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RESEARCH PAPER

HORTICULTURAL STUDIES

Composition, Abundance, and Distribution of Thrips (Thysanoptera) Species on The Bitter Orange (*Citrus aurantium* L.) in Adana Province, Türkiye

Ekrem ATAKAN[1]

[1] Çukurova University Agriculture Faculty Plant Protection Department, 01330, Adana, Türkiye

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Corresponding Author
E-mail: eatakan@mail.cu.edu.tr

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Abstract

Although the thrips (Thysanoptera) fauna of citrus varieties with economic importance and widespread cultivation in Türkiye has been studied, thrips species in bitter orange trees, which are used for different purposes, are not known. This study was conducted in the Balcalı location of Adana province in 2022 and 2023 to determine the Thysanoptera fauna on bitter orange trees used for landscaping purposes. Thrips were collected from the flowers and fruits of the trees using the beating method. As a result of the study, 14 species were identified. The most common species, all belonging to the family Thripidae, were: Western flower thrips, *Frankliniella occidentalis* (Pergande) (33.14%), *Oxythrips ajugae* Uzel (20.66%), and Rubus thrips, *Thrips major* Uzel (15.08%). Only a few predatory thrips species from the genus *Aeolothrips* (Thysanoptera: Aeolothripidae) were found. Thrips were collected mainly from the flowers of the trees. It was recorded that *O. ajugae* and *T. major* reproduced in the flowers. The thrips species used the bitter orange trees as temporary habitats and did not cause damage to various organs of the trees.

1. Introduction

Türkiye's citrus production in 2024 was 5,481,576 tons, with nearly all of this production coming from the Aegean and Mediterranean regions (TÜİK, 2024). Adana Province accounts for approximately 40% of total citrus production. Orange production in Türkiye is 1,610,000 tons, mandarin production 1,988,000 tons, and lemon production is 1,730,000 tons. Bitter orange production, on the other hand, is recorded as 3,576 tons. In Adana, bitter orange production is 2,440 tons, representing 70% of Türkiye's total production (TÜİK, 2024).

Bitter orange (*Citrus aurantium* L.) is a citrus product with a distinct aroma and fragrance, utilized for various purposes in the Mediterranean Region (Aksu and Karahan, 2004). The peels of bitter orange fruits are used for making marmalade and bitter orange jam. Due to the high acidity of its juice, it is particularly used as a sour flavoring in salads and dishes (Tokgöz and Gölükçü, 2009).

Various pests, mites, diseases, and weed factors have been identified in citrus production in Türkiye, among which thrips from the order Thysanoptera are also included (Uygun, 2001). Thrips are known as opportunistic and invasive species, with body sizes smaller than 1 mm (Lewis, 1997). Of the approximately 6,000 species in this order, about 10% are phytophagous and harmful to agricultural products (Lewis, 1997). Some species feed on fungi, while others are known to be predatory (Morse and Hoodle, 2006). In Türkiye, Thysanoptera species have mostly been studied in the Mediterranean (Tekşam and Tunç, 2009; Tunç, 1996), Aegean (Tunç et al., 2012), and certain parts of Central Anatolia (Tunç and zur Strassen, 1984), and a comprehensive catalog of Thysanoptera species in Türkiye has been published (Tunç and Hastenpflug-Vesmanis, 2016). Until 2015, thrips

were not considered significant pests in Türkiye citrus crops (Nas et al., 2007; Ölçülü and Atakan, 2013). However, in that year, the Hawaiian flower thrips (*Thrips hawaiiensis* Morgan) (Thysanoptera: Thripidae) was recorded for the first time in Türkiye in Yediveren lemons in the Erdemli district of Mersin, where it caused serious damage (Atakan et al., 2015). In 2020, another invasive species known as the chili thrips (*Scirtothrips dorsalis* Hood) (Thysanoptera: Thripidae) was reported for the first time in Türkiye, causing significant damage to blueberry plants in Adana (Atakan and Pehlivan, 2021). Nearly four years later, serious damage caused by this species was observed on the summer shoots and fruits of all citrus varieties in Adana (Satar and Kalkan, 2024).

Although the Thysanoptera fauna of citrus fruits has been well-studied in Turkish provinces such as Adana and Mersin, the thrips species present on bitter orange—also used as a citrus rootstock—remain largely unknown. In coastal cities like Adana and Mersin, bitter orange trees are often used ornamentally along boulevards, medians, parks, and walking paths, contributing to visual aesthetics. Due to their abundant blossoms, bitter orange trees are increasingly favored in landscape design. Adana has become a symbolic city associated with bitter orange. Despite its lower production volume compared to other citrus species and varieties, the thrips fauna on bitter orange in Türkiye remains unknown. In urban environments, unlike agricultural areas, the use of pesticides against pests and diseases on perennial cultivated plants such as bitter orange is generally limited, the population densities and reproductive potential of thrips species on bitter orange could affect the overall composition of thrips species by spreading to nearby cultivated plants.

2. Material and Methods

2.1. Sampling area

The study was conducted on bitter orange trees (*Citrus aurantium*) planted for landscaping purposes along a main road route within the Çukurova University campus in the Balcalı location of Adana province, Türkiye where no chemicals had been applied (coordinates: 37.058906 N, 35.360304 E). The bitter orange trees were planted along a 270-meter-long walking path with a width of 3 meters. The spacing between trees was 6 meters, with a total of 45 trees, each approximately 10 years old. Rubber trees were also present sporadically along this walking path. No pesticide was used during the sampling period in both years.

2.2. Thrips sampling

Sampling was conducted weekly for 5 weeks between March 30 and April 25 in 2022, and for 11 weeks between March 7 and May 19 in 2023. In 2022, sampling started with the flowering period, while in 2023 it began when flower buds appeared. In both years, sampling ended when fruit diameters reached approximately 1 cm. On each sampling date, 10 trees were randomly selected.

Flowering shoots or fruits measuring 20–25 cm in length were shaken into a white container from four different directions of each tree. Thrips individuals collected from four different directions were gathered using an aspirator and transferred into 1.8 cm plastic tubes containing 60% ethyl alcohol. Thus, 10 tubes were collected per sampling date.

2.3. Thrips identification

The thrips inside the tubes were examined under a stereomicroscope. Common and well-known species (*Frankliniella occidentalis, Oxythrips ajugae, Thrips hawaiiensis, Thrips major*) were counted and recorded. In each sample, 20% of the adult individuals and all second-instar larvae were prepared for slide mounting.

To soften their bodies, the thrips specimens were kept in AGA solution (9 parts 60% ethyl alcohol, 1-part glacial acetic acid, 1-part glycerin) for 2 days. Temporary slides were then prepared from these specimens. For this purpose, specimens were placed in 5% NaOH and incubated on a hot plate at 45°C for 30–45 minutes. The contents of the thrips' bodies were cleaned using a fine-tipped needle in 70% alcohol, and mounted in Hoyer's medium for microscopic examination. The slides were then dried in an oven at 45°C for 5 days. Published identification keys were used for species identification (Masumoto and Okajima, 2006; Nakahara, 1994; Priesner, 1951; Vierbergen et al., 2010; Yakhontov, 1964; zur Strassen, 2003).

2.4. Data analysis

A total of 50 samples were collected in 2022 and 110 in 2023. The ratio of each species' adult individuals to the total number of thrips was calculated. Additionally, the total mean number of individuals of the four most common thrips species was compared using Tukey's test at a significance level of $P<0.05$.

The distribution of the dominant species across flower and fruit organs during both sampling years was presented in the relevant table. No samples were taken from fruits in 2022. In 2023, the sampling dates for flowers (April 11–25, 3 weeks) and fruits (May 2–16, 3 weeks) were combined, and the average number of individuals for each plant organ was calculated. The data followed a normal distribution (Shapiro-Wilk test), and variance analysis (ANOVA) showed that the effect of plant organ was significant. Means were compared using an independent samples t-test at $P<0.05$ significance level.

3. Results and Discussion

3.1. Thrips composition

The number of thrips species and adult individual counts collected from bitter orange trees in the Balcalı region of Adana in 2022 and 2023, along with their proportional occurrence among adults, are presented in Table 1. A total of 14 species were identified: 3 from the Aeolothripidae family, 1 from the Melanthripidae, 8 from the Thripidae, and 2 from the Phlaeothripidae family. Similarly, a study conducted on various citrus species in Adana also identified 14 species. In contrast, broader surveys in Antalya reported 36 species on citrus plants (Tekşam and Tunç, 2009). In this study, a total of 79 adult thrips were collected in 2022, whereas a higher number of samples taken in 2023 yielded 226 individuals. While *Oxythrips ajugae* Uzel and *Thrips major* Uzel were more abundant in 2022, the most frequently collected species in 2023 was *Frankliniella occidentalis*, followed by *Thrips hawaiiensis* (Table 1). In 2022, the seasonal average number of *T. major* individuals was significantly higher compared to other species (F = 17.714, df = 1.36 , P<0.0001), while in 2023, *F. occidentalis* was collected from the trees in significant and high numbers (F = 17.714, df = 1.36, P<0.0001; Figure 1). Of the identified species, only *T. hawaiiensis* is known to be a pest on lemon. When the numerical data from both years are evaluated together, *F. occidentalis* appears as the most common species, followed by *O. ajugae* (Table 1).

Table 1. Thysanoptera species and their total numbers in bitter orange in 2022 and 2023.

Thysanoptera species	2022	2023	Total (2022+2023)	Percentage
Aeolothrips collaris Priesner	0	2	2	0.65
Aeolothrips ericae Bagnall	0	3	3	0.98
Aeolothrips gloriosus Bagnall	0	10	10	3.28
Melanthripidae				
Melanthrips fuscus Bagnall	2	5	7	2.3
Thripidae				
Oxythrips ajugae Uzel	21	42	63	20.66
Odontothrips confusus	2	0	2	0.65
Frankliniella occidentalis (Pergande)	8	93	101	33.14
Thrips australis	0	2	2	0.66
Thrips hawaiiensis (Morgan)	1	41	42	13.77
Thrips major Uzel	36	10	46	15.08
Thrips meridionalis (Priesner)	0	1	1	0.32
Thrips tabaci Lindeman	5	5	10	3.27
Phlaeothripidae				
Haplothrips distinguendus (Uzel)	0	4	4	1.31
Haplothrips reuteri (Karny)	4	8	12	3.93
Total	79	226	305	100

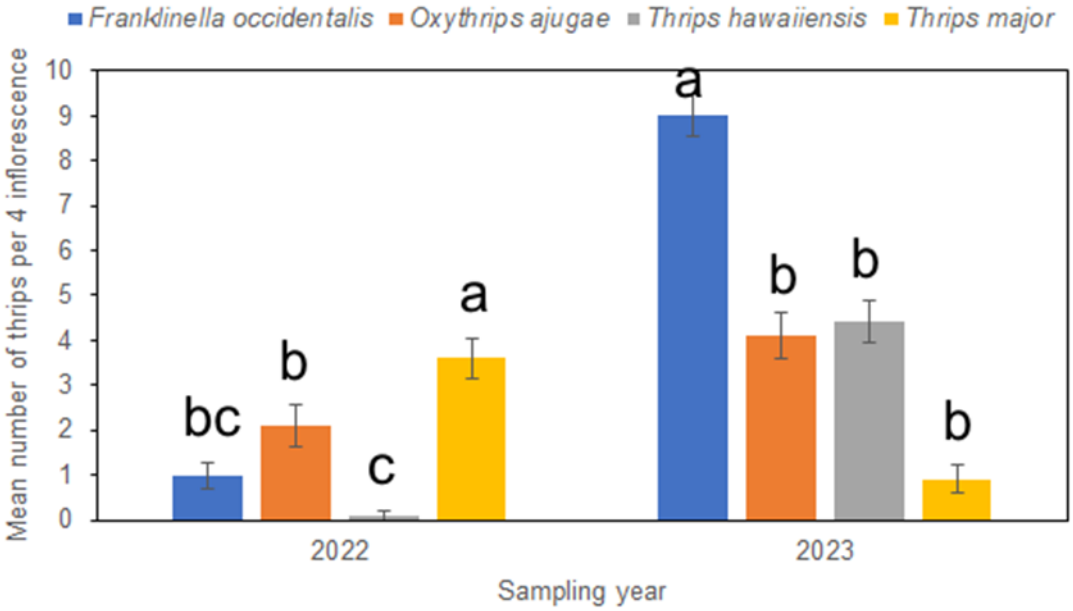

Figure 1. Seasonal mean numbers (±SEM) of four common thrips species in bitter orange during 2022 and 2023. The differences in means marked with different letters on the bars are significant according to the Tukey test (P<0.05).

Table 2. Total numbers of common pest thrips species found on two plant parts in bitter orange during 2022 and 2023.

Year	Plant part	*T.hawaiiensis*	*F. occidentalis*	*O. ajugae*	*T. major*	*T. tabaci*	Total
2022	Flower	1	7	21	20	4	53
	Fruit	0	1	0	16	1	18
2023	Flower	36	91	39	10	5	181
	Fruit	5	2	3	0	0	10
Total		42	101	63	46	10	262

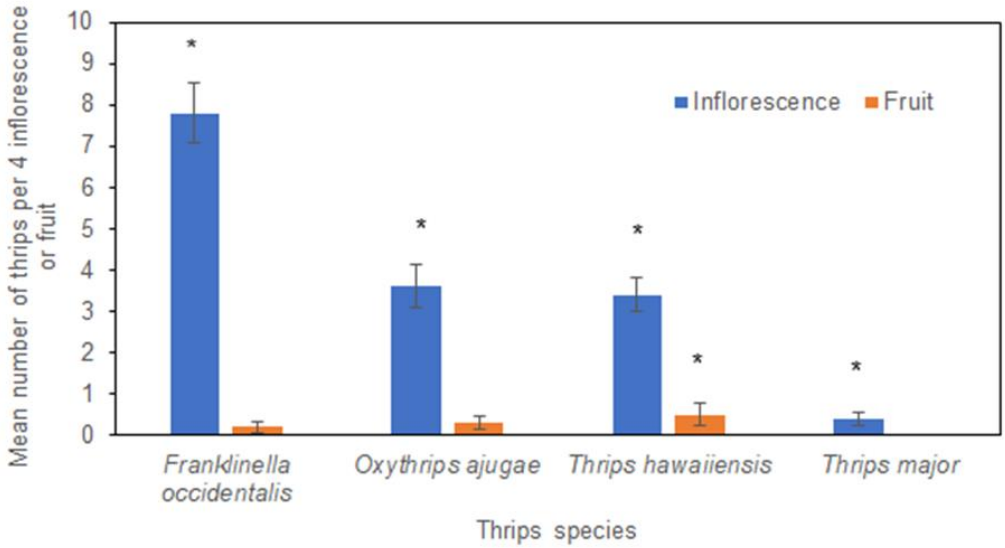

Figure 2. Seasonal mean numbers (±SEM) of common thrips species on two plant parts in 2023. The averages indicated with asterisks on the bars are significant according to the independent samples t-test (P<0.05).

Thrips major, which is a primary species on pome and stone fruit trees in Adana (Atakan, 2008), ranked third with a proportion of 15.08%. *Oxythrips ajugae* was recorded for the first time on citrus in Adana with this study. Approximately 75% of the larvae collected were identified as this species, and the remaining larvae belonged to *T. major*. There are six known species of this genus in Türkiye (Tunç and Hastenpflug-Vesmanis, 2016), and the species was first recorded in Türkiye by Blunck (1958). Its economic importance in Türkiye remains unclear. However, Tunç et al. (1989) reported a single adult of this species on orange (*Citrus sinensis*). In Manisa, Türkiye, *O. ajugae* was collected in very low numbers in vineyards (Özsemerci et al., 2006). Some species within this genus are known to reproduce on *Pinus* (Pinaceae) and *Juniperus* (Cupressaceae), while several European species have been recorded on *Quercus* (Fagaceae) and *Fraxinus* (Oleaceae) (Anonymous, 2025). Given that the university campus is surrounded by forested areas (mostly pine), it is thought that these species migrated from the forest ecosystem to flowers and reproduced there.

3.2. Distribution of thrips on plant organs

Thrips were mainly sampled from flowers (Table 2). The seasonal average individual counts of common species on flowers were significantly higher compared to fruits (*F. occidentalis*: F = 101.531, t = 10.076, df = 1.18, P < 0.0001; *O. ajugae*: F = 36.985, t = 6.082, df = 1.18, P < 0.000; *T. hawaiiensis*: F = 33.052, t = 5.749, df = 1.18, P < 0.0001; *T. major*: F = 6.182, t = 2.449, df = 1.18, P < 0.05) (Figure 2). Flowers are known to be rich in carbohydrates and proteins, which are important for the development and reproduction of thrips (Brodbeck et al., 2001; Brown et al., 2003). Jervis et al. (2008) reported that specific types of amino acids, proteins, lipids, and vitamins found in pollen positively affect insect development and reproduction. Although *O. ajugae* and *T. major* are known to reproduce, no damage was observed on plant organs (including flowers and fresh shoots) throughout the two-year study period.

3.3. Population development of common species

Thrips were not observed in the pre-flowering stage, i.e., on fresh shoots and flower buds. Average individual counts were lower in 2022 than found in 2023 (Figure 3 a, b). This lower density in 2022 may be due to frost observed in April, which likely reduced flower density (Figure 3a). In both years, *O. ajugae* was the first species to appear in flowers. Its peak population density was recorded on the first sampling date in 2022, with 1.80 ± 0.38 individuals per four inflorescences. Although the thrips fauna of pine trees is not well documented, it is thought that this species migrated from nearby

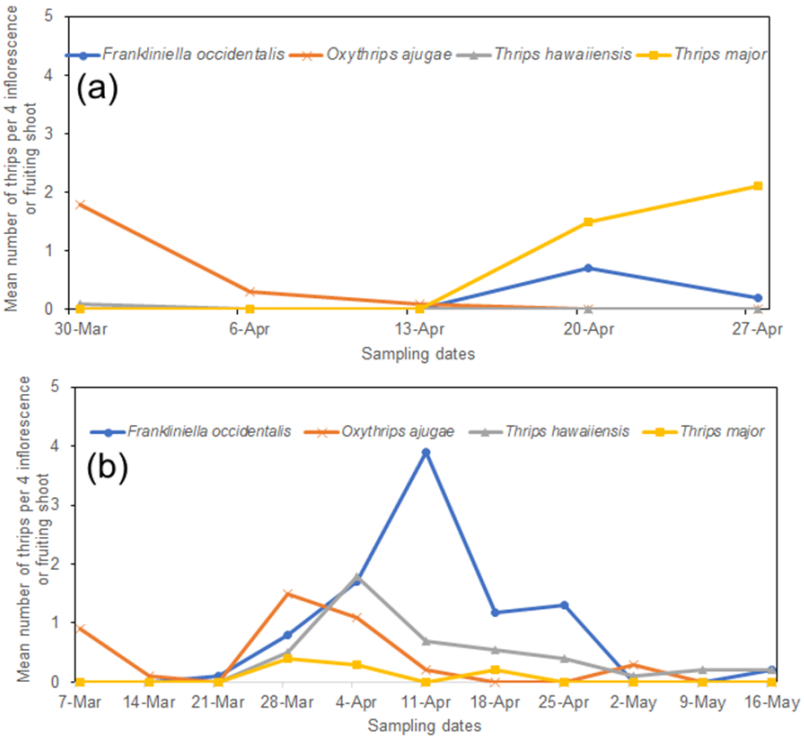

Figure 3. Population developments of common thrips species in inflorescences or fruiting shoot during 2022 (a) and 2023 (b).

pine trees to citrus flowers and reproduced quickly. The adult populations of *F. occidentalis*, *T. hawaiiensis*, and *T. major* increased after the decline abundance of *O. ajugae*. In 2022, *T. major* reached its peak on April 27 with 2.10 ± 0.23 individuals per four inflorescences, while *F. occidentalis* peaked on April 20 with 0.20 ± 0.13 individuals per 4 inflorescences (Figure 3a). In 2023, *O. ajugae* peaked on March 28 (1.50 ± 0.26 per 4 inflorescences), *F. occidentalis* on April 11 (3.90 ± 0.31 per 4 inflorescences), and *T. hawaiiensis* on April 4 (1.80 ± 0.38 per 4 inflorescences) (Figure 3b). *Thrips major*, which was found in low numbers in flowers in 2022, reached its highest density level in 2023 on April 4 (0.40 ± 0.16 per 4 inflorescences) (Figure 3b). Differences in adult population densities among species may be related to the presence of alternative hosts or interspecific competition. Among them, *F. occidentalis* stands out as the largest and most active species, and during the March 28–April 28 period, the average individual numbers of other species found were lower. In May 2023, when bitter orange trees were in the fruiting stage, very few thrips individuals were recorded (Figure 3b).

4. Conclusion

The thrips species identified on bitter orange trees also utilize bitter orange flowers as sources of nectar and pollen. However, widespread species such as *Frankliniella occidentalis*, *Thrips hawaiiensis*, and *Thrips tabaci*, which are common on many plant species, are unable to reproduce on bitter orange. *Thrips major* can reproduce at low levels on the flowers. Among the species identified, *Oxythrips ajugae* is capable of reproducing and developing on bitter orange flowers, although it is rarely observed on cultivated plants. Given the limited agricultural production in the surrounding areas, chemical control against thrips during the flowering period of bitter orange trees is not meaningful, as these species use the citrus flowers only as a temporary habitat. Furthermore, field observations in the sampling area indicated that no harmful pest species (e.g., scale insects, mealybugs, or soft scales) were present on bitter orange trees. In contrast, in urban boulevard plantings within the city center, *Planococcus citri* (citrus mealybug) (Risso) (Hemiptera: Pseudococcidae) may become a significant problem, often due to excessive pesticide applications that are conducted without proper justification, leading an increase in the population of minor pests such as thrips.

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