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Potential Bee Pollinators of Sweet Cherry in Inclement Weather Conditions

Yasemin GÜLER[1] Fatih DİKMEN[2]

[1]Plant Protection Central Research Institute, Gayret Mah., Fatih Sultan Mehmet Bulvarı, No: 66, 06172 Yenimahalle, Ankara, TURKEY, e-mail: yaseminguler@gmail.com
[2]Hacettepe University, Faculty of Science, Department of Biology, 06800, Beytepe, Ankara, TURKEY, e-mail: dikmen@hacettepe.edu.tr

ABSTRACT

Many varieties of sweet cherry are self-incompatible and the honey bee is the main pollinator used in the orchards. However, honey bee is not active in the weather temperature below 12°C or in rainy weather conditions. This study was initiated to determine the pollinator bee species of three sweet cherry orchards in Sultandağı reservoir (Turkey) during 2008 and 2009. Active bee species in the unfavourable weather conditions were also investigated. Malaise traps were used to collect a total of 1476 bee specimens. A total of sixty-three species belonging to Andrenidae (five species), Anthophoridae (seven species), Apidae (only one species), Halictidae (fourty-six species) and Megachilidae (four species) families were identified. It was observed that thirty-seven species were active in full bloom period of sweet cherry and thirteen of them could maintain their activities in the air temperatures below 12°C, in general. Additionally, five bee species were also active in the rainy days.

Key words: Apoidea, bees, pollinators, sweet cherry orchard, inclement weather, Turkey.

INTRODUCTION

Sweet cherry [*Prunus avium* (L.) Moench] is one of the early flowering species among temperate climate fruit species. There are approximately 1500 sweet cherry varieties throughout the world and all of them except a few ones (such as the Stella) are self-unfruitful (Burak, 2003). Therefore, cross-pollination among the compatible varieties leads to high fruit-set (Delaplane, 2000; Bosch and Kemp, 2000). The pollen transfer between different varieties in sweet cherry orchards is realized by bees (Bosch *et al*., 2000). In practice, the honey bee is the main and more economic pollinator compared to the commercially- managed others used in sweet cherry orchards, because it is cheaper for farmers to provide honey bee colonies and they have much more workers in the colony comparing to the other pollinator bees (Delaplane, 2000). Since cherry has very early blooming period, rainy weather conditions and lower temperatures limit the pollination activity of honey bee (Roversi and Ughini, 1996; Huang, 2003). The activity of honey bee is limited to 150 m away from the hives at below 12°C temperature and during rainy weather (Goodman, 1994). Additionally, other bee species may display better activity under the same conditions. For instance, *Osmia cornuta* (Latreille, 1805) (Hym.: Megachilidae) can maintain its activity during the temperatures below 10 - 12°C, light rain and 200 W/m^2 wind power (Vicens and Bosch, 2000).

Turkey is one of the main sweet cherry producers in the world with the production amount of 417.905 tons per year (Anonymous, 2010). Sultandağı reservoir where the study was carried out represents 6.3% of the cherry production in Turkey (Çakaryıldırım, 2003). This region is located between the Akşehir Lake and the Sultandağı Mountain at the inner west of Anatolia. The climate of the area has transition feature between terrestrial climate and Mediterranean climate (Taş, 2009). Oskay and Kalyoncu (2006) state that annual average temperature and rainfall for the region are 14- 26°C and 450-1300 mm, respectively. The average temperature and rainfall of Sultandağı reservoir during the approximately three months between bud swell and green fruit stages were recorded as 9.2°C and 65.4 mm from 2001 to 2009 and the average number of rainy days is 19.8 (unpublished data). These climatic conditions can sometimes lead up to insufficient fertilization among sweet cherry flowers.

Due to these reasons other potential pollinators have to be investigated. The aims of the study are to identify the bee species in cherry orchards in Sultandağı reservoir (Turkey) and to determine potential alternative pollinators which can be active under negative weather conditions.

MATERIALS AND METHODS

Study was conducted in the three sweet cherry orchards in Sultandağı (Afyonkarahisar) (two orchards, 38°35'03.69''N- 31°16'46.70''E and 38°29'54.57''N- 31°17'14.04''E) and Akşehir (Konya) (one orchard, 38°23'22.44''N- 31°23'31.49''E), towns located at the inner west of Anatolian. There were a total number of 1675 trees in the three orchards. 1255 of them were composed of 0900 Ziraat cherry variety which was produced to be exported. The rest of them were varieties as Bing, Gılli and Stella which were used as pollenizers. The ground and surrounding of the orchards were usually covered with wild weed species belonging to Brassicaceae family as *Capsella bursa-pastoris* (L.) Medik., *Thlaspi perfoliatum* L. and *Barbarea vulgaris* R.Br. Besides, *Taraxacum turcicum* van Soest (Asteraceae), *Muscari neglectum* Guss (Liliaceae) *Lamium purpureum* L. (Lamiaceae) and *Veronica hederifolia* L. (Scrophulariaceae) were also extensively run across. Integrated Pest Management Program (IPM) was applied in all of orchards.

The samples were collected by totally five Malaise traps in years 2008 and 2009. The Malaise trap model used was Townes style with 1.70m high in front and 0.90m high in back, and 1.15m wide by 1.80m long (Townes 1972). In literature could not found a standardised method about the number of Malaise trap used in the similar studies. Therefore, one trap per 325 sweet cherry trees, which was the number of minimum trees in the orchards, was decided to use. The traps were placed the centre of the each 325 tree group in order to not more affected from surrounding vegetation at the out of orchards. Thus, three traps were set in the first cheery orchard, one of each trap in second and third orchards in the bud swell period and lifted in the green fruit period. The samples collected in the killing bottle were killed via either ethyl acetate or ethyl alcohol. Malaise traps were controlled everyday in blooming period and every fortnight in the bud swell period and the green fruit period. All captured bee specimens were properly prepared for collections. Daily data on temperature, relative humidity and rain frequency were obtained from meteorology stations established in Sultandağı and Akşehir.

At the end of two-year study, a total of 1476 samples belonging to Apoidea (Hymenoptera) superfamily were analysed. Species identification were based on Ebmer (1969), Pesenko (1978, 1984, 1985, 1986), Pesenko *et al*. (2000), Amiet *et al*. (2001) and by comparing the specimens with the bee collections of Natural History Museum of Vienna, Austria (NHMW), Oberösterreichisches Landesmuseum-Biologiezentrum of Linz, Austria (OLML) and Polish Institute of Zoology (ZIN) for Halictidae; Scheuchl (2000) and Terzo *et al*. (2007) for Anthophoridae; Osychnyuk *et al*. (1978), Banaszak and Romasenko (1998), Michener (2000), Amiet *et al*. (2004) and Scheuchl (2006) for Megachilidae. Determinations of *Andrena* spp. (Hym.: Andrenidae) were carried out by Dr. Tomozei (Museum of Natural Sciences “Ion Borcea” Bacău, Romania). Identifications of the Eucerini tribe (Hym.: Anthophoridae) were carried out by Mr. Risch (Leverkusen, Germany). The honey bee, *Apis mellifera* Linne, 1758, was not included to the study. All of the collected specimens were deposited in the Plant Protection Museum of the Plant Protection Central Research Institute, Ankara (Turkey).

RESULTS

The mean temperature, relative humidity and rain rates of Sultandağı and Akşehir during the field studies are given below (Fig. 1, 2, 3 and 4). The dates of full bloom in 2008 were from 15 to 22 April. 18 April was the only rainy day for Sultandağı and three days (namely, 17, 18 and 19 April) were below 12°C for both towns. Full blooming stage in 2009 took place from 20 to 30 April. This stage except for first three days (20 and 22 April) was colder and rainier than 2008.

Sixty-three bee species belonging to Andrenidae (five species), Anthophoridae (seven), Apidae (one), Halictidae (forty-six) and Megachilidae (four) were identified (Table 1). We found that thirty-seven species (Table 1) were active during the blooming period of cherry trees (15-22.IV.2008 and 20- 30.IV.2009). Thirteen of them [*Andrena dorsata* (Kirby, 1802), *A. flavipes* Panzer, 1799, *Cubitalia parvicornis* (Mocsary, 1878), *Eucera curvitarsis* Mocsary, 1879, *E. flavicornis* Risch, 2003, *E. parnassia* Perez, 1902, *Evylaeus linearis* (Schenck, 1868), *Ev. malachurus* (Kirby, 1802), *Ev. morio* (Fabricius, 1793), *Ev. obscuratus* (Morawitz, 1876), *Halictus resurgens* Nurse, 1903, *Lasioglossum leucozonium* (Schrank, 1781) and *Osmia bicornis* (Linnaeus, 1798)] were observed actively foraging at temperatures below 12°C (UF, Table 1) and only *A. dorsata*, *A. flavipes*, *Ev. linearis*, *Ev. malachurus* and *L. leucozonium* were active during both rainy and colder weather; their pollination efficiency, however, could not be observed, so we define them as potential pollinators of sweet cherry. On the other hand, the species of *C*. *parvicornis*, *E*. *curvitarsis* and *E*. *flavicornis* were just represented by male individuals during this period, and they were not regarded as potential pollinators of sweet cherry.

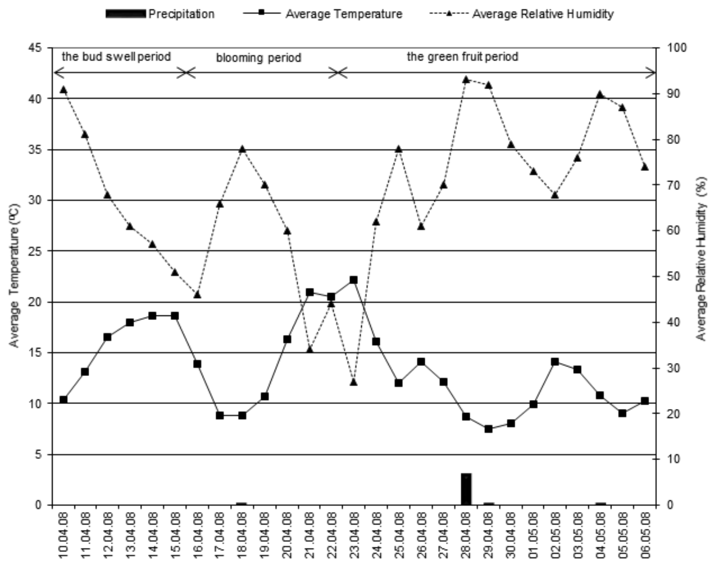

Fig. 1. Seasonal data on Sultandağı (Afyonkarahisar) from 10 April to 06 May 2008.

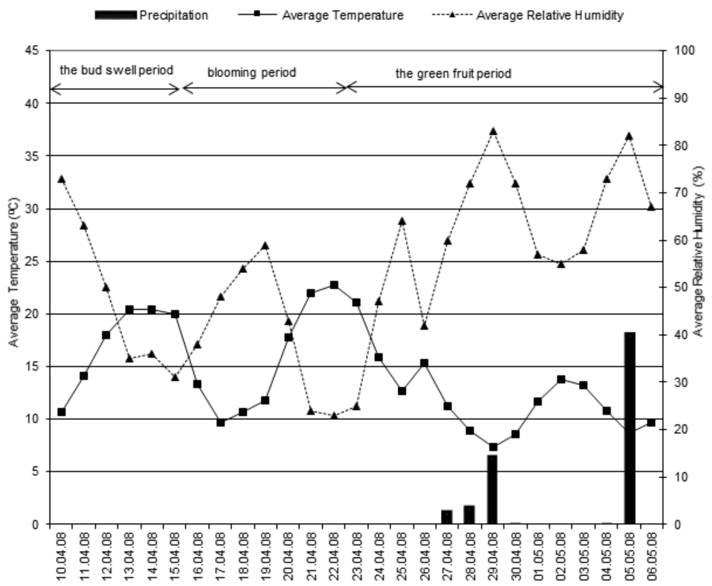

Fig. 2. Seasonal data on Akşehir (Konya) from 10 April to 06 May 2008.

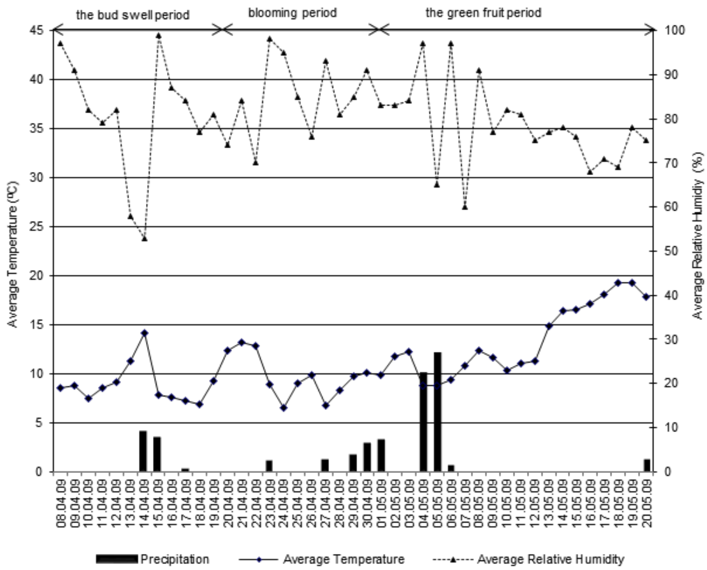

Fig. 3. Seasonal data on Sultandağı (Afyonkarahisar) from 08 April to 20 May 2009.

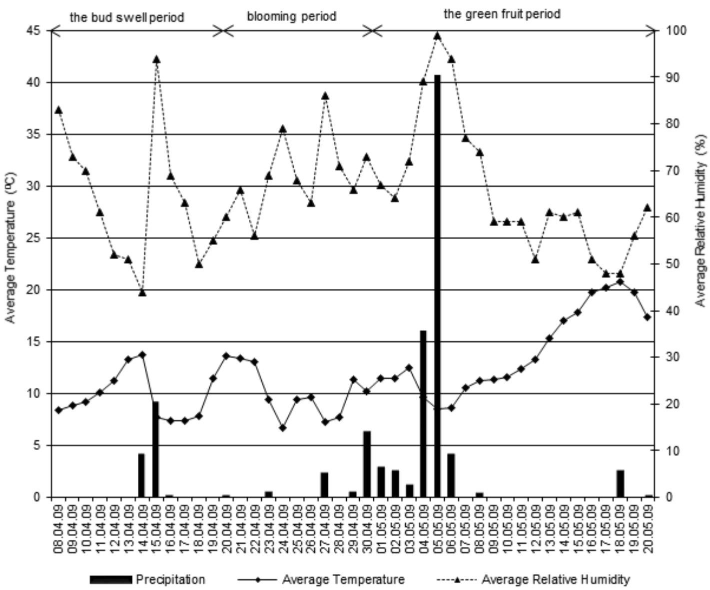

Fig. 4. Seasonal data on Akşehir (Konya) from 08 April to 20 May 2009.

Table 1. The list of the collected species. BS= Bud swell period, BL= Blooming period, UF= Unfavourable condition (Under120C), GF= The green fruit period.

				2008				2009			
No	**Family**	**Species**	**Author**	**BS**	**BL**	**UF**	**GF**	**BS**	**BL**	**UF**	**GF**
1	Andrenidae	*Andrena dorsata*	(Kirby, 1802)	+	+	+	-	+	+	+/+	+
2	Andrenidae	*Andrena flavipes*	Panzer, 1799	+	+	+	+	+	+	+/+	+
3	Andrenidae	*Andrena limata*	Smith, 1853	+	-	-	-	+	-	-	-
4	Andrenidae	*Andrena comta*	Eversmann, 1852	-	-	-	+	-	-	-	-
5	Andrenidae	*Andrena thoracica*	(Fabricius, 1775)	+	-	-	-	-	-	-	-
6	Anthophoridae	*Cubitalia parvicornis*	(Mocsáry, 1878)	+	+	+	+	-	+	+	+
7	Anthophoridae	*Eucera chrysopyga*	Pérez, 1879	-	-	-	-	-	-	-	+
8	Anthophoridae	*Eucera curvitarsis*	Mocsáry, 1879	+	+	+	+	+	+	-	-
9	Anthophoridae	*Eucera flavicornis*	Risch, 2003	+	-	-	-	-	+	+	+
10	Anthophoridae	*Eucera interrupta*	Bär, 1850	-	-	-	-	-	-	-	+
11	Anthophoridae	*Eucera parnassia*	Pérez, 1902	+	+	+			+	-	
12	Anthophoridae	*Xylocopa valga*	(Gerstaecker, 1872)	-	-	-	-	-	-	-	+
13	Apidae	*Bombus argillaceus*	(Scopoli, 1763)	-	-	-	+	-	-	-	-
14	Halictidae	*Evylaeus aeratus*	(Kirby, 1802)	+	-	-	-	-	-	-	+
15	Halictidae	*Evylaeus albipes*	(Fabricius, 1781)	-	+	-	-	-	-	-	-
16	Halictidae	*Evylaeus anellus*	(Vachal, 1905)	-	+	-	-	-	-	-	+
17	Halictidae	*Evylaeus annulipes*	(Morawitz, 1876)	-	-	-	-	-	-	-	+
18	Halictidae	*Evylaeus brevicornis*	(Schenck, 1868)	-	-	-	-	-	-	-	+
19	Halictidae	*Evylaeus calceatus*	(Scopoli, 1763)	+	+	-	+	-	-	-	-
20	Halictidae	*Evylaeus crassepunctatus*	(Blüthgen, 1923)	+	+	-	+	-	-	-	+
21	Halictidae	*Evylaeus euboeensis*	(Strand, 1909)	-	+	-	-	-	-	-	-
22	Halictidae	*Evylaeus glabriusculus*	(Morawitz, 1872)	-	-	-	-	-	-	-	+
23	Halictidae	*Evylaeus limbellus*	(Morawitz, 1876)	+	+	-	-	-	-	-	+
24	Halictidae	*Evylaeus linearis*	(Schenck, 1868)	+	+	+	+	-	+	+/+	+
25	Halictidae	*Evylaeus lucidulus*	(Schenck, 1861)	-	+	-	-	-	-	-	+
26	Halictidae	*Evylaeus malachurus*	(Kirby, 1802)	-	+	+	+	-	+	+	+
27	Halictidae	*Evylaeus marginatus*	(Brullé, 1832)	-	+	-	-	-	-	-	+
28	Halictidae	*Evylaeus mesosclerus*	(Pérez, 1903)	-	-	-	-	-	-	-	+
29	Halictidae	*Evylaeus minutissimus*	(Kirby, 1802)	-	-	-	-	-	-	-	+
30	Halictidae	*Evylaeus morio*	(Fabricius, 1793)	-	+	+	+	-	+	-	+
31	Halictidae	*Evylaeus obscuratus*	(Morawitz, 1876)	-	+	+	-	-	-	-	+
32	Halictidae	*Evylaeus pauxillus*	(Schenck, 1853)	-	+	-	+	-	-	-	+

Table 1. (Continued).

				2008				2009			
No	**Family**	**Species**	**Author**	**BS**	**BL**	**UF**	**GF**	**BS**	**BL**	**UF**	**GF**
33	Halictidae	*Evylaeus punctatissimus*	(Schenck, 1853)	-	+	-	-	-	-	-	+
34	Halictidae	*Evylaeus puncticollis*	(Morawitz, 1872)	-	-	-	-	-	-	-	+
35	Halictidae	*Evylaeus pygmaeus*	(Schenck, 1853)	-	-	-	-	-	-	-	+
36	Halictidae	*Evylaeus setulellus*	(Strand, 1909)	-	-	-	-	-	-	-	+
37	Halictidae	*Evylaeus trichopygus*	(Blüthgen, 1923)	-	-	-	-	-	-	-	+
38	Halictidae	*Evylaeus villosulus*	(Kirby, 1802)	-	-	-	-	-	-	-	+
39	Halictidae	*Halictus asperulus*	Pérez, 1895	-	+	-	-	-	-	-	+
40	Halictidae	*Halictus cochlearitarsis*	(Dours, 1872)	-	+	-	-	-	-	-	+
41	Halictidae	*Halictus compresus*	(Walckenaer, 1802)	-	+	-	-	-	-	-	-
42	Halictidae	*Halictus luganicus*	Blüthgen, 1936	-	+	-	-	-	-	-	+
43	Halictidae	*Halictus maculatus*	Smith, 1848	-	+	-	-	+	-	-	+
44	Halictidae	*Halictus patellatus*	Morawitz, 1874	-	+	-	-	-	-	-	+
45	Halictidae	*Halictus pentheri*	Blüthgen, 1923	-	-	-	-	-	-	-	+
46	Halictidae	*Halictus resurgens*	Nurse, 1903	-	+	+	-	-	+	+/+	+
47	Halictidae	*Halictus sajoi*	Blüthgen, 1923	-	-	-	-	-	+	-	-
48	Halictidae	*Halictus senilis*	(Eversmann 1852)	-	-	-	-	+	+	-	+
49	Halictidae	*Lasioglossum aegyptiellum*	(Strand, 1909)	-	-	-	-	-	+	-	+
50	Halictidae	*Lasioglossum discum*	(Smith, 1853)	-	-	-	-	-	-	-	+
51	Halictidae	*Lasioglossum fallax*	(Morawitz, 1873)	-	+	-	-	-	-	-	-
52	Halictidae	*Lasioglossum leucozonium*	(Schrank, 1781)	-	-	-	+	-	+	+/+	+
53	Halictidae	*Lasioglossum quadrinotatum*	(Kirby, 1802)	-	+	-	-	-	-	-	-
54	Halictidae	*Seladonia verticalis*	(Blüthgen 1931)	-	-	-	-	-	-	-	+
55	Halictidae	*Seladoni apollinosa*	(Sichel, 1860)	-	-	-	-	-	-	-	+
56	Halictidae	*Selabonia seladonia*	(Fabricius, 1794)	-	-	-	-	-	-	-	+
57	Halictidae	*Seladonia smaragdula*	(Vachal, 1895)	-	-	-	-	-	-	-	+
58	Halictidae	*Seladonia vestita*	(Lepeletier, 1841)	-	-	-	-	+	+	-	+
59	Halictidae	*Sphecodes albilabris*	(Fabricius, 1793)	-	-	-	-	-	-	-	+
60	Megachilidae	*Osmia bicornis*	(Linnaeus, 1758)	+	+	+	+	+	+	-	-
61	Megachilidae	*Osmia brevicornis*	(Fabricius, 1798)	+	+	-	-	-	-	-	+
62	Megachilidae	*Osmia caerulescens*	(Linnaeus, 1758)	-	+	-	+	+	+	-	+
63	Megachilidae	*Osmia melanura*	Morawitz, 1871	-	-	-	-	-	-	-	+
			S (Number of Species)	15	31	11	14	9	17	8	49

DISCUSSION

Özbek (2008) recorded 123 bee species visiting flowers of temperate fruit trees in Turkey. As a result of our study, forty-five more bee species were also added to this list. We found that while thirty-one species were active in full bloom period at 2008, seventeen species were active at 2009. Similarly, the number of species active at unfavourable conditions also decreased by 2009 (Table 1). This decrease could be the result of colder air temperatures observed between April and May 2009 (Fig. 3- 4). Likewise, it is possible that because of the increased temperature in May, forty-nine species were recorded within green fruit period during 2009.

Halictidae is the dominant family in the orchards with forty-six species and likewise, dominates in abundance (Pesenko *et al*., 2000; Dikmen, 2007). Many members of this family have been indicated as effective pollinators of clover (*Medicago sativa* L.) (Pesenko *et al*., 2000). Al-Ghzawi *et al*. (2006) reported some Halictidae species as the most frequent native insect visitors of fruit flowers and wild plants in the highland gardens of Jordan. These findings indicate that Halictidae is one of the most important pollinator groups because of its large abundance especially in fruit gardens. Moreover, Halictini members build their nests generally in the soil and many of them can form intensive colonies and populations under the proper conditions (Pesenko *et al*., 2000). *Ev*. *linearis*, *Ev. malachurus* and *L*. *leucozonium*, which were found active under unfavourable weather conditions in this study, are the most common and widely distributed Halictidae species in Turkey and Europe. These species were represented in very large numbers in Sultandağı reservoir region. Thus, it is reasonable to argue that they have intensive colonies near the cherry fields. Whereas *L. leucozonium* has solitary a life-style and prefers sandy soil in dry habitat, *Ev. linearis* and *Ev. malachurus* are primitively eusocial. The females of these species are active during the spring and summer seasons (Pesenko *et al*., 2000). It is likely that due to these characteristics, they may be active over a wide range of ambient conditions and therefore, continue to pollinate during intervals that are sub-optimal for honey bee foraging.

Although *A*. *mellifera* is the most important pollinator, many other insects also visit fruit tree flowers. Notable among these are bumble bees and solitary bees of the families Andrenidae and Megachilidae (Free, 1993). Boyle and Philogene (1983) found in Ontario (Canada) that more than 90% of the pollen on honey bees, *Bombus* and *Andrena* was from fruit trees. In our study *Bombus*, *Andrena* and *Osmia* spp. (totally 10 species) appear to be likely the potential pollinators of sweet cherry flowers. Among them, the species belonging to the genus *Osmia* (Hym.: Megachilidae) are also significant for the study, since they are regarded as an alternative for honey bees in fruit fields (Bosch and Kemp, 2000; Vicens and Bosch, 2000; Huang, 2003). Of these, *O*. *bicornis* has been identified as important for pollination in cherries, plum, pear and apple (Benedek, 2008) and has been used as orchard pollinator in Europe since the second half of the 20th century (Krunic and Stanisavljevic, 2006).

Pollen holding scopae of the species of *Andrena* (Hym.: Andrenidae) are localized at several positions of their body so that when they visit the flowers, the possibility of touching the stigma and so transferring the pollens is very high. Therefore, they may be regarded as good pollinators (Klug and Bünemann, 1983). Up to now, a total of thirty-seven *Andrena* species that visit fruit gardens has been identified in Turkey. *A. flavipes* that is also identified in our study is one of the commonest species of this genus (Özbek, 2008). Pollen contents that had been collected by *A. flavipes* specimens caught from the study area was studied by Güler and Sorkun (2010). They concluded that *A. flavipes* collected sweet cherry pollen, but that the sweet cherry flowers did not represent a primary pollen source therein.

Other species that are active during unfavourable weather conditions should be also analysed with regard to collecting pollen. Thus, it will be clarified if they are primary pollinators of sweet cherry or not. Besides, it is possible that the population of species as *O. bicornis* is supported to using artificial nests. Therefore, the studies of the artificial nest which is limited number in Turkey should be considered importance. As a result, testing the effectiveness and efficiency of using such pollinators of orchards in the future studies would be a very worthwhile effort. Thus, prevention of economic loss arising from inadequate pollination would also be possible in the future.

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