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First Assessment of Soil Mite Communities in Togo with Special Reference to Mesostigmata as Potential Biological Control Agents

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A survey of soil arthropods was conducted in two contrasting localities of southern Togo, SEAL (Agronomic Experimental station) and GOUNOU KOPE, to assess the richness of soil mites, with a focus on Mesostigmata with potential in biological control. A total of 14,369 arthropods were collected, of which 11,510 were from SEAL and 2,859 from GOUNOU KOPE. Mites were the most abundant group overall (66.2%; 9,056 individuals), followed by Collembola (19.6%) and other

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insects (14.3%). Arthropod abundances varied by site and land-use type: uncultivated soils supported higher densities than cultivated soils at SEAL, whereas the opposite trend was observed at GOUNOU KOPE. Mite abundance was significantly influenced by site (df = 1, F = 49.16, $P < 0.0001$), soil type (df = 1, F = 50.12, $P < 0.0001$), and season (df = 1, F = 36.70, $P < 0.0001$), with higher densities consistently found at SEAL, in uncultivated soils, and during the rainy season. Taxonomic analysis revealed two mite orders, Oribatida and Mesostigmata, with Oribatida dominating across sites and land-use types. Within Mesostigmata, three families were identified: Ologamasidae, Parasitidae, and Uropodidae. Ologamasidae was the most abundant family, representing 70% and 67% of Mesostigmata in cultivated and uncultivated soils at SEAL, and 56% and 59% at GOUNOU KOPE, respectively. These findings highlight marked spatial and seasonal variation in soil arthropod communities and underline the predominance of predatory Mesostigmata families with potential relevance for biological control in West African agroecosystems.

Keywords: Arthropods; mite abundance; uncultivated soils; agroecosystems.

1. INTRODUCTION

Soil is a dynamic, living system whose functioning results from interactions between abiotic factors, such as climate and parent material, and biotic factors, including plants and soil communities. It represents one of the richest habitats on Earth, hosting a vast diversity of organisms that spend all or part of their life cycles within it (Monrozier, 2006; Anthony et al., 2023). Soil fauna is commonly classified by body size and ecological role into microfauna, mesofauna, and macrofauna (Turbé et al., 2010). Among these groups, mesofauna, comprising organisms between 0.2 and 2 mm in size (Gobat et al., 2004) is dominated by mites and springtails, which account for up to 95% of its abundance (Ghezali, 2012).

Mites (Acari) are minute arthropods, barely visible to the naked eye, and are particularly diverse and abundant in tropical ecosystems (Walter and Proctor, 1999). The Oribatida and Mesostigmata are the most prominent groups (Seniczak, 2021). Due to their small size, mites exploit a wide range of microhabitats, from soil to plants (Orgiazzi et al., 2015), often ranking among the most abundant and species-rich arthropods in these environments (Seniczak et al., 2019). Soil mites contribute substantially to forest biodiversity (Lindo et al., 2006) and play key roles in organic matter decomposition and nutrient cycling (Potapov et al., 2022). Their high densities, species richness, and sensitivity to environmental conditions make them suitable indicators for evaluating the effects of management practices on soil biodiversity (N'Dri et al., 2018). Consequently, they are widely recognized as valuable bioindicators of ecosystem health and change (Andrievski and Syso, 2012).

From an agricultural perspective, the Mesostigmata are of particular interest because they include families of predatory mites (Vásquez et al., 2007; Lindquist et al., 2009). Many of these predators, especially members of the Phytoseiidae, are well known for their role in the biological control of phytophagous mites and insect pests, as well as nematodes (McMurtry et al., 2013). More recently, increasing attention has been directed towards soil-dwelling families such as Ascidae (sensulato), Laelapidae, Macrochelidae, and Ologamasidae for their potential use in crop protection (Castilho et al., 2009).

Despite their ecological and agricultural importance, the biodiversity of soil mites remains poorly studied in West Africa, and virtually no data are available for Togo, in contrast to other regions where such investigations have been more extensively undertaken (Britto et al.,2011).

The objective of this study was to investigate the diversity and composition of soil mites in Togo, with particular emphasis on the group Mesostigmata. By providing the first baseline data on soil mite communities in this country, we aim to contribute to a better understanding of their ecological roles and potential importance for soil health and sustainable agriculture in West Africa.

2. METHODOLOGY

2.1 Sampling Sites

Soil samples were collected from two sites in the Maritime region of Togo: SEAL (Agronomic Experimental station) (6°22'N, 1°13'E) characterized by ferralitic soils derived from continental deposits, and GOUNOUKOPE (6°12'51"N, 1°31'58"E) along the coastline, with sandy soils of marine origin. Both sites share similar equatorial Guinean climatic conditions, with annual rainfall of 800–1200 mm, mean temperatures of 24–30 °C, and a bimodal rainfall pattern with rainy seasons from April to July and September to December (Worou, 2002).

The two sites differ in their soil types. The Lomé Agricultural Experiment Station is characterized by ferralitic soil, locally known as "barre soil," derived from continental deposits. This soil type covers approximately 47% of the Maritime region (Worou, 2002) and is also present in Côte d'Ivoire, Ghana, Benin, and Nigeria (Louette, 1988). In contrast, the GOUNOU KOPE coastal site has raw mineral soils of marine origin, predominantly sandy in texture, typical of coastal market gardening areas.

2.2 Sample Collection and Extraction of Soil Microarthropods

Priority was given to market gardening sites. At each site, five plots were randomly selected, spaced 200–300 m apart. Within each plot, six sampling points were defined using the "two diagonals" method, with points at least 10 m apart. At each point, soil and litter were collected at a depth of 0–10 cm (Duarte, 2013) using a small shovel within a 40 cm diameter. Samples from the six points were pooled to form a composite sample per plot. Meanwhilesamples were also taken from adjacent plots of natural vegetation, representing areas unused or long abandoned for cultivation (considered herein as "Uncultivated soils"), following the same procedure.

Sampling was conducted during both the dry season (December–April) and the rainy season (May–August) of 2022, at a frequency of two sampling rounds per month.The samples collected were placed in plastic bags, each labeled with all relevant information and taken to the laboratory for extraction.

Soil microarthropods were extracted using a modified Berlese-Tullgren method (Tullgren, 1918; Roy et al., 2008; Melo-Molina, 2022). This method is widely recognized as one of the simplest, most efficient, and rapid techniques for extracting microarthropods from soil samples. The principle relies on a temperature gradient that forces organisms to move downward through the soil sample into collection containers (Tullgren, 1918; Roy et al., 2008).Mites were separated from other arthropods (insects, springtails, and non-target mites) under a stereomicroscope. The collected mites were then transferred into 1.5 ml tubes containing 70% ethanol for subsequent identification. Mites wereslide-mounted inHoyer's medium for examination under a phase-contrast microscope,and identified based on illustrated keys provided by Krantz and Walter (2009).

2.3 Statistical Analysis

The analysis of variance (ANOVA) was used to test the effect of sampling season (dry season vs raining season), soil type (Cultivated vs Uncultivated) and the collection site (SEAL vs GOUNOU KOPE) on the abundance of mites, followed by Turkey HSD multiple range tests to separate means. All analyses were performed using R software (version 4.3.0; R Core Team, 2023).

3. RESULTS

3.1 Arthropods Fauna

A total of 14369 arthropods, including mites, springtails, and insects, were collected across the two sampling sites during the study period. Of these, 11510 specimens were obtained from SEAL and 2859 from GOUNOU KOPE (Fig. 1). At SEAL, uncultivated soils harbored higher arthropod abundances than cultivated soils, whereas the opposite pattern was observed at GOUNOU KOPE. Overall, the GOUNOU KOPE site had considerably fewer arthropods than SEAL, regardless of land-use type. Among all arthropods, mites were the most abundant group, followed by springtails (Fig. 2).

Across all samples, mites were the dominant group, representing 66.2% of total specimens (9,056 individuals), followed by collembolans at 19.6% (2,810) and other insects at 14.3% (2,053) (Fig. 2).

3.2 Mite Abundance by Site and Soil Type

Temporal variation in mite densities by sampling site and soil type is shown in Fig. 3. Sampling site had a highly significant effect on mite abundance ($F = 49.16$, $df = 1$, $P < 0.0001$), with SEAL consistently harboring more mites than GOUNOU KOPE. Significant effects were also detected for soil type ($F = 50.12$, $df = 1$, $P < 0.0001$) and sampling season ($F = 36.70$, $df = 1$, $P < 0.0001$), as well as for most of their interactions (Table 1). Overall, mite densities were lower at GOUNOU KOPE than at SEAL, regardless of soil type. Across both sites, mites were significantly more abundant in the rainy season than in the dry season, and in uncultivated soils compared to cultivated soils (Table 2).

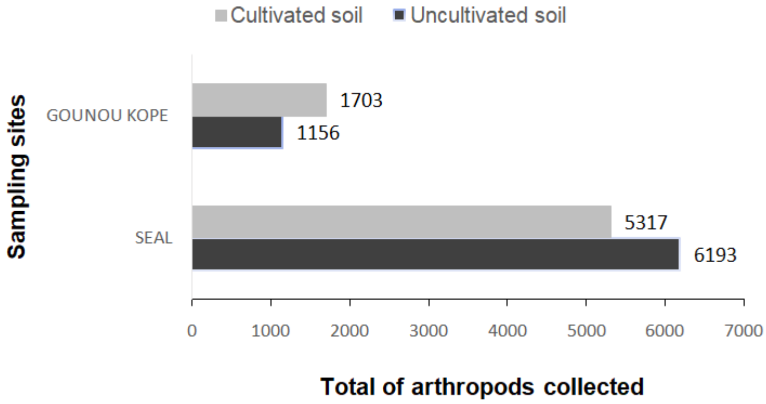

Fig. 1. Total number of arthropods collected from soils of the two localities

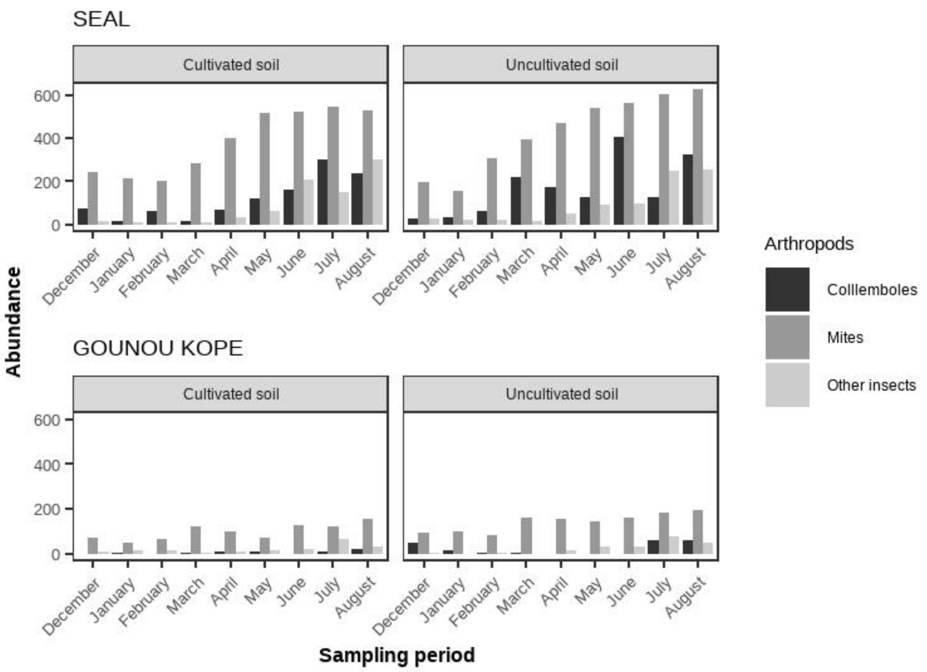

Fig. 2. Dynamics of the three groups of arthropods across sampling date in the two localities

Table 1. Analysis of variance of the effects of sampling site, season and type of soil on theabundance of mites

Source	df	MS	*F*	*P*
Site	1	198436.40	49.16	<0.0001
Season	1	148292.90	36.74	<0.0001
Type of soil	1	202306.61	50.12	<0.0001
Site x Season	1	63037.73	15.62	<0.0001
Site x Type of soil	1	335275.5	83.06	<0.0001
Site x Season x Type of soil	1	7611.50	1.89	0.1806
Error	1	12441.73	3.08	0.0901
	28			

Table 2. Mite abundance at each site and by sampling season and soil type

	SEAL		GOUNOU KOPE	
Season	**Uncultivated soil**	**Cultivated soil**	**Uncultivated soil**	**Cultivated soil**
Raining season	585.2 ± 19.1 aA	173.50 ± 45.3 aB	171.5 ± 10.7 aA	120.0 ± 16.9 aB
Dry season	305.2 ± 59.2 bA	26.80 ± 6.74 bB	118.4 ± 16.1 aA	82.2 ± 11.9 bA

Means followed by the same lowercase letter within each column and the same uppercase letterwithin each row are not significantly different (Tukey's HSD test; P > 0.05)

Table 3. Abundance of the three families of mites collected from the sampling sites

	SEAL		GOUNOU KOPE	
Season	**Uncultivated soil**	**Cultivated soil**	**Uncultivated soil**	**Cultivated soil**
Ologamasidae	3003 (70%)	2149 (67%)	465 (56%)	698 (59%)
Parasitidae	858 (20%)	610 (19%)	191 (23%)	272 (23%)
Uropodidae	429 (10%)	449 (14%)	174 (21%)	214 (18%)

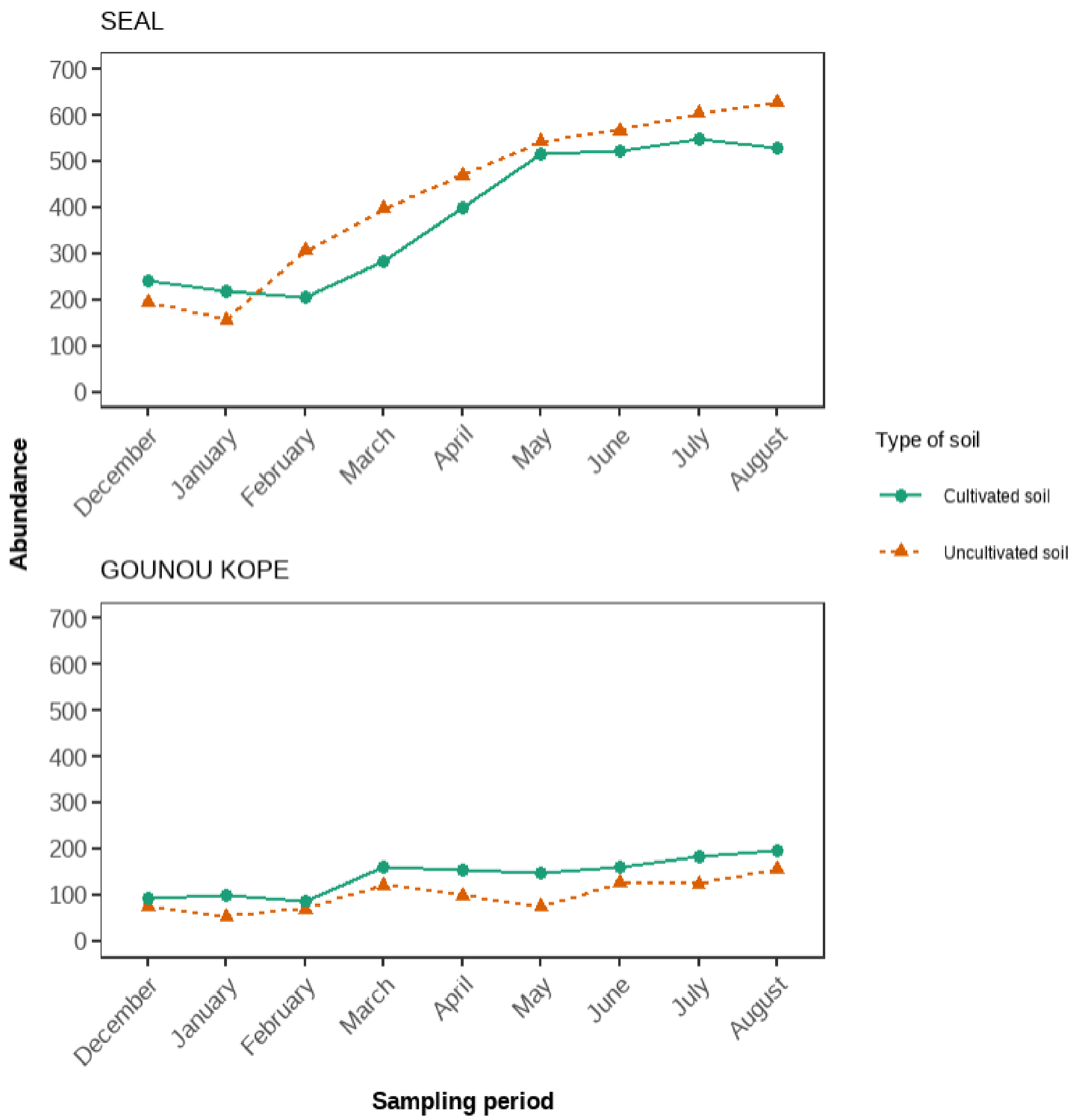

Fig. 3. Mite abundance across sampling date in the two localities

3.3 Taxonomic Composition of Mites

Two orders of mites were identified during the study: Oribatida and Mesostigmata. At both sites, and in both cultivated and uncultivated soils, Oribatida were consistently more abundant than Mesostigmata.

For family-level identification, only Mesostigmata were considered because of their agricultural relevance, particularly their role as potential biological control agents. A total of 9512 Mesostigmata individuals were collected across all sites, belonging to three families: Ologamasidae, Parasitidae, and Uropodidae. The most abundant family was Ologamasidae, with 6315individuals, followed by Parasitidae with 1931 individuals.

At SEAL, family abundance was higher in uncultivated soils than in cultivated soils. Ologamasidae represented 70% of Mesostigmata in cultivated soil and 67% in uncultivated soil. At GOUNOU KOPE Ologamasidae also dominated, accounting for 56% of individuals in cultivated soil and 59% in uncultivated soil (Table 3).

4. DISCUSSION

This study provides the first assessment of soil mite communities in Togo, offering essential baseline data on their diversity and composition. The focus on Mesostigmata highlights their potential role in biological control and sustainable pest management. These findings contribute valuable insights to the understanding of soil biodiversity and its relevance to agroecological sustainability in West Africa.

Our results highlight new insights into the abundance and distribution of soil arthropods, particularly mites, in cultivated and uncultivated soils at two contrasting sites in southern Togo. A total of 12,793 arthropods were collected, with mites representing the dominant group, followed by collembolans and insects. The predominance of mites is consistent with previous studies highlighting their numerical dominance and ecological importance in soil communities (Walter & Proctor, 1999).

A significant site effect was observed, with SEAL supporting higher arthropod and mite abundances than GOUNOU KOPE. This may reflect differences in soil characteristics, microclimate, and land-use history, which are known to influence soil fauna (Nielsen et al., 2010). Soil type also influenced arthropod numbers: at SEAL, uncultivated soils supported more individuals than cultivated soils, whereas at GOUNOU KOPE, a marginal difference was observed between the two types of soil. Such patterns likely result from the effects of cultivation practices, such as tillage, organic matter management, and pesticide use on soil structure and microhabitats (Wardle, 2002; Bardgett & van der Putten, 2014).

Mite abundance varied seasonally, with higher densities recorded during the rainy season compared to the dry season. Increased soil moisture and enhanced decomposition rates during the rainy season likely improve habitat quality and food availability for soil mites (Larsen et al., 2004).

Oribatida were consistently more abundant than Mesostigmata, reflecting their well-known role as decomposers and contributors to nutrient cycling (Behan-Pelletier, 1999). Among Mesostigmata, Ologamasidae, Parasitidae, and Uropodidae were identified, while families such as Ascidae, Melicharidae, and Macrochelidae, often cited for their biological control potential, were absent from our collections. This absence may be due to the limited scope of our sampling sites, which did not encompass the full range of habitats where these families typically occur. Expanding the study to additional sites with varied vegetation types and soil conditions could reveal the presence of these important predatory mites.

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Overall, the results indicate that soil arthropod communities in southern Togo are influenced by site-specific factors, soil management, and seasonal dynamics. The dominance of mites, and the presence of agriculturally significant Mesostigmata, highlight the potential of these communities for ecological functions and biological control in local agroecosystems. Future studies with broader spatial coverage are needed to fully capture the diversity of predatory mites and assess their role in sustainable pest management.

5. CONCLUSION

The present study demonstrates that soil ecosystems in southern Togo harbor a rich assemblage of Mesostigmata mites, particularly members of Mesotigmata. Their high representation suggests that West African soil ecoystems constitute an important reservoir of natural enemies with prospective applications in biological control. Their dominance across localities, land-use types, and seasons highlights the sensitivity of these organisms to moisture and disturbance. Further taxonomic and ecological investigations are warranted to elucidate the species composition, functional roles, and biocontrol potential of these Mesostigmata communities in local agroecosystems.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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