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FACTORS INFLUENCING THE CONTROL OF THE SIREX WOODWASP IN SOUTH AFRICA

by

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PHILOSOPHIAE DOCTOR

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DECLARATION

I, Brett Phillip Hurley declare that the thesis, which I hereby submit for the degree *Philosophiae Doctor* at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Brett Phillip Hurley

July 2010

I dedicate this thesis to my family. To my wife Tania, my son Joshua and my daughter Mikayla. To my parents, Philip, Linda, Henry and May. To my brothers and sisters, Gareth, Steven, Jonathan, Jim, Shirley and Julie. To my grandmother Joan. And to the rest of my family, both present and future.

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"*To praise you is the desire of man, a small piece of your creation. You stir man to take pleasure in praising you, because you have made us for yourself, and our heart is restless until it rests in you.*" **Confessions, by St Augustine (AD 397)**

SUMMARY

Thesis title: Factors influencing the control of the Sirex woodwasp in South Africa

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Degree: PhD

The woodwasp *Sirex noctilio* is one of the most serious invasive pests of *Pinus* plantations in the southern hemisphere. Extensive control programs have been developed to manage this pest, of which biological control has been a major component. This thesis examined the factors that could influence the control of *S. noctilio* in South Africa. A critical comparison of *S. noctilio* infestations and control efforts throughout the southern hemisphere revealed that control has not been uniformly effective, and local adaptation of control strategies is likely required as *S. noctilio* moves to new areas. The parasitic nematode *Deladenus siricidicola* is considered the primary biological control agent of *S. noctilio*. This nematode also feeds on the fungal symbiont of *S. noctilio*, *Amylostereum areolatum*. Possible factors influencing the success of this nematode in the summer rainfall areas of South Africa were examined. Data from a field trial revealed that moisture content of the wood influences inoculation success and this is influenced by the time of inoculation and the section of the tree inoculated. Laboratory-based assays revealed that incompatibility between the strain of *A. areolatum* and *D. siricidicola* was unlikely to

be the cause of low inoculation success with the nematode, but that artificial inoculations could be affected by competition of *A. areolatum* with sapstain fungi. The parasitic wasp *Ibalia leucospoides* is another biological agent for *S. noctilio*. Mitochondrial and nuclear DNA sequence data reflected the extensive introduction of *I. leucospoides* into the southern hemisphere, followed by genetic bottlenecks that fixed only a few haplotypes in the introduced populations. Promoting awareness of *S. noctilio* in the forestry community has also been an important component of the control strategy. Data from a survey questionnaire showed that the awareness campaign had been generally successful, but the lack of basic knowledge to identify *S. noctilio* and its symptoms and the poor reach of the awareness media to some sectors of the forestry community, was of concern. This thesis has contributed towards understanding the factors that influence the control of *S. noctilio* in South Africa, with relevance to other regions where *S. noctilio* has been introduced.

PREFACE

Biological invasions can cause considerable losses both to the environment and to the economy of a country. Biological invasions involve the introduction, usually accidental, of a non-native organism, which adapts and establishes in its new environment. In many cases, favourable conditions for the invasive organism, such as the absence of natural enemies, result in an 'unnatural' increase in their numbers. The consequences of such invasions include out competing the native biota and / or drastically reducing the new food resource.

Plantation forestry is particularly vulnerable to biological invasions. This is because plantation forestry often consists of larg stands of exotic trees grown in a monoculture. These plantation trees do well in the absence of their native pests and pathogens. But, when one of these pests or pathogens is introduced, the large expanse of vulnerable hosts, and the absence of natural enemies, makes an ideal environment for their rapid establishment - often rising to epidemic levels.

One of the most serious biological invasions in pine plantation forestry in the past century, particularly in the southern hemisphere, has been the Sirex woodwasp, *Sirex noctilio*. *Sirex noctilio* is native to Eurasia, but has been accidentally introduced to the southern hemisphere, and more recently to North America. In Chapter One of this thesis, we review the introduction and spread of this wasp in the southern hemisphere, and the consequent losses to pine forestry. We also critically evaluate the methods used to control this pest and how successful they have been.

The parasitic nematode, *Deladenus siricidicola*, is regarded as the primary biological control agent against *S. noctilio*. This nematode has been used throughout the southern hemisphere in an effort to manage populations of *S. noctilio*. However, the evaluation of these efforts presented in Chapter One shows clearly that there is variation in the success of this biological control agent. The summer rainfall region of South Africa is an area that has shown particularly poor success with the artificial introduction of *D. siricidicola*. In Chapter Two, I report on an extensive field trial in which possible factors that may influence success with *D. siricidicola* in the summer rainfall areas of South Africa are examined.

Amylostereum areolatum is the fungal symbiont of *S. noctilio*. Together, *A. areolatum* and *S. noctilio* overcome the defence of pine trees, resulting in their death. Besides its mutualistic association with *S. noctilio*, which includes providing nutrition for *S. noctilio* larvae, *A. areolatum* is also a food source for the nematode *D. siricidicola*. In the first two chapters of this thesis the possibility is raised that incompatibility between the strain of *A. areolatum* and the strain of *D. siricidicola*, and / or competition of *A. areolatum* with sapstain fungi in the wood, may influence success with *D. siricidicola* as a biological control agent. In Chapter Three, we describe laboratory based studies to test these two hypotheses. Following on from results obtained in Chapter Two, the effect of water availability on the competitive interactions was also considered in Chapter Three.

Although *D. siricidicola* is considered the primary biological control agent against *S. noctilio*, various parasitic wasps have also been successfully used for this purpose. Of these, *Ibalia leucospoides* has been one of the most successful. This parasitoid wasp has been introduced from its native range in the northern hemisphere to

the southern hemisphere. In Chapter Four we examine the introduction history of *I. leucospoides* using mtDNA and nuclear DNA markers. We also compare the diversity between native and introduced populations.

Sirex noctilio has easily been one of the main, if not the main, pest threats to South African pine plantation forestry. Part of the management strategy for *S. noctilio* in South Africa has been to promote awareness of this pest in the forestry community. In Chapter Five we report the use of a survey questionnaire and telephonic interviews to understand the efficacy of these efforts, by examining the perception and knowledge of *S. noctilio* and other forestry pests in the forestry community of South Africa.

Local adaptations to control strategies are often needed as pests move in to new environments. The critical examination of the efforts to control *S. noctilio* in the southern hemisphere (Chapter One) and the results from the field trial (Chapter Two), suggest that such local adaptations to control *S. noctilio* are required in South Africa. Chapter Six of this thesis is a review of the history of *S. noctilio* in South Africa. This includes the current efforts to control the pest as it spreads in the summer rainfall region, where local adaptation to existing control strategies has been required.

The aim of the work represented in this thesis is to contribute to understanding the factors that influence the control of *S. noctilio*. Although the majority of this thesis focused on the southern hemisphere, and more particularly on South Africa, we believe that the findings will have relevance for wherever *S. noctilio* has been introduced. Each of the chapters in this thesis has been written as a potential scientific publication. Thus, some repetition, especially in the introduction of the chapters, was unavoidable.