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BEE FAUNA POTENTIAL VISITORS OF CORIANDER FLOWERS *CORIANDRUM SATIVUM* L. (APIACEAE) IN THE MITIDJA AREA (ALGERIA)

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Abstract

Coriander *Coriandrum sativum* L. (Apiaceae) is a year-round condiment and aromatic Mediterranean plant. It is cultivated in several countries in North Africa, in Europe, and Western Asia. In the El Harrach area of Algiers, the insect fauna visiting crop flowers includes Diptera (Syrphidae), Coleoptera, and Hymenoptera such as Chrysididae, Vespoidea, and Apoidea (Bees). The latter super-family comprises the majority of insect pollinators. Visiting bees belong to four families: Apidae, Andrenidae, Halictidae, and Colletidae. The main visitors are honeybees and six species of Andrenidae: *Andrena flavipes, Andrena thoracica, Andrena lagopus, Andrena bimaculata, Andrena discors,* and *Andrena cinerea elliptica. The three species Andrena lagopus, Andrena bimaculata,* and *Andrena cinerea elliptica* have 100% pollinating visits while *Apis mellifera* has only 63%. *Andrena cinerea elliptica* is the most frequent and the most abundant species.

Keywords: bees, *Coriandrum sativum,* insect visitors, Mitidja - Algeria.

INTRODUCTION

Coriander (*Coriandrum sativum;* Apiaceae) is one of the 20 000 species of plants in the world used for food, cosmetics, chemicals, and therapeutics (Hmamouchi, 1997). The origin of the cultivated species *Coriandrum sativum* is still not clear; it is probably Mediterranean (Skiredj et al., 2002). *Coriandrum sativum* is native to southern Europe, northern Africa, and southwestern Asia (Ivanova and Stoletova, 1990). It is grown in temperate zones. It is widely distributed and mainly cultivated for its aromatic seeds, leaves, and oil, which are used in the flavoring of food and in medicinals (Ilyas, 1980; Purseglove et al., 1981; Prakash, 1990; Mathias, 1994; Maroufi et al., 2010), in particular for its antioxidant activity (Wangensteen et al., 2004). The worldwide production of coriander may be estimated at approximately 550 000 ha annually. The yearly production of coriander fruits may be estimated at about 600 000 tons (Diederichsen, 1996). The main producers of coriander fruits are the Ukraine, Russia, India, Morocco, and Argentina.

Algeria is among the countries that produce coriander that is used in its fruit form (Diederichsen, 1996) as well as a fresh green herb or vegetable. Cultivated in the plains and sub-littoral regions, coriander is sought-after for its high nutritional value and has a very important place in the culinary arts of several regions such as the Mitidja, near Algiers. Thanks to its diverse uses, it has an important role in agricultural production and the national economy. The agronomic requirements of coriander cultivation are quite

specific, as documented by several authors in Russia (Luk'janov and Reznikov, 1976), in central Europe (Heeger, 1989), and in India (Singh and Gangwar, 1991). Coriander needs soil with high fertility and adequate moisture. Also, it needs high temperatures and sunny weather during the flowering period to deliver good fruits and its essential oil content (Diederichsen, 1996). Overall, however, it is more affected by light than by temperature (Sergeeva and Sil'zenko, 1984; Skiredj et al., 2002).

In our region (Algiers), the coriander is sown in autumn, blooms in spring between March and April, and matures in May. The flowering lasts 40 days and runs from bottom to top along the stem. A single plant produces an average of 80 inflorescences. Each inflorescence is a compound umbel, arranged as a set of umbellets grouped into a combination of central and peripheral flowers. The first umbels to bloom have hermaphrodite flowers, with possibly a few staminate ones. The later umbels have only staminate flowers. The hermaphrodite flowers are completely protandrous, so that self-fertilization is impossible; they need the intervention of pollen carriers on the receptive stigmas (McGregor, 1976; Ricciardelli D'Albore, 1986).

Coriander is a year-long herb with a cycle effected in 20 to 24 weeks. It is an excellent melliferous plant (Ricciardelli D'Albore and Intoppa, 2000). Indeed, several factors make it attractive to a wide variety of insect species. Some of the insects are pollinators; others are only casual visitors (Diederichsen, 1996). The main attractiveness features are: exposed nectar, abundant pollen production, zygomorphic flowers and compact umbels (Koul et al., 1989; Diederichsenn, 1996). The coriander plant is thus visited for both nectar and pollen (Free, 1993). Insects are attracted by the nectar that is secreted, especially during the period when the stigma is receptive to successful pollination (Koul et al., 1989).

According to McGregor (1976), Glukhov (1955) reported that when the bees were excluded, only 49.4% of the seeds were able to set, in contrast to 68.3% when the bees were present. In Sicily, Sinacori et al. (2009) reported on a study with three treatments: self-fertilization, pollination by bees, and open-pollination by the presence of all pollinators. They noted the seed production of *C. sativum* as 1 883 kg/ha with open-pollination; 1 335 kg/ha with only the bees; and 800 kg/ha in the absence of pollinators. These results substantiate the significance of the bee effect noted earlier by McGregor (1976) and observed later, in other studies. In particular, in India, Deodikar and Suryanarayana (1977) noted that bee pollination increased coriander production by 187%. Subsequently, Baswana (1984) reported that seed production by caged plants was only 56% of the output by open-pollinated plants. In Italy, Ricciardelli D'Albore and D'Ambrosio (1979) noted 15% and 33% of fruit production, respectively, from caged plants and free plants. Similar studies have been done in Egypt (El-Berry et al., 1974; Hussein and Abdel-Aal, 1982), in India (Koul et al., 1989), and in Europe (Heeger, 1989; Sinacori et al., 2009). In Jordan, Abu-Hammour (2008) showed that pollination not only produced well-shaped fruits but also increased the quality of the seed content.

According to the observations of several authors (Ricciardelli D'Albore and D'Ambrosio, 1979; Shelar and Suryanarayana, 1981; Baswana, 1984; Sinacori et al., 2009), the flowers of coriander attract many groups of insects, in particular the Diptera, the Coleoptera, and the Hymenoptera. The latter order dominates, represented mainly by the bees, which are among the potential pollinators of this crop. In India, pollinator bees are dominated by the species of *Apis* spp. In Egypt, the most cited species are *Apis mellifera* (honeybees) and diverse solitary bees. Among the latter, the most cited are *Andrena* spp., *Nomada* spp., *Nomioides* spp., *Hylaeus* spp., and *Ceratina* spp. (Hussein and Abdel-Aal, 1982). In Italy, the most cited species are *Hylaeus* spp., *Andrena* spp., and *Apis mellifera*, which are the main pollinators of coriander (Ricciardelli d'Albore and D'Ambrosio, 1979).

In Algeria, early studies focused on wild bees. But all the studies concerning the bee fauna as plant pollinators or visitors were carried out in natural ecosystems. By contrast, the insect pollination of cultivated crop plants has been rather

neglected thus far, save for recent studies of the broad bean *Vicia faba* L. in the Constantine region by Benachour et al. (2007), in the Tizi Ouzou region by Aouar-Sadli et al. (2008), and in the Algiers region by Bendifallah et al. (2011). In the context of our continuing contribution to the investigation of Algeria's natural as well as agronomical resources, our study of cultivated coriander pollinators is the first of its kind.

We tested three hypotheses to determine the floral visitors of *Coriandrum sativum*, and the main pollinators.

We tested the general prediction that bees would be the main pollinators of this crop as was demonstrated in India (Koul et al., 1989), in Italy (Ricciardelli D'Albore and D'Ambrosio, 1979), and in Egypt (Hussein and Abdel-Aal, 1982). So, a comparison of the number of individuals among visitor bees, allows us to know what bee species is the most dominant.

Also, we hypothesized that within bee populations, inflorescence attractiveness (parameters: number of open flowers) has an effect on the number of floral visitors for some species of bees, and the seasonal peak of activity of certain bees is correlated with the period when floral resources have a maximum flowering (Eickwort and Ginsberg, 1980). Thirdly, we hypothesized that time of day has an impact on the flower visitation rate. Finally, to gain a better understanding of which of the bee species are specialists and potentially the best pollinators of coriander, we estimated the frequency of floral visits and number of pollinating visits by the main bees.

MATERIAL AND METHODS

Characterization of the study area and experimental site

The study was conducted in spring, from March to June 2009, in the Algiers region (36.72 N; 3.13 E, altitude: 50 m) situated in the eastern part of the Algerian littoral. The average temperature during the study period was 13.8°C, the rainfall was 334.6 mm and the total duration of sunshine was 1366 hours (data from the meteorological station of Dar El Beida). The chosen site was located in an experimental station of the National School of Agronomy at El Harrach. The observations were made in a plot 40 m^2 large (10 m x 4 m). The main melliferous species growing at the edges of the plot were *Fumaria capreolata* L. (Fumariaceae), *Sinapis arvensis* L. (Brassicaceae), Sonchus asper (L.) Hill (Asteraceae), *Malva sylvestris* L. (Malvaceae), *Salpichroa origanifolia* (Lam.) Thell (Solanaceae), and *Papaver rhoeas* L. (Papaveraceae). A local variety of *Coriandrum sativum* was used in our experiment. The seedlings were planted on 20 October 2008 at the rate of 38 plants per square-meter. The planted area was then monitored from the first leaf stage to the fruit formation stage. For our monitoring of the flowering stage, we considered that, as suggested by Delbrassine and Rasmont (1988), the beginning of flowering is reached when half of the plants have begun to bloom, whereas the end of flowering is the time when half of the plants have no flowers.

Inventory and density of the pollinating entomofauna and the casual visitors

Observations on insect visitors were made by counting and collecting insects from umbels throughout the day. The counting method applied was the "quadrate" method (Banaszak, 1980; Sonnet and Jacob-Remacle, 1987; Abrol, 1988). This method also allows for the study of the floral density. In order to study these two criteria, 7 quadrates, 1 m^2 each, have been delineated, using wire and piles. The quadrates are well exposed to the sun, and the distance separating them from each other is 2 m. Seven quadrates were chosen for replication. Our observations were made 8 times a day and three days per week during the whole flowering period. Every hour, from 8 am to 4 pm, a designated observer slowly went around each of the plots for at least 5 minutes.

The visiting insects were identified with the help of Prof. S. Doumandji, Dr. S. Patiny, Dr. A. Pauly, and Dr. M. Kuhlmann. Diptera, Coleoptera, and Hemiptera species were mainly identified by Prof. Doumandji; the Hymenoptera species, Apoidea, were identified by Dr. Patiny for *Andrena*, Dr. Pauly mainly identified *Halictus* and *Lasioglossum* genera, and Dr. Kuhlmann

- *Hylaeus* genera. Those insects which could not be identified were each given a number for reference. In addition, in order to show if there is a correlation between floral display (number of available flowers per m^2) and density of pollinators (number of pollinators per m^2), simultaneous counting of pollinators and flowers was done in the mid-afternoon. This is the time that corresponds to the optimal opening of the flowers. Such counting allowed us to reliably estimate the mean number of "opened" flowers likely to be visited by insects. In considering this argument, we relied on the most common method currently used to compare pollinator densities in crops (Pierre et al., 1997; 1999). This method entails focusing on the number of insects counted on a defined number of clusters of 100 flowers each.

Statistical analyses

To test for differences between the number of visits of each visitor taxa in respect to the time of the day, a One-Way-ANOVA was carried out. The levels of significance are as follows: $p<0.05$*; $p<0.01$**; $p<0.001$***. The analyses were performed using PAST, vers. 1.9 (Hammert et al., 2001).

RESULTS

Flower density

By the completion of the study the plants had produced 63 ± 46.5 flowers (umbels) per square meter. In 2009, the flowering period was 40 days.

Diversity of insect visitors

According to our observations, the insects which foraged on coriander flowers were Dipterans Syrphidae (e.g. *Eristalis tenax* L.), Coleopterans Oedemeridae (e.g. *Oedemera* spp.), Hemipterans Pentatomidae (e.g. *Graphosoma lineatum* L.), and Hymenopterans Chrysididae, Vespidae, Apidae, and Halictidae (e.g. *Chrysis* spp., *Vespa germanica* L., *Apis mellifera* L., *Sphecodes albilabris* F.). The main species of insects visiting and pollinating the coriander flowers were hymenopterans Apoidea. This superfamily is composed of 4 families: Andrenidae, Apidae, Colletidae, and Halictidae. As many as 27 bee species were inventoried, most notably the honeybee *Apis mellifera* L., and wild bee species such as *Andrena flavipes* Panzer, *Hylaeus* spp., and *Sphecodes albilabris* F. (Tab. 1).

Table 1.

Pollinating entomofauna of *Coriandrum sativum* L. during flowering (2009) in the Mitidja area (Algiers region)

Families	Species
Superfamily Apoidea: bees or Apiformes; Families: Andrenidae	*Andrena flavipes* Panz. *Andrena thoracica* Fab. *Andrena lagopus* Latr. *Andrena bimaculata* K. *Andrena discors* Eric. *Andrena cinerea elliptica* Pér.
Apidae	*Apis mellifera* L. *Eucera* spp. *Xylocopa pubescens* Spin. (female) *Nomada* spp.
Halictidae	*Lasioglossum* (*Lasioglossum*) *callizonium* Pér. *Halictus* spp. *Sphecodes albilabris* Fab.
Colletidae	*Colletes* spp. *Hylaeus* spp.

Coriandrum sativum flowering and Apoidea visitors

Flowers were first observed at the base of the stems, then the development continued progressively up along the stems during the following weeks. The first umbels appeared on 16 March. The beginning of flowering was achieved in the last week of March. The period of full bloom lasted from 3 April to 24 April, when more than 50% of the plants were in bloom. The mean number of flowers per stem then decreased progressively. The end of flowering was recorded on 3 May (Fig. 1). The potential pollinators of coriander were Apoidea. The main species of bees attending coriander flowers were *Apis mellifera* L., *Andrena flavipes* Panzer, *Andrena thoracica* F., *Andrena lagopus* Latreille, *Andrena bimaculata* Kirby, *Andrena discors* Erichson, and *Andrena cinerea elliptica* Pérez (Tab. 2).

During the observation, we recorded a total of 1914 flower visits by bees to the flowers of *C. sativum.* The bee visits on coriander flowers were more numerous during the period of intense flowering. The first individuals appeared on 31 March for most species (Tab. 3).

Influence of plant inflorescence attractiveness on visitor abundance

We observed that as the number of flowers increased, so did pollinator density. The peak of affluence was reached on 18 April, after which day the density of bees regressed dramatically. This then marked the beginning of the end of coriander flowering in our experiment (Tab. 3).

Table 2.

Main density of pollinators per 100 flowers (umbels) of *Coriandrum sativum* and per square-meter during the flowering period (2009) in the Mitidja area (Algiers region)

Families	Taxa	Mean density per 100 flowers	Mean density per m^2
Apidae	*Apis mellifera* L.	10	6.4
Andrenidae	*Andrena flavipes* Panz.	3	1.6
	Andrena thoracica Fab.	<1	0.2
	Andrena lagopus Latr.	5	3.2
	Andrena bimaculata K.	9	5.4
	Andrena discors Eric.	10	6.1
	Andrena cinerea elliptica Pér.	12	7.75

Table 3.

Mean number of visits (± SD) of each visitor species during the flowering period (different time intervals of 3 days) (Number of observations per time period : 8 times a day)

Taxa \ Dates	28/03	31/03	03/04	06/04	09/04	12/04	15/04	18/04	21/04	03/05
Andrena flavipes Panz.	0	1±1.60	1.37 ± 1.68	2.25 ± 1.83	0.75 ± 1.16	2.87 ± 2.80	4.5 ± 3.74	3.37 ± 2.44	0	0
Andrena thoracica Fab.	0	0	0.125 ± 0.35	0.125 ± 0.35	0.25 ± 0.46	0.25 ± 0.46	1 ± 1.60	0	0	0
Andrena lagopus Latr.	0	0	0	0.5 ± 1.07	2 ± 2.20	3.5 ± 2.72	7.25 ± 8.77	6.75 ± 8.10	3.75 ± 6.06	1.25 ± 1.83
Andrena bimaculata K.	0	1.5 ± 2.14	1.37± 1.99	1 ± 2.45	1.25 ± 1.91	7.12 ± 6.40	10.12± 8.92	11.25± 8.24	5.87 ± 7.70	1.37 ± 1.51
Andrena discors Eric.	0.5 ± 1.07	1.63 ± 2.06	2.12 ± 1.96	2.25 ± 1.83	3 ± 2.97	6.37 ± 6.28	9 ± 10.45	12.87 ± 12.03	10.75± 9.09	0.25 ± 0.71
Andrena cinerea elliptica Pér.	0	2.5 ± 4.47	1.87 ± 2.69	2.62 ± 2.67	4.37 ± 5.09	9.87 ± 9.45	12.25± 11.10	16.37± 10.25	11.75± 12.68	2.87 ± 3.64
Apis mellifera L.	0	0.5 ± 0.75	1.37 ± 2.06	1.87 ± 2.29	3.25 ± 3.37	7.25 ± 5.47	9.12 ± 7.45	14.37± 9.53	3.87 ± 3.27	0.62 ± 1.06

Table 4.

Mean number of visits (± SD) of each visitor group during the course of day (different time intervals of 2 hours) ns = not significant

Visitor Taxa \ Temps (hrs)	7 – 9	9 – 11	11 – 13	13 – 15	15 – 17
Andrena flavipes Panz.	0.08 ± 0.05	0.22 ± 0.09	0.08 ± 0.29	--	--
Andrena thoracica Fab.	0.03 ± 0.2	0.15 ± 0.61	----	--	--
Andrena lagopus Latr.	0.14 ± 0.14	0.43 ± 0.21	0.24 ± 0.20	0.09 ± 0.11	--
Andrena bimaculata K.	0.19 ± 0.05	0.50 ± 0.15	0.33 ± 0.18	0.18 ± 0.14	--
Andrena discors Eric.	0.21 ± 0.26	0.71 ± 0.43	0.60 ± 0.22	0.30 ± 0.17	0.05 ± 0.11
Andrena cinerea elliptica Pér.	0.26 ± 0.61	0.81 ± 0.73	0.72 ± 0.50	0.55 ± 0.35	0.11 ± 0.28
Apis mellifera L.	0.31 ± 0.50	0.62 ± 0.58	0.56 ± 0.33	0.32 ± 0.20	0.14 ± 0.16
F*	1.97	10.74	8.86	5.1	1.61
p*	0.17 ns	< 0.001	< 0.001	< 0.05	0.29 ns

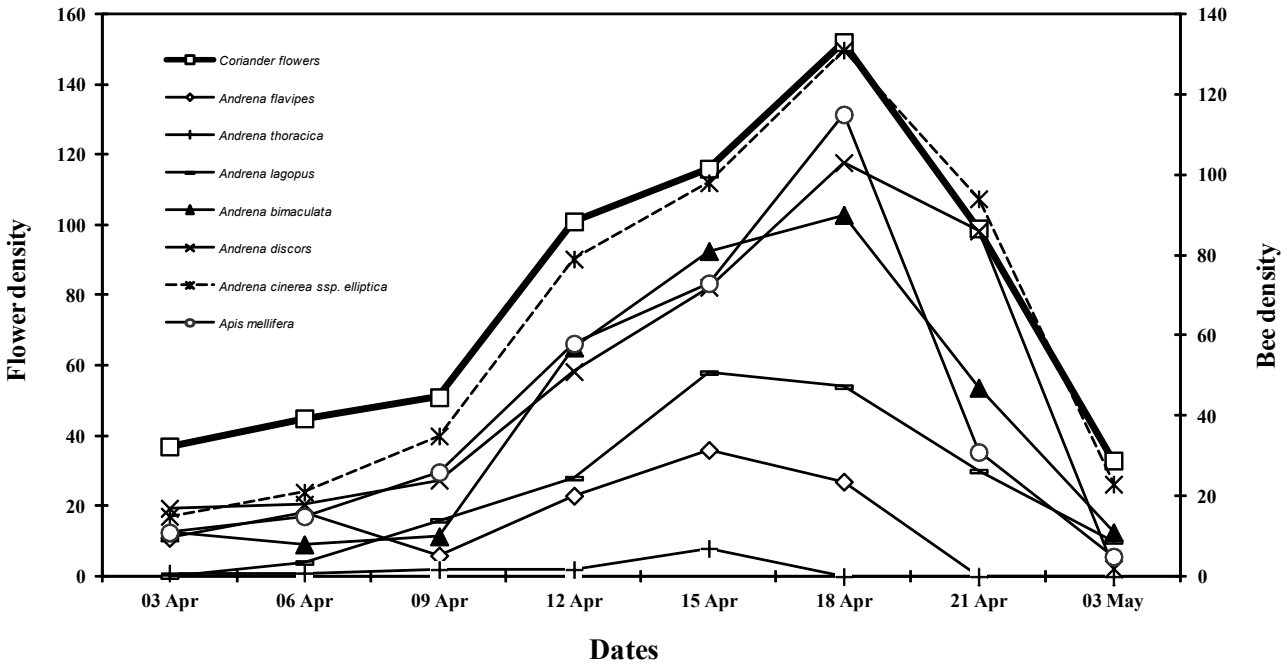

Fig. 1. Influence of coriander plant inflorescence attractiveness on visitor abundance during the flowering period (2009).

The mean number of flowers displayed per plot or quadrate was 84.75 (SD: 52.13). Inflorescence attractiveness (parameters: number of open flowers) had an effect on the number of floral visitors for *Andrena bimaculata, Andrena discors, Andrena cinerea elliptica,* and *Apis mellifera* (Tab. 3, Fig. 1), but not for *Andrena flavipes, Andrena thoracica,* and *Andrena lagopus.* Visits by *Andrena cinerea elliptica* significantly increased with more open flowers ($P<0.01$, $R^2 = 0.74$).

Influence of time of day on number and frequency of visits

No differences in the number of visits of all visitor groups could be found for the time intervals 7:00 am to 9:00 am, and 3:00 pm to 5:00 pm (Tab. 4).

Frequency of floral visits and number of pollinating visits by the main bees

Andrena cinerea elliptica was definitely the most abundant species on the coriander flowers, as it alone accounted for 27% of the observed specimens and almost a third of all visits. The honeybee contributed of Apoidea visitors with a smaller proportion of visits (17%). Unlike the *Andrena* species mentioned above (i.e., *Andrena bimaculata, A. discors, A. cinerea elliptica*), *Andrena flavipes* and *Andrena thoracica* were observed on wild plants growing near the coriander plot. These two species are polylectic. *A. thoracica* was just a casual visitor and had only a tiny proportion (0.7%) of the floral visits observed on *Coriandrum sativum*. As shown in Table 5, it could be that, aside from the polylectic *Andrena* species, the *Andrena* species are probably specialists, and potentially the best pollinators of coriander.

DISCUSSION

The study of *Coriandrum sativum* L., during flowering in 2009, in the Mitidja area (Algiers region), revealed that this vegetable attracts pollinators and casual visiting insects like most Apiaceae (Bohart and Nye, 1960; Bell, 1971; Grace and Nelson, 1981; Schlessman, 1982; Lindsey, 1984; Koul et al., 1986; Riccardelli D'Albore, 1986; Zych, 2007). The entomofauna visiting the coriander flowers was composed of Dipterans (Syrphidae), Coleopterans, and Hymenopterans, such as the Chrysididae, the Vespidae (Wasps), and the Apoidea (bees). This latter super-family accounted for most of the visiting entomofauna. The pollinator

Table 5.

Number of observed visitors, frequency of floral visits, and number of pollinating visits by the main bees on *Coriandrum sativum* flowers during the flowering period in 2009 (only one visit per individual)

Taxa	Number of observed specimens	Frequencies (%)	Number of pollinating visits	Proportion (%) of pollinating visits
Andrena flavipes	129	7	129	7.2
Andrena thoracica	14	0.7	9	0.5
Andrena lagopus	200	10.4	200	11.2
Andrena bimaculata	327	17.1	327	18.3
Andrena discors	390	20.4	390	22
Andrena cinerea elliptica	516	27	516	29
Apis mellifera	338	17.6	212	11.9

bees belonged to four main families: Apidae, Andrenidae, Halictidae, and Colletidae. Comparatively, in Sicily (Italy), Sinacori et al. (2009) noted three families of coriander pollinators represented by: Diptera (Syrphidae, Muscidae, and Calliphoridae), Hymenoptera such as Apoidea (Megachilidae and small bees of indeterminate species), and Coleoptera. Singh et al. (2010) reported five families: Hymenopterans with *Apis dorsata* and *A. florea,* Dipterans (Muscidae, Syrphidae), Lepidopterans, Hemipterans, and Coleopterans. In Haryana (India), Chaudhary and Singh (2007) noted that coriander flowers were visited by 34 species of insects belonging to 18 families and 8 orders. Apoidea (35.9%), Diptera (47.8%), and other Hymenoptera (13.2%) were the three major groups comprising 96.9% of the total visitors. However, Abu-Hammour (2008) found that honeybees are the only pollinators of coriander flowers.

This study has also shown that the Andrenidae species: *Andrena flavipes, Andrena thoracica, Andrena lagopus, Andrena bimaculata, Andrena discors, Andrena cinerea elliptica,* and the Apidae *Apis mellifera* dominate per the number of visits on coriander flowers. As to pollination success, *Apis mellifera* succeeded only in 63% of the visits, while *Andrena lagopus, Andrena bimaculata,* and *Andrena cinerea elliptica* ended up with all their visits as pollinating visits (a pollination success rate of 100%). Indeed, *Andrena cinerea elliptica* was the most abundant species, and most likely a potential pollinator, as it contributed to almost a third of the total number of pollinating visits (29%), followed only by *Andrena discors* (22%), and *Andrena bimaculata* (18.3%). As to pollinator density, it is clear that peaks presented by the density of bees and the coriander floral display coincided in time. This result confirmed Eickwort and Ginsberg (1980) findings. They pointed out that the seasonal peak of activity of certain bees is correlated with the period when floral resources have a maximum flowering. Also, we observed that four species of indeterminate *Andrena,* after having been quite successful at their pollinating task, simply disappeared during the fruiting period of our culture, giving way to small beetles. By contrast, this phenomenon was not observed in *Apis mellifera, Andrena flavipes* or *Andrena thoracica*, which were subsequently found on flowers of wild plants.

Among other families worth discussing is the Syrphidae family (Diptera). The contribution of hoverfly pollination of coriander is probably poor. In Egypt, however, El-Berry et al. (1974) noted that Dipteran Syrphydae (*Syrphus corollae*) represented 79% of the coriander visitors, while among bee species, *Andrena ovatula* was the predominant visitor. According to Waser and Ollerton (2006), the Syrphids lay half as much pollen grains per unit time as bumblebees. The low capacity of the Syrphids for transporting pollen, is due to the paucity of their hair and the simple morphology of their bristles. Bumblebees, on the other hand, are among the most heavily bearded Apoidea.

On a more general level of comparison, Thapa (2006) pointed out that over 80% of pollination activities are done by insects and that bees contributed nearly 80% of entomophilous pollination; making them the best pollinators. However, Hussein and Abdel-Aal (1982) found that in Egypt, honeybees represented 68% of bee visits, the remaining visits were due to the presence of solitary species such as *Andrena, Nomada, Nomioides, Hylaeus, and Ceratina*. In Italy, however, Ricciardelli D'Albore and D'Ambrosio (1979) found that among visiting bees, *Apis mellifera* represented only 36% while *Hylaeus* spp. represented 46%, leaving the remaining 18% for *Andrena* spp. In India, on the other hand, the best pollinators belonged to another group of species including *Apis cerana, A. dorsata, A. florae,* and *Trigona iridipennis* (Deodikar and Suryanarayana, 1977; Shelar and Suryanarayana, 1981; Baswana, 1984). Insect flower-visitors commonly change from site-to-site and from year-to-year (Tepedino et al., 2011).

CONCLUSIONS

This study established that a diversity of species was effective for pollinating coriander. The *Andrena* species *Andrena cinerea elliptica, Andrena discors, Andrena bimaculata,* and honey bees were the primary visitors on the crop.

Coriandrum sativum is very attractive for wild pollinator bees, even in the presence of a rich alternative flora. Indeed, short-tongued bees, such as *Andrena,* may be better adapted to the shallow flowers of Apiaceae than long-tongued bees such as honeybees. Thus, it is important to maintain wild bee populations at sufficiently high levels by protecting their habitats. As to the honeybee, since it is a polylectic insect, its exploitation as pollinator is possible only when competitive flora are absent. Ultimately, however, the role of pollinator bees should be verified on larger areas. It seems probable, that in sufficiently large experimental areas, the visitation intensity would suffer a considerable decrease because of the resulting dispersion of pollinators. Also, it would be interesting to generalize the study of pollinators to other species of Apiaceae.

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