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Mite diversity suborder Prostigmata associated with the plant rhizosphere soil of the Yotoco Nature Reserve, Valle del Cauca-Colombia

Diversidad de ácaros del sub-orden Prostigmata asociados a la rizosfera de plantas de la reserva natural de Yotoco, Valle del Cauca – Colombia

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Abstract

Yotoco Nature Reserve is a protected area for conservation purposes, is located at 3º53'18" N, 76º20'5" W, in the town of Yotoco with an altitude of 1526 m. a. s. l. The present research aimed to identify the diversity of mite suborder Prostigmata associated with the rhizosphere of plants of the Natural Reserve of Yotoco. Six samplings of soil and leaf litter between the surface and 5 cm depth were done in a radius of 1 m from the stem of plants, which are representative in each location of study. Samples were taken to the laboratory in styrofoam coolers. To isolate the mites, the Berlese-Tulgren funnel was used and mites were collected in vials with 70% alcohol. For permanent mounting in microscope slides, the Hoyer medium was used. A completely randomized block design with stratified replicates was used. The total of collected individuals was 181 and they were distributed in the following mite families: Microtrombidiidae, Stigmaeidae, Cunaxidae, Bdellidae, Pseudocheylidae, Cryptognathidae, Eupalopsellidae and Scutacaridae. The Stigmaeidae family was the most abundant and frequent. Among the identified mite families, 15 genera were found, from which, the genera *Stigmaeus* Koch, 1836 was the most common.

Key words: Acari, humid forest, Mesostigmata, Oribatida.

Resumen

La Reserva Natural de Yotoco es un área protegida con fines de conservación, está ubicada a 3º53'18" latitud Norte, 76º20'5" longitud Oeste del meridiano de Greenwich, en el municipio de Yotoco, con altitud de 1526m.s.n.m. Con el presente estudio se pretendió identificar la diversidad de ácaros del sub-orden Prostigmata asociados a la rizosfera de plantas de la Reserva Natural de Yotoco. Se realizaron 6 muestreos de suelo y hojarasca entre la superficie y 5 cm de profundidad; en un radio de 1 metro del tallo de familias de plantas representativas de cada zona de estudio. Las muestras se transportaron al laboratorio, en neveras de poliestireno expandido. Para la extracción de los ácaros se utilizó el método de embudo de Berlese-Tulgren y se recolectaron en viales con alcohol del 70%. Para el montaje permanente se usó medio Hoyer en placas portaobjetos. Se usó un diseño experimental en bloques completos al azar con repeticiones estratificadas. La totalidad de individuos colectados fue de 181 y se distribuyeron dentro de las familias de ácaros: Microtrombidiidae, Stigmaeidae, Cunaxidae, Bdellidae, Pseudocheylidae, Cryptognathidae, Eupalopsellidae y Scutacaridae. La familia Stigmaeidae fue la más abundante y frecuente. Dentro de las familias de ácaros identificadas, se encontraron 15 géneros de los cuales *Stigmaeus* Koch, 1836 fue el más común.

Palabras clave: Acari, Oribatida, Mesostigmata, Selva húmeda,

Introduction

Soil is a dynamic and complex component which is fundamental for the development of the terrestrial fauna. The transformation of the soil properties perform a direct relationship with its biota. This biota can be considered as microengineers, which improve processes of aeration, porosity, water infiltration and nutrient supply (Seastedt and Crossley, 1980). The mesofauna is a component of soil biota, it plays an important role for decomposing organic matter, nutrient recycling and mineralization of nitrogen and phosphorus, which are essential for the development of crops and their productivity (Usher *et al.* 2006).

In the soil mesofauna, microarthropods such as mites and springtails compose the largest part (Cassagne *et al.* 2006). They are an important resource since act like bioindicators of soil conditions, showing the different environmental or antropogenic changes. Respectively, they serve as a basis for proper management and preservation of the ecosystem. The mite fauna of the soil is highly diverse, as well as its behavior and feeding habits. Among the organisms that inhabit the soil, mites and springtails can represent 95% of the microarthropods (Neher and Barbercheck, 1999; Vu and Nguyen, 2000). Soil mites have different feeding habits: detritophagous, consumers and filters of microorganisms, phytophagous that feed on plant tissues, consumers of nematodes and generalized predators (Walter & Proctor, 1999).

The benefits can provide to their environment are valuable, as such it is the indirect nutrient input to the media as result of the decomposition of organic matter, which is done naturally (Crossley *et al.* 1992).Additionally, they can act as natural controllers of some organisms that can affect the production of plant biomass of agronomic interest (Walter and Proctor, 1999). On the other hand, despite of the high diversity and amount of soil organisms, there are several difficulties to collect them in the field, for extraction and processing of samples in the laboratory and taxonomical identification because those are laborious tasks that require extensive time.

This research aims to show the diversity of families within the suborder Prostigmata which are present in the soils of the Natural Reserve of Yotoco, in the geographical valley of Cauca river and consequently to identify the diversity of mites from the suborder Prostigmata which are associated to the plant rhizosphere of the Natural Reserve of Yotoco, Valle del Cauca, Colombia.

Material and methods

Sampling sites

This research was carried out in the ecosystem of the Natural Reserve of Yotoco (RNY), located in the department of Valle del Cauca. The six samplings were established between June 2011 and March 2012, in order to have winter and summer times.

The RNY is part of the municipality of Yotoco, it is located at the eastern side of the western mountain range, the altitudes are among 1200 and 1800 m. a. s. l. Its area is around 559 hectares, average temperature is 20 °C, annual average rainfall is 1.500 mm. It has a bimodal type of climate having two wet seasons in the year that alternate with two dry seasons. It is located at 3° 53’ 18” N, 76° 20’ 5” W.

Collection of field samples

Soil and leaf litter were collected from the superficial rhizosphere, at 1 m radius from the base of each plant belonging to the Melastomataceae, Rubiaceae, Cyatheaceae, Arecaceae, Piperaceae and Laureaceae families in order to recover the soil mites belonging to the suborder Prostigmata that are associated to them.

Samples were taken from three plants of each family. Each soil sample was collected among soil surface and 5 cm depth using an auger or cylinder of 5 cm diameter x 5 cm height with a cutting side, like the one suggested by Oliveira *et al.* (2001). The leaf litter associated to each sample was collected from the top of the soil before the soil sampling and, it was processed in the same way that the mineralized soil, the leaf litter samples were approximately the same volume as the metallic cylinder used for soil. Each soil sample was collected in a plastic bag that was labelled with the required information as treatment, replicate and type of sample (leaf litter or soil) and, these bags were kept inside a styrofoam cooler to avoid disturbance of the sample due to light or temperature. Six samplings were performed in the areas of influence of the project.

Isolation of mites from the soil

The Berlese-Tulgren funnel method, modified for mite isolation accordingly to Oliveira *et al.* (2001) was used. 70% alcohol was used for preservation and 70% alcohol plus acetic acid was used for storage of the isolates in Eppendorf flasks until the mounting process (Figure 1). The content of the flasks was filtered using filter paper, the collected mites were stored in Petri dishes, while their processing was taking place. For mounting, the Hoyer solution was used. The final slides were sealed with white nail polish to prevent dehydration and their respective identification was annotated based on the taxonomical keys used.

To identify the mites of the suborder Prostigmata at the family & genera level the keys of Krantz (1978); Walter and Proctor (2001); Krantz & Walter (2009), were performed.

Statistical analysis

The number of individuals, the diversity Alfa (α) and Beta (β) indexes and the abundance and similarity. For the Alfa diversity, or diversity degree, the Margalef and Simpson indexes were calculated (Figures 2, 3). For the Beta diversity, or similarity degree, the Jaccard and Sorensen indexes were calculated. The obtained results were statistically analyzed by analysis of variance and a comparison of means test (Tukey).

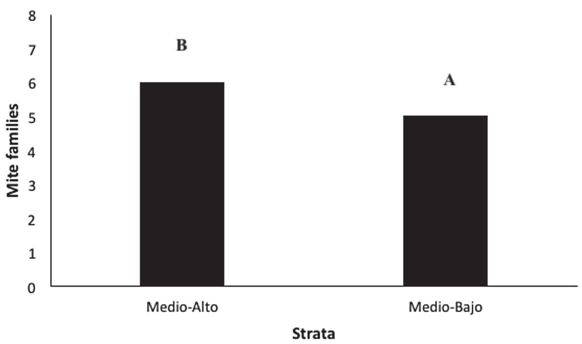

Figure 2. Comparison of the means for the mite families among the evaluated strata.

Means with the same letter are not statistically different by Tukey's test. (P≥0.05).

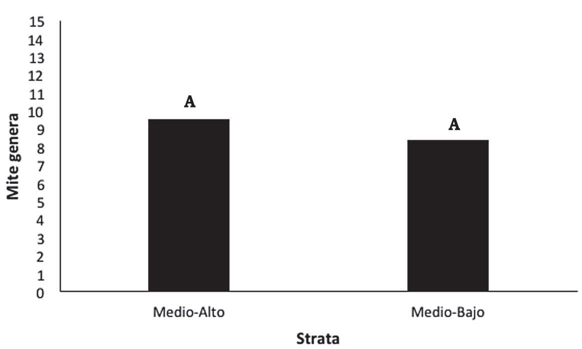

Figure 3. Comparison of means for the mite genera among the evaluated strata.

Means with the same letter are not statistically different by Tukey's test (P≥0.05).

Experimental design

The experiment followed a completely randomized block design due to the strata found in the RNY, with three replicates and six treatments corresponding to the plant families: T1 Arecaceae, T2 Cyatheaceae, T3 Laureaceae, T4 Melastomataceae, T5 Piperaceae and T6 Rubiaceae (Figure 4). The experimental unit was a sample of each family of plants. Stratified replicates according to altitude in the RNY were done for the middle-low part ± 1400 m. a. s. l. and the middle-high part ± 1700 m. a. s. l.

Results and discussion

Species accumulation curve

The observed results show that the sampling effort was enough for both locations, since 15 of the 16.53 genera expected were found which are more than the 90% of the expected genera. According to Villarreal *et al.* (2004), it can be expected that if the number of samplings is increased the results will show low variation, which is equivalent to a suitable sampling effort.

Presence of mites suborder Prostigmata associated to the studied areas

181 individuals were found belonging to the families Bdellidae, Scutacaridae, Smarididae, Stigmaeidae, Cryptognathidae, Eupalopsellidae, Cunaxidae, Pseudocheylidae and Microtrombidiidae (Figure 1) and 15 genera of mites suborder Prostigmata, were present in the soils of the RNY (Table 1). The results agree with the occurrence of some families of mites belonging to the suborder Prostigmata that inhabit the soil-leaf litter stratum of a scrubland and deciduous forest located at the Universidad Centroccidental Lisandro Alvarado in Venezuela (Vásquez *et al.,* 2007), where 19 families and 29 genera of the suborder Prostigmata were found, including: Alicorhagididae, Anystidae, Bdellidae, Caeculidae, Cheyletidae, Erythraeidae, Eupalopsellidae, Eupodidae, Nanorchestidae, Penthalodidae, Rhagidiidae, Smariidae, Stigmaeidae, Tarsonemidae, Tetranychidae, Trombidiidae, Tydeidae.

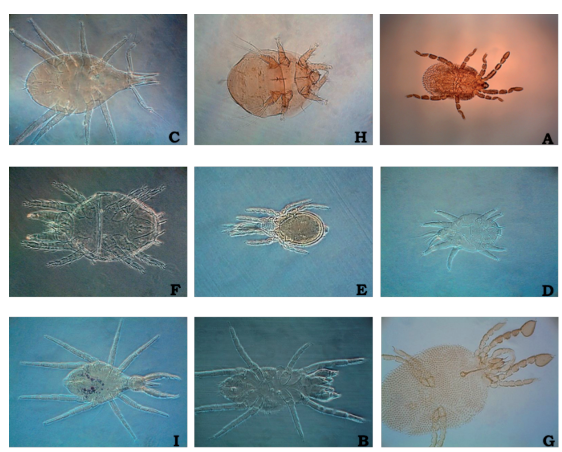

Figure 1. Families of mites suborder Prostigmata associated to soil of the Natural Reserve Yotoco. A) Bdellidae, B) Scutacaridae, C) Smarididae, D) Stigmaeidae, E) Cryptognathidae, F) Eupalopsellidae, G) Cunaxidae, H) Pseudocheylidae, I) Microtrombidiidae.

In a gallery forest of the University Park of the UCLA in Venezuela, mites from 8 families and 17 genera of the suborder Prostigmata were found, including: Cheyletidae, Cunaxidae, Erythraeidae, Eupodidae, Smarididae, Trombidiidae, Tydeidae (Fuentes *et al.,* 2008).

The evaluated strata within the RNY were classified according to their location in altitude, where the middle-low stratum was around ± 1526 m. a. s. l. and the middle-high stratum oscillated around ± 1680 m. a. s. l. The occurrence of the mite families associated to the different strata indicates that statistically significant differences were found. The middle-high stratum had the higher percentage of mites getting the highest abundance and largest diversity with 13 out of 15 genera belonging to the families Microtrombidiidae, Stigmaeidae, Cunaxidae, Bdellidae, Eupalopsellidae and Scutacaridae and, associated to plants of the families Lauraceae, Arecaceae, Melastomataceae, Cyatheaceae, Rubiaceae, Piperaceae. Moreover, besides presenting four genera which are absent from the middle-low strata *Eupalopsellus* Sellnick, 1949 associated to Melastomataceae, *Ledermelleriopsis* Willmann, 1951 associated to six families of plants, *Lophodispus* Ebermann, 1982, associated to Piperaceae and Cyatheaceae and *Scutascirus* Den Heyer, 1976, associated to Rubiaceae, Melastomataceae and Lauraceae. On the other hand, the middle-low strata had the following families: Pseudocheylidae, Cryptognathidae, Microtrombidiidae, Stigmaeidae and Cunaxidae. In this stratum, the mite families Pseudocheylidae and Cryptognathidae were found but absent in the middle-high stratum, and associated to Lauraceae and Piperaceae, respectively (Table 1).

Relation among the soil mites suborder Prostigmata associated to plant families

The plants selected in the present research, form a considerable amount of biomass in the root which can create a microclimate suitable for abundant mites suborder Prostigmata. The results of the abundance of mite families found indicates the treatment 3 (Laureaceae) and 5 (Piperaceae) hosted the largest number of families with five out of eight found in the RNY, this is possibly due to the plant biomass accumulated at the base of the plants, besides of the different exudates and volatiles that can favor the proliferation of these organisms or the different food sources associated to them (Figure 4). The results obtained in the analysis of variance showed significant differences (Figure 5), which indicates that the treatment 5 (Piperaceae) have allowed the largest number of mite families with 6.68. In contrast, the treatment 3 (Lauraceae) performed the lowest number 4.61.

Genera also showed differences associated to the evaluated stratum (Figure 6) where the treatment 3 (Lauraceae) performed the highest value 9.66 and treatment 4 (Melastomataceae) performed the lowest 7.84.

Table 1. Total number of families and genera of mite suborder

Family	Genera	Estratum	Plant family
Microtrombidiidae	*Manriquia* Boshelll & Kerr, 1942	Middle-high, middle-low	Arecaceae, Piperaceae, Rubiaceae, Cyatheaceae, Lauraceae
	Trichotrombidium Kobulej, 1950	Middle-high, middle-low	Arecaceae, Rubiaceae, Melastomataceae, Cyatheaceae, Lauraceae
Stigmaeidae	*Cheylostigmaeus* Willmann, 1951	Middle-high, middle-low	Arecaceae, Melastomataceae
	Ledermelleriopsis Willmann, 1951	Middle-high	Arecaceae, Piperaceae, Rubiaceae, Melastomataceae, Cyatheaceae, Lauraceae
	Stigmaeus Koch, 1836	Middle-high, middle-low	Arecaceae, Piperaceae, Rubiaceae, Melastomataceae, Cyatheaceae, Lauraceae
Cunaxidae	*Coleoscirus* Berlese, 1918	Middle-high, middle-low	Arecaceae, Piperaceae, Rubiaceae, Melastomataceae, Cyatheaceae, Lauraceae
	Dactyloscirus Berlese, 1916	Middle-high, middle-low	Arecaceae, Piperaceae, Rubiaceae, Melastomataceae, Cyatheaceae, Lauraceae
	Pseudobonzia Smiley, 1975	Middle-high, middle-low	Arecaceae, Rubiaceae, Melastomataceae
	Pulaeus Den Heyer, 1980	Middle-high, middle-low	Arecaceae, Cyatheaceae, Lauraceae
	Scutascirus Den Heyer, 1976	Middle-high	Rubiaceae, Melastomataceae, Lauraceae
Bdellidae	*Thoribdella* Grandjean, 1938	Middle-high, middle-low	Lauraceae
Pseudocheylidae	*Anoplocheylus* Berlese, 1988	Middle-low	Lauraceae
Cryptognathidae	*Favognathus* Luxton, 1973	Middle-low	Piperaceae
Eupalopsellidae	*Eupalopsellus* Sellnick, 1949	Middle-high	Melastomataceae
Scutacaridae	*Lophodispus* Ebermann, 1982	Middle-high	Piperaceae, Cyatheaceae

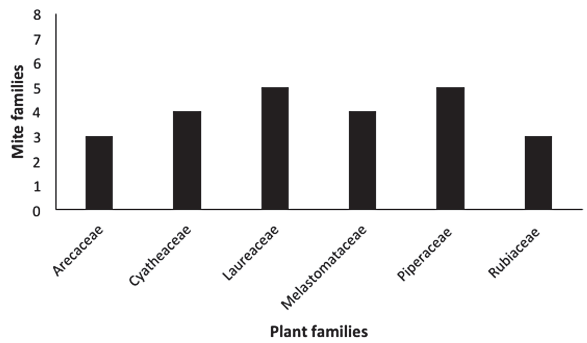

Figure 4. Number of mite suborder Prostigmata families associated to soil, by treatment.

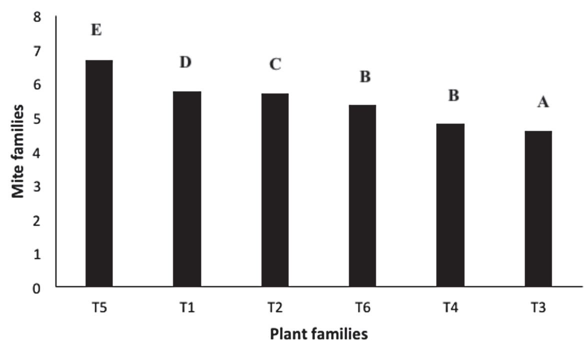

Figure 5. Comparison of means for mite families among evaluated treatments.

Means with the same letter are not statistically different by Tukey's test (P≥0.05).

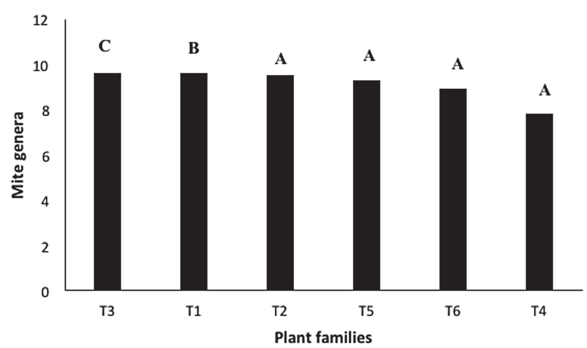

Figure 6. Comparison of means for mite genera among the evaluated treatments.

Means with the same letter are not statistically different by Tukey's test (P≥0.05).

Bandejo & Ola-Adams (2000), found the highest population of mites order Prostigmata associated to the soil of different plantations in Nigeria was in the family Pineaceae, which was associated to the mite family Caeculidae. Fuentes *et al.* (2008), evaluated the occurrence of the orders Prostigmata, Mesostigmata associated to the leaf litter of a gallery forest in Venezuela. The major composing families are as follows: Fabaceae, Burseraceae, Nyctaginaceae, Rubiaceae, Agavaceae and Bromeliaceae. The results obtained showed the mite family Eupodidae was the most abundant and frequent in that humid forest.

Diversity and similarity

The results of the diversity index "D_{Mg}" show that the middle-low stratum has a larger biodiversity than the middle-high stratum RNY, which indicates a moderate biodiversity taking into account that values lower than 2 are considered as areas of low biodiversity and, values higher than 5 are related to high diversity areas (Margalef, 1995).

The diversity index "λ" presented minimal differences, the middle-high stratum showed the highest biodiversity value (Table 2). Vásquez *et al.* (2007), obtained values for the Simpson index of 0.1837 and 0.1166 for plant communities of scrubland and deciduous forest, respectively.

The values for similarity index "I_J" showed that the similarity of the species in the two areas evaluated in the RNY is slightly high, sharing some of the individuals found (Table 2).

Table 2. Diversity indexes

Diversity indexes	Stratum	
	Middle-High	Middle-Low
Alfa (α)		
Margalef index(D_{Mg})	2.4732	2.5197
Simpson index (λ)	0.2046	0.1708
Beta (β)		
Jaccard index (I_J)	0.60	
Sorensen index (I_S)	0.75	

The "I_S" index had a moderate value similar to the "I_J" index, this agrees with the similarity results, which indicate that the similarity of species is slightly high for the two strata belonging to the RNY area (Table 2).

The values of "I_S" and "I_J" similarity indexes (Table 2), can explain that the two strata evaluated in the RNY share 9 out of the total 15 genera of mites suborder Prostigmata present (Table 1), which are equivalent to 60% of the genera found in this area. Diversity indexes values of "I_S" and "I_J" for vegetation in scrubland and deciduous forest in Venezuela were similar to 0.70 and 0.59 that are the ones found in this study in the Yotoco area, and both vegetation also share a 55% similarity in the morphospecies found (Vásquez *et al.,* 2007).

Knowing the Prostigmata mites in the RNY, including other soil mites, is crucial to understand the dynamics of the organisms composing this ecosystem. The families of mite suborder Prostigmata Microtrombidiidae, Stigmaeidae, Cunaxidae, Bdellidae, Eupalopsellidae found in this research, have predatory feeding habits, whereas the families Scutacaridae and Cryptognathidae are associated, mainly, in phoresis with Hymenoptera and Coleoptera insects, which are the mostly used (Krantz, 2009) and are mainly associated to mosses, respectively; these relationships are key to the homeostasis in this ecosystem.

On the other hand, the plant families selected that are representative of the RNY, are food source and refuge, both, in the aerial part as in the leaf litter, giving a suitable environment for diversity and abundance of mites.

Conclusion

The families and genera of Prostigmata mites found in the ecosystems, have predatory feeding habits, except for Scutacaridae and Cryptognathidae, which are found mainly in phoresis with Hymenoptera and Coleoptera insects as mostly used (Krantz, 2009) and associated to mosses, respectively.

The low population of individuals at the low part of the RNY, indicates the possibility of a contamination or external disturbance factor, due to the movement of vehicles that separates both strata the dynamics of the species can be altered; however, despite of the low population its behavior is similar to the middle-high stratum, although the number of individuals collected was lower.

The highest occurrence of mites associated to the plant families Lauraceae and Piperaceae can be due to the plant biomass accumulated at the base of the plants, additionally to the different exudates and volatiles that can generate special conditions that favor proliferation of these organisms or the different feeding sources associated to them.

The results of diversity indexes show that the evaluated areas in this research have high diversity of mites suborder Prostigmata, since the results obtained from both strata were high, they belong to a humid tropical forest with low disturbance, which indicates that higher values for richness and diversity of mites suborder Prostigmata can be expected.

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