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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Population dynamics of cotton leafhoppers [*Asymmetrasca decedens* and *Empoasca decipiens* (Hemiptera: Cicadellidae)] in conventional cotton production areas of Hatay province, Türkiye

Hatay ili konvansiyonel pamuk üretim alanlarında bulunan pamuk yaprakpirelerinin [*Asymmetrasca decedens* ve *Empoasca decipiens* (Hemiptera: Cicadellidae)] popülasyon dinamikleri

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ABSTRACT

In this study, the population dynamics of cotton leafhoppers [*Asymmetrasca decedens* (Paoli) and *Empoasca decipiens* (Paoli)] in conventional cotton production areas of Hatay province were investigated using the sweep-net sampling method. In the Melekli district, while 68.75% of the 5.480 individuals collected in 2022 were in the generative stage, while this population reaches 5,803 individuals in 2023, this population is predominantly (63.53%) were concentrated in the vegetative period, but the peak of the population period (generative) remained the same. In the Reyhanlı district, the 6.762 individuals collected in 2022 showed a relatively similar distribution across the vegetative and generative stages of cotton (56% and 44%, respectively). In 2023, the number of individuals collected decreased by 36% (4.382), with the population predominantly concentrating in the vegetative stage (70.2%) compared to the previous year, while the peak period (vegetative) remained the same. In the Altınözü district, 13,470 individuals collected in 2022 showed more presence in the vegetative period (83%) and increased significantly to 25,490 in 2023 (83.2%), 63.8% of the population was concentrated in the vegetative period and the peak period of the population remained the same in both years (vegetative). These findings are important for the detection of *A. decedens* and *E. decipiens* presence and the implementation of appropriate pest management programs in cotton production areas.

ÖZET

Bu çalışmada, Hatay ilindeki konvansiyonel pamuk üretim alanlarında bulunan pamuk yaprakpirelerinin [*Asymmetrasca decedens* (Paoli) ve *Empoasca decipiens* (Paoli)] popülasyon dinamikleri atrapla örnekleme yöntemiyle araştırılmıştır. Melekli ilçesinde 2022 yılında toplanan 5.480 bireyin %68.75'i generatif dönemde varlık gösterirken, 2023 yılında 5.803 bireye ulaşan popülasyon ağırlıklı olarak (%63.53) vejetatif dönemde yoğunlaşmış ancak popülasyonun zirve yaptığı dönem (generatif) aynı kalmıştır. Reyhanlı ilçesinde 2022 yılında toplanan 6.762 birey, pamuğun vejetatif ve generatif dönemlerinde birbirine yakın bir dağılım göstermiştir (%56 ve %44). İlçede 2023 yılında toplanan birey sayısı %36 azalmış (4.382), önceki yıldan farklı olarak popülasyon vejetatif dönemde yoğunlaşmış (%70.2), zirveye ulaşılan dönem (vejetatif) ise aynı kalmıştır. Altınözü ilçesinde 2022 yılında toplanan 13.470 birey vejetatif dönemde daha çok varlık göstermiş (%83), 2023 yılında ise önemli ölçüde artarak (%83.2) 25.490'a yükselmiş, popülasyonun %63.8'i vejetatif dönemde yoğunlaşmış ve popülasyonun zirve dönemi (vejetatif) her iki yıldada aynı kalmıştır. Bu bulgular, pamuk üretim alanlarında *A. decedens* ve *E. decipiens* varlığının saptanması ve doğru zararlı yönetim programlarının uygulanması açısından önemlidir.

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.), an important member of the Malvaceae family, is a crucial agricultural commodity cultivated in approximately 100 countries across temperate and tropical regions worldwide (Ozyigit & Gozukirmizi, 2009; Datta et al., 2020; USDA, 2020).

Cotton serves as a versatile raw material for various sectors. While its fibers are fundamental importance to the textile industry, cotton is also valuable to the oil and feed industries through its seeds. Additionally, byproducts of cotton, such as lint, are used in paper production (Ozyigit, 2009; Munir et al., 2020). Furthermore, cottonseed oil is used in biodiesel production, offering an alternative to fossil fuels (Sharma et al., 2020; Sundar & Udayakumar, 2020). With all these aspects, cotton has a wide range of applications in producing countries, presenting opportunities for value addition and employment (Majumdar et al., 2019; Rehman et al., 2019).

In the 2021/22 season, Türkiye achieved a significant position in the global cotton market, ranking third in the world with a yield of 1.930 kilograms per hectare (kg ha^{-1}). With this performance, Türkiye also secured the seventh place in global cotton production and the fourth place in global cotton consumption (ICAC, 2022). In 2023, 2.1 million metric tons of seed cotton were processed on an area of 4.77 million hectares in the country, resulting in the production of 777.000 tons of fiber cotton. Notably, 86.3% of Türkiye's cotton production in 2023 was concentrated in six provinces: Şanlıurfa with 42%, Diyarbakır with 14.43%, Aydın with 11.55%, Hatay with 8.81%, İzmir with 5.48%, and Adana with 4.06% (TÜİK, 2024).

The Cicadellidae family, with over 40 subfamilies and more than 20,000 described species, is the largest within the Hemiptera order (Abdollahi et al., 2015). Studies and records indicate 476 species of Cicadellidae in Türkiye and this number reached to 483 with new records in the following years (Demir, 2006a, 2006b, 2006c; Demir & Demirsoy, 2008; Mutlu et al., 2008a; Mutlu et al., 2008b; Güçlü, 2010; Zeybekoğlu, 2010; Karavin et al., 2011; Demir, 2016; Gnezdilov & Özgen, 2021; Gnezdilov et al., 2021; Mutlu et al., 2023; Uğur & Bayhan, 2023). In this family, insects can feed on almost all vascular plants and can cause significant damage to agricultural crops. Most of these species, also known as leafhoppers, feed by sucking sap from the phloem tissue of plants, causing to both direct and indirect damage (Dietrich, 2013; Bayhan & Ölmez Bayhan, 2022). Leafhoppers invade fields from cotton emergence and remain damaging throughout the growing season. Heavy infestations cause leaf spot and can severely hinder seedling development in the early stages, resulting in growth retardation and loss of both quality and quantity (Room & Wardhaugh, 1977; Forrester & Wilson, 1988). Species in this family have been observed to cause particularly severe damage to the hairless and broad-leaved cotton varieties (Delvare, 1996; Özgür et al., 1988; Bayhan & Ölmez Bayhan, 2022).

The leafhoppers *Asymmetrasca decedens* (Paoli) and *Empoasca decipiens* (Paoli) (Hemiptera: Cicadellidae) ranks among the most important primary pests due to their wide host range, including various cultivated crops such as cotton, soybean, maize, potato, pepper, citrus, eggplant and numerous non-cultivated plants (Atlihan et al., 2003; Gencsoylu & Yalcin, 2004; Rassoulian et al., 2005; Sertkaya & Yaşarer, 2006; Naseri et al., 2007; Demirel & Yildirim, 2008; Atakan, 2009, 2011; Awadalla et al., 2013; Soylu et al., 2017; Kılıç & Sertkaya, 2019; Akmeşe & Sertkaya, 2021; Birbiri & Sertkaya, 2022). Both nymphs and adults of *E. decipiens* cause damage by directly sucking sap from plant tissues and vital cells, resulting in injury to leaves and other plant parts, thus weakening the entire plant (Raupach et al., 2002; Backus et al., 2005). Additionally, during feeding, they inject toxins into the plant phloem, inducing curling of the leaves downwards from the edges; initially, these curls turn yellow, then brown, and eventually die (Nielson, 1985; El-Gindy, 2002; Backus et al., 2005). Furthermore, *A. decedens* and *E. decipiens* acts as a vector for pathogens such as bacteria, viruses, mycoplasma, and spiroplasma, causing indirect damage (Weeb, 1987; Nault & Ammar, 1989; Kersting & Şengonca, 1992; Malaschi, 1995; Orenstein et al., 2003; Beanland et al., 2006; Abou-Jawdah et al., 2014; Çarpar & Sertkaya, 2022).

The leafhopper species complex consisting of *A. decedens* and *E. decipiens* is most commonly encountered in cotton

fields in Türkiye, and both species have caused significant damage to agricultural crops. In particular, *A. decedens* has been noted as the dominant species in various regional contexts (Başpınar, 1994; Göçmen et al., 1996; Efil & Güçlü, 2004; Durusoy, 2005; Atakan 2009, 2011; Uğur & Bayhan, 2023).

Several studies have been carried out on leafhoppers in cotton growing areas in Türkiye (Özgür et al., 1988; Başpınar et al., 1996; Göçmen et al., 1996; Efil et al., 1999; Atakan et al., 2004; Efil & Güçlü, 2004; Demirel & Yildirim, 2008; Atakan, 2009, 2011; Mart & Sunulu, 2011; Dündar et al., 2012; Uğur & Bayhan, 2023). However, there is a lack of research on population dynamics, population density, and the relationship between population development and different development stages of cotton in conventional cotton growing areas of Hatay province.

Present study aims to determine the population density, dynamics and fluctuation of *A. decedens* and *E. decipiens* in conventional cotton production areas in Hatay province and their relationship with different development stages of cotton.

MATERIALS and METHODS

Study site

The study was carried out in the Melekli, Reyhanlı, and Altınözü districts of Hatay province in 2022 and 2023. Three different fields (18 in total) planted with cotton (*Gossypium hirsutum* L.) were selected from each district (Table 1). Various cotton varieties such as Armada, Lazer, BA1010, and 455 were used for cultivation in the fields. Cotton plants were sown with a 75 cm inter-row spacing, and conventional farming practices were followed throughout the vegetation period.

Table 1. District, size (hectares), cotton variety, sampling year, and location of fields where the study was carried out

Çizelge 1. Çalışmanın yürütüldüğü tarlalara ait ilçe, büyüklük (da), pamuk çeşidi, örnekleme yılı ve lokalite bilgileri

District	Field	Size (da.)	Variety	Sampling year	Coordinates
Melekli	Melekli-1	84.4	Armada	2022	36°16'46.8"N 36°16'52.7"E
	Melekli-2	61.9	Armada	2022	36°16'57.8"N 36°16'53.6"E
	Melekli-3	61.4	BA1010	2022	36°17'06.9"N 36°16'54.2"E
	Melekli-4	36.6	Lazer	2023	36°15'28.9"N 36°19'57.3"E
	Melekli-5	55.7	BA1010	2023	36°15'29.1"N 36°19'40.9"E
	Melekli-6	46.9	BA1010	2023	36°15'25.7"N 36°19'46.6"E
Reyhanlı	Reyhanlı-1	36.2	Lazer	2022	36°18'18.2"N 36°21'05.3"E
	Reyhanlı-2	19.6	BA1010	2022	36°18'37.4"N 36°21'06.2"E
	Reyhanlı-3	19.9	Armada	2022	36°18'37.6"N 36°21'09.9"E
	Reyhanlı-4	38.2	455	2023	36°18'30.6"N 36°21'07.5"E
	Reyhanlı-5	19.8	455	2023	36°18'36.1"N 36°21'14.4"E
	Reyhanlı-6	51.7	455	2023	36°18'29.5"N 36°21'16.0"E
Altınözü	Altınözü-1	84.4	455	2022	36°01'44.9"N 36°21'52.0"E
	Altınözü-2	52.8	455	2022	36°01'38.9"N 36°21'52.1"E
	Altınözü-3	71.3	BA1010	2022	36°01'53.4"N 36°21'52.4"E
	Altınözü-4	172.2	Armada	2023	36°01'27.5"N 36°21'49.7"E
	Altınözü-5	151.6	BA1010	2023	36°01'14.3"N 36°21'51.8"E
	Altınözü-6	196.8	Armada	2023	36°01'00.9"N 36°21'54.5"E

Sampling method

Sampling of leafhopper individuals in the fields started at the beginning of the vegetative stage of the cotton plant, which occurred in July, August and September 2022 and in June, July, August and September 2023. Sampling was conducted with a with a 45 cm diameter sweep net on the middle and lower leaves of the cotton plant. The sweeping procedure was synchronized with a walking speed, covering one meter with each step and one sweep per step. In order to prevent the escape of captured insects, the net was quickly rotated 180° at the end of each sweep and at the beginning of the next step.

Each sweep sample consisted of 100 step sweeps, and separate sampling was performed for each of the 18 fields. Sampling was carried out weekly throughout the vegetation phase of the cotton plant. The collected samples were placed inside plastic bags with drying paper along with labels indicating the field number, sampling count, field size, collection date, collector's name, and field owner. These bags were transported to the Hatay Mustafa Kemal University Entomology Laboratory and stored at -18°C for preservation.

The frozen samples were carefully removed from the plastic bags and cleaned of soil and plant remnants using a fine-toothed brush. The morphological structure of the cleaned samples was examined under a stereomicroscope to separate nymph and adult individuals. Because of the extremely low number of nymphs, only counts of adult individuals were recorded. The counted samples were placed in Falcon tubes containing a 70% alcohol solution, labeled, and stored at +4°C until the genital preparation.

Identification of insect samples

The species identification was made according to Oman (1949). Fifty leafhopper individuals were randomly selected and subjected to genital preparation to ensure that they were either *A. decedens* or *E. decipiens*. Male individuals were used for genital preparation, in which their abdomens were dissected from their bodies and heated in a 10% KOH solution until boiling. Afterward, the boiled solution was allowed to cool to room temperature (25°C). The material in the cooled solution was placed on a coverslip containing glycerol and examined under a stereomicroscope. Genitalia were separated from the abdomen using a needle and examined under a microscope in the same environment (Kaya & Başpınar, 2019). After diagnosis, the genitalia were placed in 1.5 ml Eppendorf tubes containing 70% alcohol solution and preserved throughout the study.

Meteorological data

The climate parameter data used in this study were provided by the Hatay Meteorological Directorate (Anonymous, 2023).

RESULTS and DISCUSSIONS

Population dynamics of Asymmetrasca decedens and Empoasca decipiens

Figure 1 illustrates the weekly seasonal population dynamics of *Asymmetrasca decedens* and *Empoasca decipiens* in the Melekli district in 2022. Analysis of the data shows that the population exhibits a fluctuating trend in general, with a significantly lower trend in the vegetative phase compared to the reproductive phase. The highest population recorded during the vegetative phase was 168.6±11.37. As the reproductive phase approached, the population underwent a sharp rise, reaching its peak on August 27th (325.6±143). However, in the subsequent weeks, the population trend declined, experiencing a significant drop from September 17th to 34.6±20, marking the lowest population observed throughout all development stages of cotton.

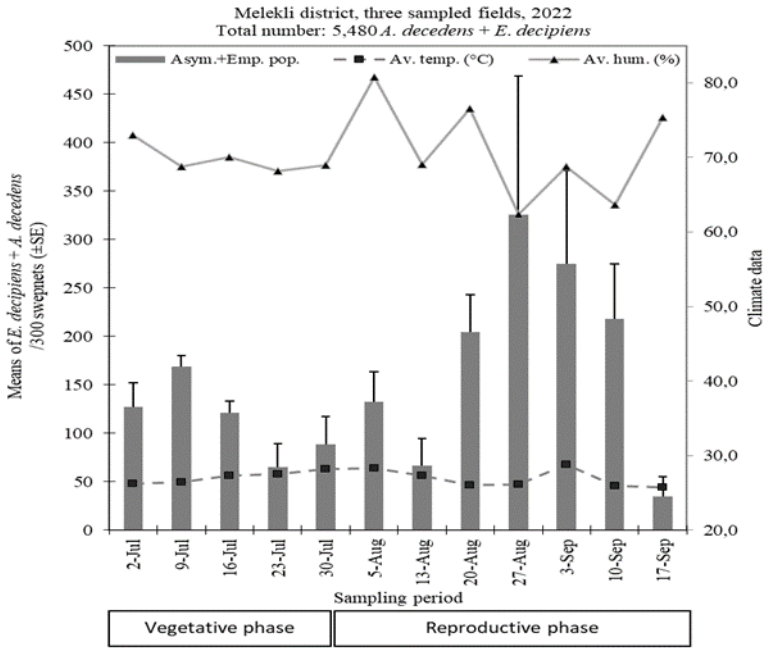

Figure 1. Weekly seasonal population dynamics of *Asymmetrasca decedens* and *Empoasca decipiens* in the Melekli district in 2022

Şekil 1. Asymmetrasca decedens ve Empoasca decipiens'in pamukta 2022 yılında Melekli ilçesindeki haftalık mevsimsel popülasyon dinamikleri

Figure 2 illustrates the weekly seasonal population dynamics of *A. decedens* and *E. decipiens* in the Reyhanlı district in 2022. In the first week of the vegetative phase (July 2), the population was 249.6±125 and reached the peak of the vegetative phase (413.6±83.2) on July 16. However, in the following week (July 23rd), the population sharply declined to 135.3±65.9, maintaining a lower and mildly fluctuating trend until September 3rd. On September 3rd, the population reached its highest level (360.3±286.4) but then experienced a sharp decline (40±23.6).

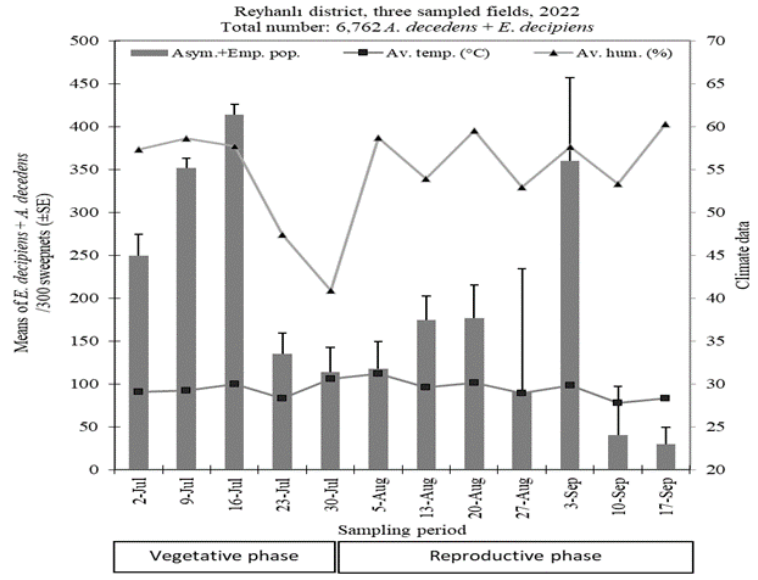

Figure 2. Weekly seasonal population dynamics of *Asymmetrasca decedens* and *Empoasca decipiens* in the Reyhanlı district in 2022

Şekil 2. Asymmetrasca decedens ve Empoasca decipiens'in pamukta 2022 yılında Reyhanlı ilçesindeki haftalık mevsimsel popülasyon dinamikleri

Figure 3 illustrates the weekly seasonal population dynamics of *A. decedens* and *E. decipiens* in the Altınözü district in 2022. The population was significantly higher in the vegetative phase than in the reproductive phase. The population, which stood at 359.6±153.1 on July 2nd, rapidly increased until July 23rd, reaching its peak (1534±570.2) on this date. However, during the first week of the reproductive phase on July 30th, the population sharply declined to 234.3±43.6. Subsequently, on August 5th, there was a slight increase (334±60.7), followed by a slight decrease on August 13th (262.3±105.5), and in the remaining weeks, the declining trend continued, failing to reach a significant population level.

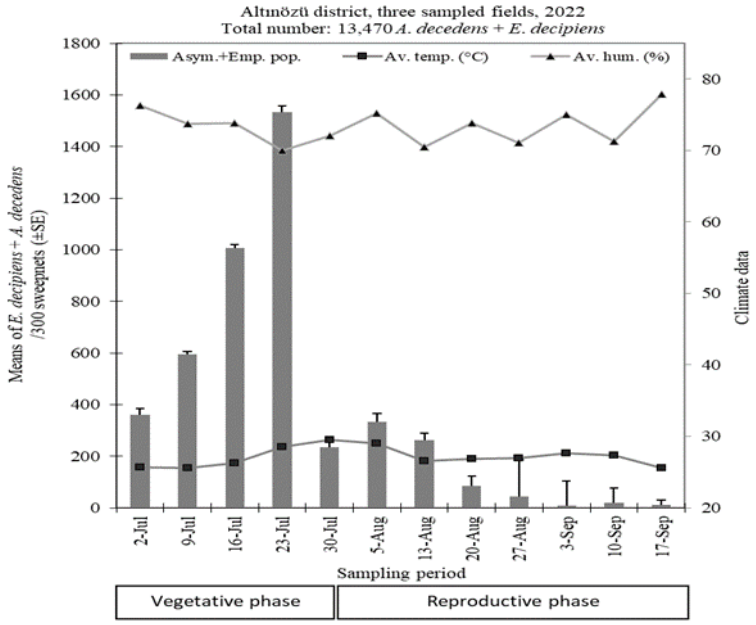

Figure 3. Weekly seasonal population dynamics of *Asymmetrasca decedens* and *Empoasca decipiens* in the Altınözü district in 2022

Şekil 3. Asymmetrasca decedens ve Empoasca decipiens'in pamukta 2022 yılında Altınözü ilçesindeki haftalık mevsimsel popülasyon dinamikleri

Figure 4 illustrates the weekly seasonal population dynamics of *A. decedens* and *E. decipiens* in the Melekli district in 2023. In the first two weeks of the vegetative period (June 24 and July 1), the population was high with 474.6±238.5 and 387.3±274.3, respectively. However, on July 8th, the population experienced a sharp decline (65.6±14.9), maintaining a low and fluctuating trend until August 19th, which fell within the reproductive phase. On August 19th, the population rose sharply to its peak (572.6±180), but in the subsequent weeks (August 26th and September 2nd), it did not reach a notable level.

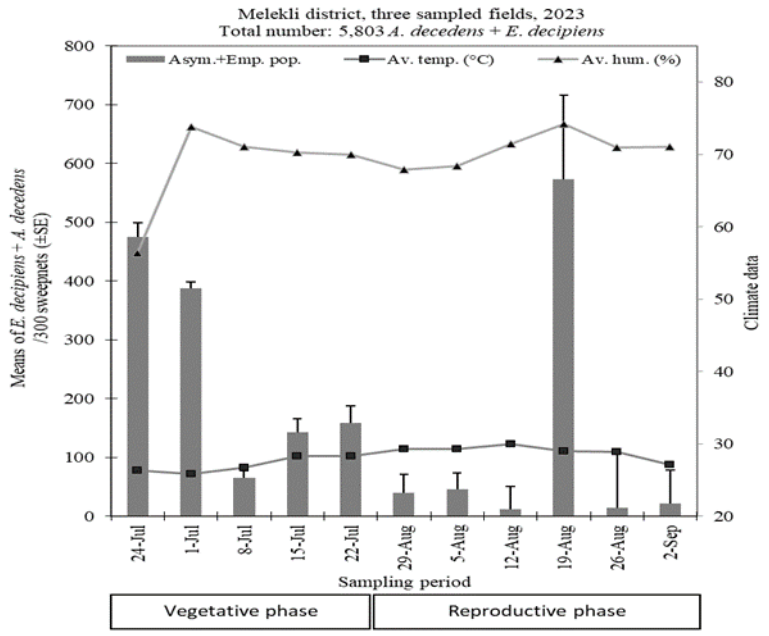

Figure 4. Weekly seasonal population dynamics of *Asymmetrasca decedens* and *Empoasca decipiens* in the Melekli district in 2023

Şekil 4. Asymmetrasca decedens ve Empoasca decipiens'in pamukta 2023 yılında Melekli ilçesindeki haftalık mevsimsel popülasyon dinamikleri

Figure 5 illustrates the weekly seasonal population dynamics of *A. decedens* and *E. decipiens* in the Reyhanlı district in 2023. During the first week of the vegetative phase (June 24th), the population distribution reached its peak (349.3±204.3). Subsequently, declines were observed on July 1st and July 8th (151.6±96.6), followed by an increase on July 15th (156.6±35). On July 22nd and August 5th, populations near the peak point were reached (271±63.17 and 275.6±312.4, respectively), while notable populations were not observed in the remaining weeks.

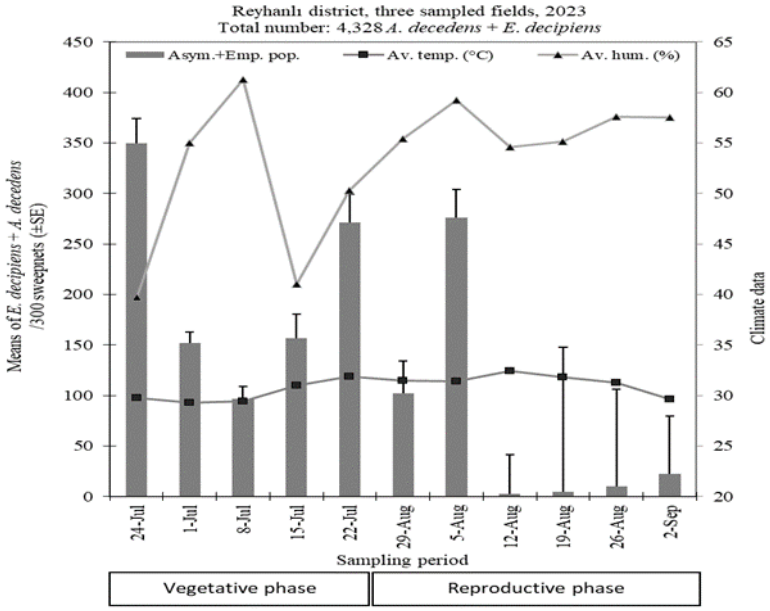

Figure 5. Weekly seasonal population dynamics of *Asymmetrasca decedens* and *Empoasca decipiens* in the Reyhanlı district in 2023

Şekil 5. Asymmetrasca decedens ve Empoasca decipiens'in pamukta 2023 yılında Reyhanlı ilçesindeki haftalık mevsimsel popülasyon dinamikleri

Figure 6 illustrates the weekly seasonal population dynamics of *A. decedens* and *E. decipiens* in the Altınözü district in 2023. The population increased at a very high level on June 24th (3290.6±2108.0), representing the peak point. The population showed a declining trend on July 1st and July 8th (678.6±319.5 and 325.3±64.5, respectively), but rebounded on July 15th (496.6±196.3) and gradually increased, reaching the highest population level observed during the reproductive period on August 5th (1608.6±65.6). During the remaining weeks, no significant population levels were observed.

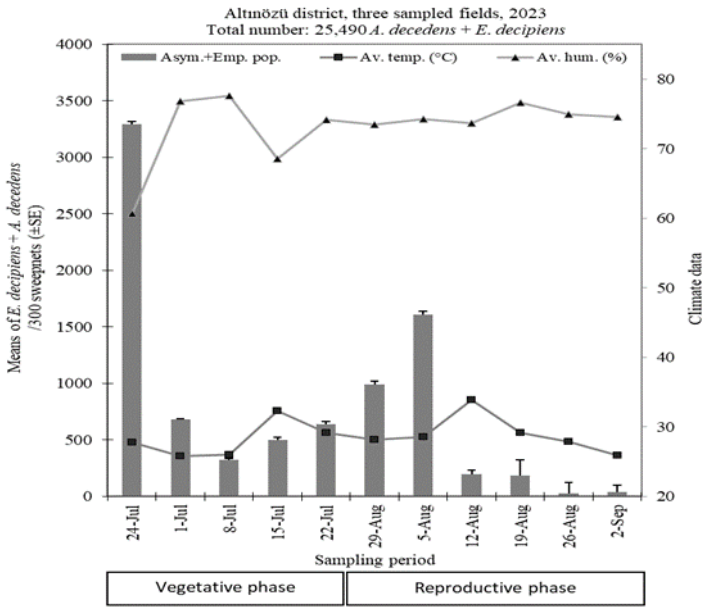

Figure 6. Weekly seasonal population dynamics of *Asymmetrasca decedens* and *Empoasca decipiens* in the Altınözü district in 2023

Şekil 6. Asymmetrasca decedens ve Empoasca decipiens'in pamukta 2023 yılında Altınözü ilçesindeki haftalık mevsimsel popülasyon dinamikleri

According to the data obtained from the study, the population density and periods of population concentration of A. decedens and E. decipiens varied across districts, cotton varieties, years, and cotton phenological stages. In Melekli district, during field samplings conducted in 2022, a total of 5.480 leafhopper specimens were collected, with the population predominantly (68.75%) concentrated in the reproductive stage. Similarly, in the same district in 2023, a similar number of individuals (5.803) were collected; however, contrary to the previous year, the population was predominantly (63.53%) concentrated in the vegetative stage, and the population peak, as observed in the previous year, was reached during the reproductive stage. During field sampling in 2022 in Reyhanlı district, a total of 6.762 leafhopper specimens were collected, with the population showing a relatively closer distribution between the vegetative and reproductive stages (56% and 44%, respectively). In the same district in 2023, a 36% decrease in the number of individuals (4.382) was observed compared with the previous year, and the population was predominantly concentrated in the vegetative stage, unlike in the previous year. However, the population peaked during the vegetative stage as in the previous year. During field samplings in 2022 in Altınözü district, 13.470 leafhopper specimens were collected, and a significant portion of the population (83%) was concentrated in the vegetative stage. Similarly, in the same district in 2023, there was a significant increase of 83.2% compared to the previous year, with a total of 25.490 leafhopper specimens collected, and 63.8% of the population was presence in the vegetative stage as in the previous year. The periods of the population peak remained the same in both years (vegetative stage). Additionally, the leafhopper population in Altınözü district was significantly higher than that in other districts in both years.

Previous research on this topic has indicated that leafhopper populations tend to be highest during the period of cotton maturation and boll formation (Baloch & Soomro, 1980; Monsef, 1981; Lodos, 1982; Salem et al., 1988; Göçmen et al., 1996; Başpınar et al., 1996; Atakan et al., 2004; Mart & Sunulu, 2011). Uğur and Bayhan (2023), in a study conducted in cotton production areas in different provinces, reported that leafhopper densities reached the highest levels in August and September. However, the findings of this study reveal that the density, distribution, and specific development stages at which leafhopper populations reach their peak can differ from year to year and between provinces.

In this study, population density, dynamics, and distribution of leafhoppers in conventional cotton cultivation areas in Hatay province were investigated as well as their relationship with different developmental stages of cotton. The findings of this study showed that A. decedens and E. decipiens populations varied according to different developmental stages of cotton, provinces, and years. The findings on this variation in population fluctuations and dynamics may assist to determine the presence of these pests in cotton cultivation areas and to implement correct pest management programs.

STATEMENT OF CONFLICT OF INTEREST

The authors declare no conflict of interest for this study.

AUTHOR'S CONTRIBUTIONS

The authors declare that they have contributed equally to this study.

STATEMENT OF ETHICS CONSENT

Ethical approval is not required as there are no studies with human or animal subjects in this article.

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