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New records of soil mites (Acari) from citrus orchards of Tunisia

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Abstract
An inventory of soil mites from citrus orchards was carried out in four localities situated in the regions of Mornag and Bizerte, northern Tunisia. The soil sampling was performed monthly under the canopy throughout the two years of the study (2016 and 2017). A total of 31 species of mites belonging to 20 families were identified. The acari fauna was predominantly composed of Oribatida followed by Mesostigmata mites. The most frequent and abundant Oribatida families were Oribatulidae and Phenopelopidae, while Parasitidae, Laelapidae and Pachylaelapidae were the predominant families of Mesostigmata.

Keywords: Acari, soil mites, citrus orchards, Tunisia

1. Introduction
Arthropods may represent as much as 85% of the soil fauna. Isopoda, Myriapoda, Insecta, Acari and Collembola are the five groups chiefly represented. Acari and Collembola are by far the most abundant and diverse [1]. They play an essential role in the biological fertility of the soil and they contribute greatly to the decomposition of the organic matter, the synthesis of humus, the restitution of biogenic elements, the stimulation of fungal and bacterial metabolism [2, 3] and the water cycle.
Acari can be grouped into two major groups based on their habits and habitats: the free-living and parasitic forms. The free-living forms are ground predacious, phytophagous, mycophagous, saprophagous, coprophagous, and necrophagous mites [4]. The parasitic forms include important phoretic species [4]. The predatory mites are one of the most abundant groups of arthropods in the soil, most of them being mobile predators, which predominantly feed on nematodes, insect eggs and larvae of micro arthropods [5, 6].
In Tunisia, despite the high diversity and abundance of mite fauna in the soil, mites are largely ignored by researchers due to their small size and because soil is a very cumbersome medium [6]. In the northern part of the country, there are many reports of mites inhabiting various crops (greenhouse crops, apple and citrus orchards, and vineyards), while in the southern part, information comes mainly from areas involved in date palm production [7, 8]. From these studies was compiled a list of 37 species, belonging to eight families of mites, among them 30 species of Phytoseiid mites from the northern region [7] and twelve from the southern [8] which were new records for the Tunisian mite fauna. Other surveys, whose objective was to collect Phytoseiid mites from citrus orchards, reported the presence of 13 species in three citrus orchards managed with contrasted pesticide and weeding management [9].
Hence, the knowledge of Tunisian mite fauna has been based primarily on mites living on crops [7-9], while studies of soil mites in natural environments and agronomic habitats are scarce. For this reason, the main objective of this study was to contribute to the knowledge of the soil mite community composition in citrus orchards in the northern region of Tunisia, especially that certain species can act as natural enemies against some citrus pests.

2. Material and Methods
Mites were collected from the soil of four citrus orchards located in Bizerte (37°10.1466′ N 10°2.0868′ E, elevation: 100m a.s.l.) and Mornag (36°40.7586′ N 10°17.517′ E, elevation: 32m a.s.l.) regions of northern Tunisia. The soils were sampled monthly over two consecutive years (2016, 2017). In each orchard, four samples were collected randomly under the foliage of citrus trees, from a surface area of 20 cm x 20 cm and at 5 cm depth.

In the laboratory, mites were extracted from soils using Berlese funnels and 70° alcohol as extractor liquid. Mites were sorted from insects found in the same soil sample under a binocular loupe.

Before taxonomic identification, specimens were cleared in Nesbit fluid at 45 °C and later mounted on glass slides using Hoyer's medium. Morphological observations were done under a phase contrast microscope.

3. Results and Discussion

3.1 Inventory of soil mites

Thirty-one species of mites were identified using specialized keys [10-15].

The identified species were classified into three suborders, eight of them belonging to the suborder Oribatida (Table1; Plate1), nineteen species to the suborder Mesostigmata (Table 1; Plate 2) and four species to the suborder Prostigmata (Table1; Plate 3).

In the suborder Oribatida, *Zygoribatula exilis* (Plate 1. d) and *Z. connexe* (Plate 1.h) were the most abundant species of the family Oribatulidae in the studied soils of Tunisian citrus orchards with 37.68% of all mites collected. The species *Nothrus reticulatus* (plate1, b) was fairly represented in the soil of the four citrus orchards, especially in the month of November, with 10.65% of all mites collected. Other Oribatida species (plate 1: a, b, c, e, f) were in the soil (tabl.1).

For the suborder Mesostigmata, the species *Parasitus americanus* (Plate 2; a) was the most abundant in the soil of the four citrus orchards, especially in the spring season. The rest of species (plate 2: from b to r) are more or less abundant.

In Prostigmata suborder, the genera *Cyta* and *Odontoscirus* (Plate 3: a; b), both members of the family Bdellidae, are very conspicuous in the soil due to their red-orange color and are easily detected at a glance. They are present throughout the year, sometimes as the dominant species. The genus *Allothrombium* and *Neothrombidium* (Plate 3: c and d) were present in all orchards but were not particularly abundant.

The genus *Neothrombidium* was present in some weeds from the family Asteraceae such the species *Calendula bicolor* in citrus orchards associated with larval and adult instars of thrips.

Table 1: Acari collected from soil of citrus orchards in Tunisia

Suborder	Family	Months of dominance	Number of mites	Percentage (%)	Species
Oribatida	Nothridae	November –December	2956	10.65	*Nothrus reticulatus* (Sitnikova, 1975)
	Oribatulidae	November- December March	10455	37.68	*Zygoribatula exilis* (Nicolet, 1855) *Zygoribatula connexa* (Berlese, 1904)
	Galumnatidae	November- December-March –April	313	1.12	*Galumna tarsipennatum* (Oudemans 1914)
	Phenopelopidae	November- December	145	0.52	*Eupelops halophilus* (Pérez-Iñigo, 1969)
	Galumnatidae	March April	320	1.15	*Pilogalumna alliferum* (Oudemans, 1919)
	Scheloribatidae	November- Febrile	121	0.43	*Scheloribates latipes* (Koch, 1844)
	Oppiidae	November- December	265	0.95	*Lasiobelba africana* (Kok, 1967)
Mesostigmata	Parasitidae	April –May-June	8108	29.22	*Parasitus americanus* (Berlese, 1905) *Parasitus coleoptratorum* (Linneaus, 1758) *Parasitus hyalinus* (Willmann, 1949) *Holoparasitus calcaratus* (C.L. Koch, 1839)
	Phytoseiidae	April-May	152	0.55	*Neoseiulus barkeri* (Hughes, 1948)
	Laelapidae	March- April-May	1209	4.36	*Stratiolaelaps scimitus* (Womersley, 1956) *Ololaelaps veneta* (Berlese, 1904) *Pseudoparasitus centralis* (Berlese, 1920) *Euandrolaelaps karawaiewi* (Berlese, 1903)
	Pachylaelapidae	March- April-May-June	1245	4.48	*Pachylaelaps imitans* (Berlese, 1920) *Pachylaelaps karawaie* (Berlese, 1920) *Pachylaelaps hispani* (Berlese,1908)
	Machrochelidae	March- April-May-June	258	0.92	*Macrocheles merdarius* (Berlese, 1889) *Holostaspella bifoliata* (Trägårdh, 1952)
	Ascidae	April- May	452	1.62	*Arctotis semiscisus* (Berlese, 1892)
	Melicharidae	April- May	121	0.43	*Proctolaelaps bickleyi* (Bram, 1956)
	Sejidae	Octobre- May	36	0.12	*Sejus balochi* (Athias-Henriot, 1960)
	Uropodidae	April- May	214	0.77	*Uropoda sp.* **(**Kramer, 1881)
	Stigmaeidae	May	410	1.47	*Stigmaeus luteus* (Summers, 1962)
Prostigmata	Bdellidae	Febrile-May- August-September	876	3.15	*Cyta sp.* (Von Heyden, 1826) *Odontoscirus sp.* (Tohr, 1913)
	Trombidiidae	April- May	60	0.21	*Allothrombium sp.* (Berlese, 1903)
	Neothrombiidae	April-May	26	0.09	*Neotrombidium sp. (*Klimov, 2000)
Total			27742	100	31 species

Plate 1: Species of Oribatida acari mounted (G*4 and *10): a: *Scheloribates latipes*; b: *Nothrus reticulatus*; c: *Lasiobelba africana*; d: *Zygoribatula exilis*; e: *Galumna tarsipennatum*; f: *Pilogalumna alliferum*; g: *Eupelops halophilus*; h: *Zygoribatula connexa*.

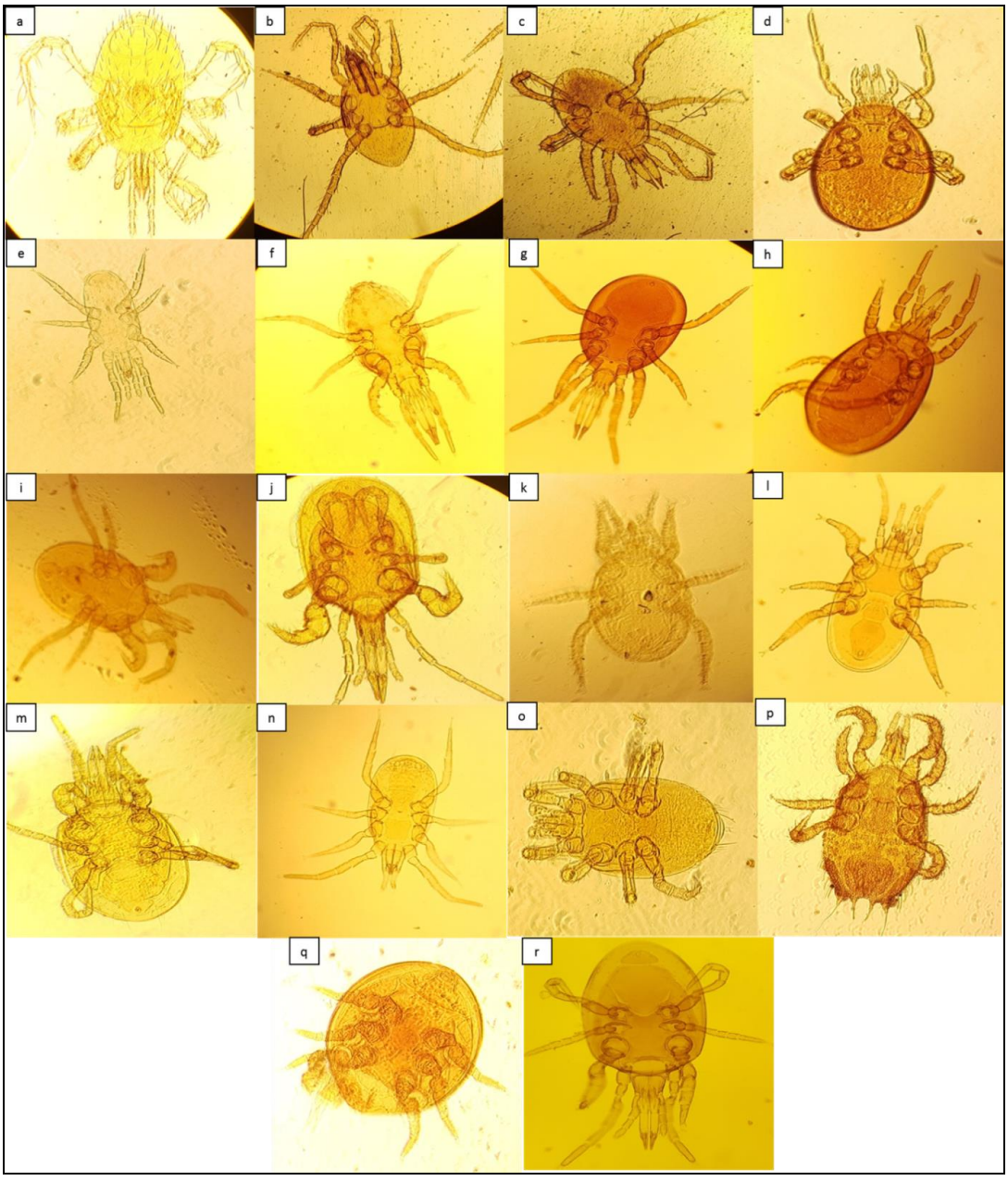

Plate 2: Species of Mesostigmata cleared and mounted (G*4 and *10): a*: Parasitus americanus*; b: *P. coleoptratorum*; c: *P. hyalinus*; d: *Holoparasitus colcoratus*; e: *Neoseiulus barkeri*; f: *Stratiolaelaps scimitus*; g: *Ololaelaps veneta*; h: *Pseudoparasitus centralis*; i: *Euandrolaelaps karawaiewi*; j: *Pachylaelaps imitans*; k: *Holostraspella bifoliata*; l: *Macrocheles merdarius*; m: *Pachylaelaps hispani;* n: *Arctotis semiscisus*; o: *Proctolaelaps bickleyi*; p: *Sejus balochi*; q: *Uropoda sp*; r: *Pachylaelaps karawaie.*

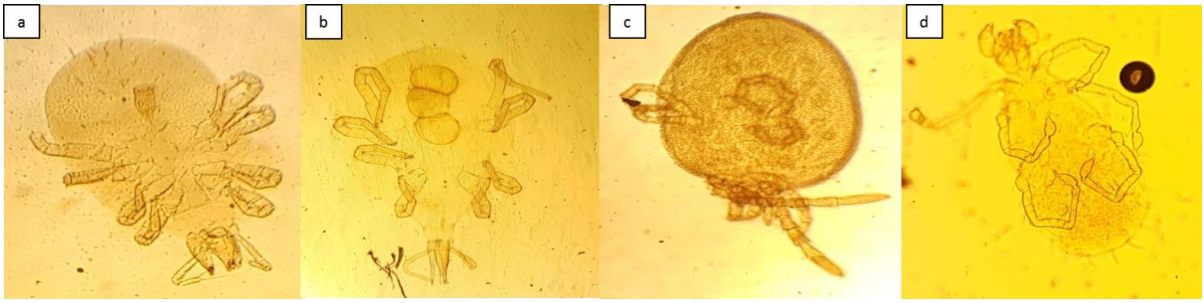

Plate 3: Species of Prostigmata cleared and mounted (G*4 and *10) a: *Cyta sp.*; b: *Odontoscirus sp.*; c: *Allothrombium sp.*; d: *Neotrombidium sp.*

3.2 Abundance of soil mites in Tunisian citrus orchards

3.2.1 Oribatid mites

The Oribatid mites represent the most abundant suborder in the soil of citrus orchards found in this study. They constitute 52.53% of all mites collected from soil between the years 2016 and 2017. These mites are usually fungivorous or detritivorous [16]. They play a significant role in decomposition processes because they fragment the organic matter and influence the biomass and species composition of fungi and bacteria [17, 18]. Oribatulidae is the most abundant family of Oribatid (71.73%) collected from citrus soil in this study, and Nothridae is the second most abundant family (20.28%). The rest of Oribatid mites appear with percentages varying from 0.83% to 2.19% (Fig.1).

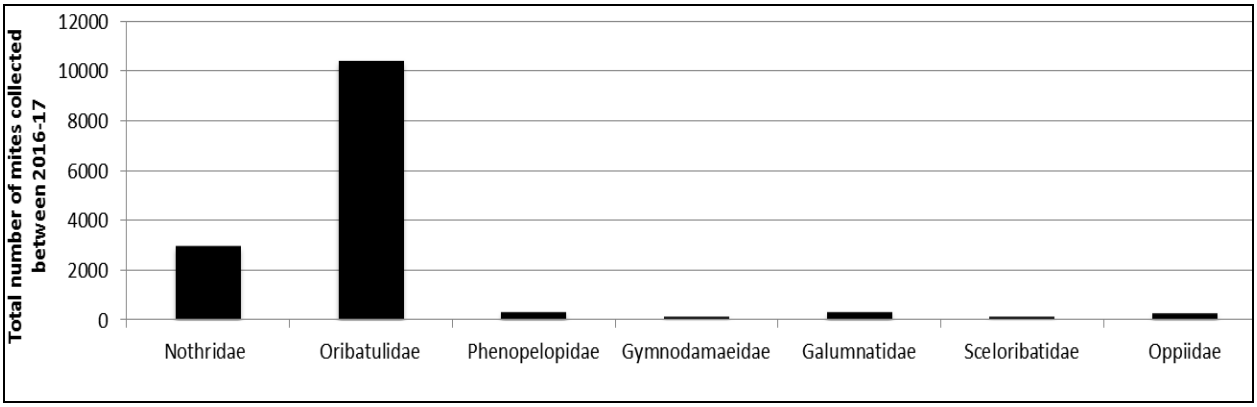

Fig 1: Abundance of Oribatida families

3.2.2 Mesostigmatid mites

Mesostigmatid mites constitute 43.99% of all mites collected from soil during the years 2016 and 2017. They are especially abundant in the soil during the spring and the beginning of summer. These mites are known as predators of other small fauna, although a few species are fungivores and may become numerous at times [16].

Within this suborder, Parasitidae is the most abundant family (66.43%) collected from citrus soil. This family contains mainly predators that feed upon other microarthropods, including their eggs and on nematodes [19].

Laelapidae and Pachylaelapidae are the second abundant families, with abundances of 9.9% and 10.2%, respectively. The Laelapidae family includes hundreds of species that are free-living predators in soil, as well as many others that have varying degrees of association with other animals, both vertebrates and invertebrates [20]. The same trophic habit is reported for the family Pachylaelapidae, represented by a numerous group of free-living predatory mites of variable body size [21].

The rest of Mesostigmatid families are less numerous with percentages varying from 0.29% to 3.7% of all mites collected (fig.2).

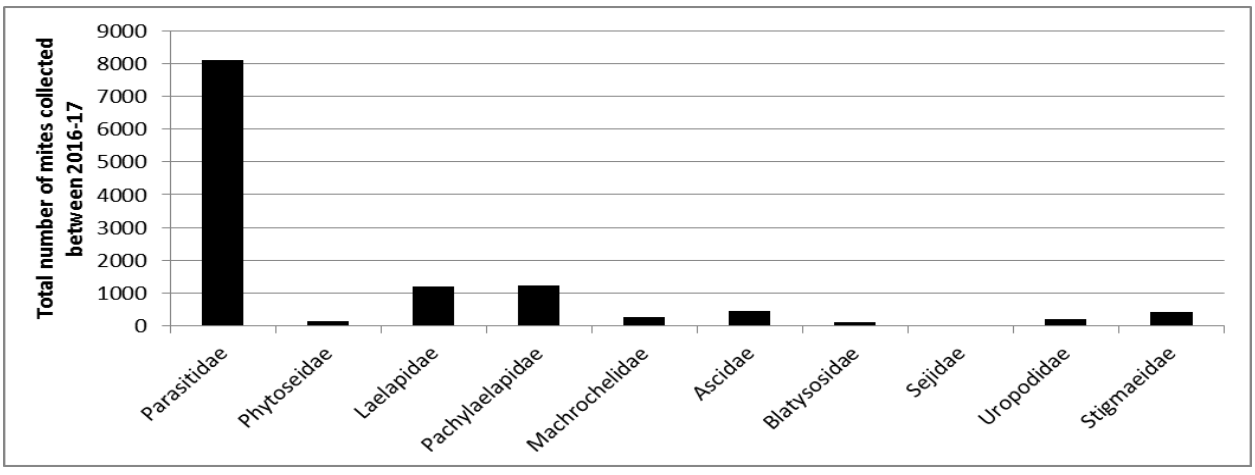

Fig 2: Distribution of Mesostigmatid families

3.2.3 Prostigmata mites

Prostigmata mites are the least abundant suborder in the soil of citrus orchards of Tunisia. They constitute 3.46% of all mites collected from soil between the years 2016 and 2017. The group contains a wide diversity of mites with several feeding habits [16].

Bdellidae is the most abundant family (91.06%) and its members are known to be soft-bodied predators of small arthropods [14].

The families Trombidiidae and Neothombiidae are less abundant, representing 6.23% and 2.7%, respectively, of all Prostigmata collected (fig.3). Trombidiidae mites are considered to have the potential to be biological control agents as their prey and hosts include insect and mite pests of economic importance [22].

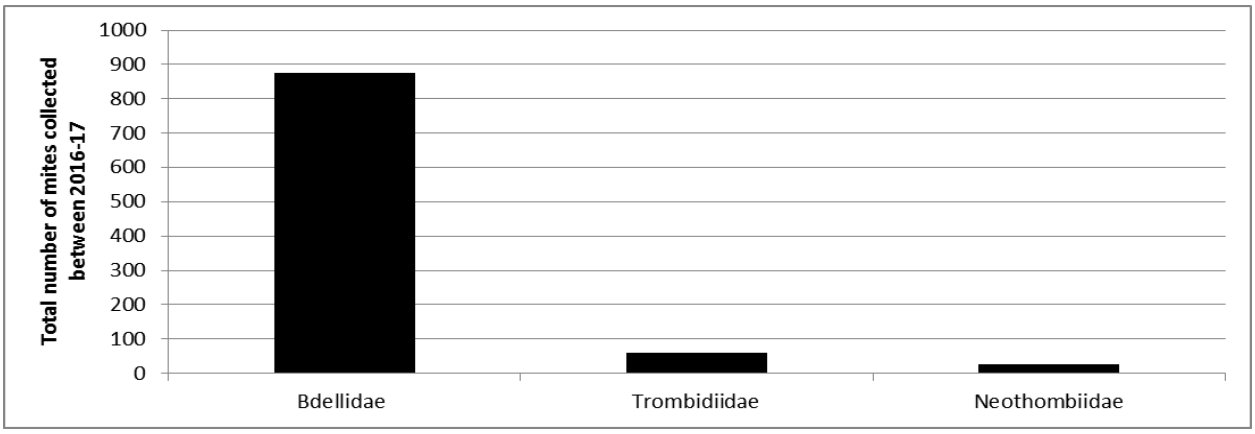

Fig 3: Distribution of Prostigmata families

A similar study was done in citrus orchards of Baghdad [3], showing a diverse trophic groups with twenty-two species of soil mites. The most predominant group was Mesostigmata with *Rhizoglyphus sp*, *Tyrophagus putrescentiae*, *Pachylaelaps longisetis* and *Stratiolaelaps miles*, were the most abundant and frequent species, constituting 50.8%. These results were comparable to ours in the fact that the acari fauna was composed by Mesostigmata mites with 43.99% of all soil mites collected. These results suggest a well-developed microflora associated with addition of organic matter [3] and to the presence of a wide range of preys in the soil since it were observed in the examined samples such as Collembola and insects.

4. Conclusion

This research was the first record to the soil acari fauna of citrus orchards in the north of Tunisia. It represents an important contribution to the inventory and to the knowledge of species and family diversity and their abundance in the soil of citrus orchards. This survey shows that the soil of citrus orchards is a host to a highly diverse and abundant number of soil dwelling predators belong to the suborder Mesostigmata. Most of this group is known as free-living and predatory of insects and others mites. Further research and more investigations are needed in order to demonstrate the impact of predatory mites on citrus phytophagous, and to understand more clearly the factors that are responsible for the presence of such populations of soil mites in the citrus orchards.

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