

ARTHROPOD FAUNA BIODIVERSITY IN ALFALFA AGROECOSYSTEMS UNDER HYDRIC STRESS CONDITIONS: A PRELIMINARY STUDY

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Abstract

Alfalfa (Medicago sativa L.) provides a long-term agricultural habitat in which arthropod assemblages can develop and persist, making it a suitable system for examining faunal responses to environmental constraints. In recent climatic contexts, hydric stress has emerged as a key factor shaping arthropod distribution and community structure within agroecosystems. This study was conducted during the 2024 growing season in an experimental alfalfa field located in Ghilad, western Romania, at a stage corresponding to the third year of crop establishment and under conditions of reduced water availability. Arthropod fauna was surveyed from April to September through monthly sampling events using sweep netting and direct visual observations, followed by laboratory-based taxonomic identification. The arthropod fauna recorded under hydric stress conditions comprised eight major taxonomic orders, with Coleoptera and Hemiptera accounting for the highest numerical dominance. Community composition was strongly skewed toward phytophagous species, particularly Phytodecta formicata and Aphis craccivora, which together represented a substantial proportion of the total abundance. Statistical analyses revealed significant differences among orders, families, and species, indicating a pronounced functional imbalance within the assemblage. Overall, the observed taxonomic and functional patterns highlight the influence of hydric stress on the distribution and relative dominance of arthropod groups associated with alfalfa agroecosystems.

Key words: arthropod fauna, alfalfa agroecosystem, hydric stress, community structure, taxonomic diversity.

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is a perennial forage legume belonging to the subfamily *Papilionoideae* and plays a key role in livestock production systems due to its high nutritional value and widespread use in animal feeding (Daud et al., 2025; Varol et al., 2024). Cultivated for more than 9,000 years, alfalfa is among the oldest plants used for forage production and is currently widely distributed across numerous agricultural regions worldwide (Michaud et al., 1988; Bellague et al., 2018; Li and Huang, 2008; Singer et al., 2018). Its remarkable ecological adaptability and strong regenerative capacity have facilitated its extensive integration into agricultural systems, with alfalfa frequently referred to in the scientific literature as the “queen” or “king” of forage crops (Peng et al., 2025; Zhang et al., 2025). In the context of ongoing climate change, the frequency of extreme climatic events has increased considerably, being characterized by rising mean temperatures, reduced precipitation,

and the occurrence of prolonged drought episodes (Tyshchenko et al., 2020). Under such conditions, abiotic stress, particularly water deficit, is considered a major limiting factor for agricultural productivity (Li et al., 2021; Zhang et al., 2025). Although alfalfa exhibits relatively high tolerance to water deficit compared with other cultivated legumes, its productivity remains strongly influenced by environmental conditions, while hydric stress may substantially reduce both biomass yield and forage quality (Daud et al., 2025; Huang et al., 2018; Capstaff and Miller, 2018; Bellague et al., 2018; Liu et al., 2021).

The functioning of agricultural ecosystems largely depends on the biodiversity of organisms associated with crop systems. Insects, mites, and spiders perform essential ecological functions, contributing to processes such as pollination, biological control of pests, and the recycling of organic matter (Schowalter, 2016; Losey & Vaughan, 2006). The structure of these biological communities can reflect the ecological status of agroecosystems and provide

valuable insights for the development of sustainable management strategies (Gurr et al., 2003). Species distribution is influenced by specific ecological traits that determine how organisms respond to environmental variability (Gaston, 2003; Holt, 2003).

In perennial forage crops such as alfalfa, these ecological interactions are particularly pronounced. Alfalfa stands support diverse arthropod communities, including phytophagous species, entomophagous organisms, and pollinators (Razzaq & Al-Saffar, 2016; Flanders and Radcliffe, 2013). More than 1,000 species have been reported in association with this crop, of which approximately 100-150 may cause varying degrees of damage, while the majority fulfil important ecological roles within the agricultural ecosystem (Flanders and Radcliffe, 2013). Previous studies have revealed the complexity of these assemblages, with alfalfa ecosystems supporting hundreds of morphospecies belonging to multiple taxonomic orders and families. For example, Aljoboory et al. (2022) reported 205 arthropod species distributed among 92 families and 10 orders, including representatives of the order Araneae, underscoring the considerable biodiversity associated with alfalfa agroecosystems. This diversity is often dominated by phytophagous species, yet entomophagous organisms and pollinators play an important role in maintaining ecological balance (Bengouga et al., 2026). In Eastern Europe, studies conducted in alfalfa fields have also revealed a considerable diversity of coleopteran species associated with this agricultural habitat (Munteanu et al., 2014). Despite these findings, the biodiversity of organisms associated with forage crops remains insufficiently investigated, particularly within agroecosystems in Romania (Lisenchi - Murariu & Moglan, 2006; Vîrteiu et al., 2012; Pustai et al., 2015; Otavă et al., 2019). At the same time, agricultural intensification and biodiversity loss may reduce the capacity of agroecosystems to maintain ecological balance, whereas perennial crops such as alfalfa may provide favorable habitats for the conservation of biological diversity and the maintenance of associated ecosystem services (Tscharniske et al., 2005; Kremen & Miles, 2012).

In this context, the present study aimed to evaluate the species diversity and community

structure of arthropods associated with alfalfa agroecosystems under hydric stress conditions in an experimental field located in Ghilad (Timiș County, Romania) during the 2024 growing season.

MATERIALS AND METHODS

Study area and experimental design

The study was conducted in 2024 in an experimental alfalfa field located in Ghilad (Timiș County, western Romania), in the Timiș Plain, part of the Western Romanian Plain. The area is characterized by predominantly flat terrain at an altitude of approximately 85–95 m above sea level, providing suitable conditions for field sampling. Climatic conditions during the study period were characterized by above-average temperatures and a pronounced precipitation deficit, resulting in the development of both atmospheric and pedological drought in western Romania, including the study site in Ghilad (Timiș County). These conditions generated hydric stress in agricultural ecosystems, affecting the growth and productivity of crops such as alfalfa (*Medicago sativa* L.), and provided an appropriate ecological context for investigating the response of arthropod biodiversity to hydric stress conditions.

The experimental field covered approximately 0.5 ha and was cultivated exclusively with alfalfa (*Medicago sativa* L.). At the time of the study, the crop was in its third year of growth. The experiment was arranged in three replications, and a representative sampling area of 100 m² was selected within each replication. Each plot measured 25 m × 4 m, with 16 rows spaced 25 cm apart. No chemical treatments were applied during the monitoring period.

Arthropod sampling

Arthropod sampling was conducted monthly between April and September 2024, resulting in six sampling events. Sweep netting was used as the main sampling method to collect arthropods active on vegetation. For each plot, 50 double sweeps were performed during each sampling (figure 1). The collected specimens were placed in paper bags, immobilized, and transported to the laboratory for identification. Direct visual observations were also performed during field

visits in order to document ecological interactions such as feeding, predation, or flight activity.



Figure 1. Experimental field

Identification of specimens

All specimens were sorted and identified in the Plant Health Diagnosis and Expertise Laboratory of the Faculty of Agriculture using stereomicroscopes and taxonomic keys (Pălăgeşiu et al, 2000; Grozea, 2015). Individuals were classified according to their taxonomic affiliation (order, family, genus, or species). Specimens that could not be identified to species level were assigned to higher taxonomic categories and included in the analyses.

Statistical analysis

Arthropod community structure was characterized using relative abundance (AR%), calculated for each taxon in relation to the total number of collected individuals. Community diversity was evaluated using the Shannon diversity index (H'), Simpson dominance index (D), and Pielou's evenness index (J).

To explore the influence of climatic conditions on arthropod communities, relationships between arthropod abundance and environmental variables (temperature and precipitation) were evaluated using Spearman's rank correlation coefficient.

Climatic data and hydric stress assessment

Meteorological data used in this study were obtained from the historical records available on the Freemeteo platform (https://freemeteo.ro/...), using the nearest available location to the experimental field in Ghilad (Timiș County, western Romania). Monthly mean air temperature ($^{\circ}\text{C}$) and monthly total precipitation (mm) were considered for the

monitoring period between April and September 2024. Official ANM reports on pedological drought in western Romania during 2024 were also used to support the assessment of hydric stress conditions. Hydric stress was defined as the combined effect of below-normal precipitation and elevated temperatures during the vegetation period, associated with reduced water availability and increased atmospheric evaporative demand.

RESULTS AND DISCUSSIONS

During the sampling period, a total of 1230 arthropod individuals belonging to 30 species were collected from the experimental alfalfa field located in Ghilad (Timiș County, Romania). These taxa were distributed among seven arthropod orders, namely *Araneae*, *Orthoptera*, *Hemiptera*, *Hymenoptera*, *Coleoptera*, *Lepidoptera* and *Diptera* (Table 1). The presence of these taxonomic groups reflects a relatively diverse arthropod assemblage associated with the alfalfa crop, including phytophagous insects, predators, parasitoids and pollinators. Among the recorded orders, *Coleoptera* and *Hemiptera* clearly dominated both in terms of species richness and abundance. This pattern is typical for herbaceous agroecosystems, where phytophagous insects exploit the abundant plant biomass provided by the crop canopy, while predators and parasitoids contribute to the ecological complexity of the system. The analysis of relative abundance revealed a pronounced dominance structure within the arthropod community associated with the alfalfa crop. The most abundant species was *Phytodecta fornicata*, representing 37.40% of the total number of individuals collected. Other abundant taxa included *Aphis craccivora* (17.07%), *Adelphocoris lineolatus* (8.62%) and *Sitona lineatus* (6.91%). Together, these four species accounted for approximately 70% of the total individuals recorded during the sampling period. Such a community structure, characterized by the dominance of a limited number of highly abundant species, is commonly observed in herbaceous agroecosystems where specialized herbivores exploit the available host plant resources.

The trophic structure of the arthropod assemblage reflected the coexistence of several

functional groups associated with the alfalfa crop. Herbivorous taxa such as *Phytodecta fornicata*, *Aphis craccivora*, *Adelphocoris lineolatus* and *Sitona lineatus* represented the largest proportion of the collected individuals. Overall, phytophagous species accounted for more than 80% of the total number of individuals, highlighting the strong dependence

of the arthropod assemblage on the plant resources provided by the alfalfa crop. In addition to herbivores, the community also included predatory species, such as *Coccinella septempunctata* and *Adalia bipunctata*, which are well-known biological control agents of aphid populations.

Table 1. Arthropod species recorded in the alfalfa field and their relative abundance during the 2024 sampling period

ORDER	FAMILY	SUBFAMILY	Genus	Species	RA(%)
ARANEAE	LYCOSIDAE	PARDOSINAE	<i>Pardosa</i>	<i>P. agrestis</i>	0.81
	THOMISIDAE	THOMISINAE	<i>Xysticus</i>	-	0.33
ORTHOPTERA	TETTIGONIIDAE	TETTIGONINAE	<i>Tettigonia</i>	<i>T. viridissima</i>	2.93
HEMIPTERA	MIRIDAE	MIRINAE	<i>Adelphocoris</i>	<i>A. lineolatus</i> – a+l	8.62
		DERAEOCORINAE	<i>Deraeocoris</i>	<i>D. trifasciatus</i>	0.49
	NABIDAE	NABINAE	<i>Nabis</i>	<i>N. ferus</i> – l	0.65
	APHIDIDAE	APHIDINAE	<i>Aphis</i>	<i>A. craccivora</i>	17.07
	APHROPHORIDAE	APHROPHORINAE	<i>Philaenus</i>	<i>P. spumarius</i> – a+l	3.66
HYMENOPTERA	EURYTOMIDAE	-	-	-	1.79
	PTEROMALIDAE	-	-	-	1.06
	CHALCIDIDAE	-	-	-	0.81
	ICHNEUMONIDAE	-	-	-	0.57
COLEOPTERA	CHANTARIDAE	CHANTARINAE	<i>Cantharis</i>	<i>C. rustica</i>	0.89
	BYRRHIDAE	BYRRHIDAE	<i>Byrrhus</i>	<i>B. pilula</i>	1.14
	MORDELLIDAE	MORDELLINAE	<i>Mordellistena</i>	<i>M. parvula</i>	0.24
	COCCINELLIDAE	COCCINELLINAE	<i>Coccinella</i>	<i>C. septempunctata</i>	4.96
			<i>Adalia</i>	<i>A. bipunctata</i>	1.07
	CHRYSEMELIDAE	CHRYSEMELINAE	<i>Phytodecta</i>	<i>P. fornicata</i>	37.40
		CRIOCERINAE	<i>Oulema</i>	<i>O. melanopus</i>	0.08
		CEUTORYNCHINAE	<i>Ceutorhynchus</i>	<i>C. pallidactylus</i>	0.08
				<i>S. lineatus</i>	6.91
				<i>S. sulcifrons</i>	0.33
	CURCULIONIDAE	ENTIMINAE	<i>Sitona</i>	<i>S. humeralis</i>	1.63
				<i>S. hispidulus</i>	0.08
				<i>H. variabilis</i>	0.98
		TYCHIINAE	<i>Tychius</i>	<i>T. flavus</i>	0.24
	APIONIDAE	APIONINAE	<i>Eutrichapion</i>	<i>A. ervi</i>	2.28
			<i>Protapion</i>	<i>A. tenue</i>	1.54
LEPIDOPTERA	PLUTELLIDAE	PLUTELLINAE	<i>Plutella</i>	<i>P. xylostella</i> – a	0.89
DIPTERA	SYRPHIDAE	SYRPHINAE	<i>Episyrphus</i>	<i>E. balteatus</i>	0.49

*a - adult; l- larvae; RA(%) - relative abundance

Predatory taxa represented approximately 11% of the total arthropod assemblage, while parasitoids belonging to families such as Ichneumonidae, Chalcididae and Pteromalidae accounted for a smaller fraction of the community. Furthermore, pollinating insects such as *Episyrphus balteatus* were also recorded, highlighting the functional diversity of the arthropod community associated with the alfalfa field. The distribution of species and individuals among the main trophic groups is summarized in Table 2.

Table 2. Trophic structure of the arthropod community recorded in the alfalfa agroecosystem (Ghilad, 2024)

Trophic group	Number of species	Number of individuals	RA (%)
Phytophagous	14	1012	82.28
Predators	9	137	11.14
Parasitoids	4	52	4.23
Pollinators	1	6	0.49
Other / omnivorous	2	23	1.86
Total	30	1230	100

The diversity of the arthropod assemblage was further evaluated using several ecological diversity indices. The calculated values of Shannon, Simpson and Pielou indices are presented in Table 3.

Table 3. Diversity indices of the arthropod community recorded in the alfalfa agroecosystem (Ghilad, 2024)

Index / Parameter	Value
Number of individuals (N)	1230
Number of species (S)	30
Shannon diversity index (H')	2.27
Simpson dominance index (D)	0.18
Simpson diversity index (1-D)	0.81
Pielou's evenness index (J')	0.67

The Shannon diversity index ($H' = 2.27$) indicated a moderate level of species diversity within the arthropod community. Similarly, the Simpson index ($1-D = 0.81$) suggested a relatively high probability that two randomly selected individuals belong to different species. However, the evenness value ($J' = 0.67$) revealed a moderately uneven distribution of individuals among species, reflecting the strong dominance of a few highly abundant phytophagous taxa, particularly *Phytodecta fornicata*, *Aphis craccivora* and *Adelphocoris lineolatus*. This pattern is consistent with the dominance structure previously observed in the arthropod community associated with the alfalfa crop. The rank–abundance curve (Figure 2) illustrates the dominance structure of the arthropod assemblage recorded in the alfalfa agroecosystem. The distribution shows a steep decline in relative abundance from the most dominant species to a large number of rare taxa. *Phytodecta fornicata* clearly dominated the community, largely exceeding the abundance of all other recorded species, while most of the remaining taxa occurred at relatively low abundances. Beyond the dominance structure of the assemblage, the temporal distribution of arthropod abundance revealed pronounced seasonal variation throughout the sampling period.

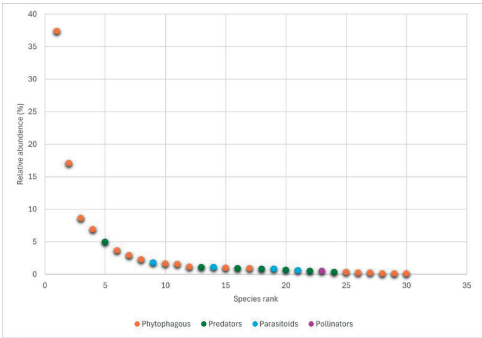


Figure 2. Rank-abundance curve of arthropod species recorded in the alfalfa agroecosystem located in Ghilad (Timiș County, Romania) during the 2024 sampling period. Species are ranked according to their relative abundance (RA%). Colors indicate the trophic affiliation of species: phytophagous (orange), predators (green), parasitoids (blue), pollinators (purple)

The seasonal distribution of arthropod abundance is illustrated in Figure 3. The lowest abundance values were recorded at the beginning of the sampling period, while a marked increase occurred during late spring and early summer, reaching a peak in June and July. After this period, abundance values gradually declined toward the end of the growing season.

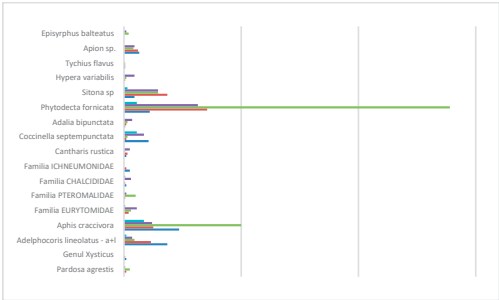


Figure 3. Seasonal structure of arthropod abundance recorded in the alfalfa agroecosystem during the 2024 sampling period

A more detailed view of the species-level dynamics underlying this seasonal trend is provided in the heatmap of dominant species (Figure 3).

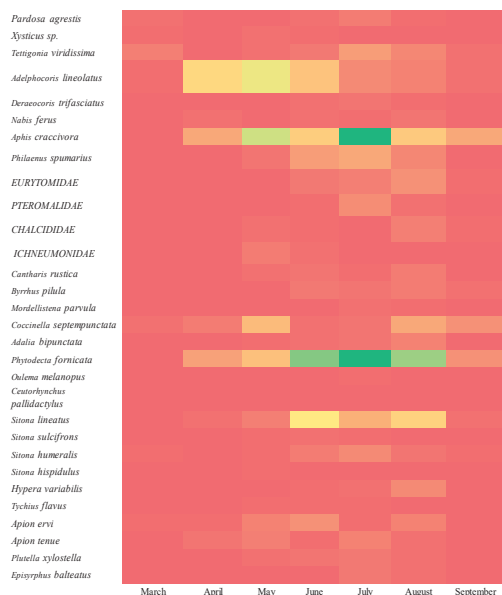


Figure 4. Seasonal distribution of dominant arthropod species recorded in the alfalfa agroecosystem located in Ghilad (Timiș County, Romania) during the 2024 sampling period. Species are arranged according to total abundance (dominance gradient), while columns represent sampling months (April-September). Color intensity reflects abundance values, with warmer colors indicating higher abundance

The heatmap of dominant species (Figure 4) highlights the taxa responsible for the seasonal patterns observed in community abundance. The distribution clearly indicates the predominance of phytophagous species, particularly *Phytodecta fornicata* and *Aphis craccivora*, which exhibited pronounced abundance peaks during June and July.

To further explore the influence of climatic factors on these seasonal patterns, correlations between trophic groups and climatic variables were evaluated using Spearman's rank correlation analysis (Table 5).

Table 5. Spearman correlation coefficients between climatic variables (temperature and precipitation) and arthropod trophic groups

Trophic group	ρ Temperature	p-value	ρ Precipitation	p-value
Phytophagous	0.771	0.072	-0.314	0.544
Predators	0.543	0.266	-0.200	0.704
Parasitoids	0.886	0.019	-0.371	0.468
Pollinators	0.845	0.034	-0.304	0.558

Spearman correlation analysis performed at the trophic-group level indicated that temperature was the main climatic factor influencing arthropod dynamics in the alfalfa agroecosystem under hydric stress conditions. Parasitoids showed the strongest positive and statistically significant correlation with temperature ($\rho = 0.886$, $p = 0.019$), followed by pollinators ($\rho = 0.845$, $p = 0.034$). The phytophagous group, which numerically dominated the assemblage, also exhibited a strong positive association with temperature ($\rho = 0.771$), although the relationship was only marginally significant ($p = 0.072$). Predators displayed a weaker positive correlation with temperature ($\rho = 0.543$, $p = 0.266$), suggesting that their population dynamics were less directly controlled by thermal conditions and possibly mediated by prey availability.

In contrast, precipitation showed generally negative relationships with all trophic groups, although these correlations were not statistically significant. The strongest negative association was observed for parasitoids ($\rho = -0.371$, $p = 0.468$) and phytophagous arthropods ($\rho = -0.314$, $p = 0.544$). These patterns suggest that reduced rainfall and increased temperature during the summer months may have created hydric stress conditions within the alfalfa agroecosystem, favoring the activity and development of several arthropod groups, particularly phytophagous species. Such climatic conditions may alter the functional balance of the arthropod community by promoting herbivore population growth while exerting weaker or indirect effects on higher trophic levels.

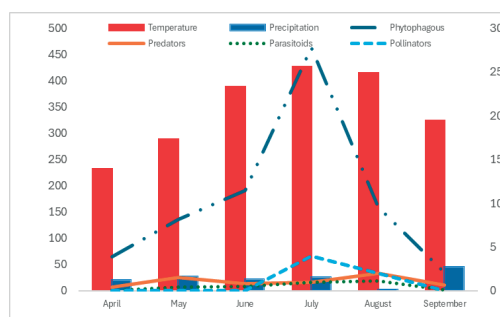


Figure 5. Seasonal distribution of arthropod abundances recorded in the alfalfa agroecosystem during the 2024 growing season

These patterns are further illustrated in Figure 5, which depicts the seasonal distribution of arthropod abundances in relation to temperature and precipitation during the sampling period. The figure reveals a clear expansion of abundance distributions during the mid-summer months, with a pronounced peak in July, corresponding to the period of highest temperatures recorded in the agroecosystem. This seasonal increase supports the positive relationships observed between temperature and several trophic groups, particularly parasitoids and pollinators.

During the same period, precipitation remained relatively low, with a marked reduction in August, indicating the development of hydric stress conditions within the alfalfa crop. Under such circumstances, the arthropod community appears strongly dominated by phytophagous taxa, which contributed most to the broader abundance distributions observed in the figure. In contrast, higher trophic levels, such as predators and parasitoids, were present at comparatively lower abundance levels, reflecting the typical trophic structure of drought-affected agroecosystems.

Overall, both the statistical analyses and the graphical patterns indicate that temperature represents the primary climatic factor structuring arthropod dynamics, while reduced precipitation likely contributed to the hydric stress conditions observed in the alfalfa agroecosystem, potentially influencing the trophic structure of the arthropod community.

The results of the present study indicated the presence and seasonal abundance of 30 arthropod taxa in alfalfa fields located in Ghilad (Timiș County). The occurrence of several taxonomic orders and functional groups is consistent with previous studies reported in Romania (Lisenchi–Murariu et al., 2006 a, b; Dima et al., 2010; Fiera et al., 2013; Pustai et al., 2015), which have shown that perennial forage crops such as alfalfa provide stable habitats for numerous arthropod taxa.

The pronounced dominance of phytophagous species observed in the present study (*Phytodecta*, *Aphis*, *Adelphocoris*, *Sitona*) is typical of herbaceous agroecosystems and reflects the bottom-up influence exerted by plant resources on phytophagous populations (Razzaq

& Al-Saffar, 2016; Kaplin et al., 2020). Similar dominance patterns, characterized by a few highly abundant species and numerous taxa with low abundance, have frequently been reported in alfalfa ecosystems (Shebl et al., 2009). We found that the complex of predators, parasitoids, and pollinators was dominated by *Coccinellidae*, closely associated with parasitoids *Hymenoptera*, which is consistent with other studies (Soroka et al., 2020; Meseguer et al., 2021; Ríos Martínez et al., 2024).

Seasonal dynamics and climatic conditions also played an important role in structuring arthropod abundance. Our data suggests considerable variation in seasonal abundance trends of phytophagous taxa and natural enemies across the sampling months. The highest abundance values were recorded during the warmest months of the growing season, highlighting the positive effects of air temperature on the arthropod community, particularly on phytophagous taxa. These effects may be explained by the dual role of temperature: on the one hand, through the direct stimulation of insect development, reproductive capacity, and survival rates (Nikolova, 2018), and on the other hand, through the indirect influence on the availability of food resources (Lessard et al., 2011).

In addition to air temperature, precipitation also plays an important role in influencing insect species richness and abundance (Zhu et al., 2014). In this context, reduced precipitation during summer contributed to the development of hydric stress conditions in the alfalfa crop. Our results indicate that the lack of precipitation was associated with lower abundance of natural enemies and an increase in phytophagous taxa. These relationships may primarily be explained by unfavorable habitat conditions caused by moisture deficit, which can influence plant physiology and the nutritional quality of resources available to insects (Bao et al., 2026). Consequently, climatic variability, particularly increasing temperatures combined with reduced precipitation, influenced both the seasonal dynamics and the trophic structure of arthropod communities associated with alfalfa agroecosystems.

CONCLUSIONS

The present study highlights the biodiversity and trophic organization of arthropod fauna associated with an alfalfa agroecosystem exposed to hydric stress. The community was strongly dominated by phytophagous species, whereas predators, parasitoids, and pollinators occurred at comparatively lower abundances. Arthropod dynamics showed marked seasonal variation, with peak abundance during the warmest months of the growing season. Our results suggest that the combination of increasing temperature and reduced precipitation reshaped both seasonal dynamics and trophic balance within the arthropod assemblage.

These findings underline the importance of arthropod monitoring during dry years, when environmental stress may favor herbivore proliferation and increase the risk of pest outbreaks. Under such conditions, regular surveillance and integrated management strategies are essential for maintaining ecological balance and ensuring the sustainable management of alfalfa agroecosystems.

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