sciendo Agriculture (Poľnohospodárstvo), 70, 2024 (1): 1 − 11

Original article

DOI: 10.2478/agri-2024-0001

HARMFUL AND USEFUL THRIPS IN *MEDICAGO SATIVA* L.

IVELINA NIKOLOVA

Agricultural Academy, Bulgaria

Nikolova, I. (2024). Harmful and useful thrips in *Medicago sativa* L. *Agriculture (Poľnohospodárstvo)*, *70*(1), 1 – 11.

Spring alfalfa sowing was grown under non-irrigated conditions in the Experimental field of the Institute of Forage Crops, Pleven, Bulgaria. From 2018 to 2021, forage harvesting was performed at the flowering stage in four regrowth periods during the growing season. Sweeping with an entomological net was used. Canonical relationship analysis revealed that the population density of Thysanoptera phytophagous and predator species was positively related to the temperature while humidity and rainfall negatively affected the thrips numbers. Thirteen species from three families, as well as eight genera of Thysanoptera, were identified. The family Thripidae was the most diverse, with a participation rate of 53.17%, represented by five genera and ten species. The Aeolothripidae family had a participation rate of 44.0% with two species. Harmful species comprised 55.16% of the Thysanoptera species, while useful species accounted for 44.0%. The dominant species, *Thrips tabaci* Lindeman, 1889, made up 37.38% of the population, followed by the subdominant species *T. atratus* Haliday (1836) at 9.66%. The dominant species *Aeolothrips intermedius* Bagnall, 1934, accounted for 43.81% of the population density and mostly represented predatory thrips. Throughout the alfalfa growing season, *T. tabaci* was present, with the highest density observed during the second regrowth from late May to late June. The peak density occurred in the first ten days of June, during the button and early flowering stages. The population dynamics of *A. intermedius* corresponded with those of *T. tabaci,* indicating its significant role as a biological agent in alfalfa.

Key words: alfalfa, harmful and predatory species, population density, Thysanoptera order

Thrips, which are representatives of the Thysanoptera order, are commonly found in the plant communities of legumes, such as alfalfa (*Medicago sativa* L.). Thrips have rasping-sucking mouthparts that they use to extract plant juices and induce biochemical changes in the plant. The damage they cause includes deformation and wrinkling of the leaves due to irregular growth around the affected area. When their feeding is concentrated near the central node, the leaves may curl and resemble half-open funnels (Gao & Reitz 2017). Thrips damage not only reduces productivity but also serves as a vector for virus diseases in plants.

The Thripidae family is a numerous family of Thysanoptera, including the most economically important pests, among which the primary group feeds, damages and reproduces on the foliage and/or flowers of plants, and only a few species are obligate predators (Remani *et al.* 2023; Moritz 2024).

Thrips tabaci Lindeman (1889) is a widespread insect that feeds on an extensive host range. Thrips feed on leaves and damage the chlorophyll pigments in the leaf tissue. Destroying chlorophyll pigments in the leaf mesophyll caused by thrips leads to a reduction in plant photosynthetic activity. That may impede the transport of nutrients to generative organs

Ivelina Nikolova, Agricultural Academy, Bulgaria, Institute of Forage Crops, 89 Gen. Vladimir Vazov Street, Pleven 5800, Bulgaria. E-mail: imnikolova@abv.bg.

(Pushpendra *et al.* 2014). Thrips are becoming increasingly important because they reproduce quickly and can move easily. *Thrips tabaci* is most active during midday, regardless of the plant's growth stage. Large adult thrips numbers are usually found in the upper parts of the plants (Pobożniak & Koschier 2014). In the monitoring and developing methodology process for proper sampling, it is crucial to consider thrips control strategies and apply them as needed.

Loredo Varela and Fail (2022) found that *T. tabaci* and *Caliothrips fasciatus* Pergande (1895) had high population densities in alfalfa fields. These species were significantly more destructive and harmful than *Frankliniella occidentalis* Pergande, 1895. Authors reported that alfalfa grown under non -irrigated field conditions can be more significantly susceptible to damage from thrips than alfalfa grown under irrigation.

The Aeolothripidae family are found on the flowers of their hosts and mainly feed on larvae of other species of Thysanoptera and small arthropods (mites, psyllids, whiteflies, etc.) inhabiting the plant flowers (Alavi & Minaei 2018; Moritz 2024). Adults and larvae of many species are facultative predators, although some are herbivores.

Aeolothrips intermedius Bagnall, 1934 is the most common species of this family on the Old Continent and is often mentioned in the context of biological control (Orosz *et al.* 2018). The species is usually not only the most numerous Aeolothripidae representatives but is a predator of economic importance to phytophagous thrips and mites, being considered a potentially very effective autochthonous facultative predator among zoophagous thrips in Europe (Abenaim *et al.* 2022).

Many Thysanoptera species are polyphagous, enabling them to survive and develop in diverse agricultural ecosystems. Certain species consistently endanger alfalfa and various other crops (Pustai *et al.* 2015).

In Bulgaria, *Frankliniella intonsa* Trybon, 1895, *T. tabaci, Teniothrips frici* Uzel, 1895, *Haplothrips aculeatus* Fabricius, 1803, *H. angusticornis* Priesner, 1921, etc. were reported as harmful thrips on alfalfa (Donchev 1968; 1972; 1976). Karadjova and Krumov (2015) compiled data on thrips in Bulgaria and found 26 species on alfalfa, with Thripidae being the most diverse family.

Research on the composition and seasonal dynamics of thrips in alfalfa is insufficient and scarce in Bulgaria. Similar studies are substantial because they help identify the appropriate plant development stage for controlling thrips pests when they exceed the economic threshold of harm. Also, these studies help Bulgarian farmers reduce losses from phytophagous insects.

Therefore, this study aimed to identify the species composition and population dynamics of the main thrips in alfalfa.

MATERIAL AND METHODS

From 2018 to 2021, a study was conducted in the Experimental field of the Institute of Forage Crops in Pleven, Bulgaria, focusing on the order Thysanoptera in alfalfa cultivated for forage. Alfalfa was sown in spring and grown under non-irrigated conditions with an area of 300 m^2, 25 kg/ha sowing rate, and an inter-row distance of 11.5 cm. The crop was grown after an oat predecessor for four years. Forage harvesting was performed at the flowering stage in four regrowth periods during the growing season following alfalfa forage technology (Radeva *et al.* 2006). Sweeping with an entomological net is used. Samples were taken once a week throughout the growing season. Each sample for a given week included eight replicates and covered 20 sweeps. Replications were performed diagonally. The method was used in warm and sunny weather in the time range between 9 and 11 o'clock. It is considered the most appropriate method for studying insects found in the upper parts of plants. Each sample comprised the collected individuals by 20 sweeps with an entomological net. Collected individuals were placed into dark-coloured glass vials containing 70% ethyl alcohol. Each vial was marked with the date, month, year, and replication number for identification. The collected material was processed in the entomology laboratory at the Institute of Forage Crops.

The meteorological factorsas temperature, relative humidity, and precipitation affecting the thrips number were taken from a meteorological Pleven station.

The classification of species was made by Boychev (1975) that: *-dominant species with more than 15% participation, **-subdominant – from 5 to 15% ***-secondary – from 1 to 5% ****-tertiary – less than 1% contribution to the total population density of pest. The determination of species was made using a collection by Prof. Kiran Donchev.

The analysis focused on the climatic parameters between March and September to study the occurrence of thrips and their predators in the field. Canonical correspondence analysis (CCA) was performed to evaluate the impact of specific climatic variables on the population density of the species. The Paleontological Statistics Software Package (PAST) (Hammer *et al.* 2001) assisted with the calculations.

RESULTS AND DISCUSSION

Meteorological conditions during the years of study determined different thrips densities during the growing season. The highest thrips population was observed in 2019, accounting for 43.9% of the total density for 2018–2021. That was influenced by high mean day-night air temperatures, moderately high relative humidity, and relatively even distribution of precipitation favorably influenced thrips development and reproduction. On average, the temperatures were 1.4, 1.2, and 0.9°C warmer than in 2018, 2020 and 2021, respectively (Figure 1). The higher average day and night air temperatures in 2018 and 2020, along with moderate precipitation, led to the successful development of pests. Consequently, the population of thrips increased to 16.4% in 2018 and 19.4% in 2020 compared to the total density for 2018–2021. The thrips population in alfalfa in 2021 (20.4%) was similar to the numbers in 2020.

Higher temperatures, longer sunshine duration and higher air pressure contributed to the thrips population increase, according to Orosz *et al.* (2016). Temperature had the most significant impact on thrips migration among meteorological factors. Higher temperatures led to the rise of migrating individuals. Orosz *et al.* (2016) also noted that more sunny hours and an optimal air humidity of around 62% had a positive impact. Wind, however, made the migration process difficult.

CCA was conducted to examine the relations

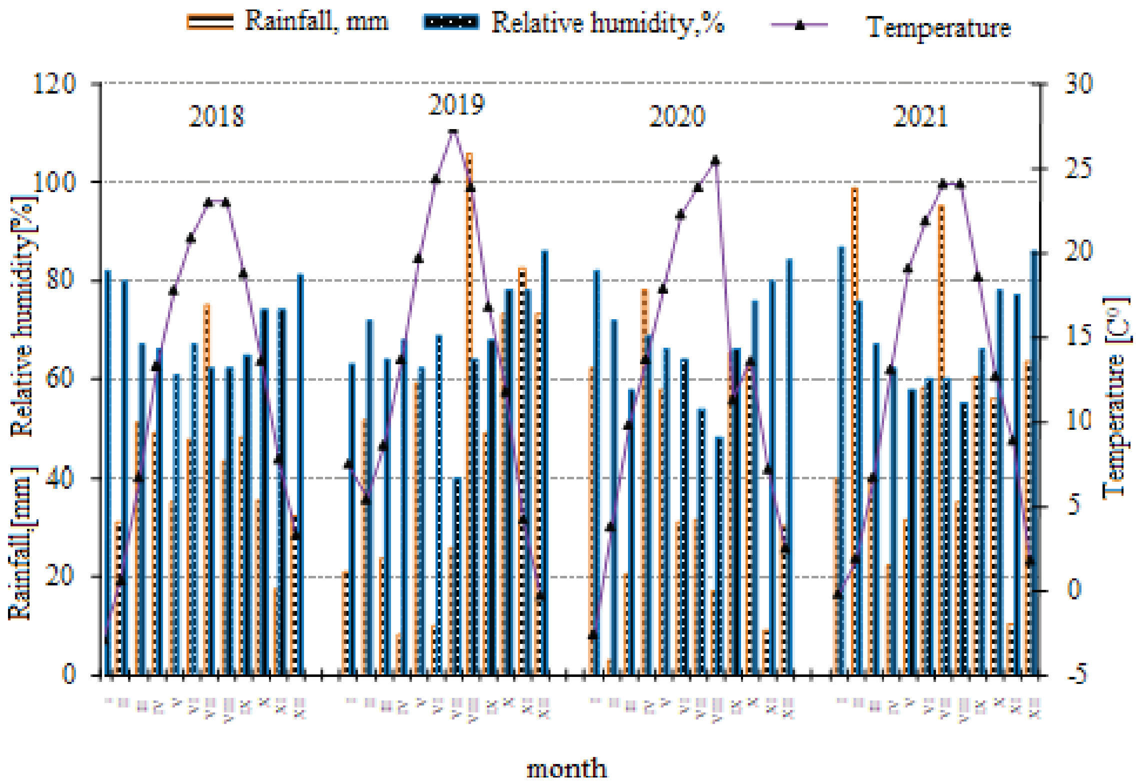


Figure 1. Agrometeorological characteristics for the Pleven region.

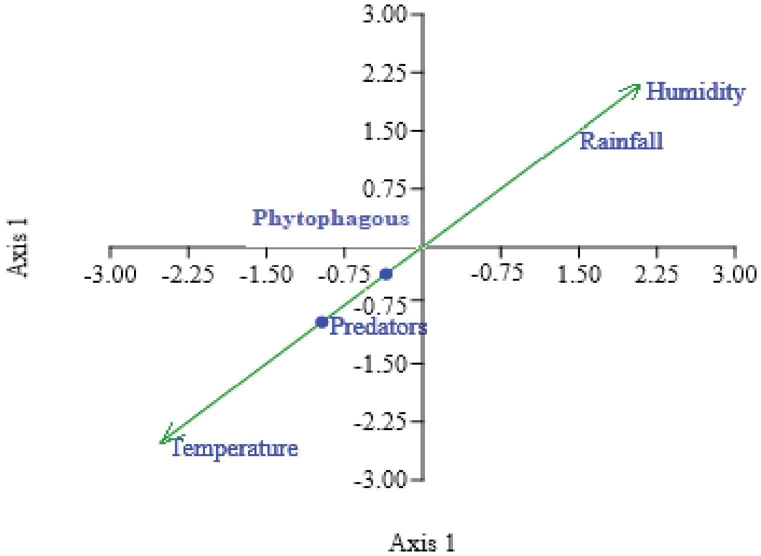
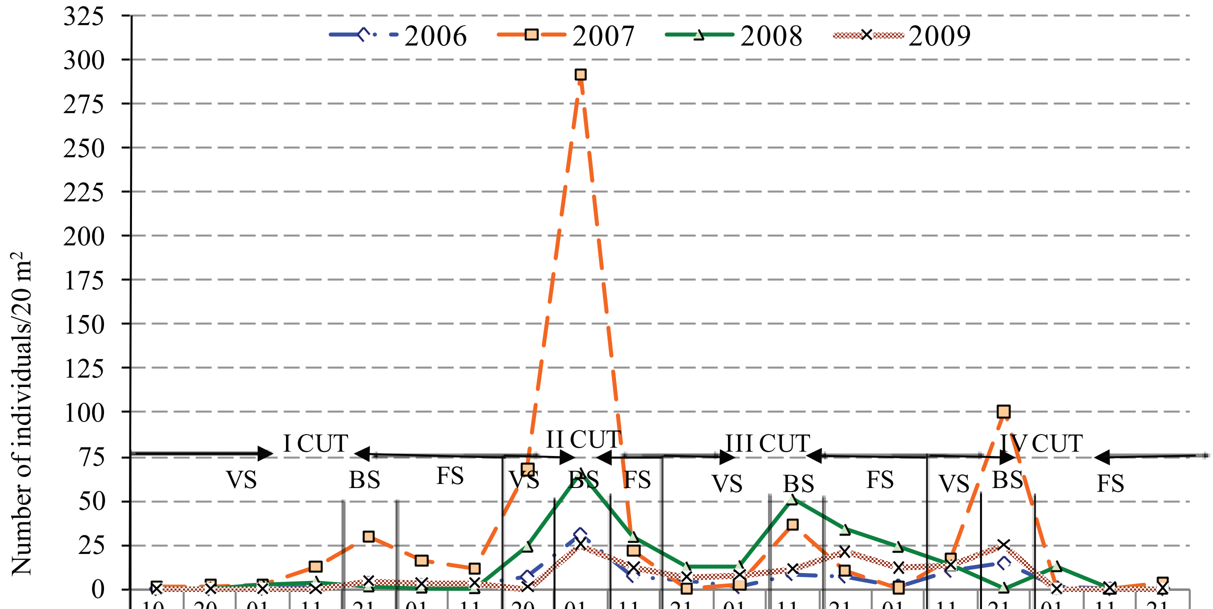


Figure 2. Canonical correspondence analysis (CCA) graph based on the correlation of population density of phytophagous thrips and predator thrips for *Medicago sativa* L. according to several climatic parameters. The period analysed was from March to September.



	10-20.03	20-31.03	01-10.04	11-20.04	21-30.04	01-10.05	11-20.05	20-31.05	01-10.06	11-20.06	21-31.06	01-10.07	11-20.07	21-31.07	01-10.08	11-20.08	21-30.08	01-10.09	11-20.09	21-31.09
2006	0	0	0,2	1	3,2	2	1,9	6,7	30,5	7,3	4,6	1,1	8,4	7	1,7	10,2	14,4	0,7	0	0
2007	1,3	1,7	2,1	12,7	29,8	15,9	11,3	67,5	291	21,9	0	2,6	36,3	10,6	0,6	16,9	101	0	0	3,8
2008	0	0,6	1,9	4,1	1,3	0,6	0,3	24,1	66,3	29,7	12,2	13	51,2	33,8	24	13,4	0,6	12,9	0	0
2009	0	0	0	0	4,4	3,1	3,5	0,9	25,5	11,9	6,9	8,2	11,3	21,3	12,1	13,5	25	0,3	0,7	0,6

Legend: VS – vegetative stem; BS – button stage; FS – flowering stage; I CUT – first regrowth; II CUT – second regrowth; III CUT – third regrowth; IV CUT – fourth regrowth.

Figure 3. Population dynamics of *Thrips tabaci* in alfalfa.

between the population density of phytophagous and predator species and climate factors (Figure 2). The population of harmful and predator thrips was positively correlated with temperature, while humidity and rainfall negatively affected thrips numbers.

In Figure 2, the arrow representing a quantitative variable passed from the center of the chart to a point indicating the correlation of the variable with the axes. Each element in the diagram allowed for interpretation. The positioning of the agrometeorological variables showed that the synthetic gradient (i.e., the explained variation in predatory density) had a higher positive impact than phytophagous. Rainfall and humidity had a more negative impact. These factors are substantial to consider when assessing the effects of harmful and useful thrips on alfalfa.

From 2018 to 2021, 2,411 adult and larvae individual thrips were recorded. Thysanoptera was represented by 13 species from three families and eight genera, as shown in Table 1.

The Thripidae family had the greatest genera and species diversity, constituting 53.17% of the order's population density. There were ten different species belonging to five different genera. The Aeolothripidae family came in second, occupying 44.00% of the population with two species. The Phlaeothripidae family had a minor involvement, with only one species making up 2.0%. The study investigated the thrips species and their seasonal dynamics in alfalfa grown for forage.

Established harmful species had the highest density, of which the dominant species was *T. tabaci* with 37.38% participation, followed by subdominant species *T. atratus* Haliday (1836) (9.66%) and minor species *Haplothrips niger* Osborn, 1883 (1.99%), *F. intonsa* (144 %) and *Odontothrips confusus* Priesner, 1926 (1.329 %). Predatory thrips had a comparatively high population represented mainly by the dominant species *A. intermedius* (43.81% in the population density of the order).

Harmful species were more prevalent than predatory thrips. From 2018 to 2021, pests accounted

T a b l e 1

Species composition and abundance of Thysanoptera in alfalfa forage, average for vegetation period

Family/species	2018 Numbers / %		2019 Numbers / %		2020 Numbers/ %		2021 Numbers/%		Total Numbers / %	
Aeolothripidae										
Aeolothrips intermedius (Bagnall 1934)* a	188.4	47.60	432.0	40.86	144.0	30.85	291.6	59.41	1,056.0	43.81
Melanthrips pallidior (Priesner 1919)**** a	1.2	0.30	1.2	0.11	0.0	0.00	2.4	0.49	4.8	0.20
Phlaeothripidae										
Haplothrips niger (Osborn 1883)*** b	6.0	1.52	22.8	2.16	3.6	0.77	15.6	3.18	48.0	1.99
Thripidae										
Frankliniella intonsa (Trybon 1895)*** b	0.0	0.00	14.4	1.36	8.4	1.80	12.0	2.44	34.8	1.44
Frankliniella occidentalis (Pergande 1895)**** b	0.0	0.00	12.0	1.14	4.8	1.03	6.0	1.22	22.8	0.95
Frankliniella tenuicornis (Uzel 1895)**** b	0.0	0.00	3.6	0.34	3.6	0.77	9.6	1.96	16.8	0.70
Odontothrips confusus (Priesner 1926)*** b	7.2	1.82	8.4	0.79	13.2	2.83	2.4	0.49	31.2	1.29
Odontothrips phaleratus (Haliday 1836)**** b	0.0	0.00	2.4	0.23	1.2	0.26	3.6	0.73	7.2	0.30
Odontothrips loti (Haliday 1852)**** b	0.0	0.00	1.2	0.11	0.0	0.00	1.2	0.24	2.4	0.10
Neohydatothrips gracilicornis (Williams 1916)**** b	0.0	0.00	3.6	0.34	2.4	0.51	4.8	0.98	10.8	0.45
Stenothrips graminum (Uzel 1895)**** b	6.0	1.52	8.4	0.79	4.8	1.03	2.4	0.49	21.6	0.90
Thrips atratus (Haliday 1836)** b	46.8	11.82	82.8	7.83	78.0	16.71	25.2	5.13	232.8	9.66
Thrips tabaci (Lindeman 1889)* b	136.8	34.56	459.6	43.47	196.8	42.16	108.0	22.00	901.2	37.38
Unknown thrips	3.4	0.86	4.8	0.45	6.0	1.29	6.0	1.22	19.2	0.84
Total	395.8	100.00	1,057.2	100.00	466.8	100.00	490.8	100.00	2,410.6	100.00

Legends: *-dominant species with more than 15% participation, **-subdominant – from 5 to 15% ***-secondary – from 1 to 5%, ****-tertiary – less than 1% contribution to total population density of pest; a – phytophagous; b – predators.

for 55.16% of the total Thysanoptera species, while predatory thrips comprised 44.00%, and species of unknown status made up 0.84%.

Depending on weather conditions during the study, *T. tabaci* appeared in alfalfa during the entire growing season (Figure 3).

The species is known to feed on a plant variety and can produce over eight generations/year. In Bulgaria, thrips attacks on over 80 types of cultivated plants.

Thrips tabaci is the most significant and numerous insect pest from the Thysanoptera order. During early spring, overwintering individuals leave their wintering grounds and move on to weedy and cultivated plants. The species was first observed in alfalfa crops on March 19, 2019, during the stem formation stage. The number of individuals was relatively low, ranging from 0.6 to 29.8 adult individuals/20 m^2 from the second half of March to the second half of May during the first regrowth, with a slight increase observed in the budding stage. The weak presence of the species in the same stage was based on the lower average day-night air temperature and higher amount of precipitation compared to other years.

During the second regrowth period, the density increased from the second half of May to the second half of June. The highest numbers were recorded in the first ten days of June during the budding and beginning of flowering stages, ranging from 25.5 to 291.4 individuals / 20 m^2.

In the third and fourth regrowth, the species occurred in significantly lower numbers due to higher temperatures and lower precipitation in July and August. That suppressed the development of tobacco thrips. In the second half of July and August, coinciding with the budding and onset of flowering, there was a slight rise in numbers. The density peaked at subsequently 51.2 and 100.6 adult individuals per 20 m^2, respectively. *Tobacco thrips* at the end of September had a minor presence (from 0.6 to 3.8 number of individuals / 20 m^2).

According to some authors (Devi & Mahadevappa 2021), hot and dry weather favored the growth of *T. tabaci* populations and the extent of the damage. It was difficult to determine whether the damage results from feeding or reduced mortality of thrips in the absence of rainfall (Raut *et al.* 2020). It suggested that water stress can increase the nutritional value and attractiveness of the host plant (Ahmed *et al.* 2017). After heavy rainfall, thrips species can be flushed from plants (Makwana & Dulera 2018), observed in the present study.

According to Karadjova and Krumov (2015), *T. tabaci, F. occidentalis,* and *H. tritici* Kurdjumov, 1912 were species of great economic importance in Bulgaria. They were reported as insect pests of *M. sativa* in earlier faunal studies by Donchev (1972) and others. Also, according to Ábrahám (2012), the most common species in alfalfa were *O. confusus, T. tabaci* and *F. intonsa,* which not only feed on and damage forage plants but also reproduce on them.

The population dynamics suggested that treating against *T. tabaci* can be done from late May to early June, during the budding stage of the second regrowth.

Thrips atratus was reported for the first time in our country on alfalfa in 1972 by Donchev (1972). A subsequent study by Karadjova and Krumov (2015) confirmed the presence of pests in alfalfa crops. From 2018 to 2021, *T. atratus* was a subdominant species and was present annually in alfalfa in higher numbers than the other established species (except *T. tabaci*). The pest emerged in late March or early April and persisted until the end of the growing season (Figure 4). It was found in high numbers from the beginning of April to the beginning of June. It reached a maximum at the start of budding and flowering stages of the first regrowth, with 21.3 and 15.0 adult individuals per 20 m^2, respectively. The peak value was in the budding stage of the second regrowth (reaches 25.0 number of individuals / 20 m^2). The thrips density in the following third and fourth regrowth was negligible and varied from 0.1 to 5.3 number of adult individuals / 20 m^2.

Harmful thrips may cause significant yield losses, either through reductions in yield or quality. When the *T. atratus* population reaches the economic harmfulness threshold, it is crucial to carry out treatment at the beginning of the first and second regrowth, specifically in early April and late May.

It is possible to apply control measures at the same time to both *T. atratus* and *T. tabaci.*

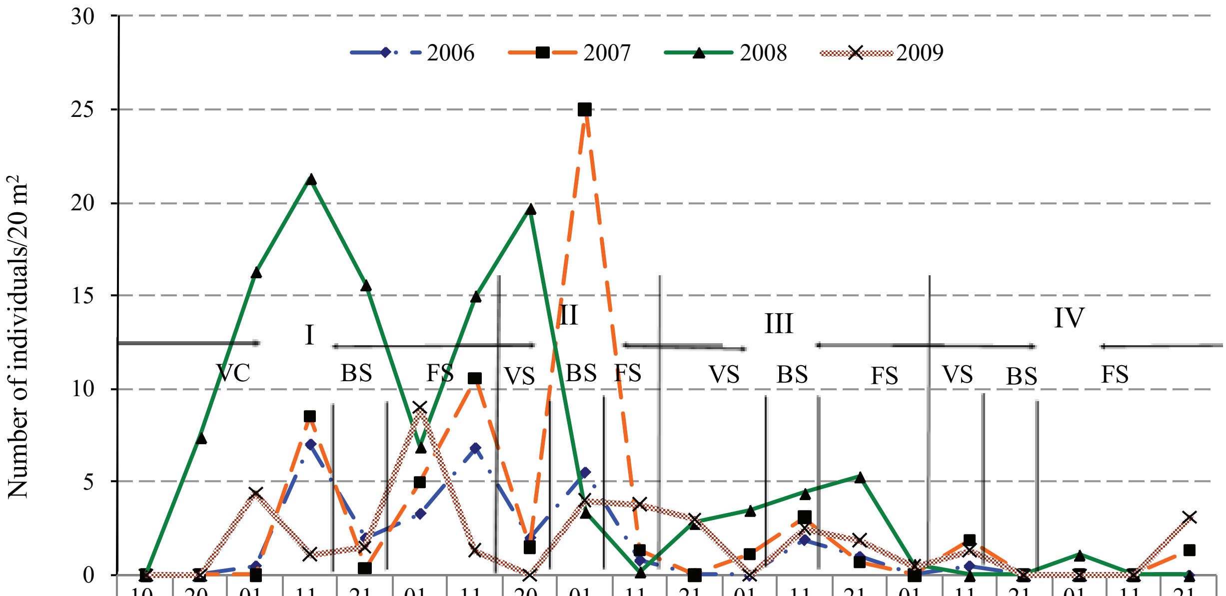
Haplothrips niger and *O. confusus* were reported by some authors as one of the main harmful thrips in alfalfa grown for seed (Bournoville *et al.* 1986;

Vîrteiu *et al.* 2021). They referred to the harmful species, which mainly damage the flowering parts. The study found that thrips had a low density and did not pose a threat to the plants. In Hungary, Bayar (2000) studied the seasonal dynamics of *O. confusus* and the predatory thrips *A. intermedius* in alfalfa. The research reported that both species predominated in crops, with the first specimens of species observed at the end of May and populations reaching their maximum in mid-August.

Odontothrips loti Haliday, 1852 and *F. occidentalis* during the period 2018–2021 had a minor contribution (0.0 and 1.22%, respectively), while other authors reported that these species were one of the most common thrips in alfalfa crops (Badieritakis *et al.* 2015; Vîrteiu *et al.* 2021). The proportion of *F. intonsa* (1.44%) prevailed over *F. occidentalis* and was classified as a minor pest. Under certain conditions, its numbers can increase considerably and become a potential pest for alfalfa plants.

Ullah and Lim (2015) found that *F. intonsa* and *F. occidentalis* were pests that coexist in the same areas and have overlapping ranges in many field crops in Korea. The authors noted that temperature fluctuations significantly affected the developmental time range and sex of both species. The complete developmental cycle from egg to adult in *F. intonsa* was shorter than that of *F. occidentalis* regardless of temperature, and the proportion of female individuals was higher in *F. intonsa* (72.1–75.7%) compared to *F. occidentalis* (57.4–58.7%) under constant and variable temperature regimes. Ullah and Lim (2015) concluded that *F. intonsa* exhibited a higher natural growth rate. Therefore, the species may have a higher pest potential.

The dominant species of predatory thrips were *A. intermedius* and *Melanthrips pallidior* Priesner, 1919. A study by Diaz-Montano *et al.* (2011) found that *A. intermedius* was present in 30 different host plants from 16 botanical families, always in mixed populations of phytophagous or facultative phytophagous insects. This species in Bulgaria is com-



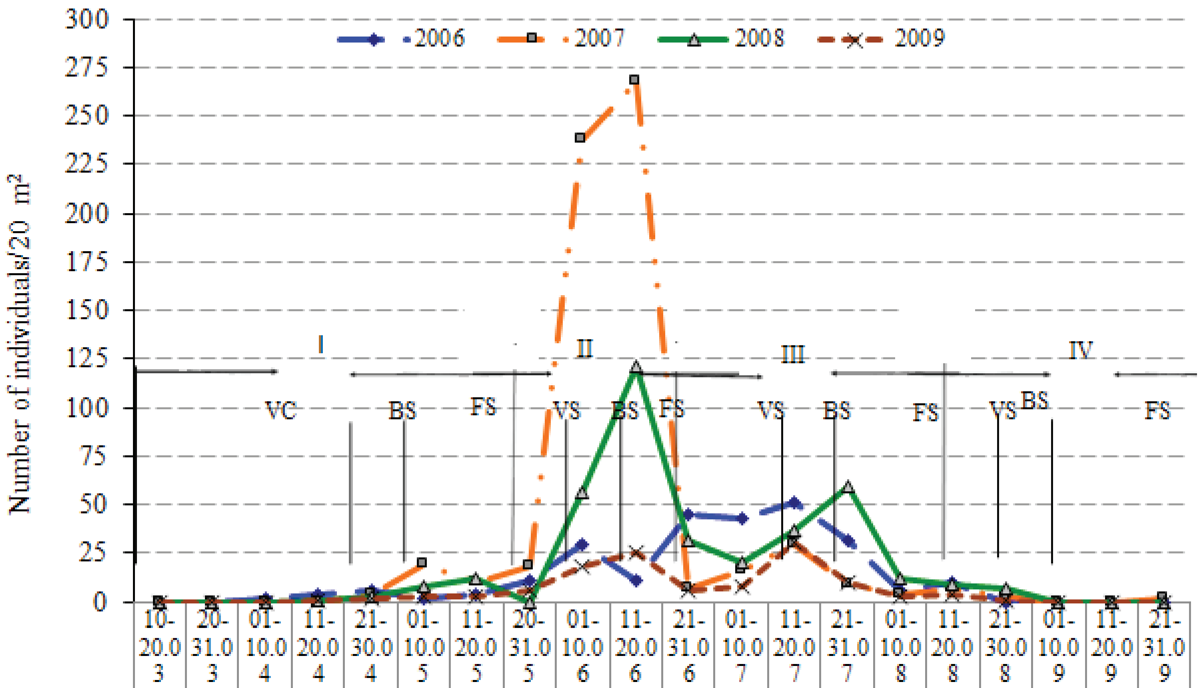
	10-20.03	20-31.03	01-10.04	11-20.04	21-30.04	01-10.05	11-20.05	20-31.05	01-10.06	11-20.06	21-31.06	01-10.07	11-20.07	21-31.07	01-10.08	11-20.08	21-30.08	01-10.09	11-20.09	21-31.09
2006	0	0	0,5	7	2	3,3	6,8	2	5,5	0,8	0,1	0	1,9	1	0	0,5	0	0	0	0
2007	0	0	0	8,5	0,4	5	10,6	1,5	25	1,3	0	1,1	3,1	0,7	0	1,9	0	0	0	1,3
2008	0	7,4	16,3	21,3	15,6	6,9	15	19,7	3,4	0,2	2,8	3,5	4,4	5,3	0,6	0	0	1,1	0	0
2009	0	0	4,4	1,1	1,5	9	1,3	0	4	3,8	3	0	2,5	1,9	0,5	1,3	0	0	0	3,1

Legend: VS – vegetative stem; BS – button stage; F – flowering stag, I – first regrowth; II – second regrowth; III – third regrowth; IV – fourth regrowth.

Figure 4. Population dynamics of *Thrips atratus* in alfalfa.

monly found in annual and perennial leguminous crops (Donchev 1968; Dimitrov 2008; Nikolova & Georgieva 2011). During the vegetation period of four years, its population density ranged from 0.4 to 267.5 numbers per 20 m^2. *Aeolothrips intermedius* first appeared in early April and could be observed until the end of the growing season (Figure 5). The species had a low population during the initial regrowth, with a slight increase observed in the first half of May at the flowering stage. The population density substantially increased during the second regrowth of alfalfa at the button and flowering stages. The highest number of thrips was found in the second decade of June during the flowering stage, with a density reaching 267.5/20 m^2 in 2019. Predatory thrips perchance fed on the eggs and young larvae of plant-eating thrips, and their population dynamics corresponded mainly with *T. tabaci*. After harvesting, the thrips numbers decreased, and a significant increase in species occurred in the third regrowth from the end of June to the end of July, with the density varying from 2.2 to 59.4 per 20 m^2. In the fourth regrowth, the highest value reached 8.8 numbers/20 m^2. Males outnumbered females, with a Sexual Index (ratio of male to female) ranging from 0.30 to 0.58 over the years, and the mean for the period was 0.43. Predators can regulate the density of harmful thrips up to a certain number and help reduce their population due to their high consumptive ability. *Aeolothrips intermedius* was consistently present in alfalfa agrocenosis and played a significant role as a bioagent.

Kaplin *et al.* (2020) also reported comparable dynamics in the density of predators in alfalfa fields. The authors observed that the first adults appeared in early April and the last thrips in late September. The highest number of adults was recorded in mid -June, mid-July, and the second half of August. The authors suggested that the species had three or four generations. Bournier *et al.* (1978) noted two peaks in the density of *A. intermedius* – in mid-June and mid-July. However, a third peak was missing due



	10-20.03	20-31.03	01-10.04	11-20.04	21-30.04	01-10.05	11-20.05	20-31.05	01-10.06	11-20.06	21-31.06	01-10.07	11-20.07	21-31.07	01-10.08	11-20.08	21-30.08	01-10.09	11-20.09	21-31.09
2006	0	0	1,2	4,1	5,8	2	3,7	10,4	29,9	11,3	45	42,5	51,5	31	5,5	10	0	0	0	0
2007	0	0	0	0	3,8	18,8	10	18,1	238	268	6,9	15,8	29,4	8,8	4,1	6,3	3,1	0	0	1,3
2008	0	0	0	0,4	2,4	7,6	12,2	0	56,7	121	31,2	20	36,9	59,4	12	8,8	6,3	0	0	0
2009	0	0	0	0,5	1,9	2,5	3,1	5,8	17,7	25,8	5,2	8	30	10	2,2	4	1	0	0	0

Legend: VS – vegetative stem; BS – button stage; FS – flowering stage; I – first regrowth; II – second regrowth; III – third regrowth; IV – fourth regrowth.

Figure 5. Population dynamics of *Aeolothrips intermedius* in alfalfa.

to different temperature conditions in August. According to Abenaim *et al.* (2022), predator efficiency was closely related to host plant developmental stages. Khosbayar (2001) observed a mass emergence and strong presence of thrips during the flowering stage when plants were most attractive. However, there was no consensus on whether this phenomenon was due to better access to high-quality pollen or the presence of more arthropods. Some entomologists did not attribute a particularly considerable role to pollen in thrips development (Milne *et al.* 1996; Nakao 1999), while others asserted its crucial importance in their diet (Gruss *et al.* 2019; Abenaim *et al.* 2022). A third perspective suggested that pollen served as an alternative food source, leading to higher reproductive rates but shorter lifespans (Teulon & Penman 1991) and generally diminishing the predation efficiency of thrips (van Rijn & Sabelis 1993).

According to some authors (Kaya 2018; Kaplin *et al.* 2020), alfalfa, as a plant host, provided both alternative foods for *A. intermedius* and sheltered many potential pests. Therefore, the predator's presence suggested the impending appearance of its potential prey. Years of research have consistently shown that *A. intermedius* primarily and preferentially food on the larvae of *T. tabaci,* as observed in pre-collected leaf samples. Moreover, the population dynamics of the predator were closely aligned with its prey. Conti (2009) reported a similar pattern, noting that the predator's abundance was mainly related to the presence of *T. tabaci* and *F. intonsa* in alfalfa, indicating a trophic dependency of *A. intermedius* larvae on the larvae of these pest species. Wang *et al.* (2022) also found that *A. intermedius* favored *T. tabaci* larvae, as they allowed for the predator's highest fecundity. Other researchers, including Ábrahám (2012), had similarly concluded that there was a strict trophic relationship between *A. intermedius* and *T. tabaci,* underscoring the predator's significant role in regulating alfalfa agroecosystems.

Further research on the feeding activity of *A. intermedius* needs to be conducted, using polymerase chain reaction to analyse genomic and mitochondrial deoxyribonucleic acid (DNA) from the species' gut contents. These DNA products, enzymatically amplified, should be limited by primers based on those used for *T. tabaci.* Such studies could form the basis of future research endeavors.

Considering the synchronized population dynamics of *A. intermedius* and *T. tabaci,* when applying chemical control, it is necessary to use selective and environmentally friendly insecticides to protect the natural populations of the beneficial organisms.

Predatory thrips, feeding on the eggs and young larvae of herbivorous insects, may serve as effective biological regulators of thrips pests.

Males were more frequently observed than females, with the sex index (the ratio of males to females) ranging from 0.30 to 0.58 over the years, with an average of 0.43.

Due to their high consumption capacity, predators can regulate the population of harmful thrips to a certain extent and help reduce their numbers. Aeolothrips intermedius was a constant presence in the alfalfa agroecosystem, playing a crucial role as a biological control agent.

Fostering conditions that increase the density of predatory species is a significant and economically viable method in biological control strategies.

Until now, no similar study has been conducted in our country regarding the species composition and numerical dynamics of the primary species of the Thysanoptera order in alfalfa, representing an original contribution to Bulgarian entomological science.

CONCLUSIONS

Canonical relationship analysis revealed that the population density of Thysanoptera phytophagous and predator species was positively related to the temperature, while humidity and rainfall negatively affected the thrips numbers.

The Thysanoptera order of alfalfa grown for forage had 13 species from three families and eight genera. The Thripidae family was the richest genus, represented by five genera and ten species – with 53.17% participation, followed by Aeolothripidae – 44.00% with two species. Harmful species had 55.16% and useful ones – had 44.00%.

The main pest was the dominant species *T. tabaci* with 37.38% participation, followed by subdominant species *T. atratus* Haliday – 9.66%. The predatory thrips *A. intermedius* was dominant also, accounting for 43.81% of the population density.

Thrips tabaci can be found in alfalfa throughout the growing season. It had the highest density in the second regrowth from the second half of May to the second half of June. Thrips reached the maximum values in the first ten days of June, in the button and the beginning of flowering. *Aeolothrips intermedius* dynamics corresponded with the *T. tabaci* ones. Aeolothrips intermedius is an effective predator that may play an important role in the biological control of Thysanoptera.

Acknowledgement: This work was financially supported by the Agricultural Academy of Bulgaria for the project "Ecological breeding and technological research in alfalfa".

REFERENCES

Abenaim, L., Bedini, S., Greco, A., Giannotti, P., and Conti, B. (2022). Predation capacity of the banded thrips Aeolothrips intermedius for the biological control of the onion thrips Thrips tabaci. *Insects, 13*(8), 702. DOI:10.3390/insects13080702.

Ábrahám, R. (2012). First investigation of species composition of thysanoptera inhabiting alfalfa based on their second-stage larvae. *Acta Phytopathologica et Entomologica Hungarica, 47*(1), 81 − 86. DOI:10.1556/APhyt.47.2012.1.10.

Ahmed, M.H., Ullah, M.I., Bakar, A., Afzal, M., Khaliq, A., Iftikhar, Y., and Aatif, H.M. (2017). Population dynamics of Thrips tabaci (Lindeman) in relation to abiotic climate factors on Bt and Non-Bt cotton cultivars. *Pakistan Journal of Zoology, 49*(6), 1937 − 1943. DOI:10.17582/journal.pjz/2017.49.6.1937.1943.

Alavi, J. and Minaei, K. (2018). Studies on the genus Aeolothrips (Thysanoptera: Aeolothripidae) in Iran, with a key to species. *Zootaxa, 4446*(3), 343 − 360. DOI:10.11646/zootaxa.4446.3.3.

Badieritakis, E.G., Thanopoulos, R.C., Fantinou, A.A. and Emmanouel, N.G. (2015). A qualitative and quantitative study of thrips (Thysanoptera) on alfalfa and records of thrips species on cultivated and wild Medicago species of Greece. *Biologia, 70*(4), 504 − 515. DOI:10.1515/biolog-2015-0050.

Bayar, K. (2000). The seasonal dynamics of the Thysanoptera species living on alfalfa in Hungary. *Russian Agricultural Sciences, 10,* 16 − 19. Available at: https://www.cabidigitallibrary.org/doi/full/10.5555/20023011528 [Accessed 29 Sept. 2024].

Bournier, A., Lacasa, A. and Pivot, Y. (1978). Biologie d'un Thrips prédateur Aeolothrips intermedius (Thys.: Aeolothripidae). *Entomophaga, 23*(4), 403 − 410. DOI:10.1007/BF02373058.

Bournoville, R., Doutchev, K. and Sedivy, J. (1986). Les ravageurs de la production de graines de Luzerne en Europe. Eucarpia, Section Fourrages-Fodder Crops Section, Groupe "Medicago sativa": La production de fourrage et de semences de Luzerne en Europe: maladies, ravageurs et variétés: 25 − 30, Paris.

Boychev, D. (1975). *Biology.* Zemizdat Publishing House, Agricultural Sciences Category, 179p.

Conti, B. (2009). Notes on the presence of Aeolothrips intermedius in northwestern Tuscany and on its development under laboratory conditions. *Bulletin of Insectology, 62*(1), 107 − 112.

Devi, R.S. and Mahadevappa, S.G. (2021). Effect of weather parameters on the incidence of thrips, Thrips tabaci Lindeman on Bt cotton. *International Journal of Environment and Climate Change, 11*(12), 107 − 112. DOI:10.52804/ijaas2021.2116.

Diaz-Montano, J., Fuchs, M., Nault, B.A., Fail, J., and Shelton, A.M. (2011). Onion thrips (Thysanoptera: Thripidae): A global pest of increasing concern in onion. *Journal of Economic Entomology, 104*(1), 1 − 13. DOI:10.1603/EC10269.

Dimitrov, D. (2008). *Harmful and useful entomofauna in some legumes.* PhD Thesis, General Toshevo, 170p.

Donchev, K. (1968). Contribution to the Thysanoptera in Bulgaria. *Plant Science, 5*(6), 89 − 97.

Donchev, K. (1972). Contribution to the Thysanoptera in Bulgaria II. *Plant Science, 9*(3), 131 − 135.

Donchev, K. (1976). Contribution to the Thysanoptera in Bulgaria III. *Plant Science, 13*(1), 175 − 181.

Gao, Y.L. and Reitz, S.R. (2017). Emerging themes in our understanding of species displacements. *Annual Review of Entomology, 62*(1), 165 − 183. DOI:10.1146/annurev-ento-031616-035425.

Gruss, I., Twardowski, J.P. and Cierpisz, M. (2019). The effects of locality and host plant on the body size of Aeolothrips intermedius (Thysanoptera: Aeolothripidae) in the southwest of Poland. *Insects, 10*(9), 266. DOI:10.3390/insects10090266.

Hammer, Ø., Harper, D.A.T. and Ryanh, P.D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica, 4,* 1 − 9. Available at: https://doc.rero.ch/record/15326/files/PAL_E2660.pdf [Accessed 29 Sept. 2024].

Kaplin, V.G., Volodina, I.A., Kuryanovich, A.A. et al. (2020). Dynamics of the composition and density of insects on aboveground organs of alfalfa in the forest-steppe of Samara Province. *Entomological Review, 100,* 591 − 619. DOI:10.1134/S0013873820050036.

Karadjova, O. and Krumov, V. (2015). Thysanoptera of Bulgaria. *Zookeys, 50*(4), 93 − 131. DOI:10.3897/zookeys.504.9576.

Kaya, K. (2018). Determination of insect fauna and population density of some species in the alfalfa production area in Hatay. *Turkish Journal of Agriculture – Food Science and Technology, 6*(3), 352 − 359. DOI:10.24925/turjaf.v6i3.352-359.1747.

Khosbayar, B. 2001. The seasonal dynamics of the Thysanoptera species living on alfalfa in Hungary. *Russian Agricultural Sciences, 10,* 16 − 19. Available at: https://www.cabidigitallibrary.org/doi/full/10.5555/20023011528 [Accessed 28 Sept. 2024].

Loredo Varela, R.R.C. and Fail, J. (2022). Host plant association and distribution of the onion thrips, Thrips tabaci cryptic species complex. *Insects, 13*(3), 298. DOI:10.3390/insects13030298.

Makwana, D.K. and Dulera, J.G. (2018). Seasonal incidence of sucking pests with relation to weather parameters in Bt cotton. *Gujarat Journal of Extension Education, 29*(2), 167 − 170. Available at: https://www.gjoee.org/papers/938.pdf [Accessed 30 Sept. 2024].

Milne, J.R., Walter, G.H., Kaonga, D., and Sabio, G.C. (1996).

The importance of non-pollen plant parts as food sources for the common blossom thrips, Frankliniella schultzei. *Entomologia Experimentalis Et Applicata, 78,* 271 – 281. DOI:10.1111/j.1570-7458.1996.tb00791.x.

Nakao, S. (1999). Resource utilization of composite thrips, Microcephalothrips abdominalis (Crawford), and ecological significance of wing polymorphism in males. *Japanese Journal of Applied Entomology and Zoology, 43,* 25 – 33. DOI:10.1303/jjaez.43.25.

Nikolova, I. and Georgieva, N. (2011). Study on cicada and trips entomofauna in winter vetch (Vicia villosa Roth.). *Banat's Journal of Biotechnology, 2*(3), 29 – 34.

Orosz, S., Bujdos, L., Varga, L., and Fekete, T. (2018). Investigations of Thrips tabaci and Aeolothrips intermedius population dynamics in tobacco plantations. *Acta agraria Debreceniensis, 74,* 121 – 127. DOI:10.34101/actaagrar/74/1676.

Orosz, S., Szénási, Á., Puskás, J., Ábrahám, R., Fülöp, A., and Jenser, G. (2016). Observations on the flight pattern of some Phlaeothripidae (Thysanoptera) species by using suction trap in Hungary. *Agriculture and Environment, 8,* 16 – 26. DOI:10.1515/ausae-2016-0002.

Pobożniak, M. and Koschier, E. (2014). Effects of pea (Pisum sativum L.) cultivars on Thrips tabaci Lindeman preference and performance. *The Journal of Agricultural Science, 152*(6), 885 – 893. DOI:10.1017/S0021859613000518.

Pushpendra, E., Thakur, A.S., Thomas, M., Bhowmick, A.K., and Sharma, H.L. (2014). Screening of onion genotypes against Thrips tabaci Lind. in Central India. *Internal Journal of Biodiversity and Conservation, 6*(12), 806 – 813. DOI:10.5958/0974-4576.2019.00066.5.

Pustai, P.M., Oltean, I., Florian, T. and Bodis, I. (2015). Monitoring of the crop pests of forage legumes in the area Raciu, Mureş. *Veterinary Medicine, 72*(1), 202 – 208. DOI 10.15835/buasvmcn-agr: 10632.

Radeva, V., Dimitrova, Ts., Kertikov, T., Kertikova, D., Akirilov, A., Krachunov, I., Ilieva, A., Pachev, I., Vasilev, E., Vasileva, V., Stoykova, M., and Nikolova, I. (2006). Alfalfa forage production technology. *Agriculture Plus, 2,* 17 – 24. (Bg).

Raut, A.M., Pal, S., Wahengbam, J. and Banu, A.N. (2020). Population dynamics of onion thrips (Thrips tabaci Lindeman, Thysanoptera; Thripidae) and the varietal response of onion cultivars against onion thrips. *Journal of the Entomological Research, 44*(4), 547 – 554. DOI:10.5958/0974-4576.2020.00092.4.

Remani, R.R., Thippeswamy, R., Ramasamy, G.G., and Shivalingegowda, S. (2023). New record of two thrips species (Thysanoptera: Terebrantia: Thripidae) from India along with redescription, host association and DNA barcode of Euphysothrips minozzii Bagnall. *International Journal of Tropical Insect Science, 43,* 1675 – 1681. DOI:10.1007/s42690-023-01087-3.

Teulon, D.A.J. and Penman, D.R. (1991). Effects of temperature and diet on oviposition rate and development time of the New Zealand flower thrips, Thrips obscuratus. *Entomologia Experimentalis et Applicata, 60*(2), 143 – 155. DOI:10.1111/j.1570-7458.1991.tb01533.x.

Moritz, G. (2024). Thrips.net. A microcosm of biodiversity. University of Halle, Germany, All Rights Reserved. Available at: https://thripsnet.zoologie.uni-halle.de/ [Accessed 12 Apr. 2023].

Ullah, M.S. and Lim, U.T. (2015). Life history characteristics of Frankliniella occidentalis and Frankliniella intonsa (Thysanoptera: Thripidae) in constant and fluctuating temperatures. *Journal of Economic Entomology, 108*(3), 1000 – 1009. DOI:10.1093/jee/tov035.

van Rijn, P.C.J. and Sabelis, M.W. (1993). Does alternative food always enhance biological control? The effect of pollen on the interaction between western flower thrips and its predators. *Bull OILB/SROP, 16,* 123 – 125. Available at: https://www.cabidigitallibrary.org/doi/full/10.5555/19931182358 [Accessed 29 Sept. 2024].

Vîrteiu, A.M., Ștef, R., Cărăbeț, A., Molnar, L., and Grozea, I. (2021). Revision of the genus Odontothrips amyot & Serville (Thysanoptera, Thripidae) with the redescription of Odontothrips loti (Haliday, 1852) species on Lotus corniculatus crops. *Research Journal of Agricultural Science, 53*(2), 2.

Wang, Z., Mound, L.A., Hussain, M., Arthurs, S.P. and Mao, R. (2022). Thysanoptera as predators: their diversity and significance as biological control agents. *Pest Management Science, 78,* 5057 – 5070. DOI:10.1002/ps.7176.

Received: April 11, 2024
Accepted: September 26, 2024