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Evaluation of the Red Imported Fire Ant Foraging Behavior

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Introduction

The Coachella Valley Mosquito and Vector Control District (CVMVCD) examined the activity of red imported fire ants, *Solenopsis invicta*, from May 2015 until May 2016. Ant abundance was measured to determine the most effective time for vector control technicians to conduct surveillance and to make treatments to control the ants. Since ants adapt and exploit their environment, the purpose of the study was to understand when the ants forage, so that the CVMVCD can manage the ants effectively. During the summer months, the temperatures can get up to as high as 120°F (49°C). These high temperatures are not safe for staff and so the work shifts are adjusted during the year. From May through September, technicians work from 5:30 a.m. to 2:00 p.m. and from October through April from 7:00 a.m. to 3:30 p.m. Since temperature is the driving force for insect development, growth, and behavior, under extreme hot and cold temperatures, insect growth and behavior is restricted. During winter, daytime temperatures can range from 68°F (20°C) to as high as 88°F (31°C) and the nights in the Coachella Valley can get as low as 30°F (1°C).

CVMVCD operates under the California Health and Safety code, Division 3, Sections 2000-2910 and covers 2,400 square miles. The District is located in Coachella Valley, southern California and is a special district that protects the public health. It is a popular desert destination for tourists and snowbirds and has great weather almost year-round, except during the hot summer months. The valley's landscapes are man-made artificial oasis in a desert environment. Since the ants prefer a temperate, moist environment, daily irrigation to lawns, golf courses, and other horticultural landscapes in the Coachella Valley has provided ideal conditions for *S. invicta* to survive in an arid desert and establish.

RIFA are native to South America and were first introduced into the states at Mobile, Alabama at about 1940. In California they were introduced in 1997-1998 when they were brought in on almond groves from Texas (Greenberg et. al. 2002).They spread through the movement of soil and plants which was associated with commerce, either on vehicles, trucks, and trains. In California, the red imported fire ant (RIFA) is a quarantined pest. RIFA are holometabolous and mating flights allows the ants to colonize. The female alate mates, snaps her wings off and finds a suitable place to begin a new colony and lay her eggs. The queen's wing muscles break down to provide the nutrients for the young larvae. The first workers burrow out of the chamber and forage for food to feed the new larvae and queen. The larvae are fed a liquid diet by trophallaxis until they reach the third instar. At the fourth instar stage, the larvae are able to eat and digest solid foods. The queen is fed to support egg production and can lay hundreds of eggs daily. The ants vary in size and caste is determined by how much food is given to the larvae (Greenberg et. al. 2002). The colonies are either monogyne or polygyne; having one queen or multiple queens per colony, respectively. When a mound is disturbed, red imported fire ants emerge aggressively to bite and sting. The sting of the ant possesses venom of an alkaloid nature, which exhibits a potent necrotoxic activity (Collins and Scheffrahn 2001). It is a major

agricultural and urban pest and nest in lawns, sidewalk edges, foundations, concrete driveways, and electrical boxes and can invade lawns, golf courses, parks, and school yards.

A component of the CVMVCD Integrated Vector Management program is to protect residents from the red imported fire ant, *S. invicta*. The program was established in 2005 to reduce the potential for injury and economic impact to the residents and visitors. The ants are aggressive and inflict a painful sting to animals and humans. Since the program began, the number of treatment applications made by District technicians to control the fire ants has increased in the Coachella Valley (Henke 2015). This increase in treatments could possibly be attributed to the ants spreading since the program began. Monitoring when the ants forage is necessary, so that control efforts are successful at managing the ants. Thirty-two RIFA mounds were surveyed every two weeks during the time of day when District technicians were working. A hot dog slice was placed 3 ft. (1 m) from the mound for one hour. After one hour, the number of ants was estimated, the hot dog slice was removed, and a new hot dog slice was placed 90° from the previous location (for instance, if the first slice was north of the mound, the next slice was east of the mound). The lures were moved hourly so that the ants would follow a different trail of pheromones to the food. Air temperature and relative humidity were measured, and air temperature was found to be a good predictor of ant activity. The project examined ant abundance for one year during the summer, fall, winter, and spring. CVMVCD used this study to revise its Standard Operating Procedures to make effective and efficient treatments.

Objectives

- Determine what the optimal foraging hours are for *Solenopsis invicta* during the work schedule of CVMVCD technicians.

- Determine if air temperature or shade impact the foraging behavior of *Solenopsis invicta*.

Materials and Methods

A one-acre site located at The Vintage Country Club, Indian Wells, California, was selected based on a history of *S. invicta* activity. Thirty-two mounds located at the base of trees were chosen from the site. From May 2015 through May 2016, the site was sampled every two weeks. The site was sampled once a month only on May 2015 and on December and January. The sampling method consisted of using 1/8” hot dog slices as a food lure (bait) anchored with a marking flag to the ground (District’s Red Imported Fire Ant Standard Operating Procedures 2014).The anchored bait was put 3 ft. (1 m) from the base of each of the thirty-two trees at the beginning of each hour so that there was only one bait at each tree (Figure 1). The baits were evenly distributed to have eight located on the north, east, south, and west location of the trees (Figure 2). Ants were allowed one hour to forage and the number of ants found at the bait at the end of the hour was counted. An estimate of the number of ants on the hot dog slice was recorded based on a 0 – 10 score (Table 1) and if the bait was in the sun or shade. The bait was replaced and the location of it was switched 90˚ around the tree at the beginning of each additional hour. At the beginning of each hour, air temperature, relative humidity, wind direction, and wind speed was measured with an ambient weather WM-4 comprehensive wind meter®.

Figure 1. Hot dog slices anchored with a marking flag to the ground were used to assess ant abundance. One slice was placed hourly, 3 ft. away from the base of each tree where the fire ant mound was located.

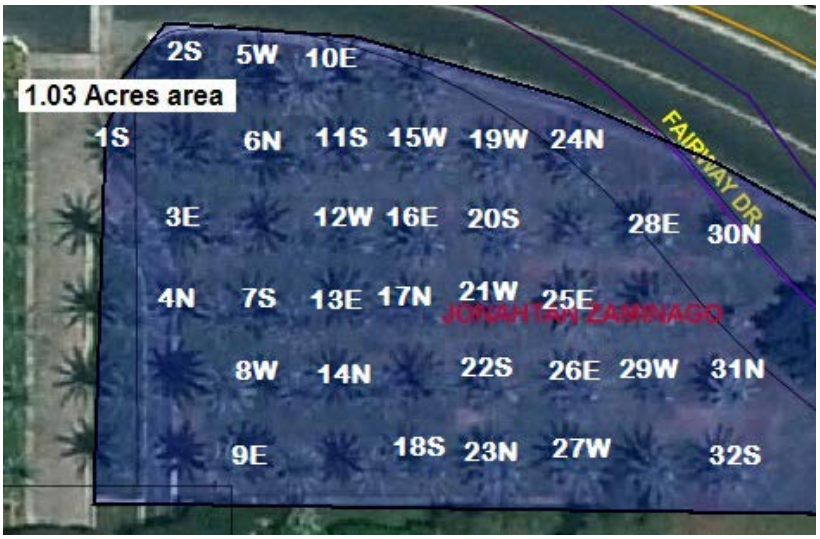

Figure 2. A one acre site at The Vintage Country Club in Indian Wells, California was selected. Hot dog baits were put at the base of thirty-two trees and evenly distributed to have eight on the north, east, south, and west location of each tree. Map shows the number of the tree and the location of where the first bait was placed. The bait was replaced every hour and switched 90° around the tree at the beginning of each hour.

From May through September, the food lures were set hourly at 6, 7, 8, 9, 10 and 11 am. From October through April, the baits were set hourly at 8, 9, 10, and 11 am; and at 12 and 1 pm. The shift was made to coincide with the shift in the work schedule of the technicians. Evaluations were conducted as described above.

Table 1. The number of ants on each hot dog slice was estimated based on a score from 0 to 10.

Score	Approximate Number of Ants
0	0

1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	>91

Results

Thirty-two mounds located at trees were examined for one year. Hot dog slices were placed 3 ft. (1 m) away from the mounds and replaced every hour and the number of ants on the hot dog slice was estimated and recorded. The average number of ants at the baits at the third hour and the last hour of sampling was recorded on a graph to show ant abundance for the year (Figure 3). Ant activity at the third hour of the day was representative of earlier foraging. More ants were foraging at the third hour compared to the sixth hour, especially during the summer. In the summer, ants were most active earlier in the day before the air temperature was 100°F (38°C). In the winter, more ants were foraging at the sixth hour compared to the third hour. Ants were most active later in the day when the air temperature was above 60°F (16°C). Ant activity was recorded to show ant abundance for each month (Figures 4 – 16).

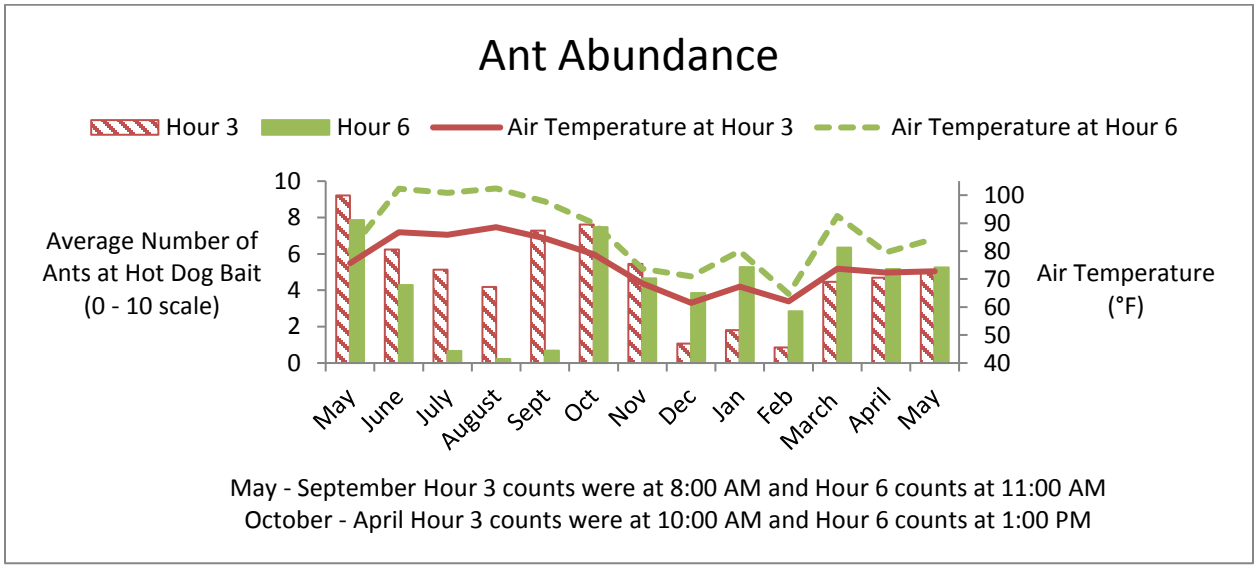

Figure 3. From May 2015 through May 2016, there were more ants foraging at the third hour (hour 3) especially during the summer. Ant abundance was greater earlier in the morning hours

compared to later in the day. During the winter, there were more ants later in the day (hour 6) compared to earlier in the morning.

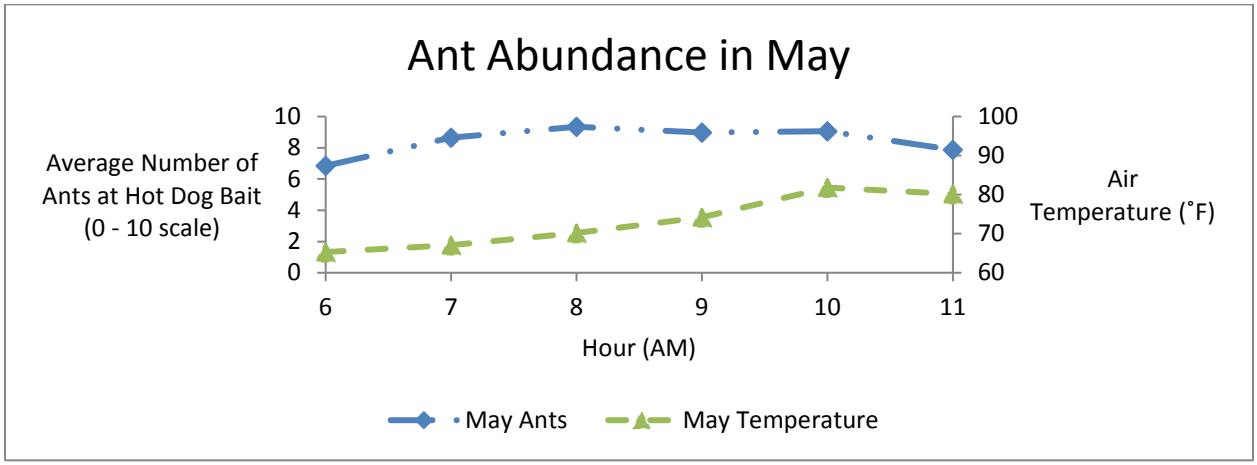

Figure 4. In May, ants were actively foraging throughout the day when temperatures remained between 60 - 80°F.

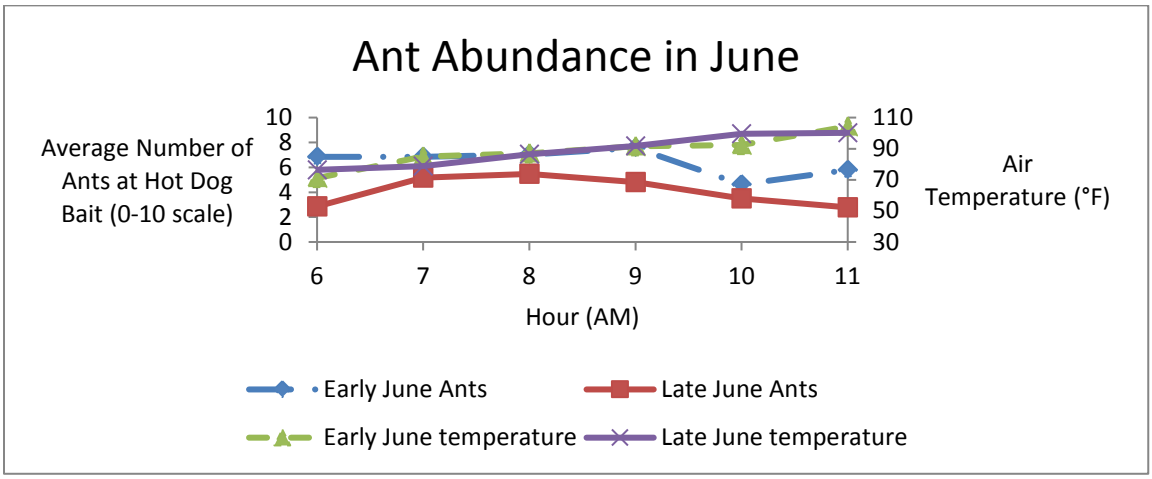

Figure 5. In June, ant abundance was similar for both sampling evaluations.

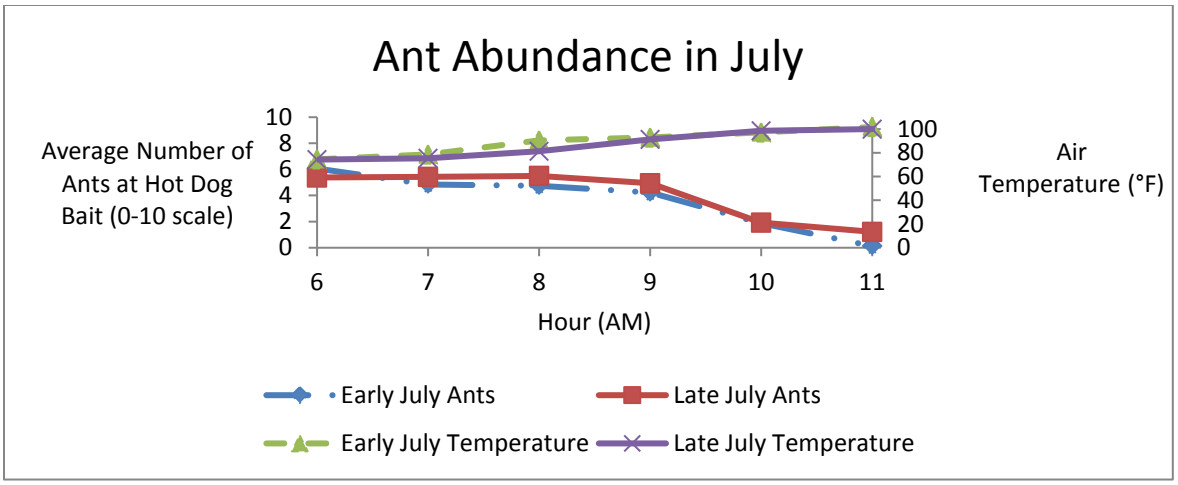

Figure 6. In July, there were more ants actively foraging earlier in the day when the air temperatures were cooler.

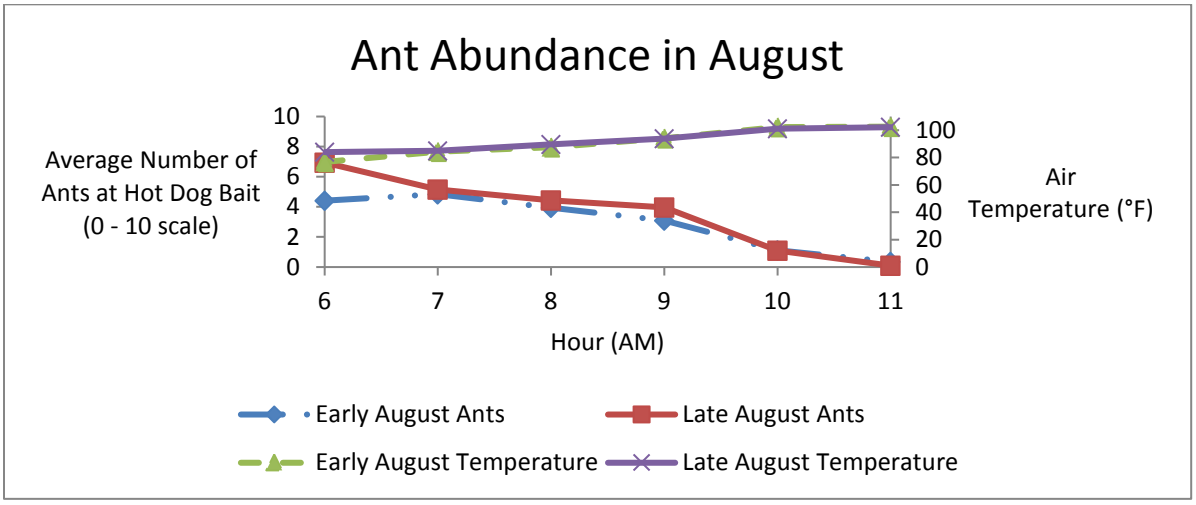

Figure 7. In August, there were more ants actively foraging earlier in the day when the air temperatures were cooler.

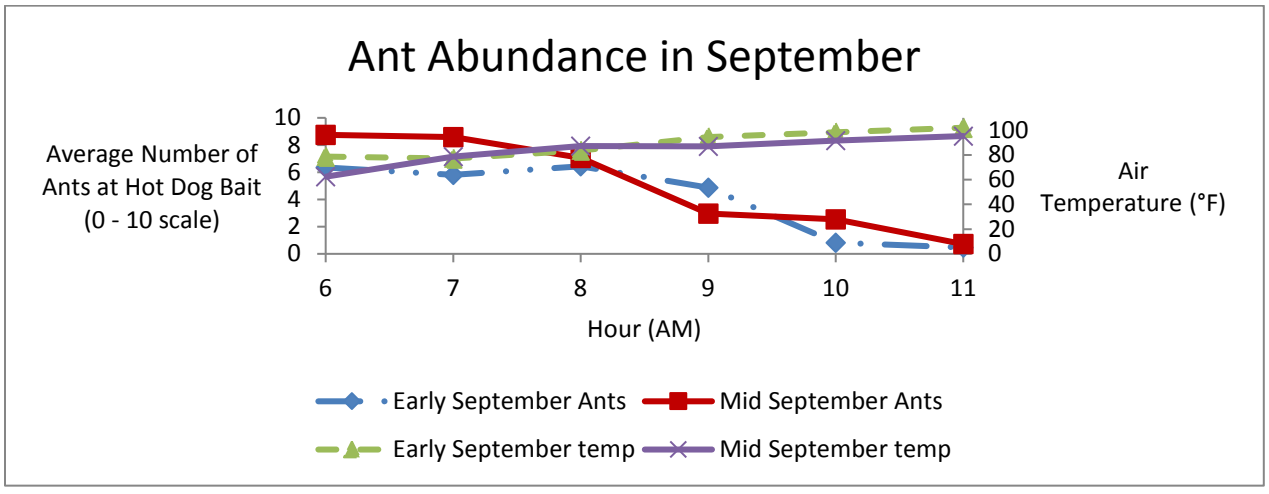

Figure 8. In September, there were more ants actively foraging earlier in the day when the air temperatures were cooler.

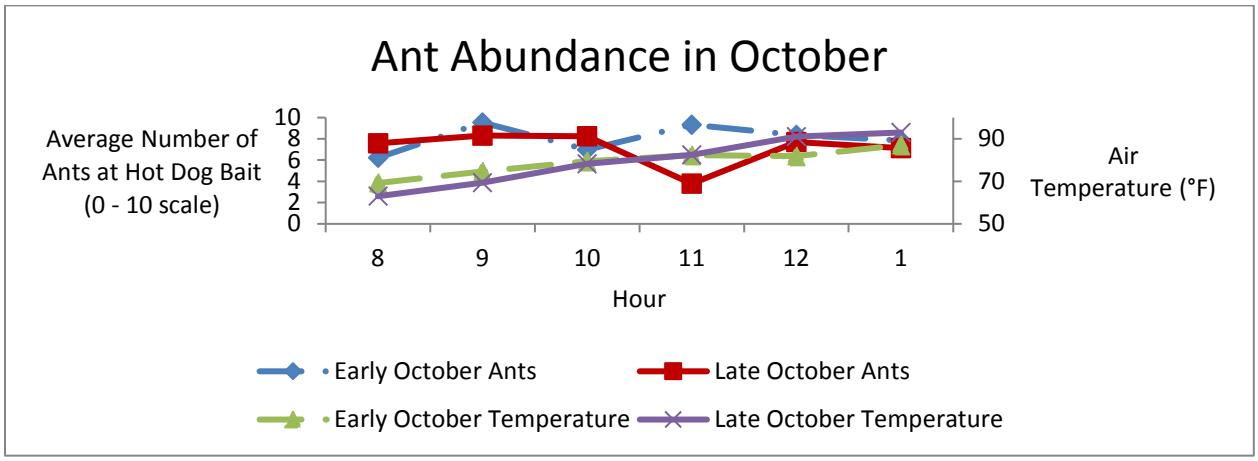

Figure 9. In October, ants were active throughout the day. Hot dog slices were missing during the counts taken at 11:00 a.m.

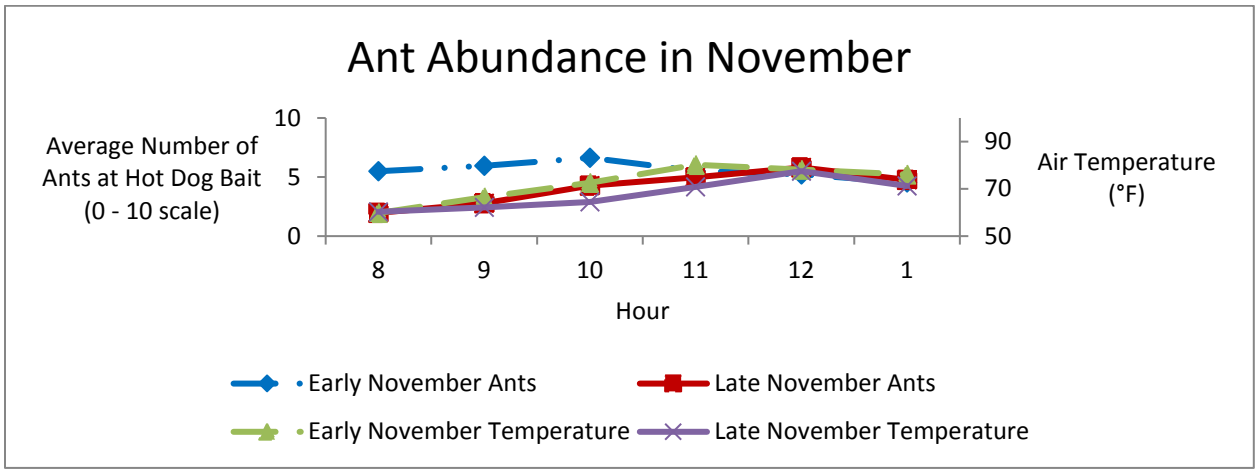

Figure 10. In November, ant abundance was similar for both sampling evaluations.

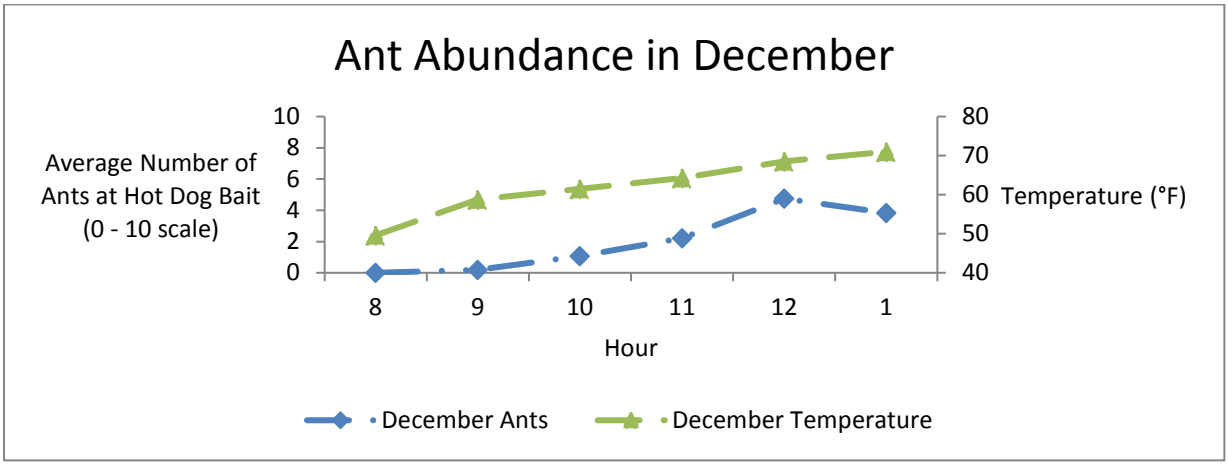

Figure 11. In December, there were more ants active later in the day. The site was sampled once in December.

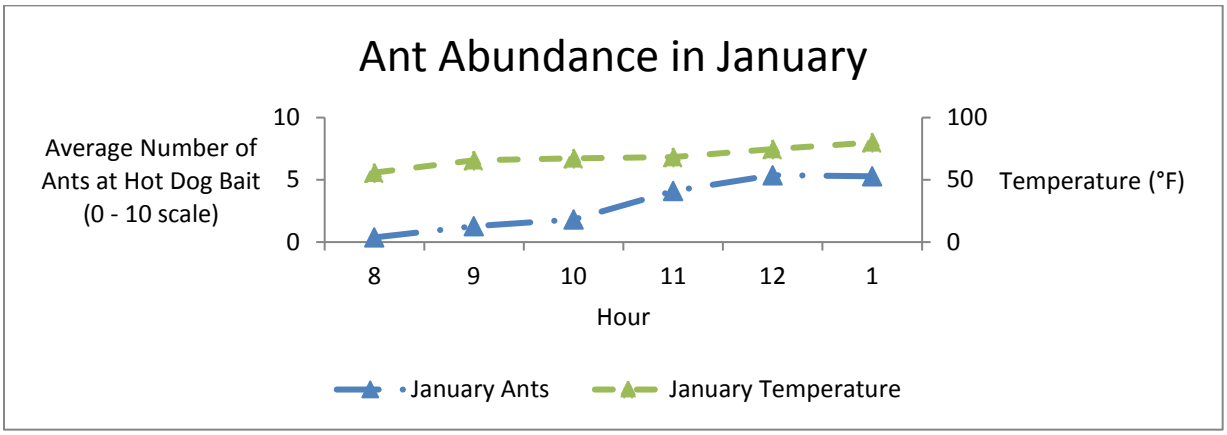

Figure 12. In January, there were more ants active later in the day. The site was sampled once in January.

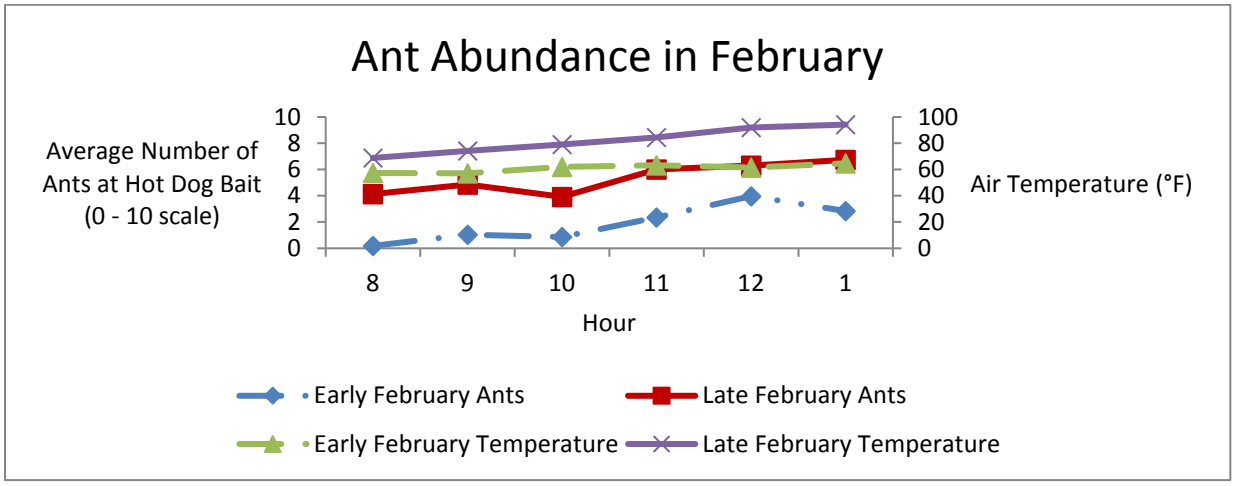

Figure 13. More ants were actively foraging throughout the day during the second evaluation in February.

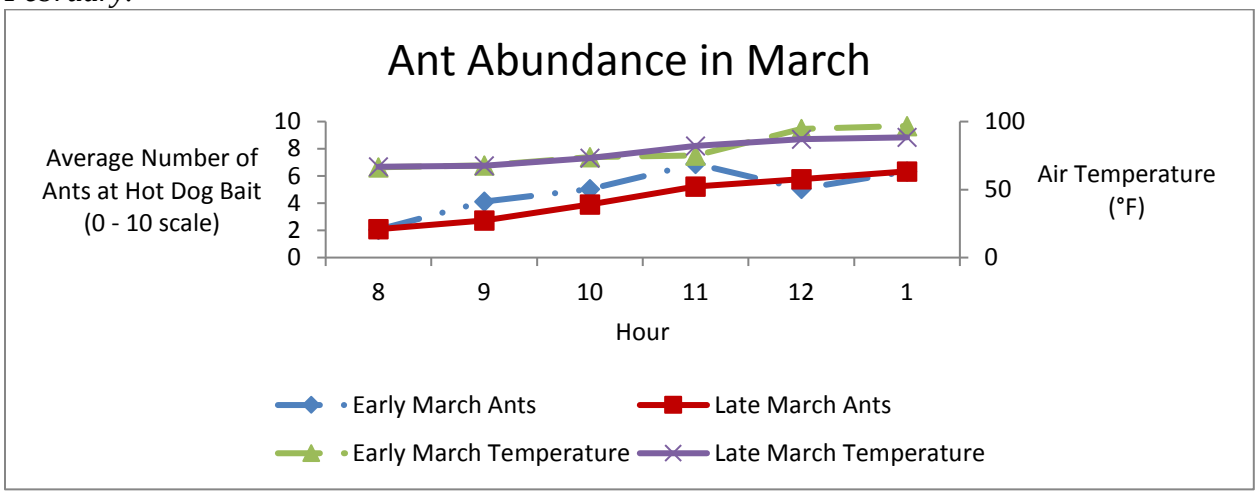

Figure 14. Ant abundance was similar in March for both sampling evaluations.

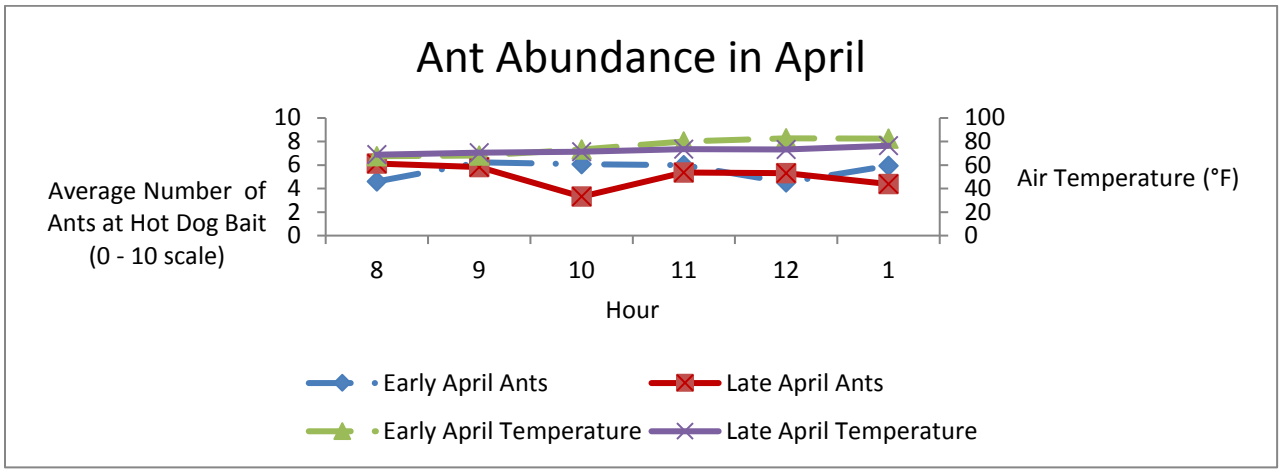

Figure 15. Ant abundance was similar in April for both sampling evaluations.

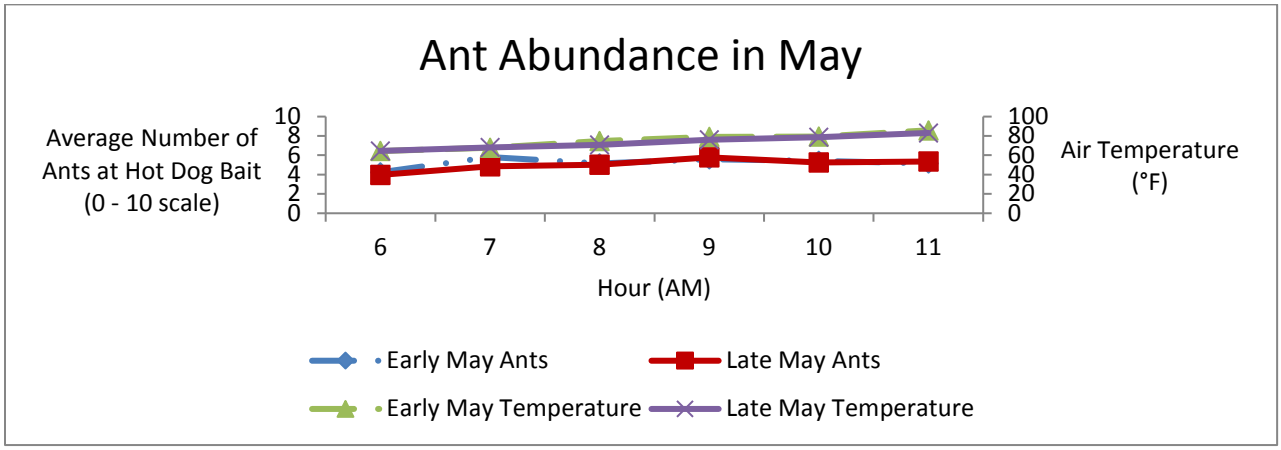

Figure 16. Ant abundance was similar in May for both sampling evaluations.

Table 2. Vector control technicians use the Food Lure Baiting Survey Method (hot dog slices) to perform surveys of properties which determines the level of RIFA infestation. The number of hot dog slices that have ants determines if the treatment assigned to the property will either be a broadcast or spot treatment (District's Red Imported Fire Ant Standard Operating Procedures 2014). When the infestation rate is less than 30%, a mound treatment is made. If the rate is 30% or greater, a broadcast treatment is made. The presence and percent infestation was determined for one year. Food lures (hot dog baits) were used to calculate the percentage of infestation of ant abundance. This was done by taking the total number of positive locations from the total number of locations sampled (32 trees). Sampling later on the same day during the summer resulted with a substantially different infestation rate. During the winter, sampling earlier on the same day resulted with a substantially different infestation rate.

2015 RIFA Percentage of Infestation

Hour	May	Early Jun	Late Jun	Early Jul	Late Jul	Early Aug	Late Aug	Early Sept	Mid Sept	Late Sept	Early Oct	Late Oct.	Early Nov	Late Nov
1	84	84	34	91	88	81	84	84	100	100	100	100	78	56
2	94	88	91	88	94	94	72	84	100	100	100	100	88	47

3	100	97	97	88	94	94	78	94	100	100	100	100	100	84
4	100	100	97	78	100	97	88	78	66	94	100	100	97	84
5	100	88	84	50	56	53	44	34	41	59	94	100	91	94
6	97	94	63	**13**	34	**25**	**9**	**9**	**22**	**25**	91	100	91	94

2015 – 2016 RIFA Percentage of infestation

Hour	Dec	Jan	Early Feb	Late Feb	Early Mar	Late Mar	Early Apr	Late Apr	Early May	Late May
1	**0**	**9**	**6**	41	41	38	81	97	69	69
2	**6**	**19**	**28**	63	53	56	91	97	84	72
3	**22**	34	**28**	34	69	69	78	81	88	81
4	47	59	44	63	84	91	97	91	84	84
5	63	75	63	82	66	69	88	88	88	81
6	56	66	56	84	84	75	100	88	88	97

Table 3. An estimate of the number of ants on the hot dog baits exposed to sun and shade was recorded for each hour. The estimates were based on a 0 – 10 score (Table 1). Although there were slightly more ants on the baits in the shade during the summer and more in the sun during winter, there was no preference if the baits were exposed to the sun or shade for all months.

		Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Average
May	sun	6.00	8.72	9.19	9.19	8.83	7.82	8.29
	shade	6.07	8.6	9.23	8.77	9.36	9.00	8.51
June	sun	6.79	6.08	6.20	6.53	3.70	2.00	5.22
	shade	3.47	5.80	6.34	6.08	5.00	6.20	5.48
July	sun	4.86	4.34	4.95	3.19	1.33	0.31	3.16
	shade	6.50	6.36	5.21	5.04	3.80	1.65	4.76
August	sun	5.41	5.55	5.74	3.25	0.79	0.15	3.48
	shade	6.31	5.06	4.5	4.63	2.90	1.60	4.17
September	sun	9.25	8.48	7.25	3.26	1.75	0.81	5.13
	shade	8.11	8.56	8.07	4.88	4.14	0.76	5.75
October	sun	6.71	9.00	8.22	5.77	7.78	6.97	7.41
	shade	7.00	8.86	7.00	7.08	8.23	7.84	7.67
November	sun	4.05	7.41	5.56	6.15	7.00	5.88	6.01
	shade	3.18	3.37	5.28	3.75	5.27	4.32	4.20
December	sun	0.00	0.40	1.93	2.86	8.25	0.00	2.24
	shade	0.00	0.00	0.29	1.78	2.94	3.97	1.50
January	sun	0.60	1.82	2.09	4.38	6.00	6.53	3.57
	shade	0	0.67	1.11	3.32	4.75	3.88	2.28

February	sun	2.70	2.44	2.09	5.42	4.88	4.61	3.69
	shade	1.56	3.81	0.63	2.28	5.5	5.03	3.14
March	sun	2.18	4.37	5.22	6.53	4.86	4.98	4.69
	shade	2.06	2.73	3.72	4.50	5.6	4.8	3.90
April	sun	5.80	6.34	3.22	5.37	5.97	4.45	5.19
	shade	5.97	5.83	5.75	5.97	4.16	5.82	5.58
May	sun	3.77	4.93	5.63	5.39	5.33	4.91	4.99
	shade	4.42	7.32	4.7	5.85	0.19	1.59	4.01

Discussion

Control products used by the District consist of bait formulations that red imported fire ants carry back to the nest. Applying the control product when the ants forage provides the best control. Since ants are sensitive to changes in temperature, air temperature is a good predictor of when the ants will more likely go to the bait. When air temperatures are between 60 (16°C) and 100°F (38°C), technicians use the bait method of food lures to determine the level of fire ant infestation.

When temperatures remained cool, ants were actively foraging throughout the day. Baiting earlier or later in the day should yield similar results. During the summer months, more ants were actively foraging earlier in the morning when the air temperatures were below 100˚F (38°C). Baiting earlier in the day can yield better results. In colder temperatures, such as the winter months, baiting later in the day can yield better results when air temperatures are above 60°F (16°C). Relative humidity was recorded and range from 14 to 70%. As air temperature increased during the day, relative humidity decreased. Although humidity impacts the foraging behavior of ants, it was clear that air temperatures impacted when the ants would go to the hot dog slices.

The positive percentage result of the Food Lure Bait Method determines whether a technician should make a broadcast or mound treatment. If the result averages 30% or more of the total number surveyed, the technician makes a broadcast treatment; less than 30%, a mound treatment is made. Air temperature impacted when the ants were foraging. During the summer, false negatives were observed (Table 2). Hot dog baits that were set at 11:00 a.m. determined that a mound treatment be made. However, when sampling was done earlier the same day, a broadcast treatment should have been made. Baiting should take place earlier in the day during the summer months because baiting later in the day can result with an ineffective treatment application. Also, during the winter, hot dog baits set at 8, 9, and 10 a.m. determined that a mound treatment be made and sampling that was done later the same day showed that a broadcast treatment should be made. False negatives were also observed during the summer and winter.

Fire ants build mounds in open sunny areas because the mound absorbs heat from the sun and ants will build mounds in shade if there is enough sunlight on the ground for several hours (Extension 2016). Although there were slightly more ants on the baits in the shade during the summer and more in the sun during winter, there was no preference if the baits were exposed to

the sun or shade for all months. It was undetermined if the ants preferred one over the other. Their behavior can be attributed to the soil temperature, since air temperature can impact the temperature of the soil. However, in the field, technicians can monitor when RIFA will forage by monitoring the air temperature. Using portable ambient weather meters to record air temperature is a suitable tool the technicians can use to conduct surveillance.

Conclusion

Air temperature was found to be a good predictor of *S. invicta* foraging activity. In the Coachella Valley, District technicians monitor air temperature when conducting surveillance of the red imported fire ant. To prevent false negatives, baiting with hot dog slices for ants should take place early in the day if the air temperature will exceed 100°F and later in the day when temperatures are below 60°F. Treatments can be made later in the day during the summer, provided that the control product is not exposed to water. This information was used to review and update the District's Red Imported Fire Ant Standard Operating Procedures. When air temperature is between 60°F and 100°F, vector technicians will use the hot dog food lures to assess the presence and percent of infestation of a property. Lures will be set out earlier in the field during the summer months, July, August, and September and set out later in the winter months, December, January, and February.

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