALS 2018

- 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 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 (*Liohippelates* and *Hippelates* spp.) has been a nuisance pest since the turn of the 20th century. *Liohippelates 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 gnat 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 2018 trapping season, an average of 40.69 gnats/trap/day were caught. This is up from 17.76 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

- Traps were placed at Kit Carson park, the riparian habitat, south of the farm and a field that produced sunflowers in Fallbrook. No gnats were trapped in Kit Carson park while the riparian habitat produced 1815 gnats/acre/day and Fallbrook produced 3500 gnats/acre/day.

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

- A meeting between county, university, residence and golf course staff took place on September 26, 2018.

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

- A consultation visit to Yuma, Arizona was conducted on May 23, 2018 to discuss strategies and collection issues regarding eye gnats.

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 previous years 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 cut 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 to prevent gnats from escaping. 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 reveled that only 3% of the eggs produced larvae thus severely hindering results of this study. None of the totes produced any eye gnats. The trial will be terminated due to successive years of no results.

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 2011-2018. Overall population in 2018 was up compared to the preceding year. The main difference in 2018 was that traps UC#9, UC#15, UC#19, UC#22 and UC#23 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 twice as many gnats as those traps within one half mile of the farm (77.08 gnats/trap/day vs. 35. 99 gnats/trap/day). Traps within residential areas recorded an average of 28.33 adult eye gnats/trap/day.

Traps counts in 2017, showed an overall decrease of 85.2% 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	2018
1	86.50	2.24	0.75	2.44	3.64	3.67	0.72	0.96
2	25.00	11.13	3.00	0.56	2.28	0.44	3.44	2.94
3	183.25	47.13	5.13	12.43	62.19	25.73	16.53	29.83
4	417.00	14.05	31.88	59.69	90.80	5.65	8.40	18.75
5	50.00	3.80	0.88	3.96	11.67	0.22	n/a	n/a
6	15.00	1.38	0.63	6.27	6.31	2.65	0.75	1.88
8	130.50	100.18	9.35	15.44	45.39	10.93	98.13	45.83
9	44.00	21.50	15.25	7.56	51.67	8.83	8.17	90.83
10	283.00	3.40	18.88	18.25	41.47	5.71	2.83	11.46
11	289.75	14.18	3.38	11.67	6.53	3.75	0.88	7.94
12	63.00	5.64	0.63	5.25	6.31	0.58	3.82	19.92
13	317.25	8.18	10.63	9.68	10.69	4.27	6.82	5.17
14	271.67	5.46	2.63	4.21	7.00	2.31	4.65	2.69
15	354.00	37.00	16.25	49.43	40.75	16.28	33.8	132.44
16	4.25	n/a	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	2.17
18	763.25	16.38	73.13	32.49	99.89	11.21	61.40	60.94
19	1050.00	70.98	10.9	31.69	98.36	60.03	44.57	149.77
20	386.00	110.05	19.13	132.06	260.36	77.16	78.82	104.85
21	8.67	3.63	0.25	6.67	1.69	0.79	0.90	1.19
22	1083.00	13.33	3.88	34.73	144.86	35.49	43.38	129.94
23	119.25	5.30	1.38	9.69	1.53	3.27	1.99	28.25
24	384.00	14.05	2.88	12.13	30.89	13.98	8.17	21.81
25	81.00	8.75	0.75	12.58	8.81	0.88	0.94	9.73
Mean	274.06	22.9	10.2	17.75	45.28	12.84	17.76	40.69

* Data collected only in month of October 2011

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

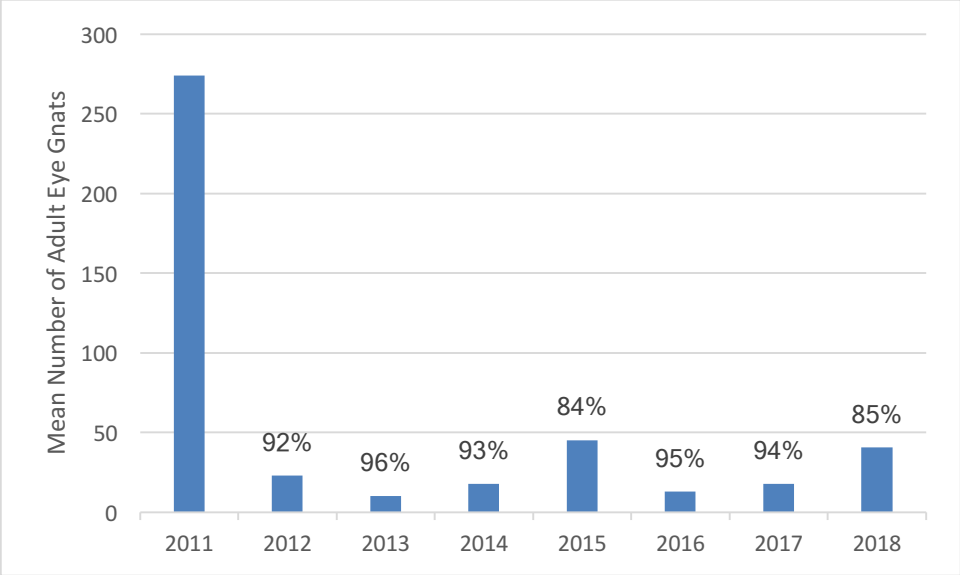

Table 3. Mean number of captured adult eye gnats/trap/day during a one-week period in the month of October for each year of data collected. Gnats were collected using UCCE collar traps as part of the historical grid sampling in south Escondido, CA.

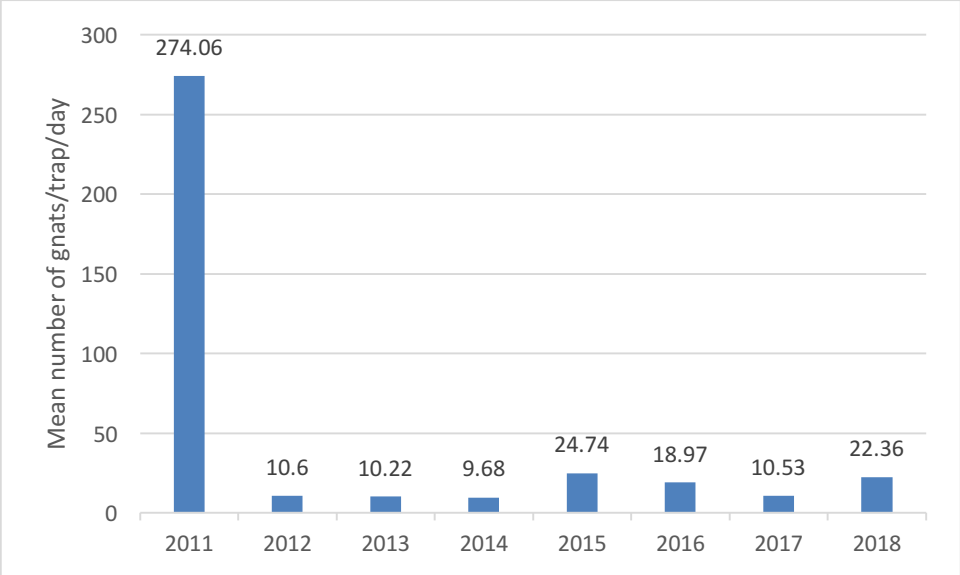

Table 4. Grouping of selected UC traps into areas of interest in 2018. Gnats were collected using UCCE collar traps as part of the historical grid sampling in south Escondido, CA.

Description of Area	UC Trap Numbers	# of Traps	Mean Gnats/Trap/Day	Importance
Proximity to Organic Farm	8, 9, 10, 15, 20	5	77.08	Population potential near the farm
South of farm (Highland Valley Rd)	2, 3, 4	3	17.17	Proximity to the farm but across open space
West of I-15	1, 6, 11, 21	4	2.99	Furthest from the farm, across freeway
Traps within a half mile of the farm	3, 4, 13, 14, 19, 25	6	35.99	Half mile proximity to farm
Traps greater than a mile of the farm	1, 17, 21, 22, 23	5	32.50	Mile proximity to farm
Traps in open areas	2, 3, 4, 6, 12, 22	6	33.88	Natural environment
Traps within residential areas	11, 13, 14, 19, 21, 24, 25	7	28.33	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 DIFFERENT ECOLOGIES AS A SOURCE OF EYE GNAT DEVELOPMENT SITES

Objective

The purpose of this study was to determine if newly established ecologies posed a threat to the development of eye gnat breeding sites.

Introduction

One changed ecosystem tested was the riparian area south of the farm and east of Lake Hodges. Clearing of invasive shrubs had taken place and new native species were planted. Mowing/incorporation of weeds was also being conducted providing a potential food source. The new plants were being watered by drip irrigation for establishment.
Complaints near Fallbrook were received from residence where the suspect source was a sunflower grower. Also, turf at Kit Carson Park in south Escondido was again tested as potential breeding site for eye gnat development and a contributing source of eye gnats.

Materials and Methods

Sampling: Collection jars were collected every 3-4 days. The contents were frozen and counted. Trapping took place over a two week period from 9/25 – 10/12.

Cage type: Emergence traps consist of a 2 ft. by 2 ft. PCV frame, covered in a black cotton fabric (Fig. 6). A glass mason jar with a funnel is attached to upper surface of the trap to collect any flying insects.

Locations: Kit Carson Park – Three emergence traps were placed. One was located near the south entrance, one near the tennis courts and one near the north border (Figure 7). All turf was irrigated with sprinklers.

Riparian area - Three traps were placed in the riparian area south of the farm and east of Lake Hodges. Since there are no obvious landmarks to pinpoint the location of the traps, see Figure 8 for sampling sites. Traps were placed over an emitter on the drip irrigation lines for the new plantings.

Fallbrook - Four traps were placed at a sunflower grower near Fallbrook, CA (cross streets of Winter Haven Road and Green Canyon Road). See Figure 9 for locations. Traps were also placed over the drip irrigation emitters.

Results

No gnats were trapped in Kit Carson park while the riparian habitat produced 1815 gnats/acre/day and Fallbrook produced 3500 gnats/acre/day. Compromised (holes dug by ground squirrels) emergence traps set at the farm in Escondido in 2011 produced approximately 1800 gnats/acre/day. The riparian area produced more eye gnats than anticipated but not all this area is being watered or under production. Only areas that received water from the irrigation lines would be able to produce eye gnats. An estimated realistic number would be approximately 400 gnats/acre/day. This would only occur until the food source is depleted and water becomes unavailable.

Emergence trapping verified that the sunflower production fields near Fallbrook were producing a large number of eye gnats. It was reported later in the year that the grower was not returning so the number of eye gnats is expected to be significantly less.

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

A meeting between Del Lago residence, the Vineyard Golf Course, county personnel and UCCE staff took place on September 26, 2018. Strategies concerning the placement of additional traps were discussed to help reduce the number of gnats affecting the community near the golf course. UCCE was not involved in any further actions.

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

A consultation visit to Yuma, Arizona occurred on May 23,2018. A meeting was requested by Elene Stefanakos of the Yuma County Pest Abatement District. A large population of eye gnats occur in Yuma due to incorporating weeds into the soil of agricultural crops. The issue is compounded by the dispersal of houses within the agricultural area. The two topics of research requested involved 1) is there any additive that can be added to the bait to make it attractive longer, 2) sometimes the bait will turn 'whitish' and seems to be highly attractive to the gnats. What chemical component makes it attractive? Research into these issues will be pursued as time permits. No solutions have presented themselves at this point.

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

Bethke, J. A., Vander Mey, B., Tanazaki, G., and Lea Corkidi. Final Report: San Diego County Eye Gnat Research and Education Project 2014. In fulfillment of San Diego County Contract #532716. 24pgs. Available online: http://ucanr.org/eyegnats

Bethke, J. A., Vander Mey, B., Corkidi L. Final Report: San Diego County Eye Gnat Research and Education Project 2015. In fulfillment of San Diego County Contract #554912. 19pgs. Available online: http://ucanr.org/eyegnats

Bethke, J. A., Vander Mey, B., Taylor, L. Final Report: San Diego County Eye Gnat Research and Education Project 2016. In fulfillment of San Diego County Contract #554912. 39pgs. Available online: http://ucanr.org/eyegnats

Bethke, J. A., Vander Mey, B., Hans, J., Final Report: San Diego County Eye Gnat Research and Education Project 2017. In fulfillment of San Diego County Contract #554912. 29pgs. Available online: http://ucanr.org/eyegnats

SELECTED REFERENCES

Anonymous. 1929. The California eye gnat. Science 69:14.

Buehler J.W., J. T. Holloway, R. A. Goodman, and R. K. Sikes. 1983. Gnat sore eyes - seasonal, acute conjunctivitis in a southern state. Southern Medical Journal. 76(5):587-589.

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.

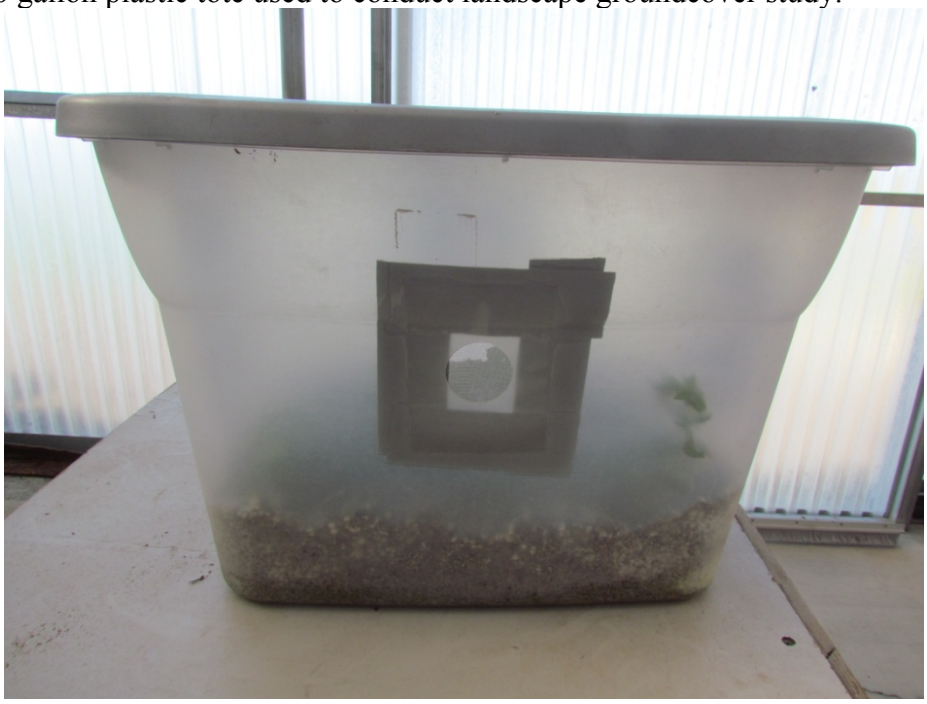

Figure 2. Inside the tote showing the vermiculite/perlite mix and red apple groundcover.

Figure 3. Components used to make UCCE collar traps. Bait jar (3-inch drainage pipe with cemented cap), 3-inch PVC collar with ¾ 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.

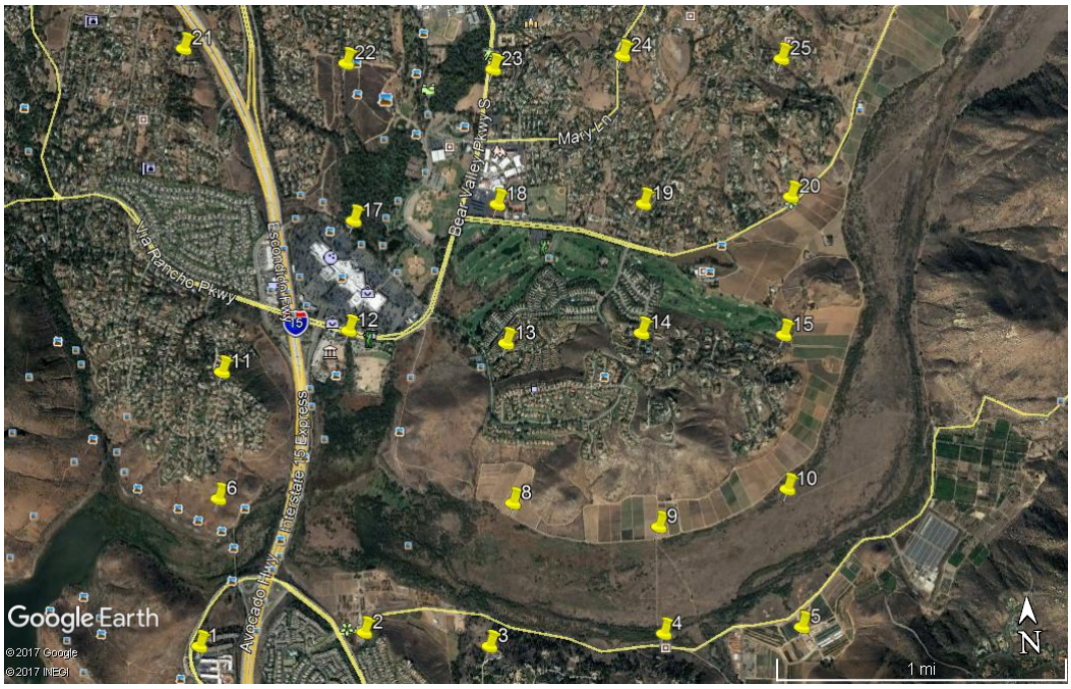

Figure 6. Emergence trap with funnel and collection jar in top center.

Figure 7. Location of emergence traps at Kit Carson Park.

Figure 8. Approximate location of emergence traps in riparian area south of farm.

Figure 9. Approximate location of emergence traps near Fallbrook, CA in sunflower production field.

APPENDIX II
Weather Data

California Irrigation Management Information System (CIMIS)

CIMIS Daily Report

Rendered in ENGLISH Units.
Friday, June 1, 2018 - Wednesday, October 31, 2018
Printed on Monday, June 17, 2019

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)
6/1/2018	0.25	0.00	726	14.9	78.7	53.2	66.9	90	41	66	55.3	4.2	100.8	70.8
6/2/2018	0.25	0.00	726	15.4	82.9	48.9	66.9	95	44	68	56.1	3.8	90.2	70.3
6/3/2018	0.26	0.00	728	16.7	84.8	52.0	68.5	96	49	70	58.4	4.3	102.5	70.7
6/4/2018	0.25	0.00	726	17.7	82.2	54.6	67.9	96	54	76	60.0	5.1	122.1	71.2
6/5/2018	0.24	0.00	706	16.9	78.7	60.6	67.7	88	55	73	58.8	5.1	121.5	71.7
6/6/2018	0.24	0.00	702	16.0	81.7	55.1	67.0	93	50	71	57.2	5.3	127.4	72.1
6/7/2018	0.26	0.00	724	14.7	81.8	54.7	67.6	94	41	64	54.9	5.2	125.7	72.3
6/8/2018	0.28	0.00	741	14.0	89.5	47.7	68.4	96	33	59	53.6	4.6	111.1	72.1
6/9/2018	0.28	0.00	740	14.4	89.2	50.6	69.5	94	30	59	54.4	5.0	119.9	72.5
6/10/2018	0.27	0.00	737	16.3	85.2	55.5	69.9	93	42	65	57.7	5.8	138.2	73.3
6/11/2018	0.27	0.00	749 R	16.6	86.8	51.8	70.2	98	37	66	58.3	4.3	104.2	73.8
6/12/2018	0.25	0.00	751 R	18.3	83.9	52.0	67.5	97	47	80	60.9	4.7	113.8	73.5
6/13/2018	0.27	0.00	733	17.9	87.2	53.7	70.7	98	43	70	60.4	4.5	108.9	72.3
6/14/2018	0.25	0.00	690	18.2	94.8 Y	56.8	71.6	97	32	69	60.8	4.1	99.1	73.1
6/15/2018	0.23	0.00	631	19.6 Y	86.8	62.0	71.4	95	55	75 Y	63.0 Y	5.3	128.0	73.3
6/16/2018	0.16	0.00	474	16.5	73.3	61.3	65.8	89	62	76	58.1	6.0	143.7	72.8
6/17/2018	0.19	0.00	572	14.3	73.1	59.8	64.7	85	54	68	54.1	4.8	114.1	71.4
6/18/2018	0.23	0.00	689	15.7	77.4	59.6	66.9	87	48	70	56.7	4.3	102.9	71.4
6/19/2018	0.22	0.00	646	17.1	80.2	59.1	67.5	91	55	74	59.1	4.8	114.1	72.1
6/20/2018	0.20	0.00	642	18.7	80.5	55.2	65.5	96	63	87	61.7	4.7	113.6	71.9
6/21/2018	0.24	0.00	685	19.2	85.6	59.8	69.2	96	54	79	62.3	4.9	118.0	72.2
6/22/2018	0.25	0.00	713	19.1	88.1	62.0	71.4	92	43	73	62.3	4.6	111.6	73.7
6/23/2018	0.24	0.00	711	18.4	77.3	61.8	68.0	91	63	79	61.2	5.8	139.8	74.4
6/24/2018	0.24	0.00	722	17.3	79.5	56.8	68.4	92	58	73	59.4	4.7	113.8	74.4
6/25/2018	0.25	0.00	732	17.2	82.9	56.2	68.7	93	54	72	59.3	4.5	107.6	74.2
6/26/2018	0.25	0.00	704	17.1	87.5	54.3	69.2	94	43	70	59.0	4.3	102.5	74.2
6/27/2018	0.26	0.00	720	16.8	85.7	53.1	69.3	95	42	69	58.6	4.5	108.6	74.1
6/28/2018	0.26	0.00	725	17.1	82.6	56.9	68.4	92	47	72	59.1	5.4	129.7	74.5
6/29/2018	0.25	0.00	712	16.2	81.2	59.3	68.4	92	48	68	57.6	5.5	131.5	74.5

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)
6/30/2018	0.25	0.00	708	16.0	82.7	57.2	69.3	91	44	66	57.3	5.4	129.9	75.2
Tots/Avgs	7.34	0.00	699	16.8	83.1	56.1	68.4	93	48	71	58.5	4.9	116.5	72.8

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)
7/1/2018	0.26	0.00	704	16.4	85.6	57.4	70.2	92	40	65	57.9	4.9	117.3	75.7
7/2/2018	0.25	0.00	679	17.5	87.4	56.3	70.8	93	41	68	59.7	4.7	113.6	76.1
7/3/2018	0.24	0.00	677	18.6	83.3	60.0	70.6	97	49	73	61.4	5.5	132.1	76.4
7/4/2018	0.26	0.00	702	18.8	88.2	59.2	71.2	98	42	72	61.8	4.6	109.3	74.5
7/5/2018	0.28	0.00	712	17.9	97.4 Y	53.8	74.4	99	30	62	60.4	4.2	101.7	74.6
7/6/2018	0.25 R	0.00	638	19.1	-- S	61.2	-- S	94 H	28 H	-- Q	-- Q	4.0	95.5	76.9
7/7/2018	0.24 R	0.00	574	21.3	103.2 R	70.5 R	-- S	79 H	34 H	-- Q	-- Q	3.8	91.1	79.4
7/8/2018	0.27 R	0.00	630	18.8	96.5	67.3 Y	81.8 R	83	31	-- R	-- I	4.2	100.2	80.2
7/9/2018	0.11	0.03	283	20.3	88.6	67.5 Y	77.5	91	43	63	63.9	3.4	82.0	79.2
7/10/2018	0.06	0.00	224	24.1 Y	84.0	69.7 Y	75.9	95	62	79 Y	68.8 Y	3.1	75.0	78.4
7/11/2018	0.25 R	0.00	656	22.3 Y	89.1	65.3	76.5	95	54	72 Y	66.7 Y	4.6	109.8	78.5
7/12/2018	0.25	0.00	657	22.5 Y	87.7	66.0	76.0	92	56	73 Y	66.9 Y	4.7	112.0	79.4
7/13/2018	0.24	0.00	649	22.3 Y	89.5	64.2	75.2	95	53	75 Y	66.7 Y	4.3	103.1	79.8
7/14/2018	0.25	0.00	652	22.5 Y	89.9	65.9	76.6	93	51	72 Y	66.9 Y	3.9	92.6	80.3
7/15/2018	0.25	0.00	646	21.8	91.0	65.4	75.8	93	46	72	66.0	4.5	108.8	80.7
7/16/2018	0.25	0.00	650	21.0	89.5	62.3	74.2	94	47	73	64.9	4.7	112.2	80.3
7/17/2018	0.24	0.00	639	22.2	90.2	64.9	74.9	93	53	75	66.5	4.6	109.7	80.6
7/18/2018	0.19	0.00	508	22.0	89.3	66.4	74.9	92	55	74	66.3	4.6	111.6	80.7
7/19/2018	0.25	0.00	635	21.3	91.8	65.3	76.2	93	46	69	65.4	4.9	116.5	80.9
7/20/2018	0.25	0.00	646	21.2	86.2	64.6	75.6	93	47	70	65.1	5.0	120.7	81.5
7/21/2018	0.24	0.00	610	21.8	90.7	65.9	76.9	91	49	69	66.0	4.9	118.1	82.2
7/22/2018	0.27	0.00	645	20.6	93.3	65.1	78.5	93	39	62	64.3	4.7	112.3	82.6 Y

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)
7/23/2018	0.27	0.00	649	21.2	100.3 Y	63.0	80.9 Y	88	34	59 Y	65.1 Y	4.3	103.0	82.9 Y
7/24/2018	0.27	0.00	650	25.4 Y	97.1	67.8 Y	81.1 Y	98	44	70 Y	70.4 Y	4.9	117.3	83.7 Y
7/25/2018	0.26	0.00	656	25.8 Y	96.9	68.5 Y	79.9 Y	100	45	74 Y	70.8 Y	4.4	106.0	82.4 Y
7/26/2018	0.25	0.00	657	24.1 Y	91.1	66.8	76.9	96	54	76 Y	68.8 Y	5.1	122.7	82.7 Y
7/27/2018	0.26	0.00	662	22.6	99.1 Y	62.4	77.6	96	30	70	67.0	4.6	109.6	82.2
7/28/2018	0.24	0.00	618	24.0 Y	88.7	69.0 Y	77.2	93	54	75 Y	68.7 Y	5.0	119.0	82.6 Y
7/29/2018	0.25 R	0.00	610	22.1	95.0	67.6	79.2 Y	94	36	65 Y	66.4 Y	4.4	106.8	82.5 Y
7/30/2018	0.26	0.00	640	21.6	93.6	68.5 Y	80.8 Y	92	36	60 Y	65.7 Y	4.0	96.2	83.1 Y
7/31/2018	0.25	0.00	625	22.2	94.4	68.6 Y	79.6 Y	93	42	64 Y	66.5 Y	4.4	105.4	83.7 Y
Tots/Avgs	7.46	0.03	619	21.4	91.6	64.7	76.4	93	44	70	65.5	4.5	107.5	80.2

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)
8/1/2018	0.26 R	0.00	629	21.8	96.1 Y	67.6	80.6 Y	89	40	61 Y	65.9 Y	4.0	95.8	83.9 Y
8/2/2018	0.24	0.00	640	23.8 Y	90.7	68.7 Y	77.6	96	48	74 Y	68.6 Y	4.1	99.0	83.9 Y
8/3/2018	0.25	0.00	644	23.6 Y	92.5	64.8	77.9 Y	98	46	72 Y	68.3 Y	4.0	95.6	82.2 Y
8/4/2018	0.25	0.00	659	23.1	94.7	64.2	76.9	94	44	73	67.6	4.0	94.8	82.3 Y
8/5/2018	0.26	0.00	677	20.3	92.8	59.2	76.1	95	38	66	63.9	3.5	84.7	81.8
8/6/2018	0.23 R	0.00	664	19.3	96.7	58.0	78.2 Y	94	31	58 Y	62.4 Y	1.2 R	28.5 R	81.5
8/7/2018	0.27	0.00	653	21.2	97.9 Y	62.3	80.0 Y	93	30	61 Y	65.1 Y	4.0	95.9	81.9 Y
8/8/2018	0.28	0.00	640	19.4	96.5	64.0	80.7 Y	91	31	54 Y	62.6 Y	4.5	107.0	82.3 Y
8/9/2018	0.25	0.00	540	19.5	99.1 Y	66.5 Y	82.7 Y	82	32	51 Y	62.8 Y	4.3	103.1	82.8 Y
8/10/2018	0.27 R	0.00	589	20.9	94.2	69.9 Y	82.2 Y	84	38	56 Y	64.8 Y	5.0	119.9	83.7 Y
8/11/2018	0.25	0.00	588	20.8	94.2	66.5 Y	79.6 Y	87	37	60 Y	64.6 Y	4.4	106.1	83.6 Y
8/12/2018	0.24	0.00	610	23.2 Y	91.2	67.5 Y	77.8	94	49	71 Y	67.8 Y	4.8	115.1	84.1 Y
8/13/2018	0.23	0.00	609	21.0	87.3	64.4	74.4	96	43	72	65.0	4.8	114.3	83.7 Y
8/14/2018	0.23	0.00	621	21.3	87.4	61.4	73.0	98	48	77	65.3	4.7	113.2	80.8
8/15/2018	0.21	0.00	581	22.9 Y	85.3	66.5 Y	74.4	91	62	79 Y	67.3 Y	5.0	120.4	81.5
8/16/2018	0.22	0.00	592	23.2 Y	86.5	66.7 Y	75.2	93	60	78 Y	67.8 Y	5.0	119.8	81.9
8/17/2018	0.22	0.00	594	24.0 R	88.8	67.7 Y	76.6	93	57	-- R	-- I	4.6	110.0	82.3
8/18/2018	0.23	0.00	592	23.6 Y	88.8	68.6 Y	77.1	92	54	74 Y	68.2 Y	4.2	100.3	83.0
8/19/2018	0.23	0.00	593	22.6 Y	88.3	66.9 Y	76.2	92	52	73 Y	67.0 Y	4.5	108.0	82.9
8/20/2018	0.20	0.00	523	22.4 Y	86.5	66.4 Y	74.3	93	58	77 Y	66.7 Y	4.6	109.3	82.6
8/21/2018	0.21	0.00	555	21.7	87.9	66.5 Y	75.2	92	51	73	65.9	4.5	108.2	82.4
8/22/2018	0.23	0.00	597	21.2	87.9	65.0	75.3	91	48	71	65.2	4.5	108.6	82.6

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)
8/23/2018	0.22	0.00	597	20.9	88.0	63.1	73.6	93	50	74	64.8	4.4	105.6	82.3
8/24/2018	0.18	0.00	523	21.2	84.8	62.1	71.3	97	57	81	65.2	4.2	101.0	82.1
8/25/2018	0.18	0.00	525	20.8	84.3	60.5	70.8	98	59	81	64.6	4.4	106.6	79.5
8/26/2018	0.18	0.00	533	20.2	84.7	61.8	71.6	93	55	77	63.8	3.9	93.4	79.6
8/27/2018	0.20	0.00	557	19.1	84.7	60.2	71.0	93	50	74	62.2	4.4	104.7	79.2
8/28/2018	0.21	0.00	593	18.7	85.0	57.8	70.2	94	53	74	61.5	3.8	90.3	78.2
8/29/2018	0.21	0.00	581	18.6	88.7	56.9	72.1	95	47	69	61.5	3.6	86.5	78.0
8/30/2018	0.23	0.00	619	17.0	91.5	55.7	72.7	95	30	62	58.9	3.6	86.9	78.0
8/31/2018	0.22	0.00	603	19.0	88.0	55.9	71.7	94	46	72	62.0	4.3	102.8	77.9
Tots/Avgs	7.09	0.00	597	21.2	90.0	63.7	75.7	93	47	70	64.9	4.2	101.1	81.7

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)
9/1/2018	0.21	0.00	567	19.9	83.2	64.7	72.2	91	52	73	63.3	5.4	128.8	79.0
9/2/2018	0.20	0.00	531	19.3	83.7	67.7	72.8	85	48	70	62.4	5.3	126.1	79.8
9/3/2018	0.19	0.00	524	20.0	82.9	63.6	71.9	89	56	75	63.5	4.8	115.1	80.6
9/4/2018	0.10	0.00	344	20.7	77.9	60.2	68.2	97	73	88	64.5	4.1	98.1	79.6
9/5/2018	0.19	0.00	555	20.7	84.2	62.6	71.3	97	55	79	64.4	4.8	116.1	78.3
9/6/2018	0.19	0.00	538	20.7	83.6	63.7	71.2	92	60	79	64.5	4.6	110.3	78.9
9/7/2018	0.20	0.00	555	21.1	88.2	63.9	73.5	91	53	75	65.1	4.5	107.8	79.6
9/8/2018	0.22	0.00	580	20.6	97.4	58.3	75.4	96	36	68	64.3	3.5	84.2	79.6
9/9/2018	0.20 R	0.00	600	19.4	95.3	57.8	74.8	97	31	66	62.6	1.9 Y	46.3 Y	79.5
9/10/2018	0.21	0.00	590	19.8	88.2	58.6	72.6	96	46	72	63.2	4.8	115.2	79.5
9/11/2018	0.19	0.00	555	18.2	84.2	56.2	68.6	96	50	76	60.8	4.5	108.3	78.5
9/12/2018	0.19	0.01	590	19.3	83.1	59.0	68.9	94	56	80	62.4	5.0	119.5	78.1
9/13/2018	0.20	0.00	583	17.6	88.9	52.9	70.1	98	41	70	59.9	3.3	78.7	76.7
9/14/2018	0.18 R	0.00	567	16.2	91.5	52.6	72.1	94	30	60	57.5	1.4 R	33.4 R	76.7
9/15/2018	0.20	0.00	561	15.8	88.6	53.1	70.8	90	35	62	56.9	3.3	78.9	76.4
9/16/2018	0.18 R	0.00	559	15.9	88.7	54.5	70.5	92	36	62	57.1	1.2 R	28.9 R	76.3
9/17/2018	0.21	0.00	565	15.0	88.3	53.2	69.9	89	34	60	55.5	3.4	82.6	76.0
9/18/2018	0.20	0.00	568	15.3	89.1	47.6	67.8	94	36	66	56.0	3.4	81.0	75.4
9/19/2018	0.19	0.00	548	16.2	85.5	58.2	68.8	94	37	68	57.6	3.9	94.4	75.7
9/20/2018	0.17	0.00	491	18.1	82.5	56.6	67.4	94	58	79	60.7	3.7	88.9	75.7
9/21/2018	0.18	0.00	531	17.8	86.9	50.9	68.4	97	48	75	60.2	3.0	72.9	75.5
9/22/2018	0.18	0.00	510	19.5	89.9	56.5	72.2	96	45	72	62.7	3.4	81.7	76.3
9/23/2018	0.15	0.00	451	20.9	86.1	60.0	70.6	98	56	82	64.8	3.7	88.2	76.7
9/24/2018	0.10	0.00	334	19.6	74.9	64.8 Y	67.8	90	73	84	62.9	3.5	83.4	76.3
9/25/2018	0.13	0.00	385	18.5	82.1	57.8	68.7	92	53	77	61.3	3.4	82.1	76.4
9/26/2018	0.15	0.00	428	19.1	86.3	59.1	69.1	94	49	79	62.2	4.0	96.8	76.4
9/27/2018	0.18	0.00	499	19.2	92.2	55.9	71.2	98	42	73	62.3	3.8	91.2	76.7
9/28/2018	0.18	0.00 H	504	20.6 Y	87.0	63.9	72.8	95	49	75 Y	64.4 Y	4.3	103.9	77.7
9/29/2018	0.18	0.00	510	19.5	89.8	62.6	73.1	95	43	70	62.8	4.1	98.7	78.1

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)
9/30/2018	0.17	0.00	447	20.0	91.6	62.7	75.4	96	39	67	63.5	4.4	105.4	78.0
Tots/Avgs	5.42	0.01	519	18.8	86.7	58.6	70.9	94	47	73	61.6	3.8	91.6	77.6

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)
10/1/2018	0.12	0.00	328	21.9 Y	93.2	65.7 Y	77.6 Y	99	41	68 Y	66.1 Y	3.6	85.4	78.4
10/2/2018	0.08	0.00	239	23.1 R	85.7	64.0 Y	73.1	100	58	-- R	-- I	4.1	99.2	75.4
10/3/2018	0.14	0.00	406	18.9	82.3	64.0 Y	71.2	86	50	72	61.9	3.6	86.9	74.5
10/4/2018	0.13	0.20	418	20.6 Y	77.6	64.1 Y	69.4	98	66	84 Y	64.3 Y	3.7	88.8	74.9
10/5/2018	0.16	0.00	505	18.7	77.1	59.6	67.5	95	62	82	61.6	3.6	85.2	75.0
10/6/2018	0.06	0.00	222	17.5	73.7	56.1	64.6	97	67	84	59.7	3.4	81.2	73.4
10/7/2018	0.13	0.00	422	17.4	75.4	57.8	65.3	94	62	81	59.5	3.9	94.4	72.9
10/8/2018	0.15	0.00	495 R	16.6	77.8	53.0	63.7	97	58	82	58.2	3.5	85.0	72.8
10/9/2018	0.15	0.00	472	15.9	76.8	53.2	63.7	96	55	79	57.0	3.6	86.7	72.8
10/10/2018	0.14	0.00	498 R	15.8	70.7	54.2	63.3	91	66	80	56.9	4.5	107.9	72.4
10/11/2018	0.12	0.00	382	15.0	76.4	56.3	64.4	92	48	73	55.4	2.9	69.5	72.4
10/12/2018	0.14	0.41	428	15.9	79.4	48.7	63.8	97	52	79	57.1	4.5	106.8	70.8
10/13/2018	0.01	0.13	109	18.2	64.1	56.3	61.4	99	95	98	60.7	2.2	53.1	70.6
10/14/2018	0.08	0.00	287	17.1	76.3	54.3	62.9	100	61	87	59.1	2.2	53.6	69.8
10/15/2018	0.19	0.00	489 R	9.0	78.9	46.3	63.0	100	14	46	41.8	5.7	135.7	69.1
10/16/2018	0.16	0.00	494 R	7.9	82.0	38.6	59.3	88	19	46	38.4	3.3	79.5	66.7
10/17/2018	0.16	0.00	472 R	9.9	81.2	45.6	63.0	87	29	50	44.3	3.8	90.4	67.1
10/18/2018	0.15 R	0.00	472 R	11.4	87.7	45.6	65.5	95	22	53	48.1	2.6	62.6	67.8
10/19/2018	0.17	0.00	473 R	11.6	87.5	47.8	67.2	93	22	51	48.4	3.7	89.0	68.4
10/20/2018	0.16	0.00	462 R	12.4	93.4	50.8	69.8	84	26	50	50.3	3.5	83.5	69.0
10/21/2018	0.15	0.00	455 R	14.9	83.0	48.6	66.0	98	35	68	55.2	3.1	74.5	69.4
10/22/2018	0.11	0.00	384	17.0	83.1	56.7	64.9	97	54	81	58.9	3.7	88.2	70.1
10/23/2018	0.12	0.00	417	18.2	78.5	57.6	65.4	99	63	85	60.8	3.7	88.4	70.7
10/24/2018	0.12	0.00	389	17.9	82.5	57.7	65.9	98	54	82	60.3	3.3	80.2	71.6
10/25/2018	0.13	0.00	428	17.8	84.5	50.8	66.6	100	47	80	60.2	2.9	68.8	71.1
10/26/2018	0.14	0.00	434 R	19.1 Y	91.9	53.7	71.9 Y	100	33	72 Y	62.2 Y	2.7	63.8	71.0
10/27/2018	0.15	0.00	432 R	16.1	92.7	50.2	68.5	98	32	68	57.4	3.1	73.6	71.2 Y
10/28/2018	0.11 R	0.00	329	16.5	89.3	50.7	66.9	100	37	73	58.0	2.5	59.8	70.4
10/29/2018	0.11	0.00	336	17.7	92.6	52.8	67.0	100	38	78	60.0	3.8	91.2	69.9
10/30/2018	0.12	0.00	406	16.8	79.3	54.1	66.4	95	49	76	58.6	4.6	109.5	71.0 Y
10/31/2018	0.14	0.00	419 R	12.7	85.8	48.3	64.0	99	22	62	50.9	3.4	81.1	70.2 Y
Tots/Avgs	4.00	0.74	403	16.1	81.9	53.7	66.2	96	46	72	56.4	3.5	84.0	71.3