1985 ANNUAL REPORT ON ALMOND POLLINATION RESEARCH SPONSORED BY THE ALMOND BOARD OF CALIFORNIA

Project No. 85-M10 - Tree and Crop Research Pollination

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Objectives: To develop information on pollination by bees which will result in increased production and greater grower returns.

Interpretive Summary: Effects of sugar syrup feeding, 2 types of pollen traps, colony strength, and extra space for strongest colonies were tested against total foraging and proportion of returning pollen foragers. Only pollen traps gave significant positive effects. Beginning and ending strength counts showed no significant differences in increase of strength except between 6 and 12 frame hives with O.A.C. pollen traps (210 vs. 397 in^2 brood, P=.02). Cluster counts and frames of bee counts gave higher correlations with flight than in^2 of brood or frames of brood for ending strength counts (r^2 = 31 and 30 vs. 23 and 21). Beginning counts gave much lower correlations as in previous years. The amount of pollen collected by 12 frame colonies with O.A.C. traps was significantly higher than in lower strength colonies on the first collection, but not in the second collection. There were no significant differences in pollen collected by the different strength hives with Kremer traps, but the 8 frame colonies collected more in 5 of 7 sample periods.

Returning pollen foragers consistently had the greatest amount of loose pollen on their bodies (excluding the pollen being transported on the hind legs). Exiting pollen foragers had consistently more pollen than returning non-pollen foragers. Tests with caged blossoms showed: with no bees 0.8% fruit set, bees returning to and exiting hive (2.6 vs. 2.2%), nectar collectors and pollen collectors (11.7 vs. 13.1%) and hand pollinated (15.7%).

Several experiments were conducted to determine if there is viable pollen on bees at the hive and if this pollen is transferred from bee to bee. (Bee to bee transfer of pollen could be important, especially when bees are not moving between cultivars.) Results were: 0.2% set from residual pollen on bees overnight, fluorescent pollen transferred to bees confined in hive entrance but none to bees inside hive, transfer of about 24 grains of 20% viable pollen to 13% of bees inside hive, and 4 of 13 presumed guard bees with viable pollen. To enhance pollen transfer strips of carpet and pipe cleaner were placed at hive entrance. Germination of these and comparative sources gave: carpet 58%, pipe cleaner 53%, pollen trap 66%, almond blossoms 78%.

Pollen inserts through which exiting and returning bees had to pass were loaded with NePlus pollen. No consistent increase in fruit set or yield was found. To determine the dose of compatible pollen on almond stigmas for maximum fruit set, a single bristle brush was coated with pollen and drawn over stigmas of emasculated flowers from 1 to 6 times. Fruit set was 60-70% with 5-6 applications and 33% or less with fewer applications.

Osmia lignaria and *O. cornuta* populations emerged in synchrony with almond bloom and provisioned new nests with almond pollen. Neither population showed an increase.

COLONY MANAGEMENT

Previous studies have shown that various colony management practices may affect flight activities and pollination efficiency of honey bee colonies during almond pollination. These experiments were conducted to determine what effects sugar syrup feeding, 2 types of pollen traps, colony strength, and extra strength in the strongest colonies have on flight and colony build up.

Experimental Procedure: Sixty-five colonies were selected from a total of 182 colonies in overwintering yards by cluster size and frames of bees (FOB) estimates described in previous reports. Selected colonies were moved into an almond orchard near Dixon, CA, February 22 and 25. O.A.C. pollen traps were placed on colonies on February 25 and 27. Kremer pollen traps were placed on hives on February 27. Pollen traps were activated on February 27. (Information on pollen collections is given in the following section of this report.) On February 27, one super with empty drawn out combs was placed in each of 5 colonies in the 12 FOB strength category. All but five of the colonies were fed with about 1 gallon of sugar syrup on February 28 and March 12. Foragers returning with and without pollen were counted as they landed on hardware cloth screen placed over the entrance of a hive for 30 seconds at all hives on seven days between March 4 and 14.

Results: Table 1 gives the effects of the treatments on colony build-up. (Five "left-over" colonies in a thirteenth treatment were not considered in the analyses because of their diversity in strength.) All treatments had significant increases in FOB except the eight frame colonies with O.A.C. and Kremer traps, the unfed colonies with 8 FOB; and in all of the 12 frame colonies. The only significant differences in change in colony strength in comparable treatments was between the 4 and 6 frame colonies with O.A.C. traps versus the 12 frame O.A.C. colonies, and between the 4 and 8 frame colonies with no traps versus the 12 frame colonies with no traps. In only one set of treatments was a statistical difference found in increase of brood from beginning to end counts. Colonies with 6 FOB and O.A.C. traps had significantly less brood than 12 frame colonies. (210 vs 397 in^2, P=.02).

Table 2 gives the effects of treatments on total colony flight and pollen non-pollen collector ratio. The bottom of Table 2 categorizes those t-tests that were significant. The treatments had much more effect on pollen collectors and total collectors than it did on strength (4 significant tests with strength versus 12 and 8 for pollen collectors and flight). Feeding and extra space had no significant effect on either pollen collectors or total foragers. Pollen traps increased bees with pollen and total foragers for colonies with 4 and 8 FOB. For 12 FOB, O.A.C. traps decreased pollen foragers and had no significant effect on total foragers. In the eight frame category, the Kremer traps had significantly higher numbers of pollen and total foragers than O.A.C. traps. O.A.C. traps resulted in significantly less increase in pollen collectors as the strength category increased. Kremer traps on the other hand had an increased effect on both pollen collectors and total foragers as the colony strength category went from 6 to 8 FOB. With the exception of the 6 frame category, pollen collectors and total collectors increased significantly as the strength category increased in without traps.

Discussion: In the eight frame category, it appears that both types of pollen traps and lack of feeding produce significantly less bee increase than fed colonies without traps. Why the 8 FOB strength group is more sensitive to these factors needs investigation. In general, this year, the higher the strength category, the

less was the increase in strength. Two of the 12 FOB treatments actually showed decreases. The fact that the 12 frame colonies with extra space have shown slight, but not significant increases in strength while those with normal space have shown decreases both in 1984 and 1985 may indicate that further work needs to be done. The fact that there were significant decreases in strength of the 12 frame O.A.C. traps compared to the 6 and 4 frame traps seems to indicate that traps are more detrimental to bee increase in the higher strength categories. The 12 frame colonies are producing significantly more brood than the 6 frame colonies. This may help explain the greater effect of traps on pollen foragers. More detailed analyses of brood needs to be done as time permits. The fact that the 4 and the 8 frame colonies without traps increased significantly over the 12 frame hives confirms results from previous years.

The fact that extra space had no significant effect on foraging confirms the test from last year. Apparently, something other than lack of hive space is limiting colony growth and activity in the higher strength categories. The fact that feeding had no effect on flight this year confirms data from last year, but contradicts the previous year indicating possibly that environmental factors mediate the effect of feeding. Increased pollen foraging and total foraging with pollen traps in the 4 and 8 frame colonies confirms previous work. Possibly, decrease in pollen foraging in the 12 FOB category may be related to the decrease in strength noted in this same treatment. The fact that O.A.C. traps gave significantly less increase in pollen flight as the strength category increased while the Kremer traps significantly increased pollen foraging from the 6 to 8 frame level, may be due to differences in efficiencies of the two traps. The O.A.C. traps are probably more efficient than the Kremer traps in removing pollen. The fact that pollen foraging and total foraging increased significantly as the strength category increased, with the exception of the 6 frame category, confirms previous research. Something anomalous is happening at the 6 frame category causing the increase not to be linear.

AMOUNT OF POLLEN COLLECTED AS AN INDEX OF COLONY STRENGTH

In our continuing effort to find fast, easy, and effective means of evaluating colony strength, we decided to see how the amount of pollen collected in pollen traps relates to colony strength. In previous studies we have attempted to find a relationship between the total incoming flight and pollen to nectar forager ratio, and colony strength. We felt that possibly the amount of pollen collected would be a good index of colony strength since theoretically it should reflect both total flight and pollen collector ratio.

Materials and Methods: In conjunction with the multifactorial experiment mentioned elsewhere in this report, two types of pollen traps were placed on colonies of different strength categories. The O.A.C. trap was used with 5 colonies each containing 4, 6, 8 and 12 frames of bees. The Kremer trap (a very small pollen trap that fits on the front of the hive) was used with 5 colonies each of 4, 6, and 8 frames of bees. Pollen was sampled three times during the season from the O.A.C. traps. Pollen was collected seven times during the season from the Kremer traps. Samples were stored in a freezer and dried and weighed as convenient.

Results: See Tables 3 & 4. The O.A.C. traps showed significant differences between the 12 frame hives and the lower strength groups. With the Kremer traps there were no significant differences, but the 8 frame colonies collected more pollen than those with 4 or 6 frames in 5 of 7 sample periods.

Discussion: Differences are apparent between different colony strength groups in the amount of pollen collected. The O.A.C. traps seemed to show these differences better than the Kremer traps. This research needs to be repeated with more frequent sampling from the O.A.C. traps and with better built Kremer traps.

POLLEN GERMINATIONS

Several studies required tests of pollen viability. Pollen was germinated on solid agar media and incubated for from 4-24 hours. Pollen was stained with basic fuchsin, and counted.

POLLEN MOVEMENT WITHIN AND AROUND THE HIVE

Recent research with apples has indicated that pollen may be moved from bee to bee within the hive. This movement could result in pollination if this pollen is viable and is carried back out to a receptive stigma of a compatible cultivar. Observations in almonds have revealed that bees will often work down a row of one cultivar without crossing over to an adjacent row of another cultivar. This results in no pollination. However, if compatible, viable pollen is transferred between foragers within the hive this could result in increased pollination. Below are several pilot studies which were undertaken this year to determine whether there is transfer of viable pollen within and around the hive.

POLLEN VIABILITY ON BEES WITHIN THE HIVE

In order to determine whether pollen remains viable on bees overnight within the hive an experiment was set up in a greenhouse.

Materials and Methods: Two Nonpareil, one Texas, and one Milow potted almond trees were placed in four separate screen cages inside a large plastic greenhouse on February 10 prior to bloom. A hive of bees was placed in each cage. Bouquets from a volunteer seedling and IXL trees were placed inside the greenhouse but outside the cages. On alternate days bees were allowed to forage either inside or outside of the cages. Therefore, any pollination on trees inside cages would have to be from pollen remaining on bees overnight. One limb of each tree was bagged as a control. Because of the difficulty of maintaining bouquets in good condition, the experiment was modified on February 21. Two of the hives were removed from the greenhouse. The remaining two hives were switched between cages with compatible varieties every day before or after the foraging period of the bees.

Results: The bagged limbs had no fruit set while the unbagged limbs averaged only .24% set. This appears to indicate that there is very little viable pollen remaining on bees overnight. However, we had problems with the cooling system in the greenhouse which resulted in higher than normal temperatures for almond pollination, and could account for the very low fruit set.

COLLARED BEE EXPERIMENT

In order to determine whether pollen is being transferred from bee to bee at the hive entrance, an experiment was set up using collared bees.

Materials and Methods: Six honey bees were fitted with circular plastic disks with slits and a hole in the center so that they would fit between the head and thorax. The "collared" or "yoked" bees were placed in the runway for bees entering and exiting a hive. The collared bees were corralled inside the runway using pollen trap grids. This allowed the other bees to go in and out, but because of the diameter of the

collars the collared bees could not. The observation hive entrance opened into a screen cage in which there was a mixture of pollen and fluorescent powder for bees to forage on. (A test of the germinability of almond pollen when mixed with fluorescent pigment gave 65% germination on an agar medium for both a pure almond pollen sample and for one with 15% fluorescent powder.) After four hours bees were removed and examined with a blacklight.

Results: All six bees showed fluorescence on their appendages and bodies. Pigment was also observed on the pollen grids.

Discussion: These rusults support the research of DeGrandi - Hoffman et al with pinned bees at the hive entrance. We cannot be certain that pollen grains would be transferred as easily as pigment so more work needs to be done with just pollen grains.

FLUORESCENCE TRANSFER INSIDE THE HIVE

Observations in a densely packed observation hive revealed numerous contracts between bees. We were curious to know whether pollen was transferred as a result of these contacts.

Materials and Methods: An observation hive with very dark colored bees was placed in a small glass greenhouse. A comb of emerging brood from a hive with light-colored bees was added to this hive. Foragers from the hive were allowed to collect a pollen-fluorescent powder mixture for about 6 hours. Later that evening, the newly emerged bees, which do not forage, were examined for fluorescence.

Results: Although foraging bees were observed to have fluorescence on their bodies, no fluorescence was detected on the non-foraging newly emerged bees.

Discussion: Although no fluroescence was observed on the newly emerged bees, this does not rule out the possibility that there might be transfer of pollen from forager to forager in the hive. Possibly there is more contact between foragers and other foragers than between nonforagers because of dance behavior or other behavioral differences. An experiment needs to be performed to test this.

GERMINABLE POLLEN ON GUARD BEES

Because of the success in detecting fluorescence on bees coralled in the entrance runway, we felt that checking guard bees for viable pollen might be profitable. Guard bees stand at the entrance of the hive and challenge incoming bees and other organisms to make sure no unwanted intruders enter the hive.

Materials and Methods: Guard bees were captured by dangling a piece of black felt in front of a hive. The undersides of these bees were pressed three times against an agar medium.

Results: Counts on these media showed that four of the thirteen bees samples had germinable pollen.

Discussion: This test needs to be repeated with a larger number of bees and with a better method of collecting guard bees to rule out the possibility of collecting foragers by accident. Guard bees seem to be in a perfect position to pick up pollen from incoming bees whether they would do equally well in transferring it to outgoing bees is another question.

GERMINABLE POLLEN ON BEES WITHIN THE HIVE

Another experiment was performed to determine whether germinable pollen is transferred between bees within the hive.

Materials and Methods: In a large plastic-covered greenhouse an observation hive was placed, and newly emerged marked bees were introduced. Fresh anthers from Fremontia, Flannel Bush, were placed in feeders for bee forage. After four hours of exposure to foraging bees, 50 newly emerged bees were examined for germinable pollen.

Results: Three bees were excluded because of lack of adequate data leaving 47 for analyses. The results on the remaining 47 bees are as follows:

% Bees with viable pollen	6/47	12.8%
% Bees with viable pollen (excluding bees with no pollen)	6/10	60.0%
% Viable pollen	48/240	20.0%
Number of pollen grains per bee	5.1	
Number of pollen grains per bee (excluding bees with no pollen)	24.0	

Discussion: These data do indicate that there is a very small amount of viable pollen being transferred from foraging to non-foraging "clean" bees More research needs to be done using almond pollen to determine how much transfer is occurring between foraging bees and how this transfer can be enhanced.

ENHANCEMENT OF POLLEN TRANSFER AT THE HIVE ENTRANCE

Because the pollen grid is exposed to view in the Kremer pollen trap (mentioned in another part of this report), we were able to more easily observe what was happening at this interface than with the traps used in previous years. On one day we noted bees "robbing" pollen from incoming pollen foragers at the pollen grid. This behavior was noted on only one day (March 11), possibly due to lack of pollen foraging the previous day due to rain or a new very attractive pollen source starting to bloom. We also noted that pollen appeared to be building up on the surfaces of the pollen grids. This suggested that pollen traps or other devices might be used to enhance interchange of pollen at the hive entrance.

Materials and Methods: Germinations were made on solid agar media of samples from pollen trap grid surfaces, and of carpet strips and pipe cleaners which had been pinned and stapled to hive entrances. Also counts were made of the number of pollen grains washed from some of these strips of carpeting. Germinations were also made of pollen collected from pollen traps and directly from fresh almond flowers for comparison.

Results: Unfortunately, the samples from the pollen grids did not turn out, but germinations of the rest of the samples are as follows:

Pollen Source	N	Mean S.D.	Significance (T-test)
Carpet	6	57.7 (35.1)	A P<0.02 - A & B
Pipe cleaner	11	53.0 (16.9)	C P<0.001 - C & B
Trap	6	65.5 (16.3)	D P<0.008 - D & E
Mission	4	94.9 (4.5)	E
NePlus	7	73.2 (11.9)	
Thompson	3	78.5 (9.7)	
Peerless	8	74.7 (16.6)	
Nonpareil	7	76.0 (13.3)	
All cultivars	29	77.9 (14.0)	B

Substantial quantities of pollen were found on the carpets. Detailed counts are not yet available.

Discussion: The fact that the carpeting and pipe cleaners had viable pollen on them is cause for hope that possibly this pollen could contaminate outgoing bees thus increasing pollen flow between cultivars, fertilization and yield. The fact that there is a significant amount of viable pollen in pollen traps, gives hope that with the development of proper methods of breaking up this pollen and allowing the bees to distribute it or by distributing it by other means, pollination could be enhanced. More intensive studies of this nature and with pollen grids need to be initiated to see what the potential is for enhancing pollen transfer in and around the hive.

VIABLE POLLEN ON BEES COMING INTO AND OUT OF THE HIVE

In another section of this report amounts of pollen on incoming and outgoing bees is discussed. A test was performed to see if any of this pollen is viable and thus available for pollinating.

Materials and Methods: Incoming and outgoing bees were captured and separated from each other using a trap at the hive entrance developed by Dr. Norman Gary. Bees of each category were placed in separate limb cages with almond blossoms previously not exposed to bees. As a control some cages had no bees.

Results: Counts of the number of fruit set on these limbs gave the following % fruit sets:

	N	Mean	S.D.
Incoming bees	4	2.6	1.1
Outgoing bees	3	2.2	2.6
No bees	2	0.0	0.0

Discussion: These results indicate that outgoing bees do carry viable pollen that is probably responsible for some pollination in almond orchards. This work needs to be repeated with larger samples and to be expanded to determine how to increase the amount and diversity of pollen on exiting bees especially of cultivars other than that on which the individual bee is predominantly or exclusively working.

POLLINATING EFFICIENCY OF POLLEN AND NECTAR FORAGERS

Previous research has indicated that pollen foragers are more efficient pollinators than nectar foragers. A test using a different experimental design than before was set up to confirm this previous research.

Materials and Methods: Almond flower buds were caged with screen cages to exclude bees. Bees were captured while foraging on flowers of compatible cultivars and were placed in cages designated for either pollen or nectar collectors.

Results: The results are as follows:

Treatment	N	% Fruit Set	S.D.
Pollen Collector	5	13.1	12.4
Nectar "	6	11.7	12.6
Control (No bees)	4	.8	1.0

Discussion: None of the treatments were significantly different, but the trend was in favor of more set with pollen foragers. This experiment should be repeated with more replications.

EFFECTS OF POLLEN INSERTS ON FRUIT SETS AND YIELD

This experiment was set up to determine whether placing hand collected pollen in inserts at the hive entrance, where incoming and outgoing bees have to pass through them, increases fruit set and yield.

Materials and Methods: Pollen inserts were placed on eight strong colonies (10-17.5 frmaes) at the east end of a 27 acre almond orchard near Davis, California. A total of 50 colonies, in five fairly evenly spaced drops, were placed in the orchard. NePlus pollen was added to the inserts once during peak Nonpareil and Mission blooms. Fluorescent powder was mixed with some of the pollen applied during Nonpareil bloom to see if the movement of the pollen could be followed with a blacklight at night. Viability of pollen was tested by fruit set and pollen tube growth in styles of emasculated and hand pollinated flowers. Fruit set counts were made on tagged limbs on the east and west sides of the orchard. The planting pattern of the orchard was 4 rows of Nonpareil, 4 rows of Mission, and 2 rows of NePlus. Therefore, counts were made of the row nearest to and the row farthest from the pollinizer for Nonpareil and Mission cultivars to determine if there was a difference in fruit sets. Estimated yield data were taken of east and west sides of the orchard by measuring the volume of nuts produced from a known number of trees on each side of the orchard.

Results: Fruit set and yield results are given in Tables 5 & 6

Discussion: Hand pollinations of Nonpareil flowers produced 82% fruit set with NePlus pollen used in the inserts whether tagged with fluorescent powders or not. Fruit set data showed no positive effects as a result of the inserts. In fact, the side of the orchard with no inserts had significantly higher set in both cultivars. Yield figures were also higher on the side with no inserts for Nonpareil, but were reversed for Mission. In Nonpareil, the rows near the pollinizer had higher set as might be expected if pollination were the limiting factor. In Mission, possibly due to better pollination conditions allowing more even dispersal of pollen, there was no significant difference between the inner and outer rows. This experiment

should be repeated either reversing the side of the orchard with inserts, or in a larger more uniform orchard. Also, an orchard where yield data could be obtained by weight would be better than the approximate volumes which was all we could obtain in this orchard.

BLUE ORCHARD BEE

Blue orchard bees Osmia lignaria, from the 1984 season were maintained and managed in 1985 in order to find ways to increase populations.

Materials and Methods: On February 21, twenty-four milk cartons containing new nesting material and 9 or 10 bee cells each were placed in a wooden domicile on the north edge of an almond orchard. Sixteen other milk cartons set up in the same manner were placed singly in trees running due south of the domicile. Every other milk carton in the domicile had either styrofoam or a foam insulation surrounding the soda straw nests. The cartons in the trees were alternated between the two types of foam also.

Results: The number of nests provisioned per milk carton in 1985 are as follows:

	N	MEAN	S.D.
STYROFOAM DOMICILE	12	3.1	8.0
OTHER FOAM "	12	2.5	3.9
STYROFOAM TREES	7	6.9	8.0
OTHER FOAM "	9	4.1	9.3

None of these differences were statistically significant, but the tests might bear repeating with larger sample sizes. There was 63.5% emergence of bees in the domicile and 52.9% in trees.

Discussion: Apparently many bees are dispersing into the surrounding area and are not renesting in the man-made nests. More work needs to be done to find ways to prevent this and to increase the percent emergence. Further tests with larger samples need to be done to find the best nesting materials and nest locations.

OSMIA CORNUTA

Spanish orchard bees, Osmia cornuta, were introduced near Dixon, CA to determine whether they would emerge in synchrony with, collect pollen from and reproduce successfully during almond bloom.

Materials and Methods: 1,200 live bees received from Spain were divided equally into 4 groups, each wintered differently from 1 September to 1 December 1984 at the USDA Wild Bee Laboratory in Logan, Utah. Each group was placed in a different orchard near Dixon, CA on 3 December 1984. Nest boxes were taken to Utah in April for analyses. Half the nests were returned to Davis in July and placed out on the University farm to test summer survival. The other half were returned to Davis and both groups put out in one almond orchard near Dixon on 17 December for overwintering.

Results: Bee emergence in February 1985 varied by orchard, but was generally synchronized with first bloom. A total of 920 bees emerged. These constructed 976 cells of which 882 survived.

Discussion: Although some population loss occurred, the Spanish orchard bee, Osmia cornuta, did emerge in synchrony with and collect pollen from almond bloom following its first winter in California. Follow-up tests are underway to determine methods of increasing the population.

ASSESSING COLONY POLLINATION EFFICIENCY BY STRENGTH AND FLIGHT: MULTIYEAR ANALYSIS

Over the past twenty years we have made numerous comparisons between various measures of colony strength and correlated flight activities of bees in colonies used for almond pollination. We have begun to reanalyze these multiyear data in light of our findings in more recent years to see what broader patterns may exist.

Materials and Methods: Our initial data sets compared square inches of brood with outgoing flight measured by placing a large screen cone over the entrance of a hive for 30 seconds and counting all existing bees during that period. Susequent data compared FOB with outgoing and later with returning flight partitioned by whether or not the bees had pollen loads on their hind legs. Return flight was measured by covering the hive entrance with a screen and counting the numbers of bees with and without pollen alighting on the screen in 30 seconds. "Cluster" counts are made by lifting the hive lid and counting the number of tops of frames covered with bees (FOB). The front of the top box is lifted so the bottom of frames covered with bees can be counted. If there is a difference, an average is taken. Sometimes the total cluster can be observed by tilting the top box, and observing the silhouette against the sky. If the bottom box of the hive is attached down, only observations of the top of the bottom box can easily be made. In "intensive" counts, each frame is removed from the hive, and the number of frames covered with bees and the amount of brood are estimated.

Results: Table 7 gives regression analyses of flight with various strength measures. Table 8 gives comparisons between different methods of strength evaluations. Table 9 shows the actual number of frames by intensive count that can be expected from a particular cluster count.

Discussion: As in previous years, ending strength assessments were more highly correlated with flight than beginning counts. Possibly, colonies are changing rapidly in both directions early in the almond bloom period, but toward the end of the period the populations are stabilizing in their direction of growth. Regression analyses indicate that flight is in general more highly correlated with FOB by intensive counts than the other strength measures. Some years give higher correlations than others possibly due to variations in quality and quantity of observers and colonies assessed. As in previous years, cluster counts, appear to be an effective and relatively quick and easy means of evaluating colony strength especially in colonies of less than 9 FOB which are the ones the grower would be most concerned about assessing. In future years, as time permits, we would like to work up multi-year data on weight of pollen collected from various colony strength categories to see if the amount of pollen collected has a good correlation with strength. Some previous research using pollen income from traps as an indicator of the value of a colony for pollination may need to be re-evaluated since pollen traps themselves appear to affect a colony's pollination efficiency.

PUBLICATIONS

Loper, G. M., R. W. Thorp, and R. Berdel. 1985. Improving honey bee pollination efficiency in almonds. Calif. Agric. 39(11-12):19-20.

Table 1. Comparisons of changes in colongy strength from initial to final counts and between treatments (N = 5 for all treatments).

FRAMES OF BEES

	Treatment		Initial		Final		Initial vs. final T-Test	Change in Strength		Significant T-Tests between comparable treatme	
	Fed	Trap	$\bar{X}$	S.D.	$\bar{X}$	S.D.		$\bar{X}$	S.D.	Treatments	P-Value
1	yes	O.A.C.	4.2	0.3	7.7	1.6	0.010	3.4	1.3	1 vs. 10	0.000
2	yes	Kremer	4.3	0.3	6.5	1.6	0.033	2.3	1.6	4 vs. 10	0.003
3	yes	None	4.2	0.3	7.2	1.6	0.015	3.0	1.5	3 vs. 12	0.008
4	yes	O.A.C.	5.5	0.7	7.8	0.6	0.000	2.3	0.5	8 vs. 12	0.034
5	yes	Kremer	5.6	0.5	8.6	0.8	0.000	3.0	0.8		
6	yes	O.A.C.	7.6	0.4	9.1	1.7	N.S.	1.5	1.8		
7	yes	Kremer	7.5	0.6	8.7	1.4	N.S.	1.1	1.7		
8	yes	None	7.5	0.8	9.4	1.1	0.016	1.9	1.3		
9	no	None	7.6	0.3	9.3	1.2	N.S.	1.7	1.5		
10	yes	O.A.C.	10.2	0.6	10.0	0.7	N.S.	-0.2	1.0		
11	yes	None, extra space	11.7	0.6	12.0	1.3	N.S.	0.2	1.6		
12	yes	None	11.6	1.0	11.4	1.4	N.S.	-0.2	1.2		

Table 2. Mean numbers of bees and ratio of pollen collectors returning to colonies managed by different techniques. (Bees/30 Sec.)*

Treatment			Bees with Pollen			All Bees			Ratio of Bee with Pollen/without Poll		
			N	X	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
1 fed	O.A.C.	4 FOB	223	2.3	2.9	223	10.0	8.5	198	0.43	0.61
2 fed	Kremer	4 FOB	201	2.6	3.7	201	11.1	9.9	183	0.42	0.59
3 fed	None	4 FOB	211	1.4	2.3	211	6.4	6.8	181	0.37	0.58
4 fed	O.A.C.	6 FOB	199	1.7	2.3	199	9.3	8.9	181	0.39	0.63
5 fed	Kremer	6 FOB	199	2.2	3.4	199	9.5	10.7	173	0.42	0.71
6 fed	O.A.C.	8 FOB	214	2.2	3.0	214	9.7	8.3	193	0.42	0.62
7 fed	Kremer	8 FOB	200	3.1	4.1	200	12.8	12.3	187	0.49	0.65
8 fed	None	8 FOB	211	1.6	2.3	211	7.4	7.2	190	0.38	0.51
9 No	None	8 FOB	215	1.7	2.5	215	8.4	7.7	193	0.35	0.60
10 fed	O.A.C.	12 FOB	190	1.7	2.2	190	9.2	8.8	172	0.31	0.48
11 fed	None, extra space	12 FOB	171	2.1	2.6	171	11.2	9.4	162	0.34	0.45
12 fed	None,	12 FOB	245	2.3	3.5	245	10.1	9.5	223	0.41	0.55

*Significant T-Tests:

Treatment No.	Strength	Bees with Pollen Testing	Increase (+) Decrease (-)	P-Value	Total Bees Increase/ Decrease	P-Value
1 vs. 3	4 FOB	O.A.C. vs. No Traps	+	.001	+	.000
6 vs. 8	8 FOB	O.A.C. vs. No Traps	+	.021	+	.003
10 vs. 12	12 FOB	O.A.C. vs. No Traps	-	.020		
2 vs. 3	4 FOB	Kremer vs. No Traps	+	.000	+	.000
7 vs. 8	8 FOB	Kremer vs. No Traps	+	.000	+	.000
6 vs. 7	8 FOB	Kremer vs. O.A.C.	+	.011	+	.003
1 vs. 4	4 vs. 6 FOB	O.A.C. Traps	-	.040		
1 vs. 10	4 vs. 12 FOB	O.A.C. Traps	-	.020		
6 vs. 10	8 vs. 12 FOB	O.A.C. Traps	-	.049		
5 vs. 7	6 vs. 8 FOB	Kremer Traps	+	.014	+	.004
3 vs. 12	4 vs. 12 FOB	No Traps	+	.001	+	.000
8 vs. 12	8 vs. 12 FOB	No Traps	+	.008	+	.001

COLONY SIZE 1985	4 FOB* N	4 FOB* $\bar{X}$	4 FOB* S.D.	6 FOB N	6 FOB $\bar{X}$	6 FOB S.D.	8 FOB N	8 FOB $\bar{X}$	8 FOB S.D.	12 FOB N	12 FOB $\bar{X}$	12 FOB S.D.
3-5	5C	5.8	(3.8)	5D	5.2	(5.2)	5A	4.5	(3.8)	4B	15.1	(2.6)
3-13	5	67.6	(44.9)	4	89.2	(55.5)	5	93.8	(59.8)	5	86.9	(25.6)
3-20	5	360.2	(127.4)	2	368.7	(243.7)	5	472.0	(315.5)	-	-	-

Significant P Values

A & B - P = 0.001
B & C - P = 0.003
B & D - P = 0.007

*FOB = Frames covered with bees both sides

TABLE 4 POLLEN COLLECTED WITH KREMER TRAPS (g.)

COLONY SIZE 1985	4 FOB* N	4 FOB* $\bar{X}$	4 FOB* S.D.	6 FOB N	6 FOB $\bar{X}$	6 FOB S.D.	8 FOB N	8 FOB $\bar{X}$	8 FOB S.D.
3-4	5	2.2	(1.7)	5	0.8	(0.7)	5	1.2	(0.2)
3-8	5	1.1	(0.6)	5	0.5	(0.4)	5	1.2	(0.7)
3-11	5	11.4	(10.5)	5	8.6	(8.6)	5	20.0	(18.4)
3-13	5	16.7	(12.4)	5	17.7	(10.3)	5	29.6	(23.9)
3-14	5	15.8	(7.1)	5	18.2	(16.3)	5	18.2	(16.3)
3-15	5	16.6	(7.5)	5	16.6	(11.2)	5	27.0	(21.5)
3-20	5	47.6	(27.5)	5	41.1	(26.1)	5	59.4	(28.1)
All Days	35	15.9	(18.5)	35	14.2	(17.1)	35	22.4	(25.2)

No Significant T-Tests

*Colo[illegible]trength in frames of bees (FOB)

Table 5. Fruit Set on Plots with and without Pollen Inserts

Cultivar	Distance from Pollinator Row Near (Adjacent Row) Away (Separated by 1 Row)	Pollen Inserts			No Inserts			T-Test	
		$\bar{X}$(%)	S.D.	N	$\bar{X}$	S.D.	N	Near vs. Away	Insert vs. No Insert
Nonpareil	Away	16.4	8.1	20	27.5	20.0	20	P<.001	P=.002
	Near	32.3	13.6	21	43.0	16.1	20		
Mission	Away	26.5	11.5	10	36.6	11.7	9	N.S.	P=.01
	Near	25.5	9.9	10	36.4	17.1	11		

Table 6. Yield on Plots with and without Inserts

Cultivar	Pollen Inserts			No Inserts			Significance by T-test
	$\bar{X}$(ft.^{3})	S.D.	N	$\bar{X}$(ft.^{3})	S.D.	N	
Nonpareil	1.9	.5	4	2.1	.6	4	N.S.
Mission	2.0	.4	5	1.2	.2	5	P=.002

YEAR	Flight incoming (I) or outgoing (O)	Frames of Bees (FOB) by cluster count		FOB by Intensive count		Brood (in_2)		Frames of Brood	
		Beginning Count	Ending Count	Beginning Count	Ending Count	Beginning Count	Ending Count	Beginning Count	Ending Count
1965	O					.498		.606	
1966	O					.260	.344	.026	.114
1970	O			.210	.489	.235	.042	.409	.240
1981	I	.117	.461						
1982	I		.433	.706	.558	.318	.444	.108	.381
1984	I	.063	.364	.243	.539	.256	.269	.224	.361
1985	I	.003	.309	.085	.229	.125	.227	.091	.205

TABLE 8 COMPARISONS BETWEEN DIFFERENT METHODS OF COLONY STRENGTH EVALUATION USING REGRESSION ANALYSES (r^2 VALUES)

YEAR	Brood Frames Versus (vs.) $Inch^2$ Brood		Brood Frames vs. F.O.* Bees		Cluster vs. F.O. Brood		Cluster vs. $Inch^2$ of Brood		Cluster vs. F.O. Bees	
	Beginning Count	Ending Count	Beginning Count	Ending Count	Beginning Count	Ending Count	Beginning Count	Ending Count	Beginning Count	Ending Count
1965	.728									
1966	.351	.793								
1981	.370		.123		.061		.211		.667	
1982	.698		.351		.235		.413		.630	
1983							.432	.732	.723	.769
1984	.325	.862	.205	.761	.313	.592	.171	.544	.479	.667
1985	.810	.776	.371	.608	.242	.574	.214	.621	.683	.753

* F.O. = Frames of

Table 9. Relationship between number of frames of bees determined by counting the cluster versus counting each frame separately.

Cluster Size (FOB) Category	1985 Intensive Counts $\bar{X}$	SD	N	81-85 Mean Intensive Counts $\bar{X}$	N
0-2	2.6	1.9	3	1.8	99
3-4	4.8	1.6	50	3.8	198
5-6	6.0	1.1	21	5.4	159
7-8	7.8	1.7	33	7.2	179
9-10	8.7	2.1	29	7.9	148
11-12	9.3	1.6	26	9.5	122
13-14	10.5	1.1	14	11.1	67
15-16	11.2	1.6	6	11.3	23
17-18	-	-	-	12.3	3
19-20	-	-	-	14.5	3
TOTAL			182		1001