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Preliminary study of the mite community structure in different black truffle producing soils

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Abstract

Aims of the study: The goals of this paper are to provide preliminary data on the composition of the mite community in truffle-producing soils (both wild and plantations), and to elucidate those species which may interact with the black truffle life cycle.

Area of study: The study was carried out in two black truffle productive zones in Navarra (Spain), in four different plantations and five wild production areas.

Material and methods: Fauna was extracted using Berlese Tullgren funnels. Animals were separated into taxonomic groups, and mites were identified. To analyse the composition and community structure of the different habitats, parameters such as abundance, species richness, and Shanon Weiner diversity index (H') were calculated.

Main results: A total of 305 mites were recognized, belonging to 58 species representing the three major taxonomic groups (Oribatida, Prostigmata, Mesostigmata).

Research highlights: The results show a possible trend towards wild areas having greater diversity and species richness than plantations. Furthermore, community analysis shows differences in species compositions among different study areas, and oribatid mites always exhibit the highest relative abundance and species richness.

Key words: Acari, *Tuber melanosporum,* Oribatida, Mesostigmata, Prostigmata, truffle orchards.

Introduction

The genus *Tuber* P. Micheli ex F.H. Wigg. is a set of hypogeous, ectomycorrhizal ascomycete species. One of them is the black truffle (*T. melanosporum* Vitt.) whose fruiting body has a high social and economic value in the market (Boa, 2004; Mello *et al*., 2006). This species establishes mycorrhizal symbioses with roots of several arboreal species, including oaks [*Quercus humilis* Miller and *Q. ilex* subsp. *ballota* (Desf.) Samp.] and hazel (*Corylus avellana* L.) (Ceruti *et al*., 2003). It is found in the Mediterranean region in calcareous and silty soils of Spain, France and Italy, in addition to being introduced in inoculated plants in other countries (Reyna Domenech, 2012; Yun and Hall, 2004; Sáez García Falces and De Miguel Velasco, 2008). In Spain, the average annual truffle production is estimated to be approximately 20 tons, although it can vary depending on the climatological conditions (Reyna Domenech, 2012). The agronomic requirements for the plantations are well studied and, in general, the fungus begins to develop sporocarps after 10 years of plantation (Shaw *et al.,* 1996).

Because of the commercial interest in this fungus, demand for which exceeds production, it has now been cultivated for some decades, and this practice has developed considerably with the discovery and use of mycorrhizal plants since 1970. Knowledge of truffle cultivation has advanced greatly in recent years, but there are many aspects that remain unclear (Granetti, 2010). One of the least studied aspects is the relationship of the fungus with the surrounding microbiota and mesofauna. This relationship may be important not only because they share the same habitat, they may also establish important biological interactions. Trappe and Claridge (2005) indicate that spores can be dispersed by mycophagous animals that feed on sporocarps, known as hidnophagous animals (Pacioni, 1989), but there are other ways by which spores are carried from one habitat to another in addition to mycophagy.

The fungus life cycle starts with germination of spores resulting in a primary uninuclear free-living myce-

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lium (Paolocci *et al.,* 2006). This mycelium contacts the apical roots of vascular plants to become an ectomycorrhiza. New hyphae emanate from the mycorrhiza, and help in the absorption of nutrients and water, producing "brûlé" against competitors and, under favorable conditions, maturing into fruiting bodies. When the truffle is mature, spores will disperse, closing the cycle. To induce spore dispersion volatile substances, such as thio-bis-methane (Bratek *et al.,* 1992), are produced (Hochberg *et al.,* 2003). These strong odors attract mammals such as boars, deer and rodents, and after ingesting the sporocarp, the mammals may disperse spores over long distances (Genard *et al*., 1986; Talou and Kulifaj, 1992). Furthermore, Insects (Diptera and Coleoptera) have also been reported as fauna nutritionally related to the carpophore (Pacioni, 1989). The most notable insects are the "truffle flies", eight species of *Suillia* (Heleomyzidae) (Janvier, 1963; Pacioni, 1989; Bratek *et al*., 1992, Callot, 1999; García-Montero, 2004), and the mycophagous beetle *Leiodes cinnamomea* (Panzer, 1973), which is a pest in plantations (Arzone, 1971; Pacioni, 1989; Bratek *et al*., 1992; Callot, 1999; Barriuso *et al.,* 2012).

Biodiversity in the foodweb plays an important role in providing good agricultural productivity, healthy ecosystems, and resistance to stress and disturbance (Brussaard *et al*., 2007; Culman *et al*., 2010; Du Pont *et al*., 2010). Besides the research mentioned above, there are few studies about the relationship between fauna and truffle biology. Outstanding among these is the work of Callot (1991), who discussed the importance of some animals in truffle soils. Nematoda and Protozoa maintain the relationship between microbial activity and the truffle, while at the same time, Acari and Collembola, besides regulating this relationship, also help to disseminate spores. Finally, large animals, in addition to helping in the previously mentioned functions, also affect soil structure.

Mites are of particular interest because they have multi-trophic habits, interacting in many different ways with other animals in the soil foodweb (Cao *et al*., 2011). They are responsible for the decomposition of organic matter, disperse microbiota and propagules of the soil, regulate the development to mycelia, and feed on and are eaten by other animals (Beare *et al.,* 1997; Petersen and Luxton, 1982; Renker *et al*., 2005).

The present study aims to provide preliminary data on the composition of the mite community in truffle-producing soils (both wild and plantations), with the main objective of finding those species which may interact consistently with the black truffle life cycle.

Material and methods

Study area and sampling method

The study was carried out in two black truffle producing areas (Tierra Estella and Valdorba) in Navarra (Spain), based on four soil samples obtained from four different plantations and five samples from wild areas (Table 1). The plantations consist of holm oaks growing on what were previously cereal fields, while the wild areas correspond to mesic-supramediterranean forests, dominated by holm oaks and shrubs (*Spiraeo obovatae-Querceto rotundifoliae sigmentum* Rivas Godoy ex Loidi & F. Prieto, 1986) (Loidi and Báscones, 1995). Samples were obtained under truffle-producing trees, to ensure the presence of mycelium in the soil.

In each plot, in the winter of 2012 (the season when the sporocarps are produced), a sample of 300 cm^3 of soil using a metal corer was obtained 1m away from the tree trunk. The litter on the upper part of the soil had previously been removed. Each sample was stored in a marked plastic bag, transported to the laboratory and stored at 4°C before being processed.

Community analysis

Soil mites (Oribatida, Prostigmata, Mesostigmata) were extracted using modified Berlese-Tullgren funnels (Coineau, 1974) under 25W light, over a period of 10 days, and stored in 70% ethanol. In order to identify the species collected, specialized references were used. To identify adult oribatid mites, works by Balogh and Mahunka (1983), Balogh and Balogh (1992), Pérez Iñigo (1993, 1997) and Subías (2001) were used, (immature instars were not identified). For Mesostigmata mites, we relied on the work of Gilyarov and Bregetova (1977a,b), and for Prostigmata mites, Krantz and Walter (2009).

To calculate the diversity values for the two different proposed productive areas, the Shannon-Wiener index (H') was used:

$$H' = -\Sigma P_i \log_2 P_i$$

in which P_i is the ratio between the number of individuals of species i and the total number of individuals.

Table 1. Characteristics of the study plots in Navarra (Spain)

	W-EC	W-ER	W-OG	W-LA	W-EO	P-OL	P-ER	P-OG	P-O
Location	Echagüe	Eraul	Ollogoyen	Larraiza	Ollogoyen	Oloriz	Eraul	Ollogoyen	Ollobarren
Region	Valdorba	Tierra Estella	Tierra Estella	Tierra Estella	Tierra Estella	Valdorba	Tierra Estella	Tierra Estella	Tierra Estella
Habitat type	Wild	Wild	Wild	Wild	Wild	Plantation	Plantation	Plantation	Plantation
Nearest mountain range	Sierra de Alaiz	Sierra de Urbasa	Sierra Lóquiz	Sierra Urbasa	Sierra Lóquiz	Sierra de Alaiz	Sierra Urbasa	Sierra Lóquiz	Sierra Liquiz
Macrobioclimate	Mediterranean	Mediterranean	Mediterranean	Mediterranean	Mediterranean	Mediterranean	Mediterranean	Mediterranean	Mediterranean
Average temperature (ºC)	12.3	12.2	12.2	11.1	12.2	12.3	12.2	12.2	12.2
Annual rainfall	782,2	746	746	995,5	746	782,2	746	746	746
Texture	n.d.	n.d.	n.d.	n.d.	n.d.	Loam	Loam	Loam silt	Loam
pH (water)	n.d.	n.d.	n.d.	n.d.	n.d.	8.1	8.3	8.3	8.4
Host tree	Holm oak	Holm oak	Holm oak	Holm oak	Holm oak	Holm oak	Holm oak	Holm oak	Holm oak
Preceding	—	—	—	—	—	Cereal	Cereal	Cereal	Cereal
Sporocarp production (kg/ha/year)	n.d.	n.d.	n.d.	n.d.	n.d.	5-10	0-5	0-5	>10
Year of plantation	—	—	—	—	—	1993	2000	1992	1990
Sampling date	27/01/2012	28/01/2012	29/01/2012	03/03/2012	29/01/2012	27/01/2012	28/01/2012	29/02/2012	29/02/2012

W: wild plot. P: plantation plots.

Results

A total of 305 individuals belonging to three principal groups of mites (Oribatida, Prostigmata, Mesostigmata) were identified: 201 individuals belonging to 32 species of Oribatida, 43 belonging to 16 species of Prostigmata, and 21 belonging to 10 species of Mesostigmata. These taxa represent 41 families of Acari. The checklist of species found in the two areas is given in Table 2. There are some unidentified species: *Tyrophagus* sp. in the Oribatida; *Spinibdella, Labidostoma, Speleorchestes, Penthaleus, Bakerdania, Diversipes, Stigmaeus, Bryobia* and *Tydeus* in Prostigmata and *Macrocheles* in Mesostigmata. In addition, some genera of the family Acaridae (Oribatida), Rhagidiidae and Tarsonemidae (Prostigmata), and Pachyelaelapidae (Mesostigmata) were unidentified.

Many of these species were recorded for the first time in Spain (species marked with an asterisk in Table 2).

A clear difference in abundance and richness (number of species) between the two types of studied habitats is observed (Table 3). In wild plots the number of collected mites was 261 compared to 44 in plantations (52 species in the wild area and 22 in man-made orchards). Among the 58 species found, 16 (28% of the total) were present in both habitats. Thirty-six species appeared exclusively in the wild area (62% of the total) and 6 species (10% of the total) were recorded exclusively in plantations.

Passalozetes ruderalis and *Tectocepheus velatus* were the most frequent species, found in four of the nine plots studied. Furthemore, Oppiidae and Tectocepheidae were the best represented families, appearing in seven of the nine plots. The most abundant species were *Passalozetes ruderalis* (18.1% of the total), *Arthrodamaeus reticulatus* (6.0%), Astigmata sp.1 (4.6%), *Bryobia* sp. (3.7%), and *Tectocepheus velatus* (2.6%). Acaridae phoretic deutonymphs (7.7%), *Epilohmannia cylindrica minima* (2.9%), *Trhypochthonius tectorum* (2.6%), and *Medioppia obsoleta* (2.0%) were the most abundant species collected exclusively in the wild area. *Ramusella puertomonttensis, Scheloribates barbatulus, Scutovertex* sp., *Spinibdella* sp., *Diversipes* sp., and *Stigmaeus* sp. were exclusively collected in plantations and with a low relative abundance (0.3%).

In general terms, abundance and species richness were both higher in wild productive habitats (Table 3). This is reflected in the Shannon-Wiener (H') index, which was higher in wild soils (H' = 3.176) than in plantations (H' = 2.650).

Analyzing the community structure in different productive plots, in terms of abundance and species richness (Fig. 1), oribatid mites were found to dominate the community in both wild and plantation soils, followed by prostigmatic and mesostigmatic mites respectively.

Table 2. Mites checklist present in the two habitats. (*) Represents first time recorded in Spain

Taxa	Habitat type	
	Wild	Plantation
Oribatida		
Acaridae		
**Tyrophagus* sp. (Oudemans, 1924)	+	
Acaridae sp.	+	+
Acaridae (phoretic deutonymph)	+	
Ceratozetidae		
Ceratozetes laticuspidatus (Menke, 1964)	+	
Chamobatidae		
Chamobates pusillus (Berlese, 1895)	+	+
Cosmochthoniidae		
Phyllozetes tauricus (Gordeeva, 1931)	+	
Epilohmanniidae		
Epilohmannia cylindrica minima (Schuster, 1960)	+	
Eremaeidae		
Euremaeus granulatus (Mihelcic, 1955)	+	
Euphthiracaridae		
Rhysotritia ardua penicillata (Pérez-Íñigo,1969)	+	
Gymnodamaeidae		
Arthrodamaeus reticulatus (Berlese, 1910)	+	+
Haplozetidae		
Pilobates carpetanus (Pérez-Íñigo, 1969)	+	+
Hermanniellidae		
Hermanniella dolosa (Grandjean, 1931)	+	
Liacaridae		
Dorycranosus curtipilis (Willmann, 1935)	+	
Licnodamaeidae		
Licnodamaeus pulcherrimus (Paoli, 1908)	+	
Nothridae		
Nothrus biciliatus (C.L. Koch, 1841)	+	+
Oppiidae		
Ramusella (*Ramusella*) *puertomonttensis* (Hammer, 1962)		+
Oppiella (*Oppiella*) *nova* (Oudemans, 1902)	+	+
Microppia minus longisetosa (Subías and Rodríguez, 1988)	+	
Ramusella (*Insculptoppia*) *eliptica* (Berlese, 1908)	+	
Ramusella (*Insculptoppia*) *subiasi* (Pérez-Íñigo Jr, 1990)	+	
Medioppia obsoleta (Paoli, 1908)	+	
Oribatulidae		
Oribatula tibialis (Nicolet, 1855)	+	
Passalozetidae		
Passalozetes ruderalis (Mínguez y Subías, 1984)	+	+
Scheloribatidae		
Scheloribates barbatulus (Mihelcic, 1956)		+
Scutoverticidae		
Scutovertex sp. (Michael, 1879)		+
Suctobelbidae		
Suctobelbella subcornigera (Forsslund, 1941)	+	
Tectocepheidae		
Tectocepheus velatus (Michael, 1880)	+	+
Tectocepheus minor (Berlese, 1904)	+	
Tectocepheus alatus (Berlese, 1913)	+	+
Trhypochthoniidae		
Trhypochthonius tectorum (Berlesse, 1896)	+	
Xenillidae		
Xenillus tegeocranus (Hermann, 1804)	+	
Immature	+	+
Prostigmata		
Bdellidae		
**Bdella muscorum* (Ewing, 1909)	+	
**Spinibdella* sp. (Thor, 1930)		+
**Cyta latirostris* (Hermann, 1804)	+	+
Cunaxidae		
**Cunaxa setirostris* (Hermann, 1804)	+	
Eupodidae		
**Eupodes vexoncollinus* (Thor, 1934)	+	+
Labidostomatidae		
**Labidostoma* sp. (Kramer, 1879)	+	
Nanorchestidae		
Nanochestes pulvinar (Grandjean, 1942)	+	
Speleorchestes sp. (Tragrdn, 1909)	+	
Penthalodidae		
**Penthaleus* sp. (Berlese, 1891)	+	
Pygmephoridae		
**Bakerdania* sp. (Sasa, 1955)	+	
Rhagidiidae		
**Rhagidiidae* sp.	+	

Table 2 (cont.). Mites checklist present in the two habitats. (*) Represents first time recorded in Spain

Taxa	Habitat type	
	Wild	Plantation
Scutacaridae		
*_Diversipes_ sp. (Berlese, 1903)		+
Stigmaeidae		
*_Stigmaeus_ sp. (Koch, 1837)		+
Tarsonemidae		
*_Tarsonemidae_ sp.	+	
Tetranychidae		
*_Bryobia_ sp. (Koch, 1836)	+	+
Tydeidae		
*_Tydeus_ sp. (Koch, 1837)	+	+
Mesostigmata		
Ascidae		
Gamasellodes bicolor ♀ (Berlese, 1918)	+	+
Iphidozercon minutus (Halbert, 1915)	+	
Laelapidae		
Gaeolaelaps sardoa (Berlese, 1911)	+	
Macrochelidae		
Macrocheles sp. (Latreille, 1829)	+	
Pachylaelapidae		
Pachylaelapidae sp.	+	
Parasitidae		
*_Holoparasitus inornatus_ (Berlese, 1906)	+	
*_Parasitus infernalis_ (Willmann, 1940)	+	
Rhodacaridae		
Rhodacarus mandibularis ♀ (Berlese, 1920)	+	+
Rhodacarellus silesiacus ♀, ♂ (Willmann, 1936)	+	
Uropodidae		
Olodiscus minima ♀ (Kramer, 1945)	+	

Discussion

It is known that agriculture simplifies the ecosystem structure (Bird *et al.,* 2000) affecting the soil fauna community. It has been suggested that harvesting, site preparation and intensive cultivation practices can lead to loss of nutrients and organic matter, alteration of physical soil properties, reduction in productivity, and changes in the trophic soil system (Likens *et al.,* 1970; Pritchett and Wells, 1978; Bormann and Likens, 1994). Truffle cultivation from a forestry point of view helps to increase the woodland soil area, and from an agriculture perspective truffle growers should employ agricultural techniques to insure the establishment and maintenance of plantations (Chevalier and Sourzat, 2012). Agricultural intensification can produce important changes in soil biological communities affecting mites, which are considered indicators of soil conditions due to their unique biological features (van Stralen, 1998; Gulvik, 2007). Agricultural impacts often decrease abundance of soil arthropods, eliminate key species and alter trophic relationships (Beare *et al.,* 1997; Wood *et al*,. 2000; Cao *et al*., 2011). This preliminary results show that mite richness and abundance were lower in cultivated plantations, which led us to obtain a lower value of Shannon's diversity index (3.176 in wild ground compared to 2.650 in plantations), highlighting differences in the biological organization at community level (Arroyo *et al*., 2005). The low diversity values obtained in plantations in this

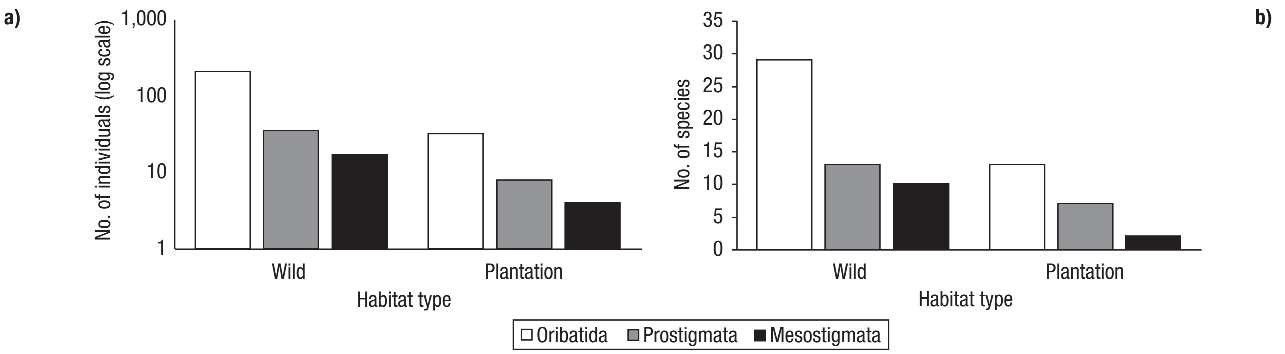

Figure 1. Total number of mite type individuals (in log scale) in the two habitats; b) Total number of mitespecies in the two habitats.

Table 3. Biological parameters of mite communities in different plots

Plot	Habitat type	Abundance	Species richness	*H'*
W-EC	Wild	67	20	2.61
W-ER	Wild	10	8	2.025
W-OG	Wild	38	15	2.330
W-LA	Wild	49	22	2.731
W-EO	Wild	97	13	1.514
Total	Wild	261	52	3.176
O-OL	Plantation	3	3	1.099
O-ER	Plantation	20	8	1.329
O-OG	Plantation	6	4	1.330
O-OB	Plantation	15	9	2.026
Total	Plantation	44	22	2.650

study could be the direct result of an impoverishment of the habitat as a result of truffle cultivation, however, we note that this habitat had previously undergone agricultural management.

Oribatid mites dominate the community in terms of abundance and species richness in wild and plantation soils. Oribatid mites, though they sometimes have been reported to be the most diverse group in agricultural soils, were also poorer in species than nearby forest (Mahunka and Paoletti, 1984; Tomlin and Miller, 1987). Oribatid mites generally have low metabolic rates, slow development and low fecundity, and they are considered to be "*k*-selected" organisms (Crossley, 1977). Nevertheless, individuals from the family Tectocepheidae and Oppiidae were the most widely represented in both habitats; these mites are "*r*-selected" organisms (higher fecundity, faster development and much higher reproductive rate) according to Behan-Pelletier, 1999. Similarly, Minor and Cianciolo (2007) reported that Mesostigmata with "*k*- selected" traits such as Veigaiidae, Zerconidae, Parholaspidae, and Trachitidae were associated with forest habitats, while "*r*-selected" families such as Ascidae, Digamasellidae, Laelapidae and Phytoseiidae were associated with agricultural ones. In our research, the most abundant species found in plantation plots belonged to the Ascidae.

The higher values of abundance and diversity of mites in wild truffle soils are consistent with the results obtained by Parladé *et al.* (2013). They found a significantly greater amount of mycelium in natural ground compared to the man-made truffle plantation, even though truffle plantations are especially cultured to favor fungal persistence. Dissemination of propagules can be more effective in natural forests due to major dispersal of fungal spores by animals (Maser *et al.,* 2008). Most oribatid mites are mycophagous and they could have a direct relationship with the black truffle cycle, interacting in the mycelium and spores dispersion. In some cases, it has been seen carrying spores attached to their bodies. Because of their high population density in wild truffle areas, *Passalozetes ruderalis* iberian endemism (Pérez-Íñigo, 1993), and *Arthrodamaeus reticulates* (Pérez-Íñigo, 1997)*,* could be the potential species related with the truffle cycle. Because of this, they should form the main object of future research. Mesostigmatic and prostigmatic predator mites may will have an indirect relationship in the cycle, participatingin the regulation of the whole community associated with the production of the fungus.

As we mention above, samples were obtained within the zone known as *brûlé*, the circular zone with scanty vegetation around the host plant colonized by ectomycorrhizal fungi (Ciccarello, 1564). This phenomenon is a result of the phytotoxic effects of metabolites emitted by some *Tuber* species, which affect the herbaceous cover and roots of host plants (Pappa, 1980; Pacioni, 1991; Plattner and Hall, 1995; Lanza *et al*., 2004). These compounds are released during all stages of the truffle's biological cycle (Talou *et al*., 1989; Menotta *et al.,* 2004; Zeppa *et al.,* 2004; Splivallo *et al.,* 2007, 2009, 2011), creating a special environment (low humidity, modified temperature regime and different soil properties inside the brûlé), and producing changes in the biota living there. Napoli *et al.* (2008) found that mite community composition was different inside and outside of the brûlé. Similarly, González-Armada *et al.* (2010) and Martegoute (2002) observed that flora composition inside the brûlé was dominated by therophytic plants, which adapt their life cycle to the truffle cycle, avoiding the period when the mycelium is more aggressive. Furthermore, recent studies by Menta *et al.* (2011) and Tarasconi *et al.* (2011) report interactions between mesoarthropods and *T. melanosporum*, showing a lower density of mites and ants inside the *brûlé*. We can assume that mite species found in the present study were, in fact, capable of living in habitats with high concentrations of these aliphatic compounds. Further study of the mite fauna in both patches would be interesting in order to establish the effects of these compounds within them.

This study constitutes the first contribution considering mesofauna associated to black truffle biology, and provides relevant information to advance in the science of truffle cultivation. A first list of mites that can have direct interaction with truffle biology is provided. Nevertheless, future research in this area would have to be developed to establish the relationship between truffle-production and biodiversity over time, effects of volatile compounds in the soil-fauna community, and species directly related to truffle life cycle.

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Appendix

Abundances of mites in different plots

	W-EC	W-ER	W-OG	W-LA	W-EO	P-OL	O-ER	P-OG	P-OB
Oribatida									
Acaridae (phoretic deutonymph)	0	0	0	0	27	0	0	0	0
Acaridae sp.	0	0	0	3	0	0	13	0	0
Arthrodamaeus reticulatus	17	0	2	0	0	0	0	0	2
Ceratozetes laticuspidatus	4	0	0	0	0	0	0	0	0
Chamobates pusillus	0	0	0	2	3	0	0	0	1
Dorycranosus curtipilis	4	0	0	0	0	0	0	0	0
Epilohmannia cylindrica minima	7	1	0	0	2	0	0	0	0
Euremaeus granulatus	1	0	0	0	0	0	0	0	0
Hermanniella dolosa	1	0	0	0	0	0	0	0	0
Inmature	2	2	4	9	0	0	0	0	1
Licnodamaeus pulcherrimus	0	0	4	0	0	0	0	0	0
Medioppia obsoleta	0	1	5	1	0	0	0	0	0
Microppia minus longisetosa	4	0	0	0	1	0	0	0	0
Nothrus biciliatus	0	0	1	0	0	1	0	2	0
Oppiella (*Oppiella*) *nova*	1	0	0	1	0	0	1	0	0
Oribatula tibialis	0	0	2	1	0	0	0	0	0
Passalozetes ruderalis	0	1	0	9	49	0	0	0	4
Phyllozetes tauricus	0	0	2	0	0	0	0	0	0
Pilobates carpetanus	1	0	0	0	0	0	0	0	1
Ramusella (*Ramusella*) *puertomonttensis*	0	0	0	0	0	0	0	0	1
Ramusella (*Insculptoppia*) *eliptica*	4	0	0	0	0	0	0	0	0
Ramusella (*Insculptoppia*) *subiasi*	2	0	0	0	0	0	0	0	0
Rhysotritia ardua penicillata	3	0	1	0	1	0	0	0	0
Scheloribates barbatulus	0	0	0	0	0	0	0	0	1
Scutovertex sp.	0	0	0	0	0	0	1	0	0
Suctobelbella subcornigera	0	1	0	2	0	0	0	0	0
Tectocepheus alatus	0	0	1	0	0	0	1	0	0
Tectocepheus minor	0	0	1	0	0	0	0	0	0
Tectocepheus velatus	0	0	0	3	4	1	0	1	0

Appendix (cont.). Abundances of mites in different plots

	W-EC	W-ER	W-OG	W-LA	W-EO	P-OL	O-ER	P-OG	P-OB
Trhypochthonius tectorum	6	0	0	3	0	0	0	0	0
Turophagus sp.	0	0	1	0	0	0	0	0	0
Xenillus tegeocranus	0	1	0	0	0	0	0	0	0
Prostigmata									
Bakerdania sp.	0	0	1	0	4	0	0	0	0
Bdella muscorum	1	0	0	0	0	0	0	0	0
Bryobia sp.	0	0	11	0	0	0	0	2	0
Cunaxa setirostris	3	0	0	0	0	0	0	0	0
Cyta latirostris	0	0	0	0	1	0	0	1	0
Diversipes sp.	0	0	0	0	0	0	1	0	0
Eupodes vexoncollinus	0	0	0	1	0	0	1	0	0
Labidostoma sp.	0	0	1	0	2	0	0	0	0
Nanochestes pulvinar	0	0	0	1	0	0	0	0	0
Penthaleus sp.	0	0	0	1	0	0	0	0	0
Rhagidiidae sp.	1	0	0	1	1	0	0	0	0
Speleorchestes sp.	0	0	0	0	1	0	0	0	0
Spinibdella sp.	0	0	0	0	0	0	1	0	0
Stigmaeus sp.	0	0	0	0	0	1	0	0	0
Tarsonemidae sp.	0	0	0	1	0	0	0	0	0
Tydeus sp.	0	0	0	3	0	0	1	0	0
Mesostigmata									
Gaeolaelaps sardoa	1	1	0	0	0	0	0	0	0
Gamasellodes bicolor ♀	0	0	0	0	1	0	0	0	3
Holoparasitus inornatus	0	0	0	1	0	0	0	0	0
Iphidozercon minutus	0	0	0	1	0	0	0	0	0
Macrocheles sp.	0	0	0	1	0	0	0	0	0
Olodiscus minima ♀	2	0	0	0	0	0	0	0	0
Pachylaelapidae sp.	0	0	0	1	0	0	0	0	0
Parasitus infernalis	0	0	0	1	0	0	0	0	0
Rhodacarellus silesiacus ♀, ♂	2	2	0	0	0	0	0	0	0
Rhodacarus mandibularis ♀	0	0	1	2	0	0	0	0	1

W: wild plots. P: plantation plots.