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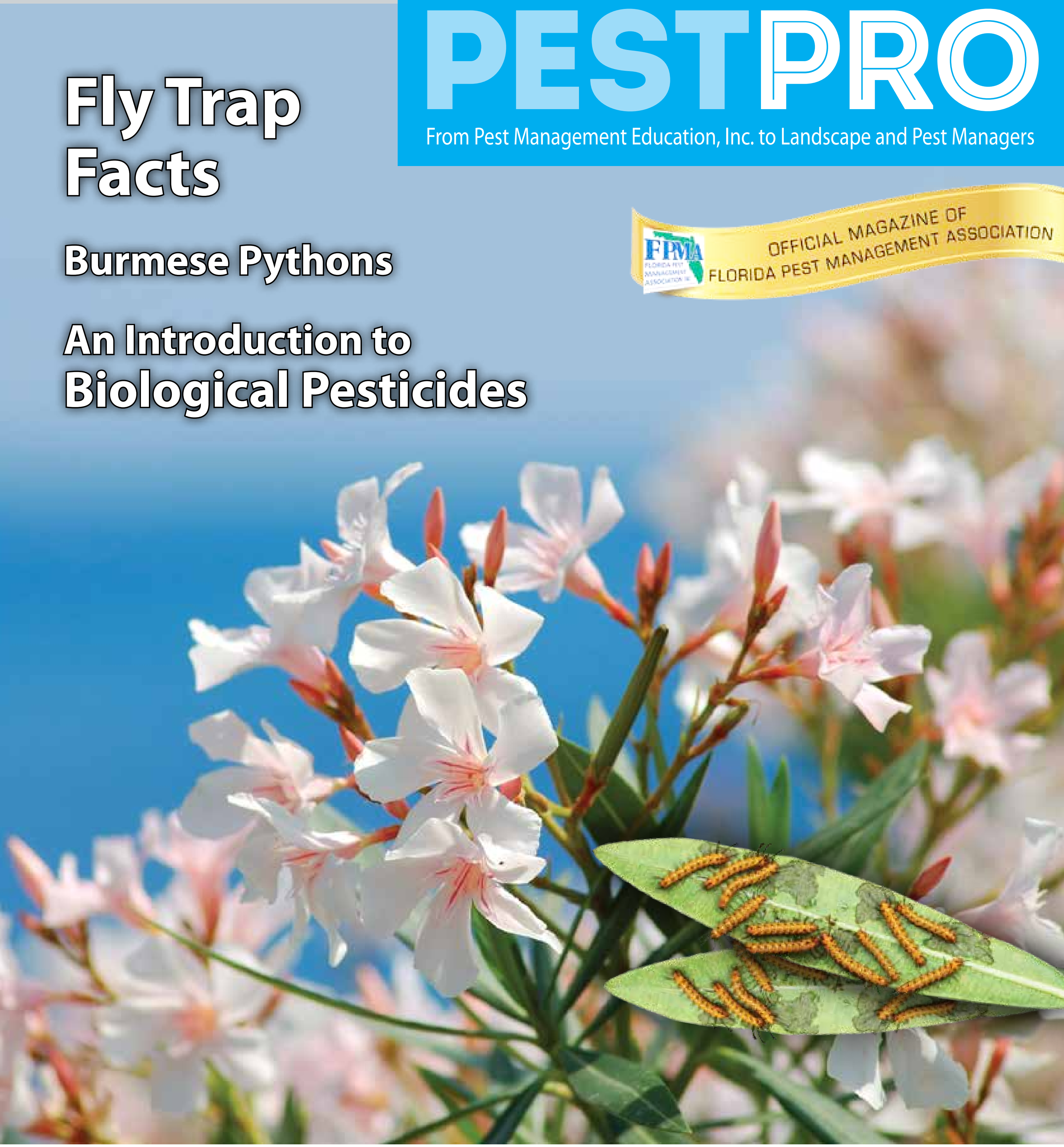
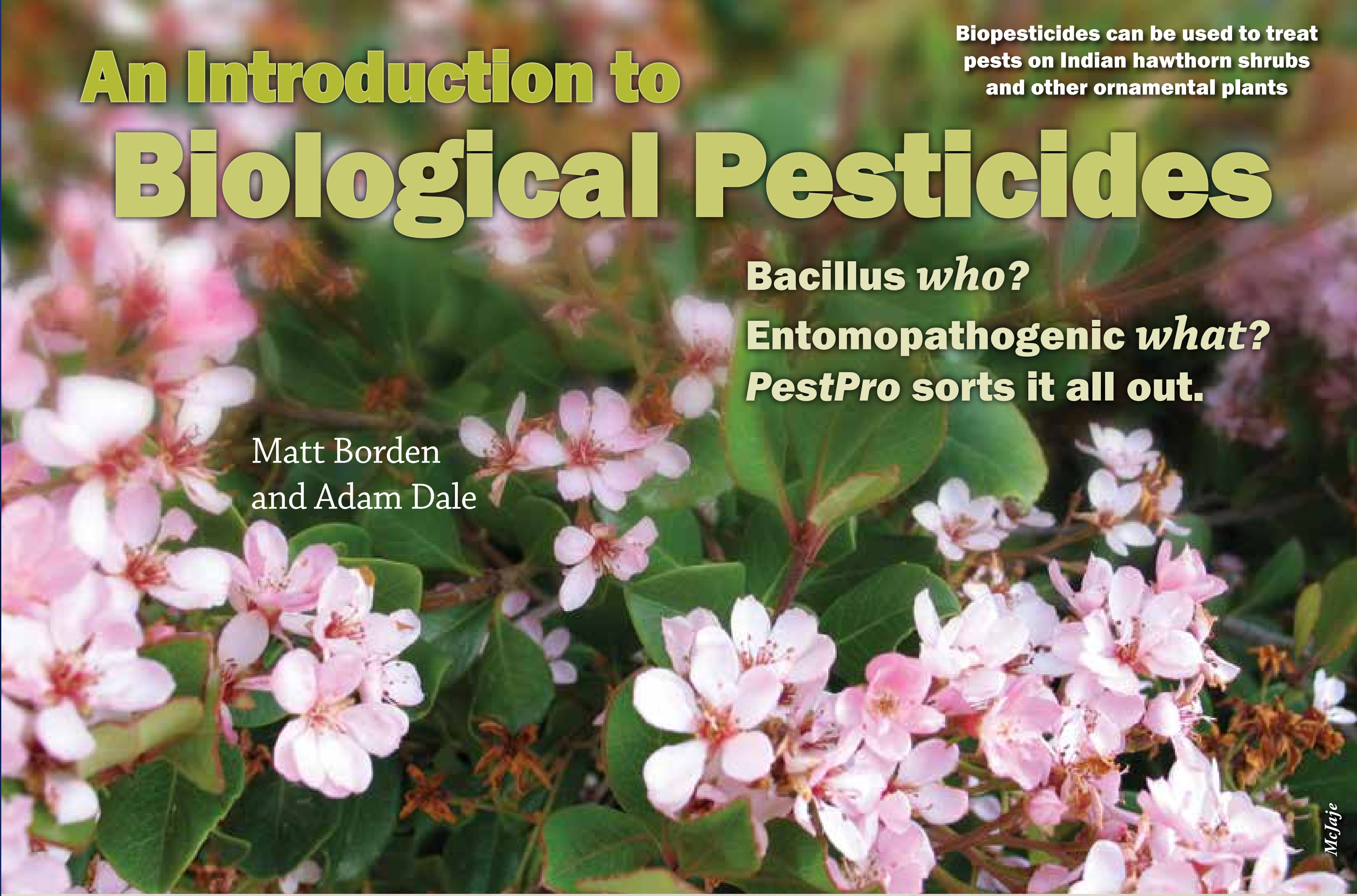


An Introduction to Biological Pesticides

Bacillus *who?*
Entomopathogenic *what?*
***PestPro* sorts it all out.**

Matt Borden
and Adam Dale



Biopesticides can be used to treat pests on Indian hawthorn shrubs and other ornamental plants

During conversations with pest control professionals, county Extension agents, and homeowners throughout Florida and the Southeast, a topic that frequently arises is natural or biological pesticides, also called biopesticides.

PEOPLE are curious about what natural products they can use to effectively and safely reduce pests without some of the constraints or unintended effects of conventional synthetic insecticides. There is a general lack of knowledge about what biopesticides are, options that are commercially available, and how to most effectively use them. However, the number of options is rapidly increasing, and we have found that many of them effectively control key plant pests.

One of the more common and effective forms of biopesticides are microbial insecticides. Microbial insecticides are a category of biopesticides that contain microorganisms like viruses, bacteria, fungi, protozoa or nematodes, or the natural toxins these organisms produce.

Microbials are valued for specifically targeting the pest of concern, with reduced risk to nontarget insects and extremely low risk to humans and the environment. They can be successfully incorporated into programs with conventional insecticides, and may be particularly useful for their short pre-harvest interval (PHI) when managing edible plants.

Some products contain live organisms and may have special requirements — e.g., kept cool, gentle agitation, modified nozzles — while others can be formulated as standard sprays, dusts, liquid drenches, liquid concentrates, wettable powders, or granules.

The more common products, such as *Bacillus thuringiensis*, spinosad, and insect-parasitic (entomopathogenic) nematodes, are readily available, while others can be difficult to find or cost prohibitive. When using microbial insecticides, it is particularly important to understand their specific limitations and strengths.

Bt, or *Bacillus thuringiensis*

Bacillus thuringiensis is a naturally occurring bacterium found in soil, fresh water, and on plant surfaces. *Bt* products are the most commonly used microbial insecticides, with different subspecies available that target specific pest groups without harming other organisms. When an insect feeds on material treated with *Bt*, it becomes activated (toxic) and the bacteria colonizes the insect, causing it to stop feeding and die within a few days. The downside to *Bt* is that it is rapidly broken down by sunlight, which means frequent and properly timed applications may be necessary for some pests.

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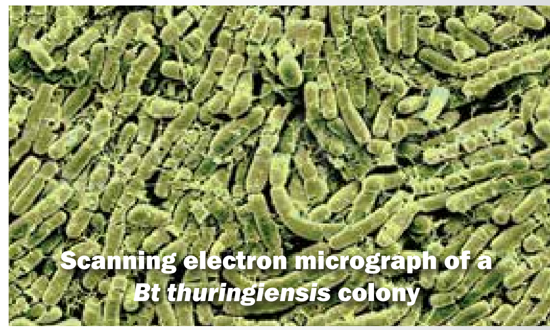

Scanning electron micrograph of a *Bt thuringiensis* colony

Lesser cornstalk borer larvae severely damage unprotected peanut leaves (left) while those feeding on Bt-protected leaves quickly cease feeding, crawl off and die. Photo by Herb Pilcher, USDA–ARS

BEFORE selecting a *Bt* product, it is important to identify the target pest and know which life stage the *Bt* will control. For example, *Bacillus thuringiensis* variety *kurstaki*, or *Btk*, is toxic to caterpillars, but not adult moths. Common caterpillars that *Bt* var. *kurstaki* effectively kills include fall webworm, cabbage looper, bagworm, tomato/tobacco hornworm, and Io and oleander caterpillars.

In recent years, *Bt* varieties have been developed that target other pest groups: fly larvae such as mosquitoes, blackflies, and fungus gnats (*Bacillus thuringiensis* var. *israelensis* [Bti]); wax moth larvae in honeybee hives (*B. thuringiensis* var. *aizawai*); and beetles (*B. thuringiensis* var. *san diego*, *B. thuringiensis* var. *tenebrionis*, and *B. thuringiensis* var. *galleriae*). We recently found that *Bt* var. *galleriae* effectively reduces Sri Lanka weevil damage on hibiscus shrubs. Among homeowners, *Bt* products are especially popular thanks to their efficacy, price and minimal risk to beneficial insects.

Spinosad

One of the most familiar and commonly used microbial products is spinosad, which is also derived from a species of soil bacteria, *Saccharopolyspora spinosa*. Spinosad is relatively broad-spectrum and controls a wider range of pests than other microbials, including caterpillars, leafminers, flies, thrips, beetles and spider mites.

Spinosad attacks the nervous systems of insects that come in contact with or ingest it, stopping feeding within minutes and causing death within two days. When used correctly, it has low-to-moderate toxicity to beneficial organisms, and very low toxicity to mammals and wildlife.

We recently demonstrated that spinosad provides rapid control of chilli thrips on Indian hawthorn shrubs with minimal impacts to its key predators. However, it does not have much residual toxicity and is highly toxic to bees when the spray is wet. Therefore, applications should be made in early morning, late evening, or at night when pollinators are not actively foraging.

Other bacterial insecticides

Chromobacterium subtsugae produces fermentation chemicals that control a broad range of insects and mites, acting as a stomach poison, feeding repellent, and by reducing reproduction. Recent pest control

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Tawny mole cricket infected with Beauveria bassiana fungus. Photo by Lyle Buss, UF/IFAS

Infective nematodes emerge from a dead moth pupa. This nematode species, Heterorhabditis bacteriophora, can attack immature stages of many beetle and moth pests. Photo by Peggy Greb, USDA–ARS

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trials have found that this bacterial product also works well against foliar feeding beetles.

It is soft on beneficial insects and is approved for organic use by the Organic Materials Review Institute, or OMRI, but should still be used carefully to minimize toxic effects to bees, aquatic invertebrates, and soil-dwelling organisms.

Fungi

There are also several insecticides developed from fungi that can provide safe and effective pest control tools. Insect-parasitic fungi thrive in moisture — humidity and rainfall — which favors the germination of fungal spores that penetrate insect bodies and produce toxins that kill the insect. Thus, unlike bacterial and viral pathogens, fungi do not need to be consumed by the insect.

Beauveria bassiana is one of the few fungal products readily available for purchase. This pathogen naturally occurs in soils, and many soil-dwelling insects may be naturally tolerant to it. Commercially available products are therefore labeled for use against foliar-feeding pests such as aphids, thrips, whiteflies, beetles, and spider mites.

On the downside, the fungi must contact the pest for infection to occur, and death may take several days. However, there is an advantage — the mold growing from dead insects provides millions of new spores for further infection.

Insect-parasitic (entomopathogenic) nematodes

Although not truly microbial, these nematodes (roundworms) are used much like microbials and are often referred to as "biopesticides."

Steinernema and *Heterorhabditis* species are common commercially available beneficial nematodes. They infect the soil-dwelling insect host by swimming through the soil and into a host's body where they release bacteria into the insect's blood. The bacteria cause the insect to die within a couple of days.

After reproducing, young nematodes exit the dead insect and search or wait for a new host. Products containing parasitic nematodes have been developed to control white grubs in turfgrasses, as well as root weevil larvae and similar soil-dwelling pests that attack lawn and garden plantings.

They work best in sheltered or undisturbed environments with high moisture levels. Before purchasing insect-parasitic nematodes, it is important to identify both the target pest and the species of nematode because many are host specific.

Explore your options

As various insect plant pests continue to create challenges, it is important to explore the various microbial pest control tools available. This is particularly important as we begin to better understand undesirable effects of our most commonly used conventional insecticides.

Although there are several effective microbial products, they remain underutilized in many plant management areas and resistance management product rotation programs. Despite challenges associated with their use, there are efforts to expand microbial insecticide options and make them more compatible with current practices.

Our recent research has found that multiple products — *Chromobacterium subtsugae*, *Bt* var. *galleriae*, and spinosad —work as well or better than commonly used synthetic products against damaging pests.

As always, the first step is to read the label to learn how and when to apply these products, since local environmental conditions — heat, sunlight, and dry conditions — affect how well they work. Then, explore the options and begin to master their safe and effective use. **PP**

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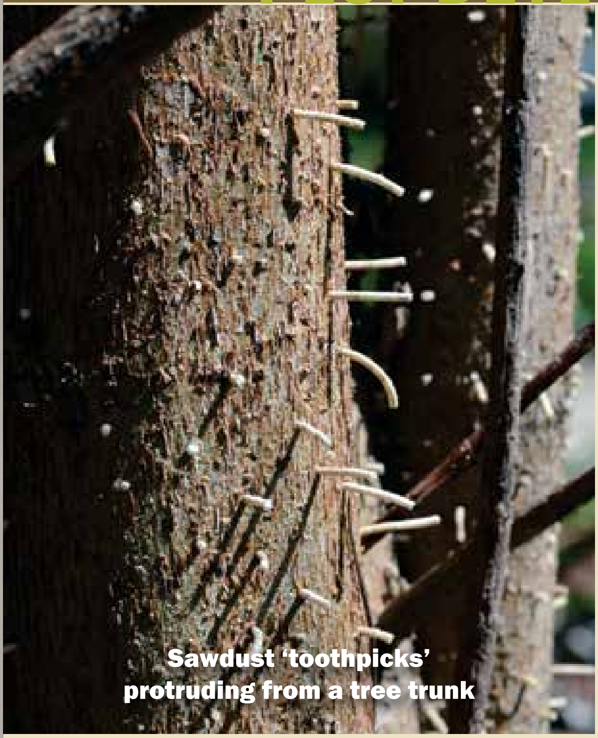

Sawdust 'toothpicks' protruding from a tree trunk

Tunnels in a mango trunk. The ambrosia fungus is black

Granulate ambrosia beetle

Photos by Lyle J. Buss.

Granulate Ambrosia Beetle

Lyle J. Buss

HAVE YOU SEEN any trees that look like they have toothpicks sticking out from their trunks? It may look like a strange prank, but it's actually a sign that ambrosia beetles are attacking!

The "toothpicks" are made of sawdust. When the female beetle attacks a tree, she chews a hole through the bark and tunnels into the wood. She pushes the sawdust out of the hole behind her. Sometimes the sawdust sticks together and may project an inch or more from the bark. These "toothpicks" are fragile and easily broken by wind or rain.

Ambrosia beetles don't feed on the tree itself. The beetle innoculates the sides of the tunnels with an ambrosia fungus. She and her young actually feed on this fungus, not on the wood. The picture above at upper right shows a mango trunk that has been cut open, and you can see the dark fungus growing in all the tunnels.

Many species of ambrosia beetles can cause these sawdust "toothpicks," but the one most commonly responsible is the granulate ambrosia beetle, *Xylosandrus crassiusculus*. It is a very small beetle, only ⅛-inch long. It attacks a very wide range of hardwood trees, shrubs and vines.

Most ambrosia beetles are secondary pests, meaning they are attracted to trees that are stressed, dying or even recently dead. Flooding, drought and construction damage are a few factors that can stress trees, leading to ambrosia beetle attacks. Ambrosia beetles are difficult to control since they bore deep into the wood, where insecticides can't reach. The best management is preventive, keeping trees as healthy as possible so that they aren't attractive to ambrosia beetles. **PP**

Lyle J. Buss, Scientific Photographer, manages the Insect Identification Lab at the UF/IFAS Entomology and Nematology Department.