Honey bees and your avocado orchard - an argument for a bee cooperative.

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The flowering process in the avocado is complex and generally occurs over a two-day period. Under optimal climatic conditions, the flower first opens in the female stage, when the stigma (the female part of the flower) is receptive. The flower closes overnight and on the second day the male stage occurs when the pollen is shed. Overlap between male and female phases may also occur under certain climatic conditions. It is commonly believed that under California conditions avocado flowers are neither wind nor self-pollinated in the male stage. Due to the difference in timing of the female and male stages, therefore, a means of transferring pollen from an individual flower to another flower (within the same tree or adjacent trees) is required. The avocado flower, therefore, requires a vector to effect pollination, which is a necessary first step in the process of fruit set. A vector is an external agent that is capable of causing the transfer of pollen grains from the anthers (the pollen bearing male part of the flower) to the stigma. Numerous pollen grains need to be deposited onto the individual stigmas for the avocado tree to have the potential for a good crop (Ish-Am).

The avocado flower is adapted to visitation by most flying insects as is evident by its open morphology and the easy access to the nectar (Visscher and Sherman, 1998). Therefore, flies, wasps, honey bees, stingless bees, bumblebees and other insects are potential pollinators of the avocado flower. To date, the honey bee has been the only commercially introduced pollinator in avocado orchards in California and elsewhere. Dr. Gad Ish-Am from Israel has recently completed an interesting and promising three-year study on the utilization of commercially supplied bumblebees as a supplementary pollinator for the avocado. Bumblebees appear to be effective in affecting cross pollination in trees which are not adjacent to pollenizer trees (personal communication). Ish-Am, together with Drs. Shmuel Gazit (Israel) and David Roubik (Panama) have been searching for the pollination vectors of avocados in their native habitats of Mexico and Guatemala. Dr. Art Schroeder (UCLA) reported on the possibility of harvesting pollen grains and applying them by electrostatic means. Although the future could hold promise for an alternative pollination vector for the avocado, we are years away from commercial adoption. This leaves us with the need to optimize the effectiveness of the honey bee as a pollination vector.

The honey bee, an Old World insect, is well suited to pollinate avocado flowers, and high pollination rates occur with sufficient visitations. However, avocado flowers are less likely to attract honey bees when other flowers such as citrus, mustard and wildflowers are present. Nectar composition, flower color, pollen size and shape and nectar flow, can be some of the reasons why honey bees prefer to forage other pastures. This preference to forage elsewhere is a major contributing factor to poor pollination and fruit set, particularly in the early blooming varieties such as 'Hass', 'Fuerte' and 'Pinkerton' (Ish-Am). At present, the honey bee is the avocado grower's most economical way of increasing the numbers of pollinating insects during bloom.

Ish-Am has convincing data in regards to the number of visitations by honey bees to effect successful pollination. His research indicates that for effective pollination one must have a minimum of 5-20 bees per tree. If this minimum can not be met then one must add more hives to increase bee density. This could translate to as many as four 'strong' colonies per acre, staged strategically in the grove. A 'strong' colony is 2 hive bodies with a honey bee population of around 40,000 bees. Migratory honey bee colonies only reach peak population of about 45,000 only in June and July. On the other hand, colonies kept under the milder conditions of Southern California during the winter manage to increase their population much earlier in the season particularly if they are stimulated by feeding of sugar water and pollen substitute following the winter solstice in late December (authors' personal observations).

Typically, avocado growers will obtain colonies from commercial beekeepers for pollination. Most honey bee colonies brought to avocado groves come from almond orchards following almond bloom. These colonies may be relatively weak. The honey bees suffer as a result of being moved from their overwintering location to the almond orchard and then to the avocado grove. Almonds bloom early, typically mid February to early March, therefore, a limited amount of forage may be available. Additionally, cold rainy weather during this period will slow down the development of the colonies. Finally, in almond orchards honey bees are potentially exposed to disease and pesticides.

From a beekeeper's perspective bee colonies are placed in avocado orchards to build their strength. Beekeepers often place colonies in large clusters in truck-accessible locations and on perimeter roads adjacent to wildflowers and neighboring orchards. This allows for easy access to the honey bee colonies but is not necessarily the most optimal placement for promoting pollination of avocado flowers. Often, colonies placed in avocado groves are split in order to build the apiary prior to the spring honey flow.

A healthy queen is capable of laying 2,000 eggs per day and the colony's population increases dramatically during the spring. It takes 21 days for a bee to develop through the pupal stage. Unless required to perform other functions, for the next 20-25 days the new bee remains inside the hive and does housekeeping chores, brood feeding, cell building, etc. It takes approximately 45 days for the new bees to be effective as avocado pollinators. Therefore, the only pollination workforce provided by colonies brought in from almond orchards consists of the existing adult bees and the 'older' young bees. If the colonies are placed in the grove in late March and peak avocado bloom occurs before late April and early May this must be considered since there may be insufficient bee numbers to give the maximum benefit for pollination. The needs of the post-almond commercial beekeeper and the avocado grower, therefore, are not necessarily compatible.

In addition to the above factors the commercial honey bee population in the United States dropped from a peak of 6.5 million hives 20 years ago to a low of 1.9 million hives in 1996 (Wilson, 1998) even though the demand for pollination services has been increasing (Traynor, 1998). Two main reasons for this dramatic decline are:

1. The wholesale price of honey dropped to approximately 40 cents per pound for several years due to increased pressure from foreign imports, particularly China. Additionally the federal government canceled a program that provided a subsidy on honey.
2. There has been an expensive uphill battle against a variety of pests and diseases. Varroa mite, Tracheal mite, Nausema and American Foul Brood have weakened and devastated many apiaries. Additionally, Dr. Eric Mussen (1998) stated, "Approximately 10% of our commercial colonies are killed each year due to contact with insecticides and the level of loss appears to be static".

The effect of the decline in availability of commercial honey bee colonies is compounded by the almost complete disappearance of feral (wild) honey bees. It is estimated that the Varroa mite reduced the feral bee population by 90%. For years these feral bees, living in canyons and hillsides, have contributed to avocado pollination in adjacent groves. The decline in avocado productivity in groves not using honey bees for pollination could be associated, in part, with the decline in feral bee populations.

What are the options? The simplest option is to find a local beekeeper who is willing, for a fee, to work with the grower and leave hives at the grove for as long as there is a potential for bloom. The normal avocado pollination service includes placement in the grove of post-almond bloom colonies which are removed at the end of the avocado flowering period. The typical fee for this level of pollination service currently ranges from $0 - $25 per colony. A more realistic cost is $50 - $70 per colony if optimal placement of strong colonies and servicing is provided. The hives could be then spread in a manner that will provide good coverage throughout the orchard. Although honey bees will forage at distances of ¾ mile or more, they tend to concentrate their foraging in a 600 foot radius, when sufficient pasture is available and this aspect should be taken into consideration when placing the hives. This is expensive, particularly if 4 colonies per acre are needed, however, the grower will be assured of adequate pollination.

The second option is for growers to own their own colonies. A large farm can establish its own apiary or a group of farmers could form a beekeeping cooperative. If a cooperative is formed, the members' groves should be located in a general area so that the beekeeper will not need to spend excessive time driving between locations.. The group can own 1,000 colonies which should be sufficient for effectively pollinating 250 acres based on the results of Ish-Am (4 hives per acre). The group hires a beekeeper that, together with some part-time help at critical periods, (an irrigator or a farm hand could be trained to assist in these tasks) can attend to the 1,000 colonies. From the tables presented below, it could be shown that such a concept is worthwhile implementing to both maximize pollination and at the same time reduce costs. The costs associated with establishing a 1,000 hive apiary are given in Table 1.

The total required initial investment for a 1,000 hive apiary is $119,088 or $119.00 per hive. The items indicated by '* ' are non-taxable items. When amortized over 10 years, the cost is $11.90 per year per hive (interest rates are not added nor the tax benefits of such an investment considered). The initial investment can be spread over a 2-year period since it will take 2 years to build the colony to maximum strength. Supers and associated supplies will be needed, therefore, only in the second year. This will reduce the initial investment to a total of $83,746 or approximately $84.00 per colony.

The total yearly expense should be approximately $66,000 or $66 per hive as outlined in Table 2 (feeding and medication are variables that may fluctuate if, for example, good honey flow occurs or low pest and disease pressure are encountered). It will cost a farmer with 20 acres an initial investment of $14,800 (80 hives, $185.00 per hive) to fully pay for this portion of the equipment and one year of colony maintenance. In the first year there will be no income from honey production since the bees draw the frames (build comb) and the colonies are still in the establishment phase. In the second year of operation the cost is reduced to maintenance only ($5,280, $66 per hive) providing all initial setup costs have been paid. To keep colonies strong the queen needs to be replaced once a year. Although many beekeepers purchase queens for approximately $8 each we anticipate that the cooperative will be able to make their own queens at the appropriate time.

In the second year there is a good potential for generating income from honey production. The average production per colony in California is 75 pounds of honey (some locations can produce over 100 pounds). The current wholesale price of honey paid to beekeepers is approximately $0.55 per pound. Honey prices declined in 1998 from a high of $0.85 in 1997. Avocado honey is dark in color and has strong flavor. Although honey quality is normally associated with light color and mild flavor, there is a specialty demand for avocado honey. This has resulted in higher prices as compared to the light honey varieties. This is due to the fact that only a relatively small proportion of the total honey produced is avocado honey. The remainder is a mixture of honey produced from wild flowers such as Sage, Buckwheat and Sumac. Extraction by outside services should not exceed $0.10 per pound, therefore, there is a good potential for earning $33.75 per hive (75 lb. x $0.45), or $2,700 per 80 hives. This will reduce the yearly maintenance cost of pollination for 20 acres to $2,580 plus the 10-year amortized fixed cost of $11.90 ($952 per 80 hives) for a total of $44.15 per hive. This is a very reasonable cost for well placed strong hives and can be considerably less than contracting with a beekeeper. The money is well spent, since under these bee densities the farmer has a much greater potential for higher fruit production. The grower would only need to increase fruit production per acre by 235 pounds (@ $0.75 per pound net return) to pay for this excellent pollination service of 4 colonies per acre.

California avocado groves in the current global economy must maximize productivity to remain viable. Limiting factors need to be identified and best methods to address these factors must be found. The discussion here identifies such a limiting factor and attempts to propose a commercially viable solution; the need for a sufficient number of pollinator insects and the provision of cooperatively owned strong honey bee colonies. By owning the colonies, the members of the cooperative are assured of availability of well placed honey bee colonies throughout the bloom period at a competitive cost. It is the experience in the Santa Barbara area, for example, that when June bloom occurs, often the rented colonies have been already removed. Experts predict that the fees for honey bee rental will increase and given the condition of post-almond colonies, the establishment of a bee cooperative for avocado pollination is a viable and realistic alternative worth investigating.

There are a number of information resources that one should examine when making the decision to pursue raising honey bees. Some of these are listed in Table 3.

References:

Ish Am, G. 1994. Interrelationship between avocado flowering and honey bees and its implication on the avocado fruitfulness in Israel. Ph.D. Thesis (in Hebrew). Tel-Aviv University. pp.157.

Mussen, C.E. 1998. Health Check of the California Beekeeping Industry. Subtropical Fruit News. 6(1):6-7.

Traynor, J. 1998. Will bee supply meet almond pollination needs? The Speedy Bee. 27(8):7,9

Visscher, P. K. and G. Sherman. 1998. Insect Visitors to Avocado Flowers. Subtropical Fruit News. 6(1):7-10.

Wilson, S. 1998. Alternative plan. California Farmer. 6(13):30-36

Table 1. Initial costs to establish a 1,000 hive apiary

Year 1	*$ per unit*	*Total $*
2,000 hive bodies	5.00 per body	10,000
1,000 cedar tops	4.85 per top	4,850
1,000 bottoms	4.85 per bottom	4,850
20,000 plastic frames and foundations	1.20 per frame	24,000
1,000 plastic feeders	3.00 per feeder	3,000
Construction and paint of hive bodies	2.00 per body	4,000
Equipment: suits, tools, pump		1,500
7.75% sales tax ($52,200 taxable)	4.00 per colony	4,046
1,000 queens and 3,000 pounds honey bees	27.50 per hive*	27,500*
Subtotal for Year 1	*83.75 per hive*	*83,746*
Year 2		
2,000 supers	4.00 per super	8,000
20,000 half frames with foundations	1.09 per frame	21,800
Construction and paint of supers	1.50 per super	3,000
7.75% sales tax ($32,800 taxable)		2,542
Subtotal for Year 2	*35.34 per hive*	*35,342*
Total initial investment for 2 years	***119.00 per hive***	***119,088***

Future years
Once the apiary is well established, there will be a need to add additional supers to the inventory (as many as 2,000) for increase honey production.

Table 2. Yearly maintenance of a 1,000 hive apiary

	$ per unit	*Total $*
Corn syrup 3 one gallon feeding	1.60 per hive	3,200
2 pounds protein substitute	1.00 per hive	1,000
Yearly preventative medication	10.00 per hive	10,000
Pay to beekeeper, occasional help and vehicle	50.00 per hive	50,000
Miscellaneous expenses (storage, repairs, etc.)	2.00 per hive	2,000
Total yearly maintenance	*66.20 per hive*	*66,200*

Table 3. Suggested references on bee keeping.

Journals:

1. American Bee Journal. Published monthly by Dadant & Sons, Hamilton, IL
2. Bee Culture. Published monthly by A. I. Root Co., Medina, OH

Books:

1. The Hive and The Honey Bee. 1992. J. M. Graham (ed.). Dadant & Sons, Hamilton, IL
2. ABC and XYZ of Bee Culture. 40th Edition. 1990. Roger A. Morse and K. Flottum (eds). A. I. Root Co. Medina, OH