Observations of *Phacelia tanacetifolia* as a Food Plant for Honey Bees and other Insects[1]

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ABSTRACT

Three consecutive sowings of *Phacelia tanacetifolia* Bentham (Hydrophyllaceae) were examined for plant growth and attractiveness to bees and other insect-visitors over a three years' study. Plants that were sown in March flowered uniformly for periods of 24 to 40 days, while those sown in June and July had a non-uniform anthesis that was impossible to estimate. Plants sown in early August, remained vegetative throughout winter and flowered the following spring.
Maximum visits of honey bees were observed between 10. 00 h and 17. 00 h. Most honey bees (>70%) collected nectar. Seasonal differences in the ratio nectar/pollen gatherers were noted. Two species of bumble bee (*B. terrestris* and *B. lucorum*) and 9 species of solitary bee visited *Phacelia.*

Introduction

Greece, with one million honey bee colonies, has the highest hive density (9. 9 hives/km^2) among the member states of the Union of European Community countries (Williams et al. 1991). In many parts of the country, the primary limiting factor in honey production is the lack of forage plants. This problem is especially acute because of intensive agriculture and mechanisation, the use of herbicides and the numerous catastrophic fires in recent years. Because of the reduction of nectar-producing vegetation, most beekeepers regularly move their colonies from one site to another. This migratory beekeeping increases the cost of honey production (Kitsopanidis et al. 1991), and makes it difficult for Greek honey producers to compete in price with the imported honey.

The scarcity of nectar plants demands either reduction in the number of colonies or enrichment of the food sources of bees. The first solution is not realistic in a country like Greece where beekeeping is a long established tradition. Thus, beekeepers with the help of their associations and the services of the Ministry of Agriculture, make efforts to increase food resources for bees. As an example, the beekeepers of the Corinthia Prefecture Association planted more than 200, 000 bee trees in a 4 years'period (Skourtis, 1989).

Another important method of improving the bees' food source is to use plants that secrete nectar intensely, so that in combination with the main crops they may ensure a continuous flow. *Phacelia tanacetifolia* (Tansy *phacelia*), is such a plant. In the past, it has been used in other countries to provide successive bee forage (Antsiferova, 1971, Kamenov, 1971, Petkov, 1973). It is classified among the world's 12 best bee plants

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(Crane, 1975), and its honey potential is among the highest, ranging between 100 and 1129 kg per hectare (Zimna, 1962, 1964, Baculinschi, 1964, Crane et al. 1984). Data concerning aspects of *Phacelia* as a food plant for bees from different countries give information about its usefulness under different climatic conditions (Zimna, 1964, Jablonski, 1960, Petkov, 1973, Orsi & Biondi, 1987, Williams and Christian, 1991). Although *Phacelia*, has been cultivated in Greece since 1949 (Tampoukou, 1992), there is little information about its value as a honey source under the Greek climate (Serelis, 1988, Makri et al., 1991, Thrasyvoulou et al. 1993). This paper reports the results of a three years' study in Greece on growth and flowering of *Phacelia* as well as its attractiveness to honey bees and other insect-visitors.

Materials and methods

Growth cycle

Four plots of *Phacelia* (3. 9 x 3. 9 m) were sown at a density of one gram/m² by hand-casting on a well prepared seedbed, in March, July and August of 1990 and 1992. In 1991, two plots (2 x 2 m) were sown in March, June and late July. After sowing the seed was covered lightly with soil, to prevent it from being blown away, and then the seedbed was levelled by trampling and watered. Thereafter, the plots were irrigated as necessary to encourage germination of seed and plant growth during dry periods.

Observations were made on the time of germination, the time of appearance of flower buds and the flowering period. The flowering period was considered as beginning when the first inflorescence opens and as ending when 90% of the inflorescences had finished. In addition, the flowering phenology and dynamics was estimated by counting daily the open and withered flowers of a number of single inflorescences.

Attractiveness to flower visitors

The attraction of Phacelia to bees was monitored by hourly counts of insect visits to a single inflorescence from 06. 00 h until 22. 00 h. For each year (viz. 1991, 1992 and 1993) three observations were made per month in June, August and October. Inflorescences that had equal numbers of open flowers (15-18) were used. Insect visitors other than honey bees were also caught and identified.

Twenty colonies of honey bees were situated approximately 150 m from the plots throughout the whole experimental period.

Results and discussion

There are differences in growth cycle of *Phacelia* between different years of sowing and between seasons of the same year (Table 1).

Plants that were sown in March flowered synchronously. Their period of flowering ranged from 24 to 40 days. Those sown in July flowered less uniformly; some plants flowered earlier or later than the majority prolonging in this way the blooming period. Due to these outliners the ending point was unclear and the estimation of the blooming period during summer was impossible.

The plants of the last sowing of 1990 were killed by frosts in February 1991. Last sowings of 1991, 1992 and 1993 remained vegetative throughout winter, resisted the low temperatures, even the snow and the frost for a few days, grew quickly when the temperature rose and eventually flowered next spring.

The flowering period of plants originating from the last sowing of 1991 was relatively long, i. e 77 days. This was mainly caused by the fact that some plants grew faster than others and flowered earlier, although in most plants the flowering was synchronous. To eliminate such differences in

TABLE 1. Days from sowing to germination and flowering of *Phacelia* plants sown on three different periods of the year.

Dates of sowing	Germination	Appearence of inflorescence	Beginning of flowering	End of flowering	Period of flowering
21/3/90	11	37	57	97	40
20/3/91	8	51	60	84	24
22/3/92	9	40	54	79	25
10/7/90	18	39	53	—*	—
15/6/91	16	30	34	—	—
8/7/92	14	36	40	—	—
10/8/90	21	—**	—	—	—
26/7/91	31	250	265	342	77
4/8/92	24	218	228	272	44***
10/8/93	25	238	255	337	82

* Not estimated because of irregular flowering.
** Destroyed by frost..
*** Fast—growing plants were eliminated.

TABLE 2. Flowering period of single inflorescences of *Phacelia tanacetifolia*.

Flowering period (days)	Number of plants		
	May	August	September
17	0	0	0
18	8	0	4
19	8	0	4
20	4	5	5
21	2	3	3
22	2	8	8
23	4	4	6
24	16	8	12
25	12	16	12
26	6	12	9
27	2	14	4
28	2	5	5
29	4	7	4
30	10	4	5
31	0	1	6
32	0	0	0
Total	80	87	87

blooming period, plants that grew more quickly than others, were uprooted in 1992, so that these early fast-growing plants could not influence the length of the flowering period. Flowering period, in this way was restricted to 44 days. The experiment was repeated in 1992-1993 without elimination of the fast-growing plants. Again the period of flowering was prolonged to 82 days.

The potential of *Phacelia* plants to overwinter was recorded by Antsiferova (1971) and Williams & Christian (1991). Jablonski (1960), in a three-year experiment, recorded slower growth in late sowings of *Phacelia* but not a delayed spring blooming. The severity of winter and other factors may affect the survival of *Phacelia* during the cold winter months. The delayed germination of late sowings can probably be explained by the influence of soil temperature and moisture.

Table 2 shows that the flowering period of single inflorescences lasted 18 to 31 days with most inflorescences ranging between 22 and 27 days. It seems that the blooming period was not affected by the day the plants were sown. Thus, differences in the duration of flowering reported by other authors (Zimna, 1964, Pellett 1976, Orsi and Biondi, 1987, Williams and Christian, 1991), can be attributed to differences in climatic conditions and to variation among individual plants.

Fig 1 shows the number of flowers/inflorescence (fls/ifl) and of withered flowers during the flowering period. Between the 10th and 21st day the number of open fls/ifl was relatively constant and ranged between 20-33. After the 21st day of flowering, the number of fls/ifl declined to 10-18. Assuming that the total number of fls/ifl is represented by the total number of withered flowers, then the total fls/ifl in May was 185.5±36.5 and in August 175±29.2. The differences were not significant.

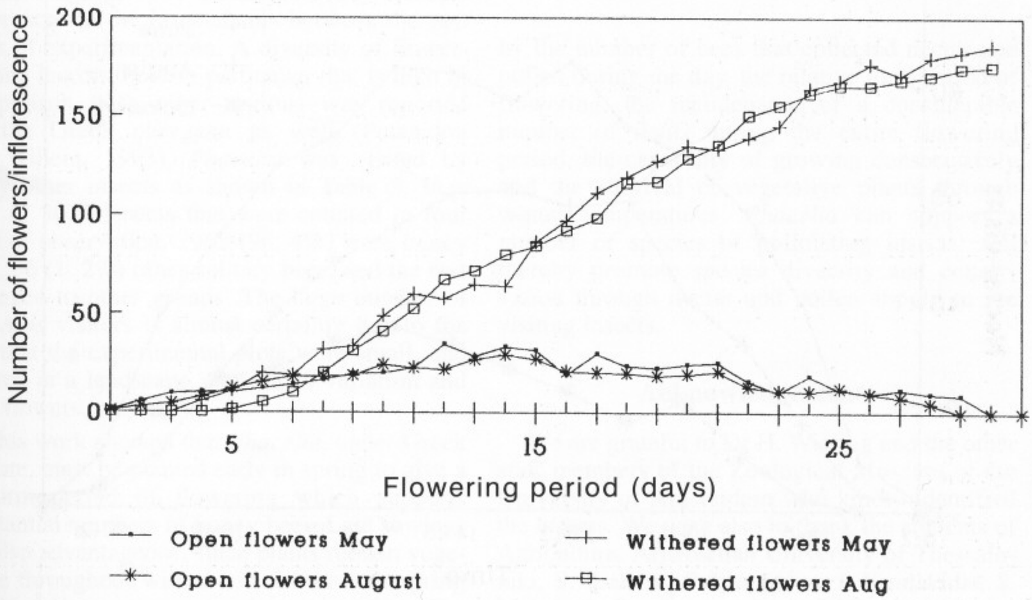
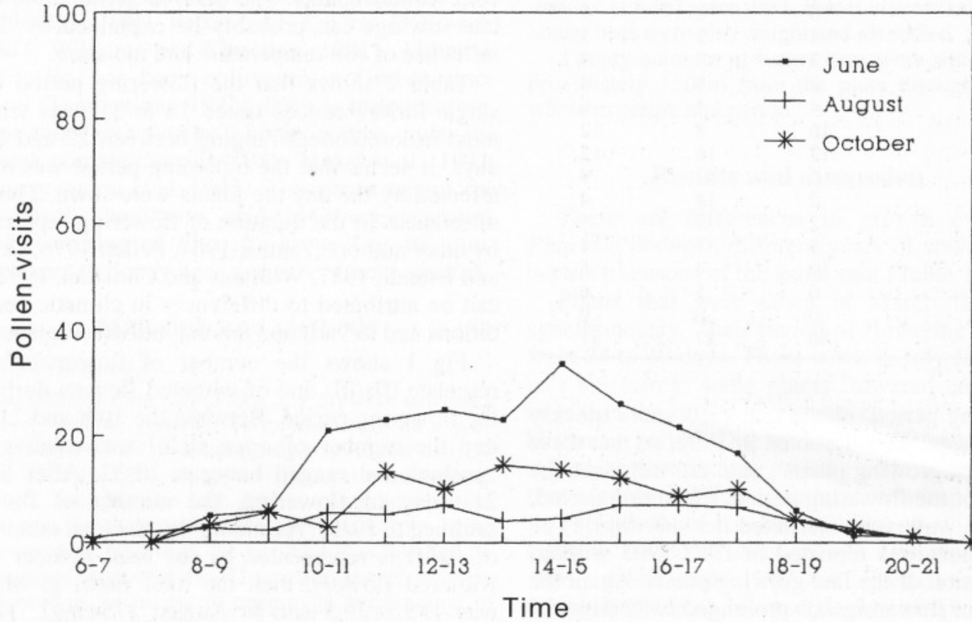


FIG 1. Number of flowers/inflorescence during the flowering period of *Phacelia tanacetifolia*.

Attractiveness to flower visitors

Honey bees started to forage on *Phacelia* between 06. 00 h and 08. 00 h and stopped around 20. 00 h - 21. 00, depending on the season (Fig. 2). Maximum visitation rate remained fairly constant between 10. 00 h and 17. 00 h. Of the total honey bee visits observed 79%, 89% and 73% were nectar-gatherers during the three months of mo-



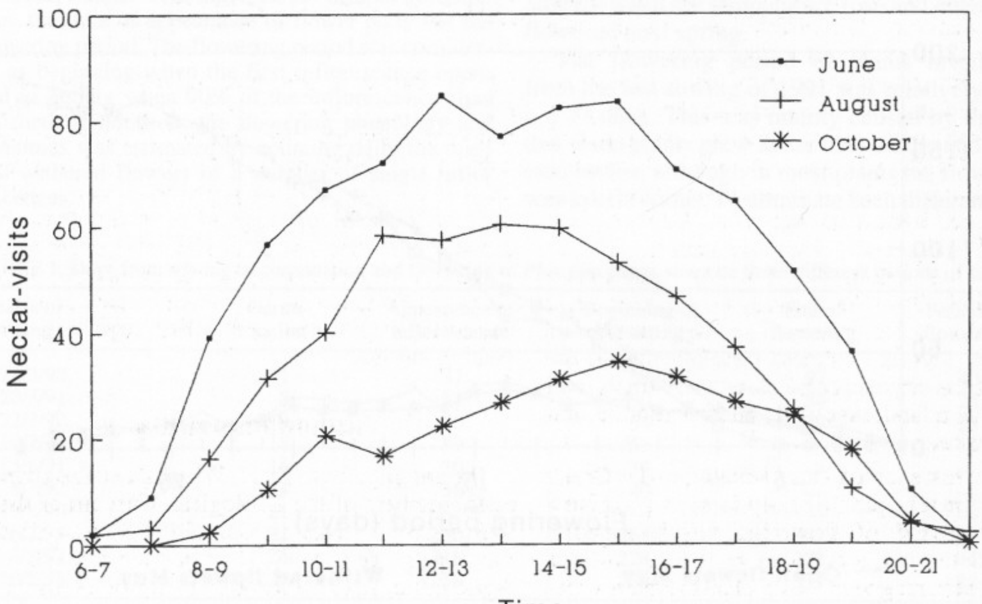


FIG. 2. Average number of honey bees visiting a single inflorescence of *Phacelia* (15-18 fls) in one day.

nitoring, respectively. The number of honey bees collecting pollen decreased during August and then increased during October, probably because other pollen sources had by then declined while pollen was still required to sustain late brood. During the late season few bees visited *Phacelia* both for nectar and pollen collection. This can be attributed to the fewer open flowers with less nectar production(Jablonski, 1960, Thrasyvoulou et al, 1993), to the variation in weather conditions, to alternative forage and to other reasons.

Two species of bumble bee were recorded, *Bombus terrestis* and *Bombus lucorum.* Only workers of these two species were seen on *Phacelia* during June. Presumably overwintering queens had established colonies and reared workers by the time that *Phacelia* started to flower in July. Queens of *B. lucorum* and *B. terrestis* appeared in the vicinity by the end of February, early March. The number of Bombus never exceeded 5/day in June and August. No visit was recorded in October, indicating that these two species have a mid-life cycle as in other countries (Alford, 1975, Williams and Christian, 1991).

Besides honey bees and bumble bees another 9 species of solitary bees belonging to the families Andrenidae, Anthophoridae and Halictidae visited *Phacelia* (Table 3). Williams and Christian (1991) observed only honey bees and bumble bees (8 species) on *Phacelia* flowers in south-eastern England. The differences may indicate differences in the insect fauna between the two areas of experimentation. A diversity of flower-visiting insects, bees in particular, that is high in comparison with other regions was reported for the Greek phrygana as well (Petanidou and Willem, 1993). *Phacelia* was visited by many other insects as shown in Table 3. In a total of 3072 insects that were counted in four days of observation, 2962 (96. 4%) were honey bees, 36 (1. 2%) other solitary bees, and the rest belonged to other groups. The large number of non-*Apis* visitors is almost certainly due to the fact that the experimental plots were small, and located in a landscape with much variation and wild flowers.

This work showed that *Phacelia*, under Greek climate, must be planted early in spring to give a uniform period of flowering which supports substantial numbers of honey bees. Late sowings are also advantageous, since plants remain vegetative throughout winter and flower next spring provided low temperatures do not interfere. The usefulness of *Phacelia* to honey bees is indicated by the number of bees that collected nectar and pollen during the day, the relative long period of flowering, the maintenance of a considerable number of fls/ifl during the entire flowering period, the capability of growing consecutively and the survival of vegetative plants through winter temperatures. *Phacelia* can support a number of species of pollinating insects, and thereby promote species diversity and conservation through nectar and pollen supply to the visiting insects.

TABLE 3. Insects that were caught on *Phacelia*

Apidae	*Bombus lucorum terrestriformis* Vogt
	Bombus terrestris Linnaeus
	Apis mellifera Linnaeus
Alleculidae	*Rodonta millleri* Kieswetter
Andrenidae	*Andrena flavipes* Panzer
Anthoporidae	*Eucera cf. dalmatica* Fabricius
	Eucera longicornis Linnaeus
	Tetralonia ruficollis Brulle
	Ceratina cucurbitina Rossi
	Eucera nitidiventris Mocsary
Chrysididae	*Stilbum calens zimmermanni* Linsenmayer
Cleridae	*Trichodes alvearius* (Fabricius)
Halictidae	*Nomioides minutissimus* Rossi
	Lasioglossum (Evylaeus)sp.
	Lasioglossum (L.) spec.
Lycaenidae	*Aricia agestis* (Denis & Schiffermuller)
Miridae	*Lygus pratensis* (Linnaeus)
Noctuidae	*Emmelia trabealis* (Scopoli)
	Tylia luctuosa (Denis & Schiffermuller)
Reduviidae	*Phinocoris iracundus* (Roda)
Scarabaeidae	*Cetonia aurata* (Linnaeus)
	Epicometis hirta (Roda)
	Oxythyra funesta (Roda)
Scoliidae	*Megascolia flavifrons haemorrhoidalis* Fabricius
	Scolia cf. fusciformis (Scopoli)
Sphecidae	*Philanthus triangulum* Fabricius
	Podalonia tydei senilis (Dahlbom)
Sphingidae	*Macroglossum stellaturum* Linnaeus
Syrphidae	*Sphaerophoria scripta* (linnaeus)
Vespidae	*Polistes dominulus* Christ

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References

Alford, D. V. 1975. Bumblebees. Ebenezer Baylis & Son Limited. The Trinity Press Worcester and London 352 pp.

Antsiferova, T. A. 1971. Efficient honey plants for beekeeping and for biologic protection of plants. Proc. XXIII Intern. Apiculture Congr. Moscow 27 August - 2 Sept. 1971: 543-548.

Baculinschi, H. 1964. Nectar production of the chief wild and cultivated plants in the steppe zone. Apic. Abst. 133/64.

Crane, E. 1975. Honey a Comprehensive Survey. Heinemann in co-operation with I.B.R.A., London UK, 384 pp.

Crane, E. , P. Walker and R. Day. 1984. Directory of Important World Honey Sources. I.B.R.A., 384 pp.

Jablonski, B. 1960. Effect of date and density of sowing on the value of *Phacelia tanacetifolia*. Apic. Abst. 341/64.

Kamenov, K. 1971. Successive nectar blossoms in conditions of intensive agriculture. Proc. XXIII Intern. Apiculture Congr. , Moscow 27 August-2 September, 1971: 552-553.

Kitsopanidis, G. E. , E. Papanagiotou and M. Martika. 1991. An economic analysis of the effect of moving and feeding of bee colonies in Greece. Aristotelian University Dept. Agric. Econ. Res. Bull., 38 pp (in Greek).

Makri, S. , S. Demberthemi, P. Koutsabelis and A. Thrasyvoulou. 1991 Exploration of capabilities of using *Phacelia* (*Phacelia tanacetifolia*) in Apiculture. Melissokomiki Epith. 5(5): 119-125 (in Greek).

Orsi, S. and A. Biondi. 1987. La *Phacelia tanacetifolia*: il potenziale mellifero. Informatore Agrario 47: 53-57.

Pellett, C. F. 1976. American Honey Plants. Dadant 467 pp.

Petanidou, T. , E. N. Willem. 1993. Pollinating fauna of a phryganic ecosystem: composition and diversity. Biodiversity Letters 1: 9-22.

Petkov, V. 1973. Possibility of providing for successive nectar flow in the plain and hilly regions in western Bulgaria. Proc. XXIV, Intern. Apiculture Congr., Buenos Aires, 14-20 Oct. 1973: 502-503.

Serelis, B. 1988. The bee plant Phacelia (*Phacelia tanacetifolia*). Melissokomiki Epith. 2(5): 142-143 (in Greek).

Skourtis, B. 1989. The activity of the Beekeeping Association of Corinthia. Melissokomiki Epith. 3(5): 123 (in Greek).

Tampoukou, A. 1992. *Phacelia,* a plant with a lot of abilities. Georgiki Technologia (7): 46-51 (in Greek).

Thrasyvoulou, A., S. Iliathou, P. Iliopoulou, I. Koulakidis, and K. Bladenopoulos. 1993. Observations on *Phacelia tanacetifolia* Bentham(Hydrophyllaceae) as food plant for honey bees in Greece. Melissokomiki Epith. 7(1): 6-10 (in Greek).

Williams, I. H. and D. G. Christian. 1991. Observations on *Phacelia tanacetifolia* Bentham (Hydrophyllaceae) as a food plant for honey bees and bumble bees. J. Apic. Res. 30(1): 3-12.

Williams, I. H. , S. A. Corbet and J. L. Osborne. 1991. Beekeeping, wild bees and pollination in the European Community. Bee World 72(4): 170-180.

Zimna, J. 1962. Comparative investigation of nectar secretion in four species of *Phacelia.* Apic. Abst. 274/62.

Zimna, J. 1964. *Phacelia tanacetifolia* as nectar plant. Apic. Abst. 848/64.

KEY WORDS: *Phacelia tanacetifolia,* date of sowing, flowering, bee forage, insect visitors

Παρατηρήσεις σχετικά με το φυτό *Phacelia tanacetifolia* ως τροφή των μελισσών και άλλων εντόμων

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ΠΕΡΙΛΗΨΗ

Η μεγάλη πυκνότητα των μελισσιών στην Ελλάδα (9.9 μελίσσια /km^2), και ο περιορισμός της φυσικής βλάστησης λόγω πυρκαγιών, εκτεταμένης χρήσης ζιζανιοκτόνων και άλλων συγχρόνων μεθόδων εντατικής εκμετάλευσης της γής επιβάλλουν την αναζήτηση νέων πηγών νέκταρος και γύρης για τις μέλισσες. Στην εργασία αυτή εξετάσθηκε ο βλαστικός κύκλος της Φακελωτής (*Phacelia tanacetifolia* Bentham) (Hydrophyllaceae) που σπάρθηκε τον Μάρτιο, Ιούλιο και Αύγουστο για τρείς συνεχείς χρονιές (1990-1992). Η διάρκεια ανθοφορίας εξετάσθηκε σε επίπεδο φυτοκοινωνίας και σε επίπεδο φυτού. Η χρησιμότητα της φακελωτής στην μελισσοκομία εκτιμήθηκε τόσο απο χαρακτηριστικά του βλαστικού κύκλου του φυτού όσο και απο την προσέλκυση των μελισσών. Fαίνεται ότι υπάρχουν διαφορές στην βλαστική περίοδο της φακελωτής τόσο ανάμεσα στα έτη σποράς όσο και ανάμεσα στις εποχές σποράς. Οι διαφορές παρατηρούνται σ'όλα τα στάδια ανάπτυξης του φυτού. Φακελωτή που σπέρνεται αρχές Ιουλίου παρουσιάζει ανομοιομορφία στην άνθηση. Μερικά φυτά ανθίζουν πιο νωρίς απο τα άλλα με αποτέλεσμα να είναι αδύνατη η εκτίμηση της περιόδου άνθησης. Φυτά που σπάρθηκαν τον Αύγουστο, δεν ανθίζουν την ίδια χρονιά αλλα παραμένουν πράσινα όλο τον χειμώνα, και την επόμενη Ανοιξη όταν ανέβουν οι θερμοκρασίες αναπτύσσονται περισσότερο και ανθίζουν.

Η μελέτη μεμονωμένων φυτών φακελωτής έδειξε οτι οι διαφορές που παρατηρήθηκαν στην διάρκεια ανθοφορίας επηρεαζόταν περισσότερο απο τις διαφορές άνθησης μεταξύ των φυτών στην φυτοκοινωνία παρά απο το χρόνο σποράς. Η φακελωτή διατηρεί στο μεγαλύτερο διάστημα της ανθοφορίας της σταθερό αριθμό ανθέων σε κάθε ανθοταξία. Δίνεται ο αριθμός των μελισσών *(Apis mellifera)* που συνέλεγαν νέκταρ και γύρη απο τις 6. 00 h μέχρι τις 22. 00 h τον Ιούνιο, Αύγουστο και Οκτώβριο. Οι νεκταροσυλλέκριες σ'όλη την περίοδο παρατήρησης ξεπερνούσαν το 70%. Δύο είδη βομβίνων (*Bombus terrestris, B. lucorum*), 9 είδη μοναχικών μελισσών, και 9 άλλα έντομα που ανήκαν σε διαφορετικές τάξεις συνελήφθηκαν στα άνθη της Φακελωτής και αναγνωρίσθηκαν.