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Metarhizium anisopliae as a new pathogen of the spruce bark beetle *Ips typographus*

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During an outbreak of the bark beetle *Ips typographus* (L.) induced by the storm "Lothar" (1999), investigations of natural enemies and their role in the regulation of this pest insect were carried out at two sites in Switzerland. As a part of this project fungal pathogens were recorded and *Metarhizium anisopliae* (Metsch.) Sorokin was found for the first time to attack *I. typographus*. In contrast to *Beauveria bassiana* (Bals.) Vuill., the percentage of bark beetles infected with *M. anisopliae* was low.

Keywords: Bark beetles, *Ips typographus*, entomopathogenic fungi, *Metarhizium anisopliae*, *Beauveria bassiana*

INTRODUCTION

The bark beetle *Ips typographus* (L.) (Coleoptera, Scolytidae) is the most significant pest insect in spruce trees (*Picea abies* (L.) Karst.) in Central Europe. Heavy outbreaks are mainly induced after windthrows and/or by conditions that increase the susceptibility of living host trees like dry weather or storms. An outbreak usually lasts 2–5 years before the populations collapse. The reasons for the break down are manifold and not yet fully understood.

In 2000, a study was initiated by the Swiss Federal Institute WSL on the bark beetle population dynamics in infestation spots in Swiss forests affected by the storm "Lothar" (Epper 2003). The development of the bark beetle populations and their antagonists including pathogens was investigated with the aim to elucidate the mechanisms of the break down of bark beetle populations. In the following we report on the occurrence of pathogenic fungal species during this multi-year study.

MATERIAL AND METHODS

Between 2000 and 2003 bark beetle populations were monitored at two locations in Switzerland: Rothenburg (canton Luzern, 660 350 / 217 150; 545 m a.s.l.) and Steg (canton Zürich, 714 900 / 242 200; between 950 and 1035 m a.s.l.). In Rothenburg two generations per year developed, in Steg there was usually only one. In each bark beetle generation bark samples of approximately 2500 cm^2 per tree from usually 10 trees per location were taken containing teneral beetles or pupae. Each year the overwintering generation was sampled both in fall and spring before flight activity started.

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The samples were kept in climate chambers at 25 °C and 70 % humidity. The beetles collected from the bark samples were divided into three groups: living, dead and mycosed. Of each group up to 20 specimens per bark sample were used for fungus identification. They were stored in the refrigerator until further processing. For the analyses the "living" and the "dead" group were transferred to temperatures between 20 and 25 °C. After 7–10 days individuals with symptoms of fungus infection were separated. The remaining individuals of the "living" group were kept for another 5–7 days at these temperatures and then again checked for presence of fungus infections. The fungi were identified mainly by visual examination of the symptoms. A number of samples of the fungi including the doubtful cases were isolated on selective media (Strasser et al. 1997) and microscopically examined to verify the visual findings.

RESULTS

In total, 1900 living, 1826 dead and 1129 mycosed beetles were examined. *Beauveria bassiana* (Bals.) Vuill. (Deuteromycota, Hyphomycetes) as the dominant pathogen was found in 47.1 % of the "living" group, in 37.7 % of the "dead" group and 86.9 % of the "mycosed" group (Table 1). Two individuals from the "living" group (= 0.1 %), eight from the "dead" group (= 0.4 %) and ten from the "mycosed" group (= 0.9 %) succumbed to *Metarhizium anisopliae* (Metsch.) Sorokin (Deuteromycota, Hyphomycetes), variety *anisopliae*. Only beetles from Rothenburg were infected with this fungus species.

Tab. 1: Number and percentage of adult *Ips typographus* infected with the pathogens *Beauveria bassiana* (*B. bassiana*) and *Metarhizium anisopliae* (*M. anisopliae*).

Location	*B. bassiana*			*M. anisopliae*		
	in living beetles	in dead beetles	in mycosed beetles	in living beetles	in dead beetles	in mycosed beetles
Rothenburg	676 (45.1%)	423 (34.5%)	602 (85.9%)	2 (0.1%)	8 (0.7%)	10 (1.4%)
Steg	219 (54.6%)	266 (44.3%)	379 (88.6%)	0	0	0
Total	895 (47.1%)	689 (37.7%)	981 (86.9%)	2 (0.1%)	8 (0.4%)	10 (0.9%)

Except from the first year *M. anisopliae* was found in all years sampled. In the other years infection rates were more pronounced in the first generation of *I. typographus*, however, *M. anisopliae* was not found in beetles that overwintered under the bark. Twelve specimens were found in a single sample of the same date and trap. Many other fungi were encountered, however, they were saprophytic rather than entomopathogenic. Cultures of *M. anisopliae* from several individuals are deposited in the collection of FAL.

DISCUSSION

M. anisopliae has not been reported so far from the bark beetle *I. typographus* (Kirschner 2001; Wegensteiner 2004). This finding is considered the first record of this fungus on this important pest insect. The fungus is known from many insect species preferably belonging to the order Coleoptera. Among the Scolytidae it is particularly known from the coffee berry borer [*Hypothenemus hampei* (Ferr.)]. Therefore, the finding itself is not surprising but rather the fact, that it has not been recorded yet from such a well studied insect. In Switzerland, *M. anisopliae* is a wide spread pathogen in agricultural soils, in meadows as well as in arable land (Keller et al. 2003). It is also present in forest soils but at a lower frequency (Rodrigues et al. unpubl.). This might be a reason for the rare occurrence of this fungus on *I. typographus*. Another reason could be that this insect shows a low susceptibility to this pathogen. In any case, when studying strategies for the microbial control of *I. typographus*, *M. anisopliae* should be considered a candidate together with the common entomopathogenic fungus *B. bassiana*.

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ZUSAMMENFASSUNG

Während einer Gradation des Buchdruckers *Ips typographus* (L.), ausgelöst durch den Sturm "Lothar" (1999), wurden an zwei Standorten Untersuchungen über das Auftreten von Antagonisten und ihre Bedeutung als Begrenzungsfaktoren durchgeführt. Bei den insektenpathogenen Pilzen konnte dabei erstmals *Metarhizium anisopliae* (Metsch.) Sorokin als Pathogen von *I. typographus* nachgewiesen werden. Im Vergleich zu *Beauveria bassiana* (Bals.) Vuill. war seine Bedeutung allerdings gering.

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