THE BLACK TWIG BORER: A STUDY OF THE DAMAGE DONE TO UNPROTECTED HAWAIIAN COFFEE

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ABSTRACT

Also known as the coffee twig borer, ambrosia beetle, and *Xylosandrus compactus* Eichhoff, the black twig borer has been found to not only attack coffee, but also over 100 other species of trees and shrubs including avocado, citrus, guava, macadamia, live oak, and several types of orchids. The female beetles bore holes in the branches of the plant and cause a white fungus to grow, and then she lays her eggs on top of this fungus for her young to feed on upon hatching. The hole-boring process causes the branch tips to wilt, turn yellow, and then eventually die. This creates problems for the coffee farmers because the death of these branches reduces the amount of viable crop. They have currently been dealing with the beetles by pruning off all wilting or yellow branches and burning them, but it is questionable as to whether or not this method is effective. The trees are most susceptible during times of drought when they are receiving little water and nutrients and are therefore stressed. However, experimentation has shown that frequent watering and fertilization may be the best strategy for preventing infestation. Why and how are the primary points of investigation, but the life cycle and damage done by the black twig borer are also researched.

INTRODUCTION

The black twig borer, *Xylosandrus compactus* Eichhoff (Coleoptera: Scolytidae), was accidentally introduced to Oahu, Hawaii from Singapore in 1961 (Hara and Sewake 1990; Staples and Cowie 2001; Smith 2003). Although the Hawaiian government placed a ban on the shipment of woody plants from the island, the borer still managed to escape to flourish on each and every one of the Hawaiian Islands. The beetles are thought to be native to Asia, but they have since spread to inhabit parts of French Guinea, East and West Africa, Madagascar, Mauritius, Seychelles, India, Malaysia, Java, Sumatra, and Fiji (Hara and Tenbrink 1994). They have even been found in several places within the continental United States including areas of Florida, Georgia, Alabama, and Louisiana (Hara and Sewake 1990). One of the reasons that these beetles are so abundant in such a huge variety of places is due to the fact that they are so easily adaptable. Although they are limited to the warmer and more tropical zones of the planet, they are known to be able to feed and reproduce in an extremely diverse assortment of trees and shrubs, both commercial and native (Howarth and Mull 1992) besides coffee. Over 100 different kinds of plants in 44 different families serve as host species for *X. compactus* including such plants as avocado, ohia, citrus, guava, Christmasberry, red ginger, macadamia, anthurium (Smith 2003; Hara and Sewake 1990; Hara and Tenbrink 1994), cattleya, dendrobium, epidendrum, vanda, cacao, brushbox, turpentine tree, paper-bark, red-ironbark eucalyptus, blackbutt eucalyptus, robust eucalyptus, koa haole, vervain, litchi, mango, mahogany, hibiscus, kukui, star jasmine, pikake, periwinkle, Surinam cherry (Hara and Sewake 1990; Hara and Tenbrink 1994), dogwood, grape, magnolia, live oak, laurel oak and many others from shade trees to orchids. (Bambara 2001).

Behind petroleum, coffee is the second largest commodity in the world (Steiman 2000). *X. compactus* has had a major impact on the 20 million dollar coffee industry of Hawaii, particularly in Kona (NASS 2003d). It is an industry in which most farms consist of approximately five acres of land (NASS 2003a), if that, which they use for growing pineapples, bananas, taro, jackfruit, and whatever else they find to be worthwhile as well as coffee (*Coffea arabica* L.), and the average age of farmers is 56.6 years (NASS 2003b). Most farms are so small that they can sustain only a small family and a few stray cats, and that's the way they like it. Selling for roughly $20 per pound on the mainland (Steiman 2000), only recently has roasted Kona coffee gained recognition for being a "profitable industry," so profitable that it has attracted a few large companies who have rushed in to purchase huge amounts of land on which to plant coffee and only coffee. The black twig borers have found this to be an extremely advantageous situation and, coupled with the recent drought (Hurley 2003), have been able to reproduce in record numbers. This has created immeasurable devastation for the Kona coffee farmers.

This paper is an attempt to research the depth of the borer damage on the Kona coffee industry with particular emphasis on the control methods which farmers have implemented in an effort to save their crop. Of special interest is the fact that many farmers have discovered that through frequent fertilization and irrigation, they are able to keep their borer damage to a minimum, yet many of the commercial pesticides they have tried are relatively ineffective.

DESCRIPTION AND LIFE CYCLE

Kona coffee (*Coffea arabica* L.) is a shrub-like tree with either a single or multiple stems, although pruning and suckering typically cause it to become a dense bush (Steiman 2000). The bark of the tree is light green-grey with a creamy colored hardwood, and it has leaves that grow in opposite pairs along the thin, horizontal or drooping branches. The leaves are also dark green in color, glossy, elliptical, acuminate-tipped, and short-petioled (Coffea arabica L 1996; Steiman 2000), and they are 10 to15 cm long and about 6 cm wide (Coffea arabica L 1996). The flowers of *C. Arabica* are sweetly scented and white with 5 petals and stamens. The time from blooming to fertilization can take just a few days, but the fruits require between 6 and 8 months to develop and mature. Typically, two seeds, or beans, develop within a single fruit called a cherry. This cherry is ovular with a 10 to 15mm diameter and a length varying between 14 to 18mm, each one weighing about .2 grams (Steiman 2000). In Kona, 84 percent of the trees produce less than 5 lbs of cherry each year, with the other 16 percent producing more than that (NASS 2003c).

The shiny, black female *X. compactus* is a very small (1/16 inch) cylindrical beetle (Bambara 2001) which bores into the thin branches of *C. arabica* leaving pin-sized entry holes (Hara and Tenbrink 1994; Smith 2003). Once inside, they excavate the cavity which takes about 5 to 9 days (Hara and Sewake 1990), and then introduce a fungus called *Fusarium solani* (Martius) Saccardo which produces a white fungal "ambrosia" (Bambara 2001), hence the name “ambrosia beetle.” Females begin to loosely deposit eggs on top of this fungus in the springtime as the weather grows warmer, and she will continue to lay her eggs until the weather cools down again in autumn. An unmated female will produce only male offspring. As well as being smooth, oval, and translucent white, twig borer eggs are extremely small (less than 1 mm long) (Hara and Tenbrink 1994) and will hatch within 3 to 5 days (Hara and Sewake 1990; Hara and Tenbrink 1994). Upon hatching, the white, legless larvae will feed on the ambrosia fungus cultured on the walls of the tunnels and brood chamber (Hara and Sewake 1990; Bambara 2001). There are two larval instars (Hara and Tenbrink 1994). This period lasts for a minimum of 7 days until the larvae pupate (Hara and Sewake 1990; Hara and Tenbrink 1994). The young pupa is white before turning a more light brown color with black wings as it approaches maturity, and this stage lasts as few as 6 days (Hara and Sewake 1990).

The newly emerged adult female remains a light brown color for 3 to 4 days before turning to the usual shiny black (Hara and Sewake 1990). The young adult male also remains light brown, but he turns to a reddish brown color instead and only grows to become half the size of the adult female (Hara and Tenbrink 1994; Smith 2003). Both sexes remain in the chamber for 7 to 9 days, in which time mating occurs. Although the male borers are incapable of flying, the females finally emerge from their galleries after a total of 29 days in search of a new host petiole. She will usually locate a suitable twig and begin to bore into it within 30 minutes (Bambara 2001). The mother beetle remains in the chamber for the entirety of her brood's development (Hara and Sewake 1990).

ASSESSING THE DAMAGE

Although some other members of the Scolytidae family most often attack only dead or dying plants, *X. compactus* can also attack plants that are in fairly good condition but they do indeed show preference for those experiencing stress (Hara and Sewake 1990). Symptoms of twig borer infestation are wilting of the tree's branch tips, leaf yellowing, and the eventual death of the branch (Smith 2003). It may be only natural to question if it is perhaps the young developing beetles feeding on the inside of the petiole which is the real cause of branch dieback, but this has proved false. Studies have shown that the larvae feed solely on the ambrosia fungus provided by their mother and it is actually the drilling of the hole and excavation of the cavity which cause the branch to die (Hara and Tenbrink 1994). Infestations often cause more extreme damage to young trees (Bambara 2001), but even large trees have been victimized and killed by severe outbreaks (Hara and Tenbrink 1994). Researchers from the University of Hawaii College of Tropical Agriculture and Human Resources (UH CTAHR) have discovered that the twig borers can most often be found traveling downhill on a farm. They also observed that infestations are always the harshest during harvest season, especially on trees that have received the least fertilizer and water, and that they are more likely to attack the tree's verticals rather than its lateral branches (Smith 2003).

X. compactus is a major cause of reduced coffee production yields in Kona, Hawaii. Unprocessed *C. arabica* cherries can sell for up to $2.10 per pound (Steiman 2000), but as black twig borers kill off more and more branches, fewer and fewer pounds of cherries are produced, and therefore, the farmer suffers as well. This can be especially devastating to Hawaiian farmers since the general cost of living in Kona can be 35 to 40 percent higher than in other U. S. cities (Living in Hawaii 1997). Rarely does the price of

Kona coffee ever reflect the actual situation. Recently, the $20 per pound price that coffee drinkers pay has remained fairly stable even when the farmers were able to produce much less than in the past (Hurley 2003). It is a common misconception that Kona coffee farmers must be rich since their coffee is often more than twice as expensive as coffee grown in other countries. In reality, the farmers are no better off than coffee farmers in Brazil or Kenya for instance because Kona farmers still have to pay American prices for food and rent which are actually much higher in comparison.

Not only is the damage done by the borers harmful to health of the branches as well as to the pocketbooks of the coffee farmers, it can be harmful to the health of the farmers too. Kona normally receives most of its yearly rainfall during the summer months, but lately Kona has been experiencing a drought (Hurley 2003). This has caused the twig borers to flourish and the coffee pickers to swelter. In the past, the coffee pickers have been able to wear long sleeves to protect their arms from sharp branches, but due to the lack of cloud cover, they can no longer wear the hot protective clothing (without passing out). Since the borers have been taking such an advantage of the weakened coffee tree situation, there are many more dead or dying branches than there would be in an average summer. What the books don't tell you and I have learned only from personal experience is that when a coffee branch dies and becomes dried out and brittle, it turns into a sharp and painful weapon waiting to either scratch off a bit of skin or poke out your eye. So, coffee pickers beware: the black twig borer is your enemy!

CONTROL METHODS

To diminish the black twig borer problem, coffee farmers must always take care to remove and destroy as much beetle-infested plant material as possible (Hara and Tenbrink 1994). Step number one to controlling the black twig borer is to monitor the plants at risk. Susceptible plants should be checked for premature yellowing of the leaves which are the most prominent sign of an infestation (Hara and Sewake 1990; Smith 2003). Once located, the branch should be inspected for pinholes 1/32 inch in diameter (Hara and Sewake 1990). If none are visible, experts suggest that you try gently bending the branch to test for weakness. The petiole will break at the point of entry if it is infested and occasionally you may even see a tiny beetle scurry out (Smith 2003). Most farmers then eliminate the infested material by burying, burning, or simply removing it from the vicinity. If the infested material is not eliminated then it will remain active and could potentially serve as a breeding ground for even more of the borers (Hara and Sewake 1990; Smith 2003).

In an UH CTAHR experiment, researchers removed all of the infected branches from the coffee trees growing on a given plot of land in Kona. They then applied fertilizer once a week through the irrigation system. The researchers were unable to find any more borer damage after a 4 month period of continuing this procedure. Next, they stopped applying fertilizer for just a month and the borers quickly returned (Smith 2003). Based on this experiment and the advice of many experts, the most effective method of control for these insects is to maintain healthy plants. Unfortunately, this is not an easy endeavor for Kona farmers. Water is a very expensive commodity for Hawaiians, and fertilizing coffee plants to the extent required is just not very feasible. Mature trees require a minimum of at least 1,600 pounds of fertilizer for each acre of land every single year (Smith 2003). There are a variety of pesticides and several biological control methods which are semi-recommended by professionals, but it is debatable as to whether or not they are effective.

One pesticide suggestion is chlorpyrifos (Bambara 2001; Hara and Tenbrink 1994), one of the most-widely used active ingredients for pest control products in the world (Dow AgroSciences 1998). According to some, Chlorpyrifos is 100 percent effective on adult females of *X. compactus* (Hara and Tenbrink 1994). Unfortunately, information regarding this statement is unavailable and so we cannot ascertain as to whether or not their method of application is feasible either. However, we do know that chlorpyrifos is one of the most effective pesticides used today to eliminate over 250 species of insect. It is an organophosphate insecticide which means that like other organophosphates, it is an acetylcholinesterase inhibitor resulting in excessive transmission of nerve impulses and eventual death of the insect (Dow AgroSciences 1998).

X. compactus has also been controlled in India through use of an insecticide called monocrotophos (Davis and Dute 1997). Aside from being banned from use in the United States in 1989 (Monocrotophos 1995), monocrotophos is another organophosphate but it is much more highly toxic than chlorpyrifos (Monocrotophos 1995; Pesticide information profiles 1995; Pesticide News 1997). It is extremely poisonous to birds, mammals, and is used especially to control a variety of sucking, chewing, and boring insects and spider mites. In fact, the Environmental Protection Agency (EPA) classifies monocrotophos as having a class I toxicity, meaning highly toxic (Pesticide information profiles 1995). It is remarkably lethal when ingested orally, as well by inhalation or absorption through the skin. Just to name a few, symptoms of poisoning may include excessive sweating, headache, weakness, giddiness, nausea, vomiting, hyper salivation, abdominal cramps, diarrhea, blurred vision, and slurred speech (Monocrotophos 1995). Luckily for the twig borer, Hawaiians will not be using this pesticide any time soon, although it is does sound like monocrotophos could be a very effective weapon.

Since there are no known definite chemical insecticides, farmers have experimented with a variety of more natural controls. Some have even reported limited success with using products made from neem tree oil; however, there is no conclusive literature to be found on the subject just yet (Smith 2003). There are also a few potential biological twig borer controllers yet to be investigated. For instance, it is known that the black twig borer is parasitized by at least one species of eulophid wasp of the genus Tetrastichus. Nine species of Tetrastichus have been introduced to Hawaii (either accidentally or on purpose), but no one has any record of the wasps parasitizing the twig borers. In the 1960s, three different species of braconid wasps were officially introduced by the Hawaii Department of Agriculture, but none of them became permanently established (Hara and Tenbrink 1994). As far as I could research, no other more natural methods of control are known to act effectively against *X. compactus*. In fact, as mentioned above, few methods are known to act effectively at all (aside from the water/fertilizer method). In reality, black twig borers are just extremely difficult insects to control. The fact that they hide within the host tree and rarely emerge except to find a new host creates a sort of barrier between beetle and chemical. Therefore, insecticides would need to be applied to the tree prior to the borer's arrival and have long residual activity in order for any dent to be made whatsoever (Oliver and Mannion 2001).

DISCUSSION

When it comes to the black twig borer, a lot more research is needed. For instance, no one is really sure exactly how much damage the borers cause each year. If perhaps there was some more statistical data available on the subject, people would realize just how big of a problem the borers create. Information particularly pertaining to how much money is lost to the insects would be especially helpful because perhaps then the attention of the government might be attracted and the proper researching funds could be made available. As of right now, the only truly effective strategy that we know of is to keep the coffee trees well fertilized and to irrigate frequently to prevent infestation. Other cultivation practices such as mulching or adding organic matter for moisture conserving purposes could also be worth a try. The thing is… coffee has been an integral part of human culture for longer than we can imagine. Many people consume at least a single cup of coffee each and every day. In the U.S., we have lovingly christened it with names like "Joe" and yet we still don't know how to properly protect it from the tiniest insects. In my opinion, further studies should be conducted in the area of biological control, especially involving the parasitizing wasps. Farmers may not always be able to count on the rainy season's eventual arrival. There happened to be a drought this year, but what if weather patterns are beginning to change permanently and in the not so distant future Kona will no longer be able to support a coffee industry? In that case, would it be best to just not bother with more in-depth researching for a dying industry, or should we make the effort now to prolong the industry's lifespan? Despite the lack of information, the black twig borer exhibits an extremely interesting relationship between plant and animal. One in which the animal is so exceptionally adaptable that there is hardly a plant whose power can match it.

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