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Araştırma Makalesi / Research Article

Observations on the Foraging Behaviors of Commercial Bumble Bee Colonies in *Prunus avium* Orchards

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Abstract

Prunus avium blooming period starts in early spring. The uncertain climatic conditions in this period can cause mis-pollination syndromes. It could be directly because of the frozen days or non-forgeable conditions for the possible pollinators or indirectly the poor quality of surrounding habitat and lack of pollinators. When wild pollinators are scarce owing to one of these reasons, introduction of commercial pollinators can be a solution to ensure pollination. Within this context, commercial bombus colonies were chosen as insurance for the pollination of sweet cherries. In the blooming period of *Prunus avium*, for two years-with totally 120 transect observations, the daily foraging activities of these bumblebees were investigated in Sultandağı-Afyonkarahisar. Before the settlement of the hives in the field, trees were marked with different colored stripes every 10 meters which makes it possible to follow how far the bumblebees fly and forage in the field. Starting at 7:00, 9:00, 11:00, 14:00, 16:00, and 18:00, six times a day, with transect observations, the number of the foragers on cherries was recorded. The average number of flowers they visit per minute was calculated. The plants blooming simultaneously with cherry trees in the trial area were determined. Pollen preferences of foragers were examined with their cobicular pollen loads. The actual foraging range was found as 10-40 meters away from the hives, the maximum activities were recorded before the noon. The average number of visited flowers per minute for bumblebees was ~ 8 flowers. *Taraxacum* spp. and *Lamium* spp. pollen were found, but cherry preference was determined to be almost 90%. It is still an uncommon agricultural practice to use commercial bumble bees in open fields, especially for the plants which have very early blooming periods in early spring, it is thought that they are very good manageable pollinator agents according to their foraging capacities.

Keywords
Bombus terrestris; foraging behavior; Prunus avium; pollination

Ticari *Bombus terrestris* Kolonilerinin *Prunus avium* bahçelerindeki Polen Toplama Davranışlarına Yönelik Gözlemler

Öz

Prunus avium çiçeklenme dönemi erken ilkbaharda başlar. Bu dönemdeki belirsiz iklim koşulları, tozlaşma sendromlarına neden olabilir. Bunun nedeni doğrudan donlu günler veya olası tozlayıcılar için uygun olmayan koşullar veya dolaylı olarak çevredeki yaşam alanlarının kalitesizliği ve tozlayıcı eksikliği olabilir. Bu sebeplerden biri nedeniyle yabani tozlayıcıların az olduğu durumlarda, yönlendirilebilen ticari tozlayıcıların getirilmesi tozlaşmayı sağlamak için bir çözüm olabilir. Bu kapsamda, ticari bombus kolonileri kirazların tozlaşması için değerlendirilmiştir. Sultandağı-Afyonkarahisar'da *Prunus avium*'un çiçeklenme döneminde iki yıl boyunca toplam 120 transekt gözlem ile günlük polen toplama faaliyetleri incelenmiştir. Arı yuvaları bahçeye yerleştirilmeden önce, kiraz ağaçları her 10 metrede bir farklı renkte olacak şekilde ipler ile işaretlenerek bombus arılarının bahçede ne kadar uzağa uçtuğunu ve polen topladığının tespit edebilmek mümkün hale getirilmiştir. Saaat 7:00, 9:00, 11:00, 14:00, 16:00, ve 18:00'de başlanan transekt gözlemler ile kiraz üzerinde polen toplayan arılar gözlemlenmiştir. Çiçekleri ziyaret eden bombus arılarının sayısı ortalama olarak hesaplanmıştır. Kiraz ile eş zamanlı çiçeklenen bitkiler örneklenmiştir. Bombus arılarının polen tercihleri korbikular polen yüklerinden alınan örneklerin değerlendirilmesi ile ortaya konmuştur. Arıların yoğunlukla bulundukları alan 10-40 metre aralığıdır, maksimum akitivite öğleden önce kaydedilmiştir. Dakikada ortalam çiçek ziyaret sayısı yaklaşık 8 çiçek

Anahtar kelimeler
Bombus terrestris; polen toplama; Prunus avium; tozlaşma

olarak bulunmuştur. %90 oranında kiraz poleni yanında *Taraxacum* spp. ve *Lamium spp.* bitkilerinin polenlerinin de tercih edildiği tespit edilmiştir. Açık alanlarda ticari bombus arılarının kullanımı hala yaygın olmayan bir tarımsal uygulamadır, özellikle erken ilkbaharda çok erken çiçeklenme dönemlerine sahip bitkiler için, polen toplama kapasitelerine göre çok iyi yönetilebilir tozlayıcı ajanlar oldukları düşünülmektedir.

1. Introduction

Prunus are members of the Rosaceae, which ranks as the third most agronomically important plant family in temperate regions. *Prunus* genus which includes economically important species such as *Prunus avium* L. (sweet cherry), *Prunus persica* (L.) Batsch (Peach), *Prunus cerasus* L. (sour cherry), *Prunus armeniaca* L. (apricot), *Prunus amygdalus* Batsch (almond), *Prunus domestica* L. (European plum), and *Prunus cerasifera* Ehrh (myrobalan plum) (Dirlewanger *et al.* 2002). *Prunus avium* L. (sweet cherry), is geographically distributed around the World, with greater prevalence in areas with a temperate climate, which encompasses much of Europe (Mediterranean and Central), north Africa, Near and Far East, South Australia, and New Zealand, and temperate zones of the American continent (USA and Canada, Argentina and Chile) (Mariette *et al.* 2010, Basanta *et al.* 2014, Bastos *et al*. 2015). According to FAO data, cherry production area in the World is about 416, 445 hectares. Turkey is in first place in the World with 627,132 tonnes of production and 85,401 hectares of cherry production area (FAO 2017, Çelik and Sarıaltın, 2019). Most sweet cherry cultivars are self-incompatible with many cross-incompatibility groups. In commercial orchards, cross-compatible cultivars belonging to different pollen incompatibility groups and flowering simultaneously must be co-cultured to ensure fruit set (Dirlewanger *et al.* 2002). *Prunus* species bloom in late winter or early spring (Kurokura *et al.* 2013, Fadon *et al.* 2018). The uncertain climatic conditions in this period can cause mis-pollination syndromes. It could be directly because of the frozen days or non-forgeable conditions for the possible pollinators or indirectly the poor quality of surrounding habitat and lack of pollinators. For one of these reasons, where wild pollinators are scarce, the introduction of domesticated commercial pollinators may be a solution to achieve pollination. The use of honeybees (*Apis mellifera*) or other managed pollinator species (*Bombus* spp., *Osmia* spp. and *Megachile* spp.) are the most common management practices for pollination in agricultural crops (Osterman *et al.* 2021). Although Turkey is really an important "beekeeping" country in the World, with its 8.733.394 honey bee hives (new and old hives), 89361 agriculture holdings in apiculture, and 96344,201 tons of honey production (TÜİK 2021, FAO 2021), renting honey bee hives for pollination is still an unfamiliar practice in this country. According to the beekeepers and fruit producers, the most important factors are the cold weather conditions, lack of legal regulations compared to the European Union or USA (oral conversation with professional beekeepers and farmers). Using *Bombus terrestris* in greenhouse production is supported by the government in Turkey (with almost 50% of the cost of a bumblebee hive). First step of ensuring pollination by a manageable pollinator is to evaluate the relationship between the target plant and the pollinator in the frame of pollination services. The objective of this study is to determine the foraging behaviors of commercial *Bombus terrestris* in cherry orchards. Within this frame, one of the most important cherry producing areas -Afyonkarahisar- was chosen. With phenological observations in the area, the blooming period of the target species- *Prunus avium* and the possible settlement time of the hives were laid out. In the blooming period of *Prunus avium*, for two years- with totally 120 transect observations, the daily foraging activities were investigated. With entomopalynological studies, it was also proved that the foraging plant preferences of *Bombus terrestris* were 90% cherries.

2. Materials and Methods

The studies were conducted in 2009 and 2013, in Sultandağı, Afyonkarahisar-Turkey. 38°32' 28''N, 31°15' 07''E, and 980 m above sea level. The field studies were conducted between 19/04/2009-03/05/2009; 04/04/20013-19/04/2013. The transection observations were done 24-29/04/2009 and 9-14/04/2013. The *Prunus avium* L. cultivars in this field were "Ziraat 900" and "Gılli". The trees were 14-16 years old with a height of nearly five meters. The field was 230 m x 80 m. The plantation system was 8x8x8 meters. Commercial *Bombus terrestris* colonies were provided by Koppert Biological Systems-Turkey. The hives were settled at one side of the field with 5% of the flowers opened in the field. Before the settlement of the hives in the field, trees were marked with different colored stripes every 10 meters which makes it possible to follow how far the bumblebees fly and forage in the field. Starting at 7:00, 9:00, 11:00, 14:00, 16:00, and 18:00, six times a day, with transect observations, the number of the foragers on cherries was recorded. For two years, along the blooming period of *Prunus avium* the bumblebees were counted according to the marked trees and with these observations, the distribution of the bumblebees in such a field was examined. The average number of flowers they visit per minute was calculated. The plants blooming simultaneously with cherry trees in the trial area were collected. The more attractive vegetation can change the foraging behaviors of the pollinator insects. To understand whether the surrounding vegetation or the *Prunus avium* trees are more attractive, all the other plants were sampled and identified. Foragers were caught with insect nets while they were getting into their hives. Pollen loads of these individuals were taken from their corbiculas (just one pollen load) and then they were released from the net. For a day only two individuals were caught, one of them was at 9:30, the second one was at 16:30. Three sets of pollen preparations were made according to the Wodehouse method (Wodehouse 1935). The first one was cherry cultivars' pollen, the second one was from the pollen loads (bee pollen) and the last one was the collected plants (surrounding vegetation). The comparisons were carried out with a Nikon Eclipse E400 microscope within the plant preparations and bee pollen. A total of 24 pollen loads (for two years) were classified as "cherry" and "not cherry". The hourly data set about the temperature and precipitation on the observed dates was obtained from the Republic of Turkey, Ministry of Environment, Urbanization and Climate Change- Turkish State Meteorological Service. The data was summarized with line charts. Observation days (6 days) were included for each year. Diagram of bumblebee activities (Figure 1: 2009 and Figure 2:2013) according to temperature, humidity and observation hours (prepared by taking the average values of 6-day observations) were given.

3. Results

List of other plants blooming simultaneously with cherry trees in the study area: *Thlaspi perfoliatum* L., *Taraxacum scaturiginosum* G.Hagl., *Lamium purpureum* L. var. *purpureum*, *Lamium amplexicaule* L., *Veronica triloba* (Opiz) Kerner, *Hypecoum procumbens* L., *Barbarea vulgaris* R.Br., *Muscari neglectum* Guss, *Androsace maxima* L., *Erophila verna* (L.) Chevall. subsp. *verna*, *Veronica hederifolia* L., *Caltha polypetala* Hochst. ex Lorent, *Lamium purpureum* L. var. *purpureum*, *Hymenolobus procumbens* (L.) Nutt. ex Torrey & Gray, *Hymenolobus procumbens* (L.) Nutt. ex Torrey & Gray, *Fumaria officinalis* L., *Descurainia sophia* (L.) Webb ex Prantl, *Gagea peduncularis* (J. & C. Persl) Pascher, *Chorispora syriaca* Boiss., *Senecio vernalis* Waldst. & Kit., *Ceratocephalus falcatus* (L.) Pers, *Asperugo procumbens* L., *Fumaria asepala* Boiss., *Tripleurospermum* sp., *Veronica campylopoda* Boiss., *Adonis aestivalis* L. subsp. *aestivalis*, *Ornithogalum umbellatum* L., *Malcolmia africana* (L.) R.Br.

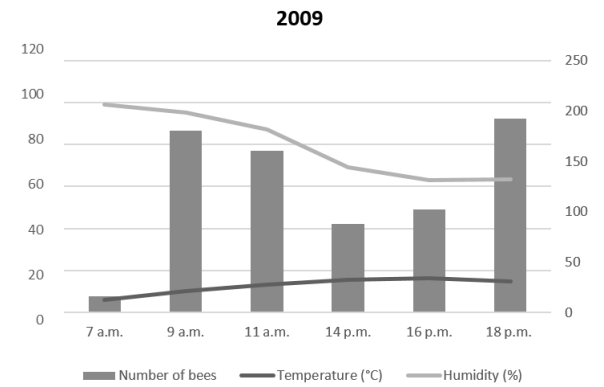

Figure 1. Diagram of bumblebee activity (2009) according to temperature, humidity and observation hours (prepared by taking the average values of 6-day observations)

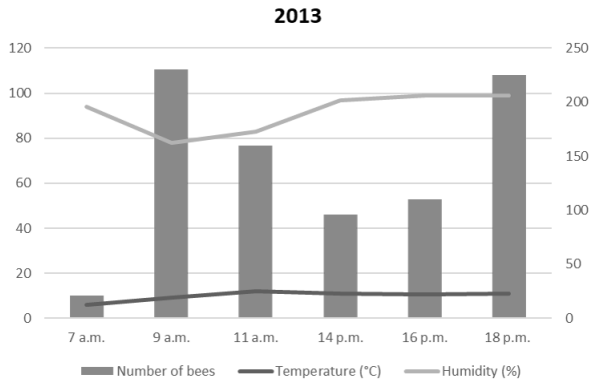

Figure 2. Diagram of bumblebee activity (2013) according to temperature, humidity and observation hours (prepared by taking the average values of 6-day observations)

The maximum foraging distance was found 150 meters from the hives, but the actual spatial distribution area was 10-40 meters. The maximum foraging activity occurred while the flowering was 100% in the field. The average number of visited flowers per minute for bumblebees is ~ 8 flowers. *Taraxacum* and *Lamium* pollen were found, but cherry preference was determined to be almost 90%. The maximum activities were recorded before the noon.

4. Discussion and Conclusion

Considering the relatively short flowering times of cherry trees, we can say that flowering begins, pollination and fertilization take place in about 5-8 days. The realization of efficient pollination in this short period of time depends on many abiotic and biotic factors. Improper pollination is thought to be one of the key factors responsible for the low productivity of many cross-pollinated crops (Hanif *et al.* 2022). Mis-pollination syndrome can be caused because of weather conditions (e.g. frozen days), lack of pollinators or the un-synchronization of the flowering periods of the plants with pollinators. With this study, a research was conducted on the behavior of *Bombus terrestris* on the target plant in open areas. Observations were made about the weather, other species blooming with cherries, the pollen preferences of the bumblebees, and their flight distances. Although we see with weather data that there are no frosty nights and days, it is known that there are microclimatic areas in the basin, which includes the study area, and frost is experienced in some gardens (personnel conversations with farmers). In this context, data collection with relatively small weather stations in the garden will be more suitable for pollinator behavior studies in future studies. Detection of flowers that bloom simultaneously with cherry is important in many different ways. The target plant and other plants are known to influence the behavior of pollinators (Spiesman and Gratton 2016, Nakamura *et al.* 2020). Certain mass flowering crops in the landscape can attract pollinators during their short time of bloom. When these crops are very abundant and widespread in the landscape the pollinator populations become diluted over the landscape (Holzschuh *et al.* 2011, Montero-Castaño *et al.* 2016, Eeraerts *et al.* 2017). However, another point to consider here is providing additional flowering and nesting resources – both as flower-rich field margins as small to medium sized patches of semi-natural habitat – in intensified landscapes is vital to support both wild and managed pollinator

populations (Eeraerts *et al.* 2017). In the study, a list of other species distributed in the area is given. During the flowering period of the cherry, the pollen collected from the corbiculas of the bees returning to the nest twice a day for 6 days, starting from the day when 100% flowering was reached, were taken and examined. *Taraxacum* and *Lamium* pollen were found, but cherry preference was determined to be almost 90%. It is thought that one of the most important data obtained as a result of the study is the determination of the plant species that can keep the timing of the colonies to be brought to the area with maximum efficiency. It is thought that after the flowering of *Muscari neglectum*, a bulbous plant, the cherries begin to bloom, and the appearance of this species in the field and the arrival of colonies in the garden are very important in terms of the general behavior of the bees and their active participation in pollination. Observations have shown that bumblebees are once again a species with a short flight distance, and the actual foraging range is between 10-40 meters. Detection is also compatible with many studies with the *Bombus terrestris* (Goulson 2010). This region is really important for sweet cherry production, and has been evaluated for pollinator bee fauna (Güler *et al.* 2011, Güler *et al.* 2015, Güler and Dikmen 2017). Observations in the field have shown that queens of *Bombus terrestris* (wild population) start to forage simultaneously with the blooming of apple trees (personel observation-Ç.Ö.). It is important to try different alternative species in order to prevent the mis-pollination syndrome caused by the lack of pollinators during the short and intense cherry blooming period. In America and Europe, it is common practice to place honey bee hives in sweet cherry orchards during full bloom. However, in a big cherry producing country like Turkey, unfortunately, the hiring and use of honey bees for pollination is still an agricultural practice that has not been guaranteed by legal contracts. In addition, bumblebees are mostly preferred in greenhouse production. In this context, it is thought that the simultaneous presence of various species with different behavioral characteristics in the area may also be beneficial for cherry producers for species where the weather conditions during flowering periods are harsh and cross-fertilization is essential for a relatively short period of flowering.

Acknowledgement

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