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Effects of Humac and Alginite Fertilization on Mite Communities (Acari, Mesostigmata) Under Post-Agricultural Land Conditions

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Abstract

Afforestation of post-agricultural land is one of the most important challenges of modern forestry, posed by economic demand and climate protection. Unfortunately, stands introduced on such degraded soils are not sustainable and their productive value is limited. The present study tested the effects of two substances—Humac and Alginite—on the community structure of mesostigmatid mites colonizing plots overgrown by *Platanus × acerifolia* (Aiton) Willd, also comparing them with the mite communities of arable field and 64-year-old stands of *Pinus sylvestris* L. and *Quercus robur* L. growing on post-agricultural land. A total of 306 mite individuals were recorded, belonging to 45 taxa and 14 families. The results indicate a moderately positive effect of Humac fertilization on the mite communities studied. A similar impact has not been demonstrated for Alginite. In contrast, all parameters studied (density, species richness and diversity of mite communities) reached the highest values in the *P. sylvestris* stand. Humac application harmonizes Mesostigmata mite community structures between young and older stands and may be considered a beneficial practice for the afforestation of former agricultural land.

Keywords: Acari; afforestation; Alginite; fertilization; Humac; Mesostigmata



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1. Introduction

Progressive climate change and diminishing freshwater resources call for increasing forest cover by introducing forests on post-agricultural lands [1,2]. Indeed, afforestation reduces soil erosion and surface runoff, which translates into improved water retention in the landscape and reduced surface water pollution [3–6]. However, the degraded soil of abandoned agricultural fields makes this process difficult and the sustainability of the introduced stands severely limited [7]. Success is determined not only by the right choice of tree species stand composition, but also by the proper reclamation of soils, preceding the restoration of full-grown forests on long-deforested areas [8,9]. The presence of a plough layer, biological disturbances and a change in chemical composition translates into physiological stress for young trees and leads to their weakening, exposing them to high mortality and susceptibility to fungal diseases [10].

A way to prepare post-agricultural land may be to properly enrich the soil with organic substances or minerals to help trees adapt and grow properly. Alginite increases soil water retention and cation exchange capacity (CEC; [11]), buffers pH and reduces mineral leaching. In studies with pine, oak and fir stands, Alginite improved survival and seedling growth in degraded soils [12]. Humac, in turn, significantly increases soil microbial activity and plant nutrient availability [13]. Alginite primarily alters soil's physical parameters, while Humac alters the soil's chemical–biological parameters. Both components can significantly reduce tree mortality in the first growth phase [14]. The course of the reclamation of post-agricultural land soils and the quality of afforestation is largely determined by the dynamics of litter degradation, micro- and macroelement cycling, which depends on the activity of the respective soil organisms [15,16]. These include predatory soil mites of the Mesostigmata order (Mesostigmata = Gamasida), which regulate the organisms' abundance and presence of lower trophic levels [17]. At the same time, mesostigmatid mites are very good bioindicators of soil changes. For example, their species composition and density can indicate the course of secondary forest succession [18].

Soil fertilization can increase the abundance of soil fauna with a limited or non-negative effect on its species diversity [19]. On the one hand, providing more minerals and nutrients stimulates an increase in the biomass of bacteria and fungi, which are the basis of the microarthropod food web, and the faster growth of trees and their root systems stabilizes soil moisture [20] and temperature [21,22]. However, this often leads to habitat homogenisation [23,24]. In the case of predatory soil mites, the effect of fertilization is more difficult to predict, but as a rule, their abundance increases under its influence and diversity decreases [25].

In the present study, six habitat types on post-agricultural land were compared in terms of density, species richness and diversity of mesostigmatid mites: (1) *Platanus × acerifolia* plantation + Humac; (2) *Platanus × acerifolia* plantation + Alginite; (3) *Platanus × acerifolia* plantation Control; (4) mature *Quercus robur* L. stand; (5) mature *Pinus sylvestris* L. stand; and (6) cultivated field. Habitat (3) was the control for the effect of fertilization. Habitat types (4) and (5) provided additional comparisons of the effect of age (continued forest present for long time, at least second generation) and species composition of afforestation. We hypothesized that mesostigmatid mite density would be higher and species richness and diversity lower in fertilized plots than in non-fertilized ones (I). Furthermore, mesostigmatid mite density, as well as diversity and species richness would be higher in older stands, compared to both younger and fertilized ones (II).

2. Materials and Methods

2.1. Site Description and Experimental Design

The field research was carried out on a site of 1.93 ha, located in Doubek, central Bohemia (50°1'21.49" N, 14°43'55.45" E), approximately 13 km from the meteorological station in Ondřejov. Within research site, a newly wooded area of 1.55 ha, surrounded by a fence of approximately 715 m in length, has been identified (Figure 1). The region belongs to the zone of moderately warm and moderately humid climate with mild winters. The average annual temperature is 9.8 °C and the average annual precipitation is about 550 mm [26]. The area lies on the border between the Central Bohemian Plateau and the Elbe Lowlands. The area is prone to episodic periods of drought and rising average temperatures. The soils show high nutrient abundance, with low mycorrhiza and pesticide residues ordinated to mesotrophic Cambisols with slight loess cover [14].

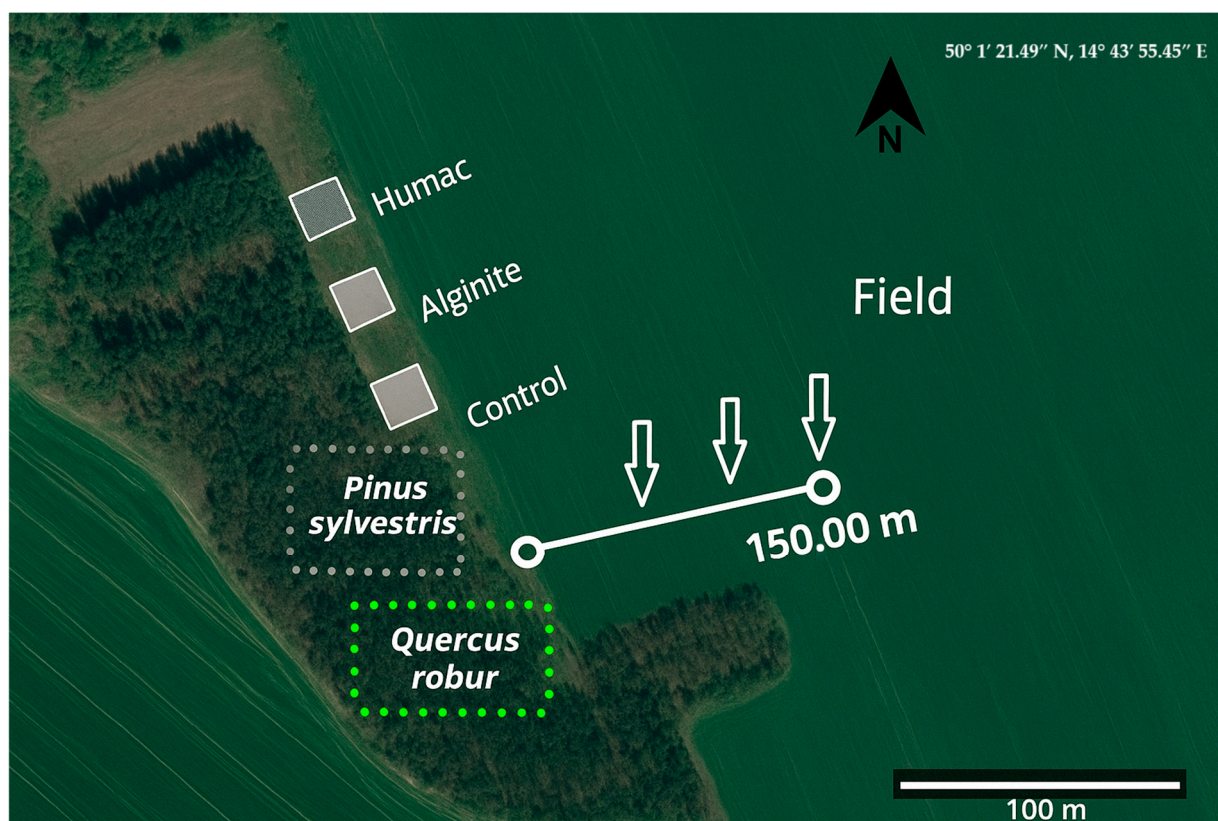


Figure 1. Map of study site in Doubek, central Bohemia. The white arrows indicate the location of the plots in the crop field (Figure compiled from orthophotos from Google Earth).

Within the described experimental site, plots of 15×20 m were designed and planted with *Platanus × acerifolia*. Planting was carried out in a 1.5 m square spacing. Three variants of surface application of reclamation materials were applied as follows: (A) Alginite—application rate of 1.5 t/ha; (B) Humac—granular Humac® Agro—application rate of 0.5 t/ha; (C) Control (no application). Humac is an organic soil conditioner rich in humic and fulvic acids, characterized by a high cation exchange capacity that enhances nutrient availability and soil fertility, though its decomposition in temperate climates is relatively slow. In contrast, Alginite is an organic–mineral rock derived from kerogen, with high humus content, abundant macronutrients (K, Ca, Mg) and exceptional water retention, functioning both as a natural sorbent for heavy metals and as a long-term soil fertility enhancer [26]. Materials were spread at the soil surface and mechanically mixed before plantation in autumn 2019. In the immediate vicinity of the experimental site there were also 64-year-old stands of *Quercus robur* and *Pinus sylvestris* (second generation on post-agricultural land) with areas of ~2 ha and an actively cultivated field (wheat). For more detailed information on the study site and the study layout, see Gallo et al. [14]. Soil properties varied markedly across plots: arable land and afforested sites showed higher pH (5.6–5.9 in H_2O ; 4.5–4.8 in KCl) compared to the old forest (4.9 and 3.6). Base saturation (V) reached 79%–85% in arable and afforested soils but only ~43%–48% in the forest. Old forest soils were more acidic, with high titratable acidity (24–27 mval/kg) and Al^{3+} (22–25 mval/kg), while afforested soils had lower acidity (<2 mval/kg) and much less Al^{3+} (<1 mval/kg). Organic matter was higher in forest soils (humus~4.9%, Cox~2.8%) compared to afforested soils (humus~2.2%–2.8%, Cox~1.1–1.6). For nutrients, Ca ranged from ~1080–1270 mg/kg in afforested soils but only 469 mg/kg in forest soil, Mg from ~110–129 mg/kg vs. 70–75 mg/kg, while available P was lowest in

afforested plots (2.7–3.5 mg/kg) and highest in arable (36–37 mg/kg). Detailed information on the physico-chemical properties of soil is given in the publication by Tama et al. [26].

2.2. Mesostigmata Mites Investigation

As part of the methodology adopted, three subplots were established in each of the habitat types studied (habitat type = fertilization × tree species variant), from which five separate soil samples were collected using metal soil corer (Ø5 cm) to the depth of 15 cm (15 samples per habitat type; 90 samples in total). The sample collection was carried out in August 2024. The arable field sample collection was carried out according to a gradient of distance from the study site—the plots were spaced in a single line every 50 m. A total of 90 soil samples were collected and analyzed separately. The samples were labelled, secured and stored in a refrigerator.

Then, the samples were placed on the Berlese–Tullgren apparatus, consisting of a funnel, a light bulb (40 W), a strainer (2 mm mesh size) and containers with 75% ethanol solution. After extraction, mites of the Mesostigmata order were isolated from the rest of the soil fauna under a stereomicroscope and placed in the lactic acid, while rare mite species were preserved in Hoyer’s medium on slides. The detailed diagnosis took place under a Zeiss Axio Scope A1 compound microscope. All individuals were classified into the appropriate instar, as well as species level or higher taxonomic unit (genus in the absence of developed or visible morphological characteristics specific to the species) using identification keys [27–31].

2.3. Data Analysis

Density, species richness and diversity were calculated per sample. Mean values and standard errors (SEs) were computed for each metric across habitat types. Density was calculated as the number of individuals per square metre. Furthermore, species richness was defined as the total number of distinct taxa observed in each sample. Moreover, the Shannon–Wiener diversity index (H') was calculated, which integrates both the species richness and the evenness of their relative abundances. Biodiversity indices were calculated using the *vegan* package. The Shannon–Wiener diversity index (H') was computed using the *diversity(comm, index = "shannon")* function. This index measures the uncertainty in predicting the identity of a randomly chosen individual from a sample, integrating both species abundance and evenness. It is defined as $H' = -\sum p_i \times \ln(p_i)$, where p_i is the proportion of individuals belonging to the i th species. Species richness was calculated using the *specnumber(comm)* function, which counts the number of unique taxa in each sample.

To assess differences in mite density, species richness and diversity across the habitat types, a Two-Way Analysis of Variance (ANOVA) was performed. Post hoc comparisons were conducted using Tukey’s Honest Significant Difference (Tukey HSD) test (*TukeyHSD()* function), which allowed for the identification of statistically significant differences between pairs of habitat types.

Species accumulation curves were generated using the *specaccum(comm, method = "random")* function from the *vegan* package. These curves illustrate the rate at which new species were observed with increasing sampling effort, providing insight into sample completeness and rare species detection. Curves were calculated separately for each habitat type.

To estimate true species richness accounting for rare taxa, the Chao1 estimator was applied using the *vegan* and *iNEXT* packages. This non-parametric method provides observed richness (the actual number of species recorded in the samples), as well as asymptotic richness estimate (Chao1; the estimated true number of species, accounting for singletons and doubletons). The comparison of observed and estimated richness was used

to evaluate sampling completeness and potential underrepresentation of rare taxa across habitat types.

To explore compositional differences in mite taxa communities among habitat types, we conducted Correspondence Analysis (CA) and Permutational Multivariate Analysis of Variance (Pairwise PERMANOVA). CA was performed using the `cca(comm~env1 + env2, data = env)` functions from the *vegan* package, visualized species–habitat associations in a reduced-dimensional ordination space, highlighting ecological gradients. Furthermore, Pairwise PERMANOVA was conducted using the `adonis2(comm~env1 + env2, data = env, method = "bray")` and `pairwise.adonis(varespec, factors = group, sim.method = "bray", p.adjust.m = "BH")` functions, and tested for significant differences in community composition between habitat types based on Bray–Curtis dissimilarities. This method employs permutation tests to assess group-level variation in multivariate spaces.

Interactions between taxa and habitat types were visualized using web plots from the *bipartite* package. The `plotweb(webmatrix)` and `specieslevel(webmatrix)` functions were employed to display the distribution and strength of species–habitat associations. Additionally, the Species Specificity Index (SSI) was calculated to quantify the degree to which a species is restricted to particular habitat types. SSI values range from 0 (ubiquitous species) to 1 (species occurring in only one habitat), providing a measure of habitat specialization. All statistical analyses were conducted using R software and the R programming language (version 4.5.0; R Core Team R: A Language and Environment for Statistical Computing; Available online: <https://www.Rproject.org/> (accessed on 15 May 2025)).

3. Results

A total of 306 mesostigmatid mite specimens were recorded, belonging to 45 taxa and 14 families. A total of 45 (14.7%) individuals were assigned to the genus level, and 2 individuals were assigned to the order level due to their early stage of development. The most abundant families were Parasitidae (81 individuals), Ascidae (55) and Zerconidae (48). All habitat types overgrown by *Platanus × acerifolia* (Humac, Alginite, Control) were dominated by taxa from the family Ascidae, while all others (arable field, *Pinus sylvestris* and *Quercus robur* stands) by taxa from the family Parasitidae. No taxon described occurred in all habitat types studied. The largest range of occurrence was for *Veigaia nemorensis* (C. L. Koch), which was absent only in the *Quercus robur* stand. As many as 16 taxa were recorded in only one habitat type. *Arctoseius brevicornis* Karg, *A. cetratus* (Sellnick), *A. eremitus* Berlese, *Pergamasus brevicornis* Berlese and *Typhlodromus* spp. occurred only in the arable field. Furthermore, *Zercon peltatus* Koch occurred only in *Quercus robur* and *Pinus sylvestris* stands. Another interesting result is the limited occurrence of taxa such as *Ameroseius corbiculus* (Sowerby) and *Asca bicornis* (Canestrini & Fanzago), which were only recorded in *Platanus × acerifolia* plots (Control, Humac, Alginite) (Figure 2).

The highest mean density was recorded in the *Pinus sylvestris* stand (3566.67 ± 891.58 ind./m²), while the lowest was recorded in both the control *Platanus × acerifolia* (966.67 ± 329.02) and the *P. × acerifolia* + Alginite plots (966.67 ± 350.06). Comparing the effect of fertilization, with Alginite plots on mite density, there is a clear difference in favour of Humac (1633.33 ± 379.43). Mite density for the plots located in the arable field and in the *Quercus robur* stand adopted intermediate values (1266.67 ± 383.80 and 1800 ± 444.01 , respectively). The Tukey HSD results showed significant differences between the *P. sylvestris* stand and the control *Platanus × acerifolia*, the *P. × acerifolia* + Alginite plots ($p = 0.0057$) and arable land ($p = 0.0207$) (Figure 3A).

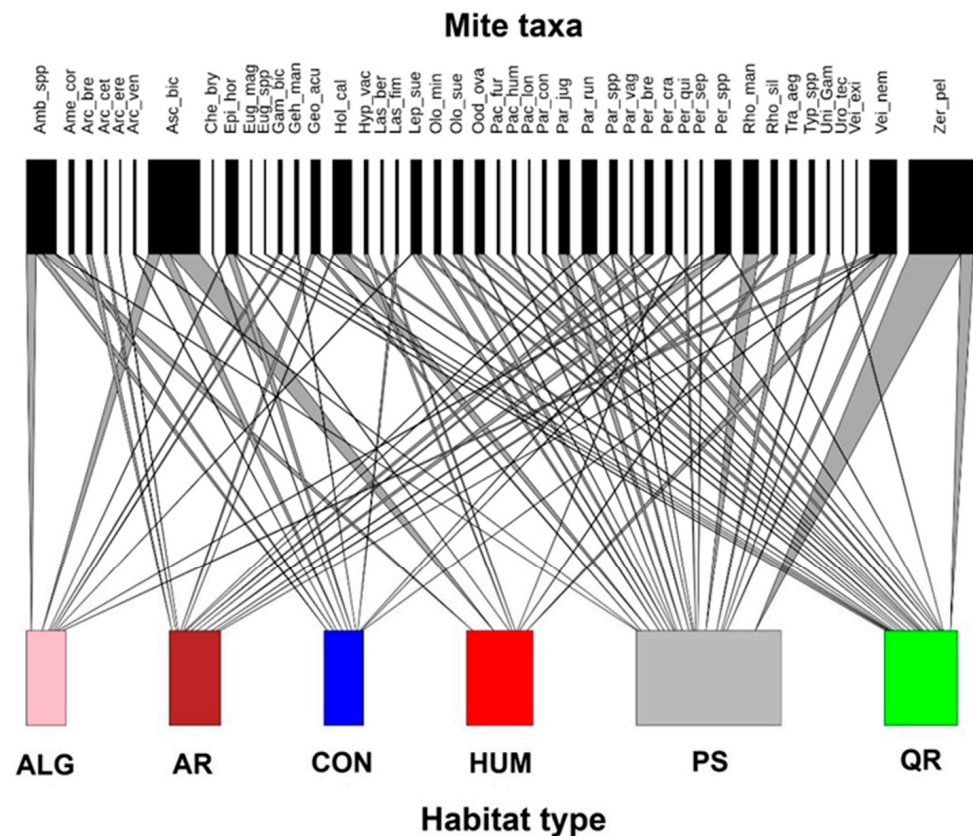


Figure 2. Co-occurrence network for bipartite relationships between mesostigmatid mite taxa (upper boxes) and habitat types (lower boxes). Boxes are proportional to total mite abundance, whereas ribbon width is proportional to the co-occurrence. Abbreviations: ALG—Alginite, AR—arable field, CON—Control, HUM—Humac, PS—*Pinus sylvestris* and QR—*Quercus robur*. Abbreviations of mite taxa indicate the first three letters of the genus name and the first three letters of the species name for each mite taxon (for abbreviations of mite taxa see Appendix A).

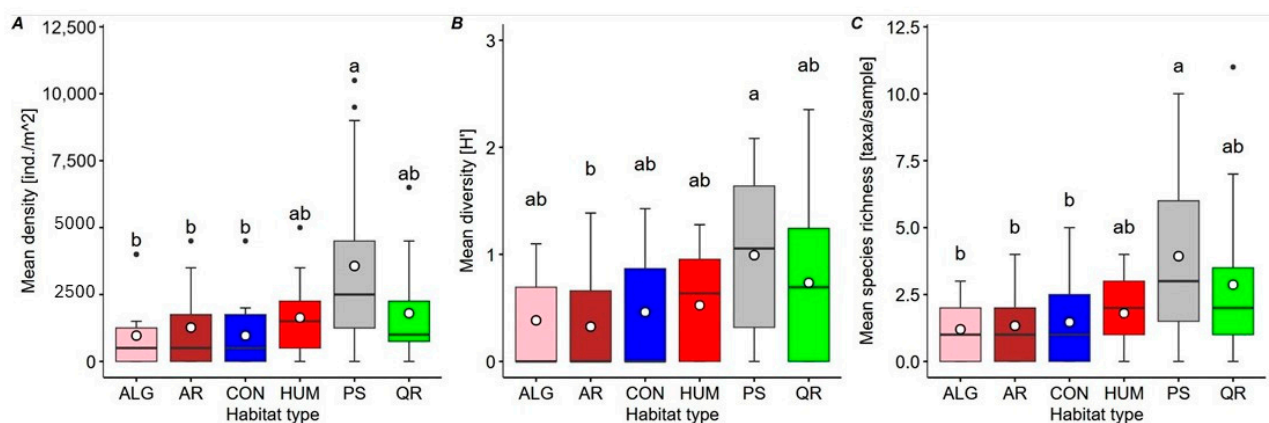


Figure 3. Mean density (A), diversity (B) and species richness (C) of Mesostigmata mite communities. White dots indicate mean values, black dots are outliers, black lines are medians and white bars indicate interquartile range. Letters above the bars indicate post-hoc test results; bars sharing the same letters are not significantly different from each other. Abbreviations: ALG—Alginite, AR—arable field, CON—Control, HUM—Humac, PS—*Pinus sylvestris* and QR—*Quercus robur*.

Mean diversity achieved the highest values in *Pinus sylvestris* (0.99 ± 0.75) and *Quercus robur* (0.74 ± 0.20) stands. Among the *Platanus × acerifolia* plots studied, the highest diversity was recorded in the plot fertilized with Humac (0.52 ± 0.12), followed by Control plots (0.46 ± 0.14) and those fertilized with Alginite (0.38 ± 0.11)

(Figure 3B). Moreover, the highest mean species richness was recorded in the mature stands (*Pinus sylvestris*— 3.93 ± 0.86 taxa; *Quercus robur*— 2.87 ± 0.75), while the lowest on the plots of *Platanus* $\times$ *acerifolia* + Alginite (1.20 ± 0.32) and the arable field (1.33 ± 0.36). The plot fertilized with Humac showed higher mean species richness than the Control plot (1.80 ± 0.33 taxa vs. 1.47 ± 0.43) (Figure 3C). Statistical analysis, based on Tukey HSD test, shows a significant difference between mite density, as well as species richness, in the soil of the *Pinus sylvestris* stand and the following three habitat types, i.e., Control *P.* $\times$ *acerifolia*, *P.* $\times$ *acerifolia* + Alginite and the arable field. In the case of diversity, such a difference occurs only between *Pinus sylvestris* and the arable field. Tukey's HSD revealed significant differences between the species richness of mites in *P. sylvestris* stands and the *P.* $\times$ *acerifolia* + Alginite plots ($p = 0.0095$), arable land ($p = 0.0159$) and the Control *P.* $\times$ *acerifolia* (0.0260). For diversity, such a difference occurred only between *P. sylvestris* and arable land ($p = 0.0348$) (Figure 3B,C).

The cumulative species richness for *Pinus sylvestris* and *Quercus robur* stands exceeded those for other examined habitat types, while it was the lowest for *Platanus* $\times$ *acerifolia* + Humac (Figure 4). Moreover, the estimated richness of mite taxa in a community based on the Chao estimates shows that arable field and Control plots have a much higher potential for diversity than what has been observed—their species richness may be up to twice as high as observed (Figure 5; Table 1). Furthermore, the Correspondence Analysis (CA) revealed significant differences in mesostigmatid mite family's distribution. Axis CA1 and CA2 explained 19.0% and 14.0% of variance in community composition, respectively. The apparent divergence between habitat types suggests that the taxonomic structure of the samples differs between habitats. The greatest differences in taxa composition can be seen between the *Pinus sylvestris* stand and *Platanus* $\times$ *acerifolia* + Humac ($F = 12.20$; $R^2 = 0.347$), as well as between the *Quercus robur* stand and *P.* $\times$ *acerifolia* + Humac ($F = 11.55$; $R^2 = 0.325$). The *Pinus sylvestris* and *Quercus robur* stands have distinctly separate mite taxa communities compared to most other habitat types studied (Figure 6; Table 2).

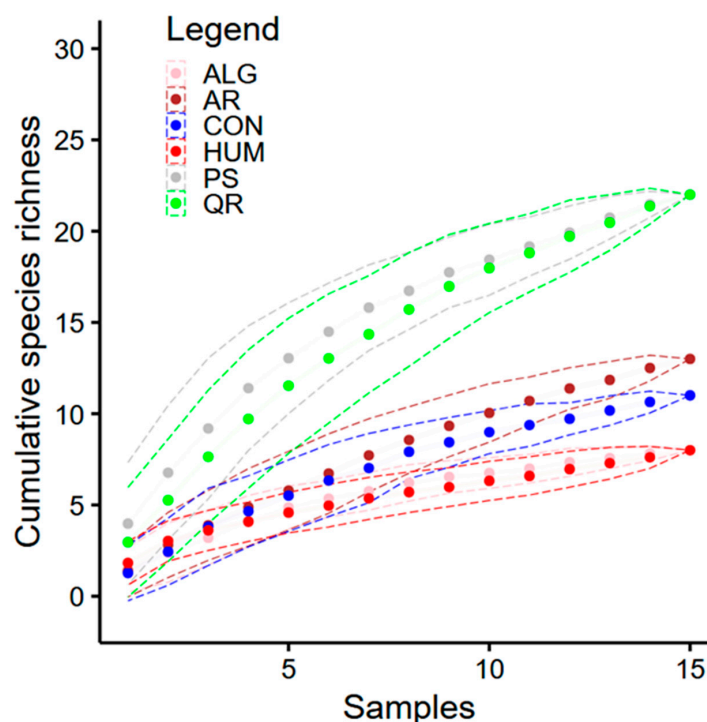


Figure 4. Cumulative species richness (data presented as mean values) for each habitat type. Abbreviations: ALG—Alginite, AR—arable field, CON—Control, HUM—Humac, PS—*Pinus sylvestris* and QR—*Quercus robur*.

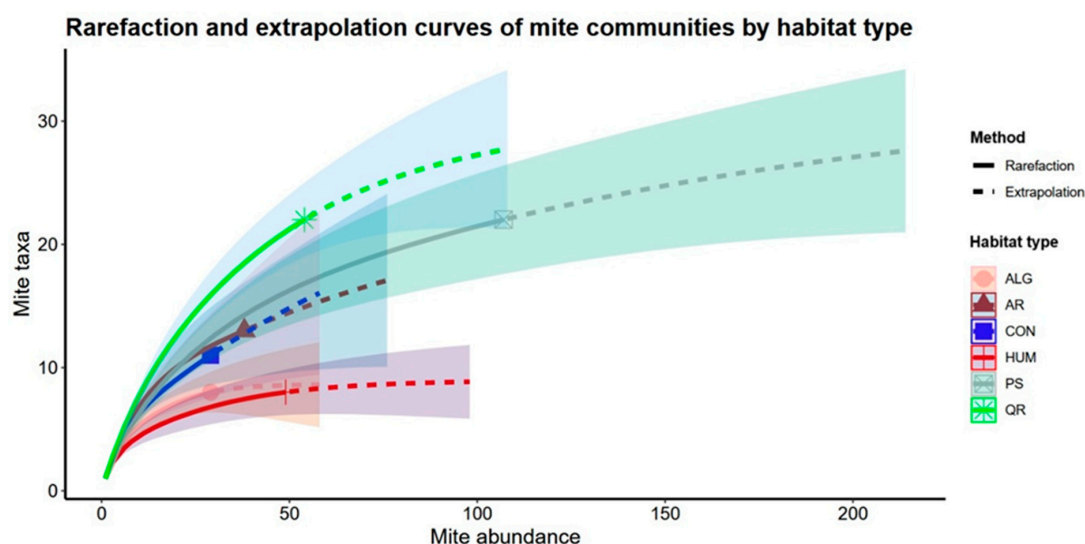


Figure 5. The estimated richness of mite taxa in a community based on the Chao estimates, type = 1 (see also Table 1). Abbreviations: ALG—Alginite, AR—arable field, CON—Control, HUM—Humac, PS—*Pinus sylvestris* and QR—*Quercus robur*. For abbreviations of mite taxa see Appendix A.

Table 1. Observed and asymptotic estimated species richness for habitat types. The table shows the observed number of mite taxa, the asymptotic estimate of species richness, and the corresponding 95% confidence intervals for each habitat type. Abbreviations: ALG—Alginite, AR—arable field, CON—Control, HUM—Humac, PS—*Pinus sylvestris* and QR—*Quercus robur*.

Assemblage (Habitat Type)	Observed Species Richness	Estimated Species Richness (Asymptotic)	Confidence Interval
ALG	8	8.64	8–14.7
AR	13	25.17	13–48.2
CON	11	28.38	11–57.5
HUM	8	8.98	8–14.7
PS	22	32.57	22–53.1
QR	22	30.18	22–54.4

Table 2. The influence of habitat variables on Mesostigmata communities (based on PERMANOVA). Abbreviations: ALG—Alginite, AR—arable field, CON—Control, HUM—Humac, PS—*Pinus sylvestris* and QR—*Quercus robur*.

C2.			F.Model	R ²	p-Value	p.Adjusted
PS vs. CON			6.98	0.269	0.001	0.015
PS vs. HUM			12.20	0.347	0.001	0.015
PS vs. ALG			5.75	0.232	0.001	0.015
QR vs. CON			5.45	0.214	0.001	0.015
QR vs. HUM			11.55	0.325	0.001	0.015
QR vs. ALG			5.21	0.207	0.001	0.015
AR vs. HUM			4.26	0.176	0.002	0.030
Term	Df	Sum of Squares	R ²	F	p-value	
Model	5	6.5124	0.27621	4.5031	0.001	
Residual	59	17.0654	0.72379			
Total	64	23.5778	1.00000			

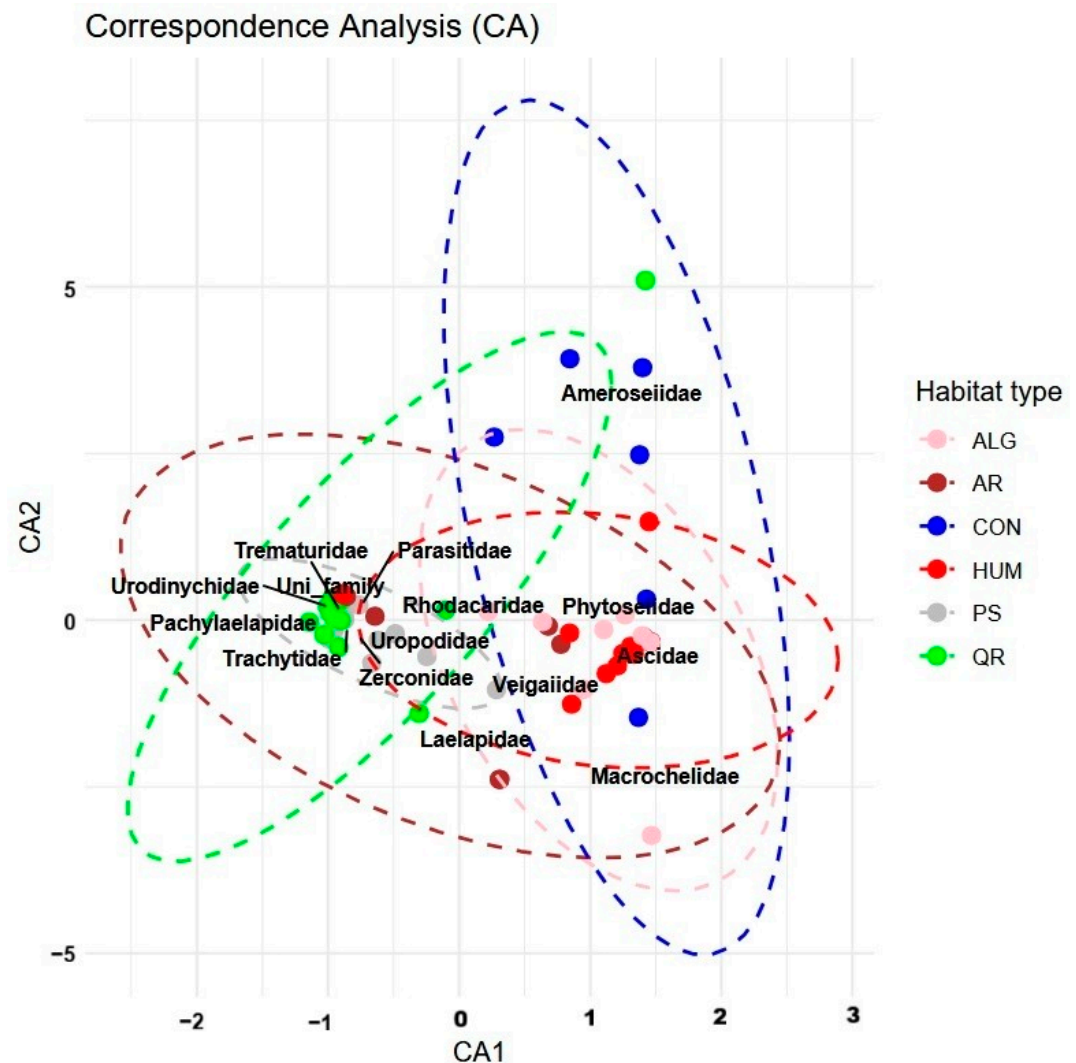


Figure 6. Correspondence Analysis for mite communities, subdivided according to Mesostigmata families. Colour dots and ellipses are samples and sample ranges for each habitat type. Abbreviations: ALG—Alginite, AR—arable field, CON—Control, HUM—Humac, PS—*Pinus sylvestris* and QR—*Quercus robur*.

4. Discussion

The results presented here support the hypothesis that soil fertilization (Humac) favours mite communities' abundance in some cases but limits their species diversity to some extent. A positive effect of such treatment on mite density in the soil occurred with Humac, but not with Alginite. Studies conducted on the plots by Tama et al. [26] showed higher potassium concentrations in control plots and plots fertilized with Alginite. Higher concentrations of this fertilizer in the soil may reduce the abundance of Mesostigmata mites [32]. High doses of potassium fertilizers, particularly in the form of KCl, can increase soil salinity and osmotic stress, potentially negatively affecting soil-dwelling predatory mites. Elevated potassium levels have been associated with reduced microbial biomass and altered nutrient availability, which may indirectly decrease the prey availability and habitat quality for these mites. Consequently, excessive potassium inputs could lead to declines in both the abundance and functional activity of predatory soil mites in agroecosystems [33,34]. These results are consistent with those of other studies [25,35,36]. Cao et al. [25] pointed out the better effect of organic fertilizers than mineral fertilizers in increasing the abundance of predatory mites in the soil, which corresponds to a higher density of mesostigmatid mites when Humac was used than Alginite in present study. This effect could be explained

by an increase in the biomass of bacteriophagous nematodes [25,37,38], on which many Mesostigmata mite species feed [17]. As noted by Holatko et al. [13], the addition of humic substances increases soil basal respiration markedly, which in turn indicates greater soil microbial activity. In fact, they provide complex organic compounds that are metabolically decomposed by microorganisms. The addition of humin also significantly increases the microbial organic carbon (MBC) content, the activity of many soil enzymes and the ammonium–nitrogen pool [13]. Increasing the above-mentioned parameters has a stimulating effect on the development of Oribatida mite communities and soil nematodes [39–41], which are the food resources of Mesostigmata mites [17]. Liu et al. [42] indicated that organic fertilizers increased soil bacterial biomass more than mineral fertilizers, which in turn promoted the growth of soil nematodes' density [42]. Moreover, plots fertilized with Alginite showed lower mesostigmatid species richness than the control plot. The addition of mineral fertilizers changes the composition and activity of soil microorganisms, which indirectly affects the abundance and diversity of soil fauna, including detritivores and predatory mites, and high doses can lead to the dominance of tolerant species and a decline in the abundance of more sensitive or more specialized groups [43].

The second hypothesis, regarding whether older stands of the second generation had much more diverse mite communities, was also confirmed. This effect was determined by lower pH and potassium, calcium and magnesium concentrations in the soil of older stands [44]. As shown by Tama et al. [26], the old forest exhibited lower pH values (more acidic conditions) and markedly reduced calcium and magnesium concentrations compared to both arable and newly afforested soils in horizons 3 and 4. In contrast, potassium showed the highest variability in horizon 3, with notably elevated levels in the Alginite-treated and Control soils, likely reflecting the influence of Alginite application or the legacy of previous fertilization practices. However, while the abundance was clearly higher in the *Pinus sylvestris* stand, it was slightly higher in the *Quercus robur* stand than that recorded in the arable field and in the *Platanus × acerifolia* + Humac variant. This is partly consistent with the findings of Cakir and Makineci [45], who showed higher densities of microarthropods, including mites, in the soil of *Pinus nigra* Arn. stands than *Quercus petraea* (Matt.) Liebl. stands, attributing a lower C/N ratio and higher pH to the soil associated with the oaks. Both of these physico-chemical factors may have a limiting effect on soil mite density [46]. Moreover, oak leaves (*Quercus* spp.), through the release of allelopathic compounds during decomposition, may influence soil fauna composition and activity, thereby affecting nutrient cycling and decomposition processes in forest ecosystems [47]. However, the impact of seasonal conditions, including the date of the sample collection, should be taken into account [48].

Plots located in sites overgrown by *Platanus × acerifolia* (both fertilized and non-fertilized) were dominated by taxa identified to the family Ascidae, which includes mainly predators of juvenile stages of Astigmata mites, springtails and nematodes, inhabiting all soil layers [49]. An interesting result is the relatively high density and species richness of mesostigmatid mites recorded in the arable field compared to those described within the afforested variants studied. Indeed, intensive agro-technical treatments, such as ploughing, are thought to reduce soil mite abundance and diversity [50,51]. The dominant genus in the arable field was the cosmopolitan *Pergamasus* spp. whose representatives are considered to be generalist soil predators found in degraded agricultural habitats, among others [52,53]. The widespread occurrence of *Veigaia nemorensis* confirms that it is a common mite species with a wide ecological tolerance, also against other mite species belonging to the same genus [54], such as *V. exigua* (Berlese), which occurred in only one habitat in the present study. In comparison, *Zercon peltatus* was present only in the mature *Pinus sylvestris* and *Quercus robur* stands, which can be considered to be most similar to typical forest

soils, indicating and confirming its habitat preference [7]. A completely different result was recorded for *Arctoseius brevichelis*, *A. cetratus*, *A. eremitus*, *Pergamasus brevoicornis* and *Typhlodromus* spp. which occurred only in the arable field. Species of the genera *Arctoseius* spp. and *Typhlodromus* spp. are considered to have low habitat requirements and have been recorded in agroecosystems [55–57]. It is worth noting *Zercon peltatus* is a species found only in mature second-generation stands in present study, which highlights and confirms its role as a bioindicator indicating stabilized forest ecosystems [18].

Reclaimed areas (experimental and control), as well as arable land, are characterized by mites in a slightly advanced succession phase [58]. Only pine and oak stands were home to mites from the Zerconidae and Pachylaelapidae and the suborder Uropodina characteristic of these stands [59]. Their presence in areas adjacent to the restored plots assures us that their gradual appearance in these areas in the coming years will inform us about the subsequent phases of succession, which will be a measure of the effectiveness of the restoration of these areas.

5. Conclusions

The results of the present study indicate a positive effect of the application of humic-containing fertilizers in the first phase of tree growth on the soil–faunal community structures. This effect was particularly noticeable for density, but also for species richness and diversity. Humac application bridges the differences in Mesostigmata mite community structure in young stands on a post-fallow ground relative to the second generation of older stands on the same ground. In the case of Alginite, the positive effect was not noted at any level of analysis; however, the moderately negative impact on the species richness and diversity of mesostigmatid mites was revealed. Although the differences between the impact of individual fertilization variants and the control area were not statistically significant, they are noticeable and should be an important basis for further research. Combined with the results of other studies, which also indicate an improvement in tree condition when humin fertilizers are applied, such treatments may be considered good practice for the afforestation of former agricultural land.

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Appendix A

Table A1. Occurrence of taxa in particular habitat types. Grey boxes indicate an established presence of mite individuals.

Mite Taxa	Abbreviation	Family	Control	Humac	Alginite	<i>Quercus robur</i>	<i>Pinus sylvestris</i>	Arable Field
<i>Amblyseius</i> spp.	Amb_spp	Phytoseiidae						
<i>Ameroseius corbiculus</i> (Sowerby, 1806)	Ame_cor	Ameroseiidae						
<i>Arctoseius brevichelis</i> Karg, 1969	Arc_bre	Ascidae						
<i>Arctoseius cetratus</i> (Sellnick, 1940)	Arc_cet	Ascidae						
<i>Arctoseius eremitus</i> (Berlese, 1918)	Arc_ere	Ascidae						
<i>Arctoseius venustulus</i> (Berlese, 1917)	Arc_ven	Ascidae						
<i>Asca bicornis</i> (Canestrini & Fanzago, 1887)	Asc_bic	Ascidae						
<i>Cheiroseius bryophilus</i> Karg, 1969	Che_bry	Ascidae						
<i>Epicriopsis horridus</i> (Kramer, 1876)	Epi-hor	Ameroseiidae						
<i>Eugamasus magnus</i> (Kramer, 1876)	Eug_mag	Parasitidae						
<i>Eugamasus</i> spp.	Eug_spp	Parasitidae						
<i>Gamasellodes bicolor</i> (Berlese, 1918)	Gam_bic	Ascidae						
<i>Geholaspis mandibularis</i> (Berlese, 1904)	Geh_man	Macrochelidae						
<i>Holoparasitus calcaratus</i> (C. L. Koch, 1839)	Hol_cal	Parasitidae						
<i>Geolaelaps aculeifer</i> (Canestrini, 1883)	Geo_acu	Laelapidae						
<i>Hypoaspis vacua</i> (Michael, 1891)	Hyp_vac	Laelapidae						
<i>Lasioseius berlesesi</i> Oudemans, 1938	Las_ber	Ascidae						
<i>Lasioseius fimetorum</i> Karg, 1971	Las_fim	Ascidae						
<i>Leptogamasus suecicus</i> Trägårdh, 1936	Lep_sue	Parasitidae						
<i>Olodiscus minima</i> (Kramer, 1882)	Olo_min	Uropodidae						
<i>Olopachys suecicus</i> Sellnick, 1950	Olo_sue	Pachylaelapidae						
<i>Oodinychus ovalis</i> (C. L. Koch, 1839)	Ood_ova	Trematuridae						
<i>Pachylaelaps furcifer</i> Oudemans, 1903	Pac_fur	Pachylaelapidae						
<i>Pachyseius humeralis</i> Berlese, 1910	Pac_hum	Pachylaelapidae						
<i>Pachylaelaps longisetis</i> Halbert, 1915	Pac_lon	Pachylaelapidae						
<i>Paragamasus conus</i> (Karg, 1971)	Par_con	Parasitidae						
<i>Paragamasus jugincola</i> Athias-Henriot, 1967	Par_jug	Parasitidae						
<i>Paragamasus runcatellus</i> (Berlese, 1903 sensu Karg, 1971)	Par_run	Parasitidae						
<i>Paragamasus</i> spp.	Par_spp	Parasitidae						
<i>Paragamasus vagabundus</i> (Karg, 1968)	Par_vag	Parasitidae						
<i>Pergamasus brevicornis</i> Berlese, 1903	Per_bre	Parasitidae						
<i>Pergamasus crassipes</i> (Linnaeus, 1758)	Per_cra	Parasitidae						
<i>Pergamasus quisquiliarum</i> (Canestrini & Canestrini, 1882)	Per_qui	Parasitidae						
<i>Pergamasus septentrionalis</i> (Oudemans, 1902)	Per_sep	Parasitidae						
<i>Pergamasus</i> spp.	Per_spp	Parasitidae						
<i>Rhodacarus mandibularis</i> Berlese, 1921	Rho_man	Rhodacaridae						
<i>Rhodacarellus silesiacus</i> Willmann, 1936	Rho_sil	Rhodacaridae						
<i>Trachytes aegrota</i> (C. L. Koch, 1841)	Tra_aeg	Trachytidae						
<i>Typhlodromus</i> spp.	Typ_spp	Phytoseiidae						
<i>Urodiaspis tecta</i> (Kramer, 1876)	Uro_tec	Urodynychidae						
<i>Veigaia exigua</i> (Berlese, 1916)	Vei_exi	Veigaiidae						
<i>Veigaia nemorensis</i> (C. L. Koch, 1839)	Vei_nem	Veigaiidae						
<i>Zercon peltatus</i> C. L. Koch, 1836	Zer_pel	Zerconidae						

Table A2. Network statistics for mesostigmatid mite taxa, describing their affiliation to habitats and specialization. Abbreviations of mite taxa are described in Table A1.

Mite Taxa	Number of Habitats	Proportion of Habitats	Species Specificity Index d'
Amb_spp	4	0.667	0.432
Ame_cor	1	0.167	1.000
Arc_bre	1	0.167	1.000
Arc_cet	1	0.167	1.000
Arc_ere	1	0.167	1.000
Arc_ven	2	0.333	0.632
Asc_bic	3	0.500	0.557
Che_bry	1	0.167	1.000
Epi_hor	4	0.667	0.509
Eug_mag	1	0.167	1.000
Eug_spp	1	0.167	1.000
Gam_bic	2	0.333	0.683
Geh_man	2	0.333	0.683
Geo_acu	3	0.500	0.515
Hol_cal	3	0.500	0.688
Hyp_vac	1	0.167	1.000
Las_ber	1	0.167	1.000
Las_fim	1	0.167	1.000
Lep_sue	3	0.500	0.536
Olo_min	2	0.333	0.651
Olo_sue	2	0.333	0.714
Ood_ova	2	0.333	0.840
Pac_fur	1	0.167	1.000
Pac_hum	2	0.333	0.683
Pac_lon	1	0.167	1.000
Par_con	2	0.333	0.683
Par_jug	2	0.333	0.742
Par_run	3	0.500	0.571
Par_spp	3	0.500	0.632
Par_vag	2	0.333	0.632
Per_bre	1	0.167	1.000
Per_cra	3	0.500	0.573
Per_qui	1	0.167	1.000
Per_sep	2	0.333	0.632
Per_spp	4	0.667	0.619
Rho_man	1	0.167	1.000
Rho_sil	2	0.333	0.651
Tra_aeg	1	0.167	1.000
Typ_spp	1	0.167	1.000
Uni_Gam	1	0.167	1.000
Uro_tec	1	0.167	1.000
Vei_exi	1	0.167	1.000
Vei_nem	5	0.833	0.415
Zer_pel	2	0.333	0.777

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