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Understanding the Threat
of the Polyphagous Shothole Borer to the Pecan Industry

The Polyphagous Shot Hole Borer (PHSB) is expanding its range in South Africa, and is appearing in more and more towns where it is killing thousands of trees. It has now been detected in all the provinces except Limpopo. The first species to succumb are usually English oaks, boxelders, Chinese maples, and London planes. In California and Israel, the beetle and its fungus is also having an impact on crop trees, especially in the avocado industry.

In the Autumn 2019 issue of SA Pecan we reported on the discovery of the PSHB on pecan trees in May 2017 in the JanKempdorp area, where there is an ongoing outbreak. It was also found infesting a few pecan trees in the Nelspruit area in early 2019. To date, pecans are the only crop tree in South Africa where PSHB has established in orchards, but it has been found on several other fruit trees in gardens in South Africa, including avocados, macadamias, citrus and stone fruits. These industries have been made aware of the beetle and are on the lookout for the problem.

Pecan wood infested with the PSHB

The beetle and its fungus. As we explained in more detail in the Autumn 2019 SA Pecan, it is not really the PSHB beetle itself that affects the trees, but rather the fungus that it cultivates in its tunnels that are killing the trees. The Fusarium fungus grows into the sapwood and essentially block the vascular tissues of the trees, preventing sapflow. This leads to wilting and eventually death of branches and trees.

The major problem with PSHB is that the beetle attacks so many different tree species. In South Africa alone it has now been found on more than 140 tree species. In about 25 of these, the beetle successfully establish with its fungus and complete its life cycle. Such trees where the beetle multiply is referred to as ***reproductive hosts***. Most of these trees will eventually die. Some may die in months, other over a period of years. However, these dying trees become a source of beetles in the environment, and the more beetles there are, the more trees are attacked.

The majority of the tree species attacked by PSHB are, however, ***non-reproductive hosts***. This means the beetle attacks the tree and puts its fungus in. The beetle either leaves again or die in the resin of the tree. The fungus can still grow and cause disease, but the beetle cannot multiply in these trees. Some non-reproductive hosts can die, some develop disease symptoms but recover, and many are not affected at all by the beetle and its fungus.

Why research on PSHB is needed. The reaction of different tree species to the PSHB differ tremendously, and cannot be predicted. As the PSHB has not been reported from commercial pecans anywhere else in the world, the discovery of the beetle in pecans raised immediate concern. The long-term impact of Fusarium disease on pecan trees is not known. SAPPA then approached FABI (Forestry and Agricultural Biotechnology Institute) at the University of Pretoria to embark on a research project to determine the threat of PSHB to the pecan industry in South Africa.

Prof. Wilhelm de Beer at FABI currently leads the PSHB Research Network, which consists of researchers from seven South African Universities. The aim of the Network is to align and coordinate research on the impact and management of PSHB on agricultural crops, in urban areas and natural forests.

The PSHB research project on pecans. To fix a bakkie's engine, you need to understand how it works! There are several aspects of the impact of PSHB on pecan trees that we need to understand before we can make any predictions on the impact on the industry or to recommend treatments. In 2019 we started a two year research project to find answers to these questions. This work is done 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. There are more than 6000 of these types of beetles, the majority of which only infests dead or dying trees and pose no risk to living trees. Similarly, there are hundreds of Fusarium species, of which only a few are known to be associated with shot hole borers and can kill trees. The identity of the beetle and its fungus thus need to be confirmed by specialists using microscopy and DNA sequencing.

We visit the Jankempdorp area regularly and every time we take samples of the beetles and fungus to confirm their identities. This is important because sister species of the beetle that carry different fungal species can also appear, as has happened in California. We also received several samples from pecans from various areas in the country over the past two years. However, apart from the Jankempdorp area and a few old neglected trees close to Nelspruit, all the other samples were other, non-threatening beetles. To date all specimens from pecans were exactly the same genotype of the beetle and fungus.

Outside symptoms of PSHB infection on a pecan tree

Internal streaking of the sapwood of a pecan tree by the Fusarium fungus

Samples can be sent to FABI for assessment, but this should be done in consultation with Hardus du Toit of SAPPA. If you suspect that you might have PSHB infestations on your trees, contact him and he shall guide you how to take samples and how to send it to FABI.

Survey for reproductive host trees in the Jankempdorp area. Apart from one dying pecan tree in 2018, we have not found any other pecan tree in which the beetle reproduced. It thus seems as if pecans are not reproductive hosts for the beetle. This means that the outbreak is caused by beetles that breed in reproductive host trees in the vicinity of the pecan orchards. We have thus surveyed the farm yards, roadside trees and other properties around the orchards in JanKempdorp, looking for possible reproductive hosts.

We have found six tree species in the area to be 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)*. Of these, only two species are reproductive hosts, the English Oaks and the London plane.

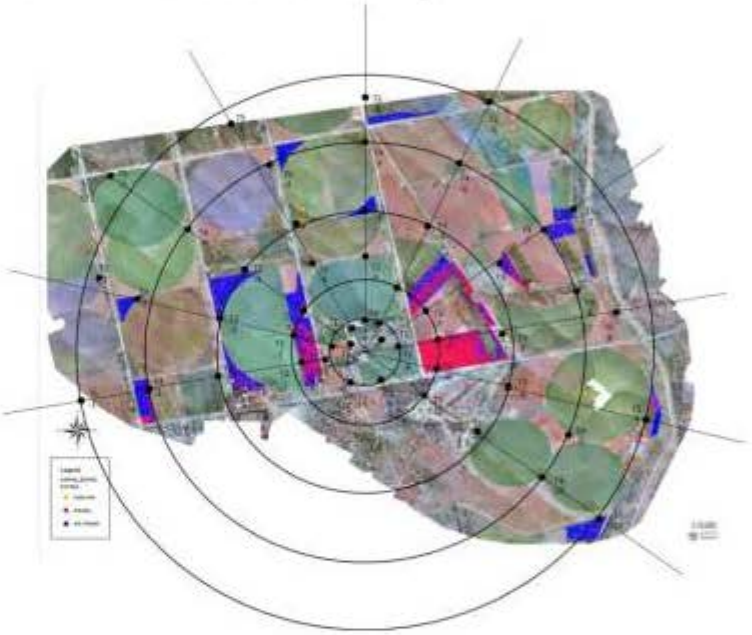
A large number of English oaks grow in the outbreak area and the majority of these are heavily infested with the PSHB. Several of these trees have died and the others are in the process of doing so. We believe these are the main source of beetles in the environment.

Using traps for monitoring purposes. The PSHB can be caught in insect traps by using a volatile chemical lure (quercivorol) to attract them. This is expensive and not feasible to try and control the beetle. However, it is a useful research tool to monitor for the beetle. We have thus tested several trap types with quercivorol in the JanKempdorp area to see whether the lure works in South African conditions, and to decide which trap type works best. Our results confirmed that the lure works and that panel traps are the best trap type to use.

Panel traps with a chemical lure (quercivorol) are being used to monitor for the presence of PSHB

Determining the geographical extent of the outbreak 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. With the help of the Northern Cape Department of Agriculture, we have obtained details drone maps of orchards in the suspected outbreak area. Together with SAPPA staff, we have walked the orchards on foot and assessed every tree for infestation with the beetle. Almost 10 000 trees were assessed. This gave is a clear view of the current extent of the outbreak area.

The question is whether the outbreak is expanding over time. Using this map, we designed a monitoring trial where 60 traps were hanged throughout the area. All insects collected in these traps are collected every two weeks and the numbers of PSHB beetles recorded. This will be done over a two year period.
At the same time weather data is recorded and together with the beetle numbers, it should give us a clear idea what times of year and/or weather conditions are favourable for beetle activity.



The geographical area of the PSHB outbreak in the Jankempdorp area. Red dots indicate infested trees, blue dots indicate non-infested trees, and black dots show where monitoring traps are placed

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 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. We are testing 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 are read at 3 month intervals over a one year period.

After sixth months it was clear that the *Fusarium* fungus cause a dark streak in the living sapwood of the tree, but not the *Graphium*. We could also re-isolate living cultures of the *Fusarium* from the lesions. However, apart from a swelling of the bark around the inoculation point, no other external disease symptoms like wilting were observed.

Inoculation of pecan trees with the fungus is done by drilling a hole the size of a beetle in the branch, and then placing a toothpick infected with the fungus into the hole.

Msc student Shawn Fell closing the wounds on the branches after inoculation with this fungus

Three months after inoculation the fungus has grown into the living sapwood of the tree.

Conclusions to date. Preliminary observations suggest that the outbreak area in Jankempdorp 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, there are repeated waves of infestation in the same area as the source population of the beetle is still present.

To date we have not observed any pecan tree infested with PSHB that have died or with serious disease symptoms. However, we know that London Plane trees take up to five years to die, so we should complete the trials before any final conclusions can be made.

What is clear, however, is that there is no reason for panic. Furthermore, we strongly advise farmers to be careful to apply products on the market that is not registered for agricultural use. Some products might not be toxic, but active compounds that stimulate tree defences can have an impact on yield.

The species name for the PSHB beetle

The species name of the PSHB is creating confusion. Initially the PSHB was referred to as *Euwallacea nr. fornicatus*. Last year we reported that a research team in the USA has renamed it in 2018 to *Euwallacea whitfordiodendrus*. However, new information has been found and in a follow-up study in 2019 the Americans have shown that the correct name for the PSHB is *Euwallacea fornicatus*. The other three species in the Shot Hole Borer complex are *E. kuroshio* (Kuroshio Shot Hole Borer), *Euwallacea perbrevis* (Tea Shot Hole Borer A) and *E. fornicatior* (Tea Shot Hole Borer B). It is important to distinguish between these species as they differ in pathogenicity and infest different host trees and occur in different countries. The correct name is needed to find the correct and most appropriate information on each species.

Alert: PSHB breeds fast in Castor bean (Kasterolie) weeds

Castor Bean/Kasterolie *(Ricinus communis)* is a common weed in the eastern parts of South Africa along roads and on farms. The PHSB can rapidly reproduce in older stems of these weeds. We thus advise pecan and avocado farmers to eradicate this weed where possible on their farms to prevent the PSHB from breeding.

The characteristics leaves of a Castor bean plant

The symptoms of PSHB infestation on the stems of older Castor bean plants

By Shawn Fell & Prof. Wilhelm de Beer