Population Dynamics and Distribution of Aphid Species on Head Lettuce In the Yuma Valley

John Palumbo, Clayton Mullis, Jr., Francisco Reyes,
Andreas Amaya, Luis Ledesma and L. Cary

Abstract

Studies were conducted in the 1999/2000 growing season to examine the population dynamics and field distribution of aphid species on winter and spring head lettuce crops. Seven, 0.25 acre planting of head lettuce were established beginning in October with final harvest occurring in April. Plant samples were conducted weekly to estimate the numbers of both alate (winged) and apterous (wingless) green peach aphids, potato aphids, cowpea aphids and lettuce aphids. Lettuce aphids were more abundant this spring than anticipated, which may indicate that lettuce aphid may be a new pest for Yuma growers. However, based on a single years data, it is difficult to measure the threat that this aphid poses to the lettuce industry. Planting date and temperature likely has a strong influence on seasonal abundance of lettuce aphids. Similarly, the consistent appearance of cowpea aphids during the season was surprising , considering that it has seldom been observed on desert lettuce. Perhaps most surprising though was the low population abundance of green peach and potato aphids in out plots. Part of this unusual event may be due to the unseasonably warm, dry growing season that was experienced this year.

Introduction

Aphids, consisting predominantly of green peach aphid, *Myzus persicae* (GPA), and potato aphids, *Macrosiphum euphorbiae* (PA), are common pests of iceberg lettuce, *Lactuca sativa*, in the western United States. These polyphagous aphid species causes economic damage to lettuce through direct injury, virus transmission, and contamination of heads. Because most Western iceberg lettuce is packed in the field at harvest, it must be relatively free of contamination by aphids and other pests. Over the past several years, aphid populations in commercial fields the Yuma area have occurred at manageable levels. These declines in aphid populations can largely be attributed to the use of Admire 2F (imidacloprid) soil treatments which provide season long protection against aphids.

An important development in the past two years has been the introduction of a new aphid species, the currant-lettuce aphid, *Nasonovia ribisnigri* (Mosley). Commonly referred to as the lettuce aphid (LA), the pest was found in Salinas in 1998 causing economic losses to summer head and leaf lettuce crops. The first reported incidence of the lettuce aphid in Yuma was on an untreated head lettuce field in mid- March 1999 in the Gila Valley, and from head lettuce plots at the Yuma Ag Center (Palumbo 1999a). The lettuce aphid was found again in the Yuma Valley in February of 2000 (Palumbo 2000). Another interesting development has been the outbreaks of the cowpea aphid, *Aphis craccivora,* on alfalfa and cotton during the winter and spring of 1998/1999. The cowpea aphid occurred again on alfalfa in large numbers in the fall of 1999 (Palumbo and Tickes 2000). Because lettuce is a known host to this aphid species it would be likely that they would utilize winter and spring lettuce as a host in the Yuma area. These changes in aphid abundance and potential for establishment of new aphid species found in the Yuma area have prompted us to initiate a multiple-year study to examine the population dynamics and inter-and intra-plant distribution of these aphid species on winter and spring head lettuce crops in the Yuma Valley of Arizona.

This is a part of the University of Arizona College of Agriculture 2000 Vegetable Report, index at http://ag.arizona.edu/pubs/crops/az1177/

Materials and Methods

Studies to examine aphid population dynamics and distribution in and between plants was conducted on head lettuce at the Yuma Agricultural Center, Yuma, Arizona. Beginning in mid-October, 0.25 acre plots of head lettuce were planted on about 2 week intervals. Table 1 provides the planting date and lettuce variety for each planting. On each planting date (PD) lettuce was direct seeded into double row beds on 42 inch centers. Each planting was subdivided into plots consisted of 4 beds, 80 feet long. Plots were arranged in a randomized complete block design with five replications with a total of a total of 10 plots established in each planting.

Within each planting date, five plots were randomly selected and imidacloprid (Admire 2F) at 16 oz / acre was applied. The remaining five plots were left untreated at planting. Data for this study was only collected from the untreated replicates. Aphid populations were assessed by estimating the number of aphids per plant by taking whole plant, destructive samples. The dates and plant stages for each sample event is shown in Table 1. On each sampling date, 8 plants were randomly selected from each plot (40 plants / sample date) and placed individually into large 4-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of alate and apterous aphids present. Once plants began to form heads (cupping stage), the within plant distribution of aphid species was measured by visually counting the number of apterous (wingless forms) aphids found inhabiting the frame/ wrapper leaves separately from aphids found on and within the cap leaves and heads.

We used Lloyd's Mean Crowding Index to estimate aggregation among the aphid species on each sample. Basically, Lloyds index is a variance to means ratio ($x^* = \bar{x} + s^2 / \bar{x} - 1$) that describes the number of individuals per individual in the same quadrant. From this we calculated the Index of Patchiness (I_P) that uses the ($X^*/ \bar{x}$) relationship to describe distributions, where a I_P value > 1 describes an aggregated population, and =1 a random distribution . In addition, Taylor's Power Law and the Patchiness regression were used to determine whether spatial patterns (inter-plant distribution) varied among aphid species. Taylor's regression uses the relationship between the sample variance (s^2) and the sample mean ($\bar{x}$) such that $s^2 = a\bar{x}^b$. The patchiness regression is based on the linear relationship between the Crowding index x^*, and $\bar{x}$, so that $x^* = \alpha + \beta\bar{x}$. The slopes of both regressions indicate the degree of aggregation of a population; b or β = 1 indicates that a population is randomly distributed, and b or β > 1 indicates that it is aggregated distribution. Mean densities and variances were generated for each plot and sampling date, and these were used for the calculations of the above indices.

Results and Discussion

Abundance of apterous (wingless) colonizing forms across the seven head lettuce planting dates is shown in Fig 1 and 2. Abundance was lowest in PD 1, where only two of the species where recorded. Similarly, aphid abundance was low in PD 2, but all aphid species were present. In particular, the lettuce aphid was most abundant at harvest. Potato aphid and lettuce aphid were the predominant species colonizing lettuce in PD 3. Overall, aphid abundance was similar in PD 4, and all species were present during February. Lettuce and potato aphids were dominant on heads late in the season. PD 5-7 consisted mainly of lettuce aphid, with a few green peach and potato aphids occurring mid-season. The latter two plantings had the highest abundance during the study, again comprised primarily of lettuce aphids.

Lettuce aphid appeared to be the dominant species found on lettuce in our studies in the Yuma Valley in 1999/2000. These aphids were first detected in our experimental area on Feb 14 in PD 3 (Fig 3). The occurrence of lettuce aphids was about a month earlier than last year. We suspect the population immigrated from the west, near Alogdones, Mexico where we received reports of lettuce aphid attacking organic lettuce about the same time. The following week, lettuce aphid alate and wingless forms were found in PD 2 which was at harvest stage. Aphid abundance was very low (<0.6 aphids/plant; <5% infestation level) in heads in both treated and untreated plots. Aphid population numbers were similar in PD 3 at that time, but increased significantly in the untreated plots the following week , when plants had reached harvest maturity . In PD 4, lettuce aphids were first detected at about 90 days after planting (DAP) when plants were just beginning to form heads. A similar trend was observed in PD 5, with the exception that lettuce aphids on untreated plants were about 5 times more abundant. Winged aphid forms were most abundant in PD 6-7, as were the wingless colonizing forms which peaked at over 150 aphids / plan during late March/April. Lettuce heads were relatively aphid free at harvest, but were being heavily colonized by several natural enemy species . Naturally occurring predators (lady beetle, lacewing and syrphid fly) averaged over 10 larvae per plant in the untreated check ion PD 6. High temperatures also occurred at this time, exceeding an average temperature of 70°F for the last two weeks of the growing season in PD 6.

Temperature has an important influence upon lettuce aphid development and supports to some degree our field observations. Based on recent laboratory studies by Bill Chaney, University of California in Salinas, the optimal temperature for lettuce aphid biological development appears to be around an average of 66 °F. This is consistent with our average temperatures during late February and March in these studies. Based on AZMET data during this period, the average daily temperature was about 65 ° F. This may explain why the populations did not appear to really increase until early March. A similar response was seen last year in our studies in Romaine lettuce (Palumbo 1999). Interestingly, we observed a sharp decline in population abundance in PD 6 and 7 following extended periods of unseasonably, warm temperatures in April (averaged 73 ° F), where daytime highs from April 4th to April 14th exceeded 90 ° F. We cannot completely attribute these dynamics to temperature because of the high densities of natural enemies associated with heavy aphid colonies (>10 larvae / plant) on lettuce plants. We feel confident though that the combination of the two factors was responsible for the decline of the lettuce aphid populations during April.

Green Peach aphids , which are normally our primary aphid species (Palumbo et al. 1999), occurred at extremely low levels in 1999/2000 in the Yuma Valley (Fig 4). Winged forms peaked in February and March in the later plantings, but did result in significant plant colonization. Planting dates 6 and 7 appeared to have a few aphids (<10/plant), but by mid-March the numbers had dropped dramatically. Increasing temperatures may have influenced GPA populations. Similarly, potato aphids occurred at low levels relative to the past few years. Alates peaked in late March, surprisingly 2 weeks after they peaked in abundance in PD 7 (Fig 5). However, PD 3 and 4 maintained a few colonies near harvest. We are not sure what influence temperature played on the PA populations, but was probably similar to GPA.

Cowpea aphids were recorded for the first time on head lettuce at the YAC. We suspected they were present in 1998/1999, but were unable to readily find them on plants. However, winged forms were picked up on our early plantings in late November and December, and peaked in early January . This is consistent with the large numbers found infesting alfalfa in the Yuma area during this time period. Although not as abundant as the other aphid species, the presence of wingless , colonizing forms was considered a significant event. Fortunately, cowpea aphids were not found infesting heads at harvest in any of the plantings. Whether cowpea aphid will continue to be present, or more abundant on lettuce in the future is unknown.

Measurements of intra-plant distribution suggests that all three species tend to be highly aggregated at low densities (Table 2). In contrast, there distribution tends to be more random at high densities and when a , high number of plants tend to be infested. However, the fact that the I_P values often varied greatly at the same density, suggests that this Index can be misleading. For instance, for lettuce aphid, a mean density pf 0.1 aphid per plant resulted in a I_P value of 0 on one week and a value of 12 the next. Overall though, at densities above 1 aphid /plant, the index suggest these aphid tend to distribute themselves in distinct patches within the field. This is also supported by the power law and patchines regression (Table 3). Both Indices suggest that these species are aggregated in the following order, potato aphid > lettuce aphid >green peach aphid. Winged aphids appeared to be less aggregated. In general, these levels of aggregation indicate that a high number of samples will be required (75-100 / field) to make precise estimates of aphid densities. Consequently, these data support recommendations from Univ. Calif. Cooperative Extension that a large number plant samples areneeded to adequately detect the presence of lettuce aphids. This is particularly important since management of this aphid species should be initiated when first detected .

The within-plant distribution of these aphids differed significantly (Table 4). Lettuce aphids were found to infest heads at a significantly higher numbers that the surrounding wrapper and frame leaves. This was consistently observed at higher aphid densities and on plants at harvest. In contrast, the distribution of green peach and potato aphids between heads and frame leaves was significant on only one sample date (Table 4). In that case, the aphids actually infested the frame leaves in higher numbers. These data are consist with other anecdotal and published accounts of aphid distribution in head lettuce. These findings also have important implications for aphid sampling and management.

In conclusion, this comprehensive data set describes the abundance of several important aphid species found in lettuce in the Yuma Valley. Lettuce aphids were more abundant this spring than we anticipated, and may indicate that this aphid may be a new pest for Yuma growers. However, based on a single years data, it is difficult to conclude whether this aphid poses a threat to the lettuce industry. The influence of planting date and temperature on the seasonal abundance of lettuce aphids is likely important. Similarly, the appearance of cowpea aphids consistently during the season was surprising , considering that they have seldom been observed on desert lettuce. Perhaps most surprising though was the lack of green peach aphid and potato aphid in out plots. These aphid species were abundant in extremely high numbers (>300/plant) on head lettuce in studies conducted last year in the same location (Palumbo et al. 1999). Part of this unusual event may be due to the unseasonably warm, dry winter and spring that occurred this year. The influence these factors have on native and desert vegetation and subsequently aphid populations may be very important to aphid seasonal population dynamics. Because it is difficult to explain our observations based on a single years data, we will consequently replicate this work during the next few years and hopefully have a better understanding of what environmental and management factors influence aphid aphid population dynamics in head lettuce.

Acknowledgments

Funding and support for this research was provided in part by the Arizona Iceberg Lettuce Research Council, Project 99-05. We would like to thank Louis Didier, Select Seed of Arizona, for providing lettuce seed for this study.

Literature Cited

Palumbo, J.C. 1998. Management of Aphids and Thrips on Leafy Vegetables, 10-14. In N.F. Oebker (ed.), 1998 Vegetable Report, University of Arizona, College of Agriculture, Series P-115, AZ1101.

Palumbo, J.C. 1999. Preliminary examination of the population dynamics and control of the lettuce aphid in Romaine, pp.130-135. In D.N. Byrne and P. Baciewicz (eds.), 1999 Vegetable Report, University of Arizona, College of Agriculture, Series P-117, AZ1143.

Palumbo, J.C. , C. Mullis, F. Reyes, A. Amaya, and L. Ledesma. 1999. Application and timing of insecticides for aphid management in head lettuce, pp. 94-107. In D.N. Byrne and P. Baciewicz (eds.), 1999Vegetable Report, University of Arizona, College of Agriculture, Series P-117, AZ1143.

Palumbo, J. C. 2000. Lettuce Aphid Returns to the Yuma Valley, pp. 6. University of Arizona, Cooperative Extension. Yuma County Farm Notes, Feb 2000.

Palumbo, J. C. and B. Tickes. 2000. Cowpea Aphid in Alfalfa, pp. 11-14. University of Arizona, Cooperative Extension. Yuma County Farm Notes, Feb 2000.

Table 1. Sample dates, plant growth stages and days after planting for seven plantings of head lettuc, Yuma Agricultural Center, 1999-2000.

Planting Date (Variety)	Event	1	2	3	4	5	6	7	8	9
1-Oct 11 (*Grizzley*)	Sample date	11/11	11/20	12/1	12/13	12/21	1/4	1/13	1/24	
	Plant stage[a]	6-8	10	15-17	16	21-23	23 (2")	25 (4")	Harv	
	DAP[b]	30	39	50	63	71	85	94	105	
2- Nov 1 (*Wolverine*)	Sample date	12/1	12/13	12/21	1/5	1/13	1/24	2/2	2/11	2/20
	Plant stage[a]	4	7	9	12-14	14-16	18-20	24(3")	24 (5")	Harv
	DAP[b]	30	43	51	66	74	85	94	102	114
3- Nov 15 (*Del Rio*)	Sample date	12/16	12/21	1/4	1/13	1/24	2/2	2/14	2/22	3/1
	Plant stage[a]	2-3	3-4	5-6	8-9	12-14	17	23 (2")	(4")	Harv
	DAP[b]	31	36	53	59	70	79	91	99	106
4 - Dec 1 (*Jackel*)	Sample date	1/13	1/24	2/2	2/14	2/23	3/2	3/8	3/15	3/23
	Plant stage[a]	3-4	7	9-10	16-18	20-22	24 (1")	3"	5"	Harv
	DAP[b]	44	55	64	76	85	92	98	105	113
5 - Dec 15 (*Diamond*)	Sample date	1/24	2/2	2/14	2/23	3/2	3/8	3/15	3/23	
	Plant stage[a]	4	7-8	12-14	15-17	19-20	22 (2")	4"	Harv	
	DAP[b]	40	49	61	70	77	86	91	98	
6 - Jan 15 (*Diamond*)	Sample date	2/23	3/2	3/8	3/15	3/23	3/29	4/5	4/13	
	Plant stage[a]	6-7	8-9	10-11	12-14	15-17	21	22 (3")	Harv	
	DAP[b]	39	46	56	60	66	73	80	88	
7 - Feb 1 (*Beacon*)	Sample date	3/2	3/8	3/15	3/23	3/29	4/5	4/13	4/20	
	Plant stage[a]	5	7	9	12	15	18	20 (3")	Harv	
	DAP[b]	31	38	44	50	57	64	72	80	

[a] Estimated avaerage number of frame leaves per plant (head diameter, in).
[b] Days after planting

Figure 1. Seasonal Abundance of Apterous (Wingless) Aphids on Head Lettuce in (A) PD 1, Oct 11; (B) PD 2 , Nov 1; (C) PD 3, Nov 15, YAC, 1999/2000.

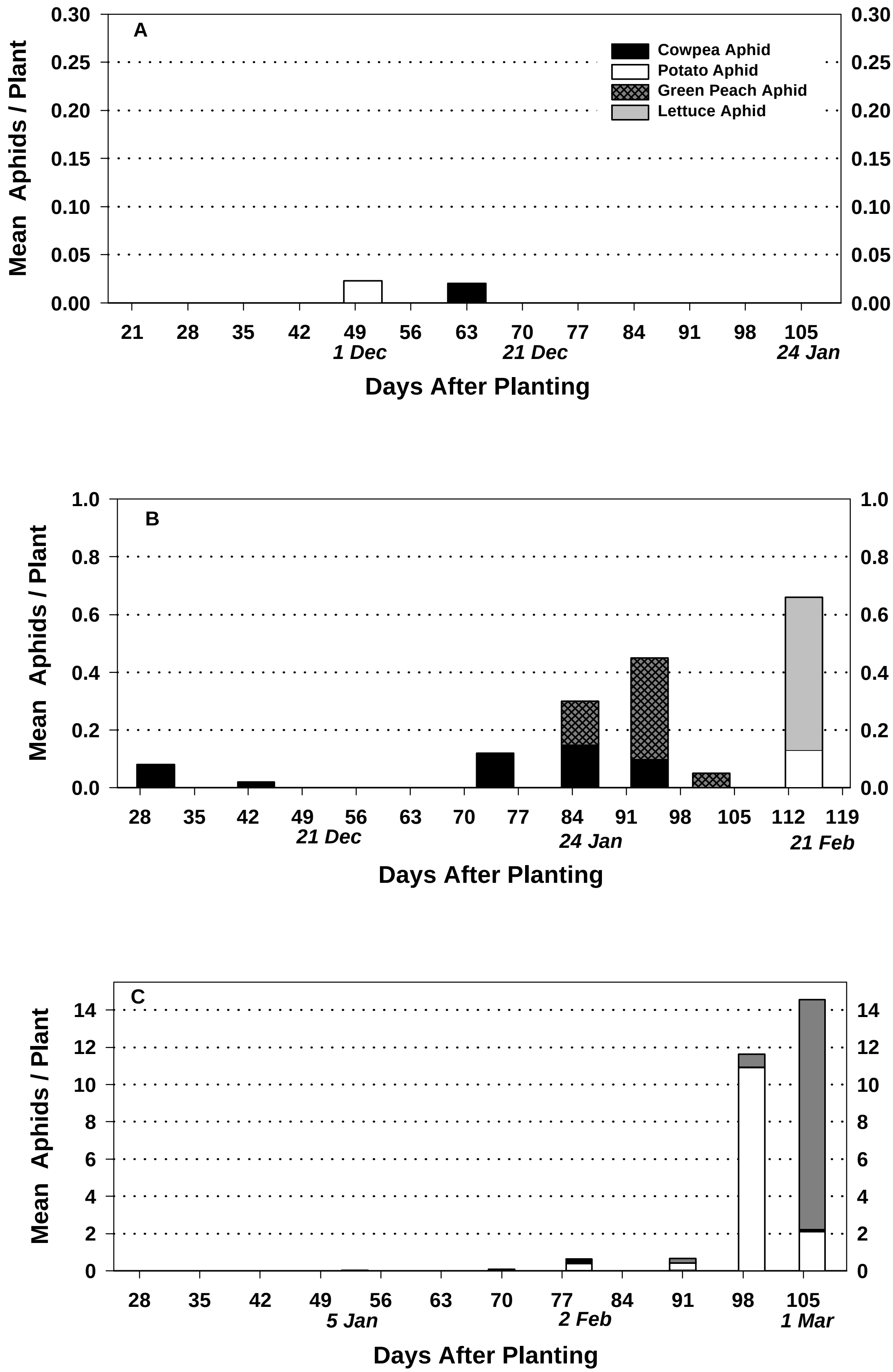

Figure 1. Seasonal Abundance of Apterous (Wingless) Aphids on Head Lettuce, YAC, 1999/2000 in (D) PD 4, Dec 1; (E) PD 5 , Dec 15; (F) PD 6, Jan 15

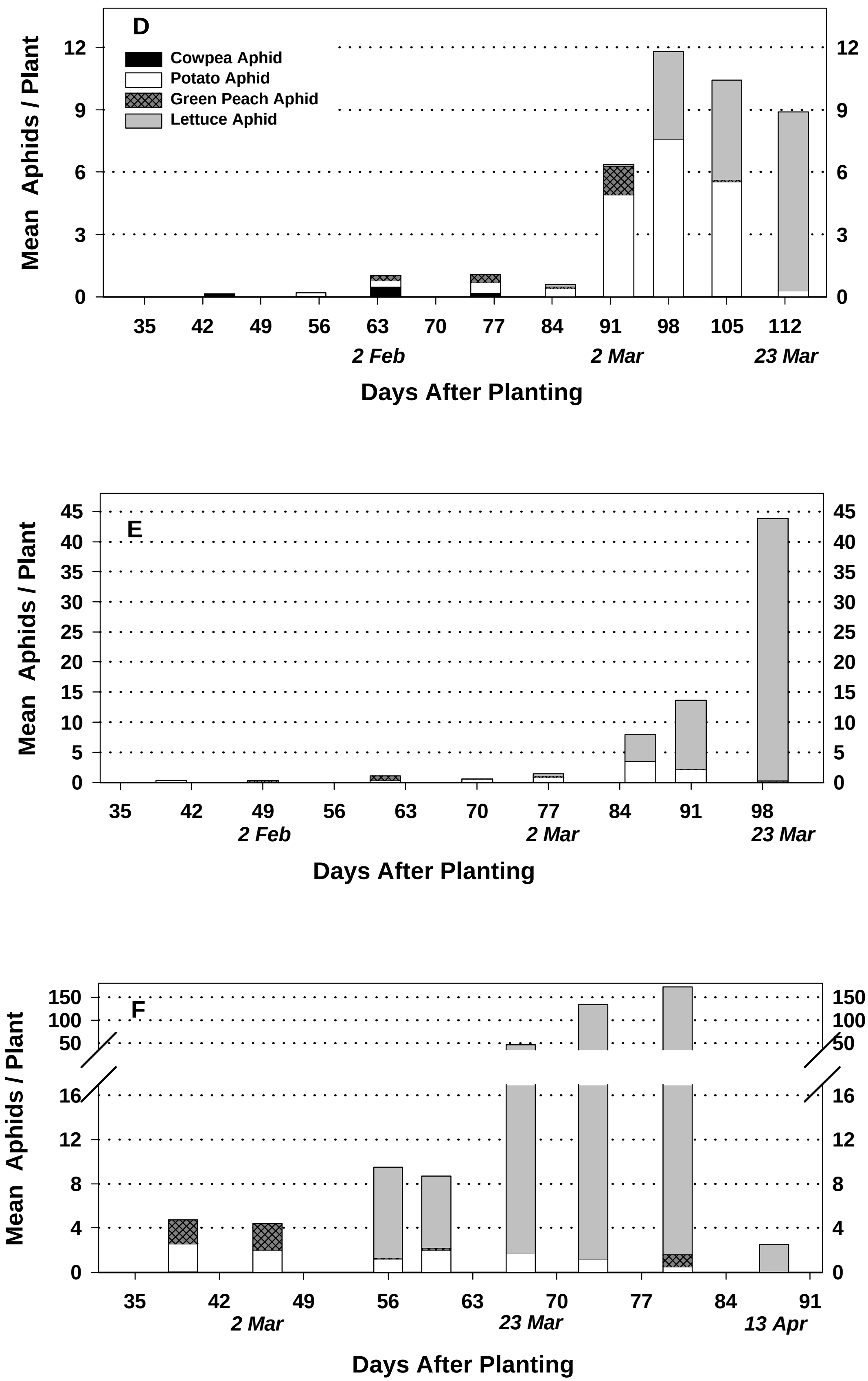

Figure 2. Seasonal Abundance of Apterous (Wingless) Aphids on Head Lettuce in PD 7, Feb 1, YAC 1999/2000

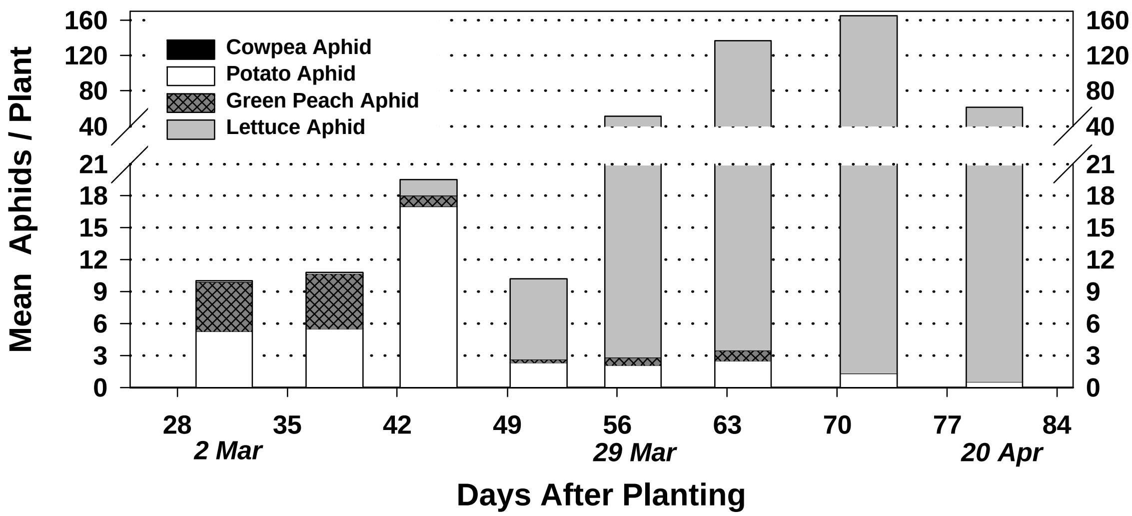

Figure 3. Seasonal Abundance of Lettuce Aphid Populations on Head Lettuce Relative to Planting Dates and Temperatures

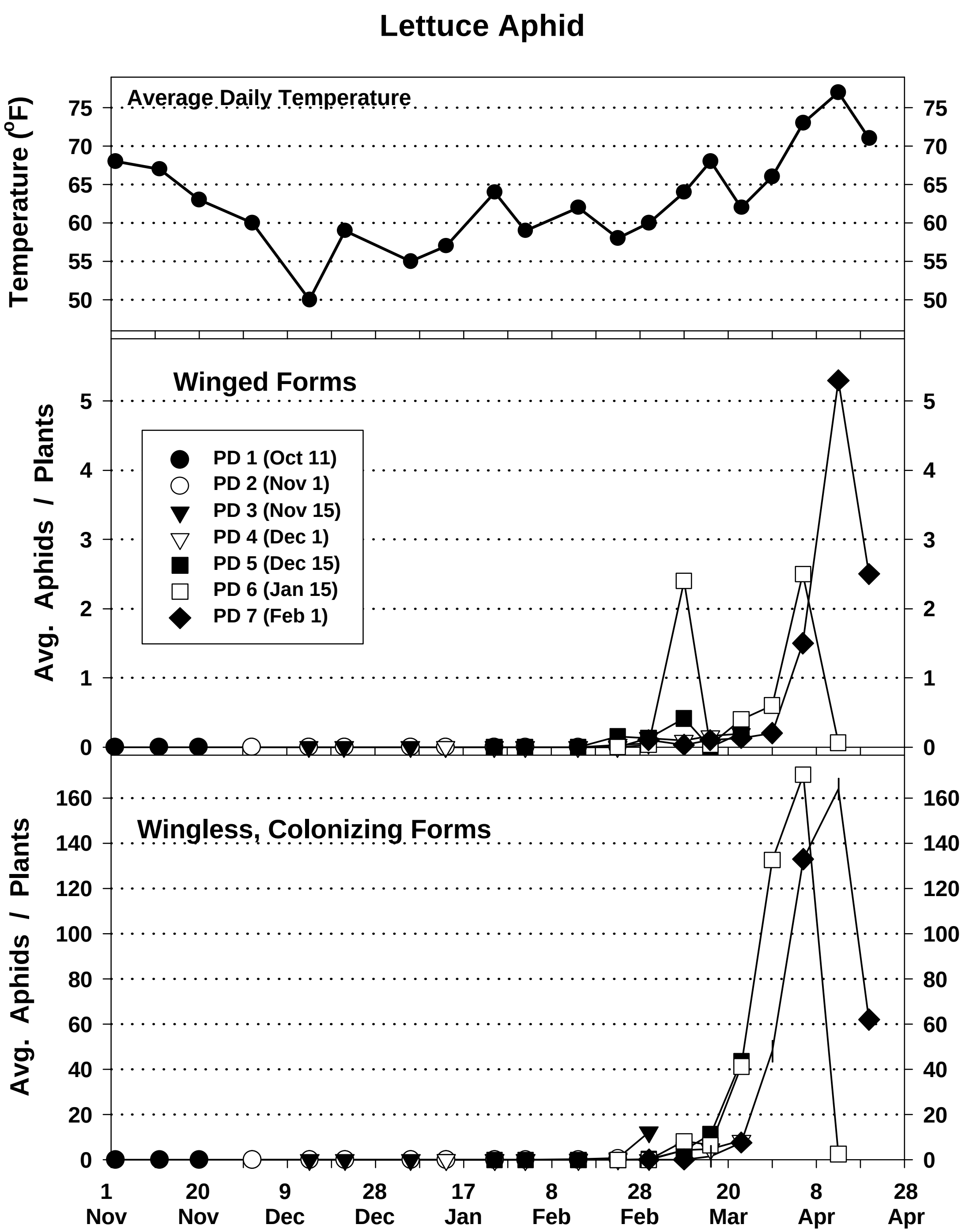

Figure 4. Seasonal Abundance of Green Peach Aphid Populations on Head Lettuce Relative to Planting Dates and Temperatures

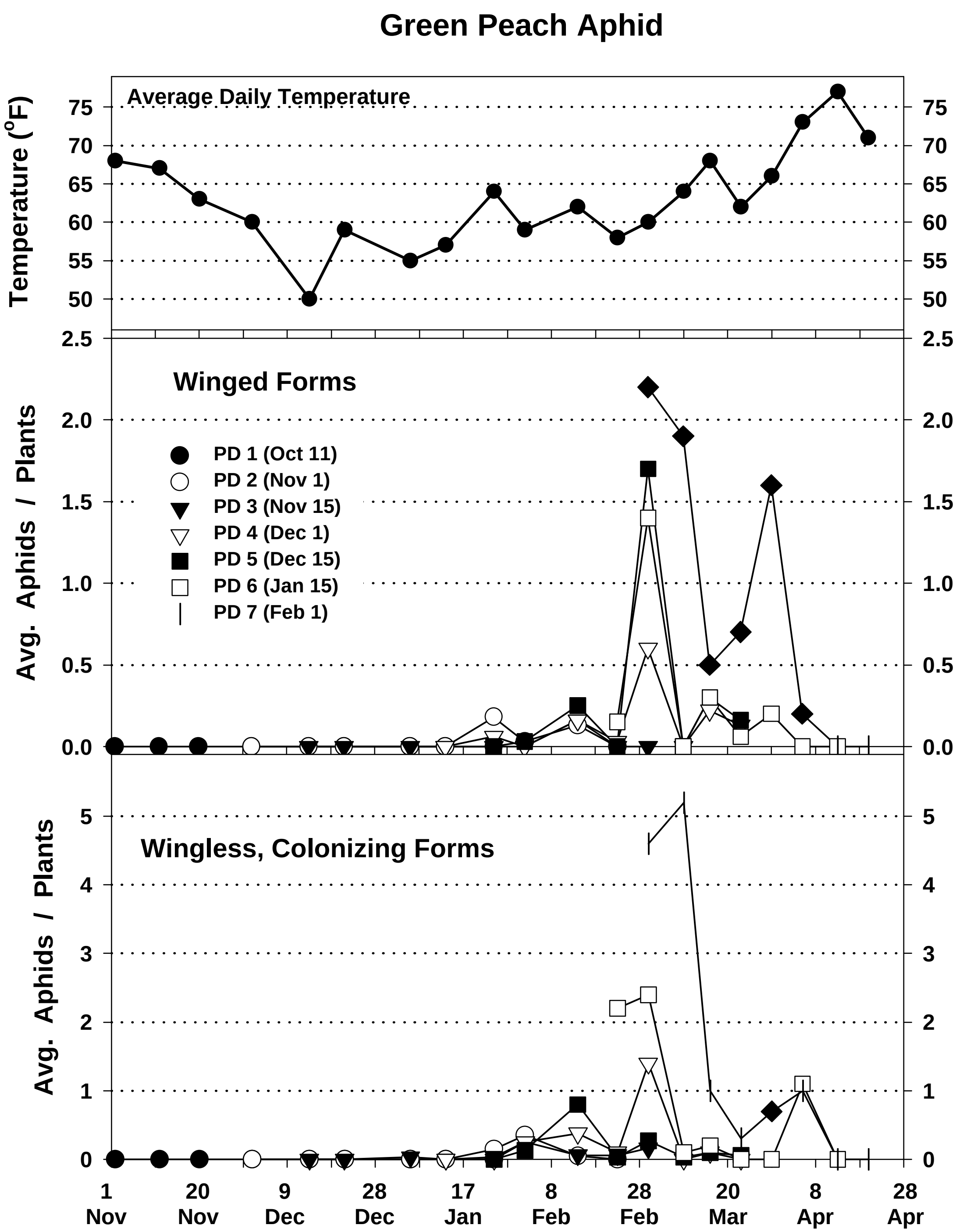

Figure 5. Seasonal Abundance of Potato Aphid Populations on Head Lettuce Relative to Planting Dates and Temperatures

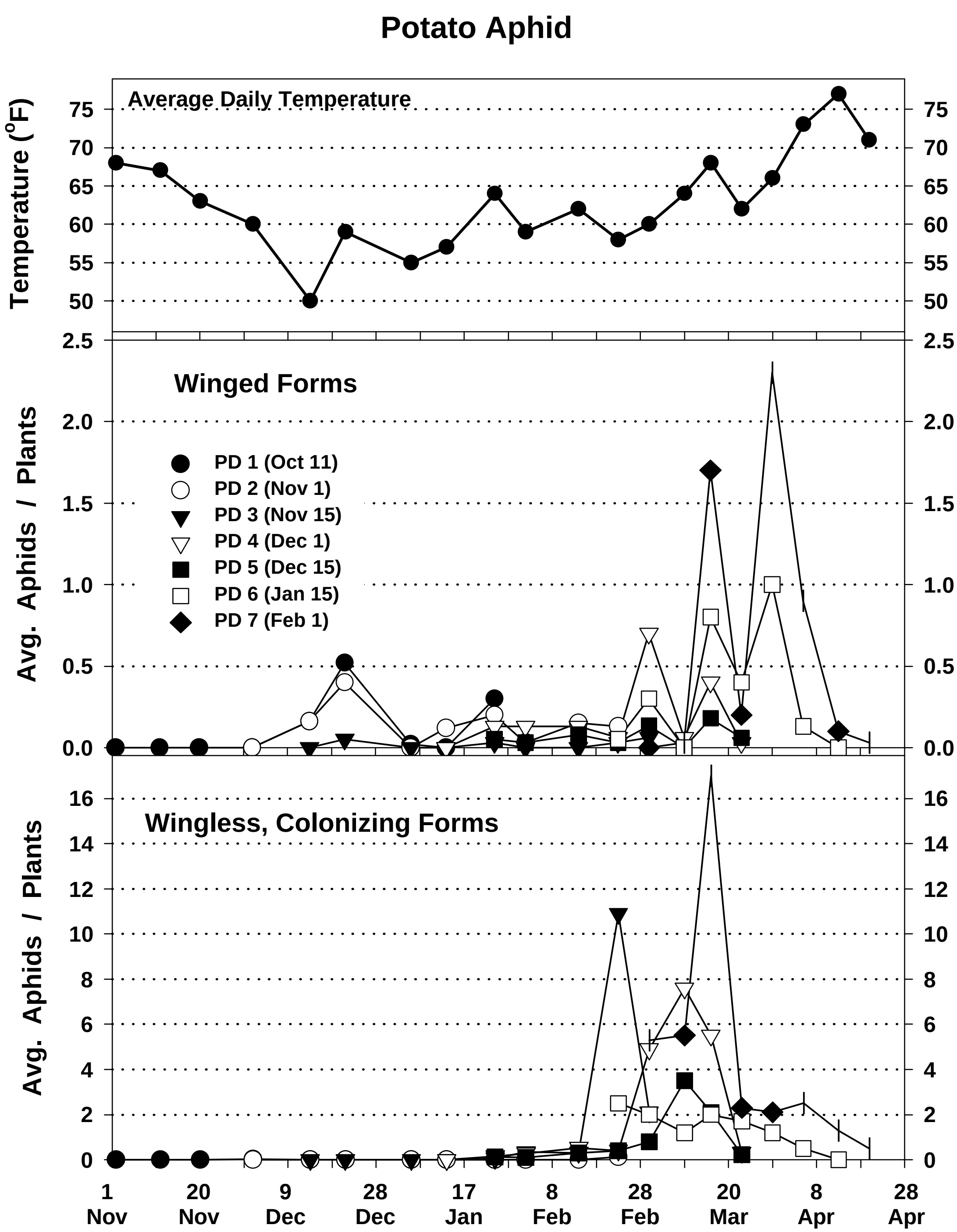

Figure 5. Seasonal Abundance of Cowpea Aphid Populations on Head Lettuce Relative to Planting Dates and Temperatures

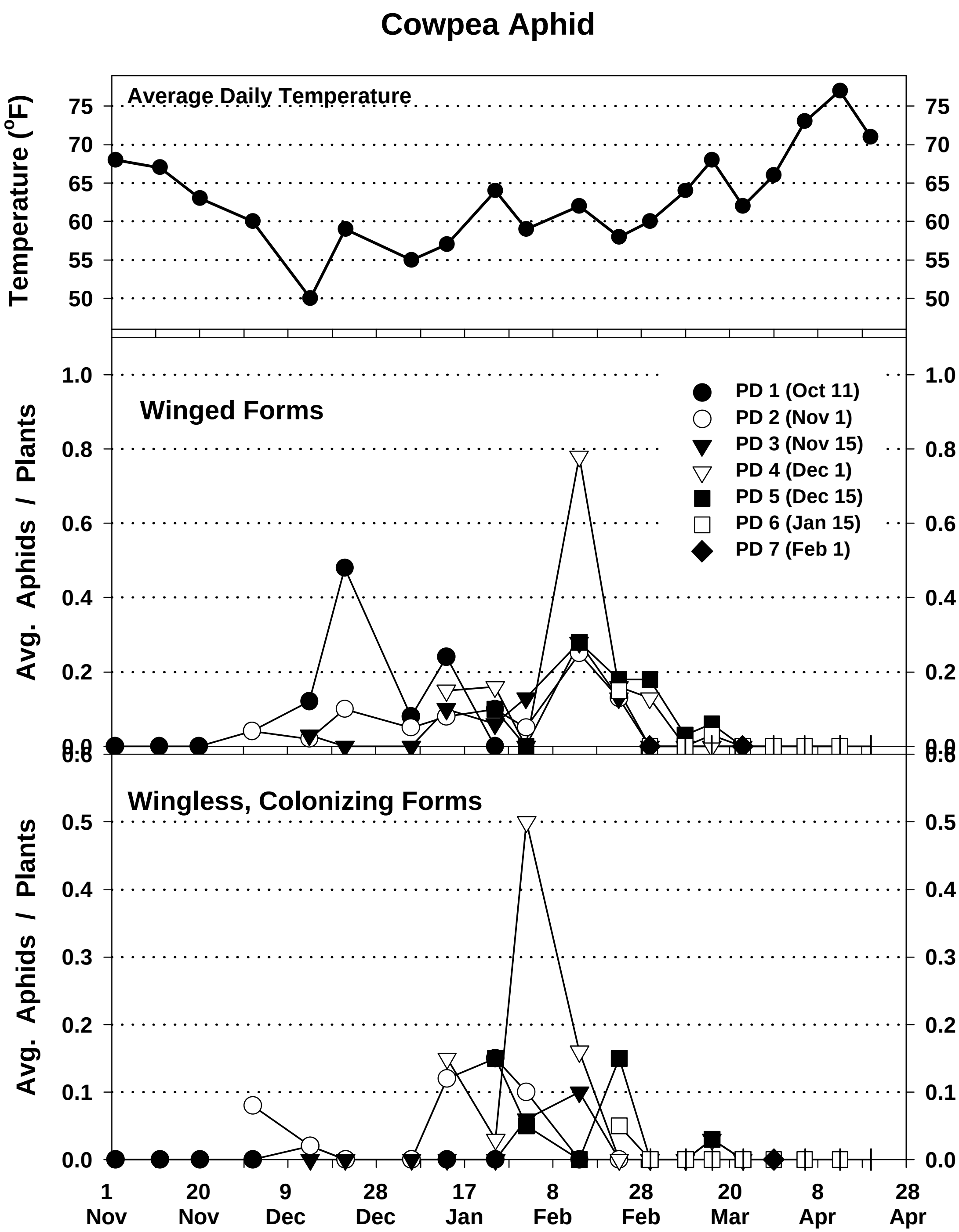

Table 2. Index of Patchiness (I_P) values for wingless Aphid forms on several plantings of head lettuce, Yuma Agricultural Center, Spring 2000.

		Potato Aphid		Green Peach Aphid		Lettuce Aphid	
PD	Date	Mean	I_P	Mean	I_P	Mean	I_P
4	23 Feb	0.4	11.8	0.1	8.0	0.1	0
	1 Mar	4.9	20.6	1.4	4.9	0.1	12.0
	8 Mar	7.6	9.5	0	0	4.2	7.3
	15 Mar	5.5	12.9	0.1	22.0	4.8	2.8
	23 Mar	0.3	2.3	0	0	8.6	3.5
5	23 Feb	0.4	6.3	0.3	0	0.1	0
	1 Mar	0.8	2.3	0.3	2.0	0.3	19
	8 Mar	3.5	8.3	0.1	0	4.4	5
	15 Mar	2.1	6.5	0.1	22.0	11.4	7.9
	23 Mar	0.2	13.5	0.1	12.0	43.5	2.2
6	11 Mar	1.2	20.0	0.1	11.1	8.2	6.5
	16 Mar	2.0	3.3	0.2	7.0	6.5	8.0
	23 Mar	1.7	8.4	0	0	41.3	3.0
	29 Mar	1.2	7.8	0	0	132.0	2.7
	5 April	0.4	4.8	1.1	7.4	170.3	1.4
7	2 Mar	5.3	2.7	4.6	2.5	0.1	22.0
	11 Mar	5.3	3.3	5.1	3.4	0.1	0
	16 Mar	17.0	1.9	1.0	9.6	1.5	12.1
	23 Mar	2.3	3.4	0.3	15.3	7.6	6.0
	29 Mar	2.1	3.5	0.3	17.0	48.1	10.3
	5 April	2.5	2.2	0.9	12.7	133.0	1.6
	13 Apr	1.3	5.0	0	0	163.3	1.3
	20 Apr	0.5	5.0	0	0	61.0	2.6

Table 3. Power law and patchiness regression parameters for aphid forms from five plantings of head lettuce.

		Taylor's Power Law			Patchiness Regression			
Aphid species	**Form**	***a*** **± SEM**	***b*** **± SEM**	R^2	**α ± SEM**	**β ± SEM**	R^2	**df**
Potato	Wingless	0.81 ± 0.05	1.72 ±0.10	0.90	6.98 ±4.15	3.85 ±1.11	0.28	30
Green Peach	Wingless	0.77 ±0.05	1.41 ±0.05	0.96	2.24 ±0.63	2.77 ±0.37	0.70	22
Lettuce	Wingless	0.90 ±0.06	1.67 ±0.04	0.98	25.6 ±11.1	1.65 ±0.17	0.80	23
Potato	Winged	0.19 ±0.04	1.12 ±0.04	0.96	0.11 ±0.09	1.54 ±0.14	0.82	27
Green Peach	Winged	0.27 ±0.05	1.11 ±0.07	0.92	0.69 ±0.28	1.21 ±0.31	0.39	21
Lettuce	Winged	0.43 ±0.07	1.37 ±0.08	0.93	-0.97 ±0.76	4.58 ±0.51	0.77	22

Table 4. Within -plant distribution of Wingless Colonizing Aphids on Heading Stages of Iceberg Lettuce, Yuma Agricultural Center, 1999-2000.

		Mean aphids / plant					
		Lettuce Aphid			Green Aphid Complex [a]		
PD	**Date**	**Head**	**Frame leaves**	$p > t$ [a]	**Head**	**Frame leaves**	$p > t$ [a]
3	1 March	12.3	0.0	*1.0*	1.6	0.6	*0.9*
4	8 March	4.1	0.1	*1.9*	1.6	6.0	*3.0**
	15 March	4.3	0.5	*3.2**	3.3	2.3	*0.3*
	23 March	8.0	0.5	*2.9**	0.0.3	0.28	*2.2*
	16 March	10.8	0.6	*1.6*	1.1	1.1	*0.2*
	23 March	42.9	0.6	*6.1***	0.2	0.1	*0.6*
6	29 March	139.0	11.8	*4.1**	0	1.2	*1.0*
	5 April	150.8	19.5	*3.9**	0.2	1.3	*1.2*
	13 April	2.5	0	*3.0**	0	0	*0*
7	5 April	108.3	24.8	*3.1**	1.1	2.3	*1.1*
	13 April 7	140.7	22.9	*5.7***	0.1	1.2	*1.7*
	20 April	58.4	2.9	*3.2**	0.2	0.3	*0.5*

Significant difference between means as detected by a paired t-test; *, P<0.05; ** p<0.01

[a] Complex consists of Green Peach Aphid and Potato Aphid.