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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Seasonal population fluctuations and damage rates of *Capnodis tenebrionis* L. and *Capnodis carbonaria* L. (Coleoptera: Buprestidae) in apricot orchards in Malatya province

Malatya ili kayısı bahçelerinde *Capnodis tenebrionis* L. ve *Capnodis carbonaria* L. (Coleoptera: Buprestidae) türlerinin mevsimsel popülasyon yoğunluğu ve zarar oranları

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Ö Z E T / A B S T R A C T

Aims: Seasonal population fluctuations and damage rates of *Capnodis tenebrionis* L. and *Capnodis carbonaria* L. (Coleoptera: Buprestidae) in apricot orchards in Malatya province.

Methods and Results: The study was conducted in 2010-2011 in thirteen apricot orchards in Akçadağ, Battalgazi and Doğanşehir districts of Malatya province. The study was carried out in seven and six apricot orchards in 2010 and 2011 respectively. In both years, the sampled apricot orchards were visited every week and counts were done by visual inspection method. After two years of the study, the population density of pest varied between each sampling year. A total of 1020 *Capnodis* adults were collected in 2010 from all the sampling areas. Among these, 805 were *C. tenebrionis* (688♂:117♀) and 215 were *C. carbonaria* (193♂:22♀). The first adult male and female emergence for *C. tenebrionis* was observed on 27th April and 18th May in 2010 respectively. For *C. carbonaria* first male and female emergence was observed on 22nd June and 20th July respectively. A total of 1170 *Capnodis* adults were collected in 2011 from all the sampling areas. Among these, 903 were *C. tenebrionis* (790♂:113♀) and 267 were *C. carbonaria* (225♂:42♀). The first adult male and female emergence for *C. tenebrionis* was observed on 23rd April and 30th April in 2011 respectively.

Conclusions: In 2010, the largest percentages of *C. tenebrionis* male were collected in August, July and September, while those of its female were collected in August, September and July. The highest number of *C. carbonaria* male and female were collected in August, September and July. In 2011, the largest percentages of *C. tenebrionis* male and female were collected in July, August, September and June. The largest percentages of *C. carbonaria* male were collected in July, August, September and June, while those of its female were collected in July, August and June.

Significance and Impact of the Study: The higher number of *C. tenebrionis* was collected by visual inspection method. The higher number of *C. tenebrionis* was collected than *C. carbonaria* in both years. The damage rates were observed on various varieties between 0.7-30 % in 2010 and 1.3-30 % in 2011.

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INTRODUCTION

Apricot, *Prunus armeniaca* L. (Rosales: Rosaceae), is one of the most important stone fruits and a total produce of 4,257,241 tons of fruit per annum in the world, about 985,000 tons of this amount is produced by Turkey (FAO, 2018). Apricot is grown in almost all orchards in Malatya, where is the most important apricot production region in Turkey (Asma, 2000; Ercişli, 2009). Malatya province has 8 million apricot trees, 73% of which consists of 'Hacıhaliloğlu', a cultivar perfectly suitable for drying, followed by 'Kabaaşı' (17%); other cultivars include 'Hasanbey', 'Çataloğlu', 'Soğanci', 'Çöloğlu', 'Alyanak', 'Sekerpare', 'Kurukabuk' and 'Ismailaga' (Asma, 2000; Asma and Birhanlı, 2004).

The peach flatheaded rootborer, *Capnodis tenebrionis* L. and the almond flatheaded rootborer, *Capnodis carbonaria* Klug have been known as important pests of Rosaceae, particularly apricot (*Prunus armeniaca* L.), plum (*P. domestica* L.), almond (*P. amygdalus* Batsch), cherry (*P. vulgaris* L.), nectarine and peach (*P. persica* L.) (Beu-Yebuda et al.1997; Lodos and Tezcan, 1995; Tezcan, 1995; Ak and Çam, 1998; Martin et al., 1998; Tozlu and Özbek, 2000; Kanat and Tozlu, 2001; Mendel et al., 2003; Çınar et al. 2004; Vit, 2004; Bonsignore and Bellamy, 2007; Bonsignore et al., 2007; Gindin et al., 2009; Ertop and Özpınar, 2011; Dicenta et al., 2011; Karaca and Demirel, 2011; Karaca, 2012; Zobar and Kıvan, 2019; Zobar et al., 2019).

Adults of *Capnodis* feed on the cortex of twigs and young branches and leaf petioles (Rivnay, 1946) and usually prefer weakened and diseased trees rather than vigorous ones prior to mating and oviposition (Malagon, 1989; Ben-Yehuda et al.,2000; Mendel et al.,2003; García del Pino and Morton, 2005; Bonsignore and Bellamy, 2007; Karaca, 2012). Female may lay more than 1000 eggs (Rivnay, 1944) and oviposit on the ground, usually into cracks of dry soil or under stones (Rivnay, 1944; Rivnay, 1946). The neonate larvae feed on the cortex of roots (Rivnay, 1944; Rivnay, 1945; Lodos and Tezcan, 1995; Mendel et al., 2003; Karaca, 2012). The major damage is caused by the larvae in the roots tunnelling between the wood and the bark (Rivnay, 1944; Rivnay, 1946; Lodos and Tezcan, 1995; Ben-Yehuda et al., 2000; Mendel et al., 2003; Bonsignore et al., 2007; Gindin et al., 2009; Dicenta et al., 2011; Karaca, 2012). One-year-old seedlings are killed by single larvae; a few larvae can lead to the death of an adult tree within one or two years (Ben-Yehuda et al., 2000; Mendel et al., 2003; García del Pino and Morton, 2005; Bonsignore and Bellamy, 2007; Karaca, 2012). The current study was to determine seasonal population fluctuations and damage rates of *C. tenebrionis* and *C. carbonaria* (Coleoptera: Buprestidae) in apricot orchards in Malatya province.

MATERIALS and METHODS

The study was conducted in 2010-2011 at thirteen apricot orchards in Akçadağ, Battalgazi and Doğanşehir districts of Malatya province in Turkey. In the first year, the study was carried out in seven apricot orchards, two of which were located in Akçadağ (orchard I (Kabaaşı), orchard II (Kabaaşı + Hacıhaliloğlu), three of them in Battalgazi (orchard I (Hacıhaliloğlu + Hasanbey), orchard II (Hacıhaliloğlu + Hasanbey), orchard III (Hacıhaliloğlu + Hasanbey), and two of them in Doğanşehir (orchard I (Kabaaşı), orchard II (Hacıhaliloğlu + Kabaaşı + Hasanbey + Çataloğlu) districts (Table 1). In the second year, the study was conducted in six apricot orchards, two of which were located in Akçadağ (orchard I (Kabaaşı), orchard II (Kabaaşı + Hacıhaliloğlu), three of them in Battalgazi (orchard I (Hacıhaliloğlu + Hasanbey), orchard II (Hacıhaliloğlu + Hasanbey), orchard III (Hacıhaliloğlu + Hasanbey), and one of them in Doğanşehir (orchard II (Hacıhaliloğlu + Kabaaşı + Hasanbey + Çataloğlu) districts.

The sampled apricot orchards contain 'Kabaaşı', 'Hacıhaliloğlu', 'Hasanbey'and 'Çataloğlu' varieties. The sampling was carried out from 27 April to 5 October in 2010 and from 23 April to 22 October in 2011. In both years, the sampled apricot orchards were visited every week in early morning and adults of flat-headed borers were collected by visual inspection method on the trunk and root part of apricot trees in each of sampled apricot orchards. The collected *Capnodis* spp from each orchard were put into petri dishes and brought to the laboratory. They were sorted out according to the species and gender and their numbers of each species were recorded. The *Capnodis* species collected from each apricot orchard were selected and separated by using the *Capnodis* identification keys prepared by Tezcan (1990) and Tozlu and Özbek (2000). All data were analyzed by analysis of variance (ANOVA) with using the SAS software (SAS Institute Inc., 1998).

Damage Rates in 2010-2011. In the preliminary study conducted in various apricot orchards in Malatya province, the *Capnodis* larvae, varying between 20-95 in different stages, were found in the root part of examined dried or peaky apricot trees removed from the orchard. Therefore, the based on the preliminary study mentioned above, the percentage of *Capnodis*

damage was calculated by counting all dried or peaky apricot trees in each of the sampled apricot orchards and multiplying by a hundred and then dividing by the total number of trees in each of the apricot orchards in order to calculate the percentage of the damaged trees within the particular orchard.

Table 1. Districts and village of sampled apricot orchards, their varieties and total area in 2010-2011.

Districts/village	Sampled orchards	Varieties of apricot	Total area (decare)
Akçadağ/Bahri	Orchard I	Kabaaşı	3
Akçadağ/Bahri	Orchard II	Kabaaşı + Hacıhaliloğlu	12
Battalgazi/Merkez	Orchard I	Hacıhaliloğlu+Hasanbey	15
Battalgazi/Merkez	Orchard II	Hacıhaliloğlu+Hasanbey	6
Battalgazi/Merkez	Orchard III	Hacıhaliloğlu+Hasanbey	7
Doğanşehir/Sürgü	Orchard I	Kabaaşı	5
Doğanşehir/Cumhuriyet Örnek Köy	Orchard II	Hacıhaliloğlu + Kabaaşı + Hasanbey+Çataloğlu	125

RESULTS and DISCUSSION

Seasonal population fluctuations of *C. tenebrionis* and *C. carbonaria* were different in each of sampling year. Both pest species were found in all sampled apricot orchards in 2010-2011. In the first year, seven apricot orchards were sampled in Akçadağ, Battalgazi and Doğanşehir districts. A total of 1020 *Capnodis* adults were collected by visual inspection method at seven sampled apricot orchards. A total of 805 *C. tenebrionis* (688♂:117♀) adults were collected by visual inspection method from all the sampling areas (Figure 1).

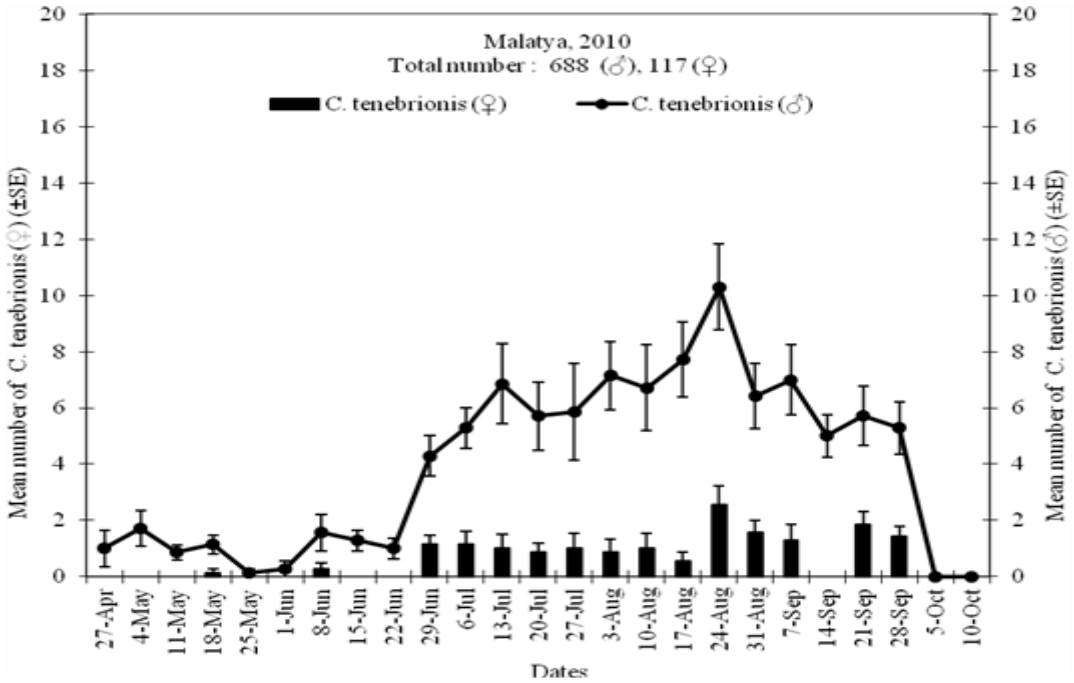

Figure 1. Mean number (±SE) of *C. tenebrionis* (♀, ♂) sampled from 20 April to 10 October 2010 at seven apricot orchards in Malatya province.

The population fluctuation of male (♂) and female (♀) adults varied during the sampling period. The first adult male emergence for *C. tenebrionis* was observed on 27th April and the first female emergence was observed

on 18th May in 2010. The highest mean number of the collected male (♂) were recorded on 24 August, followed by 3, 17 August, 7 September and 10 August. In addition, the highest mean number of the collected female (♀) were recorded on 24 August, followed by 21 September, 31 August and 28 September. The highest number of male adults was observed in August, July and September. Moreover, The highest number of female adults was observed in August, September and July. Zobar and Kıvan (2019) reported that the highest population density of *Capnodis tenebrionis* was observed in July on various cherry rootstocks.

A total of 215 *C. carbonaria* (193♂:22♀) adults were collected by visual inspection method from all the sampling areas (Figure 2).

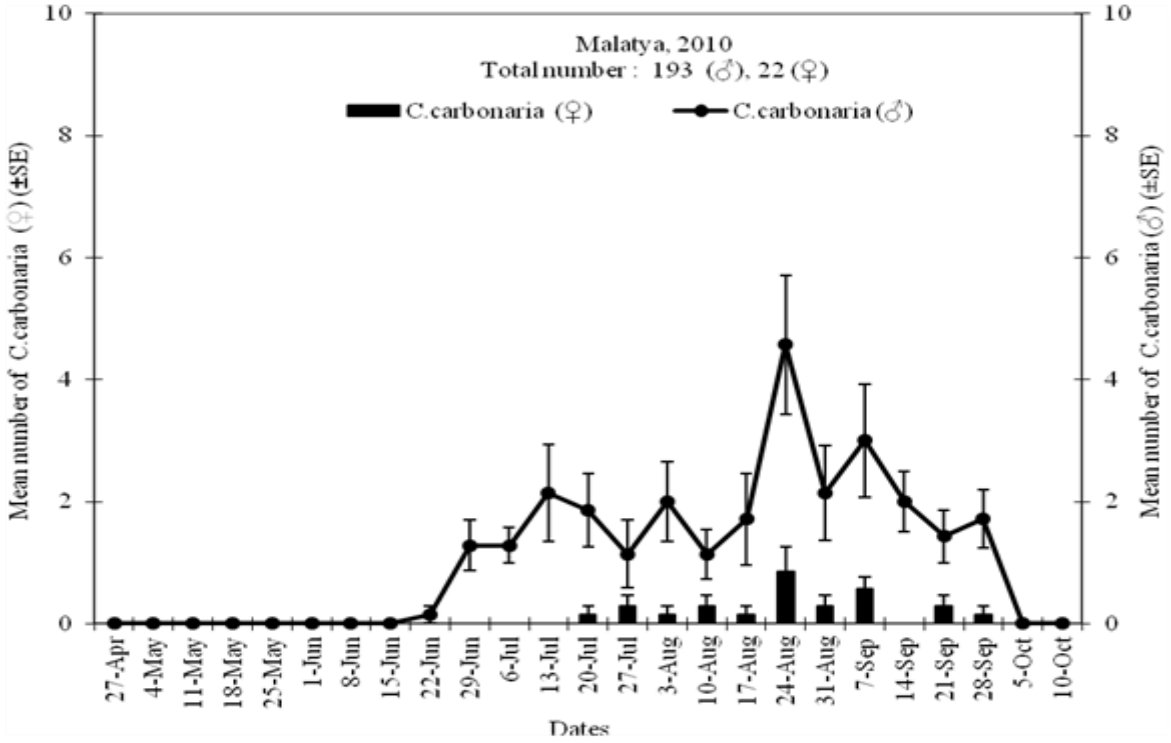

Figure 2. Mean number (±SE) of *C. carbonaria* (♀, ♂) sampled from 20 April to 10 October 2010 at seven apricot orchards in Malatya province.

The population fluctuation of male (♂) and female (♀) adults varied during the sampling period. The first adult male emergence for *C. carbonaria* was observed on 22nd June and the first female emergence was observed on 20th July in 2010. The highest mean number of the collected male (♂) were recorded on 24 August, followed by 7 September, 13 July, 31 July, 2 August and 14 September. In addition, the highest mean number of the collected female (♀) were recorded on 24 August, followed by 7 September and 31 August. The highest number of male and female adults was in August, September and July. In the second year, six apricot orchards were sampled in Akçadağ, Battalgazi and Doğanşehir districts. A total of 1170 *Capnodis* adults were collected by visual inspection method at six sampled apricot orchards, while a total of 903 *C. tenebrionis* (790♂:113♀) adults were collected (Figure 3). The population fluctuation of male (♂) and female (♀) adults varied during the sampling period. The first adult male emergence for *C. tenebrionis* was observed on 23rd April and the first female emergence was observed on 30th April in 2011. The highest mean number of the collected male (♂) were recorded on 21 August, followed by 4 September, 7,14 August and 10 July. In addition, the highest mean number of the collected female (♀) were recorded on 28 August, followed by 10, 17 July, 14 August and 4 September. The highest number of male and female adults was in July, August, September and June. Zobar and Kıvan (2019) reported that the highest population density of *C. tenebrionis* was observed in July on various cherry rootstocks.

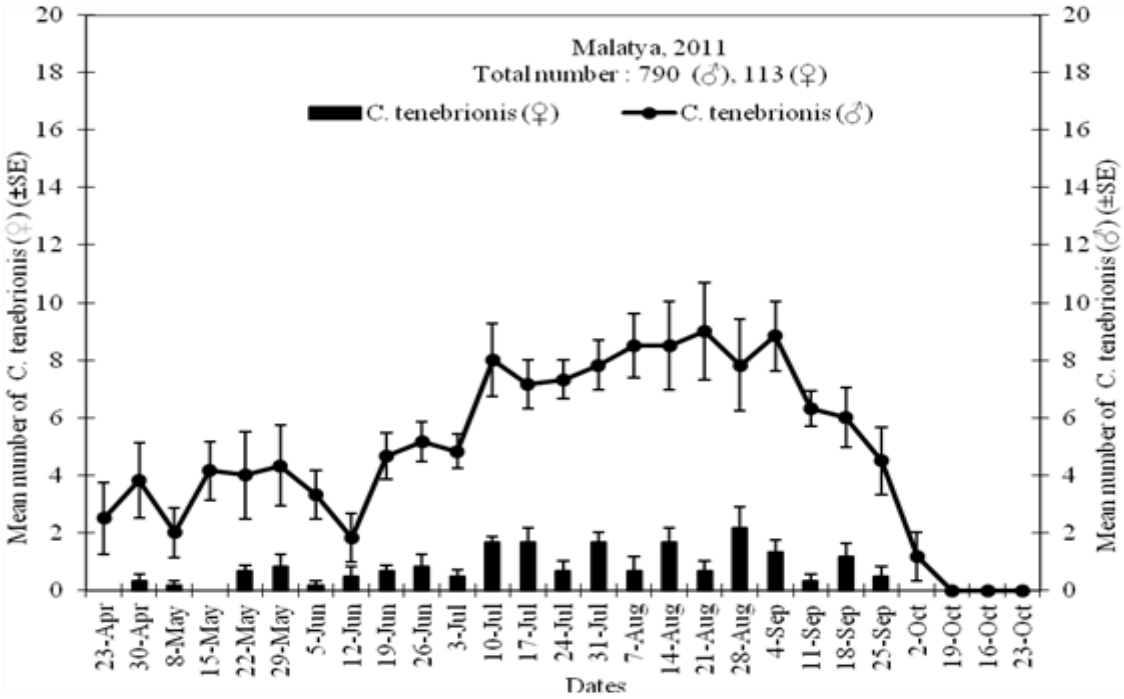

Figure 3. Mean number (±SE) of *C. tenebrionis* (♀, ♂) sampled from 17 April to 23 October 2011 at six apricot orchards in Malatya province.

A total of 267 *C. carbonaria* (225♂:42♀) adults were collected by visual inspection method from all the sampling areas (Figure 4). The population fluctuation of male (♂) and female (♀) adults varied during the sampling period. The first adult male and female emergence for *C. carbonaria* was observed on 30th April in 2011. The highest mean number of the collected male (♂) were recorded on 31 July, followed by 21, 28 August. In addition, the highest mean number of the collected female (♀) were recorded on 31 July. The largest percentages of male adults was in July, August, September and June. In addition, the highest number of female adults was observed in July, August and June.

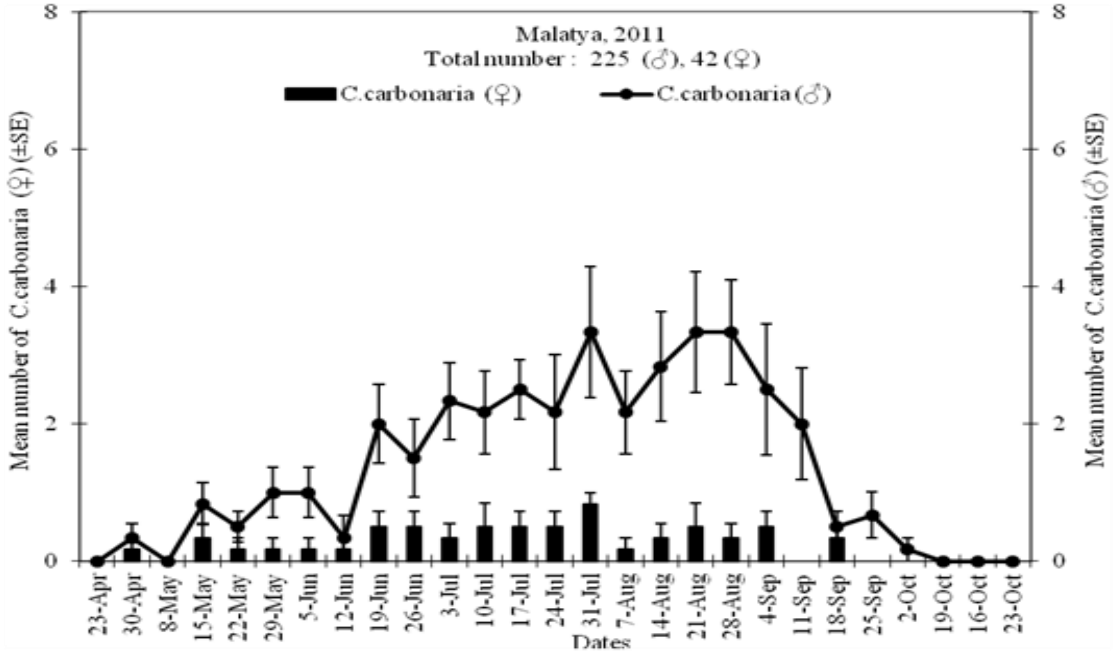

Figure 4. Mean number (±SE) of *C. carbonaria* (♀, ♂) sampled from 17 April to 23 October 2011 at six apricot orchards in Malatya province.

Capnodis tenebrionis and *C. carbonaria* adults emergence accelerated with temperatures higher than 30°C (29th June) and peaked on 24th August when temperature was recorded as 37°C in 2010 (Karaca, 2012). In addition, Karaca (2012) reported that *C. tenebrionis* and *C. carbonaria* adults' emergence accelerated with temperatures higher than 30°C (29th June) and peaked on 24th August when temperature was recorded as 37°C in 2011. On the dates on which high numbers of catches of *C. tenebrionis* were observed with the maximum temperatures of 37, 31, 30.9 and 30.4°C on 10th July, 14th August, 28th August and 4th September respectively. The maximum temperature was 40.2°C on 31st July when the highest number of *C. carbonaria* catches was observed (Karaca, 2012).

Feeding and flight activity increase in higher temperatures (Isard et al., 1999; Bonsignore and Bellamy, 2007). Feeding activity was most marked between 25°C and 40°C. No feeding was observed at temperatures below 20°C (Bonsignore and Bellamy, 2007). The optimal temperature for feeding, movement and flight was 30°C and above with negative effects occurring at 45°C (Bonsignore and Bellamy, 2007). The highest levels of activity occurred at high mean temperatures of between 30°C and 40°C, and the beetles were less active at low temperatures; at 15°C movement is already limited. Flight generally occurred in the middle of the day (Bonsignore and Bellamy, 2007).

The damage rates of *C. tenebrionis* and *C.carbonaria* were different in each of the apricot orchards and sampling year. The damage levels observed and the details of the orchards on 2010 are given as follows; 30% 'Kabaaşı + Hacıhaliloğlu' (3 years old), 22.2% 'Kabaaşı' (7 years old), 14.8% 'Hacıhaliloğlu + Hasanbey' (more than 25 years old), 6.6% 'Hacıhaliloğlu + Hasanbey' (10-15 years old), 3.7% 'Kabaaşı' (more than 20 years old), 2% 'Hacıhaliloğlu + Hasanbey' (more than 20 years old), 0.7% 'Hacıhaliloğlu + Kabaaşı + Hasanbey +Çataloğlu' (more than 20 years old) (Table 2).

The damage levels observed and the details of the orchards on 2011 as follows; 30% 'Kabaaşı + Hacıhaliloğlu' (4 years old), 16.6% 'Hacıhaliloğlu + Hasanbey' (more than 25 years old), 10.2% 'Kabaaşı' (more than 20 years old), 8.3% 'Hacıhaliloğlu + Hasanbey' (10-15 years old), 2% 'Hacıhaliloğlu + Hasanbey' (more than 20 years old), 1.3% 'Hacıhaliloğlu + Kabaaşı + Hasanbey + Çataloğlu' (more than 20 years old).

Table 2. Districts and village of sampled apricot orchards, their varieties, age, number of trees and and damage rates (%) in 2010-2011.

Districts/village	**Sampled orchards**	**Varieties of apricot**	**Age**	**Number of trees**	**Damage rates (%)**	
					2010	**2010**
Akçadağ/ Bahri	Orchard I	Kabaaşı	3	40	30	30
Akçadağ/ Bahri	Orchard II	Kabaaşı+Hacıhaliloğlu	20	107	3,7	10,2
Battalgazi/Merkez	Orchard I	Hacıhaliloğlu+Hasanbey	20 ≥	98	2,0	2,0
Battalgazi/ Merkez	Orchard II	Hacıhaliloğlu+Hasanbey	25 ≥	54	14,8	16,6
Battalgazi/Merkez	Orchard III	Hacıhaliloğlu+Hasanbey	10-15	60	6,6	8,3
Doğanşehir/Sürgü	Orchard I	Kabaaşı	7	45	22,2	-
Doğanşehir/Cumhuriyet Örnek Köy	Orchard II	Hacıhaliloğlu + Kabaaşı + Hasanbey+Çataloğlu	20 ≥	1000	0,7	1,3

Mendel et al. (2003) reported that the mean "host preference"for *C. tenebrionis* (beetle per tree per counting) for *C. tenebrionis* as arranged from the highest to the lowest value per tree was as follows: plum> apricot> peach > almond > apple. Moreover, Mendel et al. (2003) reported that the pattern of host preference by *C. carbonaria* was different from that of its congener: peach > almond >plum > apricot > apple. Occurrence on peach was significantly higher than on the two latter scions. The mean number of eggs of *C. carbonaria* per scion as arranged from the highest to the lowest values per "tree" was peach > plum > apricot >almond > apple. Tezcan et al. (2011) reported that the percentage of *C. tenebrionis* infested saplings and the number of larvae per sapling arranged from the highest to the lowest for cultivar as follows: Şekerpare > Soğancı > X1 Zerdali > Kabaaşı > Tokaloğlu > Adilcevaz 2 > X2 Zerdali > Şam > Adilcevaz 1 > Hacıhaliloğlu > Adilcevaz 4 > Hasanbey, whereas the percentage of *C. carbonaria* infested saplings and the number of larvae per sapling arranged from the highest to the lowest for cultivars as follows: Adilcevaz 1 > Adilcevaz 2 > X2

Zerdali > X1 Zerdali > Hacıhaliloğlu > Soğancı > Hasanbey > Şam > Adilcevaz 4.

In conclusion, the present study was conducted to determine seasonal population fluctuations and damages rates of *C. tenebrionis* L. and *C. carbonaria* L. (Coleoptera: Buprestidae) in apricot orchards in Malatya province. After two years of the study, the seasonal population fluctuations of the pests varied between each sampling year. A total of 1020 *Capnodis* adults were collected in 2010 from all the sampling areas. Among these, 805 were *C. tenebrionis* (688♂:117♀) and 215 were *C. carbonaria* (193♂:22♀). A total of 1170 *Capnodis* adults were collected in 2011 from all the sampling areas. Among these, 903 were *C. tenebrionis* (790♂:113♀) and 267 were *C. carbonaria* (225♂:42♀). The total number of *C. tenebrionis* was higher than *C. carbonaria* in both years. In addition, the total number of male was higher than female in both years. In 2010, the highest number of *C. tenebrionis* male were collected in August, July and September, while female collected in August, September and July. The highest number of *C. carbonaria* male and female were collectd in August, September and July. In 2011, the highest number of *C. tenebrionis* male and female were collected in July, August, September and June. The highest number of *C. carbonaria* male were collected in July, August, September and June, while the female collected in July, August and June. The damage rates were observed on various varieties between 0.7-30 % in 2010 and 1.3-30 % in 2011.

ÖZET

Amaç: Malatya ili kayısı bahçelerinde *Capnodis tenebrionis* L. ve *Capnodis carbonaria* L. (Coleoptera: Buprestidae) türlerinin mevsimsel popülasyon yoğunlukları ile zarar oranlarının belirlenmesidir.

Yöntem ve Bulgular: Çalışma 2010-2011 yıllarında Malatya İlinin Akçadağ, Battalgazi ve Doğanşehir ilçelerinde bulunan on üç kayısı bahçesinde yürütülmüştür. Çalışma 2010 yılında yedi, 2011 yılında altı kayısı bahçesinde gerçekleştirilmiştir. Her iki yılda da örneklenen kayısı bahçeleri her hafta ziyaret edilmiş ve görsel inceleme yöntemiyle *Capnodis* erginleri toplanmıştır. Çalışmanın sonucunda zararlıları popülasyon yoğunlukları örnekleme yapılan yıllara göre farklılık göstermiştir. 2010 yılında bütün örnekleme alanlarından toplam 1020 adet *Capnodis* ergini toplanmıştır. Toplanan erginlerin 805 adedi *C. tenebrionis* (688♂:117♀), 215 adedi de *C. carbonaria* (193♂: 22♀)'dır. İlk *C. tenebrionis* erkek ergin çıkışı 27 Nisan'da olurken, ilk dişi ergin çıkışı 18 Mayıs'da gözlenmiştir. Örnekleme süresince en fazla erkek ve dişi birey 24 Ağustos tarihinde yakalanmıştır. İlk *C. carbonaria* erkek ergin çıkışı 22 Haziran'da olurken, ilk dişi ergin çıkışı 20 Temmuz'da gözlenmiştir. 2011 yılında bütün örnekleme alanlarından toplam 1170 adet *Capnodis* ergini toplanmıştır. Toplanan erginlerin 903 adedi *C. tenebrionis* (790♂:113♀), 267 adedi de *C. carbonaria* (225♂:42♀)'dır. İlk *C. tenebrionis* erkek ergin çıkışı 23 Nisan'da olurken, ilk dişi ergin çıkışı 30 Nisan'da gözlenmiştir. Örnekleme süresince en fazla erkek birey 21 Ağustos ve dişi bireylere ise 28 Ağustos tarihinde rastlanmıştır.

Genel Yorum: 2010 yılında, *C. tenebrionis'*in erkekleri en yüksek rastlanma yüzdesi ağustos, temmuz ve eylül aylarında, dişiler ise ağustos, eylül ve temmuz aylarında toplanmıştır. *C. carbonaria'*nın erkek ve dişileri en yüksek rastlanma yüzdesi ağustos, eylül ve temmuz aylarında toplanmıştır. 2011 yılında, *C. tenebrionis*'in erkek ve dişileri en yüksek rastlanma yüzdesi temmuz, ağustos, eylül ve haziran aylarında elde edilmiştir. *C. carbonaria* erkekleri en yüksek rastlanma yüzdesi temmuz, ağustos, eylül ve haziran aylarında, dişiler ise temmuz, ağustos ve haziran aylarında toplanmıştır.

Çalışmanın Önemi ve Etkisi: Çalışmada daha fazla sayıda *C. tenebrionis* ergini görsel inceleme yöntemiyle toplanmıştır. Her iki yılda da *C. carbonaria*'dan daha fazla sayıda *C. tenebrionis* ergini toplanmıştır. Örnekleme yapılan çeşitlerde 2010 yılında % 0,7-30 ve 2011 yılında % 1,3-30 arasında zarar oranları belirlenmiştir.

Anahtar Kelimeler: *Capnodis tenebrionis*, *Capnodis carbonaria* , kayısı, populasyon yoğunluğu, zarar oranı, Malatya.

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CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

AUTHOR'S CONTRIBUTIONS

The contribution of the authors is equal.

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