Why is your cup of coffee so expensive? Because of a tiny bark beetle![1]

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Introduction

Sometimes an insect pest attacking crops in places as far away as Indonesia or Ethiopia can be very important to us here in Florida. One such insect is the coffee berry borer, *Hypothenemus hampei* Ferrari (Coleoptera: Curculionidae: Scolytinae), a tiny (1.5 mm) bark beetle that originated in the highlands of central Africa. It would probably remain one of the many inconspicuous little beetles in the tropics, if not for the choice of its host: seeds of several *Coffea* species.

Figure 1. A family of the coffee berry borer *Hypothenemus hampei* (adults and pupae) and their coffee bean.
Credits: Jiri Hulcr, UF/IFAS

Invasion Status and Control

After the joy of coffee was discovered by humans, the beetle's host was planted on a massive scale worldwide. The coffee berry borer followed the crop to new areas and soon invaded nearly every coffee-growing region in the world. The beetle destroys coffee beans before the farmers can harvest them, and it is causing up to $500 million damage annually. In areas without intensive management, the beetle can destroy up to 80% of coffee production (Jaramillo et al. 2011).

Until 2010, the beetle was still officially absent from one of the most remote coffee growing places on Earth: Hawaii. That changed after a large infestation was discovered in Kona, Hawaii in 2010. The beetle problem has exploded there, and now Kona is under an official USDA-imposed quarantine, which makes coffee export from Kona very difficult.

The problem is that there are very few options for control of the coffee berry borer. How could farmers control an insect that spends almost its entire life inside a berry, protected from pesticides and natural enemies? Currently the only practical management option is to be very vigilant about the cleanliness of a coffee plantation, and to remove as many of the infested berries as possible during harvest.

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Biology

The coffee berry borer is undoubtedly bad news for the world's coffee farmers and coffee lovers, but for a biologist, it is a delightfully bizarre creature. For example, its sexual life is entirely a family affair. The beetle is so small that a whole family develops in a single coffee bean. The beetle mother creates a small cavity ("gallery") in the bean and lays eggs. Most of the eggs are fertilized and diploid, with two copies of each gene, one from mom and one from dad, just like most other animals including people. But one egg is haploid—it has only one copy of each gene. From this egg, the mother somehow eliminated the father's genetic contribution. (Scientists are not sure how that happens; perhaps it is facilitated by the internal bacterium *Wolbachia*. This parasitic bacterium is ubiquitous in the reproductive tracts of many insects and is known to influence sex ratio of eggs.) This one haploid egg produces a male, whereas all the other diploid eggs produce females. When mature, the male is dwarfed, flightless, and barely able to walk. His only goal in life is to fertilize all the females in the gallery, his sisters. The male then usually dies in the bean, and it's the sisters, much stronger and with wings, that fly out into the world to find their own coffee beans.

This type of reproduction, which also occurs in the varroa mite that attacks honey bees, is called pseudoarrhenotokous parthenogenesis. It is similar to, but not the same as, the haplo-diploidy of ants, bees and some other bark beetles. In these insects, the male eggs remain haploid because they never got fertilized, not because the father's genome is eliminated. Biology textbooks teach us that repeated inbreeding fills the genome with detrimental mutations, which can lead to sick progeny. Yet, the coffee berry borer and species related to it have been inbreeding for millions of years. How did they avoid the accumulation of bad mutations? Nobody knows.

Classification

Notice that despite its classification as a "bark beetle," the coffee berry borer actually lives in seeds. This is a good example of the tremendous diversity of life history strategies that have evolved in the bark beetles. Although many of the 6000 species do live in the bark and phloem of trees, hundreds of others are seed specialists, or live inside herbs, and nearly half are fungus farmers; those are called ambrosia beetles.

Symbiotic Associates

It is a common habit of many bark beetle species to be accompanied by fungal symbionts: fungi that provide some services to the beetle in exchange for transport between trees. The coffee berry borer is frequently associated with a species of *Fusarium* and several yeasts. It is not clear, however, whether these are *mutualistic symbionts*—organisms that help one another, in this case possibly by supplementing the beetle's nutrition—or just *commensal symbionts*—hitch-hikers that take advantage of the beetle's transport between beans but don't return the favor by helping the beetle out. It was hypothesized that the fungi might help the beetle mitigate the threat of caffeine, but this was recently found not true—the fungi do not degrade caffeine to any significant degree, so the beetle does not live in decaf beans.

The Future of Coffee

The coffee berry borer is just one of many examples of how we humans "make" our own pests. Better research, quarantine, and compliance with international rules could have spared the world from this increasingly important pest against which there is very little defense. What is worse, it seems that the current rising global temperatures will be beneficial to this insect. Many coffee production areas are in high-altitude regions of the tropics that have been historically too cool for the beetle to develop. That has already changed in many montane regions throughout Indonesia, Africa and South America that have been previously protected from the beetle by low temperatures but have warmed up significantly in the past two or three decades (Jaramillo et al. 2011). Because of higher average temperatures, the pest can now produce up to two generations per year in regions where previously it was unable to complete even one!

Why does the coffee berry borer matter to you?

The coffee berry borer, as well as many other pests and diseases of the world, impact us indirectly by increasing the price of food and other commodities that we buy. Many coffee growers, especially in poor tropical regions, do not have the resources to manage the coffee berry borer and consequently may lose up to 80% of their berries. In some cases, even if most berries are still un-infested, the whole crop may not be sellable because current regulations prohibit the export and import of coffee batches with any signs of infestation. Thus, your morning latte is now a

bit more expensive, but this way you are supporting the farmers who do manage the beetle on their farms.

It has not yet been calculated how much cheaper your espresso would be without the global spread of this pest. The estimate of $500 million in damages every year seems minor compared to the coffee trade volume ($57 billion a year in the United States), but that is not the whole story—it only accounts for recorded damage. The real damage is in the amount of coffee beans that will never be harvested because of this little beetle. And that would be huge.

Acknowledgement

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Reference

Jaramillo, J., E. Muchugu, F. E. Vega, A. Davis, C. Borgemeister, A. Chabi-Olaye. 2011. "Some Like It Hot: The Influence and Implications of Climate Change on Coffee Berry Borer (Hypothenemus hampei) and Coffee Production in East Africa." *PLoS ONE* 6(9): e24528.