

## **DETERMINATION OF THE POLLINATION ACTIVITY OF HONEYBEES (*Apis mellifera*) IN THE AVOCADO TREE POLLINATION IN THE CENTRAL ZONE IN CHILE**

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Most growers have implemented the use of bees to their orchard management in order to get a high avocado production in Chile. By reason of high demand of pollinating bees, some requirements have been established for hives, such as numbers of bees and activity of the foragers. The avocados flowers are visited by a great diversity of insect species; 39 species have been identified in La Ligua and 30 in Quillota, being the majority Hymenoptera, Diptera and Coleoptera. In accordance with a model that considers number of bees on the flowers and frequency of visits, the honeybee (*Apis mellifera*) was considered to be the responsible of 88% of avocado pollination in Quillota and 82% in La Ligua. In another trial, it was established that honey bees forage a low amount of pollen in their pollen baskets, reaching up to 6% of the total. This means that bees that have active activity in avocado pollination collect nectar but not pollen. Avocado flowers are attractive for bees and sometimes it is possible to harvest avocado honey. The effect of the distance from hives on the bees found on the avocado flowers was evaluated, detecting no differences between the number of bees that visit those flowers near the hives up to a distance of 300 meters.

Keywords: *Apis mellifera*, bee, avocado, honeybees, pollinating agent, insect.

## **DETERMINACIÓN DE LA ACTIVIDAD POLINIZADORA DE LA ABEJA (*Apis mellifera*) EN LA POLINIZACIÓN DEL PALTO EN LA ZONA CENTRAL DE CHILE**

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El uso de abejas para lograr una alta producción de paltas, es una labor que la gran mayoría de los productores en Chile ha incorporado a los manejos de sus huertos.

Debido a la alta demanda por colmenas para polinizar, se han establecido algunas características que deben cumplir las colmenas, como población de abejas y actividad de las recolectoras. Existe una gran diversidad de especies de insectos que visitan las flores de palto. Se identificaron 39 especies en La Ligua y 30 especies en Quillota, siendo los órdenes Hymenóptera, Díptera y Coleóptera las más abundantes. De acuerdo a un modelo que considera número de individuos en las flores y frecuencia de visitas, se determinó que la abeja (*Apis mellifera*) es responsable de un 88% de la polinización del palto en Quillota y de un 82,8% en La Ligua. En otro ensayo los resultados demostraron que las abejas recolectan un porcentaje muy bajo de polen de palto en sus corbículas, llegando a representar como máximo un 6% del total. Esto significa que las abejas que participan activamente en la polinización del palto son aquellas que recolectan néctar y no polen. Las flores de palto resultan ser atractivas para las abejas y en algunas temporadas se puede incluso cosechar miel de palto. Se evaluó el efecto de la distancia de las colmenas sobre la cantidad de abejas encontradas en las flores de palto, no observándose diferencias entre el número de abejas que visitan las flores cercanas a las colmenas hasta 300 metros.

Palabras clave: abejas, agente polinizador, polinización, *Apis mellifera*, insecto, palto, aguacate.

## 1. INTRODUCTION

Most avocado growers in Chile look after having beehives during flowering of their avocado trees in order to obtain good pollination of their flowers, which causes high production. A great importance is given to the quality of hives to pollinate, mainly to the quantity of collecting bees in the hive (de la Cuadra, 1999). Usually 10 hives per hectare are placed, which means above 250,000 hives are currently used to pollinate the area planted with avocado trees in Chile, exceeding 8.5 million dollars for this purpose (de la Cuadra and Rodríguez, 2006). Nevertheless, the importance of bees (*Apis mellifera*) and the participation of other insects in the pollination of avocado trees had not been previously established in Chile; therefore, this was one of the main objectives of this work. In order to do this, a model considering number of bees and frequency of the insects visiting the flowers was developed (Valdés, 2002). During the flowering of avocado trees, it may be observed that bees visit flowers in great quantity but mainly to collect nectar and not pollen. In practice, this assertion is strengthened when ascertaining that in some seasons some growers achieve harvesting avocado honey from hives that have maintained through all the flowering of avocado tree (generally, late September to late November) since their identification is very easy because of their dark colour (de la Cuadra and Rodríguez, 2006). The preference of the main pollinating insects visiting avocado flowers for the north or south face of the tree was also determined, as well as if these insects

preferred to visit the flowers in the morning or afternoon and the type of collection (nectar, nectar + pollen, pollen).

## 2. MATERIAL AND METHOD:

The trial was conducted from the last week of September to late November 2001, during flowering of avocado trees, in 2 orchards representative of the avocado-growing area in the Fifth Region of Chile.

In the area of La Ligua, the trees were planted in 1991 and the planting distance 6x6 metres. All of them belong to Hass variety grafted on Mexicola rootstock; the sector where the trial was made has 18 hectares. In Quillota, the evaluated sector has an area of 3.5 ha; the trees were also Hass grafted on Mexicola rootstock with the same planting distance and planted in year 1993. From each orchard, 8 trees were selected. The quantity of hives per hectare was 6 in Quillota and 11 in La Ligua. The observations were made twice a week in each of the orchards during the flowering period of the crop at two different hours, from 10 am to 12 pm and from 3 pm to 5 pm, for 10 minutes per tree. The observation area corresponded to 2 areas of 1 square metre each, located in north face and south face of each tree, at approximately 1.5 metres high. All the insects visiting the marked area were quantified and some sample insects were collected for identification. The observations were carried out during 5 minutes on each face, that is, 10 minutes for each tree, both in the morning and afternoon.

## 3. RESULTS

Table 1 shows the most significant information on insects found in avocado flowers.

Table 1: Percentage of the main insects detected during the flowering of avocado (*Persea americana*) Hass variety in Quillota and La Ligua. Year 2001

Family	Genus-species	La Ligua %	Quillota %
<i>Apidae</i>	<i>Apis mellifera</i>	28.10	57.90
<i>Formicidae</i>	<i>Iridomyrmex humilis</i>	17.70	9.80
<i>Colletidae</i>	<i>Colletes seminitidus</i>	1.70	6.20
<i>Halictidae</i>	<i>Corynura chloris</i>	1.50	2.60
	<i>Caenohalictus monilicornis</i>	0.50	0.40
	<i>Corynura corynura chilensis</i>	0.05	0.00
<i>Vespidae</i>	Unidentified	1.20	1.30
	<i>Polystes buyssoni</i>	0.05	0.00
<i>Sphecidae</i>	<i>Nisson sp</i>	3.10	0.70
<i>Ichneumonidae</i>	Unidentified	0.00	0.20
<i>Andrenidae</i>	<i>Acamptopoeum hirsutulium</i>	0.00	0.10

	<i>Protandrena hirsutulum</i>	0.05	0.00
	<i>Acamptopoeum submetallicum</i>	0.05	0.00
<i>Pompilidae</i>	Unidentified (2 species)	0.20	0.10
<b>Total Hymenoptera Order</b>		54.20	79.30
<i>Syrphidae</i>	<i>Allograpta pulchra</i> , <i>Allograpta sp</i> <i>Eristalis tenax</i> <i>Syrphus octomaculata</i>	8.10	6.60
<i>Sarcophagidae</i> and <i>Muscidae</i>	2 unidentified species	19.10	9.30
<i>Mycetophilidae</i> and <i>Mididae</i>	2 unidentified species	1.40	0.30
<i>Lauxaniidae</i>	<i>Sapromyza sp</i>	0.30	0.30
<i>Bombyliidae</i>	<i>Villa sp</i>	0.20	0.10
<i>Tephritidae</i>	<i>Trypanea sp</i>	2.60	0.00
<i>Bibionidae</i> and <i>Rhagionidae</i>	2 unidentified species	0.00	0.10
<b>Total Diptera Order</b>		31.70	16.70
<i>Coccinellidae</i>	<i>Adalia deficiens</i> , <i>Adalia bipunctata</i> , <i>Cryptolaemus monstrosus</i> , <i>Eriopis connexa</i>	9.00	2.10
<i>Cleridae</i>	Unidentified	2.40	0.20
<i>Cantharidae</i>	<i>Haplous sp</i>	0.05	0.00
<i>Buprestidae</i>	<i>Anthaxia concina</i>	1.50	0.10
	<i>Ectinogonia buqueti</i>	0.05	0.00
<i>Mordellidae</i>	<i>Mordella luctuosa</i>	0.30	0.00
<i>Peltidae</i>	<i>Decamerus sp</i>	0.05	0.00
<i>Cerambycidae</i>	<i>Callideriphus laetus</i>	0.20	0.00
<i>Lampyridae</i>	<i>Pyraconema sp</i>	0.00	0.20
<i>Bostrichidae</i>	<i>Micrapate scabrata</i>	0.00	0.10
<b>Total Coleoptera Order</b>		13.55	2.70
<i>Pyralidae</i>	Unidentified	0.40	1.30
<b>Total Lepidoptera Order</b>		0.40	1.30
<i>Rhopalidae</i>	<i>Liorhyssus lineiventris</i>	0.05	0.00
	<i>Arhyssus tricostatus</i>	0.05	0.00
<i>Miridae</i>	Unidentified	0.05	0.00
<b>Total Hemiptera Order</b>		0.15	0.00

<b>TOTAL</b>		100.00	100.00
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In both cities, La Ligua and Quillota, the most important group found in the avocado flowers was Hymenoptera and within this group, *Apis mellifera*. This % only represents number of insects associated with flowers. However, many of these insects do not have an active participation in pollination whether because they are not in touch with sexual parts of flowers, without transporting pollen effectively, or because they visit a low number of flowers within a certain period of time. When selecting those insects that participate in pollination visiting flowers actively, the list is reduced to only 3 species of Hymenoptera (*Apis mellifera*, *Colletes seminitidus* and *Corynura chloris*), several species of *Syrphidae* family (Diptera) and 1 unidentified species of *Cleridae* family (Coleoptera).

In order to evaluate the effectiveness of the insect as pollinating agent, a model including the number of individual insects per square metre in one time unit, active presence in flowers and frequency of visit to flowers was developed.

$$VP = A \times B \times D$$

Where

VP = Value of the insect as pollinating agent

A = Number of insects per square metre

B = Presence in flowers

D = Frequency of visit to flowers

The number of insects per square metres (A) was obtained from the average of individual insects of each species recorded during the observation period. The observation time was 5 minutes.

For B a value = 1 was assigned to insects actively visiting the flowers and a value = 0 to those not visiting.

The frequency of visit to flowers (D) was determined in the main species, measuring the quantity of flowers visited per minute.

When considering only the insects that have active participation in pollination with value of B = 1, the model was reduced to:

$$VP = A \times D$$

Tables 2 and 3 show the values of A, D and VP for the main insects associated with avocado flowers in both studied cities.

Table 2: Value as pollinator (VP) of the main insects visiting avocado (*Persea americana*) flowers Hass variety in Quillota. Year 2001

Name	A	D	VP	%
	No. of insects (average/tree)	Frequency of visits (flowers/minute)	Value as pollinator	
<i>Apis mellifera</i>	4.6	7.3	33.6	88.0
<i>Colletes seminitidus</i>	0.5	5.0	2.5	6.5
<i>Corynura chloris</i>	0.2	3.0	0.6	1.6
Familia Syrphidae	0.5	3.0	1.5	3.9
			VPT = 38.2	100

$$\% = (100/VPT) VP$$

Table 3: Value as pollinator (VP) of the main insects visiting the avocado flowers (*Persea americana*) Hass variety in La Ligua. Year 2001

Name	A	D	VP	%
	No. of insects (average/tree)	Frequency of visits (flowers/minute)	Value as pollinator	
<i>Apis mellifera</i>	3.0	7.7	23.1	82.8
<i>Colletes seminitidus</i>	0.2	5.0	1.0	3.6
<i>Corynura chloris</i>	0.2	3.0	0.6	2.2
Familia Syrphidae	0.9	3.25	2.9	10.4
Familia Cleridae	0.3	1.0	0.3	1.1
			VPT = 27.9	100

$$\% = (100/VPT) VP$$

As shown in Tables 2 and 3, the value as pollinating agent of *Apis mellifera* is considerably higher than other insects when considering the number of insects per tree and the quantity of flowers visited per minute. It represents 88% in Quillota and 82.8% in La Ligua.

### 3.1 Behaviour of the main insects pollinating avocado trees

The pollinating activity of the main insects was evaluated at different hours of the day, in the north and south face of the trees, and if they collected nectar and/or pollen from the visited flowers.

Table 4 shows the percentage of visits made in the morning and in the afternoon for each of the main insects found.

Table 4: Percentage of visits made in the morning and in the afternoon to avocado flowers (*Persea americana*) Hass variety of the main pollinating insects in La Ligua and Quillota. Year 2001

Name	Quillota		La Ligua	
	10 am -12 pm	3 pm - 5 pm	10 am – 12 pm	3 pm – 5 pm
<i>Apis mellifera</i>	39.0%	61.0%	51.0%	49.0%
<i>Corynura chloris</i>	39.4%	60.6%	73.1%	26.9%
<i>Colletes seminitidus</i>	49.4%	50.6%	51.7%	48.3%
<i>Cleridae</i> Family	0.0%	100%	35.7%	64.3%
<i>Syrphidae</i> Family	57.6%	42.4%	51.8%	48.2%

It is observed that in general the insects visit flowers in the morning as well as in the afternoon, except the *Cleridae* family that in Quillota was only observed during the afternoon and not in the morning. *Apis mellifera* and *Corynura chloris* are observed in greater number during the afternoon in Quillota, probably because temperatures are lower and more mist is formed in the morning.

Table 5 shows the percentage of visits to the north face and south face of avocado trees of Hass variety made by the main insects in La Ligua and Quillota.

Table 5: Percentage of visits to the north face and south face of avocado trees (*Persea americana*) of Hass variety made by the main pollinating insects in La Ligua and Quillota. Year 2001

Name	Quillota		La Ligua	
	North Face	South Face	North Face	South Face
<i>Apis mellifera</i>	67%	33%	66%	34%

<i>Corynura chloris</i>	82%	18%	77%	23%
<i>Colletes seminitidus</i>	69%	31%	59%	41%
Familia Cleridae	-	-	71%	29%
Familia Syrphidae	60%	40%	68%	32%

It is clearly observed that the north face is much more visited by all the insects, because of being more exposed to the sun and higher temperature, which makes it more appealing to pollinating insects.

Regarding the collecting behaviour of the insects, these may collect only nectar, only pollen or both at the same time (nectar + pollen). When observing such behaviour in the main pollinating insects, it could be established that the *Syrphidae* Family and *Cleridae* Family only collect nectar from avocado flowers. *Colletes seminitidus* and *Corynura chloris* collect nectar + pollen. It is curious that in the case of *Apis mellifera*, only bees collecting nectar were observed, in spite of the fact that this species is known by collecting great amounts of nectar and pollen from flowers to fulfil the needs of the hive. These observations coincide with what was mentioned by Castillo (2002), who determined in a test in Quillota that the bees collect almost exclusively nectar from the avocado flowers, Hass variety: 98.48% collected only nectar, 1.26% nectar + pollen and 0.25% only pollen. In the case of Edranol variety, Castillo determined that bees collected greater quantity of pollen from its flowers, since 61.47% collected only nectar, 38.09% nectar + pollen and just 0.43% only pollen.

Table 6: Type of collection of the main insects in avocado (*Persea americana*) flowers of Hass variety in Quillota and La Ligua Year 2001

Name	Type of collection
<i>Apis mellifera</i>	Nectar
<i>Colletes seminitidus</i>	Nectar + Pollen
<i>Corynura chloris</i>	Nectar + Pollen
Familia <i>Syrphidae</i>	Nectar
Familia <i>Cleridae</i>	Nectar

Castillo (2002) also determined that the quantity of pollen from avocado trees collected from traps placed in hives, located in an orchard of avocado trees for its pollination, resulted in a very low value regarding the total pollen collected by bees from different plant species and never exceeded 3.3% of the mean daily total determined as average of 3 hives, with the total average only reaching 1.58%, which confirms that bees visit avocado flowers especially to collect nectar and not pollen.

#### 4. CONCLUSIONS

- There is a great diversity of insect species associated with the avocado flowering (*Persea americana*), Hass variety, identifying 39 species in La Ligua and 30 species in Quillota, with Hymenoptera, Diptera and Coleoptera orders being the most abundant ones.
- The most numerous order present during the flowering of the avocado trees is Hymenoptera, with *Apis mellifera* being the species with greater participation in La Ligua and Quillota as well.
- According to the model used to determine the participation of insect species in the pollination of avocado trees (*Persea americana*), *Apis mellifera* represents 88% in Quillota and 82.8% in La Ligua.
- There are other wild insects that participate in the pollination of avocado trees, with *Colletes seminitidus* (Family *Colletidae*) and *Corynura chloris* (Family *Halictidae*) being the most important species, together with other species of *Syrphidae* and *Cleridae* families.
- All the insects observed visit mainly the north face of trees and to a lesser degree the south face.
- *Apis mellifera* mainly collects nectar from flowers of avocado trees (*Persea americana*).

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