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Original article (Orijinal araştırma)

Investigation of possible use of pheromone trap for adult population development and control of *Ips sexdentatus* (Börner, 1776) (Coleoptera: Scolytidae) damaging black pine in Başkent University Bağlıca Campus afforestation area

Başkent Üniversitesi Bağlıca Kampüsü ağaçlandırma alanında karaçamlara zarar yapan *Ips sexdentatus* (Börner, 1776) (Coleoptera: Scolytidae)'un ergin popülasyon gelişimi ve mücadelesine yönelik olarak feromon tuzak kullanım olanaklarının araştırılması

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Abstract

The six-toothed pine bark beetle, *Ips sexdentatus* (Börner, 1776) (Coleoptera: Scolytidae), is one of the important pests of Pinus and Picea species in the forests of Türkiye. Başkent University Bağlıca Campus was established in 1993 and approximately 5 million trees have been planted in the area to date, including those that have dried up. Pheromone traps were hung in campus for monitoring the adult population development, determining the flight activities of the insect and controlling it on IPM principles. The first adult emergence of *I. sexdentatus* in Bağlıca took place in the first half of April, the highest flight activity was in April. *Ips sexdentatus* produced three generations in the region. The highest numbers of adults caught in traps were 741 (27 July 2021) and 421 (25 April 2022), respectively. In the Bağlıca Campus, a total of over 19,000 insects were caught and eliminated. Almost 328 tC of carbon stock was preserved and prevented from being released into nature and at least 11.100 black pine trees were saved or 26.640 USD was contributed to the economy. Using pheromone traps for the control of *I. sexdentatus* is recommended as a sustainable method that protects biodiversity, without any disturbance of the ecological balance.

Key words: Bark beetles, conifers, *Ips sexdentatus*, pheromone trap

Öz

On iki dişli çam kabuk böceği, *Ips sexdentatus* (Börner, 1776) (Coleoptera: Scolytidae), Türkiye'deki ormanlık alanlarda Pinus ve Picea türlerinin önemli zararlılarından biridir. Başkent Üniversitesi Bağlıca Kampüsü 1993 yılında kurulmuş ve bugüne kadar alana kuruyanlar da dahil olmak üzere yaklaşık 5 milyon ağaç dikilmiştir. Ergin popülasyon gelişiminin izlenmesi, böceğin uçuş faaliyetlerinin belirlenmesi ve IPM prensiplerine göre kontrol edilmesi için kampus alanına feromon tuzaklar asıldı. *Ips sexdentatus*'un Bağlıca'daki ilk ergin çıkışı Nisan ayının ilk yarısında gerçekleşmiş, en yüksek uçuş aktivitesi Nisan ayında olmuştur. *Ips sexdentatus* bölgede üç döl vermiştir. Tuzaklarda yakalanan en yüksek ergin sayıları sırasıyla 741 (27 Temmuz 2021) ve 421 (25 Nisan 2022) olmuştur. Bağlıca Kampüs alanında toplam 19.000'in üzerinde böcek yakalanarak bertaraf edilmiştir. Yaklaşık 328 tC karbon stoku korunarak doğaya salınması engellenmiş ve en az 11.100 karaçam ağacı kurtarılmış veya ekonomiye 26.640 USD katkı sağlanmıştır. *Ips sexdentatus* mücadelesine yönelik olarak feromon tuzakların kullanılmasının, sürdürülebilir, biyolojik çeşitliliği koruyan ve ekolojik dengeyi bozmayan bir yöntem olarak tavsiye edilmektedir.

Anahtar sözcükler: Kabuk böcekleri, iğne yapraklılar, *Ips sexdentatus*, feromon tuzağı

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Introduction

The six-toothed pine bark beetle *Ips sexdentatus* (Börner, 1776) (Coleoptera: Scolytidae) is considered one of the most dangerous bark beetles in the world. It is a quarantine pest included in the EPPO Annex III quarantine list in the EU. In Türkiye, it is included in the EPPO A2 list (EPPO, 2016) as it is one of the most important bark beetles damaging forest areas. *Ips sexdentatus* has been reported on the following species; *Pinus koraiensis* Siebold & Zucc., *Pinus leucodermis* Ant.*, Pinus nigra* J. F. Arnold*, Pinus sibirica* Du Tour*, Pinus sylvestris* L. and *Picea orientalis* (L.) Peterm (Pinelas: Pinaceae) in Europe, Caucasus, Anatolia, Siberia, Korea, Japan and Northern China (Pfeffer, 1995; Kolk & Starzyk, 1996; Faccoli, 2004; Gilbert et al., 2005; FAO, 2007; Sarikaya et al., 2012; Baydemir, 2016; EFSA, 2017; EPPO, 2023). *Ips sexdentatus* mainly attacks pines (EFSA, 2017) and was first detected in Türkiye in 1928 by Bernhard in spruce forests in the Trabzon province. Approximately one million of eastern spruce were lost due to sporadic *I. sexdentatus* infestations in Türkiye between 1928 and 1938 (Defne, 1954; Beşceli & Ekici, 1969). The pest was later detected in different regions of Türkiye and pheromone traps were used for its control (Defne, 1954; Chararas, 1966; Beşceli & Ekici, 1969; Tosun, 1975; Serez, 1984; Selmi, 1989; Sekendiz, 1991; Yüksel, 1996, 1998; Yüksel et al., 2000; Cebeci, 2003; Dönmez, 2006; Eyüpoğlu, 2011; Ozcan et al., 2011; Sarıkaya & Avcı, 2011; Sarıkaya et al., 2012; Akkuzu & Güzel, 2015; Anonymous, 2016; Özcan, 2017a, b; Yiğit, 2017; Özcan et al., 2018; Şahin, 2019).

This pest is mostly a secondary pest, which generally uses stumps, fallen trees and large branches as host material (EFSA, 2017). It is known that bark beetles generally cause damage to trees weakened by wind, frost, drought, etc. (Coşkun et al., 2010). Under normal conditions, bark beetles are known as secondary pests, but when conditions are favorable, they can become primary pests thanks to their ability to reproduce excessively (Çanakçıoğlu & Mol, 1998; Göktürk, 2002; Sarıkaya & Avcı, 2006). As a result of these attacks, *I. sexdentatus* can kill many trees in the same year due to the explosion on its population (Schimitschek, 1953; Christiansen et al., 1987; Jactel & Lieutier, 1987; Jactel & Gaillard, 1991; Öymen & Selmi, 1997; Seedre, 2005; Fettig et al., 2007; Ozcan et al., 2011; Özcan, 2017a). Bark beetles also play an important role in the transmission of pathogenic ophiostomatoid fungi (Levieux et al., 1991; Kirisits, 2004; Romon et al., 2008; Bueno et al., 2010; Jankowiak, 2012). They cause blue staining of the wood and some of them may lead to tree death (EFSA, 2017).

It is known that the host selection of bark beetles, their desire for population growth in their chosen hosts, and their behavior are quite complex (Graves et al., 2008; Pineau et al., 2016; Özcan, 2017a). The adults overwinter in the bark of their hosts or in the litter and disperse in spring, flying in search for new hosts, sometimes over large distances. Six-toothed pine bark beetle adults are capable of flying for miles in search of suitable host trees (Sarıkaya et al., 2012). Jactel & Gaillard (1991) found that 98% flew more than 5 km, 50% more than 20 km and 10% more than 45 km. In Türkiye, *P. sylvestris, P. nigra, Pinus brutia* Ten.*, Pic. orientalis, Abies nordmanniana* (Steven) Spach and *Abies bornmulleriana* Mattf. (Pinelas: Pinaceae) are common host trees. They grow in 23 provinces and many districts of Central Anatolia, Eastern Anatolia, Black Sea, Aegean and Mediterranean Regions. The bark beetle can produce 1 to 5 offsprings per year depending on climatic conditions (FAO, 2007; EFSA, 2017). In Türkiye, it usually gives two offsprings per year, but it has been determined that depending on climatic conditions, it can also give three offsprings (Ataman, 1967; Erdem, 1968; Acatay, 1969; Beşçeli & Ekici, 1969; Tosun, 1975; Sekendiz 1984, 1985; Selmi, 1989, 1998; Yüksel, 1997; Çanakçıoğlu & Mol, 1998; Yüksel et al., 2000; Yücel, 2001; Toper Kaygın, 2007; Eyüboğlu, 2011; Güzel, 2018).

Başkent University Bağlıca campus was established in 1993 at a former excavation dumping site. The campus consisted of a rocky area, with only one or two trees on the campus. However, after the establishment of the university, following the cleaning of the excavation waste, afforestation works were conducted regularly every year. Today, more than 5 million different trees such as pine, oak, spruce, etc.

have been planted. Dead trees are replaced by new plants (Anonymous, 2022). In order to prevent possible erosion on the campus area and to create terraces, Başkent University has planted many plants including *Cupressus sempervirens* L.*, Cupressus arizonica* Greene (Cupressales: Cupressaceae)*, Pinus nigra* subsp. *nigra* var. *caramanica* (Loudon) Businský (Pinelas: Pinaceae)*, Acer negundo* L. (Sapindales: Sapindaceae)*, Robinia pseudoacacia* Mattf. (Fabales: Fabaceae)*, Prunus domestica* L.*, Prunus cerasifera* Ehrh., *Amygdalus communis* L. (Rosales: Rosaceae)*, Betula verrucose* Ehrh. (Fagales: Betulaceae)*.*

In addition, Başkent University was ranked the 199th Most Environmentally Friendly and Sustainable University in the World and the 13th University of Türkiye in the 2022 UI GreenMetric World Universities Ranking. A totally, 1.050 universities participated in this evaluation all around the world. Başkent University ranks as the first university among Foundation Universities in Ankara. Especially after harsh winter months, it is observed that the black pine trees on the campus area dried up. During examinations, bark beetle entry holes were detected in the dried tree trunks. The samples obtained from the dried trees were identified by the Ministry of Agriculture and Forestry, General Directorate of Forestry as *I. sexdentatus,* a six-toothed pine bark beetle. Since Başkent University Bağlıca campus has a sensitive ecological balance and as chemical control is not preferred in forest areas. The objectives of this study were to trial the use of pheromone traps in monitoring the adult flight periods of *I. sexdentatus*, tracking their population growth, determining the flight activities of the insect, and carrying out integrated control of this insect sustainably to protect biodiversity and the environment. For this purpose, studies were carried out on Başkent University Bağlıca Campus in 2021 and 2022 with the use of Scandinavian type Three Funnel Pheromone Traps.

Materials and Methods

Geographical location of the research area

The Bağlıca campus of Başkent University is located at Ankara-Eskişehir highway 18 Km in the area of Bağlıca Village (Anonymous, 2023a). It has a total area of 36 ha and an elevation ranging from 930 m to 1150 m (Töre & Erik, 2012). Başkent University Campus is located at 39°53´19.7268" latitude and 32°39´5.5944" longitude (Anonymous, 2023b). Different tree species grow on the campus area including *P. nigra* subsp. *nigra* var. *caramanica, Pr. domestica, Pr. cerasifera, A. communis, C. sempervirens, C. arizonica, A. negundo, Astragalus microcephalus* Willd., *Astragalus strictifolius* Boiss.*, Astragalus acicularis* Bunge, *Astragalus podperae* Širj., *Astragalus nitens* Host (Fabales: Fabaceae)*, Globularia orientalis* L. (Lamiales: Plantaginaceae)*, Salvia cryptantha* Montbret & Aucher ex Benth. (Lamiales: Lamiaceae), *R. pseudoacacia* and *B. verrucosa* (Töre & Erik, 2012). This study was conducted out at Başkent University of Bağlıca Campus between 2021 and 2022.

Climate

Monthly and annual temperature values provided by the nearby Etimesgut Bağlıca station from 2017 to 2022 are given in Table 1. Average temperature on Bağlıca campus is in August (22.92°C) and in January (1.89°C). The annual average temperature is 12.89°C. The maximum temperature is 31.66°C in August, while the minimum temperature is observed in January (-1.41°C). The highest precipitation is in January with 2.41 mm. The driest month is September with 0.17 mm. The average annual precipitation is 1.05 mm.

Maximum average humidity is 93.51% in June, minimum average humidity is 22.36% in August, and annual average humidity is 62.36%. Maximum wind speed is 25.32 km/h in January and minimum wind speed is 3.87 km/h in October, with an annual average wind speed of 12.18 km/h. and it is understood that the highest precipitation falls in winter (4.52 mm), followed by fall (3.38 mm), spring (3.19 mm) summer (0.72 mm) (Table 1).

Table 1. Bağlıca meteorological data (averaged data between 2017 and 2022)

Meteorological data	Months												Annual average
	I	I II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Average Temperature (°C)	1.89	4.93	6.98	11.98	16.25	19.55	22.07	22.92	19.11	14.45	9.45	5.42	12.89
Maximum Temperature (°C)	5.49	9.46	12.30	18.30	22.86	25.98	30.19	31.66	27.40	21.68	15.49	9.63	19.15
Minimum Temperature (°C)	-1.41	0.88	1.79	4.98	8.61	12.15	13.06	13.64	10.96	7.66	4.09	1.90	6.54
Average RH (%)	78.56	72.54	63.00	56.94	59.18	63.38	56.41	52.70	53.01	55.55	60.74	73.99	62.36
Maximum RH (%)	91.65	89.79	85.04	85.29	89.55	93.51	92.65	90.01	86.47	83.84	83.76	90.20	88.55
Minumum RH (%)	61.41	53.09	41.09	33.57	34.39	36.55	26.52	22.36	24.14	29.46	37.27	54.24	38.06
Total precipitation (mm)	2.41	1.00	1.11	0.80	1.36	1.03	0.25	0.30	0.17	0.39	1.05	1.94	1.05
Maximum wind speed (km/h)	25.32	21.68	24.48	22.11	19.99	18.49	22.92	22.46	19.74	17.28	16.40	19.03	20.70
Minumum wid speed (km/h)	6.19	4.83	5.79	5.01	4.26	4.62	5.45	4.94	4.06	3.87	3.88	4.23	4.73
Average wind speed (km/h)	15.15	13.09	14.66	13.22	12.09	11.30	13.04	12.39	11.44	10.37	10.05	10.89	12.18
Wind direction (°)	210.5	202.7	215.3	213.9	230.1	211.4	182.0	151.8	204.9	178.4	155.8	190.4	194.3

Adult population monitoring of *Ips sexdentatus*

This study was conducted at Başkent University Bağlıca Campus' afforestation area between 2021 and 2022 in order to determine the basic biology, population growth, and flight periods of *I. sexdentatus* and to study possibilities of sustainable control of the pest by mass trapping. The main goal was to keep *I. sexdentatus* below the damage level by hanging pheromone traps in the study area. In this context, IPSSEX pheromone dispenser packages containing 60 mg of Ipsdienol as active substance, which is licensed in Türkiye, and Scandinavian type three funnel pheromone traps (for mass capture) were hung (Figure 1). The first bark beetle aggregation pheromone was identified in *I. paraconfusus* as a mixture of ipsdienol, ipsenol and cis-verbenol (Silverstein et al., 1966). The IUPAC name for ipsdienol, 2-methyl-6- methylene-2,7-octadien-4-ol. Detailed information about ipsdienol has documented by Blomquist et al. (2010).

Figure 1. Scandinavian type pheromone trap with three funnels.

Pheromone traps were placed in the field according to the recommendation on the label, with 4 traps per 1 ha area and the entire study area covering 2.5 ha (2021) and 5 ha (2022), respectively. The traps were hung at a height of 150-170 cm above the ground as stated in the label recommendation (Şahin, 2019), in the direction of the prevailing wind, periodically monitored and the developmental stages of the insect were observed and checked every 10 days. The study started on 17.07.2021 as soon as the pest was detected in the field (Figure 2a, b).

Figure 2. *Ips sexdentatus*: a) damage and b) larvae.

Results

Determination of adult population development of *Ips sexdentatus*

The flight activity of *I. sexdentatus* and adult population development of the pest between 2021 and 2022 on the Başkent University Bağlıca Campus are given in Figures 3 & 4. During the 2021 trials, the pheromone traps were installed on 17.07.2021. The counts showed that until the end of the season, there was a high density population. When Figure 3 is examined, two peaks are visible on 27 July and 18 October 2021 with the highest adult population recorded at 741 pieces/trap and 516 pieces/trap, respectively. In 2021, the average number of adult beetles caught in the traps during the season was determined as 1.257 per trap. In 2021, 3.120 adults were collected from traps on 27 July. On this date, the average temperature was 22.35°C, the average humidity was 57.7% and the average wind was 21.87 km/h. The peak on 27 July 2021 was understood to be the first generation of the pest and 3.120 beetles were collected from the traps. In the following period, the number of adults decreased until 10 August 2021, when the average temperature was between 18.12°C and 29.89°C, the average humidity between 35.3% and 67.3% and the average wind between 10.33 and 20.15 km/h. From 10 August to 15 September 2021, when the mean temperature ranged from 15.21 to 27.76°C, the mean humidity from 32.5% to 65.2% and the mean wind from 6.95 to 23.35 km/h, an increase in the number of adults was again observed. From 15 September to 04 October 2021, an increase in the number of adults was again detected. However, it is assumed that these increases are not due to a new generation but are probably related to the increase in temperature.

It was determined that the second generation of adults appeared on 18 October 2021, when the average temperature increased to 11.58°C and the average humidity increased to 73.2% as 2.316 adults were caught in traps. The average wind was 5.43 to 17.99 km/h. Adult flight started to decrease after October 18, 2021 and ended on November 03, 2021 in Bağlıca Campus in 2021.

In 2022, pheromone traps were hung in the campus area on 9 April and the first adult flight was observed on 16 April (Figure 4). On this date, the average temperature was 14.10°C, the average humidity was 48.29% and the average wind was 8.6 km/h. On 25 April 2022, a total of 3.199 first-generation adults were collected from the traps. On this date, the average temperature was 19.40°C and the average humidity was 49% with an average wind speed of 12.6 km/h. In the following period, there was a slight decrease in the number of adults until 23 May 2022, when the average temperature was between 8.20°C and 19.40°C, the average humidity was 39.83% to 79.13% and the average wind was 6.5 to 27.7 km/h. From 23 May to 08 June 2022, the mean temperature ranged from 8.76°C to 24.87°C, the mean humidity from 37.63% to 77.38%, the mean wind from 7.6 to 16.6 km/h and the number of adults increased again. From 08-20 June 2022, a decrease in the number of adults was observed. On 8 June and 6 September 2022, two significant population increases were detected. However, these increases were not due to a new generation but probably related to the increase in temperature.

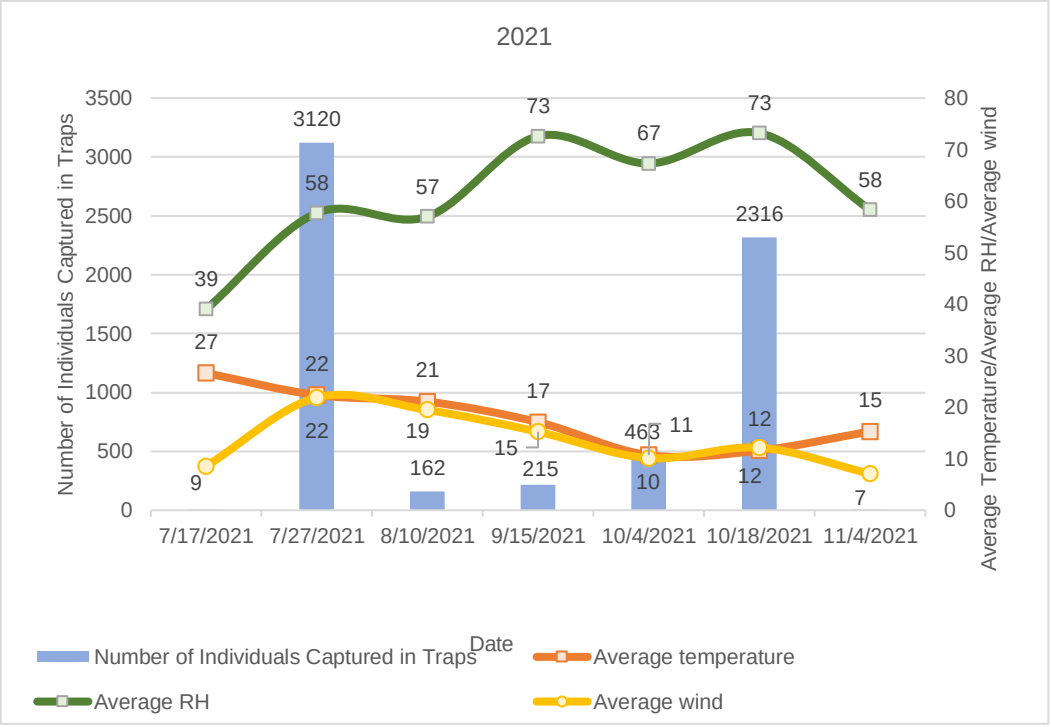

Figure 3. Adult population development and flight activity of *Ips sexdentatus* on Başkent University Bağlıca Campus in 2021.

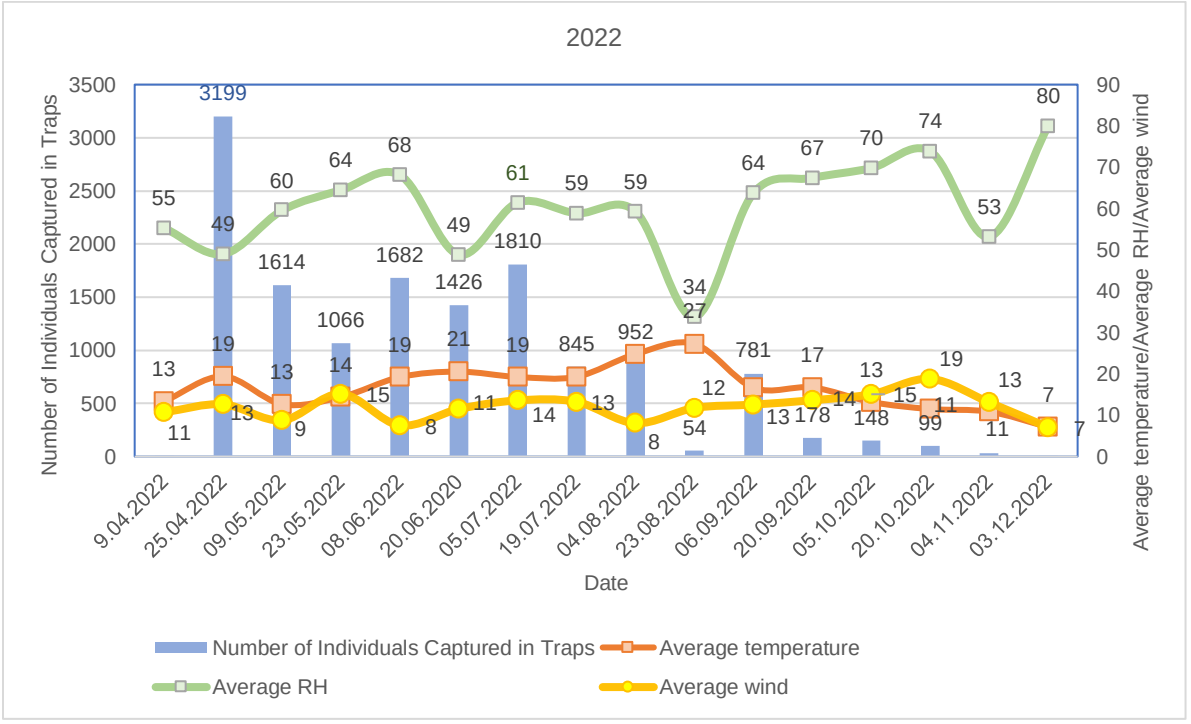

Figure 4. Adult population development and flight activity of *Ips sexdentatus* on Başkent University Bağlıca Campus in 2022.

The second generation of adults occurred on 05 July 2022, when the average temperature was 20.56°C, the average humidity 48.83% and the average wind 11.5 km/h. 1.810 beetles were caught in the traps. It was determined that a third generation of the pest occurred on 4 August 2022, when the average temperature was 24.79°C, the average humidity was 59.29% and the average wind was 8.1 km/h. 952

beetles were caught in the traps. In 2022, the highest number of adults caught for *I. sexdentatus* was on 09 May with 417 beetles per trap on average, followed by 26 June with 390 beetles per trap on average, and the number of adults caught in traps during the entire season was on average 1.892 per trap. On 26 and 30 October 2022, there were days when the minimum temperature dropped down to -0.39°C to -2.19°C and the number of adults decreased until 04 November 2022. During this period, the average humidity was 33.2% to 72.6% and the average wind was 5.43 to 17.99 km/h.

In order to determine the number of generations of the pest, Figure 4 shows that the pest population formed three main peaks on Bağlıca Campus. These peaks occurred on 25 April, 05 July and 04 August 2022. This is indicative that the pest produced three generations. To confirm, the number of generations of the pest was calculated also using meteorological data from the region. Pest development threshold and thermal constant values found by Pineau et al. (2016) were used in this calculation. Using the development threshold (10.9°C) and maximum development temperature (36°C) and thermal constant (517 day-degree) values of the pest, the daily average temperatures above 36°C were excluded from the daily average temperatures in Bağlıca district. The remaining daily average temperatures were subtracted from the development threshold temperature of 10.9°C and the remaining values were summed for the whole year and the sum of effective temperatures was calculated as 1.548,73 degree-day. When this value was divided by thermal constants, it was determined that *I. sexdentatus* could produce 2.99 generation in Bağlıca district. Considering the findings of Pineau et al. (2016), the number of generations in the Bağlıca district of Başkent University is three, which is compatible with the peaks observed in the traps.

In summary, 5.899 adults were caught in 10 traps in 2021, while 13.560 adults were caught in 20 traps in 2022. This shows how effective the control activities carried out with pheromone traps are. When the average temperature was above 10.9°C (Pineau et al., 2016), which is the development threshold of the pest, it was observed that the active flight period started. The highest number of adults caught in traps was on average 741 beetles/trap (27 July 2021) and 421 beetles/trap (25 April 2022), respectively. During the study, also the beneficial insect *Rhizophagus dispar*, the predator of *I. sexdentatus*, was caught in pheromone traps in the campus area, detected and then released back into the field.

Discussion

The present study determined that the first adult emergence of *I. sexdentatus* in the Başkent University Bağlıca campus took place in the first half of April and the pest population produced three peaks on 25 April, 5 July and 04 August, equal to three generations of bark beetles. This value was confirmed by calculations using meteorological data. The active flight period spans seven to eight months a year until end of November when the weather gets colder. Selmi (1998) stated that *I. sexdentatus* normally produces two generations per year in Türkiye and can give a third generation under suitable weather conditions. Sarıkaya (2008) determined that in the Western Mediterranean Region and Yıldırım (2011) in the forests of the Isparta-Aksu region that *I. sexdentatus* gives three generations per year. In our study, it was determined that *I. sexdentatus* gives three generations per year, which is in accordance with the studies of Selmi (1998), Sarıkaya (2008) and Yıldırım (2011). The first pheromone trap trials against *I. sexdentatus* started in 1982 in oriental spruce forests in Türkiye (Serez, 2001).

Chararas (1966) states that a total of 16.000 offsprings can occur over three generations from one female insect, assuming that the sex ratio is 1:1 (Pineau et al., 2016), mortality rate is 17% due to unopened eggs and losses due to parasitoids and predators, and a maximum of 13.280 pests could occur in the 3rd generation. The number of 13.560 adult beetles caught during this study is in line with the assumption that three generations were produced. Obtained data showed the importance of ambient temperature and humidity as well as light and moderate wind speed (Anonymous, 2023c) to the spread of *I. sexdentatus*. It is known that *I. sexdentatus* beetles have the ability to fly for kilometers in search of suitable host trees (Sarıkaya et al., 2012) and it is understood that they can increase their flight distance and spread with the help of wind (EFSA, 2017).

To evaluate the environmental and economic dimension of the present study, in order to reveal the success of the mass trapping method, the carbon stock in black pine trees was determined as 65.776 (2.225-119.686) tC/ha on average by the General Directorate of Forestry of the Ministry of Agriculture and Forestry of Türkiye (Anonymous, 2015). Considering that the study area was 5 ha, it was determined that at least 328 tC of carbon stock was preserved and prevented from being released into nature. Specific economic loss is not known for *I. sexdentatus.* However, considering that there can be 2.220 to 3.100 black pine trees in 1 ha area (Anonymous, 2014), it was determined that at least 11.100 black pine trees were saved or 26.640 USD (value of one seedling tree is assessed as 12 USD). If carbon stock is included in these figures, the economic dimension will increase even more.

Another important finding was that although the pheromones in the traps were recommended to be changed at intervals of 4-6 weeks by the registered company, it was evaluated that it is better to replace the pheromones in the traps every 4 weeks during the very hot weather conditions in order to maintain the effectiveness of the pheromone traps.

Ips sexdentatus spends its entire developmental period in plant tissue and feeds mostly on physiologically weakened trees. Trees are host to *I. sexdentatus* as a result of storm breakage and toppling, snow breakage, fires, large-scale eating of leaves by other insects and extreme droughts (Yüksel, 1996). Although *I. sexdentatus* is generally seen as secondary pest that causes growth retardation and loss of increment in coniferous forests, it can cause large damage when appearing in clusters, especially in young affforestration areas where closure is newly formed, and in some cases, it can completely destroy the afforestration site (Anonymous 2016). Therefore, Bağlıca Campus, which is a relatively young afforestration campus, is under serious threat from *I. sexdentatus*.

In the current study, 5.899 beetles were caught with the help of pheromone traps managed in Bağlıca Campus during a 4-months period starting from 17 July 2021, while this number increased to 13.560 beetles when repeating the trials as of 09 April 2022 conducted over a doubled area with twice the number of traps. It is reported that *I. sexdentatus* females lay between 10-60 eggs. Since the sex ratio is 1:1, this control effort prevented the population from reaching higher levels and reduced the number of existing ones, and successful control was performed with non-chemical methods in the forest area (Yüksel et al., 2005).

Bağlıca Campus, which is a young afforestration area, is under serious threat from *I. sexdentatus*. Since the number of trees in the Bağlıca campus increases every year, important data were obtained in this study to determine the population density of *I. sexdentatus* in the afforestation area and whether it was possible to control it with mass trapping method. The trials also showed that the pest has a very high damage potential unless precautions are taken. As the mass trapping method with the use of pheromone traps is specific to the pest species, it has no negative effects on beneficial organisms such as parasitoids, predators, honey bees and other pollinator insects, vertebrate animals and humans. In addition, this method is compatible with the environment, and does not require special tools and equipment, while it can be reused, and help reduce the use of chemical pesticides against pests. It is understood that use of pheromone traps helps beneficial insects to resettle and develop in the area. At the same time, since it minimizes or eliminates the use of pesticides, it contributes to the re-establishment of the natural balance in that area as soon as possible, which was previously disrupted due to the use of chemical pesticides (Anonymous, 2016). In spite of the advantages mentioned above, there is a disadvantage that natural enemies may fall into the trap (Wainhouse, 2005), like the beneficial insect *Rhizophagus dispar* detected in the study area.

Pheromone traps have been used for *I. sexdentatus* control in Türkiye and this project result is supported by other researches based on field findings (Defne, 1954; Chararas, 1966; Beşceli & Ekici, 1969; Tosun, 1975; Serez, 1984; Selmi, 1989; Sekendiz, 1991; Yüksel, 1996, 1998; Yüksel et al., 2000; Cebeci, 2003; Dönmez, 2006; Eyüpoğlu, 2011; Ozcan et al., 2011, 2017a, b, 2018; Sarıkaya & Avcı, 2011; Sarıkaya et al., 2012; Akkuzu & Güzel, 2015; Anonymous, 2016; Yiğit, 2017; Şahin, 2019).

In conclusion, in order to protect forest/afforestation areas against pests like *I. sexdentatus*, it is important to monitor the pest population at regular intervals and to take timely measures for its control. It is essential to regularly monitor the population level of the six-toothed pine bark beetle, *I. sexdentatus*, and within the scope of integrated pest control, it is possible to use pheromone for mass trapping, which provides a sustainable method protecting biodiversity and does not have a negative effect on natural enemies in the environment.

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