CHAPTER FIVE

Perception and knowledge of the Sirex woodwasp, *Sirex noctilio*, and other forest pest threats in the South African forestry community

Sirex noctilio is one of the most serious invasive pests of pine. In South Africa, there has been a national effort to control *S. noctilio*, which has included increasing awareness of the pest amongst the local forestry community. In this study, we considered the impacts that the arrival of the pest and the awareness campaign has had on perceptions and knowledge of *S. noctilio,* as well as other forestry pests, amongst members of the forestry community. For the data collection, a survey questionnaire was developed and used in telephonic interviews. Results of the study showed that the Sirex awareness campaign had increased awareness of forestry pests in general. However, basic knowledge regarding the identification and symptoms of specific pests, such as *S. noctilio*, was poor. This will negatively influence monitoring efficacy. Traditional paper-based media and personal contact contributed most to enhanced awareness. Electronic media were less effective and improvement would require a more focused effort. It was of concern that private farmers and contractors, as well as non-English and non-Afrikaans speakers, were less well informed about forestry pests. Clearly, a fragmented landscape in terms of ownership and language, presents challenges for effective communication of forestry pest threats in South Africa.

Introduction

Pests and pathogens pose a serious threat to forestry worldwide. This threat includes both environmental disturbance by altering natural forest habitat, and economic losses, including direct losses to the crop and indirect losses due to the required management interventions (FAO 2009, Holmes *et al.* 2009). The increase in global trade and travel has added to this threat by the consequential increase in invasive pests and pathogens (Haack 2001, Wingfield *et al.* 2008). These invasions are particularly threatening when pests and pathogens from the native range of the host tree are introduced to environments where these trees are planted as non-natives in plantations. In such cases, the presence of a host monoculture for the pest or pathogen and a lack of their natural enemies provide favourable conditions for their rapid expansion.

In South Africa, a small natural forest resource led to the introduction of non-native tree species in the eighteenth and nineteenth centuries. Species of *Pinus*, *Eucalyptus* and *Acacia* were thus used to establish plantations to service the demand for wood and wood products (Owen and van der Zel 2000). This led to a forestry industry based on non-native trees that occupies about 1 % of the land surface (about 1.3 million ha), produces nearly 18 million tons of roundwood per annum and is a major contributor to the South African economy (Godsmark 2008). Subsequent to its establishment, the South African forestry industry has been increasingly plagued by invasive pests and pathogens (Wingfield *et al.* 2008). Of these, the most serious invasive insect of pine has been the Sirex woodwasp, *Sirex noctilio* F. (Siricidae: Hymenoptera).

Sirex noctilio is native to Eurasia (Spradbery and Kirk 1978), but has been accidentally introduced to the southern hemisphere, where it has become a serious pest of pine species (Hurley *et al.* 2007), and more recently it was accidentally introduced in to the USA and Canada (de Groot *et al.* 2007, Hoebeke *et al.* 2005). Subsequent to its detection in South Africa in 1994, *S. noctilio* spread through three of the main forestry growing provinces. Together with its fungal symbiont *Amylostereum areolatum*, *S. noctilio* has caused extensive losses to pine, mainly in highly stocked *Pinus patula* stands planted for pulpwood (Hurley *et al.* 2007).

In 2002, due to increasing infestations of *S. noctilio* in South Africa, a national committee was established and tasked with identifying and implementing appropriate control strategies for *S. noctilio*. This committee included representatives from government, private companies and landowners, and research organizations. An important component of the committee's strategy was to increase the awareness of *S. noctilio* within the forestry community. This was viewed as crucially important to ensure early detection of the pest and to obtain support for the management operations, such as the introduction of biological control agents. Efforts to promote the awareness of *S. noctilio* included information presented at conferences and field days, various forms of paper-based media, and information on the internet. However, the impact that these initiatives have had on the knowledge and perception of *S. noctilio* (and other forestry pests) amongst members of the forestry community is unknown.

Questionnaire-based surveys represent a tool that is commonly used to assess the perception and knowledge of invasive plants (Andreu *et al.* 2009, Bardsley and Edwards-Jones 2006, García-Llorente *et al.* 2008), agricultural or agroforestry insect pests (Nyeko *et al.* 2002, Obipile *et al.* 2008, Rubia *et al.* 1996), insect pests of native

and exotic forestry (Chang *et al.* 2009, Flint 2006, McFarlane *et al.* 2006, Nyeko *et al.* 2007) and other invasive species (Bremner and Park 2007). Various methods can be used to collect information for a survey, including personal interviews, posted or e-mailed questionnaires, web-accessed questionnaires and telephonic interviews. Telephonic interviews offer some advantages, in that the study can be completed over a short period, substantial information can be collected within 15 to 30 minutes, there is effective sample control, ambiguities in the responses can be resolved and they have a high response rate (Churchill and Lacobucci 2002, Proctor 2005).

In this study we conducted a questionnaire using telephonic interviews to examine the current perception and knowledge of *S. noctilio* and other forest pests, amongst members of the South African forestry community. We furthermore considered how these perceptions were influenced by the socio-demographic characteristics of the respondents. Perception in this study was defined as "a way of understanding or regarding something", and knowledge as "information or skills gained through experience or education; awareness gained by experience of a fact or situation" (Oxford Dictionary of Current English 2001). We considered four key hypotheses, including: (1) whether knowledge of *S. noctilio* would be positively correlated with general pest knowledge; (2) whether perception of pests in general would influence knowledge of these pests; (3) whether exposure to elements of the *S. noctilio* awareness campaign would increase knowledge of *S. noctilio*; (4) whether socio-demographic characteristics of the respondents, such as job position, work experience, location, mother tongue and importance of major tree genera would influence the knowledge and perception of *S. noctilio* and forestry pests in general, and the exposure of the respondents to different *S. noctilio* awareness media.

Methods

Survey methods and questionnaire design

The target population for the survey was those people involved with forestry in South Africa, and who by the nature of their work should be aware of forestry pests. This included private timber growers, contractors, plantation management, researchers and senior management. Administrative staff, nursery staff and those working in paper, pulp and saw-timber mills were excluded. The sampling framework for the target population was a list of the relevant employees supplied by companies, government and a co-operative that deals with private farmers. In addition, relevant people in the existing lists of contacts of the Institute for Commercial Forestry Research (ICFR) and the Forestry and Agricultural Biotechnology Institute (FABI) were included. The complete list of people who could be contacted was not entirely comprehensive, but provided sufficient numbers for the sample required.

After the contact list had been assembled, it was refined to exclude invalid names and duplicates. The final list amounted to 561 contacts. These contacts were from the main forestry provinces in South Africa, including the Western Cape, Eastern Cape, KwaZulu-Natal, Mpumalanga and Northern Province (Fig. 1). The desired sample size was a minimum of 232. Sampling from the list of available contacts was random, but a minimum number of respondents was set for the provinces, based on the proportion of the given contacts living in that province and the importance of the province to forestry.

A questionnaire was prepared to assess the knowledge and perception regarding *S. noctilio* as well as forestry pests in general (Table 1). The questionnaire

comprised six main sections: (1) questions to obtain socio-demographic information, namely job position, work experience, location, mother tongue, importance of major forestry species and presence of *S. noctilio* in the working environment; (2) questions pertaining to general pest perception regarding importance of the impact, research and monitoring of forestry pests; (3) questions pertaining to the knowledge of some of the major forestry pests (scientific and common names were given); (4) questions pertaining to the exposure of the respondent to different media channels that had been used to increase the awareness of *S. noctilio*; (5) questions pertaining to knowledge of *S. noctilio*; and (6) questions pertaining to the perception of *S. noctilio* regarding its control, impact and time required to manage the pest. The questions were preceded by a short introduction that explained the nature and importance of the survey.

The questions were prepared with the following objectives in mind: (1) translate information required into specific, unambiguous and answerable questions; (2) motivate cooperation from respondents; (3) minimize response errors (inaccurate answers); (4) only collect relevant information (Malhotra 2004, Zikmund 2000). The questionnaire consisted of closed questions that were either dichotomous, categorical, multiple choice or scale questions (Table 1). An exception was for the questions that called for the number of years work experience, where the actual number of years was given. Scale questions were from 1-10, where a response of one indicated the lowest and 10 the highest level of importance. Where appropriate, an option for "Don't know" was given. The last question in the section dealing with knowledge of general forestry pests asked whether the respondent was aware of or had heard of *S. noctilio*. Where the response was negative, the questionnaire was terminated as the respondent would not be able to answer questions regarding their knowledge and perception of *S. noctilio*. However, the information collected concerning their knowledge and

perception of forestry pests in general was still used. Thus, this question served as a qualifier to complete the remainder of the interview.

The questionnaire survey was conducted by means of telephonic interviews provided by Consulta Research (Pretoria, South Africa). Because a pre-testing of any questionnaire is vital (Churchill and Lacobucci 2002), this was done on five individuals who were not part of the target population. The pre-testing stage made it possible to determine the clarity of the questions, particularly concerning the pronunciation of scientific names and the length of the interview, and it ensured that the respondents had a clear understanding of the questions. The interviews were carried out from 15-26 June 2009.

Data editing and analysis

The data arising from the interviews was edited for errors and incomplete interviews were discarded. Where the respondent answered 'other' for job position, the response was changed to one of the existing categories where appropriate, or the interview was discarded (for example where the respondent indicated that he / she belonged to the nursery staff or administration). Interviews that contained missing fields were not considered. This excluded the interviews that terminated due to the qualifier question. Two variables were derived from the data set. The first derived variable indicated the number of general forestry pests known by the respondent (score out of five; considered as a categorical variable) and the other derived variable indicated the number of correct answers the respondent gave to the questions pertaining to their knowledge of *S. noctilio* (score out of 17; considered as a continuous variable). These derived variables were used in subsequent analyses to

represent knowledge for general forestry pests and knowledge of *S. noctilio*, respectively.

Statistical analyses were performed using SAS ver. 8.2 (SAS 2001). An analysis of variance (ANOVA) using a general linear model (GLM) procedure was used to examine factors that influence the knowledge of *S. noctilio*, specifically socio-demographic characteristics and exposure to different awareness media, where the derived variable (knowledge of *S. noctilio*) was continuous. Logistic regression was used to examine influencing factors where the derived variable was not continuous. This included an examination of how socio-demographic characteristics influenced the response to questions pertaining to the perception of *S. noctilio*, exposure to awareness media and knowledge and perception of general forestry pests. A Kendall Tau correlation was used to examine the correlation between knowledge of *S. noctilio* and knowledge and perception of general forestry pests. Descriptive statistics (including mean, standard deviation, standard error and 95 % confidence levels) were calculated to show the perception of general forestry pests and *S. noctilio*.

Variables were re-categorized for their use in the logistic regression analysis. This was based on an examination of frequency tables, where categories with low frequencies were grouped together. For the job description variable, contractors and private farmers were grouped together and those who responded as 'other' were categorized into an existing group, where appropriate, or they were discarded. Work experience was categorized as five years or less, more than five years but less than 20 years, and 20 years or more. Location was defined based on provinces where *S. noctilio* had been detected and provinces where *S. noctilio* had not been detected. For mother tongue, all languages besides English and Afrikaans were grouped together. All scale questions (1-10) were changed to a binary response where a score of 1-7 was

considered as not very important and a score of 8-10 was considered as very important. For the question "How long will it take to manage Sirex below economically important levels", the responses were placed in two categories representing five years or less and more than five years, the later of which included the 'never' responses. Where the respondents provided a 'Don't know' response, for this as well as other questions, these responses were not included in the analyses.

Results

Socio-demographic characteristics

A total of 240 completed interviews were obtained, which gave an error level of 4.8 % at a confidence level of 95 %. In terms of demographic characteristics of the respondents, over half (53 %) of the respondents were involved in plantation management, which included foresters, district foresters and area managers (Table 2). The remaining respondents were divided nearly equally among senior management, researchers, and private farmers and contractors. Most of the respondents had been involved in forestry for more than five years. Just over half (55 %) of the respondents were located in a province where *S. noctilio* was present, but only 43 % had *S. noctilio* in the plantation, farm or area in which they worked or for which they had responsibility. This was most likely because some of the respondents residing in areas where *S. noctilio* was present were not involved in pine forestry. Interestingly, the majority of respondents indicated their mother tongue as Afrikaans (Germanic language most closely related to Flemish and Dutch, spoken in South Africa and Namibia). In total, nine of South Africa's 11 official languages were represented as

mother tongue languages of the respondents, with only isiNdebele and Setswana not represented. Other languages included Shona (Zimbabwe and southern Mozambique), Luganda (Uganda) and German. The majority of respondents considered pine and eucalypts as very important, and wattle as not very important to their work.

Knowledge and perception of general forestry pests

There was a high knowledge of general forestry pests. In this case, 94 % of the respondents knew of at least three of the main forestry pests mentioned, 75 % knew at least four and 45 % knew all of them. *Sirex noctilio* and *Gonipterus scutellatus* were the pests that were best known by the respondents, with 98 % and 93 % respectively of the respondents being aware of or having heard of them. Only four of the respondents (2 %) had never heard of *S. noctilio* and they were, therefore, unable to continue with the questions pertaining to their knowledge and perception of *S. noctilio*. Whitegrubs, *Leptocybe invasa* and *Thaumastocoris peregrinus* were not as well known as *S. noctilio* and *G. scutellatus*, with 77 %, 74 % and 70 % respectively, of the respondents being aware of or having heard of them. How important the respondents considered eucalypts for their work significantly influenced their knowledge of general forestry pests ($p = 0.02$). Thus, those respondents who considered eucalypts to be very important in their work were more likely to have a greater knowledge of general forest pests. None of the other socio-demographic characteristics significantly influenced the knowledge of general forestry pests (Table 3).

The majority of respondents considered the impact of forestry pests on plantation forestry in South Africa to be very important (mean score = 8.3, SD = 1.7). Research

on forestry pests and monitoring for forestry pests were perceived to be very important for their control (mean score = 9.0, 9.0, SD = 1.3, 1.4, respectively). The level to which respondents considered pine and eucalypts important to their work significantly influenced their perception of the importance of the impact of forestry pests (Table 3). Here, those that considered pine and eucalypts to be very important to their work were more likely to consider the impact of forestry pests as very important.

The mother tongue of the respondent significantly influenced their perception on the importance of research on forestry pests (Table 3). Those whose mother tongue was Afrikaans or English were more likely to consider research on forestry pests as very important. None of the other socio-demographic characteristics significantly influenced the perception of general forestry pests. Those who perceived research on forestry pests to be very important were more likely to have a greater knowledge of general forestry pests than those that did not consider research on forestry pests as very important ($p = 0.04$).

Sirex awareness media

Results showed that most of the media avenues used to increase awareness of *S. noctilio* had provided a high degree of exposure (Fig. 2). All the different media tools, except conferences and the internet / websites, had reached over 80 % of the respondents. Only 67 % of the respondents had heard of *S. noctilio* at a conference and only 51 % of the respondents were informed of *S. noctilio* through the internet / website. Respondents also indicated they had been exposed to *S. noctilio* via emails, 'word of mouth', personal communication with staff of the ICFR and TPCP (Tree

Protection Cooperative Programme), internal meetings / communications, studies at tertiary institutions, or that they had seen *S. noctilio* themselves.

Certain socio-demographic characteristics significantly influenced whether respondents had been exposed to some of the awareness media (Table 3). Job position significantly influenced whether the respondent was exposed to *S. noctilio* through posters, pamphlets or pests identification cards and conferences. Work experience significantly influenced whether a respondent had been exposed to knowledge of *S. noctilio* through pamphlets or pest identification cards. Furthermore, geographic location of the respondents significantly influenced whether they had been exposed to *S. noctilio* through magazines or newspapers and field days. Those involved in plantation management were more likely to have been made aware of *S. noctilio* through posters, followed by senior management, researchers and private farmers and contractors. Private farmers and contractors, and those with the least work experience were the least likely to have been exposed to *S. noctilio* through pamphlets or pest identification cards. Researchers were the most likely to have been exposed to *S. noctilio* at conferences and by other types of media (listed above), followed by senior management, plantation management, and private farmers and contractors. Those living in a province where *S. noctilio* was present were more likely to have been exposed to knowledge of *S. noctilio* through magazines and newspapers or at field days. The mother tongue of the respondent did not significantly influence their exposure to any of the media (Table 3).

Knowledge and perception of *S. noctilio*

Of the 17 questions asked to assess the knowledge of *S. noctilio*, the average number of correct answers from the respondent was 12.1 (71 %) (SD = 3.1; range = 3-17). Most of the respondents had a basic knowledge of the trees infested by *S. noctilio* (pine) and the age of trees infested (generally above seven years old), but knowledge regarding the identification of *S. noctilio* and symptoms of infestation were poor (below 50 % of the respondents) (Fig. 3). Regarding the distribution of *S. noctilio*, most respondents answered correctly that *S. noctilio* had been detected in the Western Cape, Eastern Cape and KwaZulu-Natal and not yet reached the Northern Province. However, only 40 % of the respondents answered correctly that *S. noctilio* had not been detected in Mpumalanga at the time that the survey was conducted (Fig. 3). Most of the respondents knew that *S. noctilio* could spread by natural flight, round wood, and on wooden pallets, but only 60 % of respondents knew that *S. noctilio* could not spread via the movement of bark (Fig. 3). Most of the respondents were aware that parasitic nematodes and plantation management were being used to control *S. noctilio* in South Africa, but less (65 %) knew that parasitic wasps are also used (Fig. 3).

Knowledge of *S. noctilio* was significantly influenced by the job position and mother tongue of the respondent (Table 4). Private farmers and contractors and those whose mother tongue was not Afrikaans or English had significantly less knowledge of *S. noctilio*. Exposure to *S. noctilio* awareness media significantly influenced knowledge of *S. noctilio* for all the media except articles in ICFR / TPCP newsletters and internet / website, where those exposed to these media had a greater knowledge of *S. noctilio* than those who were not (Table 4). There was a significant positive correlation, although weak, between the knowledge of *S. noctilio* and knowledge of

general forestry pests (r_k = 0.32, $p < 0.0001$) (Table 5). There was no correlation between knowledge of *S. noctilio* and the perception of general forestry pests, relating to the importance of their impact, importance of research and importance of monitoring (Table 5).

Perception regarding the importance of using parasitic nematodes, parasitic wasps and plantation management to control *S. noctilio* was very high (score of above 8 on a scale of 1-10) (Fig. 4). The use of parasitic nematodes was, on average, perceived to be most important and the use of parasitic wasps the least important, but these differences were not significant. *Sirex noctilio* was perceived as a very serious problem for both current and future forest productivity in South Africa (score of above 8 on a scale of 1-10) (Fig. 4). The perceived threat to future productivity was slightly higher, but this difference was not significant. The majority of the respondents thought that *S. noctilio* would be managed below economically important levels within the next five years (42 %) or in more than five years (48 %). Only 3 % thought that *S. noctilio* would be managed below economically important levels within the next year and only 2 % thought that *S. noctilio* would never be managed below economically important levels. The remaining 5 % did not know when *S. noctilio* would be managed below economically important levels.

The perception of *S. noctilio* was influenced by certain socio-demographic characteristics of the respondents (Table 3). Job position significantly influenced the perception of how important plantation management was to control *S. noctilio*, the threat of *S. noctilio* to future forest productivity and the time needed to control *S. noctilio* below economically important levels. The perceived importance of plantation management was highest for plantation managers, then for researchers, private farmers and contractors, and lowest for senior management. Plantation managers were

more likely to consider the threat of *S. noctilio* to future forest productivity as very high, and this level of importance was perceived as progressively lower by private farmers and contractors, researchers and senior management. Researchers were most likely to consider that *S. noctilio* would be controlled below economically important levels in five years or less (68 % of researchers), followed by senior management (50 %), plantation management (46 %) and private farmers and contractors (28 %). The importance of pine in their work significantly influenced the perception of the threat of *S. noctilio* to current and future forest productivity. Those respondents that considered pine very important in their work were more likely to consider the threat of *S. noctilio* to current and future forest productivity as very high. The importance of eucalypts in their work also significantly influenced the perception of the threat of *S. noctilio* to future forest productivity. Thus, those respondents that considered eucalypts very important in their work were more likely to consider the threat of *S. noctilio* to future forest productivity as very important.

Discussion

This study examined the current perception and awareness (knowledge) of *S. noctilio* and general forest pests in South African forestry, and how these are influenced by various socio-demographic factors relevant to this community. The results showed that: (1) knowledge of *S. noctilio* was positively correlated with knowledge of pests in general; (2) perception regarding pests in general did influence the knowledge of these pests; (3) exposure to *S. noctilio* awareness media increased knowledge of *S. noctilio*; (4) socio-demographic characteristics influence the knowledge and perception of *S. noctilio* and forestry pests in general, as well as the

exposure to *S. noctilio* awareness media. A closer examination of the results revealed various successes and failures in efforts to increase awareness of *S. noctilio* in the forestry community. They also provided useful information on how a serious pest threat and efforts to control it can influence the knowledge and perception amongst members of the affected community.

Knowledge of general forestry pests and *S. noctilio*

Awareness of the most important forestry pests was relatively high, but it should be more acute, considering that the pests listed can cause serious losses. Besides *S. noctilio*, *G. scutellatus* was the pest that most respondents were aware of. *Gonipterus scutellatus* is an invasive pest of *Eucalyptus*, native to Australia, which was first detected in South Africa in 1916 (Tooke 1955). Its presence as a serious pest of various *Eucalyptus* species for nearly 100 years in South Africa explains why this insect is very well known. *Thaumastocoris peregrinus* and *L. invasa* are also serious invasive pests of *Eucalyptus* spp., but their appearance in South Africa has been much more recent, which probably explains why these pests are not as well known as *G. scutellatus*. *Thaumastocoris peregrinus* was first detected in South Africa in 2003, and on plantation *Eucalyptus* in 2005 (Jacobs and Nesser 2005, Nadel *et al.* 2009), and *L. invasa* was first detected in 2007 (Dittrich-Shröder *et al.* 2008), and on plantation *Eucalyptus* in 2009. Whitegrubs are larvae of native Scarabeiidae beetles and are pests of various plants, including forestry species (Govender 2007). Insecticides can be used to control whitegrubs which has possibly reduced the pest status and awareness of these insects.

Almost all respondents were aware of *S. noctilio*. This included people from different geographic locations, work experience, home language and differing importance of pine in their work environment. This can most likely be attributed to the major economic threat that *S. noctilio* poses for forestry in South Africa (Hurley *et al.* 2007). Consequently, the publicity that it has received, in media such as those considered in this study, including posters and pamphlets, field days, as well as word of mouth and other media, has been a vehicle to disseminate information.

Although awareness of *S. noctilio* was very high, it is of concern that there was a low basic knowledge regarding characteristics needed to identify the insect and symptoms associated with its damage. It is important that those involved in forestry are able to identify *S. noctilio* and its symptoms in order to ensure early detection of *S. noctilio* in new areas of infestation. This will ensure that management strategies can be established when the population of the insect is still low (Haugen *et al.* 1990). Clearly, future efforts to disseminate information regarding *S. noctilio* will need to focus on identification of the insect and symptoms associated with infestation.

Parasitic wasps have been used to a lesser extent than parasitic nematodes to manage *S. noctilio* populations. This must explain why control based on the use of these parasitoids was less well known. The confusion surrounding the current distribution of *S. noctilio* was to be expected as *S. noctilio* had been detected on the border of Mpumalanga at the time of the survey. This explains why many of the respondents thought that *S. noctilio* was already in that Province. A lack of accurate knowledge regarding the distribution of the insect can, however, affect the spread of the insect if people move infested wood because they perceive the insect to already be present in an area. This is a matter that will require attention in the future.

Perception of forestry pests and how this influences general pest knowledge

The impact that forestry pests have on plantation productivity, as well as the importance of research and monitoring aimed at their control was perceived as very important. This reflects the seriousness of pest infestations in South African plantation forestry. *Sirex noctilio* alone was estimated to result in approximately R300 million losses per annum to the forestry industry during its peak in the KwaZulu-Natal province (Hurley *et al.* 2007). Infestations of *G. scutellatus* are increasing. *Thaumastocoris peregrinus* has spread rapidly through South Africa and is now considered one of the main pests of *Eucalyptus* (Nadel *et al.* 2009). Likewise, *L. invasa*, although only recently detected in plantations, poses a serious threat to *Eucalyptus* forestry (Dittrich-Shröder *et al.* 2008). Three of these invasive pests have been detected in the last 15 years and indications are that the rate of appearance of new invasive pests is increasing with time (Wingfield *et al.* 2008). The seriousness of native pest infestations is also increasing with the cossid moth, *Coryphodema tristis* causing extensive losses of *E. nitens* (Boreham 2006, Gebeyehu *et al.* 2005). Infestations of these pests are particularly serious as in most cases effective control measures are not available.

The perception that people have of pests can influence their knowledge of pests in general. Our study showed that those respondents that perceived research on forestry pests and their control to be very important had a better knowledge of forestry pests. However, this influence was only marginally significant and the perception of the impact of forestry pests and monitoring aimed at controlling them did not significantly influence general pest knowledge.

Exposure to *S. noctilio* awareness media

Awareness campaigns provide an effective means to support the management of pests and to share information regarding their impact (Garcia-Llorente *et al.* 2008). Heong *et al.* (1998, 2008) for example showed how different forms of communication, including radio broadcasts, information posters and leaflets, can be used effectively to alter management practices. The results of the present study indicate that the media used to increase awareness of *S. noctilio* has largely been effective in reaching members of the forestry community and significantly increased the knowledge of the pest. In particular, posters, pamphlets / pest identification cards, field days, and magazines and newspaper articles have had a high level of penetration into the forestry community and they have effectively increased knowledge of *S. noctilio*.

Conferences and the internet or websites were the least effective media to inform people about *S. noctilio*. Conferences are generally not attended by members of all sectors of the forestry community and only a limited number of people can attend these meetings due to restricted costs and time constraints. The poor reach of the internet or websites in promoting awareness of *S. noctilio* is possibly because many members of the forestry community do not have frequent access to the internet. Furthermore, at the time of the survey there was no website that provided a good source of information on *S. noctilio*. Although online advertising in South Africa recorded the fastest growth rate from all English-language countries in 2008, there is still a very slow growth in internet access, with only 8 % of the population estimated to have internet connection in 2007 (www.worldwideworx.com). An informative website on *S. noctilio* has recently been developed that is specifically targeted at the

forestry community in South Africa. This is expected to increase knowledge of *S. noctilio* among those that have internet connections, but it will not assist those people without access to the internet.

A medium to promote knowledge of *S. noctilio* that could be very successful is the mobile phone. The use of mobile phones is increasing globally, including in Africa, and they are replacing land lines as the preferred means of communication (Hodge 2005). Most people in South Africa have a mobile phone (Esselaar and Stork 2005), and penetration using this medium will be high. Forms of communication will be much more limited, but potentially simple alerts with attached images could be dispatched, with the recipient directed to a contact number or website for more information should they suspect the presence of the pest in their area. This could be particularly useful in monitoring the spread of newly discovered pests.

Influence of socio-demographic characteristics

The influence of socio-demographic characteristics on the knowledge and perception of pests and other invasive species has been clearly shown in various studies (Chang *et al.* 2009, Garcia-Llorente *et al.* 2008, McFarlane *et al.* 2006, Nyeko *et al.* 2002, Obopile *et al.* 2008). The influence of socio-demographic characteristics on the exposure to awareness media is also important because these media make it possible to develop the knowledge and perception of a problem amongst members of a given community. This survey exposed the negative issue that private farmers and contractors were shown to have the least exposure to awareness media and the lowest knowledge of *S. noctilio*. This was not because of the importance of pine to these farmers and contractors, as this variable was not found to significantly influence

exposure to awareness media or knowledge of *S. noctilio*. Rather, it appears that the media used to promote awareness regarding *S. noctilio* have not penetrated this sector of the forestry community as successfully as others, and this has resulted in the lower level of knowledge regarding *S. noctilio*.

Posters, pamphlets / pest identification cards and conferences were the particular media that failed to reach private farmers and contractors effectively. This weakness will need to be addressed in the future. The forestry sector in South Africa is currently undergoing significant, and government supported transformation (see http://www2.dwaf.gov.za/webapp/ProjectsBBBEE.aspx), which will continue to increase private ownership. The lack of awareness in this sector evident from this survey is consequently of particular concern.

Respondents of this survey whose mother tongue was neither English nor Afrikaans had a lower level of knowledge concerning *S. noctilio*. Furthermore, they considered the importance of research for the control of forestry pests as less important than those whose mother tongue was English or Afrikaans. The lower level of knowledge regarding *S. noctilio* was not due to the awareness media having been in English or Afrikaans, as mother tongue did not significantly influence exposure to awareness media. This result might at least partially be explained due to the higher percentage of private farmers and contractors that were included in this group of respondents (Table 6). Furthermore, the surveys were conducted in English with an option for Afrikaans, but not for the other languages spoken in South Africa, and this could have influenced how well the questions pertaining to the knowledge of *S. noctilio* were understood. The reason for why this group considered research for the control of forestry pests to be less important is unclear, and this difference was only marginally significant. The future transformation of ownership in the South African

forestry industry will increase the number of non-English and non-Afrikaans speaking people owning plantations. Thus, home language will need to be more carefully considered in future awareness campaigns.

Four of the five pests mentioned in the general pest knowledge section of the questionnaire were pests of *Eucalyptus*. This explains why those respondents who considered *Eucalyptus* as very important in their work scored a higher knowledge of general forestry pests. These four pests and *S. noctilio*, which attack pine, have a serious impact on forest productivity. This then explains why the impact of forestry pests was perceived as higher by those who considered eucalypts and pine as very important in their work. The importance of wattle did not influence the perception of forestry pests in general. This was possibly because insect pests on wattle do not currently pose as serious a threat as do those on pine and eucalypts. Not surprisingly, those respondents that considered pine as very important also perceived the use of parasitic nematodes as biological control agents and the threat of *S. noctilio* as very important.

Interestingly, geographic location of respondents did not influence perception or knowledge of forestry pests in general or *S. noctilio*. It would have been expected that the perception and knowledge of *S. noctilio* would differ between areas where *S. noctilio* is present and those where the pest is absent, but this was not the case. This is in contrast to for instance the study of McFarlane *et al.* (2006) where public living in areas where the mountain pine beetle (*Dendroctonus ponderosae*) outbreaks occurred had a more informed view of the pest and they were also more likely to support efforts to control it. The lack of location affect on the knowledge and perception of *S. noctilio* is likely because it is a national threat to forestry and because efforts have been made to distribute information to all forestry areas.

Conclusions

The South African forestry community regards the threat of *S. noctilio* and other forestry pests, and the need to control them as extremely important. The national programme to increase the awareness of *S. noctilio* amongst members of the forestry community has largely been effective in increasing the knowledge of the pest. This will consequently increase chances of early detection of *S. noctilio* in new areas of infestation and increase the support for management operations. This result demonstrates the value of a nationally co-ordinated awareness campaign.

Where the awareness campaign failed was in its ability to reach private farmers and contractors. This demonstrates the affect that a fragmented and diverse forestry community poses for communication and, therefore, pest management. Pest management in the future will need to consider more effective means of communication in order to effectively reach all the sectors of the forestry community. The diversity of languages spoken amongst the target group also needs to be considered and there could be value in conducting marketing research to better understand this and other aspects of the target group.

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Table 1. Summary of survey questions

Questions	Scale / categories
Socio-demographic information	
Which one of the following describes your position the best?	6 categories[a]
How many years have you been involved in forestry?	Continuous
In which province do you work or are based in for the majority of time?	9 provinces
What is your mother tongue?	11 official languages
Indicate the importance of the following exotic tree species for your work: pine, eucalypts, wattle	Scale (1-10)[b]
Do you have Sirex in the area that you work in or are responsible for?	Yes / No
General pest perception	
How important do you consider the impact of forestry pests on plantation productivity in South Africa?	Scale (1-10)[b]
How important do you consider research on forestry pests for their control?	Scale (1-10)[b]
How important do you consider monitoring for the presence of forestry pests for their control?	Scale (1-10)[b]
General pest knowledge	
Which of the following forestry pests in South Africa are you aware of or have heard of: *Thaumastocoris peregrinus, Leptocybe invasa, Gonipterus scutellatus*, whitegrubs, *Sirex noctilio*? (common names were also given)	Yes / No
Exposure to awareness media	
Were you informed of Sirex through: posters; pamphlets or pest cards; articles in ICFR / TPCP newsletters; internet or website; magazines or newspapers; field days; conferences; other?	Yes / No[b]
Sirex knowledge	
(17 questions relating to knowledge on the identification, symptoms of attack, distribution and means of spread and control)	Multiple choice, Yes / No[b]
Sirex perception	
How important are the control measures: parasitic nematodes; parasitic wasps; plantation management?	Scale (1-10)[b]
How serious a problem is Sirex for forest productivity in South Africa (current and future)?	Scale (1-10)[b]
How long will it take to manage Sirex below economically important levels in South Africa?	5 categories[c]

[a]contractor, private farmer, plantation management, researcher, senior management, other
[b]respondants were also given the option "Don't know"
[c]within the next year; within the next five years; more than five years; never; don't know

Table 2. Socio-demographic characteristics of sample population

Socio-demographic characteristic	Category	% of sample population
Job position	Private farmers / contractors[a]	15
	Plantation management	53
	Researcher	14
	Senior management	18
Work experience[b]	Five or less years	15
	More than five years	47
	More than 20 years	38
Location	In Sirex-infested area[c]	55
	Not in Sirex-infested area[d]	45
Mother tongue	English	32
	Afrikaans	46
	Other[e]	22
Importance of pine	Very important[f]	79
	Not very important[g]	21
Importance of eucalypts	Very important[f]	70
	Not very important[g]	30
Importance of wattle	Very important[f]	21
	Not very important[g]	79
Presence of Sirex in working area	Yes	43
	No	57

[a]private farmers and contractors were combined for analyses
[b]years of work experience grouped into three categories for analyses
[c]Western Cape, Eastern Cape, KwaZulu-Natal
[d]Mpumalanga, Limpopo, Gauteng, Free State
[e]isiXhosa, isiZulu, Sepedi, Sesotho, Siswathi, Tshivenda, Xitsonga, Shona, Luganda, German
[f]score of 8-10
[g]score of 1-7

Table 3. Influence of socio-demographic characters on perception of *S. noctilio*, exposure to awareness media, general pest knowledge and general pest perception. Results are from logistic regression analysis, where the dependant variables were categorical.

	Socio-demographic characters							
	Job position	Work experience	Location	Home language	Importance of pine	Importance of eucalypts	Importance of wattle	Presence of Sirex woodwasp in working area
General pest knowledge	0.1	0.9	0.06	0.5	0.8	0.02*	0.1	0.8
General pest perception								
Impact of forestry pests	0.5	0.7	0.7	0.8	0.03*	0.03*	0.6	0.1
Research on forestry pests	0.6	0.2	0.4	0.04*	0.3	0.6	0.1	0.4
Monitoring of forestry pests	0.5	0.6	0.5	0.07	0.3	0.2	0.1	0.7
Exposure to awareness media								
Posters	0.003**	0.7	0.9	0.1	NA	NA	NA	NA
Pamphlets or pest cards	0.008**	0.0001***	0.8	0.1	NA	NA	NA	NA
Articles in TPCP / ICFR newsletters	0.1	0.3	0.8	0.1	NA	NA	NA	NA
Internet or website	0.2	0.4	0.9	0.9	NA	NA	NA	NA
Magazines or newspapers	0.2	0.1	0.03*	0.5	NA	NA	NA	NA
Field days	0.3	0.9	0.02*	0.3	NA	NA	NA	NA
Conferences	0.0002***	0.9	0.7	0.8	NA	NA	NA	NA
Other	0.05*	0.9	0.8	0.4	NA	NA	NA	NA
Sirex perception								
Importance of nematodes for control	0.4	0.4	0.4	0.9	0.02*	0.6	0.8	NA
Importance of wasps for control	0.3	0.6	0.7	0.5	0.8	0.1	0.2	NA
Importance of plantation management for control	0.01**	0.9	0.6	0.1	0.3	0.3	0.2	NA
Current threat of Sirex	0.2	0.9	0.08	0.3	0.004**	0.07	0.2	NA
Future threat of Sirex	0.05*	0.06	0.7	0.7	0.0004***	0.01**	0.2	NA
Time needed to control Sirex	0.03*	0.7	0.7	0.3	0.8	0.3	0.3	NA

*significant at 5% level, $p < 0.05$
**significant at 1% level, $p < 0.01$
***significant at 0.1% level, $p < 0.001$

Table 4. Factors affecting knowledge of *S. noctilio*. Results from ANOVA using general linear model, where dependant variable was continuous.

Variable	df	F value	p value
Socio-demographic characteristics			
Job position	3	10.03	<.0001***
Work experience	2	2.29	0.1
Location	1	0.98	0.32
Home language	2	8.45	0.0003***
Importance of pine	1	1.46	0.23
Importance of eucalypts	1	0	0.96
Importance of wattle	1	0.46	0.5
Presence of Sirex woodwasp in working area	1	1.48	0.23
***S. noctilio* awareness media**			
Posters	1	4.18	0.042*
Pamphlets or pest cards	1	4.9	0.028*
Articles in TPCP / ICFR newsletters	1	3.72	0.055
Internet or website	1	1.05	0.31
Magazines or newspapers	1	9.89	0.0019**
Field days	1	12.25	0.0006**
Conferences	1	10.87	0.0011**
Other	1	8.33	0.0043**

*significant at 5% level, $p < 0.05$
**significant at 1% level, $p < 0.01$
***significant at 0.1% level, $p < 0.001$

Table 5. Correlation between knowledge and perception of general forestry pests and knowledge of *S. noctilio.*

	r_k	p value	n
General pest knowledge	0.32	<0.0001	236
Importance of impact of forestry pests	-0.028	0.57	236
Importance of research on forestry pests	0.079	0.12	236
Importance of monitoring for presence of forestry pests	0.023	0.66	236

r_k = Kendall Tau Correlation Coeffecient

Table 6. Break-down of mother tongue groups by percentage of different job opportunities represented in each group

	Contractor / Private	Plantation managment	Researcher	Senior management	All
Afrikaans	10%	63%	8%	19%	100%
English	17%	36%	26%	21%	100%
Other	23%	60%	8%	9%	100%

Figure 1. Map of South Africa, showing provinces and pine plantation distribution (in black)

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Figure 2. Exposure to different *S. noctilio* awareness media.

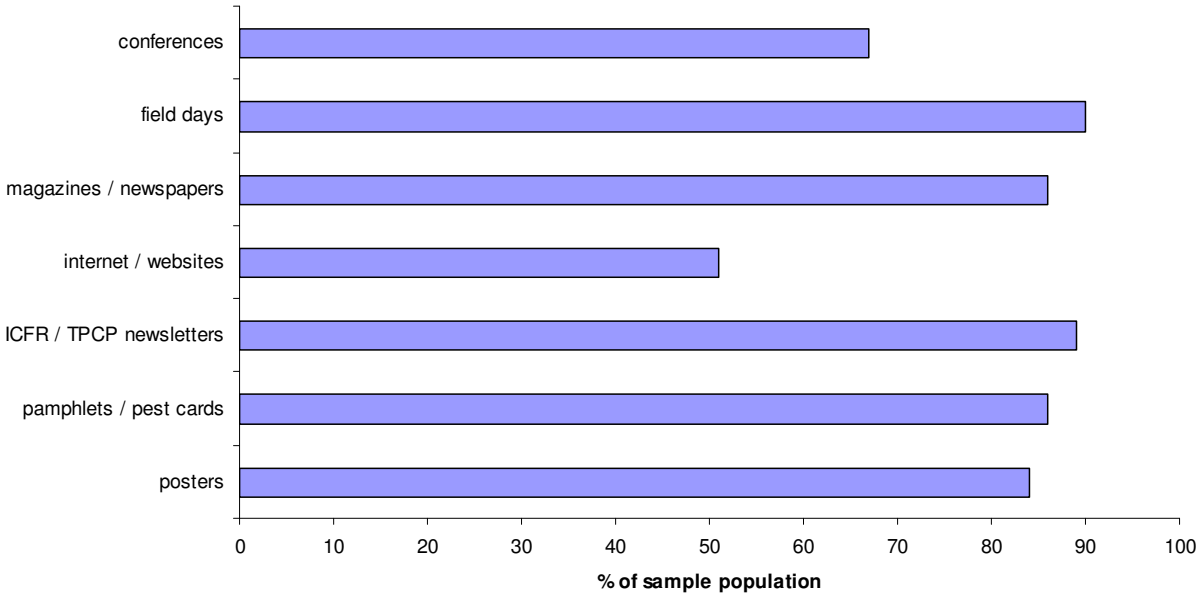

conferences
field days
magazines / newspapers
internet / websites
ICFR / TPCP newsletters
pamphlets / pest cards
posters
0
10
20
30
40
50
60
70
80
90
100
% of sample population

Figure 3. Knowledge of *S. noctilio*. Correct responses to questions around the identification, symptoms, distribution, and means of spread and control.

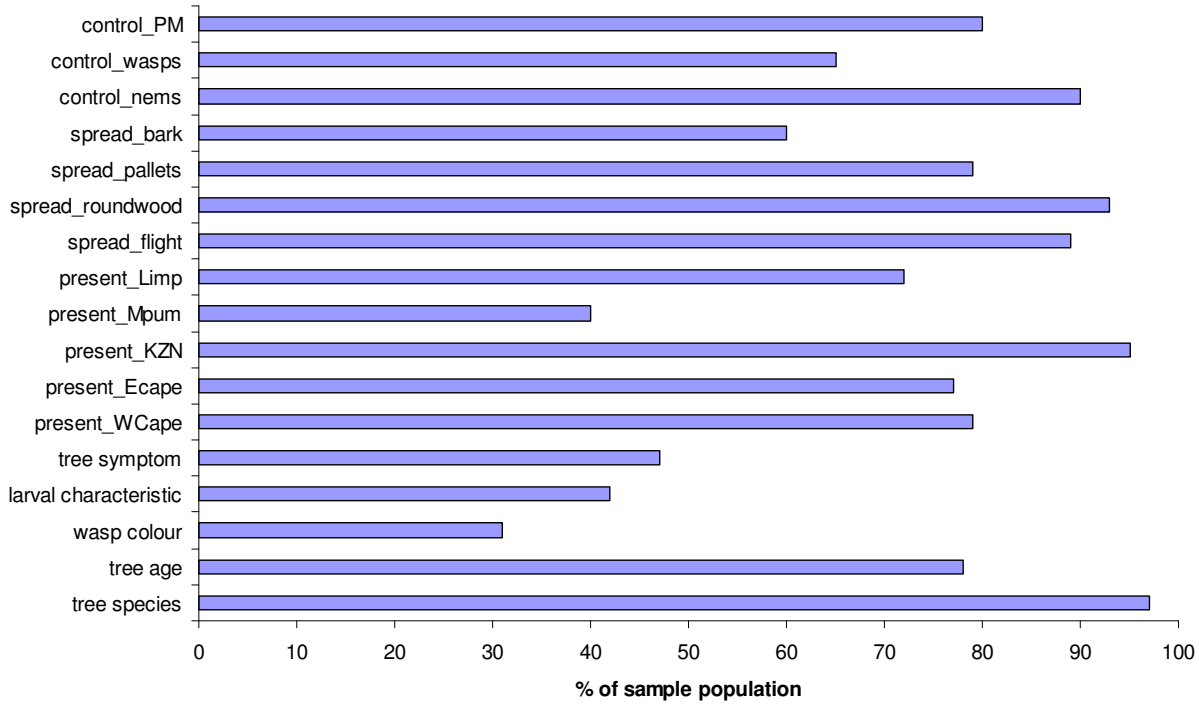
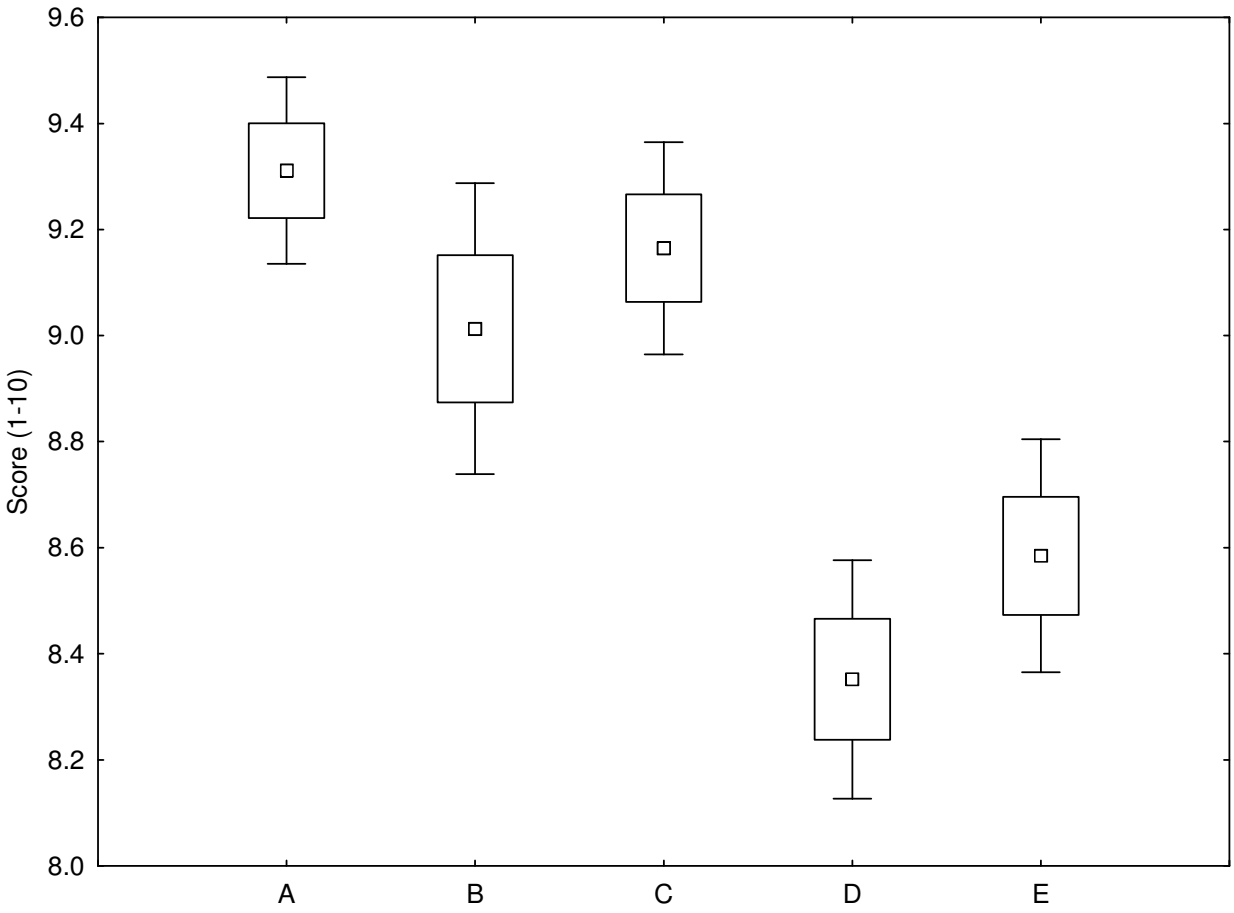

control_PM
control_wasps
control_nems
spread_bark
spread_pallets
spread_roundwood
spread_flight
present_Limp
present_Mpum
present_KZN
present_Ecape
present_WCape
tree symptom
larval characteristic
wasp colour
tree age
tree species
0
10
20
30
40
50
60
70
80
90
100
% of sample population

Figure 4. Perception of *S. noctilio*, as scored on a scale of 1-10, with one being not important and 10 being very important. A. Importance of nematodes to control *S. noctilio*. B. Importance of parasitic wasps to control *S. noctilio*. C. Importance of plantation management to control *S. noctilio*. D. Seriousness of *S. noctilio* for current forest productivity. E. Seriousness of *S. noctilio* for future forest productivity. Small squares show mean, large squares show standard error and error bars show 95 % confidence levels.


9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
Score (1-10)
A
B
C
D
E