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Original article (Orijinal araştırma)

The status of the red mason bee in the orchards of Ankara and Çankırı Provinces, Turkey[1]

Kırmızı duvarcı arısının Ankara ve Çankırı (Türkiye) illerinin meyve bahçelerindeki durumu

Yasemin GÜLER[2*]

Abstract

Research on the red mason bee, *Osmia bicornis* (L., 1758) (Hymenoptera: Megachilidae), which is an important pollinator particularly for stone fruits, in Turkey is limited to the last decade. After the first report in sweet cherry orchards of Afyonkarahisar, this study aimed to determine the presence and the density of the red mason bee and to collect data on its nesting biology between 2014 and 2016 in the mixed orchards of Ankara and Çankırı Provinces. Although the red mason bee was detected in almost all orchards sampled using the Malaise trap, the nesting activity was recorded in only four orchards in 2014 and 2015. Reeds with an inner diameter of 6-9 mm and a length of 15-25 cm were used as the artificial trap-nests. It was determined that the percentage of the nesting success varies between 6 and 48%. The cocoons that originated from the nests were placed in the incubator to stimulate diapause. Then, the temperature of the incubator was gradually increased to complete the life cycle of the species with starting the bud stage of stone fruits in early spring. Consequently, the emergence rates of the adults from the 135 cocoons collected in 2014 were 36 to 95%. It was not recorded the adult emergence from any of the 143 cocoons obtained from the dissections of the nests in 2015. The sex ratios, both between orchards and from 2014 to 2015 in the same orchard ranged between 1:1.5-1:4 (♀:♂). The results are discussed based on stress conditions such as weather, limited pollen and nectar sources and insecticide application.

Keywords: Malaise trap, Megachilidae, *Osmia bicornis*, sex ratio, trap-nest

Öz

Özellikle sert çekirdekli meyvelerin önemli bir polinatörü olan Kırmızı duvarcı arısı, *Osmia bicornis* (L., 1758) (Hymenoptera: Megachilidae) ile ilgili araştırmalar, Türkiye'de son on yıl ile sınırlıdır. Afyonkarahisar'daki kiraz bahçelerinde ilk çalişmanın ardından 2014 ile 2016 yılları arasında Ankara ve Çankırı illerindeki karışık meyve bahçelerinde yürütülen bu çalışma, Kırmızı duvarcı arısının varlığını ve yoğunluğunu belirlemek ile yuvalanma biyolojisi hakkında veri elde etmeyi amaçlamıştır. Kırmızı duvarcı arısı, Malaise tuzak kullanılarak örneklenen hemen tüm bahçelerde belirlenmiş olmasına rağmen, yapay yuvalanma 2014 ve 2015 yıllarında sadece dört bahçede kaydedilmiştir. İç çapı 6-9 mm, uzunluğu 15-25 cm olan kamışlar yapay tuzak yuva olarak kullanılmışlardır. Yuvalanma başarısının %6 ile 48 arasında değiştiği belirlenmiştir. Yuvalardan elde edilen kokonlar diapozu başlatması için inkübatöre yerleştirilmiştir. Daha sonra inkübatörün sıcaklığı, erken ilkbaharda sert çekirdekli meyvelerin tomurcuk kabarması döneminin başlaması ile türün yaşam döngüsünü tamamlaması için kademeli olarak arttırılmıştır. Sonuç olarak, 2014 yılında toplanan 135 kokondan ergin çıkışı oranı %36 ile 95 olmuştur. 2015 yılına ait yuvaların diseksiyonundan elde edilen 143 kokonun hiç birinde ergin çıkışı kaydedilmemiştir. Eşey oranları hem tüm bahçeler arasında hem de aynı bahçenin 2014 ve 2105 yıllarında 1:1.5 ile 1:4 (♀:♂) arasında çeşitlilik göstermiştir. Sonuçlar, iklim, sınırlı polen ve nektar kaynakları ile insektisit uygulaması gibi stres koşullarına dayandırılarak tartışılmıştır.

Anahtar sözcükler: Malaise tuzak, Megachilidae, *Osmia bicornis*, eşey oranı, tuzak yuva

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Introduction

Mason bees, *Osmia* spp. Panzer, 1806 (Hymenoptera: Megachilidae) are important in the pollination of early flowering fruits, such as almond, plum and cherry (Bosch & Blas, 1994; Eeraerts et al., 2019b), because they are able to be activity even in cool and rainy weather conditions below 12ºC, which limit the pollinator activity of the honey bee (Vicens & Bosch, 2000b). In addition, only a few female individuals of *Osmia* spp. are sufficient for pollination of a single flowering fruit tree, in contrast with hundreds of the honey bee workers (Krunić & Stanisavljevic, 2006a). Another advantage is that the nesting areas are aboveground in contrast to many other species of solitary bees, so that their populations can be managed using low cost artificial nests (Krunić & Stanisavljević, 2006b; Benedek, 2008). Research on the use of mason bees in orchards started in the second half of the twentieth century. Today, several species are used commercially for pollination of flowers in orchards in the USA, Japan, England, Denmark, Spain, Serbia and Italy (Sekita, 2001; Krunić & Stanisavljević, 2006a; Benedek, 2008; Matsumoto & Maejima, 2010). One of these species is *Osmia bicornis* (L., 1758) (syn. *Osmia rufa* L., 1758) (Hymenoptera: Megachilidae), the red mason bee.

In addition to being one of the few solitary bee species active in early spring, the red mason bee has a wide distribution area in Europe, Caucasus and Central Asia (Banaszak & Romasenko, 1998) as well in Turkey (Özbek, 2013; Güler et al., 2014). It is univoltine and spends the winter as adult in the cocoon (Raw, 1974; Strohm et al., 2002). It uses nests abandoned by other bees, dry stalks, cavities opened to the ground by other insects, wall crevices and empty snail shells (Müller, 2018). The nests consist of cells, which contain septa between them, are arranged linearly and plastered with a mixture of saliva-clay (Güler, 2012). This species collects pollen and nectar from tens of plant species belonging to 19 families (Müller, 2018). One of these families is Rosaceae, which contains both economically and commercially important fruit species (Bertrand et al., 2019). Güler & Özkök (2016) reported that Rosaceae pollen is one of the most encountered pollen within the artificial nests of *O. bicornis* in sweet cherry orchards.

Data on to presence of the mason bees in orchards of Turkey are limited to the last decade. Currently, five mason bee species [*O. bicornis*, *Osmia brevicornis* (Fabricius, 1798), *Osmia caerulescens* (L., 1758), *Osmia cornuta* (Latreille, 1805) and *Osmia melanura* Morawitz, 1871] have been recorded from the orchards, as well as many species belonging to other solitary bee families (Özbek, 2008; Güler & Dikmen, 2013).

The prominent fruit production in the provinces investigated in this study are pome fruit, sour cherry and sweet cherry in Ankara, and plum and cherry in the Çankırı (TÜİK, 2019). Among the pome fruits, the two fruits most commonly produced in both provinces are apple and pear (TÜİK, 2019). All of these fruits, except for sour cherry, are not self-fertile. They need pollinators to ensure the exchange of pollen between their cultivars, and to increase fruit set (Klein et al., 2012; Martins et al., 2015; Eeraerts et al., 2019a). Hansted et al. (2012, 2014) recommend the use of pollinators even in sour cherry orchards to obtain quality products. In practice, the honey bee is the main pollinator used in orchards. However, frequent unfavourable weather conditions, especially in early spring, lead to low fruit set production, and thus, economic losses. Also, such solitary bees complement honey bee in the pollination of various other plant species.

Given these circumstances, the main purpose of this study was to determine the presence and density of the red mason bee, which is one of several the species shown as an alternative, or supportive to the honey bee and has a manageable potential with trap-nests in Ankara and Çankırı orchards.

Materials and Methods

Field studies were conducted in the orchards in Ankara and Çankırı Provinces of Turkey from 2014 to 2016. These were mixed orchards consisting of apple, sweet and sour cherry, peach, pear, almond, and plum trees. The smallest orchard had 100 trees, and the largest had 2350 trees. All orchards were located in intensively agricultural areas. The distance between orchards ranged from 2 to 106 km.

In 2014, the presence of the red mason bee was determined by Malaise traps in eleven orchards. The traps were installed during the budding period of stone fruits (late-March and mid-April) and were removed during the green fruit period (mid- to late-May). The traps were checked on a weekly basis and the specimens in the killing bottles recorded.

In addition, the artificial nests were used to determine the occurrence and abundance of the red mason bee in 8 of 11 orchards with Malaise traps in 2014. The trap-nests were hung on the south-facing branches or posts at about 1.5 m above the ground in all the orchards on the same day as the installation of the Malaise traps. Each nesting site was consisted of at least 25 reeds with an inner diameter of 6-9 mm and a length of 15-25 cm, inserted into PVC pipes. Also, traps were set in the orchard of the Plant Protection Central Research Institute in Yenimahalle, Ankara, which had apple, sweet cherry, pear, and mulberry trees. These traps were to determine the abundance of red mason bees with the artificial nests, in that orchard as the bees had previously been detected in that orchard (unpublished data). In 2015, trap-nests were only hung to four orchards (Eldivan 1, 2, 3 and Yenimahalle) to determine the change in red mason bee abundance from the previous year. At the end of the flowering period, all reeds were collected from the orchards and kept in ventilated cylindrical plastic containers (20 cm diameter, 27 cm long) under laboratory conditions until autumn. In October of 2014 and 2015, the reeds were separated based on whether they contained red mason bees. During this process, all reeds were also checked for parasitoids, cleptoparasites, predators and other nesting hosts. The cocoons of *O. bicornis* in the reeds were removed (Figure 1) and stored in the climate chamber under controlled conditions at 4-6ºC and 50-60% RH for hibernation. To achieve the synchronization of the adult *O. bicornis* emergence with the flowering period of fruit trees, the temperature was increased incrementally to 10, 15 and 20ºC starting from mid-March 2015 and 2016 (Bosch & Kemp, 2004; Krunić & Stanisavljević, 2006b). The number of adults and their sex were recorded daily and then released to the orchards.

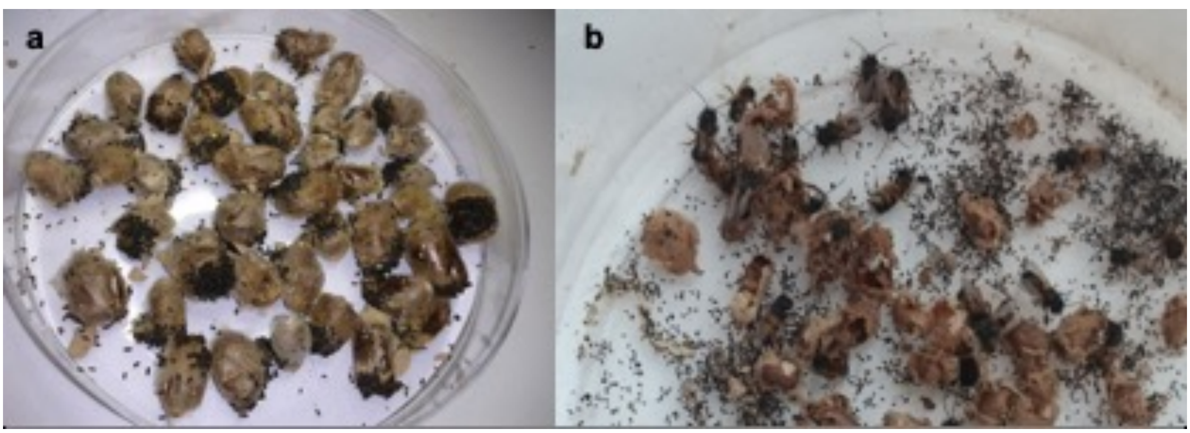

Figure 1. Red mason bee a) cocoons, and b) adults.

Results

The study focused on red mason bee because this is the only species of *Osmia* recorded in both Malaise traps and trap-nests. Results from the samples obtained from the Malaise traps showed that *O. bicornis* was present in all orchards except one in the Ankara Province. Given that the bees were first recorded between 27 and 28 March 2014 in Malaise traps, it is concluded that their flight activity began between in late-March to early-April in the orchards of Ankara and Çankırı Provinces (Figure 2). Males were active before females and their numbers were generally higher (total of 46 males and 27 females from all traps). Adult flight activity continued until early-May (Figure 2). Within this period, the stone fruits and the early cultivars of the pome fruits were flowering. Since all the fruit cultivars in these orchards were in the green fruit stage in early-May, it is concluded that the mason bee may be effectively pollinate of these cultivars.

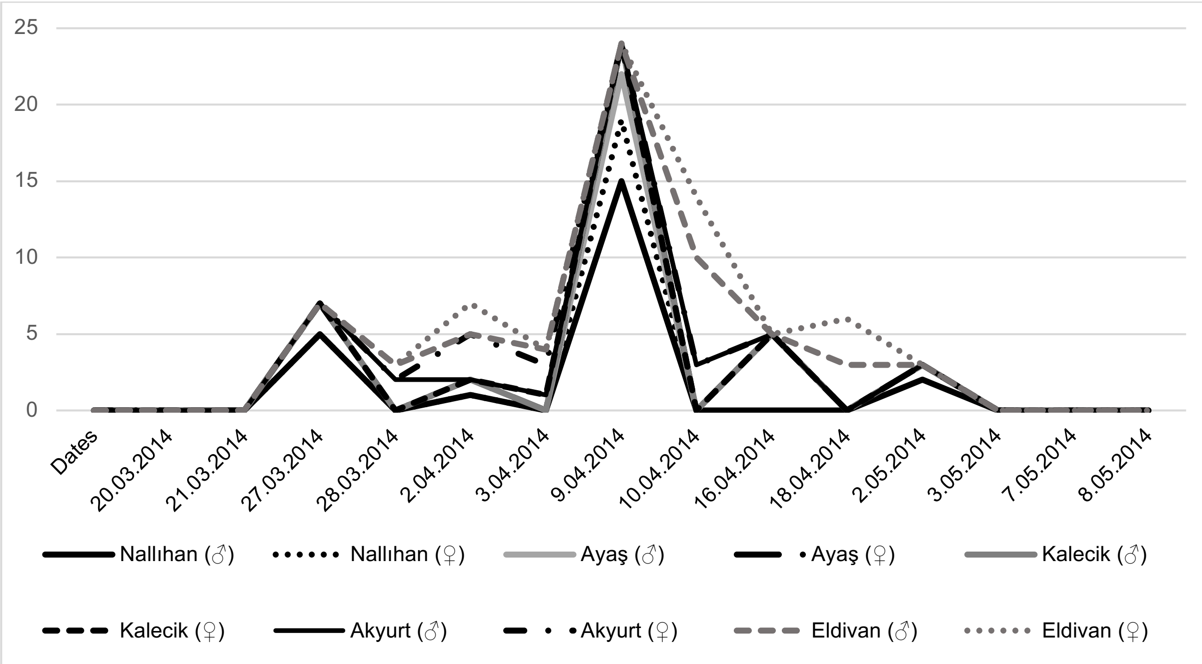

Figure 2. The activity of the red mason bee, determined by Malaise traps installed in 11 orchards in Ankara and Çankırı Provinces in 2014.

The nesting successes, the number of the cocoons, the percentage of the adult emergences, and the sex ratios of *O. bicornis* from 2014 to 2015 are shown in Tables 1 and 2. As a result of the dissected reeds, the nesting activity of *O. bicornis* was recorded in three of eight orchards placed the artificial nests as well as in the garden of the Institute in Yenimahalle in 2014 (Table 1). Therefore, the study was continued in only four orchards (Eldivan 1, 2, 3 and Yenimahalle) in 2015. In 2014, the highest number of cocoons (78) was obtained from the orchard of the Institute known to have a resident population of *O. bicornis* (Table 1). While the number of cocoons was limited to 18 in the same area, the highest number (122) was recorded from the Eldivan 2 orchard in 2015. Furthermore, *Ancistrocerus parietum* (L., 1758), *Ancistrocerus claripennis* subsp. *claripennis* Thomson, 1874 (Hymenoptera: Vespidae: Eumeninae) and *Chrysis* spp. (Hymenoptera: Chrysididae) were encountered in the reeds both with low-nesting and without nesting in both years (Table 1). *Ancistrocerus parietum* was recorded from the nesting in several locations in Ankara, but *A. claripennis* subsp. *claripennis* was found only in Eldivan.

Table 1. Results obtained by dissection of the reeds in artificial nests of the red mason bee in 2014 and 2015

Orchards	2014			2015		
	Cocoons	*Ancistrocerus* spp.	*Chrysis* sp.	Cocoons	*Ancistrocerus* spp.	*Chrysis* sp.
Eldivan 1	14	2	3	3	4	0
Eldivan 2	42	0	1	122	0	1
Eldivan 3	1	9	0	0	5	2
Yenimahalle (Institute)	78	0	0	18	0	0
Ayaş*	0	16	0	-	-	-
Akyurt*	0	7	0	-	-	-
Kalecik*	0	4	0	-	-	-
Nallıhan*	0	19	0	-	-	-
Total	135	57	4	143	9	3

* In these orchards, the study was not continued in 2015 because no nesting was recorded in 2014.

Table 2. Nesting successes, adult emergence and sex ratios in the artificial nests of the red mason bee in 2014 and 2015

Orchards	The nesting success (%)		The adult emergence ratio	The sex ratio (♀:♂)	
	2014	2015	2014	2014	2015
Yenimahalle (Institute)	47.8	8.9	94.9	1:2.4	1:3.2
Eldivan 1	6.0	3.7	35.7	1:4.0	1:3.0
Eldivan 2	28.0	24.2	69.1	1:2.2	1:1.5

The high degree of the nesting success and the adult emergence ratio in 2014 were obtained from the reeds of the orchard of the Institute (Table 2). The nesting success in all orchards in 2015 was dramatically lower compared to 2014. Although there was 143 pupae collected in 2015 in incubation, adult emergence was not recorded. Therefore, the adult emergence ratio of 2015 could not be calculated. The sex ratio of *O. bicornis* in 2015 was calculated by dissection of the cocoons.

The sex ratios of *O. bicornis* varied between orchards and years (Table 2). The highest female number among three orchards was obtained in Eldivan 2 with a ratio of 1:1.5-2.2. While the sex ratio of the red mason bee in the orchard of the Institute in Yenimahalle changed had an increased proportion of males in 2015, the ratios in the other orchards moved in favor of females.

Discussion

The artificial nests have been used for *Osmia* spp. in the orchard of the Plant Protection Central Research Institute in Yenimahalle, Ankara since 2009 but only a few records were kept. It was noted that especially the population of nesting *O. bicornis* increased gradually year by year (unpublished data). Therefore, a 48% nesting success recorded in 2014 was not surprising. The continued development toward the creation of a resident population was destroyed in 2015 due to an insecticide application on 17 April 2015 to the orchard of the Institute (without our knowledge) at the time of the flight activity of *O. bicornis*. It is concluded that this a possible reason for the significant decrease in the number of the cocoons of 2015 (Table 1). In Eldivan 2, which was recorded as the second orchard having a high abundance of cocoons (42) in 2014, this number increased in 2015 (122 cocoons). This rise can be explained by the fact that the location of the orchard is more suitable for the resident population of the red mason bee compared to other orchards of Eldivan (Table 1). The upper side of Eldivan 2 was adjacent to a meadowland (Figure 3) instead of being surrounded by other orchards as in Eldivan 1 and 3. The meadowland was covered with the plant species belonging to Asteraceae (including *Senecio vernalis* Waldst. & Kit., *Taraxacum* sp. and *Sonchus* sp.), Boraginaceae [including *Asperugo procumbens* L. and *Buglossoides arvensis* (L.) I. M. Johnst.], Brassicaceae [including *Alyssum desertorum* Stapf., *Camelina hispida* Boiss., *Capsella bursa- pastoris* (L.) Medik., *Lepidium draba* L., *Microthlaspi perfoliatum* (L.) F. K. Mey.] and Lamiaceae (including *Lamium amplexicaule* L. and *Lamium orientale* E. H. L. Krauser) families which attract many bee species. Meadowlands, which have a high diversity and abundance of flowering plants, provide support to bee populations for supplying both alternative nesting areas and alternative food sources (Öckinger & Smith, 2007). It is known that increased landscape heterogeneity enhances pollinator richness and abundance, as well as pollination service (Steckel et al., 2014). The connection of species and landscape in bees is stronger than other insect groups due to the mutualistic relationship between bees and flowering plants. Thus, comparable to the results of Steffan-Dewenter (2003) and Kremen (2008) the densities of bee populations, especially in standard commercial farms such as all the orchards in this study, are more influenced by habitat connectivity. Consequently, *Osmia* spp., just like other bees, do not tend to disperse from the nesting areas if they have access to suitable food sources (Vicens & Bosch, 2000a). They prefer to nest in older nests, both for more efficient use of their energy and to avoid the higher pressure of natural enemies.

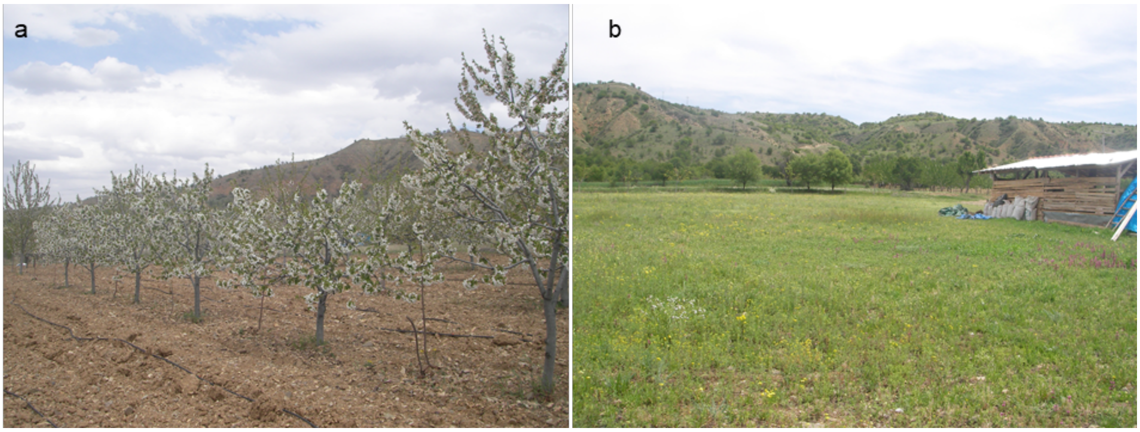

Figure 3. a) The flowering period of the Eldivan 2 orchard, and b) the meadowland covered with flowering plants that attract bees.

In a study by Krunić & Stanisavljević (2006a) that aimed to increase the population of the red mason bee in Serbia, the adult emergence rate ranged between 83-94%. The ratios in this study were 36, 69 and 95% (Table 2) in Eldivan 1, Eldivan 2, and the Institute orchard, respectively. Danks (1971) reported that the preadult mortality rates in solitary bees nesting in dry stalks are 50-60% and these mortality rates can be evaluated as a relatively low when compared with animals, which are parental care, such as bird and mammal and social insects. Solitary bees have a relatively long preadult period in which they are vulnerable to many biotic and abiotic factors. The basic biotic factors are predators, parasitoids, cleptoparasites and pathogens. Güler (2012) reported that the parasitoid *Melittobia acasta* (Walker, 1839) (Hymenoptera: Eulophidae) and the nest destroyer *Trogoderma versicolor* (Creutzer 1799) (Coleoptera: Dermestidae) from the artificial nests in the sweet cherry orchards of Sultandağı (Afyonkarahisar). In that study, the parasitoid was found in 25-74% of all nests while the nest destroyer was found in 33%. In this study, however, these species were not encountered, but a total of 66 *Ancistrocerus* spp. as predator and seven *Chrysis* sp. as cleptoparasite were recorded from some of the reeds (Table 1). The members of the Eumeninae subfamily, which includes *Ancistrocerus* spp., actually nest in empty reeds. However, they destroy the nests of other species such as *Osmia*, if they cannot find empty reeds (Krunić et al., 2005). Moreover, the flight activity of the first offspring of *Ancistrocerus* sp. synchronizes with that of *O. bicornis* females and their nesting needs overlap with 53-97% of the preferences of the red mason bee (Budriene et al., 2004). These species also construct linear nests in reeds of 4-10 mm diameter and use mud to separate cells (Boesi et al., 2005). In this study, *Chrysis* spp. was not only determined from the nests of the wild bee, but also found in the nests of *Ancistrocerus* spp. (Table 1). They have typically a cleptoparasite behavior; their eggs are deposited inside nests of other bee and wasp species, consuming pollen provided by the host, the development of their larvae is more rapid than the host larvae (Krunić et al., 2005).

The most important abiotic factors that affect the flight activity of bees are temperature and precipitation. Between 15 March and 15 May, when the red mason bee is active, meteorological data for Yenimahalle (location at the Institute) and Eldivan (location at Eldivan 1 and 2 orchards) towns was analyzed. The number of days within this period in 2014 with an average temperature of less than 10ºC was 16 d in Yenimahalle increasing in 2015 to 22 d (Figure 4). In Eldivan, the days of average temperature in 2014 was 22 increasing to 33 d in 2015 (Figure 5). In both locations, the number of days when the temperature dropped below zero was only 3 and 11 d in 2014, respectively. In 2015, however, the number of days below zero increased by two to three times; 10 d in Yenimahalle and 20 d in Eldivan. The number of days with precipitation at both locations did not change much between years; 24 d in 2014 and 23 d in 2015 in Yenimahalle, and 24 and 19 d in Eldivan. These climatic conditions suggest that temperature might have been responsible for both the decline in nesting success and the emergence of adults from cocoons in 2015. In addition, the pesticide application in April 2015 may have had an impact on all data from Yenimahalle.

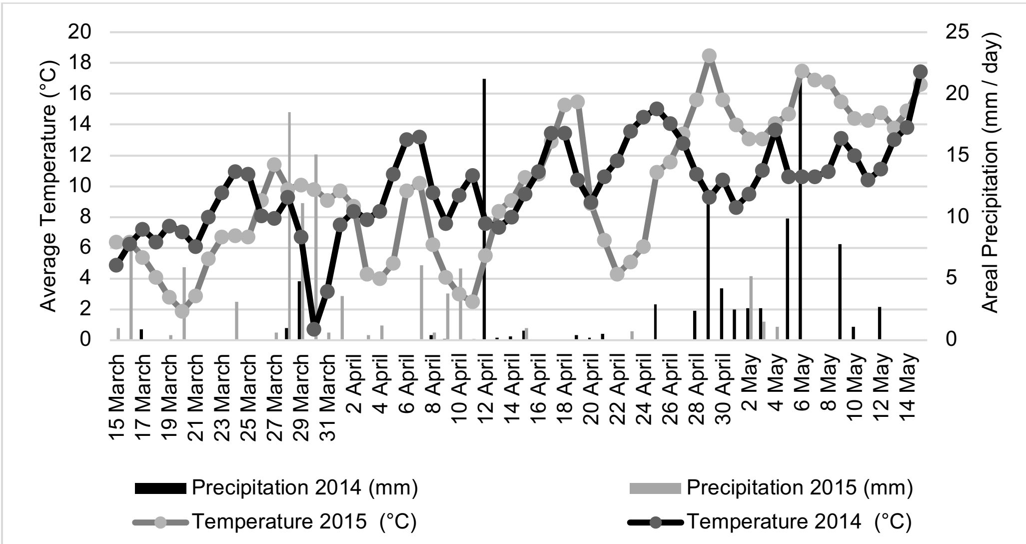

Figure 4. Average temperature and precipitation in Yenimahalle (Ankara) during the orchard flowering periods of 2014 and 2015.

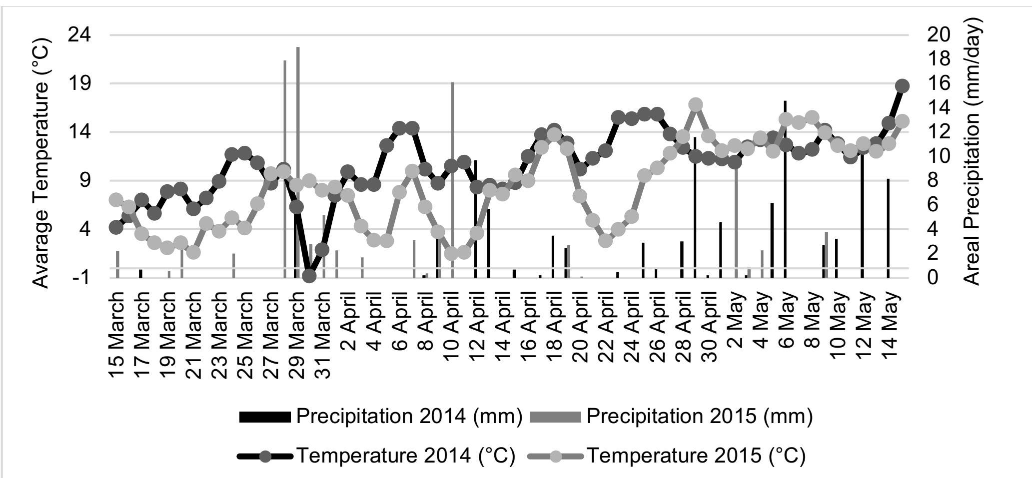

Figure 5. Average temperature and precipitation in Eldivan (Çankırı) during the orchard flowering periods of 2014 and 2015.

The sex ratios varied between 1:1.5 and 1:4 (♀:♂; Table 2). This ratio for *O. bicornis* population in the cherry orchards of Sultandağı (Afyonkarahisar) was previously recorded as 1:3.7 and 1:4 (Güler, 2012). Krunić & Stanisavljević (2006a) reported that the sex ratios of the same species changed between 1:1.35 and 1:2.68. It is known that the sex ratio is a parameter which changes according to weather and trophic conditions (Ivanov, 2006; Sampson et al., 2009). The ratio favors males under unfavorable conditions. As in all bees, *Osmia* females have the ability to control the number of males in a ratio of 1:2 or 1:3 (Sampson et al., 2009).

Conclusion

The red mason bee, one of the commercially used pollinator species in many countries, is found naturally under Ankara and Çankırı ecological conditions, although the farmers are not aware of it like other wild bees. The main pollinator in many agricultural and natural areas is undoubtedly the honey bee (Kremen, 2008; Aslan et al., 2016; Hung et al., 2018). However, it has a limitation because pollination effectiveness decreases seriously under unfavorable weather conditions (days below the 12.8°C, raining, or windy blowing over 32 to 40 kph) (Spivak & Mader, 2010). However, some wild bee species are more effective pollinators of some crops such as stone and pome fruits, and forage plants than *Apis mellifera* (Maeta & Kitamura, 1981; Tepedino, 1997; Bosch & Kemp, 2000; Vicens & Bosch, 2000c; Richards, 2020). Therefore, pollination service is usually provided by the activity of more than one bee species (Garibaldi et al., 2013). Wild bee species are insurance for the pollination system in cases of colony collapse or adverse weather conditions for the honey bee. In order to provide a sustainable pollination services, natural bee populations need to be protected and supported. Identifying these species and creating conditions to support their populations will bring a healthier environment and a higher quality product. As the data from Eldivan 2 shows, if the artificial nests including reeds of appropriate diameter are placed and alternative sources of food are found in the environment, it is possible to increase the population of the red mason bee in the orchard. Importantly, at this point, farmers should be informed about bees and pollination services, and be encouraged to permanently support red mason bee populations in their orchards at minimal cost.

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