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Short communication

Association of *Sphaeropsis sapinea* with insect infestation following hail damage of *Pinus radiata*

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Abstract

Following a hail storm in the southern Cape province of South Africa, about 2000 ha of *Pinus radiata* plantations suffered die-back associated with *Sphaeropsis sapinea*. A series of sample plots in these plantations yielded information on the association of trees infected by *S. sapinea* with colonisation of tissue by two species of cambiophagous insect pests. The infestation of diseased trees, first by *Pissodes nemorensis* and then by *Orthotomicus erosus*, mostly coincided with the zone of tissue discolouration associated with *S. sapinea*. *Pissodes nemorensis* proved to be more common than *O. erosus* and demonstrated the ability to infest healthy tissue adjacent to discoloured areas colonised by *S. sapinea*. It therefore displayed the potential to facilitate the further colonisation of healthy cambial tissue by *S. sapinea* and thus exacerbate die-back of trees.

Keywords: *Sphaeropsis sapinea*; *Pinus radiata*; Insect infestation; Hail damage

1. Introduction

The fungus, *Sphaeropsis sapinea* (Fr.) Dyko and Sutton, is a pathogen of *Pinus* spp. throughout the world (Punithalingam and Waterston, 1970; Peterson, 1977; Gibson, 1979). Die-back attributed to infection by *S. sapinea* after hail injury has resulted in extensive losses in South African plantations of *Pinus radiata* D. Don (Laughton, 1937; Lückhoff, 1964; Gibson, 1979). The fungus–host relationship as well as environmental conditions favourable to the development of disease are complex. They usually involve numerous interacting factors intrinsically related to the pathogen or its host, or the influence of the physical environment on both components (Swart and Wingfield, 1991).

The initiation and outcome of infection by *S. sapinea* is usually associated with physiological stress (Buchanan, 1967; Wright and Marks, 1970; Minko and Marks, 1973; Brown et al., 1981) and mechanical damage such as hail injury or pruning (Laughton, 1937; Gilmour, 1964; Lückhoff, 1964; Swart et al., 1987). Wounding of pine tissue by bark beetles can also provide infection courts for *S. sapinea* (Haddow and Newman, 1942; Wingfield and Knox-Davies, 1980; Wingfield and Palmer, 1983; Swart et al.,

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1987). Infestation of pine trees by cambiophagous insects is often confined to trees that are stressed or unhealthy (Whitney, 1982). It follows, therefore, that owing to the opportunistic nature of *S. sapinea* and these insects, they could share responsibility for the die-back of pine trees. However, such an interaction has to date not been studied.

Following a hail storm on 3 February 1986, an extensive outbreak of die-back was recorded at Kruisfontein State Forest in the Southern Cape Forest Region of South Africa, (33°53′S and 22°3′E to 34°3′S and 23°14′E) (Zwolinski et al., 1990a,b). This outbreak provided the opportunity to obtain information on a possible association between *S. sapinea* infection of hail-damaged *Pinus radiata* trees and infestation by cambiophagous insects.

2. Materials and methods

The study area was located in Block D of plantations half-way between the forest stations of Kruisfontein and Harkerville (34°2′S, 23°10′E). The topographically differentiated area rises in altitude from 190 m to 310 m. Three months after the 1986 hailstorm, three square sample plots of 0.25 ha each were established in a 13-year-old stand of *Pinus radiata*. The plots were located on a top slope (Plot 1), western mid-slope (Plot 2), and western low-slope (Plot 3), and spaced approximately 50 m apart. Trees in the compartment had been planted 2.7 m apart and pruned to 5 m height in 1983.

Five heavily infected trees displaying at least 90% foliage discolouration were randomly selected in each plot during May 1986, September 1986 and March 1987. All trees selected in this manner were felled and examined for discolouration of the phloem, pith and wood and insect infestation. Isolations were made from discoloured tissue in the laboratory on 2% malt extract agar to confirm the presence of *S. sapinea*. Six visibly healthy trees were selected as controls during June 1986.

Distribution and intensity of infestation of two cambiophagous insect pests, the European bark beetle, *Orthotomicus erosus* (Coleoptera: Scolytidae) (Tribe, 1990a) and the pine weevil, *Pissodes nemorensis* (Coleoptera: Curculionidae) (Tribe, 1991b) were recorded on the total length of a longitudinally de-barked strip of stem, exposing one-eighth of the circumference. Severity of infestation by *Pissodes nemorensis* was calculated as the average number of larvae, pupae and mature insects recorded on the de-barked strip of all the trees infested. Severity of *O. erosus* infestation was categorised as light, medium or heavy if the average percentage of cambium area damaged was less than 10%, 10–50%, or greater than 50%, respectively.

Canadian hanging cone traps with Cela Merck's CME 51966 (Linoprax) pheromone were used to investigate the abundance of winged *O. erosus* for 19 months from May 1986 to January 1988. Three traps were located 300 m apart in a straight line near one of the sites in which heavily infected trees were selected. A control trap was established in a healthy-looking *Pinus radiata* stand approximately 20 km from the closest area affected by *S. sapinea* and 50 km from the other traps. Beetles in both sets of traps were counted twice a month to January 1988 and the mean number of insects trapped monthly were compared with the number of insects collected from the control trap.

3. Results

At the first assessment during May 1986, approximately 15 weeks after the hail storm, 93.3% of trees in each plot had fully grown *Pissodes nemorensis* larvae compared with 40% for *O. erosus* (Table 1). Trees having *O. erosus* larvae at this time were classed as 67% with light and 33% with medium damage to the cambium. No trees were classed as being heavily damaged. The percentage of trees infested by larvae and pupae of *O. erosus* at the second assessment during September 1986 was 73.3% compared with 93.3% for *Pissodes nemorensis*. At this stage, the percentage of trees displaying light cambial damage was 46% while trees with heavy damage had increased to 18%. At the next evaluation during

Table 1
Percentage of trees infested and intensity of infestation by *Pissodes nemorensis* and *Orthotomicus erosus*

Species and recorded characteristics	Date of assessment		
	May 1986	September 1986	March 1987
P. nemorensis			
Developmental stage	Larvae	Larvae/pupae	Emerged adults
(%) trees infested	93.3	93.3	100.0
Insects per tree	114	1435	1670
O. erosus			
Developmental stage	Larvae	Larvae/pupae	Emerged adults
(%) trees infested	40.0	73.3	86.7

March 1987, 86.7% of trees had mature *O. erosus* adults compared with 100% for *Pissodes nemorensis*. The greatest proportion of trees with *O. erosus* adults had less than 50% of their cambium damaged.

On average, the extent of tissue infested by both species of insects during the first assessment coincided with the zone of timber discolouration presumably due to *S. sapinea* colonisation (Fig. 1). In September 1986, however, *Pissodes nemorensis* had demonstrated the ability to infest apparently healthy tissue of 43% of all the infested trees. Well established *Pissodes nemorensis* galleries were found on these trees at an average distance of 2.1 m from any discolouration attributed to *S. sapinea*.

The number of winged *O. erosus* beetles in the study area far exceeded that in the control stand (Fig. 2). Beetle numbers showed a steady increase in the study area from May 1986 to January and February 1987 when the maximum was reached. Population numbers then showed a definite decrease and were recorded at approxi-

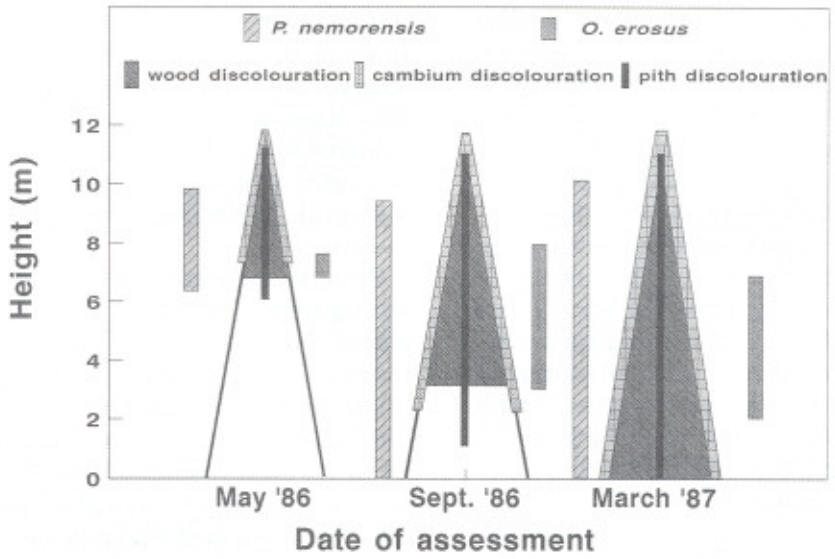

Fig. 1. Discolouration of wood, pith and cambium, and ranges of infestation by *Pissodes nemorensis* and *Orthotomicus erosus* during a period of 14 months after hail.

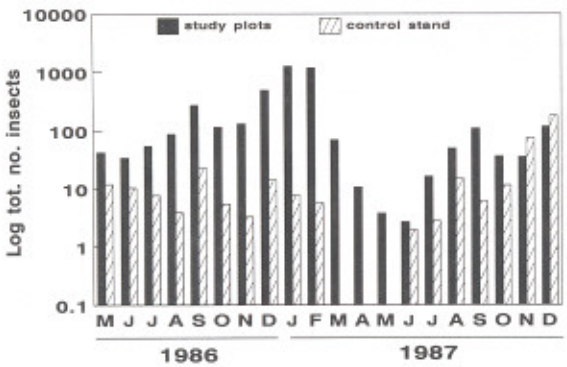

Fig. 2. Total monthly numbers of beetles of *Orthotomicus erosus* collected from the pheromone traps in the study area and in the healthy control stand.

mately the same level from October 1987 to January 1988.

4. Discussion

The results of the present study suggest a relationship between infection and colonisation of pine trees by *S. sapinea* and infestation by cambiophagous insects following hail injury. The complexity of this relationship is enhanced by the fact that the initial cause of insect infestation, i.e. colonisation of tissue by *S. sapinea*, can in the case of *Pissodes nemorensis*, become the effect of infestation of healthy tissue. Thus, in simpler terms, secondary colonisation by *Pissodes nemorensis* of hail-damaged trees infected by *S. sapinea*, could exacerbate the spread of *S. sapinea* and consequently the onset of die-back through girdling of branches and the bole.

Of the two insect species involved in this study, *Pissodes nemorensis* infested trees much faster than *O. erosus*. The relative increase in the *O. erosus* population during the period May 1986 to March 1987 was slower than that of *Pissodes nemorensis*. At 15 weeks after the hail storm, *O. erosus* was present as adults having galleries with medium-sized larvae. At this stage, *Pissodes nemorensis* were present as fully grown larvae, pupae and teneral adults. *Pissodes nemorensis* therefore has a relatively short generation time, probably approximating the 9–13 weeks of *Pissodes strobi* Peck. (MacAloney, 1930). This could probably be attributed to the ability of *Pissodes nemorensis* to colonise healthy tissue whereas *O. erosus* is more dependant on tissue previously having been colonised by *S. sapinea* (Tribe, 1990a,b). It is noteworthy that *Pissodes nemorensis* has been observed feeding on juvenile shoots of healthy trees which subsequently became infected by *S. sapinea* (Swart et al., 1987).

The extent to which cambiophagous insects shared direct responsibility with *S. sapinea* for die-back was not resolved in the present study. However, die-back of foliage, top crowns and entire trees visibly increased after well established infestation by insects had been recorded. Trees in which portions of the bole became girdled by insects could not recover and eventually died. This suggests that trees which initially had discoloured foliage but which were reported to have recovered 18 months after the hail storm (Zwolinski et al., 1990a) were probably not infested by insects.

Prior to the outbreak of die-back, post-harvesting piles of untreated logs left on the perimeter of compartments were heavily infested with insects. These logs were undoubtedly the source of the mother generation which found abundant breeding material in surrounding trees infected by *S. sapinea*. Sanitation will however reduce forest insect populations and consequently lessen the impact they might have on hail-damaged trees in association with *S. sapinea* infection. Indeed, such sanitation is prescribed for the manage-

ment of all pine-infesting cambiophagous insects in South Africa, including *O. erosus* (Tribe, 1990a,b, 1991a).

The association between *S. sapinea* and cambiophagous forest insects in the context of die-back in pine trees following hail damage, has not previously been demonstrated. In South Africa, it is commonly accepted that die-back of pines after hail damage is caused by the independent action of *S. sapinea* (Swart et al., 1987). Although we do not wish to cast any doubt on the importance of *S. sapinea* in hail-associated die-back of pines, it is our belief that forest insects can also play a decisive role in determining the eventual outcome of infection. It follows therefore that by taking active measures against these insects in pine plantations following hail damage, the severity of die-back due to infection by *S. sapinea* could be significantly reduced.

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