Polyphagous Shot Hole Borer
A THREAT TO OUR URBAN FOREST
Johannesburg City Parks and Zoo (JCPZ) is the custodian of the City of Johannesburg’s green heritage and as such is responsible for enhancing and increasing the green canopy.

Johannesburg has approximately 10 million trees, these trees are on the city’s sidewalks, parks, conservation areas and private stands. The management of trees within the City of Johannesburg is undertaken through an integrated approach that combines planting, maintenance, care and management within all parks, cemeteries, conservation areas, streets, nature reserves and urban agriculture areas. Tree selection, management and pruning methods are based on history, species, research and environmental factors.

Johannesburg City Parks and Zoo (JCPZ) mandate is limited to maintain trees on zoned open public spaces as per legislation; and does not maintain or remove trees on private stands. Trees on private stands are the responsibility of the owner.

Trees across South Africa are under attack from a beetle known as Polyphagous Shot Hole Borer (PSHB) which carries a deadly fusarium fungus and the beetle has been found in the City of Johannesburg, thus posing danger to the City’s green canopy.
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Euwallacea formicatus or commonly known as Polyphagous Shot hole Borer, seems to be a newcomer to South Africa. It was discovered in the country for the first time in 2017 by Dr. Trudy Paap, postdoctoral fellow at the Forestry, Agriculture and Biotechnology Institute (FABI) at the University of Pretoria. During a survey for diseases in the Kwa Zulu-Natal National Botanical Gardens in Pietermaritzburg, Paap et al. (2017) found a lane of infested plane trees (Platanus x. acerifolia).

The Polyphagous Shot Hole Borer (PSHB), Euwallacea sp. (figure 1: A-D), is an invasive ambrosia beetle and carries symbiotic fungus which infects living trees. The beetle attacks a wide range of trees and it has been reported to attack more than 200 tree species and more than 80 families. The fungus carried by the beetle is Fusarium euwallacea, which it inoculates (cultivates) in a tree as a source of food. The adult female (figure 1: A - B) tunnels galleries into trees, where it lays its eggs and grows the fungus. Furthermore, it has been reported that the beetle feed on the fungus it farms, and it does not feed on plant material. The fungus blocks the xylem and the phloem, thus interrupts transport of water and nutrients to various parts of the tree and the tree will eventually die, this phenomenon is called a fusarium dieback.

Figure 1: A, B - Female. C,D - Male
Controlling the spread of PSHB is challenging due to the mating strategies of the beetles. Within a host tree, female beetles mate with sibling males prior to leaving the natal gallery and are capable of haplodiploid (haplodiploidy) reproduction (Cooperband et al. 2016). Furthermore, living in host galleries protect PSHB from contact with pesticides, and systemic pesticides are not effective because the beetle does not feed on the tree sap, further limiting management options. The beetle attacks native, ornamental and agricultural tree species as reproductive hosts; this diversity complicates control of infestation.

Current management options in agriculture and urban forests include the use of pesticides, chipping, solarisation, and removal of infected material; management options in the natural setting are limited to chipping, solarisation, and material removal (Eskalen, 2016a). Infested material is chipped to sizes smaller than 5mm, then the material is solarised or composted (Jones and Paine, 2015).

Once composting and solarisation processes are complete, the plant material can be used as bark chips and compost for garden maintenance, or wood logs can be used as firewood (Wood, 2016). Solarisation is dependent on the time of year and the cover material used as this method is most effective during the summer months when temperatures are at their peak and plant material can be solarised between 8 to 12 weeks. Larger logs can be kept for longer period of time. Furthermore; solarisation may be used in winter months, provided that plant material is kept longer (Jones and Paine, 2015).

**KEY POINTS TO NOTE:**

a. There are more than 6,000 species of Ambrosia beetles in the world and some of which are indigenous species in South Africa

b. There are two types of host trees for the beetle: reproductive and non-productive hosts.
   - Reproductive hosts are regarded as trees which the fungus and beetle life cycles can be completed and the fungal growth then results in the tree dying.
   - Non-reproductive hosts occur when the beetle does not reproduce or complete the life cycle and the fungus may or may not kill the tree.

c. Currently there are emergency chemicals registered in South Africa to control PSHB. It is unfortunately not known if the product works. There are many side effects associated with the use of these chemicals.

d. There is no scientific data in South Africa to backup the claim that removal of infested trees is a solution to the management of the spread of PSHB.
Like all living things, trees are susceptible to pests and diseases. A tree needs a good supply of light, water, carbon dioxide and nutrients from the environment for optimum growth. A lack of one or more of these may lead to reduced growth and put the tree under stress. Street trees are highly vulnerable to pests and diseases because of microclimate, excessive heat from tar, excessive shade, soil compaction around the trunk and drought. Therefore, a stressed tree does not have sufficient defense mechanisms to be resistant to pests and diseases and will eventually die.

Sometimes when a tree dies, it can be difficult to diagnose the original cause, because problems are often complex and cumulative. A tree could have been weakened by drought and then become susceptible to a fungal attack and sometimes more than one disease may be present.

There are various diseases that attack trees such as fungal, bacterial and viral diseases. Below are other diseases that may contribute to tree death.

a. Fungal diseases

Heart rot and White rot

Heart rot is caused by a fungal disease that causes the center of the trunk and branches to decay. The most obvious symptom is the presence of mushrooms or fungal growths (Ganoderma lucidum) on the stem.

White rot (Armillaria spp.) attacks all parts of the wood, turning it into a pale spongy mass and brown rot resulting in the decayed wood becoming dry and crumble into cubes. There are other important fungal diseases that attack trees such as Fusarium oxysporum and Phytophtora ramorum amongst others which resulting in dieback.

Fungal diseases are mainly spread by pests, wind, water, soil and working tools.

b. Bacterial and viral infections

There are various bacterial and viruses that can cause diseases in trees.
Symptoms

HOW TO SPOT AN INFECTED TREE

EXTERNAL SYMPTOMS

Symptoms vary among host tree species. Staining (Fig. B - C), sugary exudate (Fig. D), gumming (Fig. E - F), and/or frass (Fig. G) may be noticeable before the tiny beetles (females are typically 1.8 to 2.5mm long).

Beneath or near these symptoms, you may also see the beetles entry/exit holes (Fig. H), which are 0.85mm in diameter.

The abdomen of the beetle can sometimes be seen sticking out of the hole. “Gunshot” wounds (Fig. I) and dieback (Fig. K).
INTERNAL SYMPTOMS

*Fusarium euwallaceae* causes brown to black discoloration in infected wood.

Scraping away bark over the entry/exit hole reveals dark staining around the gallery (Fig. J), and cross sections to cut branches (Fig. L), show the content of infection. Advanced infections eventually lead to branch dieback (Fig. M).

DESCRIPTION OF SYMPTOMS:

1. Staining, sugary exudate, gumming and/or frass may be noticeable.
2. Beneath or near these symptoms, you may also see the beetle’s entry/exit holes.
3. The abdomen of the female beetle can sometimes be seen sticking out of the hole.
4. It affects vascular bundles on the tree.
5. Advanced infections lead to dieback.

IMPACTS OF PSHB

- Loss of urban forest and benefits associated with its ecological, environmental and aesthetic value, etc.
- Loss of CoJ landscape, selling point and identity
- Reputational damage
- Requires funding
# List of Host Trees

## Reproductive Host Trees

Host trees in which both the beetle and the fungus establish [thrive], and where the beetle successfully reproduces. In most cases the reproductive hosts will eventually be killed by the fungus.

<table>
<thead>
<tr>
<th>Latin name</th>
<th>Common name</th>
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<tbody>
<tr>
<td>Acacia melanoxylon</td>
<td>Blackwood</td>
</tr>
<tr>
<td>Acacia mearnsii</td>
<td>Black wattle</td>
</tr>
<tr>
<td>Acer buergerianum</td>
<td>Trident (Chinese) maple</td>
</tr>
<tr>
<td>Acer negundo</td>
<td>Boxelder</td>
</tr>
<tr>
<td>Acer palmatum</td>
<td>Japanese maple</td>
</tr>
<tr>
<td>Brachychiton discolor</td>
<td>Pink flame tree</td>
</tr>
<tr>
<td>Gleditsia triacanthos</td>
<td>Honey locust</td>
</tr>
<tr>
<td>Liquidambar styraciflua</td>
<td>American sweetgum</td>
</tr>
<tr>
<td>Magnolia grandiflora</td>
<td>Southern magnolia</td>
</tr>
<tr>
<td>Pearsea arboricola</td>
<td>Avocado</td>
</tr>
<tr>
<td>Platanus x acerifolia</td>
<td>London Plane</td>
</tr>
<tr>
<td>Quercus palustris</td>
<td>Pin oak</td>
</tr>
<tr>
<td>Quercus robur</td>
<td>English Oak</td>
</tr>
<tr>
<td>Ricinus communis</td>
<td>Castor bean</td>
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<tr>
<td>Salix alba</td>
<td>White willow</td>
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</tbody>
</table>

## Non-Reproductive Host Trees

Host trees that are attacked by the beetle and where the fungus establishes, but where the beetle does not successfully breed. The fungus might, or might not cause disease and kill the trees.

<table>
<thead>
<tr>
<th>Latin name</th>
<th>Common name</th>
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</thead>
<tbody>
<tr>
<td>Bauhinia purpurea</td>
<td>Butterfly orchid tree</td>
</tr>
<tr>
<td>Betula pendula</td>
<td>Silver birch</td>
</tr>
<tr>
<td>Camellia japonica</td>
<td>Common camellia</td>
</tr>
<tr>
<td>Carya illinoinensis</td>
<td>Pecan nut</td>
</tr>
<tr>
<td>Ceiba pentandra</td>
<td>Kapok</td>
</tr>
<tr>
<td>Cinnamomum camphora</td>
<td>Camphor</td>
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<tr>
<td>Citrus limon</td>
<td>Lemon</td>
</tr>
<tr>
<td>Citrus sinensis</td>
<td>Loquat</td>
</tr>
<tr>
<td>Eriobotrya japonicum</td>
<td>Aloe coral tree</td>
</tr>
<tr>
<td>Erythrina livingstoniana</td>
<td>River red gum</td>
</tr>
<tr>
<td>Eucalyptus camaldulensis</td>
<td>Common fig</td>
</tr>
<tr>
<td>Ficus carica</td>
<td>European ash</td>
</tr>
<tr>
<td>Fraxinus excelsior</td>
<td>Jacaranda</td>
</tr>
<tr>
<td>Jacaranda mimosifolia</td>
<td>Syringa</td>
</tr>
<tr>
<td>Melia azedarach</td>
<td>Mulberry</td>
</tr>
<tr>
<td>Morus sp.</td>
<td>American plane</td>
</tr>
<tr>
<td>Platanus occidentalis</td>
<td>Californian plane</td>
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<tr>
<td>Platanus racemosa</td>
<td>Frangipani</td>
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<tr>
<td>Plumeria rubra</td>
<td>Lombardy poplar</td>
</tr>
<tr>
<td>Populus nigra</td>
<td>Black plum</td>
</tr>
<tr>
<td>Prunus nigrum</td>
<td>Peach</td>
</tr>
<tr>
<td>Prunus persica</td>
<td>Guava</td>
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<tr>
<td>Psidium guajava</td>
<td>Pepper tree</td>
</tr>
<tr>
<td>Schinus molle</td>
<td>Swamp cypress</td>
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<tr>
<td>Taxodium distichum</td>
<td>English elm</td>
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<tr>
<td>Ulmus minor procera</td>
<td>Chinese elm</td>
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<tr>
<td>Ulmus parvifolia</td>
<td>Viburnum</td>
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<tr>
<td>Viburnum sinensis</td>
<td>Grapevine</td>
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<tr>
<td>Vitis vinifera</td>
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*The above list is subject to being reviewed on an ongoing basis*
Strategies To Manage PSHB In CoJ

The City of Johannesburg (CoJ) is known to have approximately 10 million trees and there is a greater threat of losing the green canopy.

In order for the City to commit in terms of monetary funds, the number of infected trees need to be quantified. In order to manage PSHB, the following strategies are in place:

- Johannesburg City Parks and Zoo (JCPZ) has established an internal and also multi-stakeholders’ Steering Committee to manage infestation.
- Sterilize pruning equipment after each use.
- Cut down and remove dead trees (W. de Beer, FABI).
- JCPZ designated dumping sites to cut wood for operation and solarisation processes is still under investigation.
- Train staff to identify reproductive host trees.
- Ongoing research and development.
- Mapping and assessing the status quo of PSHB infestation and overall health status of trees planted in public open spaces.
- Collaborative efforts with research institutions such as FABI on how to control the infestation.
- Public participation and awareness drive.
- Risk assessments and control.
- Conducted successful solarisation experiments in Region B in the absence of dumping sites.
- Continuous engagement with stakeholders.
- Commenced with propagation of resistant trees at Huddle Park Nursery.
- Future tree planting plans to consider interplanting strategies to diversify the urban canopy to mitigate against the impacts of monoculture.
- We formed part of the PSHB National Steering Committee spearheaded by Department of Agriculture, Forestry and Fisheries (DAFF).
- JCPZ is part of the PSHB National Working Group.

WHAT ARE KNOWN TREATMENTS?

- There is emergency registered pesticides in South Africa however, it is not known if the chemical can successfully, control PSHB.
- Affected plant material can also be incinerated in a closed oven or kiln.
- Removal and solarisation of dead trees.

Solarisation is an environmental friendly method of using solar energy (sun) for controlling of plant pathogens including fungi, bacteria and insects by covering affected plant material with tarp or transparent plastic cover to trap solar energy.

- Solarisation is a suitable method for handling either infested chips or logs.
- Solar energy will heat plant material until both the beetle and fungi are killed.
- It is mostly suitable during the peak of summer, when temperatures are higher and days are longer, but maybe used during the rest of the year as long as solar exposure, time and space can be committed.

- Solarisation process
  - Use sturdy/strong plastic sheeting/tarp that can withstand rain, wind and UV.
  - Fully contain chips/logs by wrapping plastic both underneath and over the material.
  - During September to February cover chips/logs with sturdy plastic for at least 6 weeks. Temperatures during these months should be regularly above 30°C. Keep log/chip layers as thin as possible (2 logs deep maximum) to ensure even heating throughout the pile.
HOW TO REPORT A SUSPECTED TREE IN A PUBLIC OPEN SPACE

Please report a suspected tree infestation to Johannesburg City Parks and Zoo (JCPZ) on trees@jhbcityparks.com or City of Johannesburg hotline (011) 375 5555. Please report the following information i.e. only public open spaces:

• Your contact information (name, ward, suburb, street name, phone number and e-mail).
• Suspected tree species.
• Description of suspected tree’s location (and/or GPS coordinates).
• Description of suspected tree’s symptoms.
• Photos of suspected trees and close-up photos of symptoms.

Take photos of suspected trees from several angles including:

• The trunk or symptomatic branches.
• The symptoms (close-up) or entry/exit hole, if visible, with a ballpoint pen for scale (remove gumming or exudate if necessary).
• If dieback is observed, include a picture of the entire tree.

Based on the symptom description and photos, JCPZ will determine whether a field assessment is warranted.

WHAT CAN PRIVATE TREE OWNERS DO?

• Owners are advised to solarise and re-use the chipped wood for mulching in their backyard, logs for firewood, etc.
• Owners can engage with private arborists for assistance.
• Never burn wood in an open fire, the beetle will fly off as temperature rises.
• Never apply pesticides on cut wood because it will release toxic fumes when used as firewood.
• Residents may refer to FABI website for more information. https://www.fabinet.up.ac.za/pshb

TREES NOT AFFECTED BY PSHB

It is recommended to plant trees that are not reproductive host trees or are not yet on the list.

NB: JCPZ does not guarantee that trees that are not yet on the list will not be attacked by polyphagous shot hole borer and JCPZ will not be held liable for any damage caused by PSHB on newly planted trees.
Glossary

PSHB
Polyphagus Shot Hole Borer.

JCPZ
Johannesburg City Parks and Zoo.

Solarisation
The process involves covering the ground with a tarp or a heavy duty transparent polyethylene cover to trap solar energy. The sun heats the covered contents to high temperatures that kill bacteria, fungus, insects, nematodes, mites, weeds, and weed seeds.

Incinerator
Is a thermal treatment process that involves the burning of waste organic materials. Incineration of waste materials converts the waste into ash, flue gas and heat.

Frass
It is the mixture of fecal material and plant matter left by an insect after it has drilled into a tree or plant.

Staining
Is a discoloration in wood caused by certain fungus. These stains are often called sap stains because the fungus affect sapwood regions of trees where food and oxygen are found. For appearance grades, blue stain can greatly reduce the value of logs and lumber.

Gumming
Is a sticky substance that oozes out of a tree after experiencing an injury as a defense mechanism.

Dieback
Dieback is a symptom displayed by a tree due to not getting enough nutrients and water caused by fungal strangulation of vascular bundle. Dieback starts with drying of leaves and branches then a tree eventually dies.

Sterilize
It is a process of destroying bacteria or other living microorganisms on a surface to prevent transmission of diseases by use of alcohol, detergent or heat.

Reproductive Host Trees
Host trees in which both the beetle and the fungus establish [thrive], and where the beetle successfully reproduces. In most cases the reproductive hosts will eventually be killed by the fungus.

Non-Reproductive Host Trees
Host trees that are attacked by the beetle and where the fungus establishes, but where the beetle does not successfully breed. The fungus might, or might not cause disease and kill the trees.

Systemic pesticides
Systemic pesticides are chemicals that are actually absorbed by a plant when applied to seeds, soil, or leaves. The chemicals then circulate through the plant’s tissues, killing the insects that feed on them.

Kiln
A thermally insulated chamber, a type of oven, that produces temperatures sufficient to complete some process, such as hardening, drying, or chemical changes.

FABI
Forestry, Agriculture and Biotechnology Institute.
Acknowledgements


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