Acta Scientiarum 22(4):937-941, 2000.
ISSN 1415-6814.

POLLINATION IN AVOCADO FLOWERS (*Persea americana* Mill.)

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RESUMO: Foram estudadas a frequência, coleta de néctar e/ou pólen e tempo de coleta das abelhas nas flores do abacateiro e verificar o efeito de suas visitas na produção de frutos. Foram marcadas seis inflorescências, sendo que três permaneceram descobertas e três cobertas, para se avaliar o efeito da polinização cruzada na produção de frutos. Tanto para néctar quanto para pólen, as abelhas *Apis mellifera* apresentaram dois picos de frequência (entre 11 e 12 horas e às 17 horas) acompanhando a abertura das flores dos diferentes grupos do abacateiro (grupos A e B). Entretanto, para néctar as abelhas *Apis mellifera* apresentaram um pico bem maior no período da manhã comparado com o da tarde, em 1997 e o inverso ocorreu em 1998. Para pólen, não houve diferença significativa entre os períodos. Os botões florais descobertos produziram significativamente mais frutos quando comparado com os cobertos. A ausência de insetos polinizadores reduziu em 81,25% a produção de frutos.

Palavras-chave: Polinização, *Apis mellifera*, abacate, *Persea americana*.

ABSTRACT: **Pollination in avocado flowers (*Persea americana* Mill.).** The experiment aimed to study the frequency, nectar and/or pollen and hoarding time of bees in avocado flowers and verify the effect of their visits in fruits production. It was marked six inflorescences (three covered and three uncovered) with two replications to evaluate the effect of cross pollination in fruition percentage. The honey bees showed two peaks of hoarding (by 11 to 12 a.m. and 5 p.m.) following the flowers opening of different avocado groups (groups A and B), as much nectar as pollen. However, the honey bees presented a peak greater in the morning than afternoon for nectar, in 1997 and changed in 1998. There was not difference between the periods, for pollen. The fruition percentage was significantly different between the covered treatments (produced less) and uncovered ones (produced more). The crop reduced 81.25% without pollinators.

Key words: Pollination, *Apis mellifera*, avocado tree, *Persea americana*.

INTRODUCTION

The fruits and seeds production in many cultures of economic interests depends on insect pollination in general and, especially, by *Apis mellifera* Linnaeus, 1758. In certain crops, the flowers that are not appropriate pollinated may abort or result in fruit of small size and low quality (McGREGOR, 1976; FREE, 1993).

Because of indiscriminate use of pesticides, fires and increasing deforestation, it is observed a reduced number of native bees that actively participate in

pollination of crops. Because of this, the use of *A. mellifera* within the crops has been increasing and in some countries, it is quite common renting beehives to make the pollination in time of bloom. According to TODD & McGREGOR (1960), in the United States of America, since 1910 it is note the practice of renting beehives.

In Brazil, many studies were performed about the pollination of fruit trees (*Passiflora sp* – passion fruit, *Myrciaria sp* – jabuticaba tree). The avocado crop is considered very important in the global fruit growing. The several varieties freely intersect and hybrid cultivar has become important in commercial plantations (DONADIO *et al.*, 1978). It can be cultivated in all Brazilian regions. Some varieties withstand temperatures bellow zero, while others are adapted of hot and damp climates (GOMES, 1982).

The avocado is a tree that reaches higher of 8 to 12 meters, having the crown of the tree variable, sometimes, compact and rounded in some varieties and open many branches in other. It produces small yellow flowers, hermaphrodites, grouped in terminal panicles or sub in large numbers. Despite of the complete flower, occurs the dicogamy protogynous phenomenon, in other words, the pistils and the stamens of the same flower reaches the sexual maturity at different times (FREE, 1993). Because of this behavior, STOUT (1933) framed the varieties in two flower groups: group A – the flowers open in the morning, close up at middle day and reopen in the following afternoon; group B - the flowers open in the afternoon, close up that the same night and reopen in the sunrise the next day.

To the commercial cultures has been recommended the overplanting of varieties of both groups, to increase the efficiency of pollination and, therefore, ensure greater production. However, since that the light amount is very variable, the flowers not follow the standard, then, always there is sufficient pollen available to guarantee the fruit production, even in uniform plantations of a single cultivar. In Israel, ISH-AM & EISIKOWITCH (1991) showed that the opening and closing of flowers that the same tree is not perfectly synchronized and the flowers open in the morning may extend over the opening at the afternoon, therefore, overlap period between pistillate and staminate stages may occur during the day. In the humid conditions in Florida, DAVENPORT (1982, 1986) suggests that the stigmas remain receptive and self-pollination can occur.

PETERSON (1955) concluded that the Zutano e Hass varieties are able producing fruits when isolated from others cultivars, if the bees are presents.

According with BERGH (1967), all the fruit set are originated from cross-pollination provided by insects. The gravity or wind can have an effect but are rare and can be despised by farmers. Bees are responsible of cross-pollination in avocado flowers and his factor was determinant to survival and adaptation of avocado in California and concluded that the average production of avocado is higher where there are many bees. In fact, the avocado needs of insect pollinators and the production is great when the varieties is alternately planted.

The higher fruiting can be achieved through cross-pollination, by appropriate flowers intercalation, kinds of Bloom and availability of appropriate agents realizing the pollination (BERGH, 1969).

Many pollination agents visit avocado flowers to collect pollen and nectar: A. *mellifera*, many species of native bees, wasps, flies and hummingbirds (CHAPMAN, 1964). Therefore, only *A. mellifera* are sufficiently abundant in flowers, in all schedules, for the formation of satisfactory fruit production (McGREGOR, 1976).

RUEHLE (1958) mentioned that a good production can be obtained in plantations located at a considerable distance from beehives and their presence provides an increase in production. POPENOE (1963) found that *A. mellifera* are necessary for a

good pollination, unless there are plenty of native bees in the area.

STOUT (1923) recommends put beehives on plenty and control others plants in the same area and nearby that could attract these bees, drifting them of the main crop flowering. STOUT (1933) reports that are necessary 2.5 beehives/ha for satisfactory production, this because of bloom habit of the avocado flowers. LECOMTE (1961) suggested two colonies/ha.

DEGANI & GAZIT (1984) verified that different avocado progenies found that in the presence of beehives, the percentage of cross-pollination ranged 7 to 92%. VITHANAGE (1990) studding the introduction of beehives in avocado bloom found that there was significant increase in production, in the average, 227.2 fruits/tree in the crop without beehives and 788.2 fruits/tree with beehives, evidencing an increasing of 247% in the production. The density of two beehives was sufficient to increase the production, therefore, three beehives/ha increasing significantly the average fruit weight in the experimental area.

Based on the above proposed, a test to study the flowers development of avocado (*Persea americana* Mill.), the insects that act in their pollination, the behavior harvesting of these insects (pollen or nectar) and the effects of these pollination in fruits production was performed.

MATERIAL AND METHODS

The experiment was carried out in an avocado crop (*Persea americana* Mill., Fortune var.) at the Faculty of Agronomy "Dr. Francisco Maeda" (FAFRAM), Ituverava, SP, located at 20°20'30" of South latitude and 47°47'30" of West longitude, and altitude of 631 m, in State of Sao Paulo - Brazil.

The crop remained under observation in bloom period from August 21 to August 27, 1997 and from September 04 to September 15, 1998. In these two consecutive years (1997 and 1998) were evaluated, in each year:

- The insects frequency (collected and preserved in alcohol 70%, properly labeled and identified);
- The frequency of insects visitations, during the day (was obtained by count, in the first 10 minutes of each schedule, of 8 at 18 o'clock, with four repetitions);
- nectar and/or pollen collection and collection time, in seconds, insects frequency (30 repetitions);
- the interaction of environment temperature and relative humidity with the frequency of visitations, throughout the day, using the hygrometer.

To observe the cross – pollination effect, were marked six Bloom, randomly, being that three remained covered and three covered with wire frames covered with woven nylon, marked with colored line, during the button phase until the fruit formation, with two repetitions. The blooms were covered during all the Bloom period which was two weeks. The fruits were analyzed related with: time of formation of fruit, since flowers withering until their crops, number and weighing of fruits obtained in different traits by crops.

The data were analyzed by variance analysis in a completely randomized design in ESTAT (software developed by computational department of Faculdade de Ciências Agrárias e Veterinárias de Jaboticabal – UNESP) that includes Tukey test (5%) to mean comparison of all variables and regression analysis for orthogonal polynomials in REGPOL software, to test each variable in time.

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RESULTS AND DISCUSSION

More frequent insects in 1997 and 1998 were *Apis mellifera* (94.3% and 84.6%, respectively), followed by *Trigona spinipes* – Fabricius, 1793 (4.7% and 13.4%) and *Tetragonisca angustula angustula* - Latreille, 1811 (1.0% e 2.0%). In both years, it was observed sporadic visits of Coccinellidae, Lepidoptera, Formicidae, Vespidae, Diptera and *Chloralictus sp* and *Xylocopa sp* bees.

In 1997, *A. mellifera* and *T. spinipes* preferred ($P<0.05$) collect pollen in this crop (57.3% and 60.5% visits, respectively). The *T. angustula* collected nectar and pollen ($P>0.05$) in the same proportion (51.0% and 49.0%, respectively). In 1998, *A. mellifera* preferred ($P<0.05$) collect nectar (66.7%), the *T. angustula* preferred ($P<0.05$) collect pollen (75.6%) and the *T. spinipes* collected pollen and nectar ($P>0.05$) in the same proportion.

By polynomial regression in time, it was observed in 1997 as in 1998, both for nectar and pollen gathering, *A. mellifera* increased their frequency until 11 o'clock, decreased until 15 o'clock, subsequently increased since 16-17 o'clock, decreased since the end of the afternoon. To *T. spinipes* and *T. angustula*, the frequency not presented significant difference during the day, in 1997. Already in 1998, *T. spinipes* presented the same pattern presented by *A. mellifera* during the day, as nectar as pollen. The *T. angustula* increased the pollen collection until 11 o'clock, decreasing then the end of the afternoon. To nectar, this bee not presented preferably during the day.

It was evaluated only in the period of the day by characteristics of opening avocado flowers, which its close at night. Those that remained open in the evening, group A already fertilize or were wilted and falling, or not fertilized.

In both years, as nectar collection as pollen, the Africanized honeybees presented two frequency peaks (within 11 and 12 o'clock and 17 o'clock) following the opening of flowers of different avocado flowers groups (groups A and B). However, for nectar, these bees presented a higher peak in the morning compared to the afternoon, in 1997, and the inverse occurred in 1998, although, bees collected more nectar in the afternoon. For pollen, did not have significant difference ($P>0.05$) between morning and afternoon (Figures 1 and 2).

Apis mellifera stayed 9.2 ± 0.8 seconds to collect nectar and 5.4 ± 0.5 seconds to collect pollen.

In this crop, there was no correlation between environment temperature and relative humidity with bee frequency, probably, due to the pattern of opening of flowers in avocado.

The time of fruit set was about three months in both years. As 1997 as 1998, the number of obtained fruit in the uncovered treatment was significantly higher (16 fruits in total or 2.6 ± 2.5, in average) than covered treatment (three fruits in total or 0.5 ± 0.5, in the average). It was observed that on treatment in which the flowers were prevented from being visited by bees there was a decrease of 81.25% in fruits production.

Those flowers that remained covered, not surprisingly zero fruiting, therefore, according with VITHANAGE (1990), although coverage does not allow the arrival of outside pollen, it can exist flowers changing to the staminate phase out of the sequence, inside the cages and, thus, freeing up some pollen. The bloom movement, caused by the wind, could spread pollen about a small quantify pistillate flowers within the coverage causing a self-pollination, in a small proportion. This prevented the assessment of the fruit rate.

The fruit weight was, in average, 264.5 ± 7.3 g and there was no significantly difference between covered 261.2 ± 10.0 g and uncovered, 265.1 ± 7.0 g treatments and within studied years.

It is emphasize that, beside the avocado crop, there was an orange orchard, which bloom in the same season, in both years, ended a little bit before avocado flowering. It was verified that at the orange flowering, increased bee frequency in the avocado flower. In Israel, EISIKOWITCH & MELAMUD (1982) found that the avocado pollination was low when the *Citrus sp* was bloom within a radius of 3 km; when the *Citrus sp* bloom ended, the pollinators in the avocado increased immediately. According to VITHANAGE (1990), avocado flower are not relatively attractive.

It can concluded that insects more frequent were *A. mellifera*, followed by *T. spinipes* and *T. angustula*. As pollen as nectar collection, *A. mellifera* presented two frequency peaks, within 11 and 12 o'clock and 17 o'clock, following the opening of flowers of different avocado groups (group A and group B). However, to nectar, *A. mellifera* presented a higher peak in the morning than the afternoon, in 1997 and the inverse occurred in 1998.

The flower bud uncovered produced significantly a lot of fruits than the treatment of covered flowers. The absence of insect pollination reduced on 81.25% the fruit production.

REFERENCES

BERGH, B.O. Reasons for low yields of avocados. *Calif. Avocado Soc. Yearbook* 51, 1967. p.161-172.

BERGH, B.O. Avocado. In: FERWERDA, F.P., WIT, F. *Outlines of Perennial Crop Breeding in the Tropics*. Wageningen: H. Veenman and Zonen, 1969. p.23-51.

CHAPMAN, G.P. Pollination and the yields of tropical crops: in appraisal. *Euphytica*, (13):187-197, 1964.

DAVENPORT, T.L. Avocado growth and development. *Proceedings of Florida State Horticultural Society*, (95):92-96, 1982.

DAVENPORT, T.L. Avocado flowering. *Horticultural Review*, 8:257-289, 1986.

DEGANI, C., GAZIT, S. Self and crossed proportion of avocado progenies produced by caged pairs of complementary cultivars. *HortScience*, 19(2):258-260, 1984.

DONADIO, L.C., PEREIRA, F.M., LAM-SANCHES, A. Simpósio sobre abacaticultura. In: SIMPÓSIO SOBRE ABACATICULTURA, 10º, 1978, Jaboticabal, *Anais*...Jaboticabal: FCAVJ, 1978. 75 p.

EISIKOWITCH, D., MELAMUD, H. A preliminary report on the role of honeybees in avocado pollination. *Alon Hanotea*, (37):19-29, 1982.

FREE, J.B. *Insect pollination of crops.* New York: Academic Press, 1993. 684 p.

GOMES, P.R. Fruticultura Brasileira. 8ª ed., São Paulo: Nobel, 1982. 448 p.

ISH-AM, G., EISIKOWITCH, D. Possible routes of Avocado tree pollination by honey-bees. In: INTERNATIONAL SYMPOSIUM ON POLLINATION, 6., 1990, Tilburg, The Netherlands, *Acta Horticulture, n.*288, Tilburg: Acta Horticulture, 1991. p.225-233.

LECOMTE, J. [Observations on pollination of the avocado in the french antilles.] *Fruits*, 16(8):411-414, 1961. [In French]

LESLEY, J.W., BRINGHURST, R.S. Environmental conditions affecting pollination of avocados. *Yb. Calif. Avocado Soc.*, 1951. p.169-173.

McGREGOR, S.E. *Insect pollination of cultived crop plants.* Washington: Agric. Res. Serv. United States Dept. of Agric., 1976. 411 p.

PETERSON, P.A. Dual cycle of avocado flower : study of the continuous dual opening cycle of the avocado flower shows need of large flying insects for pollination. *Calif. Agr.*, 9(10):6-7,13, 1955.

POPENOE, J. The ruehle avocado. *Fla. Agr. Expt. Sta.*, Circ. 5-144, 1963. 4 p.

RUEHLE, G.D. The Florida avocado industry. *Fla. Agr. Expt. Sta.*, Bulletin 602, 1958. 100 p.

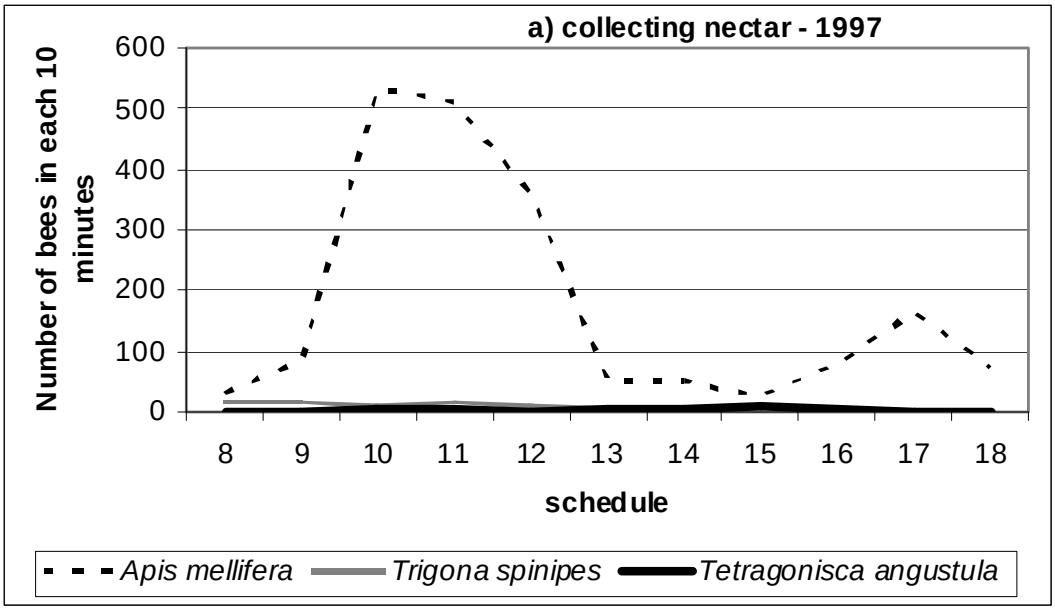
STOUT, A.B. A study in cross-pollination of avocados in Southern California. *Calif. Avocado Assoc. Ann. Rpt* 1922-23, 1923. p.29-45.

STOUT, A.B. The pollinations of avocado. *Fla Agr. Expt. Sta.*, Bulletin 257, 1933. 44 p.

TODD, F.E., McGREGOR, S.E. The use of honey bees in the production of crops. *Annual Review of Entomology*, 5:265-278, 1960.

VITHANAGE, V. The role of the European honeybee (*Apis mellifera* L.) in avocado pollination. *Journal of Horticultural Science*, 65(1):81-86, 1990.

Acta Scientiarum 22(4):937-941, 2000.
ISSN 1415-6814.



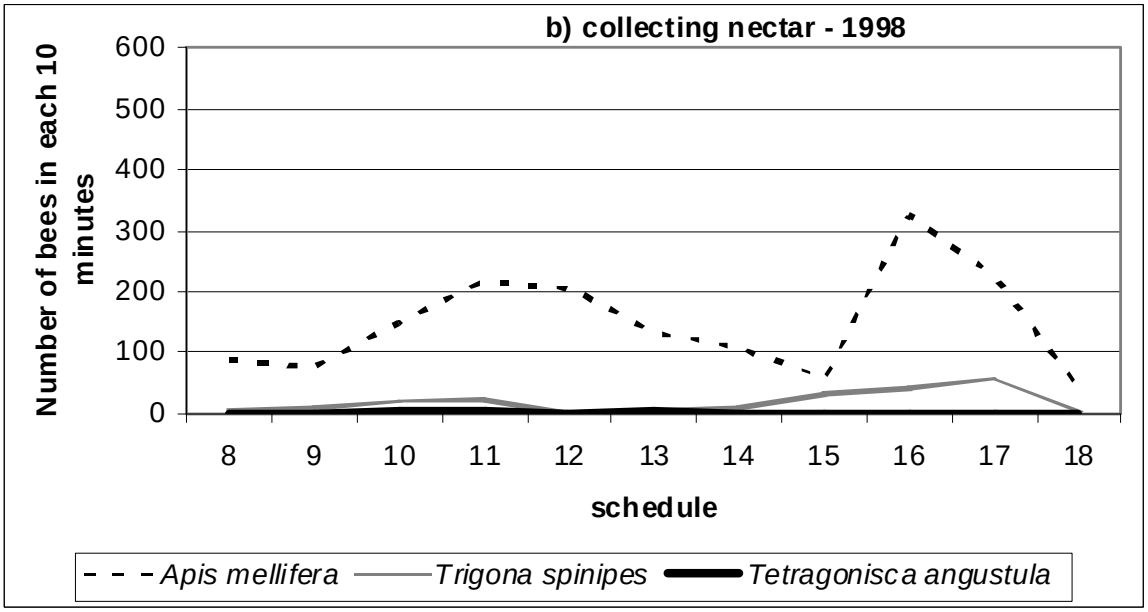


Figure 1 – Number of forager bees colleting nectar in avocado flowers (*Persea americana* Mill.) on the a) 1997 and b) 1998 years.

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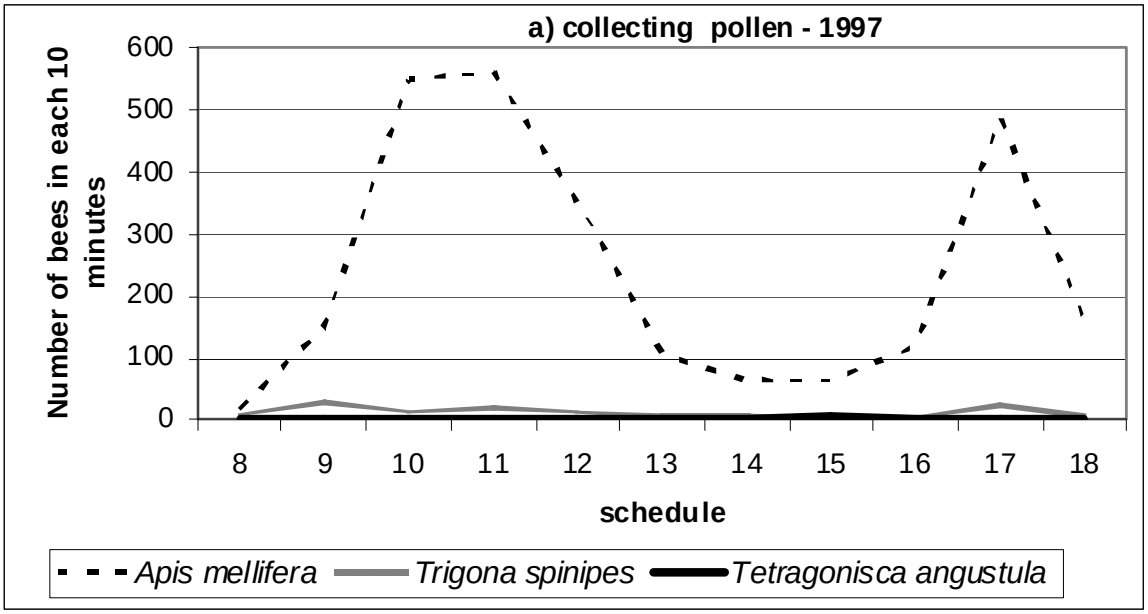
ISSN 1415-6814.



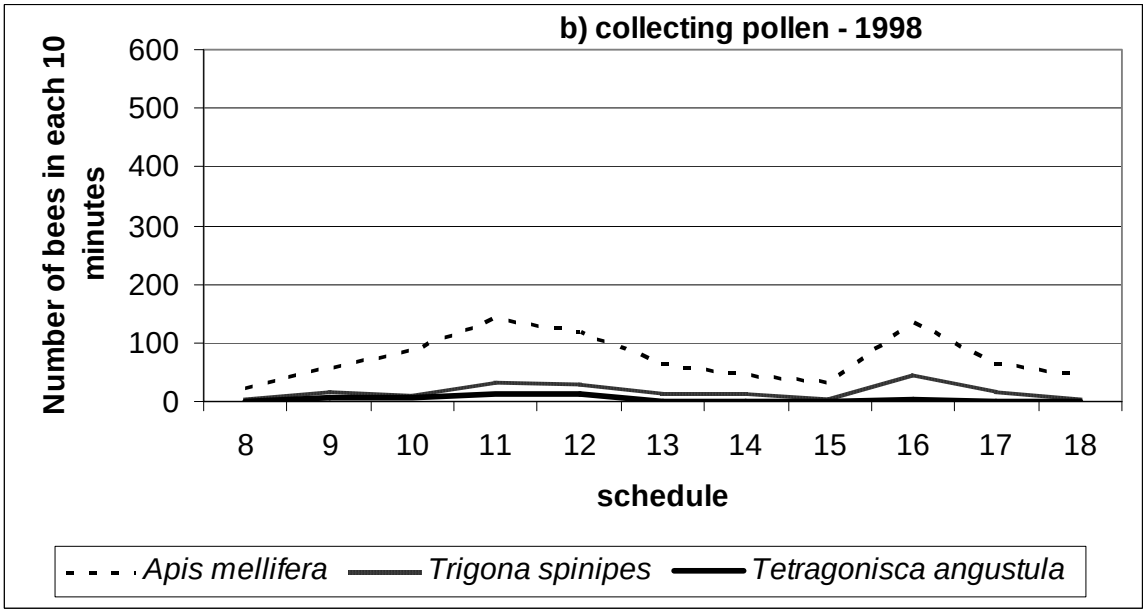


Figure 2 – Number of forager bees collecting pollen in avocado flowers (*Persea americana* Mill.) on the a) 1997 and b) 1998 years.