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A qualitative and quantitative comparison of mite fauna between bifenthrin-treated and non-pesticide treated alfalfa hay fields in Central Greece

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Summary The mite fauna in foliage and litter of a sprayed alfalfa hay field with the acaricide-insecticide bifenthrin, was studied based on monthly samplings from foliage and litter in Central Greece between 2008-2009. Potential differentiations between this field and two adjacent alfalfa hay fields, which were not subjected to pesticide applications and were managed with different number of cuttings, were also evaluated in terms of population fluctuation over time, population density, species richness, diversity and spatial distribution. The sprayed field hosted 50 and 68 species and morphospecies in foliage and litter respectively, depicting high relative abundance of oribatid and prostigmatic mites. *Neoseiulus aristotelisi* Papadoulis, Emmanouel and Kapaxidi, was a new record for alfalfa, previously found in rice in Macedonia, Greece. The seasonal fluctuation of mites, particularly in foliage, was similar in all fields. The spatial distribution of a *Zygoribatula* species, which was common and dominant in all fields, was also aggregated. Finally, the sprayed field shared similar mite diversity with the two non-sprayed fields, but not similar species richness.

Additional keywords: alfalfa, bifenthrin, mites, qualitative, quantitative study

Introduction

The ecological role of mites in terrestrial ecosystems is significant, since they can be plant pests, predators of other mites and insects (e.g. phytoseiid mites as thrips predators), decomposers, detritivores, scavengers, and parasites (Sabelis and Van Rijn, 1997; Schneider *et al.*, 2004; Krantz, 2009). Apart from faunistical surveys, a lot of work has been carried out within the framework of studying the impact of agricultural practices, such as the use of slurry in combination with tillage (Bosch-Serra *et al.*, 2014) or post-mining restoration treatments (Andrés and Mateos, 2006) on the population density, species richness and diversity of soil mites. Several studies have also emphasized population parameters of mites of the aerial part of crops. For instance, Wissuwa *et al.* (2012) studied how habitat age and plant species affected mesostigmatic mites in grassy arable fallows in Eastern Austria in terms of population density, species richness and diversity. The spatial distribution of mites has been limitedly studied worldwide, although new research has been added over the last few years. For instance, Alatawi *et al.* (2011) studied how the spatial patterns of *Phytoseiulus persimilis* Athias-Henriot (Phytoseiidae) and its prey, *Tetranychus urticae* Koch (Tetranychidae), affect the biological control of the latter in a greenhouse.

Alfalfa or lucerne is a major crop in Greece cultivated for hay production. According to the most recent published state statistical data (2016), the total cultivated area with alfalfa and other perennial clovers in Greece is about 119,723 ha or 46% of total cultivated area with hay plants in the country producing 1,369,377 t of hay (Hellenic Statistical Authority, 2019). Although alfalfa cuttings help remove arthropod pests hosted in foliage, pyrethroid insecticides, such as bifenthrin, may be used to control lucerne flower gall-midge (*Contarinia medicaginis* Kieffer) (Dip-

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tera: Cecidomyidae) in Greece.

Despite the economic importance of this crop in Greek agriculture, little is known about the mite fauna of alfalfa in Greece. In this respect, Badieritakis *et al.* (2014) contributed with results regarding qualitative and quantitative information over mite assemblages of foliage and litter mites of two considerably similar and non-pesticide treated alfalfa hay fields in Central Greece, which only differed in the number of cuttings. In that study we found that the population fluctuation of mites in the foliage of both fields was similar, unlike that of litter. The population density of mites also significantly differed between the fields except for Prostigmata. Moreover, litter was more species abundant in the less harvested hay field, although the opposite was observed in the foliage of that field when compared to the foliage of the more harvested field. The latter also exhibited higher mite diversity apart from Prostigmata. Finally, the spatial distribution of mites was aggregated in all habitats.

Based on these findings (Badieritakis *et al.*, 2014), the present work has as main objective to compare the mite fauna as well as the relative abundance of mites in the foliage and litter of a bifenthrin-treated alfalfa hay field located in the same area (approximately 100 meters away) with the non-pesticide treated fields as well as the species richness, diversity and spatial distribution of mites in the foliage and litter.

Materials and methods

Sampling sites

This study took place between 2008 and 2010 within the experimental farm of Agricultural University of Athens in Kopais Valley (Central Greece) (38°23′51.68″N, 23°5′23.87″E). The field used for this purpose was about 1,000 m^2 and succeeded a maize crop. This field, thereafter indexed as "C", was approximately 100 m away from those reported as field A and field B by Badieritakis *et al.* (2014), and was subject to the same agricultural practices and sown with the same alfalfa cultivar on the same day with the others. All fields were cut between May and October every year. Both fields, A and C, were harvested once a month on the same day, in comparison to field B which was cut almost bimonthly. In addition, field C was also sprayed with bifethrin 100 g/l EC in August and October 2008 and approximately bimonthly between March and September 2009. This pesticide was applied by local farmers at the application rate of 25 ml/50 l per 1,000 m^2 to control the population of *C. medicaginis*.

Sampling procedure and identification of mites

The sampling procedure and mite identification has been described by Badieritakis *et al.* (2014). In total, 240 foliage samples and 288 litter samples (10 foliage samples and 12 litter samples collected once a month) were randomly collected from each field during the two-year sampling period (2008-2010) with metallic quadrats of 25*40 cm for foliage sampling and 14*16 cm for litter sampling. Mites were extracted with a modified apparatus following the Berlese-Tullgren method in the laboratory and identified to species and morphospecies (e.g. sp1, sp2, etc. or species A, B, etc.) based only on adult mites (Minor and Cianciolo, 2007). The Orders and suborders of main interest under study were Mesostigmata, Sarcoptiformes: Oribatida and Trombidiformes: Prostigmata. Morphospecies were used in cases were identification was difficult due to lack of suitable dichotomous keys or mite species descriptions. Due to unsuitability of the Berlese-Tullgren method for extracting eriophyid and tetranychid mites (Badieritakis *et al.*, 2014), the latter were only recorded in Table 1 without being quantified. The dry weight of samples was also recorded for comparison reasons.

Data analysis

The classification of mite taxa as dominant, influent or recedent was carried out according to specific criteria of dominance (Palyvos

Table 1. Taxa, relative abundance (%) and total counts of adults and juveniles of mites recorded in foliage and litter of a bifenthrin-sprayed alfalfa field in Kopais Valley (Central Greece), between 2008-2010.

TAXA	Relative abundance (%)	
	Foliage	Litter
Order Mesostigmata Canestrini	0.91R	1.85R
Ameroseiidae Evans		
Ameroseius sp.	-	-
Kleemania sp.	0.01R	0.01R
Ascidae Voights & Oudemans		
Arctoseiodes sp.	0.01R	0.04R
Arctoseius sp.	-	-
Asca bicornis Canestrini & Fanzago[1]	-	-
Gamasellodes sp.	0.03R	0.21R
Protogamasellus sp.	0.01R	0.10R
Blattisociidae Garman		
Blattisocius sp.	0.01R	0.01R
Cheiroseius sp.	-	-
Lasioseius sp.	0.18R	0.15R
Digamasellidae Evans		
Dendrolaelaps sp.	-	-
Laelapidae Berlese		
Gymnolaelaps sp.	-	-
Hypoaspis sp.	0.03R	0.30R
Laelaps sp.	-	0.01R
Ololaelaps sp.	-	-
Macrochelidae Vitzthum		
Macrocheles sp.	-	-
Pachylaelapidae Berlese		
Pachylaelaps sp.	-	-
Parasitidae Oudemans		
Paragamasus sp.	-	-
Parasitus sp.	-	0.08R
Phytoseiidae Berlese		
Amblyseius andersoni (Chant)[1]	-	-
Neoseiulus aristotelisi Papadoulis, Emmanouel and Kapaxidi[1]	0.01R	0.01R
Neoseiulus barkeri Hughes	0.27R	0.28R
Neoseiulus bicaudus (Wainstein)[1]	-	-
Proprioseiopsis messor (Wainstein)	-	-
Typhlodromus kerkirae Swirski & Ragusa	-	-
Uropodoidea. not identified to Family		
Uropodoidea (one species)	-	-
Juveniles of Mesostigmata†	0.35	0.65
Order Sarcoptiformes Reuter	74.71D	85.41D
Suborder Endeostigmata Reuter		
Alycidae Canestrini & Fanzago		
Alycidae (one species)	0.01R	0.13R
Nanorchestidae Grandjean		
Nanorchestidae (one species)	0.02R	0.01R
Terpnacaridae Grandjean		
Terpnacaridae (one species)	0.01R	0.01R
Suborder Oribatida van der Hammen	74.67D	85.26D
Acaridae Latreille		
Rhizoglyphus sp.	-	0.05R
Thyreophagus sp.	0.01R	0.02R
Tyrophagus curvipenis Fain & Fauvel	0.01R	0.02R
Tyrophagus longior (Gervais)	0.43R	0.51R
Tyrophagus similis Volgin	0.05R	0.05R
Tyrophagus palmarum Oudemans sensu Robertson	0.05R	0.48R

TAXA	Relative abundance (%)	
	Foliage	Litter
Tyrophagus perniciosus Zakhvatkin	0.08R	0.24R
Tyrophagus putrescentiae (Schrank)	0.03R	0.03R
Brachychthoniidae Thor		
Brachychochthonius sp.	0.01R	-
Chortoglyphidae Berlese		
Chortoglyphus sp.	-	-
Epilohmanniidae Oudemans		
Epilohmannia sp.	-	0.10R
Euphthiracaridae Jacot		
Euphthiracarus sp.	-	0.08R
Oppiidae Grandjean		
Berniniella sp.	-	0.01R
Ramusella sp.	0.03R	0.19R
Oribatellidae Jacot		
Oribatella sp1	-	0.03R
Oribatella sp2	-	-
Oribatulidae Thor		
Zygoribatula sp1	0.84R	5.41I
Zygoribatula sp2	0.13R	1.62R
Zygoribatula sp3	15.75D	18.53D
Zygoribatula sp4	0.95R	1.25R
Scheloribatidae Grandjean		
Scheloribates sp1	-	-
Scheloribates sp2	0.16R	0.66R
Scheloribates sp3	-	-
Scheloribatidae (one species)	-	0.01R
Tectocepheidae Grandjean		
Tectocepheus sp.	0.64R	6.35I
Juveniles of Oribatida†	55.50	49.62
Juveniles of Sarcoptiformes†	55.50	49.62
Order Trombidiformes Reuter	24.38D	12.74D
Suborder Prostigmata Kramer	24.38D	12.74D
Anystidae Oudemans		
Anystidae (one species)	-	-
Bdellidae Dugès		
Bdella sp.	-	-
Bdellodes sp.	-	0.01R
Camerobiidae Southcott		
Neophyllobius sp.	-	-
Cheyletidae Leach		
Cheletogenes sp.	-	-
Hemicheyletia sp.	-	0.03R
Cunaxidae Thor		
Cunaxoides croceus (Koch)[1]	-	-
Cunaxoides paracroceus Sionti & Papadoulis[1]	0.01R	0.01R
Pulaeus subterraneus (Berlese)[1]	-	-
Ereynetidae Oudemans		
Ereynetidae (one species)	-	0.04R
Eriophyidae Nalepa		
Aceria medicaginis (Keifer)*	-	+
Erythraeidae Robineau-Desvoidy		
Abrolophus sp.	0.01R	-
Curteria sp.	-	-
Eupalopsellidae Willmann		
Eupalopsellus sp.	-	-
Eupodidae Koch		
Eupodidae (species A)	0.02R	0.07R
Eupodidae (species B)	-	0.01R
Eupodidae (species C)	-	0.05R

TAXA	Relative abundance (%)	
	Foliage	Litter
Iolinidae André		
Pronematus sp1	-	-
Pronematus sp2	-	-
Pyemotidae Oudemans		
Pyemotes sp.	-	-
Pygmephoridae Cross		
Acinogaster sp.	-	-
Pygmephorus sp1	-	0.05R
Pygmephorus sp2	-	0.02R
Pygmephorus sp3	-	0.02R
Pygmephorus sp4	-	-
Pygmephorus sp5	0.01R	-
Pygmephorus sp6	0.03R	0.14R
Pygmephorus sp7	-	0.02R
Siteroptes sp.	0.05R	0.03R
Rhagidiidae Oudemans		
Rhagidiidae (one species)	-	0.01R
Raphignathidae Kramer		
Raphignathus sp.	-	0.01R
Scutacaridae Oudemans		
Imparipes sp.	-	-
Scutacarus sp.	-	-
Stigmaeidae Oudemans		
Eustigmaeus jiangxiensis Hu. Chen & Huang[1]	-	0.03R
Eustigmaeus sp.	0.01R	-
Stigmaeus sp.	-	-
Tarsonemidae Kramer		
Neotarsonemoides sp.	0.18R	0.84R
Steneotarsonemus konoi Smiley & Emmanouel	0.15R	0.10R
Tarsonemus sp1	2.43R	3.72R
Tarsonemus sp2	1.21R	1.04R
Tarsonemus confusus Ewing	0.32R	0.05R
Tarsonemus fusarii Cooreman	0.03R	0.32R
Tarsonemus lacustris Schaarschmidt	9.65I	1.18R
Tarsonemus talpae Schaarschmidt	0.11R	0.36R
Tarsonemus waitei Banks	2.64R	0.56R
Xenotarsonemus belemnitoides (Weis-Fogh)	1.00R	0.77R
Tenuipalpidae Berlese		
Brevipalpus sp.	0.04R	0.01R
Tetranychidae Donnadieu		
Bryobia praetiosa Koch*	-	-
Bryobia sp.*	-	+
Petrobiini sp.*	-	+
Tetranychini sp.*	-	+
Triophtydeidae André		
Triophtydeus sp.	0.02R	0.01R
Trombiculidae Ewing		
Trombiculidae (one species)	-	-
Trombidiidae Leach		
Trombidiidae (one species)	0.01R	-
Tydeidae Kramer		
Lorryia ferula Baker	0.05R	-
Lorryia nesziyyonensis (Gerson)[1]	-	-
Lorryia sp.	0.13R	0.17R
Tydeus kochi Oudemans	4.86R	1.81R
Juveniles of Prostigmata†	1.41	1.25
Juveniles of Trombidiformes†	1.41	1.25
Total number of samples	240	288
Total number of individuals	10,938	12,325
Total number of species	50	68

TAXA	Relative abundance (%)	
	Foliage	Litter
Number of common species in foliage of fields A and C: 37		
Number of common species in foliage of fields B and C: 41		
Number of common species in litter of fields A and C: 61		
Number of common species in litter of fields B and C: 59		

D: Dominant (> 10%), I: Influent (5%-10%) and R: Recedent (< 5%)
[1]New records for the mite fauna of *Medicago sativa* L. ssp. *sativa* of Greece
† juveniles of mite Orders and suborders are not considered as separate taxa and are not consequently classified as dominant, influent or recedent
*not counted in the calculation of population fluctuation, population density, *Sobs*. Jackknife 1 estimator and Shannon-Weaver index (*H′*) of diversity. Instead of relative abundance (%), results are presented as "+" and "–" for these mites indicating their presence or absence respectively
Field A: Unsprayed alfalfa field managed with monthly cuttings
Field B: Unsprayed alfalfa field managed with bimonthly cuttings
Field C: Bifenthrin-sprayed alfalfa field managed with monthly cuttings

et al., 2008). The non-parametric estimator of species richness, Jackknife 1, was used (Krebs, 1999; Colwell, 2013) as well as Shannon index (*H′*) for the calculation of species diversity of mites (Hutcheson, 1970; Magurran, 2004). The spatial distribution of common and influent mite species was estimated with Taylor's power law and Iwao's regression of patchiness (Badieritakis *et al.*, 2014).

GLM of SAS JMP 7.0.1. statistical package at $\alpha = 0.05$ (after a log (x+1) transformation of the dataset) was used to compare the population density of mites between field C and fields A and B. The population density was expressed as the mean number of individuals per quadrat. The dry weight of foliage and litter samples collected was also compared between field C and the other two fields by using GLM after a log (x) transformation of the data.

Results

Dry weight comparison

The mean dry weight of foliage samples of field C was 7.70 g (± 1.37 g) without being significantly different from the respective dry weight calculated for field A (*d.f.=1*, χ^2= 0.1168, *p*= 0.7325) and field B (*d.f.=1*, χ^2= 0.0286, *p*= 0.8657). In addition, the mean dry weight of litter samples in field C was 4.09 g (± 0.40 g) revealing no significant difference with the respective dry weight calculated for field A (*d.f.=1*, χ^2= 0.0369, *p*= 0.8475) and field B (*d.f.=1*, χ^2= 1.3887, *p*= 0.2490). Therefore, no significant differences were found regarding the plant biomass of field C compared to that of the other two fields.

Mite fauna and relative abundance

In total, 23,263 individuals of mites (adults and juveniles) were collected from the foliage and litter samples collected from field C between 2008-2010. In particular, 50 and 68 species and morphospecies were respectively recorded from foliage and litter samples belonging to Mesostigmata, Sarcoptiformes and Trombidiformes, many of which were common with those found in fields A and B (Table 1). Many species were also common between field C and fields A and B. A new species record for the mite fauna of alfalfa of Greece was that of the phytoseiid, *Neoseiulus aristotelisi* Papadoulis, Emmanouel and Kapaxidi. Sarcoptiformes and Trombidiformes were the most abundant mite Orders in both foliage and litter samples. Among Sarcoptiformes the family Oribatulidae recorded high relative abundance.

Population fluctuation

Between 2008-2010 the population of total Acari hosted in the foliage of field C (Fig. 1a) presented high density in spring and summer. A similar seasonal pattern of population fluctuation was detected in the case of Oribatida (Fig. 1b). However, both Prostigmata and Mesostigmata had low population densities during the two-year study. In the case of prostigmatic mites, their population density peaked in April 2009 (Fig. 1b).

In comparison to the findings in foliage samples, the population fluctuation of mites in litter revealed high population densities of mites in summer and autumn in both years (Fig. 1c). The same seasonal pattern was detected in the case of Oribatida, although Prostigmata and Mesostigmata showed lower population densities, almost zero during long time periods (months) (Fig. 1d).

Population density

Taking into account the results presented by Badieritakis *et al.* (2014) and Table 2 of the present study, significant higher population density of mites was detected in the foliage and litter samples of field B, when compared to field C, except for Prostigmata, which were more abundant in field C. On the other hand, the population density of mites was similar in the foliage of fields C and A, except for mesostigmatic mites, whose density was lower in field C. In the case of litter, oribatid and prostigmatic mites recorded higher population density in field C than in field A, although that of total Acari and mesostigmatic mites was similar between these two fields.

Species richness and diversity

Litter hosted more mite species than foliage. Prostigmata were generally more species abundant when compared to other taxa. Taking into account Jackknife 1 estimator and its confidence limits calculated for the mite fauna in all fields, it seems that field C hosted similar number of mite species with field B in foliage and litter, but lower number of species in foliage when compared to field A. However, both fields, A and C, hosted similar number of mite species in litter. On the other hand, field C shared also the same diversity of mites with fields A and B in foliage and litter (Table 3).

Spatial distribution

Only *Zygoribatula* sp3 was dominant in foliage and litter and *Zygoribatula* sp1 was influent in litter of all fields (Table 4). These morphospecies had an aggregated pattern of spatial distribution ($b > 1$). Since parameter a of Iwao's regression of patchiness was not significantly different from zero, we can also assume that the basic component of mite populations could have been one individual per quadrat. Moreover, Taylor's power law had a better fit to the data than Iwao's regression of patchiness (correlation coefficients r).

Discussion

The findings of the present study stressed that the bifethrin-sprayed field hosted many common mite species with the two unsprayed fields. The high relative abundance of oribatid mites in the bifenthrin-sprayed field could be attributed to the previous maize crop. Maize has been reported to host Oribatida in New York by Minor and Cianciolo (2007). *Neoseiulus aristotelisi*, a new phytoseiid species, was first reported in Greece by Papadoulis *et al.* (2009) on *Oryza sativa* (Poaceae) in Macedonia, Greece. However, no other information is available on the preferred habitats of this species.

The population fluctuation of total Acari in foliage of the bifenthrin-sprayed field was similar with that in the unsprayed fields (Badieritakis *et al.*, 2014). Due to their high relative abundance among total Acari in foliage, a similar population fluctuation of oribatid mites was also observed. The similar population fluctuation of Oribatida could be attributed to their high relative abundance among total Acari. Since *Zygoribatula* was dominant in foliage and litter of the bifenthrin-sprayed field, as it happened in the unsprayed, managed with different number of cuttings, fields (Badieritakis *et al.*, 2014), we speculate that the high densities of oribatid mites in summer represented this genus. The population fluctuation of prostigmatic and mesostigmatic mites in the foliage of the bifenthrin-sprayed field was more or less similar with that in the unsprayed fields. Hence, the findings demonstrate that the

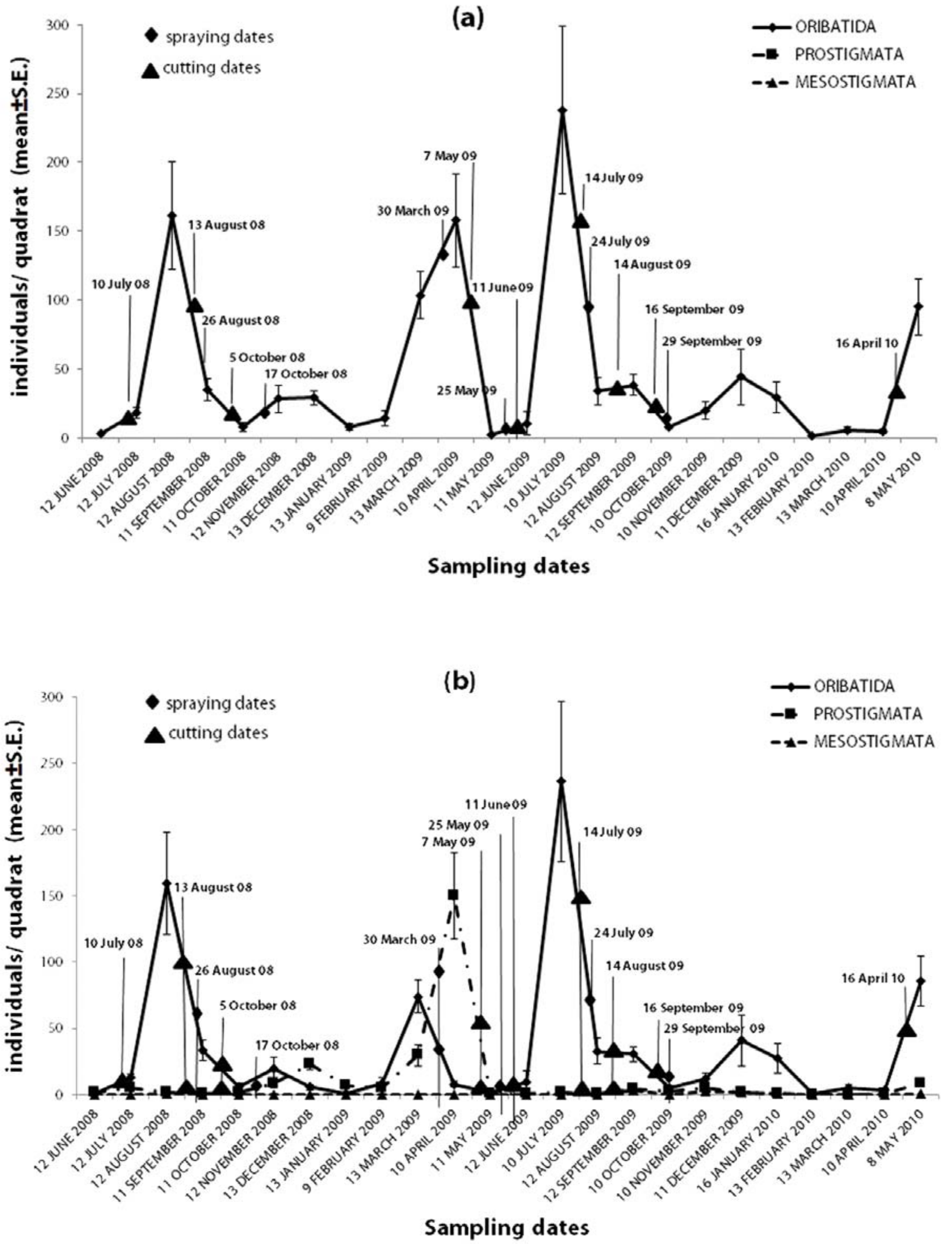

Figure 1. (a) Population fluctuation of total Acari and **(b)** main mite taxa, in foliage of a bifenthrin-sprayed alfalfa field in Kopais Valley (Central Greece) between 2008-2010.

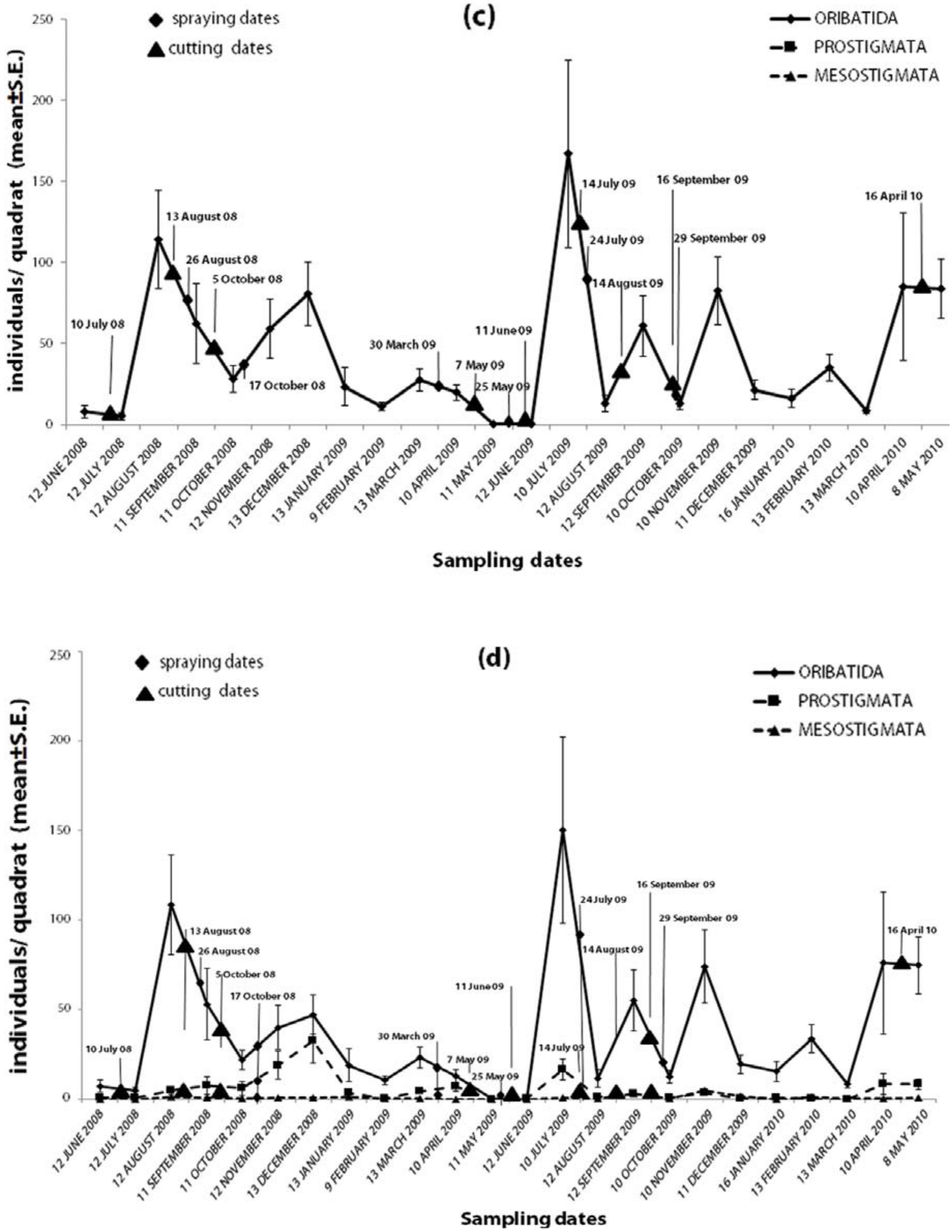

Figure 1. (c) Population fluctuation of total Acari (a) and **(d)** main mite taxa, in litter of a bifenthrin-sprayed alfalfa field in Kopais Valley (Central Greece) between 2008-2010.

Table 2. Population density (mean ± S.E.) of total Acari, order Mesostigmata, suborder Oribatida (Acari: Sarcoptiformes) and suborder Prostigmata (Acari: Trombidiformes) found in the foliage and litter of alfalfa fields receiving different management between 2008-2010 in Kopais Valley, Central Greece (GLM, $\alpha = 0.05$) for the hypothesis of similar population density .

Habitat	Taxa	Field C	Field A	Field B
Foliage	Total Acari	45.58 ± 5.28	χ^2= 0.1889, *p*= 0.6638	χ^2= 14.1997, *p*= 0.0002*
	Mesostigmata	0.4125 ± 0.0824	χ^2= 4.3212, *p*= 0.0376*	χ^2= 13.7020, *p*= 0.0002*
	Oribatida	34.18 ± 4.79	χ^2= 0.3834, *p*= 0.5358	χ^2= 31.1286, *p*<0.0001*
	Prostigmata	10.97 ± 2.36	χ^2= 0.2176, *p*= 0.6408	χ^2= 7.9220, *p*= 0.0049*
Litter	Total Acari	42.79 ± 4.55	χ^2= 3.2959, *p*= 0.0695	χ^2= 34.7409, *p*<0.0001*
	Mesostigmata	0.77 ± 0.12	χ^2= 1.5526, *p*= 0.2128	χ^2= 21.7506, *p*<0.0001*
	Oribatida	36.57 ± 3.99	χ^2= 8.6078, *p*= 0.0033*	χ^2= 40.0851, *p*<0.0001*
	Prostigmata	5.39 ± 0.88	χ^2= 4.0045, *p*= 0.0454*	χ^2= 0.5156, *p*= 0.4727

* significant difference
Field A: Unsprayed alfalfa field managed with monthly cuttings
Field B: Unsprayed alfalfa field managed with bimonthly cuttings
Field C: Bifenthrin-sprayed alfalfa field managed with monthly cuttings

Table 3. Number of species observed (*Sobs*), estimation of species richness (Jackknife 1) and diversity (Shannon-Weaver index, *H'*) of total Acari, order Mesostigmata, suborder Oribatida (Acari: Sarcoptiformes) and suborder Prostigmata (Acari: Trombidiformes) in foliage and litter of alfalfa fields receiving different management in Kopais Valley, Central Greece, between 2008-2010 for the hypothesis of similar species richness and diversity ($\alpha = 0.05$).

Habitat	Taxa	*Sobs*	Jackknife 1 estimator (95 % CL)[2]	Shannon - Wiener index (*H'*)		
				Field C	Field A[3]	Field B[3]
Foliage	Total Acari[1]	50	67.93 (60 – 76)	2.06	d.f.=4676, t=0.00286	d.f.=4676, t=0.3171
	Mesostigmata	9	13.98 (10 – 18)	0.79	d.f.=62, t=0.1907	d.f.=62, t=0.2515
	Oribatida	15	18.98 (15 – 23)	1.74	d.f.=2133, t=0.01735	d.f.=2132, t=0.0024
	Prostigmata[1]	23	28.98 (24 – 34)	1.35	d.f.=2481, t=0.0889	d.f.=2482, t=0.1497
Litter	Total Acari[1]	64	86.93 (77 – 97)	2.35	d.f.=5980, t=0.0927	d.f.=5980, t=0.2809
	Mesostigmata	11	20.98 (16 – 26)	1.50	d.f.=145, t=0.0977	d.f.=145, t=0.2041
	Oribatida	20	22.99 (20 – 26)	2.21	d.f.=4419, t=0.1332	d.f.=4419, t=0.1581
	Prostigmata[1]	30	39.97 (34 – 46)	2.00	d.f.=1401, t=0.2135	d.f.=1401, t=0.2566

[1] species belonging to Eriophyidae and Tetranychidae are not included
[2] confidence limits are rounded
[3] degrees of freedom (d.f.) and t calculated according to Hutcheson's method for the comparison of field C with fields A and B
Field A: Unsprayed alfalfa field managed with monthly cuttings
Field B: Unsprayed alfalfa field managed with bimonthly cuttings
Field C: Bifenthrin-sprayed alfalfa field managed with monthly cuttings

seasonal fluctuation of mites in foliage is not affected by agricultural practices, such as pesticide application and different number of cuttings. However, this was not the case for mites found in litter; it seems that no seasonal pattern of population fluctuation of mites in litter can be designated for alfalfa. The population densities of prostigmatic and mesostigmatic mites in litter and foliage were very low, almost zero, for many months. This could be possibly attributed to the intensive management in the sprayed field (cuttings and pesticide applications), which did not help the populations of these taxa to restore.

Mite population density in the bifen-

Table 4. Parameters of Taylor's power law and Iwao's patchiness regression of mite species in foliage and litter, which were common and concurrently dominant or influent in alfalfa fields receiving different management during 2008 - 2010 in Kopais Valley (Central Greece) for the hypothesis of aggregated pattern of spatial distribution.

Habitat	Mites	n^1	Taylor's power law			Iwao's patchiness regression		
			log $(a)^2$	b^3	r^4	a^5	b^6	r^7
Foliage	*Zygoribatula* sp3 (dominant)	22	0.42 ± 0.07*	1.77 ± 0.08*	0.98*	5.32 ± 4.35	1.78 ± 0.26*	0.84*
Litter	*Zygoribatula* sp1 (influent)	21	0.52 ± 0.04*	1.59 ± 0.08*	0.98*	1.02 ± 0.77	2.22 ± 0.22*	0.91*
	Zygoribatula sp3 (dominant)	23	0.43 ± 0.08*	1.66 ± 0.09*	0.97*	0.59 ± 1.56	2.09 ± 0.14*	0.95*

[1] Number of mean - variance and mean - mean crowding pairs used in the regressions
[2,3,4] Parameters of Taylor's power law. Parameters log (a) and b (± S.E.) and correlation coefficient r
[5,6,7] Parameters of Iwao's patchiness regression. Parameters a and b (± S.E.) and correlation coefficient r
[*] significant difference of parameters log (a), a and r from 0 and parameter b from 1 in both models (α = 0.05, t - test) at n - 2 degrees of freedom
Different management: bifenthrin-sprayed + monthly cuttings (current study); unsprayed + monthly cuttings; unsprayed + bimonthly cuttings

thrin-sprayed field was lower compared to the unsprayed field with half number of cuttings, except for the density of prostigmatic mites in litter and foliage, which were lower in the unsprayed field. By contrast, the mite population density did not differ in the case of the bifenthrin-sprayed and the unsprayed field managed with the same number of cuttings, except for mesostigmatic mites in foliage and oribatid and prostigmatic mites in litter. Agricultural practices, such as the application of pesticides can affect the mite communities of soil, particularly Mesostigmata whose density can be significantly reduced in conventional fields in comparison to uncultivated sites (Bedano and Ruf, 2007). In addition, many predatory arthropods tend to find refugia in soil or litter of grasslands after the application of pesticides (Roberts *et al.*, 2011), which could explain the lower population density of mesostigmatic mites in the foliage of the bifenthrin-sprayed field. In the case of oribatid mites the use of agrochemicals and intensive agricultural practices may reduce the organic matter of soil leading to lower population densities which cannot easily recover in the short term (Bedano *et al.*, 2006). On the other hand, Clapperton *et al.* (2002) concluded that prostigmatic mites are abundant in disturbed sites (heavily grazed prairies) in comparison to other mite taxa of soil.

In terms of species richness, the bifenthrin-sprayed field was poor in species in foliage when compared to the unsprayed field with the same number of cuttings (Badieritakis *et al.*, 2014). This result is in accordance with the findings of Koehler (1999), that species richness of mites is negatively affected by agricultural practices.

The diversity of mites was similar between the bifenthrin-sprayed field and the unsprayed fields. However, the diversity of mites was generally higher in the field with monthly cuttings than that in field with bimonthly cuttings (Badieritakis *et al.*, 2014). The diversity of mesostigmatic mites is reduced in conventional fields when compared to sites which are not disturbed (Bedano and Ruf, 2007). On the other hand, the diversity of oribatid mites is usually negatively affected by the intensity of agricultural practices (Minor and Cianciolo, 2007). In the case of the bifenthrin-sprayed field, the increased disturbance seems not to have affected the diversity of prostigmatic and oribatid mites, possibly due to an increase of relative abundance of mite species that balanced the decrease in species richness.

An aggregated pattern of spatial distribution of common and dominant or influent mites (*Zygoribatula* sp1 and *Zygoribatula* sp3) was confirmed (b > 1 in Taylor's power law and Iwao's regression of patchiness). In addition, Taylor's power law fitted better to the data when compared to Iwao's regression of patchiness. We also assume that *Zygoribatula* sp3 did not form colonies (parameter a of Iwao's regression of patchiness not significantly different from zero) as it happened in many cases of the unsprayed fields managed with different number of cuttings (Badieritakis *et al.*, 2014).

Our results show that an occasionally sprayed with an acaricide-insecticide alfalfa hay field hosted a rich mite fauna similar to that of two adjacent unsprayed alfalfa hay fields. The seasonal fluctuation of mites was also similar in all fields, although similarity in species richness mainly occurred between the sprayed field and the unsprayed field with half number of cuttings. Some differentiations in population density of mites also occurred between the sprayed field and the unsprayed ones, possibly due to the extra disturbance in the sprayed field. The spatial distribution of mites was aggregated in all fields. Our results indicate that spraying alfalfa with a pesticide slightly affects the mite populations in foliage and litter. We have to stress, however, that more replicates of fields are needed to be sure about the impact of the spraying with pesticides on mite communities.

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Ποιοτική και ποσοτική σύγκριση της ακαρεοπανίδας σε μηδικεώνες με ή χωρίς επέμβαση με bifenthrin

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Περίληψη Στην παρούσα εργασία μελετήθηκε η ακαρεοπανίδα της βλάστησης και των φυτικών υπολειμμάτων ενός περιστασιακά ψεκαζόμενου μηδικεώνα με το ακαρεοκτόνο/εντομοκτόνο bifenthrin στην Κωπαΐδα Βοιωτίας, κατά τη διετία 2008-2010, μέσω μηνιαίων δειγματοληψιών. Ο συγκεκριμένος μηδικεώνας συγκρίθηκε με άλλους δύο γειτνιάζοντες, παρόμοιους ως προς τις καλλιεργητικές πρακτικές μηδικεώνες, στους οποίους δεν διενεργήθηκαν ψεκασμοί και πραγματοποιήθηκε διαφορετικός αριθμός κοπών, με σκοπό να διερευνηθούν τυχόν διαφοροποιήσεις μεταξύ τους ως προς την πληθυσμιακή διακύμανση μέσα στο χρόνο, την πληθυσμιακή πυκνότητα, την αφθονία των ειδών, τη βιοποικιλότητα, αλλά και τη χωροδιάταξη σε ό,τι αφορά τα ακάρεα. Στον ψεκαζόμενο μηδικεώνα καταγράφηκαν 50 και 68 είδη και μορφοείδη ακάρεων, στη βλάστηση και τα φυτικά υπολείμματα αντίστοιχα, με τις υποτάξεις Prostigmata και Oribatida να εμφανίζουν υψηλή πληθυσμιακή πυκνότητα. Το *Neoseiulus aristotelisi* Papadoulis, Emmanouel and Kapaxidi (Mesostigmata: Phytoseiidae), που είχε παλαιότερα αναφερθεί για πρώτη φορά σε ρύζι στην Πιερία, αποτελεί πρώτη καταγραφή για την ακαρεοπανίδα της μηδικής. Επίσης, η πληθυσμιακή διακύμανση των ακάρεων της βλάστησης σε όλους τους μηδικεώνες εμφανίστηκε να είναι παρόμοια, όπως ομαδοποιημένη βρέθηκε να είναι και η χωροδιάταξη ενός μη αναγνωρισμένου είδους *Zygoribatula* και στους τρεις μηδικεώνες, στους οποίους καταγράφηκε ως κυρίαρχο. Ο ψεκαζόμενος μηδικεώνας δεν φιλοξένησε παρόμοιο αριθμό ειδών ακάρεων σε σχέση με τους άλλους δύο μηδικεώνες, ενώ εμφάνισε με αυτούς παρόμοια βιοποικιλότητα.

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