Fumigants & Pheromones

Digital Newsletter Delivered by Insects Limited, Inc. *Issue 169*

April Showers Bring May Flowers... and Carpet Beetles

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As a native of the Pacific Northwest, coming to Indiana 12 years ago was a real shock in a few ways.

Aside from the prolific quantities of corn fields and the ability to see a flat horizon from any direction, there are the seasons. Indiana has hot summers and cold winters.

So here in Indiana, as we are just coming out of another cold winter and into a new spring, I am starting to see (and receive phone calls about) one of our more pesky pest insects, the carpet beetle.

Carpet beetles don't just eat wool carpets! Check out this photo of feather arrow fletching and the damage that carpet beetles can do to items in long term storage. These arrows were stored in a closet for 5 years. During that time, they ate all the fletching completely off of one arrow, and damaged several others!

Carpet beetles are a member of diverse family of beetles called Dermestidae. There are over 1700 species of dermestid beetles worldwide (Háva & Herrnmann, 2021) with a variety of feeding habits and behaviors. However, feeding on dry plant (seeds, pollen) and animal (hair, skin) matter is common in this group. These insects live in abundance outdoors and can easily enter structures looking for something good to eat. Many homeowners will run across the varied carpet beetle (*Anthrenus verbasci*) at some time or another but Spring is often when we see the adults for the first time after a long winter. Adult carpet beetles are small, about the size of the head of a pin.

This time of year, the adults are out feeding on pollen from flowering plants (Spirea is one of their favorites). If only these gentle pollen feeders could just stay out there doing their thing, we could all get along! But, because they are flying around in such great numbers, it's only a matter of time before they find their way into our homes through gaps in windows, doors, or through damaged screens. The adult beetles don't do any damage directly. Once inside, they are adept at seeking out food sources for their future offspring.

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Their prime targets are food items like dog food, pasta, and cereal. What's worse, is that they don't just eat conventional food items. These insects will feed on wool, fur, feather, taxidermy, and other dead insects. The other bad news about carpet beetles is that it's not just homeowners that have to worry. Museums often contain a diversity of objects that can serve as a food source for carpet beetle larvae. Any irreplaceable museum object made of natural fibers like hair, wool, fur or feathers can be at risk. The other problem in a museum setting is that the larvae are inconspicuous and only feed on small amounts of the materials at a time.

While you may not have a cockroach this big in your home (pictured above), it is best not to let even small dead insects accumulate in your home (windows and baseboards are great places to check) because carpet beetles will happily feast on their fellow insects!

When stressed, they can also extend their larval development period by undergoing a process known as diapause (think hibernation for insects). During this diapause, they can survive for months and years while only occasionally feeding.

Diapause is a strategy that some insects use to cope with stress. They can slow their metabolism and try to ride out stressful conditions such as extreme temperatures, lack of food, and physical disturbance.

The warehouse beetle, a close relative of the carpet beetle, has been living in this vial on the same small amount of food for the last 4 years!

Another unfortunate aspect of carpet beetle biology is their hair. Some dermestid beetle larvae are covered in a fuzzy outer coating of hairs called hastisetae.

Hastisetae are a little different than the normal setae (hairs) on other insects because they have a barbed or "arrowhead" structure on the end of each one.

Hastiseatae can cause contact dermatitis and allergic reactions in many people and pets. These hairs typically serve a defensive purpose for the larvae to protect it from other arthropod predators as well as discourage other insects that might be competing for the same food resources.

Many dermestids are covered in hairs called hastisetea. These barbed hairs can cause allergic reactions in some people and pets. Small children and the elderly can be at higher risk for complications due to these irritating hairs

So now that we know that carpet beetles are gearing up for the season, what can we do?

Carpet Beetle Reduction Springtime Checklist

- Check window screens for tears and other damage

- Fix gaps and cracks around window frames and doors

- Install sturdy door sweeps on exterior doors to eliminate gaps

- Vacuum regularly while paying special attention to baseboards, windowsills, behind appliances (where you dropped those spaghetti noodles between the counter and the stove 5 years ago)

- Deploy carpet beetle and dermestid traps on windowsills and near any objects of concern (wool, fur, feathers, dry food items)

While it is nearly impossible to be 100% carpet beetle proof, by following the steps from the Carpet beetle prevention checklist, you can help reduce the number of beetles joining you in your home this Spring.

References:

Háva, J. and Herrmann, A., 2021. Checklist of Dermestidae (Insecta: Coleoptera: Bostrichoidea) of the United States.

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Lizards May Help Protect People from Lyme Disease

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Lyme disease is caused by the bacterium, Borrelia burgdorferi, and is the most common vector-bone disease infecting 476,000 people in the United States each year.

Early symptoms can be mild and include fever, headache, fatigue, and skin rash. If left untreated, Lyme disease can spread to joints, heart, and nervous system and cause more serious symptoms like facial palsy, severe joint and muscle pain, heart palpitations, episodes of dizziness, and nerve pain.

Blacklegged ticks (Ixodes scapularis), also known as deer ticks, become a carrier of Lyme disease from feeding on the blood of an infected animal host like mice, deer, and lizards.

Lyme disease is then transmitted to humans through the bite of an infected tick. Blacklegged ticks are found throughout the country, but positive Lyme disease cases are found more frequently in northern states, particularly in the Northeast.

So why is there a geographic discrepancy? New research suggests that lizards, particularly skinks, may be part of the answer.

Figure 1. Estimated distribution of the blacklegged tick, Ixodes scapularis, in the United States. Imaged obtained from the CDC (https://www.cdc.gov/ticks/geographic_distribution.html).

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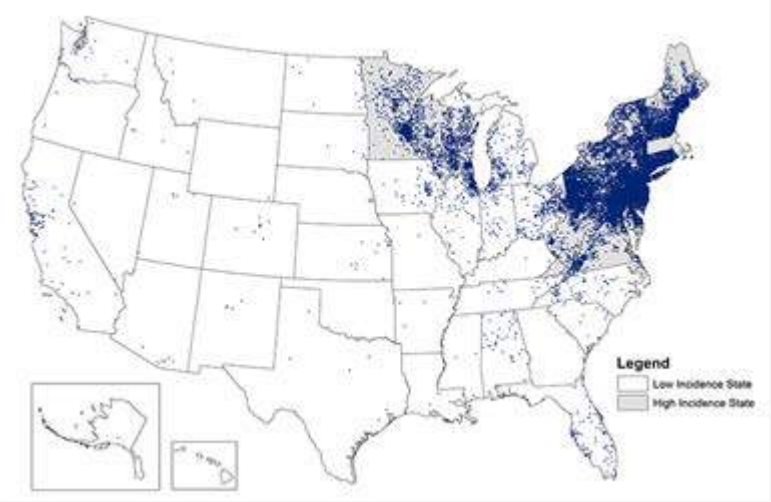

Figure 2. 2019 map of confirmed Lyme disease cases in the United States. Image obtained from the CDC (https://www.cdc.gov/lyme/datasurveillance/maps-recent.html).

According to a paper published from Ginsberg et al. in 2021, there are two reasons why Lyme disease is more common in the north and less common in the south.

First, fewer people are bitten by blacklegged ticks in the south because ticks tend to stay under forest leaf litter to avoid dehydration from higher temperatures. Whereas in the north, cooler temperatures allow ticks to venture further on top of leaf litter, leaf tops, and twigs, where ticks would encounter people more frequently.

Second, blacklegged ticks in the south have a lower prevalence of the Lyme disease bacterium because they feed primarily on skinks, compared to blacklegged ticks in the north who feed primarily on rodents. The Lyme disease bacterium does not survive as well in reptiles as it does in mammal hosts, so when a tick feeds on a skink it is less likely to become infected and transmit Lyme disease to people.

Figure 3. Life stages of the Blacklegged tick, Ixodes scapularis. Starting from the left is the larvae, nymph, adult male, and adult female. Imaged obtained from the CDC (https://www.cdc.gov/lyme/index.html).

This brings about some interesting questions as our climate changes. Currently blacklegged ticks are moving further northward into Canada with the increased prevalence of Lyme disease. Will climate change alter tick behavior? If skink populations move northward will the prevalence of Lyme disease decrease in states like Virginia? If skink populations decrease will the prevalence of Lyme disease increase?

References:

Ginsberg HS, Hickling GJ, Burke RL, Ogden NH, Beati L, LeBrun RA, et al. (2021) Why Lyme disease is common in the northern US, but rare in the south: The roles of host choice, host-seeking behavior, and tick density. PLoS Biol 19(1): e3001066. https://doi.org/10.1371/journal.pbio.3001066

Centers for Disease Control and Prevention. Available from: https://www.cdc.gov/lyme/datasurveillance/maps-recent.html

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Plumes: How Pheromones Travel

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Pheromone plumes are an intriguing and complex part of nature.

Knowing a bit more about them gives us a lot of respect for how amazing insect communication can be and it also helps us become better at setting up trap monitoring programs and providing integrated pest management.

As cooler temperatures arrive, the vision of curls of smoke coming out of the chimneys of people's homes becomes quite common.

Quaint scenes of families sitting around warm wood fires, enjoying each other's company, comes to mind.

Female Indianmeal moths release sex pheromone that is carried away in the form of a "pheromone plume" that will attract any males in the area

In the insect world, the sex pheromones released by female insects are a lot like the smoke emanating from those chimneys. Pheromone scents are whisked away from the female and carried on air currents to surrounding locations. The physical shape or structure that pheromones make after they emerge from the female are called "plumes". This terminology arose from the fact that odor plumes often resemble the shape of a feather as they start narrow at the source and spread out as they become diluted in the air.

Plume structures can be quite complex, determined by the molecule size and density of the pheromone as well as the air currents and atmospheric conditions including what the barometer is telling us.

As pheromones radiate from their source, they are initially very concentrated in the air. Typically, the odors widen and expand in a type of "molecular diffusion" as they move away from their source. They can end up very weak the further they travel from the source.

Occasionally, finger-like strands of the scent remain in high concentrations as they float away from the source, leaving odorless gaps in between.

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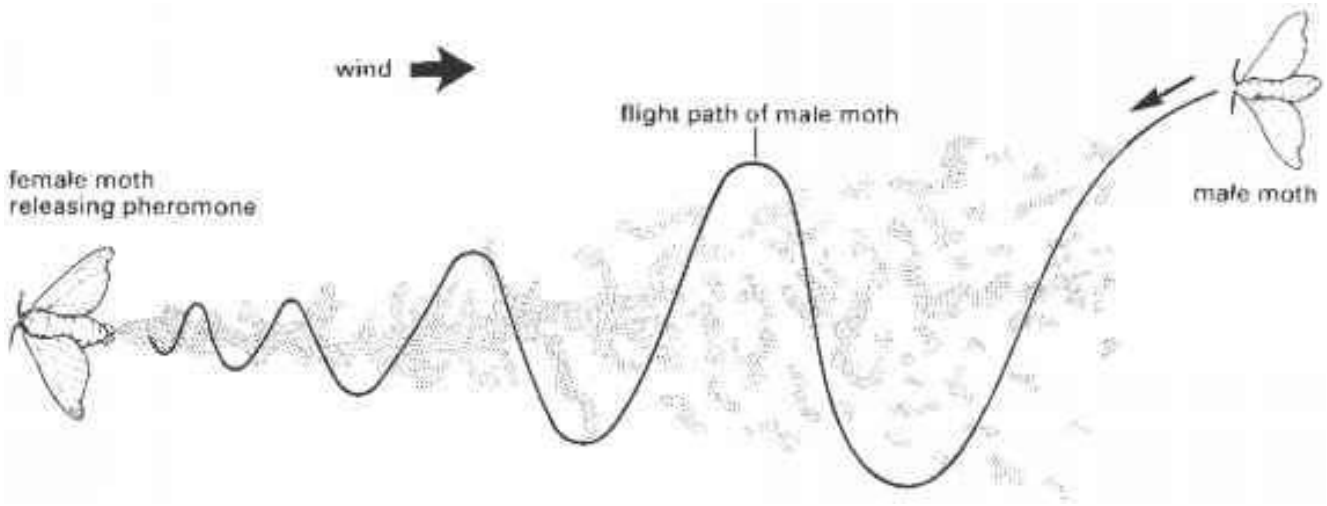
In either of these scenarios, if the plume is a sex pheromone coming from a female insect or from a pheromone lure, male insects are good at picking up plume odors and determining their origin back to that female (or a perceived female in the case of a lure).

Insects smell odors using sensory hairs in their antennae rather than a nose. In general, if an insect is looking for a mate and it picks up the correct pheromone, it will immediately react and will begin seeking out the source of the plume. Like a lock accepting a key, the antennae of some insects are specially designed to pick up the specific pheromone of their own species. Often times, the sensory hairs on antennae are so sensitive to a potential mate's pheromone that they can detect picogram quantities in the air. One picogram is equal to one trillionth of a gram. A typical paperclip weighs about 1 gram. Imagine breaking a paperclip into a trillion pieces and just how small a quantity that the male moth can detect using his antennae. Watch this video titled "Radar Love" to learn more about how insect antennae pick up pheromone scents: https://youtu.be/VAd14Srn7rI

Once an insect locks onto the plume, it will move rapidly, constantly readjusting to remain within the plume. As these oriented movements bring it closer to the source, the quantity of pheromone molecules in the air increases. The increase in pheromone concentration causes the insect to slow its rate of speed and reduce its rate of turning as it nears the source. Eventually the male insect makes physical contact with the female insect or in some circumstances (if we are monitoring with pheromone traps), they make contact with a sticky trap that contains a pheromone lure and are captured. Chalk it up as another successful account of the "Power of the Plume".



Location of pheromone-emitting female by male moth tacking upwind. The pheromone trail forms a somewhat discontinuous plume because of turbulence, intermittent release, and other factors.
Image from Insectomania/"Reception of communication molecules" 2022 https://www.insectomania.org/natural-enemies/box-42-reception-of-communication-molecules.html (After Haynes & Birch, 1985)

Note: One reason why mating disruption pheromones work well for some insects is the fact that the entire area becomes a giant pheromone plume with no actual source for the moths to find.

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The Top 5 Fabric and Museum Insects

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Up to 54% of museums and historic homes have reported damage from insects. Textiles, animal hides, taxidermy, wood works, natural fibers (like wool and cotton), books, and paintings all contain material that insects can exploit and do irreversible damage to.

In this article, I am going to break down fabric and museum insects into the top five most encountered species – the webbing clothes moth, varied carpet beetle, silverfish, cigarette beetle, and powderpost beetle.

First I would like to share a couple stories of why knowing the insect and having a good Integrated Pest Management (IPM) program is crucial to protect and ensure the continued longevity of important historical artifacts. Ss well as how some IPM programs can be difficult to implement with different cultural ideologies.

The first story is from David Pinniger, an IPM specialist in the United Kingdom, who shared his story at a pest management working group of how clothes moths destroyed the last remaining skin and feathers of the now-extinct dodo bird. The remains of the bird were hidden in a display case in the museum beneath an artistic rendering of how the bird may have looked when it was alive. When the museum staff opened the case after several years to do some cleaning, there was nothing left of the specimen except the bones.

The other story was shared by Elénore Kissel, a conservator in Paris. She was working in Tibet with Tibetan monks. Their task was to save some ancient tapestries from destruction by carpet beetles. The monks' religious view of reincarnation left them uncomfortable with physically killing the beetle larvae and adults on the tapestry, so they spent several weeks removing each insect by hand with tweezers and releasing them far away from the monastery each night.

The number one most common and detrimental fabric and museum pest is the webbing clothes moth, *Tineola bisselliella*. Webbing clothes moths can be identified by their single tone of creamy white to shiny gold color with no spots. The case making clothes moth is a similar fabric and museum pest but have small spots on their wings. Adult moths live for 15-30 days where upon mated females can lay 40-50 eggs individually or in groups. Eggs hatch in 4-10 days in warmer months and up to 30 days in cooler months.

The larvae feed and become mature in 35 days or as long as 30 months depending on food quality, temperature, and humidity. Pupation will occur in infested materials. Adults will emerge from the pupae in 8 to 40 days depending on temperature. Signs of clothes moth infestation include granular frass the size of ground pepper on or around items they are feeding on such as fabric, furs, taxidermy mounts, hanging clothes in closets, wool rugs, carpets, and upholstered furniture when rips or tears expose stuffing. Larvae can cause serious damage to wools, furs, and feathers.

Larvae create white webbing tunnels, but these are not always present. Pupae cases can be found on the surface, within a pile of carpet and rugs, or underneath these materials. The second most common fabric and museum pest is the varied carpet beetle, *Anthrenus verbasci*. Varied carpet beetles have a black to gray body with a varied pattern of white, yellow, and brown elongated scales on their elytra. The last three antennae segments are slightly enlarged and form a club shape. The female beetle will lay eggs in materials made with hair, feather, or insect parts. Larvae will feed off the food or fiber substance for about 7-10 months depending on environmental conditions. The life cycle on average will be 11 months and adults live for 30-45 days.

Adults actively fly when temperature is above 70 degrees Fahrenheit. Only larvae cause damage to plant, animal products, and textiles. Adult carpet beetles feed on pollen of flowing plants. The presence of cast or shed skins is a telltale sign of larval activity. Holes and frayed fibers in textiles may also be present. Adults are excellent fliers and are attracted to lights. Varied carpet beetles are commonly found in nests of bees, wasps, and birds, but can also attack, horn, wool, hair, silk, dead insects and is occasionally found in food and spices. The varied carpet beetle is a common household insect.

Third is the common silverfish, *Lepisma saccharinum*. Silverfish are light gray and have an elongated body with 3 long bristle-like appendages at the end of their abdomen.

Silverfish are found throughout the U.S. and are typically seen in moist, humid areas in the home, such as bathrooms, basements, and attics. A female will lay up to 100 eggs in her lifetime into small cracks and crevices. When eggs hatch into nymphs, they are whitish and look like small adults. As they molt, young silverfish develop a greyish appearance and a metallic shine, eventually becoming adults after three months to three years. They may go through 20 to 50 molts in their lifetimes and continue to molt after reaching adulthood.

Silverfish can digest cellulose due to the enzymes that in their midgut. These could include book bindings, carpet, clothing, dandruff, glue, hair, paper, photos, plaster, and sugar. Other substances they eat include cotton, dead insects, linen, silk, tapestries, leftover crumbs, or even their own molted exoskeletons. Silverfish are known to live for a year or more without eating if water is available.

Fourth most common is the Cigarette beetle, *Lasioderma serricorne*. Cigarette beetles can be identified from drugstore beetles by the many serrated teeth antennae. The female beetle will lay up to 100 eggs during a 2-4 week life span. Larvae will tunnel through the food product for about 4-5 weeks. The average life cycle will take 6-8 weeks depending on temperature and humidity. These beetles are excellent flyers and are most active in the late afternoons.

Packages and food products infested with these beetles usually have shot holes

where adults have emerged from pupation. Both adults and larvae cause product damage. Adults are excellent fliers and are attracted to lights. These beetles are commonly found in tobacco and other processed foods such as spices, flour, dog food, but can also attack horn, wool, hair, hide, pharmaceuticals and even book bindings. It is a common household pest.

Coming in at number five is the powderpost beetle. The “Powderpost beetle” is a term used to describe several species of small insects that damage wood to a flour-like powder. Larval development takes place entirely under the wood surface. The developing grub-like larvae damage wood as they create narrow, meandering tunnels as they feed. Infestations can be identified by noticing powder, accompanied by small, round “shot holes” on the wood surface.

These “shot holes” are exit holes where adult beetles have chewed out of the wood after completing their development. Newly emerged adults’ mate and lay eggs on or below the surface of bare, unfinished wood. The eggs hatch into tiny larvae that bore into the wood, completing their life cycle. Customers are more likely to see damage, rather than the beetles themselves, because the adults are cryptic and active mainly at night. Occasionally, powderpost beetles may are found near damaged wood, or on windowsills since some are attracted to light.

The three most destructive wood boring insect groups that can reinfest wood products are the lyctids which are the true powderpost beetles, anobiids or the furniture beetles, and bostrichids or the false powderpost beetles. Lyctids attack wood products manufactured from hardwood trees such as oak, ash, walnut, hickory, poplar, cherry, tropical hardwoods, and bamboo. Anobiids attack both hardwoods and softwoods, usually with higher moisture content. Bostrichids attack mainly hardwoods but have been seen on some softwoods.

Monitoring for insects provides valuable information, such as the presence of insects, insect species, population trends, and locations of infestations. Blunder traps capture pests that are moving between areas while baited traps use food or pheromone attractants to lure specific species of insect to a trap. Different styles of traps and attractants are used to monitor different species. For example, hanging traps are designed to capture flying insects while floor traps are designed to capture crawling insects. Varied carpet beetles can be best monitored by a food lure and pheromone lure in a floor trap. Moths like the Webbing Clothes Moth and Case-Making Clothes Moth are clumsy flyers can be monitored using hanging or floor traps with a pheromone lure.

There are several ways to treat an active pest infestation at museums and historic homes. The most appropriate method will depend on a variety of factors such as the type of collection, size of infestation, institutional capabilities, and budget. Some treatment options could include:

- **Isolation or Bagging** (Placing item on white paper in polyethylene bag. Waiting a few weeks then inspect for signs of insect activity such as live insects, cast skins, frass, or webbing)
- **Freezing** (Store items in freezer at -20F for 72 hours)
- **Anoxic Treatment** (Reducing oxygen concentrations to 0.5% for 21 days)
- **Heat Treatment** (Storing items in an oven or solar bag at 130 – 140F for 3 hours)
- **Fumigation** (Using Phosphine at 500 – 1,000 ppm for 72 hours above 70F or Sulfuryl fluoride at 500 – 1,000CT (depending on insect species) for 24 hours above 80F.)
- T**here is also the option of other Pesticides** such as pyrethroids, insect growth regulators, organophosphates, boric acid, or diatomaceous earth. Make sure to read and follow the label!

It is important to Start with the Insect First!

Identifying the insect and understanding their biology is the first step to an effective integrated pest management program.

Once the fabric or museum insect has been identified, inspect areas for ideal food sources such as wools, furs, or feathers.

Pheromone lures and traps are great tools to monitor and help identify the source of infestation.

Finding and treating the source can help pest management professionals solve a difficult pest problem to help protect artifacts of historical importance.

If you have any fabric and museum insect or pheromone questions, you can contact me at E.Estabrook@InsectsLimited.com.