FUNGI ISOLATED FROM STAINED WOOD ASSOCIATED WITH BARK BEETLE GALLERIES IN TIMBER TREES IN NEW ZEALAND, NORWAY AND WESTERN CANADA

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Gudrídur Gyda Eyjólfsdóttir

A thesis submitted to the
Faculty of Graduate Studies
in partial fulfilment of the requirements
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ABSTRACT

Fungi isolated from stained wood, mostly coniferous and recently attacked by bark beetles, in New Zealand, Norway, Western Canada, and the U. S. A. were grown in culture under prescribed conditions to determine their specific characteristics and taxonomic relationships.

The study resulted in the preparation of detailed descriptions of 36 taxa which represent species of the genera Acremonium, Aphanocladium, Beauveria, Chalara, Dipodascus, Engyodontium, Gliocladium, Graphium, Hyalodendron, Hyalopesotum, Hyalorhinocladiella, Leptodontidium, Mariannaea, Monocillium, Phaeoisaria, Phialographium, Phialophora, Pithomyces, Rhinocladiella, Verticillium, Volutella, and taxonomic genus 1. Of these, nine are proposed as new, and are to be found in Acremonium, Beauveria, Gliocladium, Graphium, Hyalopesotum (synanamorph Hyalorhinocladiella), Monocillium, Phialographium (synanamorph Phialophora), and one for which the new genus will be erected. In addition, to accommodate one of these species, the genus Erostella was re-established, and its type, E. minima, and the only other previously described species, E. fraxinopennsylvanica, were included for comparison with E. novae-zelandiae sp. nov. prop.

Wood-staining fungi, especially members of the Ophiostomatales and their anamorphs, many of which cause blueing of the sapwood of economically important timber trees, have been the subject of numerous studies. However, other fungi which occur in association with the wood-staining organisms in and around bark beetle galleries have largely been ignored, especially if they are non-staining. This investigation sought at least

partially to redress this neglect.

This study is a taxonomic investigation of various fungi from the bark beetle galleries. Its aim was to identify the more poorly known entities and thus add information as to the nature of the bark beetle-host tree-microorganism ecosystem.

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INTRODUCTION

When bark beetles attack their host trees and begin to construct their galleries, they vector numerous different microorganisms (Whitney 1982). These microorganisms rely on the beetles to overcome the mechanical and chemical defence systems present in the bark of the host trees. The beetles introduce them into the host's sapwood, a substratum otherwise not accessible to microorganisms except when they gain access through cracks in the bark. The presence of fungi may prevent the defensive mechanisms of the tree against insect attack from functioning properly by killing the adjacent host tissue and, when inoculated in this way, some fungi may also even kill the entire host. This would be advantageous for the beetles, because living host tissue often produces resins and callus tissue which hinder their reproduction (Whitney 1982).

Amongst such microorganisms are to be found several different groups of fungi. Of which the wood-staining fungi are the best known. Their mycelium penetrates the wood and discolours it either by producing pigments which diffuse into the wood surrounding the mycelium, or the hyphae are pigmented, and as they grow they thus discolour the wood which they colonize. Pigmented spores can also cause staining but, on the other hand, the fungus may remain non-staining until the food reserves are depleted and the mycelium enters a resting state; during the latter process the hyphae of many fungi become pigmented and thus cause staining (Whitney 1982).

These stains are most often dark, ranging from gray to black although usually referred to as blue; but green, red, yellow or brown

stains also occur. Käärik (1974) summarized the records of a variety of wood-staining fungi, while Whitney (1982) described the nature of the microorganisms that are vectored by the bark beetles. The association of the beetles and the microorganisms they vector with the host tree must be a product of a long co-evolution because they often rely on the presence of each other, i. e. exist in mutualistic symbiosis, at various stages in their life-cycles.

Dowding (1984) described the early colonists of standing trees or freshly cut logs, and noted that most of those fungi can invade weakened living tissue but do not cause decay of the wood. He pointed out that members of the Ophiostomatales grow primarily in the ray cells and produce their more complex fruiting structures under the bark, often in areas where the bark has been broken, or in the beetle galleries, usually at the end of rays and on the phloem. The simpler synanamorphs are produced on the mycelium throughout the colonized wood, while the macronematous conidiophores with their spore masses which are an important food source for many insects, mites and nematodes, are to be found primarily in the beetle galleries. However according to Dowding (1984), the bark beetles generally do not rely on species of Ceratocystis Ellis & Halst. sensu lato for food, but rather to suppress the tree defence mechanisms by killing the colonized host tissue. Batra (1967) lists a few bark beetle species which have symbiotic ambrosia fungi and are thus mycophagous. Other species such as those of the genera Cladosporium Link, Aureobasidium Viala & Boyer, Botrytis Micheli ex Pers. and Penicillium Link colonize the cut surfaces of logs, and are

mostly established by airborne spores (Dowding 1984).

Over the last eighty years, numerous studies of wood-staining fungi have been undertaken because their growth in the host's wood reduces its commercial value. Thus it is in countries where forestry is of economic importance that the staining organisms have been studied most thoroughly. The most important group of such fungi are members of the Ophiostomatales, in particular species of Ceratocystis sensu lato, and Ceratocystiopsis Upadhyay & Kendrick and their anamorphs.

Studies of wood-staining fungi in New Zealand, including species other than of the Ophiostomatales, were reported by Hutchison & Reid (1988a, b). In Norway, Robak (1932) studied fungi staining ground wood pulp, and Solheim (1986) investigated species of the Ophiostomatales which were associated with the bark beetle Ips typographus L. in Picea abies (L.) Karst. In Canada these fungi have been studied by Wright & Cain (1961), Griffin (1968), and Olchowecki & Reid (1974). Other fungi have also been reported, though less commonly, from bark beetle galleries in Canada (e. g. Tsuneda 1987; Tsuneda et al. 1986; Whitney & Funk 1977). Other studies have been published, but those listed above are considered to be most pertinent to this investigation.

While many of the fungi vectored by bark beetles do not cause disease of the host tree, some are well known tree pathogens which cause death. Others are less virulent, but if present in association with a intense attack by the beetles, they may kill enough tissue to girdle the tree (Whitney 1982) and thus contribute to the death of the host.

Some beetles have become dependent on certain symbiotic fungi.

They protect the fungus in specialized structures, mycangia, and inoculate the tunnels with the fungus. Here the fungus grows and forms a thin lining on the tunnel surface, and the beetles and their larvae then feed on the fungus. Batra (1967) studied the ambrosia fungi and Francke-Grosmann (1967) reported on the phenomenon of ectosymbiosis, i. e. when the beetle stores the symbiotic organism in external organs, the mycangia.

Other groups of fungi may be pathogenic to the beetles or their offspring. One of the best known of the entomogenous Hyphomycetes is Beauveria bassiana (Bals.-Criv.) Vuill. whose host range includes bark beetles; Verticillium lecanii (A. Zimmerm.) Viégas and Fusarium solani (Mart.) Sacc. are also considered pathogens of bark beetles (Barson 1976; Claydon & Grove 1984). Although some fungi have been tested for their ability to serve as biological control agents of bark beetles in nature, entomogenous fungi usually do not appear to seriously affect the beetle population as a whole, even if they proved effective pathogens in laboratory experiments (Barson 1976).

Some fungi such as Gliocladium roseum Bainier, Aphanocladium album (Preuss) W. Gams and certain species of the genus Verticillium Nees are known for their ability to parasitize other fungi. Hawksworth (1981) surveyed the mycophilic fungi and listed three species as parasitic or inhibitory to Ceratocystis species. The presence of a mycoparasite could suppress the actions of other, more harmful fungi.

The primary colonizers of standing or freshly felled trees are rather specialized organisms, capable of invading host tissue while it

is still alive although usually in a stressed condition. These fungi which are special to this habitat are poor competitors and do not grow in already colonized substrata. When the galleries are no longer used by the insects, these primary colonizers are usually overgrown and outcompeted by secondary invaders which take advantage of the changed conditions (Dowding 1984). These later invaders may have been present in the galleries but unable to compete successfully with the better adapted primary colonizers, or they may have been introduced into the galleries at a later date.

In general, fungi vectored by insects have reproductive processes specifically adapted for such dispersal, one being sticky spores which adhere to the insects. Since there is always a danger of the conidia drying out before they reach the new host, larger masses in a mucilaginous matrix generally increase the chances of successful dispersal. The slimy conidial masses also serve as a food source for various organisms found in the galleries. Fungi which are associated with bark beetles seem to express a high degree of pleomorphy, so there must be different selection forces affecting them, and diversity or plasticity thus maintained. Dowding (1984) described the differences in survival during transport which exists between the ascospores and conidia of Ceratocystis species.

This study deals with the specific characteristics and the taxonomic relationships of some of the lesser known fungi isolated from stained wood and which are associated with bark beetle galleries in timber trees in New Zealand, Norway and Western Canada. Its aim was to

identify and prepare descriptions of these fungi and, based on previous records in the literature, try to predict their possible function in the bark beetle - host tree ecosystem. Also to add to the basic information about species composition of the mycoflora of bark beetle galleries.

Since this study covers over 20 genera of Hyphomycetes, and in a few species also the ascomycetous teleomorph, it was decided to review the literature individually for each genus, immediately preceding the treated species assigned to the individual genera. Special attention was given to previous associations with: (1) coniferous wood, (2) bark- or wood-inhabiting insects, (3) forests, i. e. litter and soils, as well as to previous records of the species in the country of origin. The presumptive new taxa were not formally described herein but listed either with a specific epithet as sp. nov. prop., or as taxonomic sp. 1 of the appropriate genus.