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20 IS PLENTY: THE MOST INFAMOUS OF THE INVASIVE SPECIES

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Giancarlo V. Maddaloni

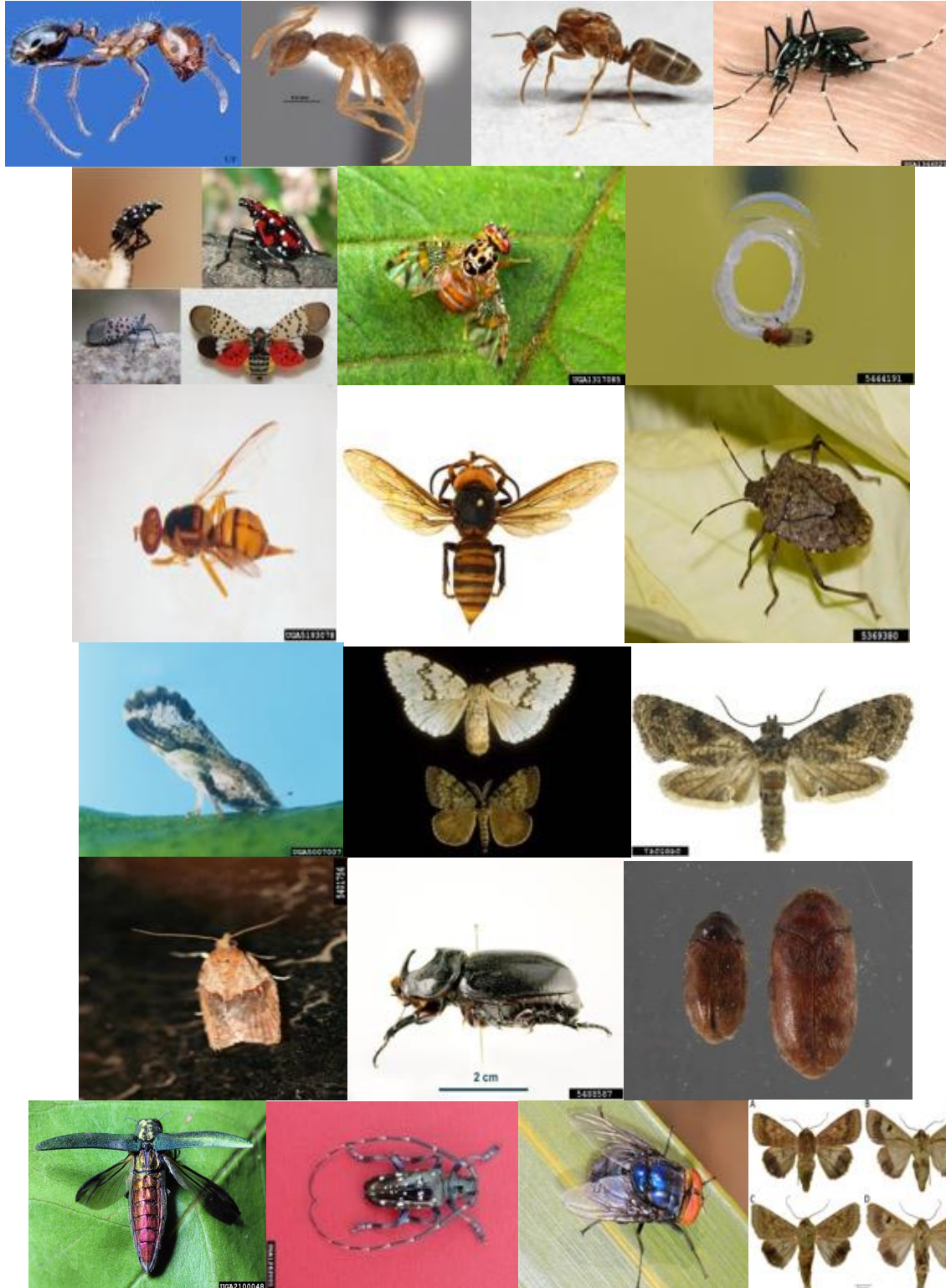
This informational resource was created to assist the general public in learning about the importance of invasive insects and provide help in identifying some of the most dangerous among them. This guide will also provide current information about prevention and control of these insects along with what high risk items travelers should be careful of returning with from abroad to control the spread of these pests. This resource also covers inter-state as well as intra-state pests of concern, illustrating the importance of adhering to quarantine guidelines while traveling through these regions. Whether or not this pest has become established, it is important for the public to be aware of their impact on controlling the spread of these extremely dangerous organisms. The effects these insects can have on the economy, human health and quality of life, can directly impact each and every one of us in some way.

The pests listed contain their common name, scientific name, and sometimes an applicable abbreviation. These abbreviations are the ones often used by the United States Department of Agriculture (USDA), and are utilized in this resource for the sake of brevity and familiarity. This guide is written in an easy to understand and pleasant to read format, which is often difficult to find when trying to find out more about these pests in one centralized location.

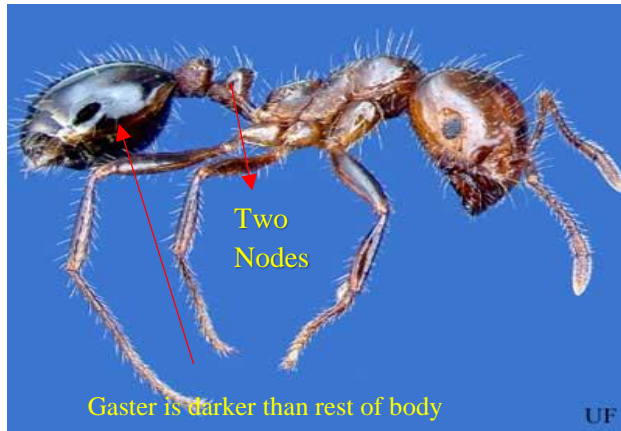
Each of us have the power to drastically minimize, if not eliminate, the risk of introducing one of these dangerous pests to other areas. One individual makes a difference, no matter how small the pest, because sometimes, it literally only takes one...and it's done!

20

IS PLENTY: THE MOST INFAMOUS OF THE INVASIVE SPECIES



RED IMPORTED FIRE ANT (*Solenopsis invicta*)



Adult Fire Ant Worker
Photo by David Almquist, University of Florida



Fire Ant Mound
Photo by Erich G. Vallery, USDA Forest Service - SRS-4552, Bugwood.org

Solenopsis invicta, commonly known as the Red Imported Fire Ant (**RIFA**), is thought to have been accidentally introduced into the United States in between 1933 and 1945, into either Mobile, Alabama, or Pensacola, Florida (Collins and Scheffrahn, 2001), more than likely from soil used as ship ballast originating from South America. Since its unfortunate introduction, this invasive ant has spread from Alabama, throughout the South Eastern United States as well as California and Puerto Rico.

Appearance: Adult workers which are the most common sighting, are, as their name implies, reddish brown in color, with the gaster being noticeably darker than the rest of its body, varying in size from 3-6mm long. Unlike other ants that may be similar in coloration and size, the RIFA has a long stinger protruding from its abdomen and have ten segmented antennae. These ants also have two nodes between its “waist” and abdomen. The RIFA is notably aggressive, and they do not hesitate to attack both humans and animals if one was to enter their territory or disturb them.

Biology: This ant lives in immense colonies, sometimes numbering up to 500,000 ants. Once the colonies become too large, multiple queens that are inhabiting the same colony venture out to start other separate colonies. Also, winged reproductives take flight multiple times during the year to start new colonies as well. The RIFA feed on both living and dead insects, plants, seeds, carrion and honeydew secretions of other insects, such as aphids.

Habitat: The RIFA is known to scavenge inside homes, feeding on sugars/starches. This ant prefers open and sunny locations for its nesting site, such as fields and lawns where water is nearby. During the peak of the summer season, colonies may migrate closer to houses/buildings and become pests by feeding on food stuffs within these locations.

Associated Problems: Painful burning bite (hence the “fire” in their name), toxic venom from stings cause painful swelling, rash, itching at bite site, as well as welts and pustules. Worst case scenario is that the stings could potentially lead to death due to anaphylaxis reaction.

Agricultural settings, such as farms/fields could be become nesting sites, which are dome-like in appearance, and can get up to 12 inches in height and up to two feet wide. These nests can damage farm equipment but can also be sources of attack on humans, cattle, as well as other livestock. Nests have also been found between walls inside buildings, basements and beneath carpets. The RIFA can also wreak havoc with electrical equipment when they decide to nest in such things as transformers, and traffic light control boxes.

High Risk Commodities: The RIFA can hitchhike on various items, such as nursery stock, hay bales, soil, farm equipment or winged reproductives may simply catch a ride long distances on an automobile. Being cognizant of items that one is transporting to another location is one simple remedy, especially in established RIFA quarantine areas.

Control Measures: The RIFA is notoriously difficult to control. Exclusion in human habitations is the best option. This can be done with proper housekeeping; keeping food scraps and even pet food inaccessible can prevent an infestation. Oftentimes people try to flood nests, but this does not kill the ants as they are able to float by forming rafts. Destroying the queen is the only way to kill a colony, which is very difficult due to the queen being deep in the nest. Chemical control methods work better than mechanical approaches, such as destroying mounds, which can often disperse the colony around more. Using chemicals that soak through deep into the mounds will be more efficient in reaching the queen, thus destroying the population. Travelers coming from RIFA states should not transport soil or plant material into a non-RIFA area to limit the spread of this invasive pest. Travelers should also check any vehicles after coming from these regions to detect any hitchhiking RIFA that could present.

Raspberry Crazy Ant or Tawny Crazy Ant

(*Nylanderia fulva*)



Raspberry Crazy Ant Worker

Photo by Joe A. MacGown, Mississippi Entomological Museum



Crazy Ant activity in wall outlet

Photo by Bill McCullough

The Crazy Ant moniker does not come from this ant's psychopathy or its penchant for raspberries but, but from its erratic movements which appear, to the casual observer, to make no apparent sense. The Raspberry aspect of the name is from the surname of exterminator Tom Raspberry that first noticed these new ants which were infesting a hospital in Texas in 2002. The crazy ant has spread faster than the Red Imported Fire Ant (RIFA) which is alarming since these ants are an extreme nuisance in homes and these ants also have a fondness for infiltrating electronics. These ants are so insidious and have such extreme population sizes that in some areas, they have out even competed fire ants. In fact, according to researchers, crazy ants are more disruptive due to their unpredictable nesting areas and behavior in comparison to the RIFA which arrived many years before and in fact, in large populations of Raspberry Crazy Ants can displace even the dominant RIFA (LeBrun et al. 2013). This illustrates the tenacity and invasiveness of this ant which is currently found in Florida, Texas, Georgia, Mississippi, and Louisiana.

Appearance: This ant is small, approximately 2-2.7mm long, glossy, almost glass-like in appearance and uniformly golden to reddish brown in coloration, with long white/gray setae (hairs) over its body along with long legs. The queen is the same coloration but is noticeably large, at about 4 mm long. The antennae are also very long with twelve segments, with the first antennal segment nearly twice the length of its head. Unlike the RIFA, the crazy Ant has only one node between its waist and abdomen. At the end of the abdomen where a stinger would seem to be, this ant has a what appears to be a tuft of dense hair in a circular formation known as an acidopore, from which formic acid is released. The formic acid is used to counteract the effects of fire ant venom, which illustrates how hardy and resilient this invasive species is, especially against such a vicious foe.

Biology: The Raspberry crazy ants expand their territory by a process known as “budding”, which is where a queen and workers leave a colony to start another near the original colony, whereby increasing the size and spread of this invasive ant’s domain. Although the crazy ant has an occasional winged reproductive class, there have not been any mating flights witnessed in the wild. Massive populations result due to this budding process, which spread these ants on average up to 95 ft. a month in urban/ industrial settings and 65 ft. in rural environments (Nester and Puckett, 2015).

Habitat: Unfortunately, the Raspberry crazy ant does not require a certain environment to flourish, as it seems to adapt effortlessly to anywhere it goes, including homes, gardens and even electronics. They are known to feed on honeydew excretions from plant feeding insects, which they in turn offer protection to, and are also comfortable invading homes for sources of food as well.

Associated Problems: Due to the unpredictable and varied nesting behavior of this ant, it seems to be as comfortable making a nest in a flowerpot as it is making one inside the walls of a home or just about anywhere, making it a severe nuisance. Compounding this concern is the fact that the Raspberry Crazy Ant seems to be attracted to electronics, and large amounts of them congregating through circuit breakers and equipment can cause electrical shortages. Once these ants have established numerous colonies, control is extremely difficult due to their tenacious foraging and immense population sizes located in one area. Native animal populations and livestock could also be affected by the crazy ant because of their ability to bite.

High Risk Commodities: Although these ants spread relatively slowly through their establishment of “budding” colonies, humans are the true transporter of these invasive ants, who can hitch a ride on a vehicle, plant material or pretty much anything. Inspecting items or treating them before they are moved to a new area is pivotal to curtailing the expanding territory of this invasive ant.

Control Measures: Keeping property clean from debris and unnecessary clutter that could provide nesting sites for this ant is important. The Raspberry Crazy Ant tends to prefer more moist and humid habitats, so controlling moisture availability, such as through watering schedules for lawns can also limit the attractiveness of an area for nesting. Unlike other ants, baits do not tend to be effective methods of control. Chemical “buffer zones” can be used to protect a building from these ants temporarily, but without cleaning these areas routinely, the massive quantities of accumulating dead ants over time form a bridge that other ants use to cross the buffer zone, keeping them separated from coming into contact with the chemicals.

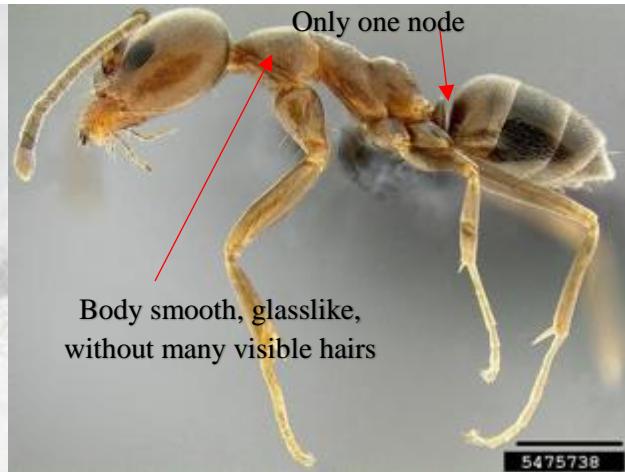
Argentine Ant (*Linepithema humile*)



Queen is much bigger and has an enlarged thorax

Argentine ant Queen

This photo by Michael A. Seymour in the fall 2007 issue of *Louisiana Agriculture*, which is published by the Louisiana State University AgCenter, Baton Rouge, La., is used with permission.



Only one node
Body smooth, glasslike,
without many visible hairs

Adult Argentine Ant

Eli Sarnat, PIAkey: Invasive Ants of the Pacific Islands, USDA APHIS PPQ, Bugwood.org

The Argentine Ant, as its name would convey, originates from South America, in particular Argentina, Brazil, Paraguay and Uruguay. It is believed that this ant has been in the United States since 1891, making entry through the port of Louisiana. The invasiveness of this ant cannot be underestimated, and this is tied specifically to its biology. Unlike most ant colonies that have only one queen at a time, an Argentine Ant colony is polygynous, meaning that there is more than one reproductive queen in a nest at any time. The ability to have more than one queen in a nest allows this ant to form massive colonies, that once they become established, control is almost impossible. This reproductive potential has allowed the Argentine ant to spread to almost every continent in the world. Though this ant is not known for a painful bite or sting, its invasiveness and attraction to human dwellings make it a formidable pest. The Argentine ant is established in the Southeastern United States, westward to California, Oregon, and Washington.

Appearance: Argentine ant workers all look the same, and are light to dark brown in coloration, approximately 2-3 mm in length. This ant is smooth in appearance with not many visible hairs present on its body. There is a single node between the abdomen and thorax that is distinctly erect. Queen ants are noticeably bigger, with an enlarged thorax region in comparison with a worker. When these ants are crushed, they release a distinctly musty scent.

Biology: As previously stated, Argentine ant colonies become immense due to their ability to have multiple queens present and these ants also exhibit a trait known as uniclonality. Uniclonality means that when separate nests are started by workers and queens, these new colonies work together and do not waste energy fighting the other established colonies, which means they can become larger and more robust forming super-colonies, which can spread for hundreds of miles! However, these cordial manners are only reserved for their ilk, and they are noted for their extreme aggression towards other ant species and are known to eat many native

animals such as baby chicks and their eggs. These ants also have a sweet tooth and are noted for their tenaciousness and extreme numbers when infestations of homes occur.

Habitat: The Argentine ants' nesting locations are ubiquitous, ranging from open areas in grass, sidewalk cracks as well as underneath buildings. Their nests are notably shallow in construction, and these ants are more mobile than most, capable of moving quite their nests quite readily, making control even more difficult.

Associated Problems: Like many other invasive ants, the Argentine ant also provides protection to other pest insects that they receive honeydew as a reward from, including aphids and scale insects. The protection of these pest insects by Argentine ants can cause their populations to increase leading to agricultural concerns from home gardens to commercial operations. The incredible population sizes of colonies due to multiple queens and cooperation among newly formed colonies disrupts local populations of birds, lizards and even plants, due to this invasive ants' lack of seed dispersal behavior, which is common in native ant species.

High Risk Commodities: Though there is not a particular commodity that is affected by this ant, residential and commercial buildings in their path provide a myriad of nesting spots and food sources. This exploitative behavior, mobile nesting capability, and multiple queens in a colony, make for a formidable and extremely difficult to control invasive species. Native or endangered wildlife including beneficial ant species are outcompeted by this "tramp" species and as such, they alter food webs, ecological niches and biodiversity.

Control Measures: Inspection of shipments for these hitchhiking ants in potted plants and any other commodity can prevent the spread of it into new areas. Once populations are established, the normal "apply a poison" control measures that are used for other ant pest species, do not work on the Argentine ant, and control requires a more focused approach. If insecticides are directly applied to nest, the members are likely to disperse, along with their multiple queens, and increase their spread even more, which is the opposite effect of what was intended. Cultural controls such as eliminating leaf litter and clutter around a property can limit nesting locations for this ant. Delayed toxins, where the ants bring the poison back to their nest are the most effective but may require many continued treatments due to the massiveness of their colonies and the multiple queens present. Travelers should avoid any bringing any plant material or soil originating from Argentine ants' countries.

Asian Tiger Mosquito (*Aedes albopictus*)



Female Adult Asian Tiger Mosquito
Photo by Susan Ellis, Bugwood.org



Asian Tiger Mosquito Larva, also called a "wiggler"
Photo by Michele M. Cutwa, University of Florida

Asian tiger mosquito, named for its black and white striped color pattern, was first discovered in 1985 in Houston, Texas and in this relatively short time period, it now is present in 40 states, and also the District of Columbia. This mosquito was introduced on tires that originated from Asia, and this is illustrative of how little water this mosquito needs to complete its life cycle, which is one its behaviors that makes it such an invasive pest. In urban environments, this mosquito is able to flourish and reproduce at ease, making use of flooded storm gutters, flowerpots with standing water, or pretty much just about anywhere. In addition to its ability to take advantage of any urban environment, this mosquito is aggressive and relentlessly follows its hosts, which is us, into transportation including busses, cars etc., which intensifies its spread to wherever humans are to be found.

Appearance: The Asian tiger mosquito has black and white markings over its body and legs, there is a distinct white line that goes from the top of the head down the length body to the wings. The legs are conspicuously banded in an alternating black and white color scheme. The adult mosquito quite small, approximately 3-10 mm in length.

Biology: This mosquito can lay its eggs in extremely small quantities of water, unlike most other mosquitoes that use larger bodies of water, for example, marshes or ponds. The eggs are laid above the water level in a container, and once the water reaches the eggs, they hatch into larvae, which are extremely active swimmers also known as "wigglers", that consume small organic materials, such as algae or fungi. The pupal stage of this insect does not feed and remains just below the surface of the water. The pupal stage is called "tumblers" due to their defensive reaction to stimuli or a threat, where they submerge, or "tumble", to the bottom of the water until they deem it safe to return again to the surface. This life cycle can occur in under 14 days from the egg hatching to the adult emerging.

Habitat: The Asian tiger mosquito is at home around anywhere that humans reside. This mosquito, unlike others which tend to fly at dusk and the evening, is a day flyer, making it much more annoying to people working in yards in rural areas to people walking around in a city.

Along with these somewhat atypical behaviors in comparison with other mosquitoes, the Asian tiger mosquito is aggressive in its feeding habits, making escape from them quite difficult when encountered.

Associated Problems: Not only is this mosquito aggressive in its feeding habits, it can also transmit multiple diseases that are not only excruciatingly debilitating but can be fatal. The diseases the Asian tiger mosquito can spread are Dengue, Chikungunya and Zika, St. Louis Encephalitis (SLE) and western equine Encephalomyelitis (WEE).

High Risk Commodities: This mosquito was transported on shipments of tires from Asia, which means that any object capable of holding standing water is a risk. Keeping cargo dry and free from standing water will definitely mitigate the introduction of this mosquito to different areas where it is currently not been introduced to. This mosquito is extremely good at hitchhiking and is capable of following people into various transportation conveyances including cars, buses and even planes. Increased vigilance of this insect in such environments could help hamper its spread as well.

Control Measures: This mosquito arrived in small amounts of water in tires from overseas, so it is easy to make the connection that any container that is capable of holding water can be used for the Asian tiger mosquito to perpetuate itself. Keeping yards and communities free from clutter and allowing proper drainage of storm drains and gutters can keep populations under control. Since this mosquito is a day flyer, the use of the usual evening municipal insecticidal treatment programs is not practical or effective in controlling the Asian tiger mosquito.

Spotted Lantern Fly (*Lycorma delicatula*)



Pictures 1. &2. are immature stages, picture 3. is an adult with wings at rest, picture 4. is adult showing open wings and Photos by Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org

Spotted Lanternfly egg mass

Pennsylvania Department of Agriculture, Bugwood.org

The Spotted Lanternfly is an unmistakable, strikingly colorful, unusual and completely alien looking insect that is even stranger in appearance as far as other unusual insects are concerned. This is a new invader to the United States with the first discovery of it occurring in Pennsylvania in 2014. This insect is a pest on many fruits, vegetables as well as trees. The Spotted Lanternfly feeds on the sap of its plant host, severely weakening and even killing it in the process. The wide host range of this insect along with the lack of natural enemies, makes it a formidable pest that will cause millions of dollars in damage if it becomes established. The lack of natural enemies of a new invasive pest allows it to go about its destructive ways unaffected. Adding to this concern of the Spotted Lanternfly is that another invasive organism, a plant known as the tree of heaven (*Ailanthus altissima*), also present in the U.S., which may be assisting in the spread of this dangerous pest. The tree of heaven seems to be the preferred host of the Spotted Lanternfly, and because of this, the insect can continue to have a source of food and shelter to perpetuate its lifecycle and spread.

Appearance: The Spotted Lanternfly, unlike its name implies, does not look like a fly, nor is it related to flies, or even a strong flier, but is what is known as a plant hopper. As an adult, this insect has two very distinct looks. With its wings closed, it is gray with black dots on its outer pair of wings which are folded tent-like over its body when at rest. A muted reddish hue is barely visible through these outer wings and at the tips of the wings is a mottled black net-like pattern. When the insect opens its wings, the lower pair of wings are then exposed as well as its abdomen, which include vibrant red and yellow colors with black polka dots, which is almost startling at first sight. The head of the insect is elongated, flattened and black in color, as is the remainder of its legs and body. The immature stages of this insect go through four growth stages, known as instars, where they get larger as they progress towards the adult stage. These are miniature wingless versions of the adult which start off black with white spots during the first three instars and during the fourth they become red with white spots. Following the fourth instar, the insect develops wings and takes on its telltale form as previously described.

Biology: The Spotted Lanternfly begins its lifecycle as an egg laid around late summer to fall, which are laid in masses on trees, plants, and even manmade structures, and resemble something akin to a smear of dried grayish putty. Each egg mass can contain up to 50 of these destructive insects. In the spring, the newly hatched nymphs begin to search out a suitable plant host, much often the tree of heaven, although it has a very wide host range. By early summer, the once immature insects have now become adults, and they are often found on their favorite host, the tree of heaven, however, many other hosts can be utilized as well.

Habitat: The Spotted Lanternfly is present anywhere there are tree hosts to be found. Its host range is broad and diverse and even though it prefers the tree of heaven, it is at home anywhere it can find plant juices to feed on. These areas could include orchards, forest settings, parks and nurseries.

Associated problems: The immature stages of the Spotted lanternfly feed on plant fluids, obtained through their straw-like sucking mouthparts which can significantly weaken or eventually kill their host. The second way these insects damage plant health is by their secretions of honeydew from feeding, which can cause not only a sticky mess below any area they are consuming, but it can increase the populations of other insects, such as ants and wasps, that are attracted to this sugary substance. Also, this honeydew fosters the growth of sooty mold, which is a kind of fungus on plants, which can become an extremely unsightly visual effect not welcome in anyone's aesthetically pleasing garden.

High Risk Commodities: Almost too many to mention, this list is expansive and includes stone fruits, apples, grapes, pine trees, birch trees, elm, hickory just to name a handful, this insect has over 70 different hosts, and probably more as well!

Control Measures: There is currently quarantines designated in 13 counties in Pennsylvania, two counties in Maryland, three counties in New York. Many sightings this insect have occurred since its introduction throughout Mid-Atlantic States, though some seem to be only a stray single hitchhiker. The crude way of trying to control this insect is by physical destruction of egg masses to prevent future generations, although this is a daunting task. The removal of the preferred host of this insect, the tree of heaven would also be a helpful measure in the battle against this pest. Since the immature stages of the Spotted Lanternfly are incapable of flight, the use of a sticky band around the circumference of the tree trunk is used to capture them on their ascent to higher ground to feed. Currently available common pesticides can be used to control these insects, including imidacloprid, malathion and pyrethrin, however since this pest is still being studied, no "magic bullet" has been discovered for all stages this insect. Travelers entering the United States should not bring back any plant material, fruits or vegetables from SLF countries to avoid an accidental introduction of this insect into more areas.

Mediterranean Fruit Fly (*Ceratitis capitata*)



Adult Mediterranean fruit fly
Scott Bauer, USDA Agricultural Research Service,
Bugwood.org



Mediterranean Fruit Fly Larvae
Photo by Florida Division of Plant Industry, Florida
Department of Agriculture and Consumer Services,
Bugwood.org

Destructive things can come in very small packages, and the epitome of this is the invasive Mediterranean Fruit fly, also known as “medfly”. Originally heralding from sub-Saharan Africa, medfly has been in the Hawaii and established there since 1910, but the first discovery of this pest in the contiguous United States was Florida in 1929. There have been more outbreaks of medfly in other states including California and Texas, however, eradication efforts have been successful in all states, but Hawaii is still remains affected. This insect has over 250 host fruits and vegetables, and it threatens some of the most valuable agriculture industries in the United States, including citrus, stone fruits, and avocados. The medfly’s immense host range make it a pest that has to be eradicated quickly once discovered, otherwise whole industries could be at risk for unimaginable economic losses should it become established.

Appearance: An adult medfly is smaller than a housefly, approximately 3-6 mm in length, with reddish brown eyes, its abdomen is striped in a brown, white and yellow/orange pattern, while the top of the thorax is white/yellow with a black blotchy pattern. The wings, which are usually somewhat sagging down from the body when at rest, have transparent portions along with orange and black banded patterning. The larvae of this pest range from 7-9 mm as they progress through their three larval instar stages. Pupae are reddish -brown and approximately 4-4.3 mm long, while eggs are white and curved and about 1mm in length.

Biology: The female medfly injects eggs under the skin of a fruit or vegetable with her ovipositor, and over her lifetime, she can lay up to 800 of them! It takes a few days for the eggs to hatch, and the newly hatched larvae then begin consuming the flesh within the affected host. The larval lifecycle timespan varies depending on temperatures, but when they reach maturity, the larvae emerge from the host and drop to the ground, where they burrow into the soil to pupate. After pupation, the adult medfly emerges from the soil to begin the cycle again, which from start to finish, takes approximately 30 days under ideal environmental conditions.

Habitat: The medfly is at home anywhere its hosts are, and this could be in a setting such as a farm, a backyard garden, an orchard, or a citrus grove. Part of the reason that this fly is such a concern is that although it originates and thrives in tropical environments, it can tolerate cooler climates, so this can increase its distribution should it become established in the United States.

Associated Problems: Most damage from the medfly comes from the larvae that consume the flesh while inside their host. This damage is not readily apparent to the casual observer, however the damage the larvae cause makes the affected fruit or vegetable unable to be eaten or sold. The damage to the fruit also weakens its ability to ward off other fungal or bacterial invaders. The financial repercussions this pest causes does not only stem from the massive damages that it can physically do to affected fruits and vegetables, but also the impact that quarantines have on the import/export market in a global sense. For example, the United States and other countries have quarantines enacted that prevent the accidental importation of this pest, and as such, this limits potential profits that could have been made without the medfly due to the prohibition of certain high-risk commodities in the market. Also, chemical, radiation or other treatments of medfly hosts before being shipped from a country for export has this factored into their costs as well, thus increasing prices for the consumer.

High Risk Commodities: This pest can affect over 250 varieties of fruits and vegetables including citrus, stone fruits, grapes, figs, avocado mangos, pears, olives, coffee, and even nuts.

Control Measures: Quarantines have been set up to prevent the reintroduction of this pest into the United States from abroad. Fruits or vegetables that are hosts of the medfly have to undergo strict import requirements including fumigation, irradiation or other methods before entering the commerce. Travelers entering the United States should avoid bringing any fruits, vegetables or plant material from any foreign country without knowing the guidelines first, to prevent the reintroduction of this pest. In areas that have been affected by the medfly, sterile males have been released as part of an eradication plan to prevent future generations, and this has been very successful. With the word “fruit” in its name, transporting fruits (or vegetables) from abroad is a major way to avoid accidental introductions, it does not take many of these flies to create havoc on our agriculture systems.

Spotted Wing Drosophila (*Drosophila suzukii*)



Adult Male Spotted Wing Drosophila, note spots on wings

Spotted Wing Drosophila Larva

Hannah Burrack, North Carolina State University, Bugwood.org

Photo by E. Beers/ Washington State University

The Spotted wing Drosophila (SWD) is a relatively recent invader into the United States as it was first discovered in California in 2008. Originating from Southeast Asia, this invasive vinegar fly has wreaked havoc on fruit producers and now has been found in 45 states. Though this fly prefers to consume damaged or rotting fruit, it is also quite comfortable to lay its eggs on healthy, unripe fruit as well, which is where it inflicts its worst economic damage. This insect prefers berries and stone fruits along with many other plants as hosts, but what makes it so difficult to control versus other vinegar flies, is its ability to use non-crop fruit species, such as elderberry, dogwood and honeysuckle as hosts. This means that treating a crop with pesticides that is affected by this fly is not a panacea, as they can be reproducing on other plants in the surrounding area, and thus, not be affected by the chemical treatments.

Appearance: As its name implies, the male SWD has spots at the tips of its wings however, the female does not. Vinegar flies are also known for their telltale red eyes of which are present on this pest. The abdomen of this fly also has dark striping that can distinguish it from other native vinegar flies, while the remainder of their body has a yellowish/amber coloration. Adult flies range in size from 2-3.5 mm, so seeing some of these characteristics is much easier under magnification. Larva of this insect ranges from .05mm to 6mm at the final larval instar, they are white in appearance, but unfortunately impossible to differentiate from other fly species with the naked eye. Pupa are yellow/brown in color with two small extensions coming out of the posterior region.

Biology: The SWD begins its life cycle as an egg that is laid by a female just under the skin of a fruit by using a saw-like ovipositor, and this pest can lay up to 60 eggs a day and up to 600 during her lifetime! The larvae then feed on the interior flesh of the fruit where they undergo three larval stages. Pupation can take place either inside the fruit or on the ground. The lifespan of an adult is approximately one month and the whole cycle from egg to adult takes about two

weeks, dependent on temperature and conditions. Because of this quick reproductive rate, this pest can easily infest an area under the radar making control extremely difficult.

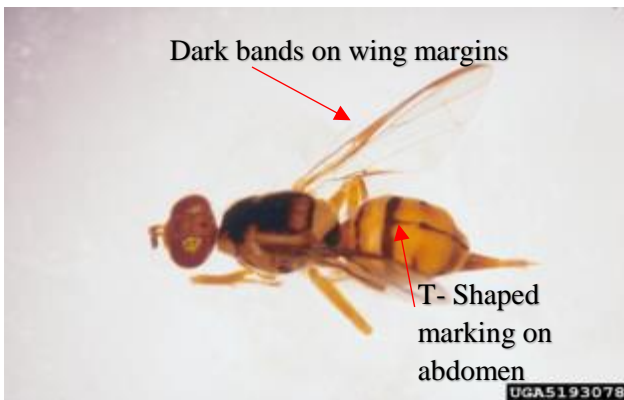
Habitat: The SWD not only inhabits areas where commercial fruit is being produced, as this invasive species can also utilize non-crop fruiting trees and shrubs. The SWD also prefers non-crop fruiting plants such as elderberry, blackberry, honeysuckle and barberry which act as a reservoir for populations so that they can continue affecting areas where nearby fruit crops are being produced.

Associated Problems: Most of the damage by the SWD comes from the larvae feeding within the fruit, causing the flesh to soften and eventually rot making it completely unable to be salvaged. The act of egg deposition by the female also causes what is called “stinging”, and these entry sites produced by her ovipositor make the fruit susceptible to fungus, bacteria or attract other pests too.

High Risk Commodities: The SWD is an equal opportunity destroyer when it comes to choosing fruit hosts, although it tends to prefer berries and stone fruits, the fleshier the better for larvae to feed upon.

Control Measures: As with any insect pest, especially invasive ones, monitoring is the one of the most important things that can be done. Since this insect can reproduce so quickly and its feeding renders fruit unsellable, knowing they are there immediately before they can continue their destruction is imperative. Removal of non-crop fruiting trees and shrubs that act as reservoirs for this pest can also be beneficial, as it limits breeding grounds for them to wait out on before they move on to other valuable fruit crops. Also, harvesting fruit crops before they linger for too long reduces the chance that they can be attacked by this opportunistic pest. Lastly, chemical treatments are effective methods of control against this pest when they are needed, but these need to be applied carefully so that they are not toxic when they reach the consumer. Though the SWD is widespread in the United States, making it less comfortable and life more difficult for it through these methods can mitigate its harmful effects.

Oriental Fruit Fly (*Bactrocera dorsalis*)



Adult Oriental Fruit Fly
Photo from Florida Division of Plant Industry, Florida



Oriental fruit fly larvae feeding on fruit
Photo by Scott Bauer, Hungry Pests, USDA, Flickr

The Oriental fruit fly, originally from Asia and sub-Saharan Africa, first made its appearance in the United States in Hawaii in the mid-1940's, and much like the Medfly, it is still present there to this day. Unfortunately, this insect also made its way to the continental United States, particularly the State of California, where it has been responsible for numerous eradication efforts to prevent its spread. This insect has also been discovered in Florida multiple times as well. The eradication programs to control this pest have been successful thus far, but this illustrates how tenacious this invasive species is, and how no one can let their guard down to prevent it from gaining a foothold in the agriculture industry. The problem with Oriental fruit Fly is not just the damage that larvae cause during feeding, which is bad enough, but the sheer magnitude of its host range. They have been known to attack over 400 kinds of fruits and vegetables and even walnuts, which is more hosts than the destructive Medfly. Basically, nothing is safe with this pest!

Appearance: The Oriental fruit fly is approximately 8mm in length, for perspective, a house fly is approximately 7 mm, so this fly is a little larger. The thorax of this insect is black with a yellow band just before the abdomen while the sides of the thorax are yellow. The abdomen is tan/brown with a "T" shaped black marking down the middle starting approximately halfway down the abdomen. The wings of this pest are clear with a dark band along the outer margins. Larvae can get to be 10 mm in length at their last developmental instar stage and are off-white in color.

Biology: The Oriental Fruit fly female lays up to 50 eggs in groups just under the skin of ripe fruit, where in typical fruit fly fashion, the larvae then proceed to consume the flesh of the affected fruit. Unbelievably, a female Oriental fruit fly is capable of laying up to 1000- 3,000 eggs in her lifetime! With this incredible reproductive rate, coupled with its ability to reach adulthood in about two weeks, it is not difficult to see the grave damage this invasive pest may cause should it become established. Once the larvae reach maturity, they fall to the ground where they pupate under leaf litter before emerging as adults.

Habitat: The Oriental fruit fly can be found around the growing regions of any of its many hosts. Though this insect hails from Asia and sub-Saharan Africa, it is just as much at home in any area where its hosts can also thrive. The Oriental fruit fly is able to tolerate cooler temperatures and although their development may not be as fast as with optimal warmer temperatures, it can survive and still be a threat.

Associated Problems: Similar to Medfly and SWD, the “sting” from the female’s ovipositor while laying eggs damages the cosmetic outward appearance of the fruit, and also make the host susceptible to opportunistic fungal or bacterial infections. The larvae feeding on the flesh of the fruit renders it useless for markets and can they completely decimate harvests if allowed to go uncontrolled.

High Risk Commodities: The Oriental fruit fly is also an equal opportunity destroyer and has over 400 potential hosts that it can exploit and survive on. The expansive host range of this insect makes it extremely dangerous to all fruit growers, whether they are small farmers or major agricultural producers. According to the USDA Agriculture Research Service, this particular invasive fly prefers fruits belonging to the fig, citrus, tomato, and squash families (Liquidor et al. 2017).

Control Measures: Monitoring of this pest is vital to its control, because the sooner it is detected the higher likelihood that it can be eradicated from an area. There have been multiple successful eradication efforts that have taken place in California and Florida which has prevented it from becoming established. These successful eradication efforts have utilized a trapping method known as the male attractant technique (MAT), which attracts male fruit flies using a chemical known as Methyl eugenol, which is also mixed with an insecticide, killing all males that visit these traps. With the male populations gone, the females cannot produce future generations of this pest which eventually leads to their eradication from an area. Travelers coming from Oriental fruit fly countries should never attempt to bring high risk fruit or vegetable host material into the United States to prevent future introductions of this pest.

Giant Asian Hornet (*Vespa madarinia*)



Aerial view of adult Giant Asian Hornet
Photo from Washington State Department of
Agriculture, Bugwood.org



Lateral view of adult Giant Asian Hornet
Photo by Allan Smith-Pardo, Invasive Hornets, USDA APHIS
PPQ, Bugwood.org

The Giant Asian hornet, frighteningly dubbed the “Murder Hornet” by various news outlets, is a recent invader into the United States with the first sightings occurring in Washington State in December 2019. This area of Washington is the most northwesterly region of the state, a short drive to the Canadian Province of British Columbia, where there were other sightings of this hornet in the late summer and fall of that same year. This insect is quite unmistakable from other native hornets, such as the bald face hornet, most notably because of its enormous size and appearance. This pest poses a major threat to the beekeeping industry that has already been seriously crippled by Colony Collapse Disorder (CCD) and the varroa mite, another invasive organism that kills honeybees that was introduced to the United States in 1987. Though this hornet is quite large and menacing looking, it is responsible for up to 50 deaths per year (Skvarla 2020), while native bees, wasps and hornets in the United States alone, were responsible for 89 deaths in 2017 (CDC 2019). Though the sting of this insect is extremely painful, and there are sometimes complications that arise from its venom, the true threat from this invader is what it can do to honeybees, which are irreplaceable pollinators in our agriculture industry.

Appearance: With some imagination, this hornet looks like a yellow-jacket wasp on steroids, with orange/red/ brown (color variation exists) and black striping on its abdomen instead of yellow and black. The head is mostly orange/yellow with large distinct black eyes. The adult Giant Asian hornet can reach two inches long, queens can get over two inches, with a wingspan up to three inches. The most fearsome anatomical feature, its stinger, is ¼ inch long!

Biology: Like other hornets, this pest also resides in large nests, though almost always subterranean. The queen is the only survivor of the winter and she begins the construction of her nest in such places as old animal burrows or tree roots within the ground during the spring. While tending to the construction of her nest, she also lays eggs which produce workers and drones that will then provide the labor to sustain the colony. These hornets are fond of honeybee nests because they provide a great food source for the young developing larvae currently growing in the cells within their own nests. These hornets, unlike any others, stage and carry out attacks on honeybee (or any other unlucky bee relatives) colonies, slaughtering the entire colony and then using the conquered bees’ larvae as food for their own. The queen will also produce

other queens and males that in the fall will leave the nest to mate, and those surviving queens will be the ones to start the new colonies after overwintering.

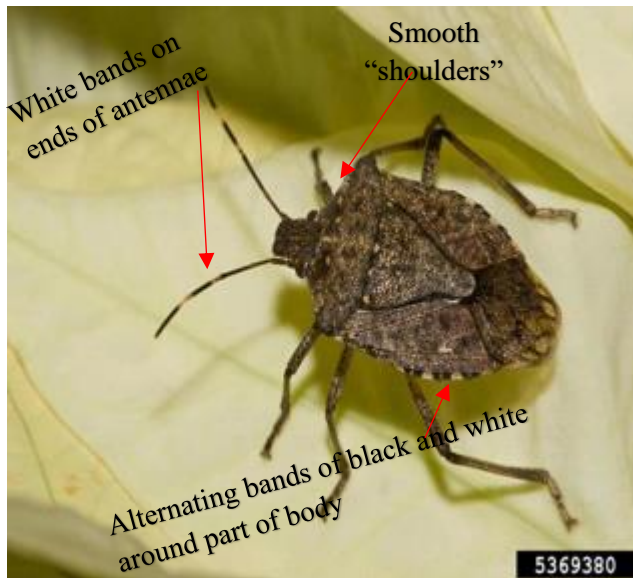
Habitat: In its native habitat, which is Asia, this hornet prefers to nest in wooded and rural areas over metropolitan or urban settings. Though it comes from temperate to tropical climates, this hornet is hardy and can withstand relatively cold winters, thus making it a risk for much of the United States, which could potentially become new territory for the hornet to inhabit, if it is not stopped.

Associated Problems: The fear of this new invader is palpable, due to its intimidating size and notoriously painful sting, though their goal is not to actively pursue humans for entertainment and to inflict suffering. The sobering and realistic threat from this invasive hornet is the damage they can cause to native honeybees. It is known that only a handful of these hornets can massacre an entire hive of honeybees in a few hours. We rely on honeybees for the pollination of many crops in this country, and this hornet becoming established is a serious threat to native honeybee pollination. Interestingly, honeybees from its native environment have developed a defensive tactic against these hornets. A swarm of honeybees covers one of these hornets in entirety and they beat their wings at a frantic pace, this act raises the temperature of the hornet, which is essentially cooked alive due to the ability of these honeybees to withstand higher temperatures. This is learned behavior by these native honeybees to stave off attacks from this predator, our honeybees would most likely not be able to do this, because they have not encountered this invasive hornet before.

High Risk Commodities: There are many ways that this hornet could enter the United States, whether through accidentally hitchhiking on cargo arriving from Asia, or by an individual trying to illegally import them into the United States. The Giant Asian hornet, like many other insects, is regularly eaten as food (the larvae and pupae) and used in traditional herbal medicine in Asia, and these live insects have been found in passenger baggage entering the U.S. (USDA 2020). It does not take many of these hornets to cause a problem, it really only takes one fertilized queen to start a colony!

Control Measures: Since this pest has not become established, it is hopeful that eradication efforts by Federal and State authorities will be successful. The public plays a major role in providing agencies such as the USDA with tips of sightings on their property, which can prevent this hornet from spreading any further. The sightings of these insects in both Canada and the United States were by concerned members of the public who informed the proper governmental agencies who were able to ascertain and mitigate any threats in timely manner, which has so far prevented these invaders from spreading.

Brown Marmorated Stink Bug (*Halyomorpha halys*)



Adult BMSB - Photo by Susan Ellis, Bugwood.org



First Instar BMSB with, Photo by Ted Kropiewnicki, Bugguide.net. Creative Commons

With a name such as the Brown Marmorated Stink bug (**BMSB**), you know that this mouthful will surely be causing a big stink, and yes, it is an extremely destructive insect that has only relatively recently landed on our shores. This pest which originates from Asia, was first discovered in Pennsylvania in 2001, one of the states that is also currently being besieged by Spotted Lanternfly as well! Unfortunately, the BMSB has spread quickly, and is known to inhabit 40 states at this time. This pest has a large host range and prefers many varieties of fruits, vegetables, nuts, as well as ornamental plants, which impacts not only large agriculture producers but also backyard gardeners as well. This insect has and will continue to cause millions of dollars in losses to the agriculture industry, in terms of damaged harvests and control programs to mitigate their numbers. Adding another layer of damage to come from this pest, is its behavior to seek shelter inside homes during the winter months, leading to concern and repulsion from any human inhabitants.

Description: This stink bug resembles other native brown stink bugs that are commonly found throughout the U.S., which are not even remotely near the level of destructive capabilities of this pest. The way to tell the BMSB from these other stinkbugs, is the black and white banding pattern starting around one edge of its body about halfway down the back and forming a “U” shape up the other side. The antennae on this pest also have a white banding pattern as well. Unlike the other native stink bugs whose shoulders have a ridge of jagged tooth-like structures, the BMSB has smooth shoulders. If the insect is viewed underneath, there is what appears to be a large straw from its mouth region extending to about the center of its body, this is its mouthpart which it uses to suck plant juices. The immatures of this pest, known as instars, start off with a mostly orange abdomen with black dashes down the center of its back and is quite small at about 2.4mm long. As the instars mature through their four stages, they begin to take on the usual characteristics of the adult, increasing in size to 12mm before fully maturing. The adult BMSB reaches approximately 17mm in length.

Biology: This insect is not hard to notice in affected areas, as it often seeks refuge during the fall and winter within homes and buildings, trying to wait out the harsh elements, sometimes in extremely large numbers. Once spring arrives, the adults venture out of their overwintering sites, whether from homes or leaf litter, in search of host plants, of which there are over 300 kinds including a variety of fruits, vegetables, nuts and ornamentals. Mating begins a couple weeks after emerging and females then lay up to 20-30 eggs on their selected plant host. The newly hatched instars feed on plant juices from their host with their straw-like mouthparts as they grow into adults, which contributes to the decline in health and appearance of the affected plant. What makes this insect even more destructive is that it can have multiple generations within a year, and each female is capable of laying more than 300 eggs in her lifetime. This pest can also fly long distances attacking multiple host plants in the process.

Habitat: Although the BMSB originates from Asia, can be found anywhere that fruits and vegetables are growing if it is present in an area. This could be citrus groves, apple orchards or small backyard gardens. Since they also feed on ornamentals and other flowering plants, no yard or environment is safe from their destruction, they will find something to feed on.

Associated Problems: This invasive stinkbug feeds on plant juices by using its straw-like mouthpart, called a stylet. This contraption can pierce many kinds of fruits and vegetables, sometimes not initially obvious, but as the crop matures, the damage becomes apparent. The stylet, upon entering the fruit, releases salivary enzymes to increase nutrient absorption for the insect and by doing so, causes necrotic rot at the feeding site. This damage not only makes the fruit or vegetable unsightly; it is also not able to be sold, leading to economic damage. After the summer is over and this pest has caused its damage to plants, it often ventures into homes, sometimes in very large numbers, causing the inhabitants much consternation. These insects also release an unpleasant banana-like smell when handled or dispatched, making them even more unpleasant than they already are.

High Risk Commodities: With over 300 plant hosts, this stink bug is able to attack many fruits vegetables and ornamentals. The BMSB prefers fruits such as apples, pears, stone fruits, peppers, and tomatoes, and vegetables such as corn, okra, beans. For ornamentals, crab apples, black cherry, black walnut, flowering dogwood and tree of heaven are some preferred varieties.

Control Measures: Since the BMSB is a highly mobile pest, capable of flight and quite good at hitchhiking not only across the country, but around the world as well, controlling it can be quite difficult. Trapping in agricultural settings can alert farmers to its presence and allow them to use discretion on the application of pesticides, only applying when the populations reach damaging levels, to prevent pesticide resistance concerns. A biological control agent, more specifically, a parasitoid wasp known as the samurai wasp (*Trissolcus japonicus*), has also come along with this pest thankfully, and time will tell if this predator will significantly reduce BMSB populations. Homeowners are also enlisted to battle this pest by making sure that entry ways to their property, such as windows and doors are properly sealed to prevent the BMSB from entering and being able to hide out until the warmer months arrive.

For trade purposes, agricultural commodities (or even vehicles and equipment) coming from BMSB regions of the world may require fumigation or other treatments to limit the introduction of this pest to new countries, slowing its spread. Individual travelers should refrain from

transporting plant material as well as fruits and vegetables from abroad, as this pest is an elusive hitchhiker, and any item could be at risk for spreading it to more areas within the county.

Asian Citrus Psyllid (*Diaphorina citri*)



ACP Nymph stage,

Photos by Jeffrey W. Lotz Florida Department of Agriculture and Consumer Services, Bugwood.org

ACP adult, note distinct 45 degree feeding posture

The Asian psyllid (ACP) has really been putting the squeeze on the citrus industry in the United States. This pest, originating from Asia, was first discovered in Florida in 1998, and since this time, it has been found in Florida, Louisiana, Alabama, Mississippi, Texas, Georgia, North Carolina and Hawaii. This insect not only damages its host by feeding off its juices, it also is a vector for an extremely destructive plant disease called huanglongbing, which translated from Chinese means “yellow dragon disease”, and commonly known as citrus greening. This disease is spread when an infected ACP feeds on a citrus plant, which ultimately leads to the death of the tree, sometimes after only a few years. The ACP is negatively affecting the citrus industry and the jobs that are dependent on it. According to a one study by researchers at the University of Florida, this pest and its accompanying transmitted disease, have been responsible for \$1.672 billion dollars of grower revenue losses, and this was only during 2012-2013 and 2015-2016 seasons, which is approximately \$418 million lost annually (Court et al. 2017). Everyone, at one level or another, is adversely affected by these losses, which are trickled down to the individual consumer purchasing any citrus product, anywhere, at any time.

Description: The ACP, like many insects, looks entirely different when in its immature phase to its development into an adult. In the immature stage, also known as the nymphal stage, this insect resembles a yellowish-orange trilobite with distinct red eyes. The nymphs of the ACP are quite small, ranging from approximately .25mm to 1.7mm as they progress through five instar stages, and often lay flat on the bottom of leaf surfaces and along branches. As the nymphs feed, they exude waxy and white colored tubules composed of honeydew, which many ants feed upon, while also providing this pest undeserved protection. The adult of this insect looks something like a cross between a plant hopper and cicada, because it is related to these other insect groups as well. In its adult stage, this insect is approximately 3-4mm long, has light brown to dark brown mottled coloration and readily jumps when approached. When this pest is observed feeding, its mouth is low consuming the juices out of the plant, while its body is raised behind it at 45 degrees in relation to the plant surface.

Biology: This pest, as its name would suggest, prefers citrus and its relatives as a host, and this is where its lifecycle takes place. The host is selected by a female that is ready to lay her eggs (she can lay up to 800 in her lifetime) and she prefers to attach them around newly formed shoots and buds, where it is assured her offspring can be provided an ample food source. The eggs hatch, and the nymphs begin to feed on the plant, progressing through five developmental stages to an adult, which takes approximately two weeks under ideal conditions. Nymphs are not very mobile, in comparison with such other plant feeding pests such as aphids and will generally stay in one area feeding during this stage. Once becoming an adult, sexual maturity occurs within a few days, and soon after this mating begins. The ACP female mates multiple times with different males throughout the season resulting in up to thirty generations per year. Much like a female mosquito needs a blood meal for egg production, a female ACP must lay her eggs on citrus that are “flushing”, a term meaning that new shoots and leaves are forming on the plant, so that nymphs have a food supply. If no newly formed tender shoots and leaves are available, adults can consume mature leaves until the tree begins developing again so that eggs can be laid to start the whole life-cycle process again.

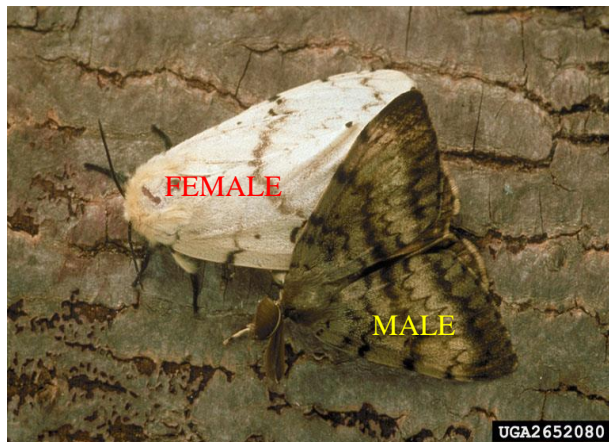
Habitat: The ACP is at home among any citrus variety or its relatives. These insects are not only found in large citrus groves but can also be found in backyard gardens that are home to a single citrus tree or even related ornamentals in the same family, such as Indian curry leaf or lime berry. Since this pest originates from warmer climates in Asia, it survives quite well in the citrus growing regions of the United States, which are quite warm to enable the production of this fruit to begin with.

Associated Problems: The problem with ACP do not just have to do with the fact that it feeds on plants like a vampire, sucking out one of its life fluids known as phloem, that is only where the damage begins. Since nymphs feed primarily on new shoots and leaves, this new growth becomes stunted, malformed and discolored. The honeydew secretions that the nymphs produce not only attract ants, which then also protect this pest from potential predators, it also begins to fall onto other leaves of the plant, promoting sooty mold growth. This psyllid is also capable of something much more sinister, and that is the spreading an extremely destructive bacteria which causes citrus greening disease through its saliva when feeding. Citrus greening causes among other problems, stunted growth of the plant, green fruit even when fully ripened, fruit that tastes horribly bitter and is malformed, and the signature yellow leaves when the disease progresses. Ultimately, this disease leads to the death of the affected tree. Citrus greening is so devastating that it has caused billions of dollars in damage to the citrus industry in the United States. Citrus trees that become infected with this disease must be destroyed so that the infections do not continue on to healthy trees, which significantly reduces harvests by removing these mature productive stands. One of the worst aspects of this disease in relation to the ACP is that once this disease is contracted by the insect, it is infected for life, and is capable of infecting even more plants.

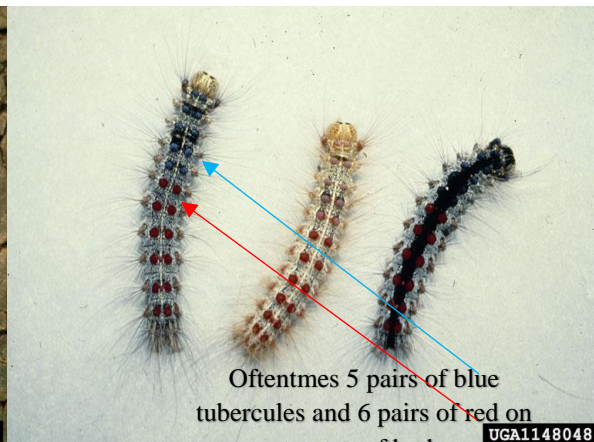
High Risk Commodities: Citrus of any variety is a concern with the Asian citrus psyllid. There are also other plants within the citrus family, such as curry leaf (*Murraya koenigii*) whose leaves are used in cooking as a spice, as well as ornamentals such as the Cape Chestnut (*Calodendrum capense*) that people could grow in their yards that serve as reservoirs for this pest. Neglected or abandoned citrus trees may also pose a severe risk for neighboring farms, because these can go unchecked and allow this pest to survive unhindered, and then spread to these agricultural areas.

Control Measures: Although there is no cure for citrus greening, there are measures that can be taken to mitigate its spread by the use of quarantines in affected areas of the country. The states of South Carolina, Georgia, Florida, Alabama, Louisiana, Texas and California all have quarantines at some level for this disease. The transportation of citrus into and out of these areas is under strict control and there are also rules in place that members of the public should adhere to, such as when selecting nursery stock for backyards, so as not to spread the insect or the disease. Numerous common insecticides are an option for controlling ACP populations as well as the use of insecticidal soaps and oils. Like many foreign invaders, the use of an enemy from its homeland is often conscripted into the fight, and for this pest specifically, a parasitoid wasp known as *Tamarixia radiata* was the one. *T. radiata* parasitizes the nymphs of this pest and as the wasp develops it feeds on the ACP, eventually hatching out of its mummified remains. An individual traveler can have a major impact on preventing the spread of this pest by not trying to import any citrus plant or its relatives into the United States without the use of the proper importing procedures. Curry leaves are regularly imported by travelers who are aware of their prohibition but do so because they are not available here in the United States from their respective countries. Being aware that a small pest hitchhiking on a seemingly harmless curry leaf or illegally imported nursery stock could potentially harbor such a tiny but destructive pest that has cost our citrus industry billions of dollars, illustrates the importance of a single individual's actions on our agriculture system.

Asian Gypsy Moth (*Lymantria dispar*)



AGM adult Female (top) and adult male (bottom)
Photo from USDA APHIS PPQ, Bugwood.org



Asian gypsy moth caterpillar, note color variation
USDA APHIS PPQ - Oxford, North Carolina,
Bugwood.org

The Asian Gypsy moth (**AGM**) is a forest pest of monumental concern, as this invasive insect, native to East Asia, has over 500 host plants that are on its menu. If the AGM were to become established in the United States, our forests, parks, and backyards would never look the same again. This pest was first found in Washington State in 1991, and since this time, a battle to prevent this insect from gaining a foothold in our country began. It has also been found in Oregon, Georgia and South Carolina, but thankfully, eradication efforts have all been successful, thus far, and programs to monitor for it are employed to avoid this pest becoming established. We already have the European Gypsy moth (since 1869) in our county which are quite damaging to trees as well, however, the females are flightless, making their dispersal distance somewhat limited and they do not feed on nearly as many hosts as the AGM. The AGM on the other hand is an adept flyer, with females capable of dispersing for up to 20 miles, and this, coupled with their immense host range, make them the evil twin of the native gypsy moth. The genetics of the European gypsy moth and the AGM is almost the same, and should these two varieties meet in the same place, massive hybridization is expected (Schweitzer 2004). Because of this hybridization, European gypsy moth females could also gain the ability to fly, thus increasing their mobility and as such, amplifying the overall destructive capabilities of these pests. Forestry related industries could be severely impacted because of the AGM's penchant for conifer trees, which could impose strict quarantines and increase costs on such items such as Christmas tree farms, nursery stock and many products produced from wood.

Description: Complicating matters with this pest, is that the AGM and European gypsy moth are almost identical in appearance. They look alike so much that only a DNA test can actually be used to correctly identify who is who. The female and male AGM look quite different, the female is larger, with a wingspan of 30-40 mm, off white in color with numerous brown/black colored bands running horizontally across the body when at rest. The smaller male has a wingspan of 37-50 mm, is smoky tan/brown in color with the darker brown bands of color running horizontally when wings are at rest. The caterpillar of the AGM starts out approximately 2-3mm long and reach up to 60 mm when fully mature. They have numerous spiky tufts of "hair" sticking out along the sides of their bodies and two pairs of bumps going down the entire

topside of their body from their head to their rear segment. These bumps, called tubercles, are oftentimes arranged with five pairs blue in color, starting at the head, and six pairs, red in color going to the end of the body, although color variation exists (see photo above). Egg masses, which are constructed using the females' dense body hairs, can contain in excess of 1,000 eggs, are brown in color and resemble something like a small pile of wet sawdust reaching a length of 20-40 mm.

Biology: The AGM is a strong flier and females will select trees, rocks, or any manmade structure to lay her egg mass during July or August, where the eggs hibernate over the winter. The eggs hatch during the spring months, and first instar larvae exhibit a behavior known as ballooning. Ballooning entails the larvae moving to the end of a leaf surface, releasing a silk strand, and due to their extremely small size and light weight, they are carried by the wind to other feeding sites, thus increasing their dispersal distance even in larval form. The early instar larvae are able to travel on average less than ½ mile just by wind dispersal alone (Sargent 2009), which beats any distance they could accomplish just by their feet. The caterpillars then voraciously feed on the foliage of their hosts, often completely defoliating them during this process, undergoing five instar phases until they begin to pupate. The pupation process begins during June or July, usually lasts a couple of weeks, and finally, adult male and female AGM moths emerge. The adult males are attracted to the pheromones that the female releases, and mating occurs, with egg masses often laid on trees. Adult moths do not eat, and their only function is reproduction to perpetuate their species, and usually die within two or three weeks after emerging from their pupal stage.

Habitat: The AGM can be found basically anywhere their many hosts are growing, and they have over 500 to choose from, in regard to trees, bushes and shrubs which can occur in forests to urban backyard environments. The problem with this moth is its ability to disperse long distances either by flight, or larval ballooning, or by means of hitchhiking on any mode of transport, including commercial maritime vessels.

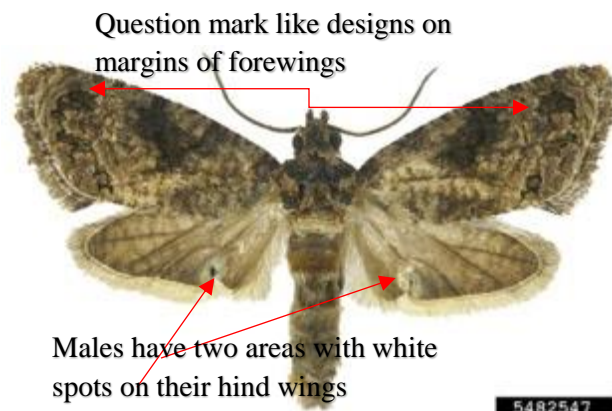
Associated Problems: The voracious appetite of the larval stage of this insect would have significant detrimental impact on forest health, which means the forestry related products are at extreme risk for economic losses. The reproductive rate for the AGM is quite large and should it become established, and even more, if hybridization occurs between it and the native European gypsy moth, countless egg masses, caterpillars denuding trees and leaving their excrement over anything below it, would become common place. Public parks, national forests, and other outdoor gathering areas would become ground zero for this pest, altering the landscape and comforts of our most cherished places. The timber industry could be adversely affected due to the loss of entire stands of trees as the caterpillars destroying their leaves destroys their means of photosynthesizing and feeding themselves. During the holidays, many Christmas trees and other evergreens trees used as greenery for decorations are at risk for defoliation and this industry is at risk as well. All of us rely on the timber industry for a variety of everyday products including paper products and this pest could dramatically impact the availability of these resources, which could result in increased costs for the consumer.

High Risk Commodities: The AGM is a notorious hitchhiker and the risk for it to be transported on maritime vessels arriving from AGM countries is a serious threat. Moths, as a

rule, are attracted to lights and the AGM flocks to the extremely bright lights on a vessel waiting in high risk ports. The USDA has developed protocol for vessel inspections undertaken by Agriculture Specialists with Customs & Border Protection (CBP) to prevent the introduction of this dangerous pest. Quarantines already exist for the already present European gypsy moth, and this includes such items as firewood, nursery stock and holiday wreaths or trees. If the AGM became a threat, these quarantines would become even stricter and impact the livelihoods of many citizens.

Control Measures: There are currently many quarantines in place for the European Gypsy moth, but its spread is being limited by stringent inter/intra-state quarantines as well as between Canada and the United States. The hybridizing of populations of European gypsy moth and AGM is a concern, so preventing the accidental introduction of the latter is of utmost importance. If the AGM were to become more established, these quarantines would probably become even more stringent to prevent this from happening. Inspections of commodities and conveyances coming from AGM countries is vital to stop this pest from destroying our forests. Past outbreaks of AGM moths in the US have also been defeated successfully with the use of a naturally occurring bacteria known as *Bacillus Thuringiensis* var *Kurstaki* (Bt) in the form of a foliar spray, which has very low toxicity in comparison to chemical pesticides. Trapping programs, undertaken by the USDA for AGM are also necessary to ensure that this pest has not arrived and to stop them before they can become established, as timing is everything. Another novel method that citizens can also play a major role in regard to early detection of this pest by reporting any sightings of this potential pest or its egg masses and by familiarizing themselves with its appearance. Travelers returning from European gypsy moth quarantine zones in Canada, as well as traveling into and out of these quarantines in the United States should inspect their conveyances for egg masses or life stages of gypsy moth as well as avoid transporting firewood into/out of these areas. The establishment of the AGM in the U.S. would be disastrous and preventing its introduction while also controlling the potential hybridization of it with the European Gypsy moth is vital to the health of our forests.

False Codling Moth (*Thaumatotibia leucotreta*)



Question mark like designs on margins of forewings

Males have two areas with white spots on their hind wings



Caterpillar of FCM

Adult male FCM, not white dots on hind wings

Photo by Todd M. Gilligan and Marc E. Epstein, TortAI: Tortricids of Agricultural Importance, USDA APHIS PPQ, Bugwood.org

Tertia Grové, Institute for Tropical and Subtropical Crops, Bugwood.org

The False codling moth (**FCM**), native to Africa, is a devastating pest on many varieties of fruits, vegetables, nuts, cotton, and can also cause damage to nursery plants as well. This pest has been prevented from making entry into the United States many times because it has been intercepted by Agriculture Specialists with U.S. Customs and Border Protection before it could have the chance to become established. There has only been one incidence of this pest being found in the wild, and this happened in 2008 in Ventura County, California. Since the FCM feeds on the inside of its host, it can often go undetected while the larvae is consuming and ruining the fruit, thus making it unsellable. Should the FCM gain a foothold in our agriculture industry, citrus, corn, figs, peppers, okra, macadamia, avocado, and walnuts are just a handful of the crops that could be affected.

Description: The adult FCM in general is a somewhat unassuming brown moth, approximately 6-9 mm in length and wingspan from 12-20 mm. This moth is often confused with the Codling moth, which is also brown in color and not nearly as destructive as the FCM. There are multiple telltale characteristics that differentiate the FCM from other similarly looking brown moths. Their front wings have a question mark shaped dark markings towards the corner of the wing margins and at the center of the wings, there are distinct white splotches of color. The front wings are darker in coloration, while the fore wings are a more uniform light brown or grayish in color, with males having two conspicuous white spots on their hind wings. The adult male FCM is smaller in size than the adult female. The larvae of this pest range from 1-20 mm from the first instar to last, which are white when immature and become pink as they get older while the head capsule is light brown. Pupae range in color from yellow to dark brown and get up to 7 mm in length.

Biology: Females of the FCM are capable of laying up to 250 eggs in their lifetime. They usually lay their eggs one at a time on their host and eggs hatch anywhere from approximately 2-20 days,

depending on environmental conditions. Once the eggs hatch, larvae choose a site and begin to bore their way into the fruit, making unsightly tunnels laden with their waste as they go. In some hosts, such as cotton, the larvae make their way through the boll, where they consume the seeds. The larval stage of this pest lasts between 12-67 days. Fruit that is infested with FCM may drop to the ground early and pupation may occur in the fallen fruit, the soil or other protected spot. The pupal stage of this pest takes anywhere from 13-48 days, and like all developmental stages, is temperature dependent. Under ideal environmental conditions, the FCM is capable of having up to 6 generations a year.

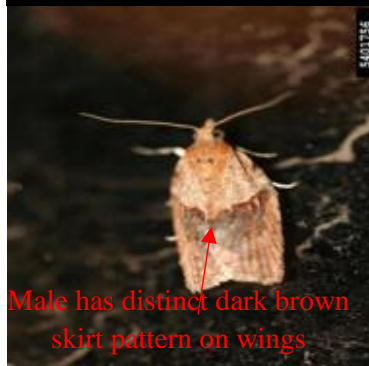
Habitat: Although the FCM is endemic to sub-Saharan Africa which is a tropical climate, it has been estimated that 20% of the continental U.S. could be at risk by providing the necessary environment for this pest to survive (Venette et al., 2003). These regions would definitely be the some of the major agriculture growing regions of the country, including California and Florida.

Associated Problems: The FCM has such a wide host range of over 200 kinds of vegetables, fruits, nuts, and even nursery stock, that the damage that it is capable of cannot be underestimated. One of the major issues with this moth is that it can be hard to detect in its larval stages, as there is oftentimes no outwardly noticeable damage occurring as the host is being consumed from within. Infestation by FCM larvae within their host can eventually cause the fruit or vegetable to fall prematurely negatively impacting harvests. The holes that larvae leave either entering or exiting its host can also make it susceptible to other pests and pathogens.

High Risk Commodities: This pest prefers certain crops over others, as do most, but will have no problem taking whatever is available. Citrus is a high-risk crop for this pest, especially in the U.S because there is such a robust citrus industry. Corn, peppers, avocado, macadamia and stone fruits, such as peaches and nectarines are also at risk from this pest. Since the FCM is also present on flowers, such as roses in its native habitat, the importation of cut flowers and their associated greenery also pose a pathway for its introduction.

Control Measures: There are currently trapping programs undertaken by federal and state authorities, such as the USDA or State Departments of Agriculture to identify if there are any FCM, should they happen to make it into the wild. Agriculture Specialists with U.S. Customs & Border Protection, inspect flowers, fruits and vegetables that could be harboring this pest at all Ports of Entry around the country every day. Although it has been found at many of these ports of entry during inspections, the FCM has been denied entry by the strict inspectional requirements and regulations in place to prevent it from becoming established. Much research is being done into effective control against this invasive pest including the use of biocontrol agents such as fungi and nematodes as well as parasitic wasps. The Sterile Insect Technique (SIT), which is where sterile FCM males are introduced into an area infested with this pest and mating done with females will not produce offspring, is also being looked at as a control method in affected countries. Since this pest is an internal feeder, the use of chemical pesticides would not be as effective as it is protected within the fruit it is consuming. Travelers making entry into the United States should avoid transporting any fruits, vegetables or plant material as even if these items were not purchased in an FCM country, they could have been imported from these affected areas.

Light Brown Apple Moth (*Epiphyas postvittana*)



Male has distinct dark brown skirt pattern on wings

Adult Male LBAM
Photo by Lesley Ingram
Bugwood.org



Female has brown dot in center of wings when folded

Adult Female LBAM
Photo by Andrew Kirby, Flickr



LBAM Caterpillar
Photo by Todd M. Gilligan and Marc E. Epstein, TortAI: Tortricids of Agricultural Importance APHIS USDA APHIS PPQ, Bugwood.org

The Light brown apple moth (**LBAM**), which is indigenous to Australia, is a threat in the United States to not only apples, but also other high value crops such as stone fruits, citrus, grapes, blueberries, cut flowers, nursery stock. In total, this pest has over 300 known fruit and vegetable hosts, so any setting is at risk, be it a backyard garden or large-scale farm. This moth was first discovered in the California in 2007, and since this time there have thankfully been no other sightings of it. Quarantines for the LBAM in the U.S. remain in effect for in 22 counties in California and all counties in Hawaii. The LBAM belongs to the family of moths, known as Tortricidae, which is the same family as the False Codling Moth, another pest with a wide host range that has been found once in California as well. This variety of moth is called a leaf roller, because larva roll the edges of leaves of plants over themselves using spun silk to form somewhat of a protective covering while they feed on them, and then utilize this covering to pupate. These rolled leaves not only make an unsightly mess, when large populations of these moths are present, but the health of the affected plant can be diminished due to their insatiable feeding and subsequent denuding of foliage.

Description: At first glance, this moth looks like another drab, brown and small (approximately 0.4 mm long) moth that are quite common to come across. This family of moths had a particular bell shape when their wings are at rest folded over the top of their body. The male has a dark brown skirting on the forewings around the bottom of the “bell” shape. The female is a little larger (7-13 mm) than the male (6-10 m), and her coloration is plainer, with some dark brown markings, also notably a single brown spot located at the center of the back the wings are at rest. As with other insects, color variation does exist in both adult and larval stages. Egg masses are green in color and have a coating on them that appears like a covering of scales. The larvae of this moth range in size from 10 mm to 20 mm from first instar to last, of which there are six. During the first few instars, the larvae are yellowish/white, but as they mature, they change to green, with a yellow/brown head capsule. Numerous white spiky hairs can also be found scattered around on the surface of this caterpillar. Pupae begin as a dark green in color and then turn dark brown as they mature.

Biology: The lifecycle of the LBAM begins when a female ready to lay eggs (she can lay up to 1500 in her lifetime), selects a host to her liking and proceeds to lay a mass of up to 50 eggs on either the leaves or even the surface of a fruit or vegetable. These eggs, under optimal condition, take just over a week to hatch, and newly hatched larvae then feed on the surfaces of fruit and leaves, where they spin cocoons that protect them while they feed and develop. Leaves that the LBAM select to feed on are often curled in appearance and stuck together with silk webbing the larvae produce. Development time varies for larvae which go through six instars, and then pupate in the same webbing, emerging as adults in up to 30 days. Should LBAM ever become established in the State of California, it is projected that this pest could complete four of five generations a year (CDFA n.d.), which means large populations of these destructive moths could be produced in warmer climates, making it an unrelenting threat to our agriculture industry.

Habitat: The LBAM is indigenous to Australia where it ravages their agriculture industry, including citrus and grapes. Even though Australia's climate is tropical, this moth will have no problem establishing itself in the warmer agriculture growing regions of the Southern U.S., such as California, Florida and Texas. Since this pest has such a large host range, it can be equally present on plants or trees in a backyard garden, an orchard, or field of crops.

Associated Problems: The LBAM destructive larval stage can be extremely damaging to both vegetation as well as the surfaces of fruit, upon which they feed. The feeding on leaves by larvae especially with large population sizes can weaken and kill their hosts. Fruit surfaces that are fed on can become susceptible to attack by fungus and bacteria, and also making them unable to be sold.

High Risk Commodities: This moth can attack over 300 kinds of fruits, vegetables, trees and ornamentals, and it is quite destructive to fruit trees which can cause economic turmoil for growers. Also, the feeding on direct surfaces of fruits by larvae, especially on fruits such as apples, grapes, plums, kiwifruit, avocado and citrus, the damage done to the outside of the fruit makes them unmarketable, leading to harvest losses (Irvin n.d.).

Control Measures: Like many other invasive insects that pose a risk to the agriculture systems in the U.S., there are currently trapping and monitoring programs in place keep an eye out for this pest. Early detection would give a much needed head start to implement an eradication program before this insect could become established in a particular area. In LBAM endemic countries, pheromone disruption is a process that is used to control populations. This process entails the release of female sex pheromones to disorient male moths, thus leading to decreased mating and reproduction. There are current quarantines enacted for this pest in numerous counties in California and these areas have regulations in place regarding the shipment of potential host material in to and out of these quarantine zones. Individuals traveling from abroad and into the ports of entry into the U.S. should not transport fruits, vegetables, or plant material from LBAM endemic areas and should declare all agriculture items when entering the country for inspection to prevent the accidental introduction of this extremely harmful pest.

Coconut Rhinoceros Beetle (*Oryctes rhinoceros*)



1. Adult Rhinoceros beetle, Photo from Pest and Diseases Image Library. Bugwood.org
2. CBR Larvae, Photo by Aubrey Moore, University of Guam
3. CRB damage to palm tree, Photo from Hawaii Coconut Rhinoceros Beetle Response

The Coconut Rhinoceros (**CRB**) beetle, may sound like humorous musical band name, but this pest is an extremely destructive pest of not only its namesake, coconuts, but also other plants in the palm family. This insect has the ability to impact the coconut industry and also take away the aesthetic and iconic palm trees wherever they may be found. Though this beetle is indigenous to Southeast Asia, it was recently discovered in 2013 in Hawaii on Joint-Base Pearl Harbor-Hickam, a military base, since then, other CRB's have been found on the base as well. (USDA 2015). Unfortunately, the appetite of this pest also includes bananas, pineapples and sugarcane, and this could have dire consequences health of these plants, and the costs of this would be passed on to the consumer. The priceless visual representation of paradise, the palm tree, could also be devastated by this beetle, not only in Hawaii, but also in the continental U.S., such as Florida and California.

Description: If one encounters this beetle, it would not be hard to miss due to its very large size of 30- 60 mm long. The rhinoceros part of its name would come from the large horn protruding from the top of its head. The CRB is shiny and black and females can be distinguished from males by the presence of tufts of brownish hairs present at the end of their abdomen. Larvae are even larger than the adult, reaching up to 100 mm in length and their bodies exhibit a scarabaeiform shape, meaning they are in the shape of a “C”.

Biology: The most damaging aspect of this pest's biology is the adult stage, mostly young adults, which bore into the crowns of coconut palms where their feeding on plant leaves often causes irreparable harm and death of the tree. Females beetles lay their eggs (up to 100 in their lifetime) in decaying plant material such as old palm trees, piles of rotting yard waste or stumps, where approximately less than two weeks later the eggs hatch. Newly emerged larvae begin feeding on the decaying plant material for up to three or four months, after which they enter their

dormant pupal stage, which continues for about four to six weeks until new adults emerge to continue their life cycle.

Habitat: Since the CRB is endemic to Southeast Asia, this pest can be a threat only where it is quite warm and tropical however this condition should not be underestimated because wherever palms and its other hosts can grow, it can become a concern even in the U.S. Besides Hawaii, warmer states in the continental U.S. that would be habitable to the CRB would be Southern California, Florida and generally the Gulf Coast area all the way to Texas.

Associated Problems: Adult beetles feeding on healthy palms causes unsightly damage on living trees. Because the beetles are feeding on living and growing leaves, as the new growth unfurls, the missing sections of fronds become an eyesore with incongruous V-Shaped gaps appearing, which is a signature trademark of this pest. The CRB also bores into the crowns and the lower section of palm fronds leaving gaping holes in these areas, making the tree susceptible to pathogenic fungi and other insect damage. Though this may not directly kill the host, the damage is unsightly, the growth is stunted, and the overall general health of the tree is impacted.

High Risk Commodities: Coconut Palm and many palm relatives. Pineapples, sugarcane and date trees and bananas are hosts for this destructive pest.

Control Measures: There are methods of control for this pest, but it is notoriously hard to find especially before the major damage is done. Multiple varieties of insecticides have been used, as have pheromone traps that employ the aggregating hormone released by males. Since CRB breeding sites are notoriously difficult to find, researchers in Guam have utilized radio transmitters that are attached to adults, who are then released and subsequently tracked back to their breeding sites, which are then destroyed. This process is fittingly known as the “Judas Technique” (Lancette 2016). A fungus known as *Metarhizium anisopliae* is also utilized to control the larval stage of this insect by being applied to breeding areas which is then passed on to the larvae.

Removal of dead trees or any decaying organic debris that could provide feeding sites for larvae can also minimize the numbers of this pest.

Travelers coming from CRB countries should never transport any agriculture items that could potentially harbor this pest. Declaring all fruits, vegetables and plant material can mitigate the chances that this pest is brought into the U.S.

Khapra Beetle (*Trogoderma granarium*)



Khapra beetle male (left) and female (right)
Photo by Rob Morrison PhD.



Khapra beetle larva, note tufts of hair on posterior
Photo by James D. Young, USDA APHIS PPQ,
Bugwood.org

The Khapra beetle (**KB**), is endemic to India, numerous Middle Eastern countries, Asia, Africa as well as some regions of Europe. This infamous insect is consistently on the USDA's most wanted list of invasive pests, and for good reason, as it has the capability to wreak havoc on stored goods, such as rice and other grains, nuts, beans, and countless other items. An infestation of a warehouse that contains such items would render these items unable to be sold and completely ruined, in a relatively short timeframe. This beetle proceeds to feed on whatever stored item it decides on, and with its high reproductive rate and its soiling of the product with its waste, it becomes extremely difficult to control, once established. The KB has a broad host range and due to its feeding inside stored grains, it is often difficult to detect until the damage has been done. Unbelievably, and thankfully, this invasive insect has not been able to set up shop in the U.S., and as of yet, there has only been one major infestation that occurred in California in 1953, but it was contained. Items coming from KB countries have stringent regulations to prevent this beetle from becoming established and this is a necessity to prevent any future problems with this pest.

Description: The KB is a very small, unassuming, brown beetle that if you look too fast, you may miss it, often because it blends in to so many objects with its mottled brown color. Viewed under a microscope, this beetle is found to be covered in hairs, which would not be visible to the naked eye. Females are larger at approximately 3 mm long and males smaller, approximately 2 mm long. Larvae of his beetle get to be approximately 5 mm in length, have a tapered tic-tac shape, are yellowish-brown in color with tufts of "hair" on their posterior.

Biology: KB begins its life as an egg (females can lay 50-100 in their lifetime), and within two weeks, the larval stage of this beetle emerges and immediately begins to feed. The larval stages of this pest last a few months, in ideal conditions, and if temperatures begin to fall, the KB larvae can enter a state of suspended animation, known as diapause. Amazingly, diapause can last for many years if necessary, until conditions improve. These insects have been known to last up to six years in diapause and another incredible capability they have is when they molt into their many instars during their larval stages, they can actually shrink to a smaller size instead of

growing larger so that if the food supply is limited, they can survive on less (Floate et al. n.d.). After pupation, adult KB emerge and within days are able to mate and continue their lifecycle.

Habitat: This pest heralds from the Middle East, so it prefers hot and dry temperatures, however, it can survive just fine in any area where cereals, grains or other foodstuffs are, such as a warehouse, pantry, or ship's stores, as long as it's not too cold, it can survive.

Associated Problems: The KB style of feeding is one of its worst traits and it is known as a "dirty feeder". This essentially means its eating style causes damage to a product and destroys more of it in the process of feeding than it actually consumes. Naturally, as the larva feeds, its waste, including discarded molt skins becomes mixed in with the food items, rendering it completely ruined. If this item is in a single individual's pantry, it is a very bad thing however if this is in a warehouse with tons of product, the results would be catastrophic. Though this pest is diminutive in size, it is amazingly tough and is able to survive for extended periods of time with little to no food, is quite tolerant to pesticides as well as extreme temperature variation. Couple this survival capability with its talent for hiding away in the smallest of hiding spots, and this pest becomes an arch-villain among the invasive pests. If a warehouse has an infestation of KB, they may clean out the entire stock, fumigate or chemically treat the premises, but some more hardy and hidden of these beetles could survive to re-infest this location, which this beetle's signature trademark.

High Risk Commodities: Any stored grains, nuts, oats, rye, dried fruits, dried beans, dried fruit, flour, meals and countless more stored food items.

Control Measures: When the KB outbreak occurred in California in 1953, agencies spent millions of dollars to eradicate this pest, and it was eventually a success. This insect has been intercepted at many of the Ports of Entry across the U.S, where Agriculture Specialists who are trained to inspect for it in a variety of settings including, personal belongings, ocean vessels arriving from KB countries as well Air Cargo have successfully prevented it from making entry. This insect can be transported in a seemingly innocuous food item, such as a small bag of rice that a person has brought from abroad. Commercial imports of products, for example, rice or chickpeas must be certified free of this pest before entering commerce in the U.S. When travelling from KB countries, avoid bringing in any stored items that may be a host for this pest, as they are not allowed entry into the U.S. Unsuspecting items such as packaging material, containing straw and also burlap bags are regulated by the USDA, as they are known hosts for this beetle.

Emerald Ash Borer (*Agrilus planipennis*)



1. Larval instars of EAB

2. Damage from EAB larvae under bark

3. Adult EAB, with open wings

Photos by David Cappaert, Bugwood.org

The Emerald Ash Borer (**EAB**) is a strikingly beautiful insect, so much so that jewelry is often crafted by using their radiant emerald green iridescent forewings. Unfortunately, along with this beauty comes a beast, and this invasive pest has wreaked havoc on our trees that were such an integral part of our national identity, from those lining main streets to those that served as refuge from the sun on a summer day in our backyard. This beetle has single handedly altered the composite of our landscape since it was first discovered in Southeast Michigan in 2002, and it has now been detected in 35 states. The EAB was more than likely introduced on solid wood packing material (e.g. pallets) in a cargo shipment arriving from Asia, the homeland of this invasive insect and it readily made its way into the wild. Since this beetle arrived in the U.S., it has destroyed hundreds of millions of ash trees and has also costed hundreds of millions of dollars in damages to the forest industry, nurseries, municipalities, and private landowners (Bott 2018). This insect has the ability to easily be spread by hitchhiking on materials such, as firewood and other plant material which can then spread to unaffected areas. Interestingly, baseball bats, which are traditionally made of ash wood are also threatened by the EAB. This beetle remains a real threat in the future, not only to our traditions in this country, but also to the landscape that we all cherish and enjoy.

Description: The adult EAB is an unmistakable with its iridescent green jewel like body, and it ranges in size from 9-13 mm. The adult beetle is somewhat bullet shaped, with prominent large black eyes. When the beetle opens its wings, it reveals a bold purple/red iridescent abdomen. The larvae of this pest are large, reaching over 25 mm in length, have numerous body segments, and are yellowish/white in color, with a somewhat bulbous head in comparison to the body. Since the larvae of the EAB tunnel through wood and feed, their bodies are somewhat flattened which makes tunneling through wood easier. The pupal stages are ghost like pale versions of the adult form that start taking on the color and appearance of the adult beetle as they mature.

Biology: A female EAB selects a tree to lay her eggs starting in mid-June until mid-August, where she deposits them individually between the outer bark on the trunk and branches of the tree (Bauer et al. 2016). Larvae emerge from eggs within a week to ten days begin to bore their

way through the wood, eventually arriving at their destination, the cambium layer just under the bark. Once in this area, the larvae begin to feed off the nutrients of the tree and as they tunnel through the xylem and phloem regions, they create numerous serpentine galleries. These areas within the tree are its transport system of essential nutrients and water, necessary for life and vigor, and the continued disruption of these regions can effectively kill the tree. The growing larvae continue to feed on the tree until the fall, and at this time, they create a pupal chamber, assume a position where they fold themselves in half, and proceed to overwinter until spring when they pupate. Adults emerge around late May and to June and the telltale sign on an affected tree are d-shaped marks that they create as they chew out an exit hole.

Habitat: The EAB's native habitat is various countries on the Asian continent, such as China, Korea, and Japan, but it can survive just fine anywhere that ash trees are growing.

Associated Problems: The principal damage to ash trees by this beetle is done during the larval stages, which are boring into the wood which prevents the trees from obtaining the water and nutrients they require. Adult feeding damage is typified by missing notches on the edges of leaves, although this does not cause significant damage to the tree.

High Risk Commodities: The EAB was originally introduced on wood packing material, and as such, these items are still high risk for a new introduction or reintroductions especially near ports of entry (air, land, or sea), where goods are shipped on wooden pallets or other packing material from EAB countries. The transportation of firewood by the public traveling from EAB areas to unaffected areas is a major factor in the continuing dispersal of this insect within the U.S.

Control Measures: Per the current U.S Code of Federal Regulations (7 CFR 301.53-3) there are currently quarantined regions to prevent the spread of EAB in 24 states and the District of Columbia. It is prohibited to transport firewood, nursery stock or other plant material that could be infested with this insect in these quarantine zones. Since wood packing material is also high risk item, there are also stringent requirements for its use and countries have to abide by IPPC (International Plant Protection Convention) stamping of all wood packing material that shows that it has been treated (fumigated or heat treated) for wood boring pests, such as EAB. These markings on a pallet or other wooden material would show the certification symbol, the country identification code where the wood originated from, the treatment type, as well as numerical certification codes to identify who manufactured and treated the material. Failure to comply with these wood packing material guidelines can result in shipments being re-exported or destroyed. Federal and State agencies also use special EAB traps that are coated with a chemical attractant and are purple (a favorite color of this beetle) which can detect if this beetle is in an area which can be used to prevent or minimize infestations of this pest. When it comes to quarantines and import requirements that have been enacted to prevent this destructive pest from spreading, industry undoubtedly plays an important part in this, but so does the individual. Abiding by these quarantine rules by not transporting firewood and other plant material into/out of these affected areas seems like such a simple rule to follow, however it unfortunately still occurs. Everyone makes a difference in trying to prevent the EAB from gaining more ground in destroying our ash trees and forever altering our iconic forests, parks and neighborhoods.

Asian Longhorn Beetle (*Anoplophora glabripennis*)



Asian Longhorn Beetle Adult (Male)

Asian Longhorn Beetle Larvae

Photos by Michael Bohne, USDA Forest Service, Bugwood.org

The Asian longhorn beetle (**ALB**), is a notorious invasive pest that has deservedly received a lot of press over the years since it was first discovered in the U.S. in Brooklyn, NY in 1996. This beetle is a destructive pest of hardwoods, such as maple, alder and elm, and its damage is altering the landscape of our forests and neighborhoods as it destroys large numbers of these and other hardwood trees. This wood borer, like the EAB, was introduced into the U.S. on solid wood packing material originating from Asia, most likely from China. The ALB is a very large beetle, as are their hungry larvae, and commensurate with this, the damage that they inflict on healthy trees is large too. Unlike other beetles that consume wood and often choose injured or weakened trees, the ALB readily attacks healthy ones. This beetle also gets around when firewood and other plant materials are moved from an infested area to one that is not, which can severely undermine efforts that are currently going on to rid this invasive pest from the U.S. for good. Fortunately, there has been much success with the eradication programs for ALB and this has been possible because of the help of the public, who inform state and federal authorities when they find this beetle on their property. Timing is everything when it comes to getting the ALB under control by preventing its establishment in new areas before it has a chance to destroy our trees that are an irreplaceable resource and a national treasure of our landscape.

Description: One thing this beetle has going for it, that is in our favor, is that it is quite large and unusual, which leads many people, even if they don't know exactly what it is, to contact an expert to report it. The adult ALB male is approximately 25 mm long and the female 35 mm long. The beetle's antennae are extremely long, which helps to explain the why they are called longhorns; The males antennae are about 2.5 times as long their body is, and the female's is about 1.3 times her body length (CABI 2019.) and the segments switch colors between black and white down their entire length. The legs of this insect often have a light powder blue color and they have a shiny black and white speckled coloration on their backs. The larvae of this beetle get very large as well, and mature larvae can reach up to 2 inches (50 mm) in length! Larvae are yellowish/white in color and their head is brown and the first segment before the head is larger and wider than the rest of the trailing body segments. The inactive pupal stage first starts off as a pale ghostlike representation of the adult beetle with their antennae coiled up in a loop next to their body due to their large size. As the pupal stage matures, the pale form of the insect begins to get darker, finally adopting its signature coloration and patterning.

Biology: The lifecycle of the ALB begins when a female lays her eggs (of which, she lays up to 90 in her lifetime) upon a hardwood tree that she selects. Before depositing an egg, the female chews a noticeable section out of the bark, wherein her single egg is laid. After a couple of weeks, the larvae hatch from the egg and begin to chew their way through the tree, and this is where the real damage begins. The larva initially feed on the phloem and cambium of the tree; the phloem is responsible for supplying essential nutrients to the tree while the cambium is the growth layer in a tree. As the larvae mature, they continue to feed further into the tree, reaching and then consuming the xylem tissue, which is what transports water through the tree. After going through multiple instar growth stages (five altogether) through the winter, the ALB larvae pupate during the following spring and early summer and then emerges the as an adult by the early to mid-summer (McCullough 2005) The adults emerge by chewing their way out of the tree, leaving a telltale gaping hole behind in the process. Mating and egg laying occur during the summer and fall with the ALB, starting the lifecycle over again

Habitat: The ALB is endemic to Asia, more specifically, China Japan and Korea. This beetle can survive anywhere there is a hardwood host, which is why this insect single handedly threatens more than 10% of all U.S. forests (Campbell 2020).

Associated Problems: When first emerging, the ALB larvae initially feed on the phloem and cambium of the tree, the phloem is responsible for supplying essential nutrients to the tree while the cambium is the growth layer in a tree. As the larvae continue to feed further into the tree, they reach the xylem which is the tissue that transports water through the tree. This consumption and tunneling through these vital areas of the tree disrupt its ability receive vital nutrients and water, eventually weakening and killing it. The weakening of the limbs and sometimes the entire tree can pose a risk to individuals and property should they fall due to their attack by ALB. Also, the exit holes created in the tree by the newly emerged adults are essentially like an open wound and make the tree susceptible to other pathogens as well as other insect damage. Besides the destruction that this beetle can do to our precious hardwood trees, it can, if it is not stopped, cause extreme economic damage to the forest industry and cause the prices of lumber and other wood products to skyrocket due diminishing supply. Other industries that are dependent on hardwood trees, such as the maple syrup industry could also be decimated by this, because this invasive pest is anything but sweet.

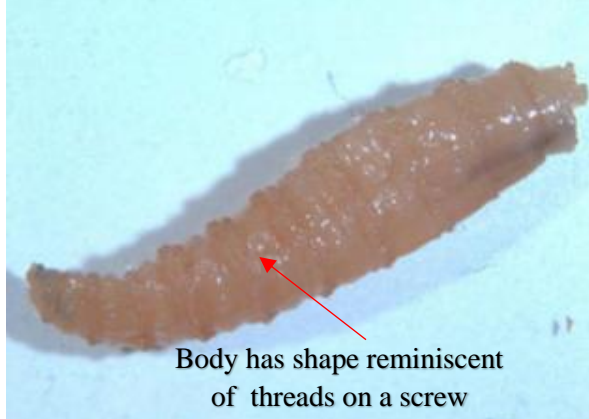
High Risk Commodities: The ALB has many hardwood tree hosts, but it definitely has its favorites, including maples, horse chestnut, willows, American elm, birch, and sycamore. The common denominator in all of these tree varieties are that they are the embodiment of our backyards, forests, parks and something was near us during major events in our lives. They may have held a swing for us as a child, given us shade under a sweltering summer sun or been the background for our most precious family photos. The loss of these trees would alter not only our landscape, but also a part of us.

Control Measures: Once an ALB infests a tree, the removal and destruction of it is the only method that can prevent the beetle from spreading, which is a crude, but necessary method to stop this beetle. Over the years, there have been improvements in the use of systemic insecticides that have been used to pretreat trees before the ALB attacks to stop the problem

before it occurs. Though this form of treatment is a huge undertaking by many agencies, it seems that there is much promise in this method.

The ALB would be almost impossible to control if the eradication programs that have been effective so far fail. When other invasive pests that attack trees have been introduced into the U.S., such as the emerald ash borer, eradication programs became less of a reality as it spread like wildfire throughout the country. Luckily, with the ALB the quarantines and eradication programs seem to be working, as this insect has yet to spread into the wild as of this current time. The public has been an indispensable part of the success by leading agencies to many outbreaks of this pest that would have otherwise probably gone unnoticed. The USDA has successfully used outreach programs, radio and billboard advertisements and other media to inform the public that they play a pivotal role in preventing the ALB from spreading, and this appears to have made a huge difference. Multiple quarantines in various states for this pest have been lifted and certified ALB free which illustrates that it is possible to prevent its spread. Regulating wood packing material coming from ALB countries has also proved effective in preventing this pest from arriving and spreading to other states. Also, stopping the transport of firewood that may contain the ALB from current quarantine areas to unaffected regions is also an extremely important guideline that needs to be adhered to by individual. This exemplifies once again, that when it comes to invasive pests, one person can make a huge difference in preventing their spread.

New World Screwworm (*Cochliomyia hominivorax*)



Body has shape reminiscent of threads on a screw

Screwworm larvae, notice its screw-like body shape
Photo by Lesley Ingram, Bugwood.org



Adult Screwworm Fly, metallic blue in color with black striping
Photo by Judy Gallagher, University of Florida

The screwworm. Even the name sounds unpleasant upon first hearing it, and unfortunately, the life and behavior of this pest matches the uncomfortable name that has been bestowed on it. This informational piece is regarding the New World screwworm, which inhabits the Western Hemisphere, and not Old World screwworm from the Eastern Hemisphere, although both of their lifecycles are the similar. The screwworm is actually the larval stage of the screwworm fly, but it is the larvae of this fly that does the damage by feeding off the living flesh of livestock and other animals, wild or domesticated. An infestation of an animal by these larvae is known as myiasis. The female screwworm fly lays her eggs on the wound of an animal after being attracted to even a minute cut or a tiny bite wound on the unfortunate creature. The larvae develop in this wound, feeding off of healthy tissue, enlarging it, and death can result from the horrific cavity that can be created by the voracious larvae. The screwworm used to be present in the U.S. up until it was eradicated in 1966, making it the poster child of one of the most successful invasive pest control programs in history. Since this pest is endemic to South America still to this day, the collaboration of multiple countries, namely Mexico and Central America, has allowed the whole region above South America to be free of this pest as well, after decades of hard work. This buffer zone between North and South America has its epicenter of control in Panama, which is home to a joint venture between the USDA and its equivalent there, The Panama Ministry of Agriculture and Livestock Development (MIDA), to prevent this pest from any future northward movement. This program oversees the release of millions of sterile screwworm adults. To this day, screwworm is still not in the U.S, Mexico, and Central America, all the way to Panama, where every year, over a billion of these sterile male flies are released. Although this program is very costly and labor intensive, it has been incredibly successful and has prevented this insect from causing an economic catastrophe in our livestock industry.

Description: The larval form of this insect undergoes three instar stages of growth, starting out as creamy white in color and when at their last instar they take on a pinkish coloration, reaching up to 17 mm in length when fully grown. Their body, especially towards the posterior end becomes tapered and looks somewhat screw-like in shape (hence their name). The adult fly has a metallic blue body with three distinct black racing stripes along its back behind the head, its eyes are red in color and it reaches up to 10 mm in length

Biology: The lifecycle of this pest begins when a female ready to lay her eggs is attracted by odors coming from an open wound or exposed area on an animal (including humans), she then lands on/near the wound to lay her 100-300 eggs. The eggs hatch very quickly, approximately within 12 hours, at which time, the newly hatched larvae work their way into the wound and begin feeding upon on the living flesh. As the size of the larvae increases with their development, so does the feeding and the wound site. After the larvae reach maturity, they drop from the wound to the ground, where they burrow into the ground, and pupate. Under ideal conditions, pupation take approximately 7 days, and the adult flies then emerge and after a couple of days become sexually mature to mate and start the lifecycle over again. This lifecycle is quite fast, and as such, the damage that these large populations of larvae can do is quite alarming.

Habitat: The screwworm is at home among livestock due to their being a lot of opportunity for finding a host however, it also can attack wild and domestic animals and humans alike. This insect is originally from tropical and subtropical regions ranging from Mexico to South America, where it has luckily been eradicated from everywhere but South America. It was able to survive just fine in the southern regions across the U.S., before it was eradicated, so it enjoys warmer weather.

Associated Problems: The wound sites that are made by the voracious larvae infestation, can cause almost cavernous damage around these affected areas. This opens up the animal to attack by other insects and the open wounds are also susceptible to infection and the animal can oftentimes die from this. When the screwworm was in the U.S. before being eradicated, the mortality of fawns on one ranch in south Texas varied from 20% to 80%, which illustrates how dangerous this pest is (Spickler 2015). If the screwworm is not controlled through the extremely successful sterile release program, it will undoubtedly become a scourge for the livestock industry should it return, It almost goes without saying that an animal is unfit for consumption once it its infested with this insect, that is, if it does not succumb to death from its injuries first.

High Risk Commodities: Even though this pest has been eradicated from the U.S., there is still a risk of it being reintroduced and we must be vigilant so that this never occurs again, In 2016 the screwworm returned, attacking deer from the National Key Deer Refuge in Florida, and it is still unknown how the screwworm made it into the deer population. In 2017, approximately 100 miles away from the Key Deer Refuge incident, a stray dog was found near Homestead, Florida and was found to be infested with screwworm as well (USDA-APHIS 2017). In both of these cases, the USDA employed the sterile release of screwworm flies, and since this time, no more of them have been found.

Control Measures: The sterile screwworm fly release program has been an incredibly successful control measure that without a doubt has eradicated this pest from the U.S. since 1966 Even better, this control method occurs without the use of pesticides or any other dangerous method to humans or animals. The collaboration of multiple countries to accomplish this goal shows that with cooperation and a common cause, anything can be possible, and everyone reaps the rewards of the eradication of this pest. Animals that are being imported in the U.S. from screwworm countries are required to have a veterinarian inspection to determine if they are free

from screwworm and this has to be officially provided on a health certificate for the animal as a requirement to enter the country. When an individual traveling from a screwworm country is transporting an animal, they should always abide by regulations and ensure that they have had the animal inspected by a veterinarian to verify that it is certified free from screwworm infestation. This simple but important step can help ensure that this extremely damaging pest never becomes established again in the U.S again.

Old World Bollworm (*Helicoverpa armigera*)



Photo of Species of *Helicoverpa armigera* in dorsal (left) and ventral (right) views. A Female. B Male. Photos: Luziany Queiroz Santos Used by permission



Old World Bollworm Larva
Photo by Paolo Mazzei, Bugwood.org

Just when you think there cannot be one more invasive moth on the list that has an insatiable appetite for some of our most valuable crop varieties and pose a significant economic threat...introducing the Old World bollworm (**OWB**). This moth is endemic to Europe, Asia and Africa and has recently become a realistic threat to the U.S., as one was discovered in Florida in 2015 and they are also intercepted often by Agriculture Specialists located at multiple ports of entry across the United States. In an interesting, and convoluted twist, this pest is so closely related to the already present moth known as the corn earworm (*Helicoverpa zea*), that the only way to tell these two pests apart is through genetic testing or dissection by an entomologist. Much like the Asian gypsy moth and the European gypsy moth, these two moth pests have the potential to hybridize. The OWB has a much broader host range than the resident corn earworm, in fact, over 180 varieties of wild and cultivated plants are at risk should this pest become established in the U.S (USDA 2020). This destructive pest should not be taken lightly, as it currently causes more than \$2 billion of crop damage a year just in Asia, Africa and Australia and leaves a devastating wake of environmental damage due to the insecticides used to control it, as well as socio-economic damage (Tay et al. 2013). Perhaps one of the most worrisome aspects of this pest, is its ability to undergo a state of suspended animation, known as facultative diapause, enabling it to ride out unfavorable environmental conditions, which would otherwise have killed them.

Description: The adult OWB, is between 14-19 mm long and a somewhat plain looking moth, the males are brown, white and tan, with dark brown bands of color along the wing margins and a dark brown kidney shaped spot around the center portion of the forewings. The adult female is darker, orange/brown in coloration with the kidney spots on the forewing as well. The caterpillar stage gets to be over 50 mm long and varies in coloration as it progresses through its six developmental instars, ranging from green to brown with lighter yellowish striping going down either side of the body from head to toe.

Biology: An OWB female searches for host upon which she will lay her eggs, depositing them singly or in groups usually oftentimes near newly forming buds or other reproductive areas of the plant. A single female is capable of laying up to 1500 eggs in her lifetime. In subtropical regions of the world, this pest has can have 3- 5 generations, but in tropical regions there can be up to 11 annually (Hayden and Brambila, 2015). Under ideal conditions, the eggs only take a few days to hatch and the newly emerged larvae begin to move into various developing areas of a fruit or vegetable, such as the ears of corn or inside a seed pod and they may not be initially be noticed because of their habit of feeding inside these structures. The larvae usually undergo six larval instar stages of development, voraciously consuming the nutrient rich pods, buds and even the fruit. The larval stage lasts a few weeks, given optimal conditions, and after which, the larvae fall to the ground, crawl into the soil, and begin their pupal stage of development. The pupal stage for this moth varies because it is able to change how long it lasts due to environmental stressors; Under ideal conditions this pupal stage could last a week, but under extremely cold temperatures (and hot) , it could be delayed for months. This process is called facultative diapause and it is one of the main reasons this pest is so successful and insidious, as it is able to adapt and survive in hostile environments. Another ability of this pest is that when food resources become limited, it is able to rise to high altitudes and allow the wind to carry if far distances to ensure survival (Hayden and Brambila 2015). The reproductive potential, dispersal capabilities and environmental fortitude of this pest are major factors in its ability to become threat to agriculture systems in the U.S.

Habitat: The OWB is functioning at its optimal for reproductive rates in tropical and subtropical areas of planet, including Asia, Europe, Africa, and Australia. The ability for the OWB to go into a suspended animation under extreme temperatures allows it to survive in areas that would for other pests be otherwise uninhabitable.

Associated Problems: The OWB has a large host range that includes many important and high value crops including peppers, tomatoes, corn, cotton, alfalfa, and soybeans among over 120 more. This pest is particularly damaging to their hosts by the manner with which it feeds. The larval stage of the OWB seek out the nutrient rich reproductive regions of its host, such as the newly formed shoots, buds, fruit, flower and pods, however, they even consume the leaves. This kind of feeding injures the plant in numerous ways including internal and external feeding damage, subsequent secondary bacterial growth in these damaged areas, as well as the premature dropping of fruit and pods. To make matters worse, the OWB has developed resistance to many pesticides and also alarming is its developing resistance to genetically modified crop varieties designed to control it. This resistance to pesticides and other control methods causes the inputs of these chemicals to increase, which could have long term negative effects on human, animal and environmental health. Convoluting the future control of this pest, should it arrive in the U.S. is the genetic similarity that it shares with the already present pest known as the corn earworm. These two pests are virtually indistinguishable except by dissection or genetic analysis, so knowing if and when they hybridize would be very difficult, which would complicate timely control measures to prevent their establishment. Though the corn earworm is already a destructive pest in the U.S., the hybridizing of it with the OWB could potentially intensify the threat.

High Risk Commodities: The OWB attacks many varieties of plants including fruits, vegetables as well as ornamentals. Unfortunately, many of our most high value and important field crops are on its host list, including corn, peppers, tomatoes, potatoes, wheat, soybeans and chickpeas. This pest also attacks ornamentals and nursery stock varieties as well, making the importation of flowers also a pathway for the OWB.

Control Measures: The OWB is notoriously hard to control due to its ability to quickly become resistant to many commonly used pesticides in the agriculture industry. Other more modern techniques of control, such as the use of genetically modified crops that use the soil microorganism known as *Bacillus thuringiensis* (Bt) and the insecticidal proteins it expresses, have also proven to not be as effective against the OWB. Like many invasive pests, monitoring for their presence is one of the most important methods to detect them early before outbreaks and spread can occur. Trapping for the OWB is very important but much more difficult due to its similarity with the already present corn earworm. Having a head start on this pest will be key to its control especially due to its ability to become resistant to pesticides and other control measures. The importation of high-risk commodities for this pest need to have appropriate treatments as well as follow all other applicable guidelines and/or certifications to reduce the risk of its introduction into the environment. Individuals traveling from OWB countries should not transport, fruits, vegetables, cut flowers and other commodities that are known hosts for this pest.

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