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The external mycoflora of the oribatid mites (*Acari*) in Turkey,
with three new mite records

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Abstract

This study examines the relation between fungi and oribatid mites of soils in Turkey. Nineteen fungi were isolated from mite surfaces, seventeen of which are new records for fungi isolated from oribatid mites in Turkey. Two of the fungi species, Beauveria bassiana *and* Cladosporium cladosporioides, *are entomopathogenic. The other fungi are mycoparasitic or saprophytic. In addition, three mite species,* Eupelops acromios *(Hermann 1804),* Galumna elimata *(C. L. Koch 1841) and* Liacarus brevilamellatus *Mihelcic 1955, were determined as new records for the Turkish fauna.*

Keywords: Oribatid mites, fungi, new records, Turkey.

Introduction

The oribatid mites are characteristic soil fauna, being actively involved in the decomposition of organic matter, nutrient cycling and soil formation. All active instars feed on a variety of foods, including living and dead plant and fungal material, lichens and carrion; some are predaceous, but none are parasitic. They disperse bacteria and fungi, both externally on their body surfaces and by feeding on spores that survive passage through their alimentary tracts. Oribatid mites have high calcium levels in their exoskeleton. Presumably, oribatids are able to sequester calcium by feeding on fungi because senescent fungal hyphae contain crystals of calcium oxalate, which may be metabolized by the mites. Thus, their bodies may form important «sinks» for nutrients, especially in nutrient-limited environments such as peat lands (Coleman & Crossley 1996; Behan-Pelletier 1997; Renker *et al.* 2005).

Mites have been considered as fungal vectors for a long time but their vectorial capacity seems to be low due to their small size. They may be important vectors of certain species of fungi by selective transfer with medicinal importance. In this way they may change fungal communities (Schneider *et al.* 2004) through selective dispersal of fungi which are suitable for their grazing. During grazing they are covered in fungal spores. This type of transport seems to be selective and depend on the mite species (Hubert *et al.* 2003).

Of particular interest here are those fungi that utilize insects and other arthropods to move their spores from the site of growth and production to new substrata for colonization. Insect-vectored spore dispersal is recognized in many groups of fungi; including Ascomycetes, Basidiomycetes, Imperfect Fungi and Zygomycetes (Abbott 2002; Seeman & Nahrung 2000), as well as in the Myxomycetes or slime molds (Stephenson & Stempen 1994). A general distinction has been made between the dispersal methods of dry versus sticky or slimy spores. Dry spores are dispersed by air, while sticky or slimy spores rely on water or vector dispersal. Morphological adaptations are similar in many groups and are the result of parallel coevolutionary forces

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Table 1. Fungi of the oribatid mites.

mite host: family	mite host: species	species of fungus
Nothridae, Berlese, 1896	*Nothrus bicilatus* C. L. Koch (1841)	*Absidia californica*
Euphthiracaridae Jacot, 1930	*Rhysotritia ardua* (C. L. Koch 1841)	*Absidia cylindrospora* var. *rhizomorpha*
		Cladosporium cladosporioides
		Cladosporium herbarum
		Penicillium verrucosum var. *cyclopium*
Oppiidae, Grandjean, 1954	*Ramusella (Insculptoppia) clavipectinata* (Michael 1887)	*Acremonium strictum*
		Mortierella alpina
Oppiidae, Grandjean, 1954	*Medioppia obsoleta* (Paoli 1908)	*Fusarium* sp.
		Penicillium granulatum
Protoribatidae J. Balogh and P.Balogh, 1984	*Liebstadia similis* (Michael 1888)	*Mucor hiemalis* f. *hiemalis*
		Penicillium jensenii
Galumnidae Jacot, 1925	*Galumna elimata* (C. L. Koch 1841)*	*Alternaria alternata*
		Aspergillus niger
		Beauveria bassiana
		Cladosporium herbarum
		Cladosporium oxysporium
		Penicillium jensenii
		Trichoderma koningii
Galumnidae Jacot, 1925	Not determined	*Cladosporium herbarum*
		Penicillium verrucosum var. *cyclopium*
Phenopelopidae Petrunkevitch, 1955	*Eupelops acromios* (Hermann 1804)*	*Gliocladium roseum*
		Mortierella alpina
		Phoma sp.
Liacaridae Sellnick, 1928	*Liacarus brevilamellatus* Mihelcic 1955*	*Penicillium jensenii*
Damaeidae Berlese, 1896	Not determined	*Penicillium luteo-aurantium*
Damaeidae Berlese, 1896	Not determined	*Mucor hiemalis* f. *hiemalis*

* *These species are new to the Turkish fauna.*

(Abbott 2002). Fungi are among the most frequently noticed groups of mite pathogen, mainly because the presence of the mycelium and spores can easily recognized (Poinar & Poinar 1998).

Herein, we determine the fungi associated with oribatid mites and discuss the relationship between those fungi found and the mites. This is the first account describing the mycoflora of the oribatid mites in Turkey. Also, in this paper, three mite species were added to the acari fauna of Turkey: *Eupelops acromios* (Hermann 1804), *Galumna elimata* (C. L. Koch 1841) and *Liacarus brevilamellatus* Mihelcic 1955.

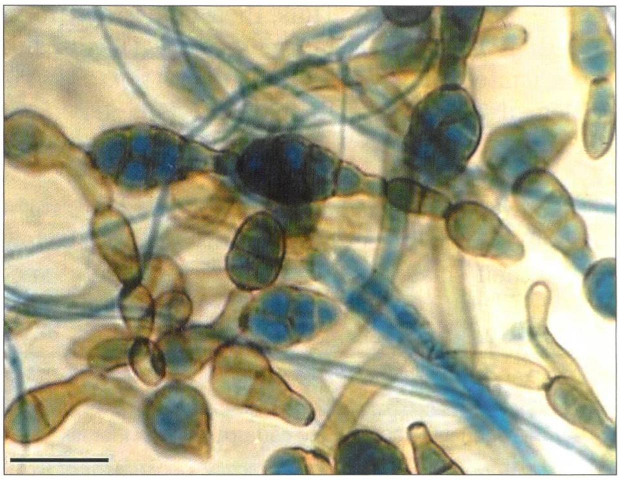
Materials and methods

Soil, litter, grass, moss and bark samples from a total of thirteen locations were taken from the campus of Atatürk University and Kiremitlik Tabya Atatürk Forest, Erzurum, in 2003. Isolation, preparation and determination of mites and fungi were made according to the methods of Doğan *et al.* (2003).

Results

A total of 19 taxa of fungi were isolated in association with the investigated oribatid mites, 17 of which are new records as the fungi isolated from the oribatid mites in

Fig. 1. Conidiophores and conidia of Alternaria alternata. *Scale 20 mm.*



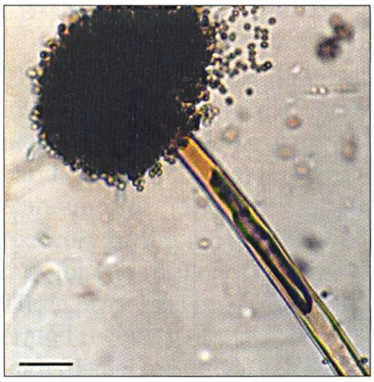


Fig. 2. Conidiophores and conidia of Aspergillus niger. *Scale 30 mm.*

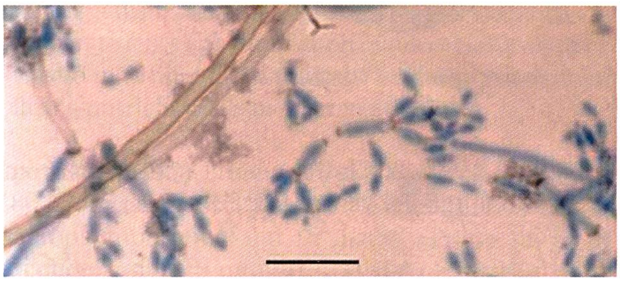


Fig. 3. Conidiophores and conidia of Cladosporium cladosporioides. *Scale 20 mm.*

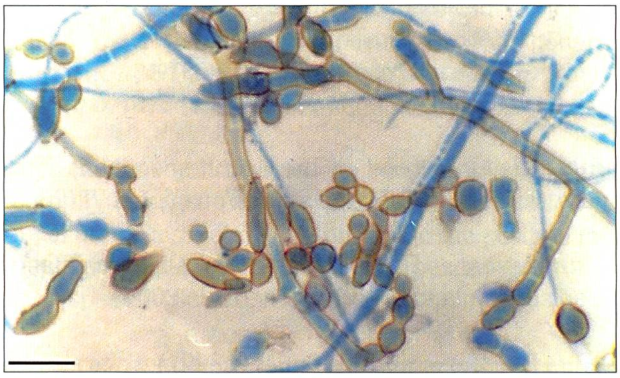


Fig. 4. Conidiophores and conidia of Cladosporium herbarum. *Scale 20 mm.*

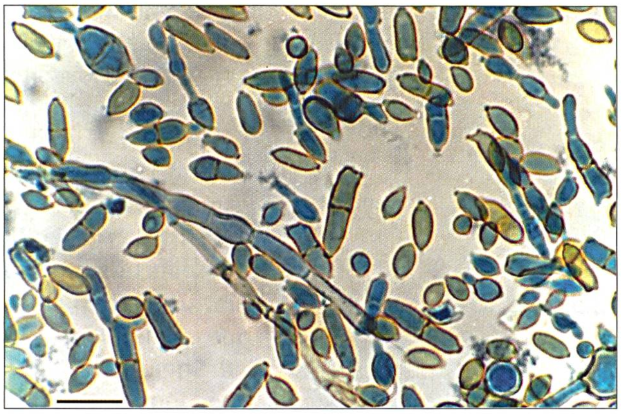


Fig. 5. Conidiophores and conidia of Cladosporium oxysporum. *Scale 20 mm.*

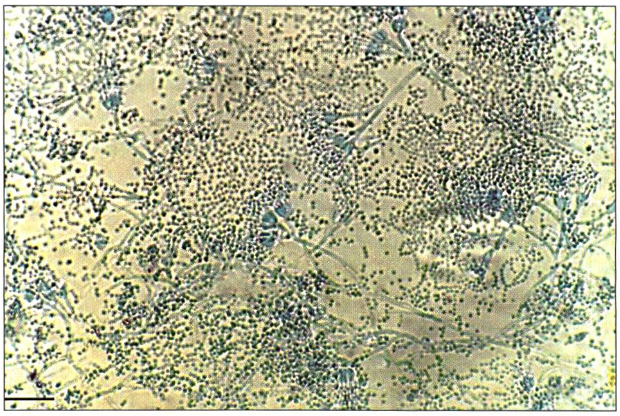


Fig. 6. Penicilli and conidia of Penicillium jensenii *Scale 30 mm.*

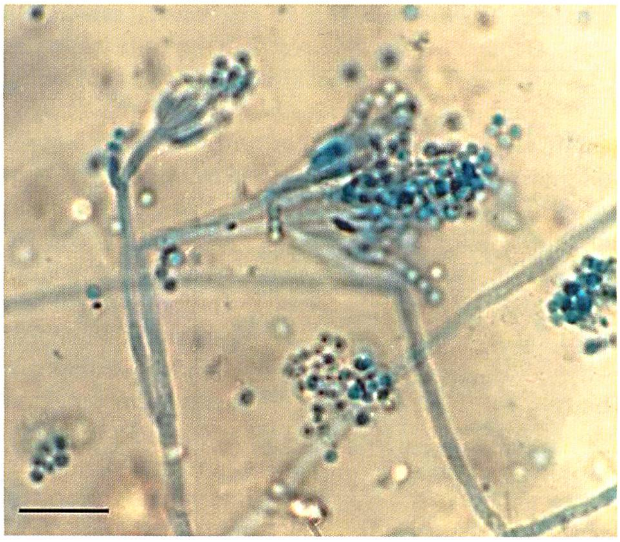


Fig. 7. Penicilli and conidia of Penicillium verrucosum *var.* cyclopium. *Scale 20 mm.*

Turkey. All fungi were isolated from the surface of oribatid mites. These are: *Absidia californica, Absidia cylindrospora* var. *rhizomorpha, Acremonium strictum, Alternaria alternata, Aspergillus niger, Beauveria bassiana, Cladosporium cladosporioides, Cladosporium herbarum, Cladosporium oxysporium, Fusarium* sp., *Gliocladium roseum, Mortierella alpina, Mucor hiemalis* f. *hiemalis, Penicillium granulatum, Penicillium jensenii, Penicillium luteo-aurantium, Penicillium verrucosum* var. *cyclopium, Phoma* sp., *Trichoderma koningii* (Table 1, Figs. 1-7). Most of the detected species are common soil saprophytic soil organisms, but some species are known to be insect pathogens. *Cladosporium herbarum* and *Penicillium jensenii* were the most prevalent in all fungi (Table 1). The highest incidence rate was represented by the genus *Penicillium.* This genus was isolated from seven mite species. Four species from the above genus were identified of which *Penicillium jensenii* isolated from three oribatids is the most common species. *Cla-*

dosporium represented by three species was the second common encountered genus isolated from the three mite species. From the three identified species, *Cladosporium herbarum* was the most prevalent. *Beauveria bassiana,* a well known entomopathogenic fungus, was only isolated from the one species cultured. Also, *Cladosporium cladosporioides,* informed as entomopathogenic fungus, was only isolated from the other one mite species (Table 1).

A total of eight species of Oribatida were represented in the samples. Three species were not previously known to occur in Turkey:

- Family: Phenopelopidae Petrunkevitch, 1955
  Genus: *Eupelops* Ewing, 1917
  Species: *Eupelops acromios* (Hermann 1804)
  [new for Turkey] (Fig 8)

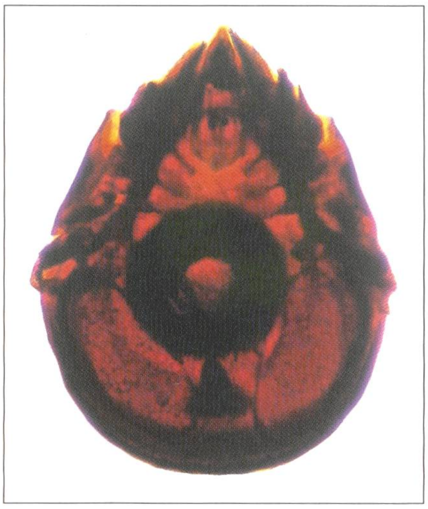


Fig. 8. Eupelops acromios – *Dorsal view.*

Materials examined – Two adult specimens from grassy soil under *Salix* sp., the campus of Atatürk University, 08. VI. 2003; three adult specimens from moss, Kiremitlik Tabya Atatürk Forest, 13. VI. 2003.

Distribution – Austria, Britain, Bulgaria, Czech Republic, Danish mainland, Finland, French mainland, Germany, Hungary, Italian mainland, Poland, Portuguese mainland, Romania, Slovakia, Spanish mainland, Switzerland, The Netherlands, Ukraine (Niedbala 2004).

- Family: Galumnidae Jacot, 1925
  Genus: *Galumna* von Heyden, 1826
  Species: *Galumna elimata* (C. L. Koch 1841)
  [new for Turkey] (Fig 9)

Materials examined – Two adult specimens from grassy soil under *Betula* sp., the campus of Atatürk University, 19. V. 2003; three adult specimens from moss, Kiremitlik Tabya Atatürk Forest, 13. VI. 2003.

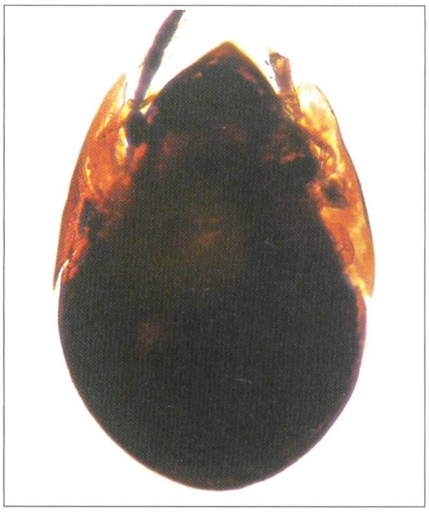


Fig. 9. Galumna elimata – *Dorsal view.*

Distribution – Austria, Britain, Czech Republic, Danish mainland, Finland, Germany, Hungary, Italian mainland, Norwegian mainland, Poland, Spanish mainland, The Netherlands, Ukraine (Nıedbala 2004).

- Family: Liacaridae Sellnick, 1928
  Genus: *Liacarus* Michael, 1898
  Species: *Liacarus brevilamellatus* Mihelcic 1955
  [new for Turkey] (Fig 10)

Materials examined – Three adult specimens from moss, Kiremitlik Tabya Atatürk Forest, 13. VI. 2003.

Distribution – Greek mainland, Italian mainland, Spanish mainland, Ukraine (Nıedbala 2004).

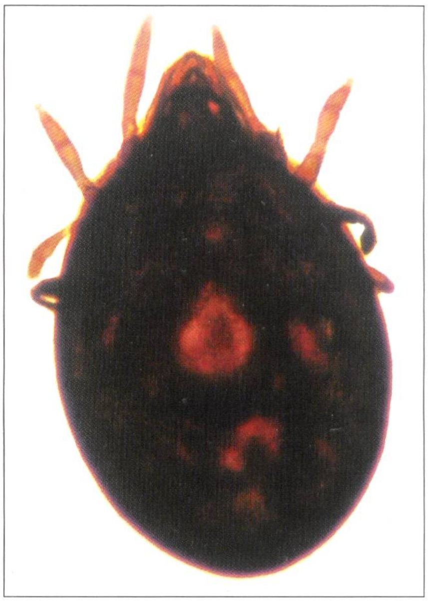


Fig. 10. Liacarus brevilamellatus – *Dorsal view.*

Discussion

The presence of oribatid mites alters the fungal community of the F-layer materials and the frequency of most fungal species was higher in treatments with oribatid mites (Maraun *et al.* 1998b). According to Maraun *et al.* (1998b), oribatid mites accelerate the recovery of the microbial community and are important for the resilience of the decomposer subsystem. Three processes presumably contributed to the accelerated recovery of the fungal community: (1) oribatid mites dispersed fungal spores and hyphae on their surface and within their faeces (2) grazing on the fungal hyphae and spores stimulated energy metabolism of microorganism and also microbial growth via mobilization of nutrients (3) stimulation of microbial growth by oribatid mite minimized nutrient leaching thereby stabilizing nutrient pools in litter materials.

Luxton (1972) considered the Damaeoidea, Oppioidea and possibly the Eremaeoidea to be wholly microphytophagous and to ingest a wide range of fungi, yeasts, bacteria and algae. Kaneko *et al.* (1995) demonstrated feeding preferences of an oppiid mite *Oppiella nova* for dematiaceus fungi; however, they offered few fungal species with hyaline hyphae (Maraun *et al.* 1998a). Stefaniak & Seniczak (1981) reported feeding of *Oppia nitens* on a wide range of fungal species including species of the genera *Penicillum*, *Trichothecium*, *Chaetomium* and *Cladosporium* (Maraun *et al.*, 1998a).

Galumnoid members have been considered as mainly microphytophages with a profound affinity for a fungal diet. This clearly demonstrates the positive influence of fungal nutrition on the population build-up of the species (Sumangala & Haq 1991).

Maraun *et al.* (1998a) found that some oribatid mites clearly preferred fungi with dark and pigmented hyphae and spores, mainly form the genus *Cladosporium* and sterile and dark forms, but *Mortierella*, *Mucor*, *Trichoderma* and *Penicillum* were less preferred or they were even rejected as food substrate. Mitchell & Parkinson (1976) reported evidence for feeding preferences of oribatid mites on dematiaceus microfungi from the genera *Cladosporium* and *Phoma*. Hartenstein (1962) found *Trichoderma koningi* and *Cladosporium cladosporioides* as the preferred food among twenty oribatid species (Mitchell & Parkinson 1976). Luxton (1972) found that oribatid mites showed a high preference for a sterile dark forms and a *Phoma* sp. while they had a low preference for *Trichoderma viride* and *Penicillum* spp. It is stated that *Mucor* spp., *Penicillum* spp. and *Rhizopus* spp. may be suitable nutrients for the deep working oribatids (Tadros 1975). Species of Eremaeidae are known fungivores (Smith *et al.* 1998). Smith *et al.* (1998) found that in culture *Eremaeus* spp. would feed only on *Phoma exigua* of seven species of fungi offered. They found gut contents of field populations full of other species of fungi (Smith *et al.* 1998).

Arlian & Woolley (1970) stated that adults *of Liacarus cidarus*, when offered a variety of foods, preferred the mold *Cladosporium* (Coleman & Crossley 1996).

Trichoderma koningii found on *Galumna elimata* is used extensively for the control of soil borne diseases in the horticultural industry with a great deal of success and may have the added benefits of increasing plant vigour. *Trichoderma koningii* employ three main methods of control: antibiosis, mycoparasitism, and a reduction of the substrate available to a pathogen through the production of cellulase enzymes (Melo & Faul 2000).

Acremonium stricum, *Cladosporium cladosporioides* and *Cladosporium herbarum* were isolated from the digestive tract of *Scheloribates laevigatus* (Oribatida). *Mucor hiemalis* f. *hiemalis* was isolated from the surface of *Scheloribates laevigatus*. *Aspergillus niger was isolated both* the digestive tract and the surface of *Scheloribates laevigatus* (Hubert *et al.* 2000). *Cladosporium herbarum* and *Alternaria alternata* commonly occur on plant surfaces or in decaying or dead tissues of plants. These saprophytic species were offered as food source for an oribatid mite, *Hemileius initialis* (Sárváry *et al.* 2000). Also, Schneider *et al.* (2005) and Schneider & Maraun (2005) offered that *Alternaria alternata* was high food quality and preferred by most oribatid mite species.

Gliocladium roseum found on *Eupelops acromios* is known mycoparasitic fungi (Bieliková *et al.* 2002). *Acremonium strictum*, *Cladosporium cladosporoides* and *Cladosporium oxysporium* were reported as natural antagonists of powdery mildew fungi (Erysiphaceae) which are one of the most conspicuous groups of plant pathogens and attack more than 1500 plant genera or being tested as their potential biocontrol agents (Kiss 2003).

Entomopathogenic fungi are important natural enemies of Acari (Davidson *et al.* 2003; Benoit *et al.* 2005). *Cladosporium cladosporioides* and *Beauveria bassiana* isolated from *Rhysotritia ardua* and *Galumna elimata* are informed as entomopathogenic fungi by Van Der Geest *et al.* (2000). It is clear that these pathogenic fungi may have a negative effect on population of oribatid mites, most of which are fungivorous and make up large part of the faunal secondary decomposers that contribute to the formation of humus.

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