Fumigants & Pheromones

Digital Newsletter Delivered by Insects Limited, Inc. Issue 154

All Pests Are Equal, But Some Pests Are More Equal Than Others

Quinn Schroeder
Fumigants & Pheromones Guest Contributor

The staff of Insects Limited had the pleasure and the opportunity to work alongside Quinn Schroeder during his time in the industry. We observed his abilities to think through situations as a keen observer, questioning occurrences that might seem normal to others. Even though we are very happy for him, unfortunately, Quinn left the industry and is now in his third year as a medical student in Phoenix, AZ.

We were however very excited when he contacted us asking if he could contribute to the Fumigants & Pheromones Newsletter by writing informative essays on a broad range of topics including ecology, biology, and biomedicine.

Please enjoy this article and keep an eye out for more from Quinn Schroeder.

"I write this article to remind the reader that many biological systems are fragile. Often the presence of a single species, or lack thereof, decides if an ecosystem is healthy or sick, and we usually don't know which species those are or just how important their roles. The slightest change in any natural system, across any discipline, can have massive ramifications."

The Green Revolution was well underway by the late 1960s throughout Southeastern Asia. *In vitro* breakthroughs provoked field trials and drove the inception of agroeconomic policies, which pressed for agendas to seek new insecticide formulations, genetic rice strains, and increased knowledge of soil nutrition – all contributing to greener fields and higher yields. Rice, undoubtedly the most essential commodity worldwide at the time – and still so half a century later – occupied 10% of all farm fields globally and accounted for one-third of the caloric intake for two-thirds of all humans on earth! The tiniest innovation in rice paddy protection meant exponential return on investment, and billions more fed.

Without long-term studies, it was unclear how the biodiversity among the fields would be affected. It just so happened these changes made the rice fields fertile for the advent of a newcomer – an insect pest called the Brown Planthopper. This stem-boring, sap-sucking menace would hijack the vascular system of the plant, drink the nutrients, and dry up millions of acres of rice crop in a single growing season (a phenomenon known as "Hopperburn" [Figure 1]). However, the egregious planthopper was not actually new to town per se but had been reported as a "minor" pest, leapfrogging throughout Asian record books for millennia. It was inferred that new high-yielding genetic varieties of rice plants paradoxically flushed planthoppers out into the open.

Figure 1. Single and multiple adult brown planthoppers (left and center). Hopperburn in a rice paddy field (right). Pictures courtesy of IRRI.

Behind the scenes, plans were constructed to knock down the populations. Equipped with molecular techniques, organic chemists could comb through thousands of potential biocidal agents. From a pool of prospects, they plucked out the formulation they liked, tested it, and slightly tweaked its chemical structure to dial in on its killing capacity. For now, this was good news for the farmers! They had antidotes. Chemical pest management became a mainstream remedy, and prophylactic practices replaced tedious "seek-and-destroy" habits. Farmers, with a "scorched-earth" approach, instead doused their fields with organophosphates and carbamates by air and on foot. In no time at all, the planthoppers receded without contest.

But after several years of chemical applications, growing seasons in the mid-1970s gave rise to planthopper levels well exceeding any years prior, and each year progressively worsened. In Indonesia alone during the 1975 and 1976 seasons, estimated crop losses exceeded US$70 million. A top producer just years before, Indonesia quickly capsized and became the largest rice *importing* country globally! Historically, rice fields accommodated an average of only one planthopper per plant. Now, many farms averaged over 500 planthoppers per plant! To add insult to injury, field studies revealed reproduction rates had doubled. Farmers, watched from the edges of their estates as the foliage yellowed – leaves initially, then the stalks. It would only take a month for planthoppers to turn lush turf into ashtrays as the paddies dried out and perished. Dinners were had with market-bought rice, while the farmers' stocks crumbled in the backyard. Crop equities depreciated, and famine was imminent. In just a few short years everything backfired. It appeared that the miracle pesticides lost their efficacy, and planthoppers spiraled out of control worse than ever before.

This begs the question: If pesticide dosing and spraying routines had increased, why were the planthoppers becoming more abundant? Several hypotheses were pondered.

One could theorize that upon the detection of unfamiliar substances, the insects altered their behaviors and began avoiding said substances. Females across many insect orders have innate survival mechanisms by which they safeguard their eggs on the underside of vegetation, where pesticide droplets hardly reach. But this should not cause a 500-fold increase in planthoppers. Logically, if avoidance played a role, population numbers would remain stagnant at best. Furthermore, even if the eggs were out of reach, the mobile and thin-skinned nymphs were still susceptible. So that theory was sidelined.

Had the planthoppers developed genetic resistance to the chemicals? It was reasonable speculation. Resistance was commonplace in "pesticide vs. pest" competition, and perhaps this case was no different. The short answer is *yes*, but it was not the main culprit. The overuse of insecticides caused *some* population resistance, which unintentionally bred genotypically unique planthopper biotypes (i.e., the few resistant individuals provided the genetic material to make up the subsequent generations, which would pass those traits to their offspring in due time). But in so few breeding seasons, it was improbable that resistance, acting alone, could have amassed such an abundance of planthoppers.

Scientists had to switch their course of thinking. Since the dawn of systemized farming, when pest management was nil, the planthoppers flew under the radar. So, what had kept them on their "leash" for tens of thousands of generations… way before chemical control was ever imagined? Even until 1950, kerosene and whale oils, hardly pesticides mind you, were some of the only killing agents commercially available, and yet planthopper populations remained well below detectable thresholds. Asian farmers had disrupted the natural cycle, just not in the way it was intended. But perhaps the problem could be fixed. If they focused on where the planthoppers fit in their ecological system – their "rules" of regulation – and what kept populations under control naturally (simply, what they ate and what ate them), the source of the problem could be worked out.

Behind the curb but persistent, entomologists caught up to what was unfolding. They turned towards predatory spiders. The liking of orb-weavers and wolf spiders were the nuclei for regulating rice paddy ecosystems in tropical Asia – not to mention many other landbound bionetworks worldwide. Often overlooked, neglected, or squashed, spiders sit atop the thrones of many food chains. In prior seasons, as the planthopper populations rose each summer, like clockwork, spiders did their duty to flatten the curve. Had the spiders taken the year off?

A simple eye-test elicits sharp dichotomy when comparing faunas of insects and spiders. Do not be fooled. Outside appearances are insignificant in contrast to their internal mechanics – like how they breathe, digest a meal, and regulate temperature. Many of the physiological processes that transpire in insects also take place in spiders. These processes are the target for disruption by many insecticides, killing two bugs with one stone. Insecticides can also be arachnicides. Bingo! With new chemicals at their disposal, farmers tried to take out the planthoppers but accidentally eliminated the off-target spider populations. Even worse, spiders that avoided direct chemical contact often succumbed to death after the consumption of poisoned planthoppers. The natural predators were affected to a higher degree than the pest and sadly did not possess the necessary life-strategies to recover from the high mortality. Even under favorable conditions, spiders are not a "typical" opportunistic pest that can effortlessly reproduce and repopulate a niche.

To help grasp the strings and slipknots that weave together food webs, try these following two thought exercises: Scenario 1 depicts ecosystems as wish-washy mosaics, like a shopping bag full of Skittles – each color representing a unique species, be that plant, insect, fish, etc. Now remove all the yellow Skittles, and the purples, reds, and greens shift around just slightly to close the gaps and maintain harmony. The bag still retains most of its size and weight, and most of the rainbow remains. This is how the public usually views ecosystems – with all inhabitants contributing equally. Sounds nice. Looks pretty. But this is not reality.

For the second scenario, think of ecosystems as having much grander structure and intricacy, but also tipping points when a particular facet is overwhelmed. One organism may hold a higher stake than the rest. George Orwell's narrative *Animal Farm* relays this well… "some animals are *more equal* than others." Species that hold high ecological rank within their food webs are known as **Keystone Species**. And like the center stone holding up a Roman archway, their livelihood provides the forces which uphold an ecosystem [Figure 2]. Dislodge the keystone (i.e., eliminate that species), and the system will collapse, paving the way for contemporaries to spiral out of control. No longer restrained by predatory spiders – the keystone species in the rice fields – planthoppers scavenged at freewill, overpopulated with ease, and disintegrated much of the harvest.

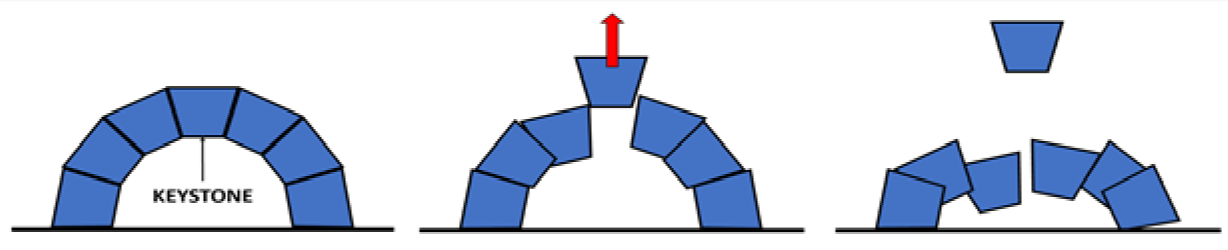

Figure 2. Most ecosystems own a keystone species, which gives the system stability. Figure by author.

The reader may be wondering if there are keystone species in other ecosystems. In fact, there are a handful of these species identified in the literature, but many are probably yet to be discovered. For example, sea otters are a keystone species in the Pacific Northwest. They prey on sea urchins, which are consumers of kelp. Poaching and fur trade nearly drove the otters to extinction by the turn of the 20th century, and the sea urchin populations skyrocketed, monopolizing entire river floors. Chowed down to stubs and left without real estate, kelp forests collapsed, taking with them necessities that many other creatures relied on for food and shelter. Wolves, keystones of the terrestrial landscapes of the American west, were hunted out of Yellowstone National Park by 1926. Once released from predatory restraints, elk populations climbed. But treasured aspen trees declined – victims to the numerous elk sharpening their antlers on the trunks.

Who would have thought spiders, often out of sight and out of mind, were the critical protectors of rice paddy crop, or otters the overseers of kelp forests, or wolves the allies of aspen?

While pest management often focuses on removal – addition by *subtraction* – the dogma of the trade must adopt regimens that seek out preservation – rather addition by *addition*. Applicators should use selective pesticides when possible, but be sure first to explore natural, pragmatic options to protect assets. Be sure to weigh control mechanisms like temperature regulation, moisture content, natural predation, and only resort to pesticides when other techniques have been exhausted. Choose an agent that aligns with the target organism, whether that is fungus, mammal, or insect. Adequate amounts of chemicals, used according to the label, can help reduce the off-target killing. Work to find a product that is deadly to the problematic organism at large, but can spare that its natural predators. Without question, pesticides are an invaluable tool when used frugally, but abuse of them will not fare well in the long run. The next time that you are spraying for springtails or cockroaches, be cognizant that predators, like spiders, are more likely friend than foe.

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Choosing the Best Outdoor Lights to Reduce Insects

Patrick Kelley, BCE
President of Insects Limited

Like a moth to a flame, serious insect pest problems can begin with the attraction to our outdoor lighting options. The same lights that we use for safety, security, and convenience can be a major factor in attracting insects into our food plants, museums, homes, and businesses.

The Reasons Why Insects are Attracted to Light

Entomologists use the term “positively phototactic” when referring to insects that have an attraction to light. One reason that some insects are attracted to light is that they use a source of natural light, like the sun or the moon as a guide to finding their way.

While both exterior lights in this picture supply valuable security lighting, one is more likely to cause insect issues than the other. The light mounted onto the building on the left attracts insects both towards and into the building while the ground-mounted security light on the right pulls insects away from the building and towards the light source.

For example, they keep the sun at a constant angle to their flight pattern. These insects can mistake nighttime as daytime and mistake man-made lighting for sources of natural light. Man-made lighting is different than natural lighting as it sends beams in all directions. The insects become confused thinking that these lights are the sun or moon and will continually fly in circles around the light as they attempt to find the correct angle. Another reason that some insects are attracted to light is that they simply would rather fly in a well-lit area so they don’t bump into things in the night.

Light Intensity and Direction Plays a Big Role

Knowing what prompts insects to be attracted to the light can assist us with reducing the number of pest insects in our structures. First of all, most outdoor lights are going to have some insect attraction qualities, but the higher intensity (brighter) lights are more attractive than low-intensity lights. This makes sense as the brighter lights more closely resemble the sun or moon in the small brains of these insects. We also know that the direction that a light shines can have a big impact. For example, an un-shielded bulb shining in all directions in a parking lot light will attract thousands of more insects than a shielded light that shines only downward simply because many more insects will see the upward projecting light as they fly high in the sky.

Outdoor lights that shine upward attract thousands of more insects than lights directed downward.

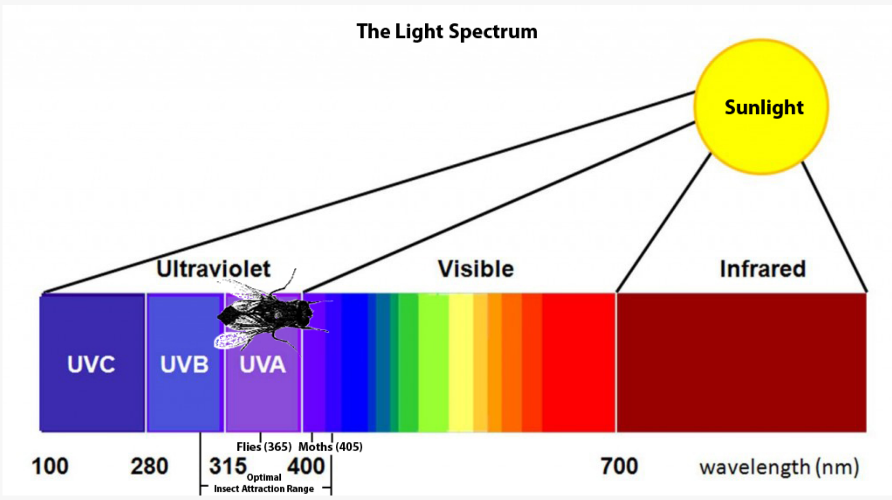
Security Light Placement

The illustration at the beginning of this article demonstrates the issues with having bright security lights mounted directed on the building and close to the entry doors of these structures. It makes more sense from a pest management perspective to place security lights on the ground or on poles at a good distance away from but directed towards entry points into the building. Wall-mounted security lights draw the insects right up to the exterior wall and entry doors where they often find their way inside. Both forms of lighting supply adequate lighting of the building but one is a much better option with IPM in mind. It is also good to consider if there are any interior lights that are left on overnight for security purposes that shine through glass windows and doors. These indoor lights can project to the outdoors and will also attract insects right up to the building.

Light Spectrum and the Insect Sweet Spot

From a pest standpoint, we know that the majority of light-attracted insects prefer light in the spectrum between 300 – 420 nm. ***House flies seem to prefer a wavelength of ~ 365 nm while moths and beetles responded best to a slightly higher wavelength of ~405 nm.*** This range of highest attraction encompasses several degrees of UV light and the beginning stages of visible light on the light spectrum scale (see illustration). Having valuable information about which wavelengths of light have the highest attraction allows us to choose lighting options outside of this range to reduce pest pressure. It is important to check the manufacturer's specifications for the wavelength of their lighting options prior to purchase. If the lights that you currently have or that you are looking to acquire produce a wavelength that is in the "sweet spot" of insect attraction, perhaps you should explore other options.

While all different light bulbs will have some attraction to insects, some have a much greater attraction than others. UV light is some of the most attractive light to insects as we see in the chart. This is why UV light is almost exclusively used in fly lights and insect light traps. Fluorescent lights also produce a lot of UV which also makes them highly attractive to insects. The other type of light bulb that is highly attractive to insects is mercury



vapor lights. These lights are so attractive that they can actually be used to pull insects away from a building. In the case of outdoor lights, it pays to do your homework! Below are some of the most popular light sources and their insect light-attraction ratings.

Ultra Violet Light (UV) - **High Attraction to Pests.** Used in insect light traps. Do not use as security light!

Fluorescent Lights- **High Attraction to Pests.** Produces lots of UV light that attracts insects. Not a good option as a security light.

Mercury Vapor Lights- **High Attraction to Pests.** Lights placed 30 or more feet from a structure can actually pull insects away from the building. Do not use near a building.

Metal Halide Lights – **Moderate Attraction to Pests**. Similar to the light spectrum produced by the sun. The UV output is also similar to the sun, negating some of its attraction to insects. Warning: These lights produce high temperatures and require Teflon protective lenses.

Incandescent Lights – **Moderate to High Attraction to Pests.** Best for indoor purposes.

High-Pressure Sodium Lights – **Moderate Attraction to Pests.** Good for use in parking lots, etc. They should be shielded so that insects flying above them are not attracted down to the light.

LED Lights - **Moderate Attraction to Pests.** While some specialized LED lights can have a broad UV spectrum and be highly attractive to insects, in general, LED lights are much less attractive than other options. Practical LED arrays are very limited below 365 nm thus taking them out of the “most attractive” category.

Postscript

There are lots of different things to consider when it comes to choosing the best type of lighting to reduce insect pest activity. The biology and behavior of insects, the light spectrum, attractiveness, and intensity of the different light sources, and the important placement and direction of each light. It is best to use all of this information when designing and choosing lighting for your home or institution. A well thought out approach will pay big dividends of less pest activity in the long run.

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Internal Feeders, External Feeders, and Fabric Feeders

Tom Mueller
Vice President of Insects Limited

As the world started to settle in to accept the presence of the coronavirus and people started to become cautiously active outside of their homes or offices, it was decided that in quarter three **Insects Limited** was going to lighten our load when it came to creating and presenting our Virtual Series on Stored Product Insects.

Receive the previously recorded episodes

The format of each episode aligned with that of each of the previous discussing individual insects.

- Distinguishing features
- Life cycle behaviors
- Biology of the insects
- The insect's communication
- Monitoring for the insect
- Controlling the insects

The theme throughout each of these episodes continues to be educating ourselves as much as we can about these insects behaviors and biology, and only then can we begin to create an integrated pest management (IPM) strategy to successfully attempt to control their presence in our facilities.

"Study the science to practice the art."

At **Insects Limited**, we have worked hard to create documents and video content to help both customers and noncustomers inform individuals and companies about insects attacking our food and fabrics.

Providing these webinars is another we live our core values of Science, Education, and Innovation, and it is our hope that the same individuals and companies will utilize the content we are creating to train employees and customers on the proper way to approach the challenges which is to **"Start with the Insect First."**

The Art of Science

We have a saying at Insects Limited. It's not fancy, wordy, or punny but it really does guide our thinking across the company and is the necessary foundation of our science. **START WITH THE INSECT FIRST**