New dangers in the woods — and the hope that research offers us

By Paul Heney | June 29, 2022

By Mark Jones

Morel mushroom hunting is an interesting and enjoyable spring activity in Michigan. Finding morels is a challenge, but if you want to eat them, finding is close to the **only option**. It takes effort, knowledge of the woods, and a trained eye. Some friends, life-long morel hunters, introduced us to the morel woods. The training of our eyes is still a work in progress.

Morels

Trillium and **trout lilies** are in bloom as we take to the woods. Trees are just beginning to leaf out. Morel hunting is a long walk in the woods, occasionally punctuated by the thrill of finding a mushroom. You don't stand still and wait for morels to wander by, you seek them. Morels are the fruit of mycelium living underground. They are a small part of a much larger organism, one that almost always sprouts more than one mushroom. Find one, and you usually find more. The bags contained 100 morels at the end of our two-hour hunt. Thoughts of energy return on energy invested bring a dose of reality to the endeavor. We bagged about 500 grams of morels, which is about **150 calories** worth. Three of us hunting expended around **2000 calories**, at least 10x more energy than returned. Adding the fossil energy used getting into the woods only makes matters worse. Morel hunting is for fun, not food. They are a treat, and not sustenance.

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Dead ash trees are the most obvious human impact. The **emerald ash borer** reaped a heavy toll in the forests where we hunt morels. Last year the dead ash trees were largely still standing, obviously dead, with large chunks of bark lost. The trees are largely down this year, their roots having succumbed to rot as if they all decided to lay down at the same time. Many of the ash groves of the past are now a jumble of dead trees, all with the telltale scars of the infestation. The cathedrals excavated beneath the bark are etched in the dead wood. The ash borer is an invasive species, one transported to Michigan by man. The destruction of the ash trees is on us.

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Dangers, at least in past years, were scarce in the morel woods. It is actually rare to see animals, with the occasional porcupine being the most dangerous looking, yet representing little real danger. This year is different. **The woods now have ticks.** I am now in my 32nd year walking in the Michigan woods. This is the first time I've found a tick. That may be on us too.

Only about **20 of the over 860 species of ticks worldwide call Michigan home**, but the number is **increasing**. Some have linked the increase **to climate**. Cold used to keep insect and arachnid pests at bay, but the coldest **temperatures are warming**. Pests now survive the milder winters. Some link the **growing deer and populations** and other **causes**. Whatever the cause, we now have at least five problematic ticks in the Michigan woods. More are coming. A population of the **Asian long-horned tick** has now taken root in the U.S. The **CDC lists 16 tick-borne diseases** present in the U.S., a number that continues to increase. Mercifully, all aren't **yet in Michigan**. Lyme disease is now well known and increasing. It is exclusively tick-borne. Recent deaths caused by the **Powassan virus**, transmitted by the same tick species that spreads Lyme disease, have been in the news. The Lone Star Tick — which is named for a dot on its body and not Texas — has **expanded its range** into Michigan. It is notable for causing a potentially fatal **allergy to meat**. It is not really a disease, but more of a syndrome due to an immune response. Ticks that have fed on another mammal may inject saliva containing material from that animal when they bite. It can contain the complex sugar galactose-alpha-1,3-galactose, or alpha-gal for short. In some individuals, this triggers an immune response rendering them allergic to red meat. Eating or even just touching mammalian meat can be deadly. An encounter with a tick can be a life-changing event.

Ticks are an unwelcome addition to the menagerie of bloodsuckers found in the wild, including pesky mosquitos, annoying black flies, and leeches. I hate them all. Of the group, ticks and mosquitos are most concerning as vectors of disease. Anyone venturing out in Michigan summers is well acquainted with mosquitos. The health risk they pose is also growing, but mainly in the tropics. Mosquito-borne illnesses account for **more than 1 million deaths per year globally**. The range of diseases like **Zika** and **Dengue** are growing. Singapore is experiencing a **sharp rise in Dengue**, in spite of control efforts.

Amber-encased ticks tell us they've been around **since the time of the dinosaurs**, just as Jurassic Park taught us about **mosquitos feasting on dinosaurs**. If I were in charge of creating beasts, I think I'd avoid the blood suckers entirely. Their prevalence, success over eons, and expansion indicates it must be a ripe ecological niche. It is unlikely they are going away. We will have to adapt.

Physics, chemistry, and biology all offer tools to help us adapt. The oldest tools are simple physical barriers. Swatting flying insects relies on physics but, in my experience, is easily overwhelmed. Screens, netting, mesh fabrics, long pants, and socks all serve to thwart arthropod blood suckers. Creating a safe perimeter, a force field against bugs, is appealing. There are many **ultrasonic devices on the market**. Research indicates they **don't work very well**. In fact, researchers find some even **increase mosquito bites**. There are occasional reports of **computerized systems that would target mosquitos**, shooting them out of the air. High-tech solutions based on physics still are elusive.

The adaptations we most frequently choose are decidedly chemical. Chemophobic friends willingly spray themselves, spray their yards, ignite chemical-containing incense and, more recently, wear little chemical-spewing fans all in hopes of keeping the bloodsuckers away.

"They don't bite, they don't even light" was a memorable line in a TV commercial for insect repellents. That commercial was heralding the power of DEET, *N*,*N*-diethyl-*meta*-toluamide or *N,N*-Diethyl-3-methylbenzamide. It was developed in the **1940s for military use and entered civilian use in the 1950s**. It is the most widely used insect repellent, one I've used for years. I've used Picaridin , or **1-methylpropyl 2-(2-hydroxyethyl)-1-piperidinecarboxylate**. It was developed in the **1980s and entered the U.S. market in 2005**. DEET feels greasy. Picaridin is non-greasy and odorless. Both are proven to work on both mosquitos and ticks. Acute health effects of DEET use do occur, though it has never happened to me. Seizures, uncoordinated movements, agitation, aggressive behavior, low blood pressure, and skin irritation have all been **attributed to DEET use**. Picaridin has **fewer concerns**. Sadly, **studies** aren't kind to the natural oils. They are both less effective and more likely to cause harm at the higher doses used.

Pyrethroids loom large in arthropod abeyance. **Synthetic pyrethroids** are compounds with structures similar to compounds extracted from chrysanthemum flowers. Esters of chyrsanthemic and pyrethroic acids are rapidly absorbed and paralyze insect nervous systems. The DoD **preferred system** for bug avoidance relies on their use on clothing and bed nets. Pyrethroids aren't absorbed through human skin very well, but do enter the body if eaten or inhaled. They are generally considered safe for humans, but **indiscriminately kill insects**. When used with DEET or Picaridin, **Permethrin**, (3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-1-carboxylate, on clothing is an effective contact poison for a broad range of biting arthropods. Ticks and mosquitos are no match.

Spatial repellents are things that keep bugs away. Candles, incense and devices emitting repellents to form a bug free zone. They work by making a cloud of pyrethroid vapor that serves to disorient or kill flying bloodsuckers. **Metofluthrin**, [2,3,5,6-tetrafluoro-4-(methoxymethyl)phenyl]methyl 2,2-dimethyl-3-(1-propenyl)cyclopropanecarboxylate, or other pyrethroids are used in several of the most effective spatial repellants. They fall well short of an impenetrable force field, but, in spite of their limitations, are proven effective.

Pyrethroids, notably Permethrin, are chemicals widely used in fogging applications. In my area, trucks spray for mosquitos at dusk — covering the neighborhood with a permethrin fog. Backyard foggers do the same thing.

These last two use patterns place pyrethroids in the air we breathe. They are rapidly absorbed through the lungs. Asking most whether they want to inhale a compound capable of killing insects at low level, one that is lipophilic and will be transported throughout the body, will almost certainly get a resounding “no.” Yet, that is exactly what we do when we light a mosquito coil, what we experience when we are outside when mosquito fogging occurs. Measuring the metabolite 3-phenoxybenzoic acid shows **the majority of us are exposed to pyrethroids**. Pyrethroids were viewed as safer than other insecticides, most notably organophosphates, like **Malathion**. Malathion, formerly widely used in fogging, interferes with **mammalian, therefore human, nervous systems**. The pyrethroids don’t. Pyrethroids now account for **over 30% of all insecticides**. They are inescapable.

I get perturbed when pyrethroids are deemed **natural** or **safe** simply because their foundational structure comes from a flower. They kill all insects, including bees. Aquatic toxicity is high. Pyrethroids are ubiquitous, having replaced several classes of insecticides deemed more problematic. We are only beginning to understand the human health and environmental toll of that widespread use. They are highly toxic to fish and other animals that live in either salt water or fresh water. Metofluthrin has a tetrafluorinated aromatic ring. Permethrin is dichlorinated. These compounds are far from natural. **Permethrin is listed by the EPA** as a “likely to be carcinogenic to humans.” Exposure was recently linked to **increased deaths by all causes**. If safe means incapable of causing harm, these compounds are far from safe, but they may be safer than going without.

Research is clearly needed to find better ways to combat disease-carrying arthropods. There is the occasional **encouraging result**, but new approaches are slow to develop. Current chemical deterrents may well keep me safe from ticks and flying insects with little risk, but fall well short of an impenetrable shield.

Arthropod control on my dog takes a decidedly different approach. He is chemically treated monthly to make him toxic to bugs. A number compounds are approved to systematically treat animals, some swallowed, some topically applied. Bites to treated animals deliver a toxic dose to the offending arthropod. Research shows that this dramatically reduces the likelihood of disease transmission to a treated animal. There are no similar treatments approved for human use.

Biology doesn't offer a shield, but it does offer new ways to combat arthropod scourges. Biological methods can focus on control of disease or control of the vector. One of the earliest methods relies on physics in the form of X-rays. Male mosquitoes are **irradiated and released**. Wild females that mate with irradiated males lay eggs that will not hatch. The population of mosquitoes is reduced but rebounds after the sterile males die. **Treating standing water with BT** is well established as effective at reducing mosquito populations, harnessing a natural bacteria to kill mosquito larvae. **New approaches** of attacking mosquitos at the midge stage continue to be developed, all use a biological or chemical control agent before the blood suckers take wing. **Singapore is attacking its Dengue fever** with a more up-to-date biological control method. Male *Aedes aegypti* mosquitoes infected with ***Wolbachia* bacteria are released to mate with wild females**. Just like with irradiated males, eggs resulting do not hatch and the mosquito population is reduced. *Wolbachia* is a common bacteria that infects many insects, just not normally *Ae. aegypti*. It is presumed safe because it is already present in the environment.

The latest in mosquito control involves release of genetically modified mosquitoes. **Oxitec** developed a **genetically modified mosquito with the potential to destroy a population**. The gene editing inserts a "self-limiting" gene. **The modification makes the mosquitoes dependent upon tetracycline, a common antibiotic**. Male mosquitoes reared in a tetracycline-rich environment are released into the environment. Released male mosquitoes mate with wild females and the tetracycline-dependent larvae don't grow to adulthood in the wild. Modified mosquitoes have been released in **Florida** and they recently **California granted permission to release there**. California is allowing release of the invasive*Ae. aegypti*, not native bugs.

CRISPR/Cas-9 technology is the latest new tool to be aimed at disease vectors. It enables the development of **"gene drives,"** self-replicating bit of DNA that don't follow normal rules of inheritance. **The DNA sequence is biased** to propagate even when traits may be disadvantaged. An engineered heritable trait is biased to be inherited at much greater than the 50:50 chance normal in breeding. The gene becomes more prevalent in successive generations, even when that trait is something catastrophic to the population, like infertility. Applied to mosquitoes, gene drives can wipe out an **entire population in as few as a dozen generations**.

There is certain appeal at using gene editing to kill an invasive population. Bringing back the ash trees would certainly require something like this to wipe out the foreign emerald ash borer population. Nipping the burgeoning invasions of **Asian long-horned tick** and **spotted lantern fly** in the bud has a lot of appeal. Stopping an invasive species feels much better than going after a native population, even one as unappealing as ticks. My hatred of ticks likely fails to appreciate their place in the ecosystem, or the impact of their removal. Deploying gene drives is controversial due to their effectiveness. Once released, there is no off switch for the gene drive. Gene drives have the potential to spread quickly, forever altering the species, even wiping it out. **Most are suggesting caution, though the potential to impact diseases like malaria is compelling.**

Research is not stopping at invasive species or at killing disease vectors. Programs looking at gene editing **native ticks** and **even mice carrying Lyme disease** are some of the more creative R&D efforts. Some have proposed inoculating **mice** to remove pathogen reservoirs. Others are working on **vaccines against ticks**, causing an immune response to halt the ticks feeding. Vaccines against the diseases transmitted are an on-going effort.

For now, my safety in the woods, my safety in the face of growing risks from arthropods, depends on chemicals. Spraying my clothes with Permethrin to ward off ticks, in addition to using DEET or Picaridin, is now my practice. I am trading chemical exposure against reducing my risk of arthropod-borne disease, or at least for a reprieve from bloodsuckers. As arthropod-spread diseases spike, there is a risk of going without chemical protection and some risk to using it. Let’s hope better solutions are on the way.