The threat of the Polyphagous Shot Hole Borer to pecan trees is perhaps less than initially expected

By Wilhelm de Beer & Shawn Fell

The tiny Polyphagous Shot Hole Borer (PHSB, or *Euwallacea fornicatus*) is spreading through South Africa, killing thousands of trees. It is has been found on more than 140 species of trees in the country, of which a few species like English oaks, boxelders, Chinese maples and London planes, are particularly susceptible to the *Fusarium* fungus that the beetle carries. These trees can die within months or over a period of up to five years, depending on the number of beetle attacks, the size, age and general condition of the individual tree.

PSHB was discovered attacking pecan trees in the Jan Kempdorp area in May 2017, where there is an ongoing outbreak (see SA Pecan Autumn 2019). Although it has been found on several other fruit trees in gardens in South Africa, including avocados, macadamias, citrus and stone fruits, pecans are the only crop tree in South Africa where PSHB has established in orchards. In California and Israel, the beetle and its fungus are also having an impact on crop trees, especially in the avocado industry.

PSHB has not been reported from commercial pecans anywhere else in the world. The discovery of the beetle in South African pecan orchards thus raised immediate concern with the industry. A major problem is that different tree species react very differently to the PSHB and its fungus. The long-term impact of *Fusarium* disease on pecan trees could therefore not be predicted at all. SAPPA requested the research team at the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria to determine the potential threat of PSHB to the pecan industry in South Africa.

PHOTO 1: Pecan tree infested with the PSHB

Reproductive host trees are trees that the PSHB beetle infests and where it successfully establishes a breeding gallery in which the fungus grows, where eggs are laid, and larvae develop into mature adults, thus completing its life cycle. The majority of reproductive hosts eventually succumb to the disease symptoms caused by the fungus.

Non-reproductive host trees are attacked by the beetle, but the beetles do not establish breeding galleries. The fungus may, or may not cause disease. Trees are generally not expected to die.

An updated list of the host trees and more information of the PSHB are available at www.fabinet.up.ac.za/pshb

The PSHB research project on pecans

To predict the impact of PSHB on pecans or to recommend treatments, there were several aspects PSHB infestations on pecan trees that we first needed to understand. A research project was thus initiated at the end of 2019 in collaboration with the Pecan Disease Programme at the University of the Free State. The project has various components. Below we report on progress in each of these areas.

Diagnosing PSHB infestations

The diagnostic clinic at FABI assists SAPPA and its members in the identification of potential PSHB infestations. As there are many beetle and fungal species that can be confused with the PSHB and its *Fusarium* fungus, respectively, the identity of the beetle and fungus need to be confirmed by specialists using microscopy and DNA sequencing. Samples of the beetle and fungi were regularly taken from the Jan Kempdorp area, and some samples were received from pecan in other parts of the country. To date, PSHB has only been confirmed on pecan orchards in the Jan Kempdorp area, a few old, stressed pecan trees in the Nelspruit area in early 2019, and in a large old pecan tree in the Durban Botanical Garden in July 2021.

PHOTO 2: Internal streaking of the sapwood of a pecan tree by the *Fusarium* fungus

Survey for reproductive host trees in the Jankempdorp area

Apart from one dying pecan tree in 2017, we have not found any other pecan tree in which the beetle reproduced during our monitoring efforts between January 2018 and October 2021. It thus seems as if pecans are not reproductive hosts for the beetle*. We hypothesized that the Jan Kempdorp outbreak is caused by beetles that breed in reproductive host trees close to the pecan orchards. A survey in and around the outbreak area in Jankempdorp revealed six other tree species infested with the beetle. These included: English Oak/Akkerboom (*Quercus robur*), London Plane/Plataanboom (*Platanus x acerifolia*), Sweet thorn/Soetdoring (*Vachellia karroo*), Camel thorn/Kameeldoring (*Vachellia erioloba*), Wild Olive/Olienhout (*Olea europaea* subsp. *cuspidata*), and Wild fig/Knoppievy (*Ficus sansibarica*). The beetle only reproduced in English Oaks and London plane trees.

A large number of English old oaks, heavily infested with the PSHB, were identified in the outbreak area. Several of these trees have died and the others are in the process of doing so. We believe these were the main source of beetles in the environment.

PHOTO 3: Oak trees dying from PSHB infestation and in which the PSHB breeds and multiplies, were the primary source of beetles at the centre of the Jan Kempdorp outbreak

Determining the geographical spread and flying seasons of the beetle

To understand the dynamics of an outbreak like this over space and time, it is important to map it carefully. Together with SAPPA staff and drone maps provided by the Department of Agriculture of the Northern Cape Province, about 10 000 pecan trees were individually assessed for infestation with the beetle in the outbreak areas, providing a clear view of the extent of the outbreak area at the beginning of the survey.

To determine whether the outbreak is expanding over time, 60 monitoring traps with a volatile chemical lure (quercivorol) that attracks PSHB beetles were hanged throughout the area. All insects collected in these traps were collected every two weeks and the numbers of PSHB beetles recorded over a one year period.

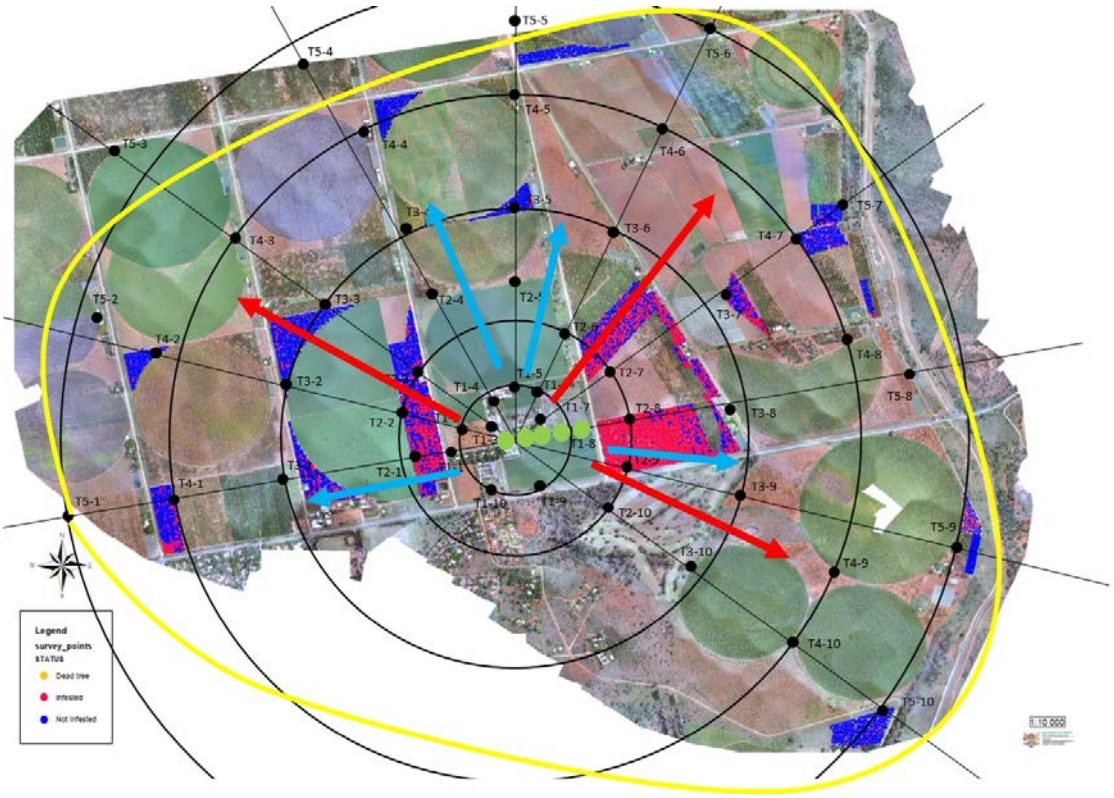

PHOTO 4: The geographical area of the PSHB outbreak in the Jan Kempdorp area. The yellow line shows the boundaries of the outbreak area, which did not increase over time. The oaks trees that were the main source of the beetles are indicated by green dots. Black dots indicate monitoring traps were placed. Different colours arrows indicated repeated mini-outbreaks when conditions were good for the beetles to fly. However, as there were no other reproductive host trees on the boundaries of the outbreak area, the area did not increase over time.

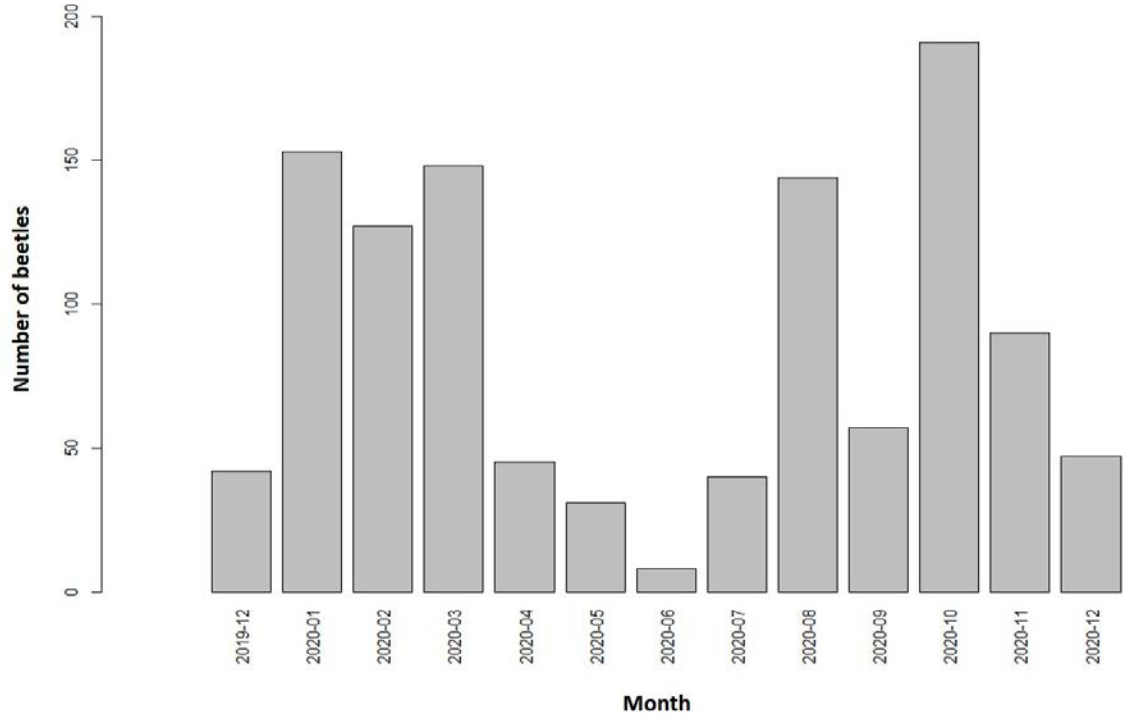

FIGURE 5: The total numbers of beetles caught within the 50 black panel traps each month over a 1-year period. There is clearly less activity during mid-winter, with most activity during spring and autumn.

Determining the impact of the fungi on pecan trees

The most important part of the project is to determine what the impact of the *Fusarium* and *Graphium* fungi carried by the PHSB are on pecan trees. To determine this we inoculated five living cultures of the fungi (3 *Fusarium*, 2 *Graphium*) into 5 cm thick branches of mature pecan trees.

The 15 year old experimental orchard where we are conducting the experiments, were planted by Dr Nicky Olivier and Prof. John Annandale on the experimental farm of the University of Pretoria. Two varieties (Witchita and Western Schley) in large numbers, and then a few smaller varieties as well. To see the impact of the fungi over time, the trials were read at 3 month intervals over a one year period.

Statistical analyses of these trials are still under way, so final conclusions can only be made once that it done. However, after 3, 6, 9, and 12 months it was clear that the *Fusarium* fungus cause a dark streak in the living sapwood of the tree, but not the *Graphium*. Living cultures of the *Fusarium* fungus were re-isolated from the lesions only after 3, 6, and 9 months, but not after 12 months. Apart from the fungal streaks in the sapwood of the branches, no other disease symptoms like wilting, dieback or visible yield loss were observed. The fact the fungus was not re-isolated at 12 months suggests that the trees host defences managed to totally suppress or even kill the fungus after 12 months.

The results of the fungal inoculations were very similar to what was observed on attacked trees in the orchards. The points of artificial fungal inoculation with time developed a swelling under the bark similar to what was seen when beetles infested trees in the orchards. However, the beetles never established and bred in the pecan trees and although bumps were still visible on the bark after even after two years, no other disease symptoms developed.

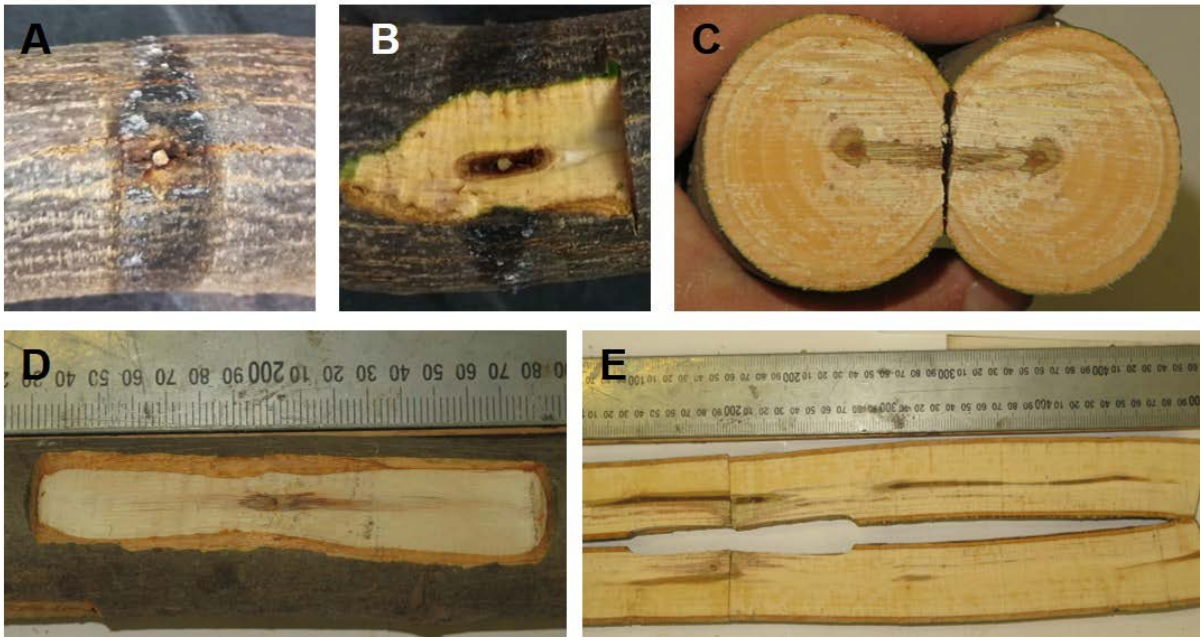

PHOTO 6: Results of inoculations of the *Fusarium* fungus on pecans. A: Exterior appearance of inoculation point. B: Inoculation site showing staining below the first layer of bark. C: A cross section through the inoculation point presenting fungal streaking. D: Streaking seen within the cambium. E: Cross section along the branch showing the spread of the fungus.

PHOTO 7: A pecan branch displaying no diseases symptoms one year after the Fusarium fungus was inoculated at five points on this branch.

Preliminary conclusions

The preliminary results of the survey suggest that **the outbreak area in Jan Kempdorp is not expanding over time**. This can be explained by the fact that the beetles do not reproduce in pecans and that very few reproductive host trees are growing among the orchards. However, repeated waves of infestation in the same area will continue as long as the source population of the beetle is still present.

During observations in the Jan Kempdorp orchards during the two year study period, and fungal inoculation trails conducted over a one year period, **we have not observed a single pecan tree that developed serious disease symptoms or have died**. This indicates that the fungal symbiont does not pose a serious threat to at least healthy Witchita and Western Schley trees. Final conclusions will be made once statistical analyses of the data is completed.

It is clear that there is that there is no reason for panic and that pecans will not be wiped out as some newspaper articles suggested. However, there are three other species of Shot Hole Borer that is not yet present in South Africa that carry different species of fungi. We cannot safely assume that those species will not be introduced into South Africa at some point, nor that they will not be able to cause disease on pecans. Therefore, together with SAPPA, it is important that farmers need to continue monitoring their orchards and reproductive host trees like London plane, oak trees, and castor bean (kasterolie) for symptoms of PSHB attack.

If you suspect that you might have PSHB infestations on your trees, contact Hardus du Toit of SAPPA him and he shall guide you how to take samples and how to send it to FABI.

**During a survey in October 2021 PSHB were found reproducing in some older pecan trees in one orchard in the Jan Kempdorp area. These trees were 18 years old and the beetles were only found in lower branches stressed and dying back due to an apparent lack of sunlight. We are currently monitoring these trees to gain a better understanding of the phenomenon.*