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List of arthropod-pathogenic mitosporic fungi from Switzerland

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Nine species of mitosporic fungi (Deuteromycota, Hyphomycetes) predominantly from pest insects collected in Switzerland are listed together with their hosts and the collection sites. The findings are discussed in the context of ecology and use for microbial control.

Keywords: arthropod-pathogenic fungi, Hyphomycetes, natural distribution, hosts, Switzerland.

INTRODUCTION

More than 800 species of arthropod-pathogenic fungi are described. The best known groups are the Entomophthorales with more than 220 species (Keller & Petrini 2005) and the mitosporic fungi, also known as hyphomycetous fungi or imperfect fungi. These fungi play a significant role in the natural regulation of arthropod populations and have big potential for microbial pest control. Mitosporic fungi prefer protected habitats like soil, under the bark of trees or related sites. Recently, arthropod-pathogenic soil fungi like *Metarhizium anisopliae* and *Beauveria brongniartii* have also been used as bioindicators to study the effects of soil and farm management (Blaser *et al.* 2004, Eggenschwiler *et al.* 2006, Rodrigues *et al.* 2005). In the present work, we list the species collected during our field studies in Switzerland together with their hosts.

MATERIAL AND METHODS

Most fungus infected insects were found during studies on the dynamics of pest populations in the period 1973–2006. Living insects were collected either with traps or with the sweep net and kept in the laboratory to assess amount and reasons of natural mortality. Occasionally, infected insects were found during field work or sent to the author by colleagues. A few fungus species were isolated from soils using the *Galleria* bait method (Zimmermann 1986). For that purpose, 60 g fresh soil was placed in plastic vials, four *Galleria* larvae added and incubated at 22 °C. In the first days the vials were turned daily to keep the larvae moving. After 16–18 days the fungus from infected larvae was isolated and identified. The identification was based on morphological criteria and growth characteristics. *Beauveria* spp. isolated from *Meligethes aeneus* and some isolates from *Melolontha melolontha* and *Amphimallon solstitiale* were additionally characterised by PCR techniques.

The fungus species are listed in alphabetical order. The Swiss cantons are given with their official abbreviation.

RESULTS

Beauveria bassiana (Bals.) Vuill.

Hosts: Lepidoptera: *Pyrausta nubilalis* (Pyralidae), overwintering larvae in maize stalks, collected in the cantons SH and AG; Hepialidae, unknown species, collected in soil, Istighofen (TG); Coleoptera: *Ips typographus* (Scolytidae), larvae, pupae and adults, Watt (ZH), Tössstock (ZH), Rothenturm (SZ), Forrenmoos (LU); *Leptinotarsa decemlineata* (Chrysomelidae), Rubigen (BE), Aug. 2004; Carabidae, adult (probably *Poecilus cupreus*), Hindelbank (BE), June 2004; *Meligethes aeneus* (Nitidulidae), adults, North and East Switzerland, (Pilz & Keller 2006); *Lema melanopa* (Crioceridae), adult, Zürich-Reckenholz (ZH), April 2005; *Otiorhynchus salicicola* (Curculionidae), adult Wädenswil (ZH); *Ceutorhynchus assimilis* (= *obstrictus*), (Curculionidae), in forest overwintering adults, Delémont (JU) (coll. T. Haye); Hymenoptera: Ichneumonidae, unidentified species, Hüttwilen (TG); Hemiptera: *Corythucha ciliata* (Tingidae), adults (TI).

The species occasionally caused epizootics in populations of *I. typographus*, *C. ciliata* and overwintering *P. nubilalis*. The species is widely distributed throughout Switzerland and was also baited from soils with *Galleria* larvae. However, it is much less common than *Metarhizium anisopliae*.

Beauveria brongniartii (Sacc.) Petch

Hosts: Coleoptera: *Melolontha melolontha* (Scarabaeidae), larvae, pupae and adults throughout Switzerland; *Amphimallon solstitiale* (Scarabaeidae), single larva, Alterwilen (TG); *Meligethes aeneus* (Nitidulidae), adults, Niederhöri (ZH), Landquart (GR) (Pilz & Keller 2006).

The species occasionally caused epizootics in populations of *M. melolontha*. The species can be baited from soils with *Galleria* larvae in regions where *Melolontha* populations exist.

Beauveria sp.

Hosts: *Meligethes aeneus* (Coleoptera, Nitidulidae), adults, Gächlingen (SH), Buch am Irchel (ZH), Lanzenneunforn (TG) (Pilz & Keller 2006).

This species differs genetically from *B. bassiana* and from *B. brongniartii* (Meyling, pers. comm.).

Engyodontium sp.

Host: *Pholcus* sp. (Arachnida, Pholcidae), Wädenswil (ZH), September 1997. The species caused an epizootic in front of cellar windows.

Hirsutella sp.

Host: *Cydia pomonella* (Lepidoptera, Tortricidae), overwintering larvae, Wädenswil (ZH).

Lecanicillium lecanii (Zimmermann) Gams & Zare

Hosts: Homoptera: *Aphis rumicis* (Aphididae), Watt (ZH), Neunkirch/Widen (SH).

Metarhizium anisopliae (Metsch.) Sorokin

Hosts: Coleoptera: *Amphimallon solstitiale* (Scarabaeidae), larvae and adults throughout Switzerland; *A. majale* (Scarabaeidae), larvae, Grindelwald (BE), Alvaneu (GR); *Melolontha melolontha* (Scarabaeidae), larvae, pupae and adults throughout Switzerland; *Phylloperta horticola* (Scarabaeidae), larvae and adults in alpine regions; *Cetonia aurata* (Scarabaeidae), larvae throughout Switzerland; *Carabus auratus* (Carabidae), adult collected in winter at a soil depth of about 20 cm, Flumserberg (SG); Carabidae, unidentified larva, Burgrain/Willisau (LU); *Cicindela* sp. (Cicindelidae), larva, Buch (TG); *Ips typographus* (Scolytidae), adults, Rothenburg (LU) (Keller *et al.* 2004); *Agriotes* spp. (Elateridae), larvae, collected in meadows in north, central and east Switzerland; *Athous* sp. (Elateridae), larvae, Jenaz (GR); *Agriotes obscurus* (Elateridae), adults, collected in pheromone traps, Guggenbühl (TG); Diptera: *Tipula* sp., probably *T. paludosa* (Tipulidae), last instar larva, Zürich-Reckenholz (ZH).

The species occasionally caused epizootics in populations of *C. aurata* and wireworms (*Agriotes* spp.). The species was baited with *Galleria* larvae from nearly all soils collected throughout Switzerland (Keller *et al.* 2003). It is the most abundant entomopathogenic soil fungus in Switzerland.

Paecilomyces farinosus (Holm ex S. F. Gray) Brown & Smith

Lepidoptera, unidentified larva, eastern Switzerland; isolated from soils with the *Galleria* bait method; Matten-Interlaken (BE), and Innertkirchen (BE).

Paecilomyces fumosoroseus (Wize) Brown & Smith

Hosts: *Melolontha melolontha* (Coleoptera, Scarabaeidae), adult (TG); isolated from soils with the *Galleria* bait method at Pradaz (GR) and Innertkirchen (BE).

DISCUSSION

Beauveria bassiana and *Metharhizium anisopliae* are the species of entomopathogenic Hyphomycetes with the widest host range in Switzerland. The former was recorded from 11 host species belonging to four insect orders. The latter was recorded from 12 species belonging to two orders but the large majority was from Coleoptera. Although *B. bassiana* is widely distributed, it was never found at high frequencies in agriculturally used land (Keller & Schweizer 2001). The most interesting finding of *M. anisopliae* was an infected adult *Carabus auratus* collected from a soil depth of about 20 cm which obviously succumbed to the disease during hibernation. The findings demonstrate that the Carabidae and Cicindelidae are natural hosts of *M. anisopliae*. Since this fungus species is used as microbial insecticide, care must be taken to avoid side-effects on these predacious and beneficial insects.

Metarhizium anisopliae together with *B. brongniartii* are the most abundant insect pathogenic soil fungi (Keller *et al.* 2003). The latter is present in most areas

where *Melolontha* spp. exist, while *M. anisopliae* can be found in all agriculturally used soils. This fungus had the highest densities in meadows with an average of 1600 colony forming units per gram soil, the densities in arable land were significantly lower (Keller & Schweizer 2001) and the lowest densities were found in forest soils (Rodrigues 2003). *Metarhizium anisopliae* was also used as indicator to study the influence of different types of farm and soil management (Blaser *et al.* 2004; Eggenschwiler *et al.* 2006).

Beauveria brongniartii is used to control the larvae of the European cockchafer, *M. melolontha*. Although the species has a narrow host range, it is characterized by a high genetic diversity. Among 35 isolates collected from an area of about a hectare, there were 29 different genotypes (Enkerli *et al.* 2001). The species was until recently considered to be a specific pathogen of *Melolontha* spp. in central Europe. The finding of *B. brongniartii* on pollen beetles, *Meligethes aeneus*, is confirmed by genetic analyses and has changed this view (Meyling *et al.* unpubl.). This finding has no consequences on the use of *B. brongniartii* for white grub control, but we must be aware, that further hosts of this fungus may exist. Bioassays have shown that isolates from *M. melolontha* caused distinctly lower mortalities of *M. aeneus* than isolates from *M. aeneus* (Keller unpubl.). *Meligethes aeneus* was also attacked by an undescribed species of *Beauveria* (Meyling pers. comm.). Some of the isolates proved to be very virulent and showed potential for pollen beetle control (Keller unpubl.).

The other species were only occasionally collected. Nevertheless, they have potential to be used as biocontrol agents. Especially *Lecanicillium lecanii*, currently registered for glasshouse application, is a candidate for outdoor aphid control. More systematic investigations certainly would result in more fungus species but also in a broader host range of the known fungi. A good knowledge of the entomopathogenic fungi and their host range together with a strain collection is a prerequisite for the development of environmental friendly pest control methods and strategies which are also applicable in organic farming.

ZUSAMMENFASSUNG

Neun Arten von entomopathogenen Pilzen aus der Gruppe der Hyphymyceten oder anamorphen Pilze (mitosporic fungi) sind zusammen mit ihren Wirten und Fundorten aufgelistet. Die meisten stammen von Schadinsekten. Die praktische Verwendung dieser Pilze in der Schädlingsbekämpfung aber auch für ökologische Untersuchungen einschliesslich der Beurteilung von Bewirtschaftungsmassnahmen wird diskutiert.

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