

## 150 Bugs!

This list of 150 bugs has been created for the 2014 CALS sesquicentennial and Entomology department Insectapalooza celebration!

The insects in this list are organized into the following categories: *Bothersome Bugs, Amazing Arthropods, Interesting Insects, Beneficial Bugs, Purposeful Pollinators, Cultured Creatures, Edible Entomology, Agricultural Antagonists & Forest Foes and Model Behavior*

### **BOTHERSOME BUGS - These Insects Really 'Bug' You**

1. **Malaria mosquito** *Anopheles* - What is the world's deadliest animal? The Malaria vector! Malaria infects about 200 million people around the world each year. The malaria parasite is transmitted by *Anopheles* mosquitoes. Here at Cornell we are working on ways to modify the mosquito so that the transmission of malaria is inhibited or populations of the mosquito can be reduced.
2. **Asian tiger mosquito** *Aedes albopictus* - One of the most invasive mosquito species on earth and a vector of numerous pathogens and parasites. The mosquito first emerged in Asia and has now spread to most continents around the world.
3. **Yellow fever mosquito** *Aedes aegypti* - This mosquito is an important transmitter of deadly yellow fever, dengue and Chikungunya viruses as well as dog heartworm. This mosquito is truly "domesticated" as it cannot survive without the humans that provide it with a habitat and blood.
4. **Deer tick (Blacklegged tick)** *Ixodes scapularis* - Watch out for these small arachnids when outdoors as they are responsible for transmitting Lyme disease which is the most commonly reported vector borne illness in the USA! About 30,000 people become infected with Lyme disease annually. These ticks also vector human anaplasmosis and babesiosis.
5. **Bed bug** *Cimex lectularius* - "Good night, sleep tight, don't let the bed bugs bite," perhaps you didn't think much of this phrase when you were a kid but now bed bugs are back! Since ancient times bed bugs have been human bed companions. These small insects hide in beds and small spaces and come out at night to bite their unsuspecting victims.
6. **Asian Rat Flea** *Xenopsylla cheopis* - A transmitter of plague bacterium that killed nearly 1/3 of the European population during the "Black Death".
7. **Black widow spider** *Latrodectus* - What spider is the most dangerous? Although they are not the most venomous spiders, members of the black widow spider genus (*Latrodectus*) hurt the most number of people around the world because of their broad distribution and ability to establish themselves in many habitats. Female black widows really will eat their mates if given the opportunity!
8. **Buthid scorpions** Buthidae - How do you know when a scorpion is dangerous? Worldwide, scorpions cause the most deaths of any of the arachnids (including spiders). The most venomous scorpions are found in the family Buthidae. Buthids have fat tails – all the better to sting you with – and delicate pinchers. In contrast, scorpions that are not dangerous have skinny tails and big pinchers to pull apart prey.
9. **Tsetse fly** *Glossina* spp. - Transmitter of the African sleeping sickness parasite which affects humans and domestic animals. Often called the "Guardian of Africa" for protecting large swaths of the continent from human habitation.
10. **Kissing bug** *Triatoma* spp. - Transmitters of American *trypanosomiasis* or "Chagas" disease. They are nocturnal and often feed around the lips of sleeping hosts - giving them their name.
11. **Louse - larger than lice** *Pediculus humanus* - Lice, have been pests throughout history. Not only do they cause itching and their saliva causes depression, which makes people feel 'lousy,' but

- they transmit typhus and other pathogens that have changed human history. Most humans were infested with lice until WWII when DDT powder was developed that killed them.
12. **Chigger** Trombiculidae - What are chiggers? Chiggers are larval mites that burrow into our skin causing itchy irritation. They feed on our tissue, then leave and then we scratch! Fortunately, chiggers are not found in NY State.
  13. **“No-see-ums”** *Culicoides* spp. - As the name suggests, these are tiny blood sucking midges (a type of fly). Most people encounter them during a beach day. Most of the flies are a nuisance and can cause an allergic reaction while some species can vector human and animal diseases.
  14. **House fly** *Musca domestica* - A notorious pest, uninvited picnic guest and important mechanical transmitter of disease agents including *Salmonella*, anthrax and polio. This fly occurs on all continents and is abundant almost anywhere people are found!
  15. **Itch mite** *Sarcoptes scabiei* - This small mite causes scabies and mange. The female of this parasitic mite burrows into the skin to lay her eggs. The nymphs feed on hair follicles. The feeding can cause intense itching, allergic reactions and can lead to skin infections.
  16. **Bullet ant/ Bola ant/ 24-hr ant** *Paraponera clavata* - The Bullet Ant is infamous in its native Neotropical range for its nasty sting. Justin Schmidt, inventor of the Schmidt Index used to categorize arthropod sting intensity, described being stung by a bullet ant as the most painful sting imaginable. Locals refer to it as the “24 hour ant” due to the pain supposedly lasting that long! Nonetheless, the bullet ant is used in rite-of-passage rituals by the Satere-Mawe tribespeople of Brazil who require teenage boys to repeatedly wear a glove interwoven with bullet ants before they can officially become a man.
  17. **Red imported fire ant** *Solenopsis invicta* - Watch your step! These invasive ants can inflict very painful stings! They also attack ground-nesting bird hatchlings and can out-compete native ants, causing serious environmental and ecological impacts.
  18. **Screw-worm fly** Calliphoridae spp. - This is a notorious flesh eating pest. This fly was successfully controlled by flooding its population with sterile males. This was the first example of this strategy being used to successfully control an insect pest.
  19. **German cockroach** *Blattella germanica* - This is a common urban pest and is widely distributed worldwide. It is found in food storage areas, homes and hospitals. These pests can vector diseases and are a source of allergens especially in urban areas.
  20. **Brown-banded cockroach** *Supella longipalpa* – This roach is an urban pest which feeds on food items that are not properly stored. These roaches can vector disease and cause allergic reactions.
  21. **Cattle tick** *Rhipicephalus microplus* - pioneering work by USDA scientists, Theobald Smith and Fred Kilborne, in 1889, showed that Texas cattle fever was caused by a parasite transmitted by this tick. It was the first definitive demonstration that an arthropod could be involved in transmission of a pathogen to an animal. This work led the way for many other discoveries including the control of an infection that devastated 90% of cattle herds in the Southern USA.

### **AWESOME ARTHROPODS – The Biggest, the Baddest and the Bugliest**

22. **Orb weavers** *Nephila* - Stronger than Steel: Orb weaving spiders produce incredibly strong silk that is as strong as steel, but extends 200 times its length. Spider silk is the strongest biopolymer known. Imagine using spider silk to make parachutes that don't break, lightweight bullet proof vests, or strong, antimicrobial stitches that have flexibility!
23. **Tiger beetles** Cicindelinae - These diurnal predators with big eyes may be the fastest running insect; some run 100-200 body lengths in a second chasing their prey. But they run so fast that

- their eyes can't keep up and the world becomes a blur, so the beetle must stop several times before it catches its prey. Who designed that system?
24. **Centipedes** Chilopoda - Wanted: Best arthropod predator with the most legs! Centipedes are incredibly fast, powerful and persistent predators. These foot-long predators attack with their strong 'venom claws' and wrap their body around prey to hold it down.
  25. **Fireflies** Lampyridae - These "flies" or lightning "bugs" are actually beetles. The males of this species court by flashing their special signal while flying, then the male waits for the female to respond after a specific interval. If she responds, he flies to her to mate. Some females get sloppy after they mate and respond to the signals of males of other species. When he arrives for some loving, she eats him instead. *Femme fatale!*
  26. **Huntsman spiders** Sparassidae - Speedy Spiders. Huntsman spiders are ubiquitous in Australia. Although these spiders are large, they rarely bite instead relying on their speed to escape predators. Many live under the loose bark of dead trees. In Australian National Parks, there is a rule that park rangers can't put fire wood in the cabs of their trucks because there have been so many accidents when groups of spiders ran out from under the bark
  27. **Carpet beetles** Dermestidae - Larvae of these beetles feed on dead, dry animal products and have a predilection for wool carpets. They are also important recyclers and remove dried sinew and flesh from bones. Many natural history museums maintain colonies of dermestids to help with preparation of skeletons for research and display.
  28. **Lesser water boatman** *Micronecta scholtzi* - This is the loudest insect and creates sound by singing with its penis, the sound can reach up to 99.2 decibels which is comparable to a passing freight train.
  29. **Dobsonfly** Corydalidae - The larvae are known as hellgrammites and are the top predator under stones in streams. At a muscular 3 inches long with tin snips for jaws they earn respect from any angler who knows they make great fish bait. Adult females have similar jaws. Males have even larger scimitar-shaped jaws, but curiously do not eat. The jaws are used in male-male competition and are rested on the back of the female before mating.
  30. **Giant water bug** *Belosomta* spp. - Fathers of the Year! Females lay their eggs on the male's back. Females prefer to mate with males who already have eggs which show they are better fathers. Because the eggs are so large, the male must move up and down at the water's surface to aerate the eggs.
  31. **Sea skaters** *Halobates* spp. - These mariners are the ocean going version of water striders that skate on the water surface buoyed up by waxes on their feet that prevent them from actually getting wet. They are the only truly marine insect and feed on plankton. They attach their eggs to floating debris including plastic.
  32. **Giant Weta** Anostomatidae - Giant orthopteran insects, which are one of the heaviest insects on earth.
  33. **Wandering spiders** Ctenidae - These spiders are the most venomous spiders!
  34. **Queen Alexandra's birdwing** *Ornithoptera alexandrae* - A wingspan of about 25 cm (9.8 inches) makes this one of the world's largest butterflies! This charismatic butterfly is endangered because of habitat loss.
  35. **Tarantula** Theraphosidae - Big hairy spiders! The tarantulas are the largest spiders in the world. Some are as large as dinner plates.
  36. **Jumping spiders** Salticidae - All the better to see you with! Jumping spiders have the best vision of any arthropod. These smart spiders can solve problems and figure out mazes.
  37. **Periodical cicada** *Magicicada* spp.- Seven different species live underground as nymphs feeding on sap in tree roots for 13 or 17 years. Adults emerge synchronously and males form very loud choruses in woodlands of the Eastern USA.

38. **Dragonflies** Anisoptera - Nymphs live in water while adults are terrestrial. They were among the earliest insects to evolve wings and are still among the best fliers. The Air Force has even copied their mechanism for flight stabilization for unpiloted aircraft.
39. **Monarch butterfly** *Danaus plexippus* - Most dramatic migration: Monarch butterflies fly thousands of miles to spend the winter in the Mexican highlands, then fly back to the eastern USA for the summers. Different parts of the northward migration are done by new generations of butterflies. Monarchs are specialists on toxic milkweeds which makes them distasteful to predators.
40. **Antarctic midge** *Belgica antarctica* - This small fly is endemic to Antarctica and is the largest animal to live there year round. They are studied to understand their tolerance of extreme cold, desiccation and UV light exposure.
41. **Army ants** Formicidae - A group of ant species in South/Central America. Colonies alternate between forming large above ground bivouacs made of individual ants and nomadic foraging columns in which animals in their way are overwhelmed and killed by tens or hundreds of thousands of workers.
42. **Vinegaroons** *Mastigoproctus giganteus* - What sprays a shot of acid when disturbed? Vinegaroons have acid glands at the base of their tails that they can activate to ward off predators!
43. **White eyed assassin bug** *Platyeris biguttatus* - Stealthy predators: Assassin bugs stalk and paralyze their prey. Their powerful venom keeps prey from struggling on their piercing mouthparts.
44. **Megarhyssa spp.** – This large parasitoid wasp has a 3-inch-long needle-like ovipositor (“modified stinger”) with which it drills deep into trees to lay an egg in the larvae of a tunneling woodwasp. The ovipositor has metal ions in it which make it strong enough to drill wood!

### **INTERESTING INSECTS – Fascinating Facts about Members of the Largest Phylum**

45. **Walking stick** Phasmida - These gentle herbivores of the tree tops are the ultimate in mimicry, looking like dead twigs. Most are wingless and move very slowly. Many species shower their eggs onto the forest floor where they are harvested by ants which eat off a small nutritious “handle” after carrying the egg to the safety of the ant nest.
46. **Silverfish** Zygentoma - Silverfish are among the most ancient of insects. They never evolved wings and they continue to shed their skin as adults, which most insects do not.
47. **Velvet ant** Mutillidae - Actually a wasp, the terrestrial, wingless females resemble ants as they scurry along searching for ground-nesting bees which they parasitize. Their sting is reported to be one of the most painful known and large species are called “cow killers.”
48. **Wandering Glider** *Pantala flavescens* - Many dragonflies make long migratory flights. They are not as regular as the fall migration of Monarch butterflies, thus they are much less well understood. Flights in the USA or Europe often contain hundreds of thousands of individuals and they have been reported at sea, long distances away from land.
49. **Praying mantis** Mantodea - These deadly predators use keen vision to aim the strike of their grabby front legs. They judge distance to the prey with binocular vision, just like humans do. But unlike humans, a male mantis can still mate after a hungry female chews his head off.
50. **American burying beetle** *Nicrophorus americanus* - An adult male and female beetle find a small rodent carcass, such as a mouse or chipmunk, bury it to hide it from other couples, and “hand-feed” bits of the decaying rodent to their larvae. A parent’s true love. This charismatic species is endangered in the USA and Canada.

51. **Antlions** Myrmeleontidae - These relatives of lacewings are more commonly encountered as larvae that lurk at the bottom of small conical pits in loose sand/dirt. When a wandering prey, typically an ant, stumbles into the pit, the antlion larva bites it and drags it below the surface.
52. **Scaphinotus spp** - This flightless, nocturnal ground beetle specializes in eating snails right out of the shell! The head is long and slender to fit inside the shell and the legs brace against the opening.
53. **Oil fly** *Helaeomyia petrolei* - This family of flies is called shore flies, but the “shores” that these larvae live near are natural petroleum seeps in California (think La Brea tar pits), where the larvae feed on animals trapped in the crude oil.
54. **Spider wasps** Pompilidae - Females of these twitchy wasps parasitize spiders and the wasp maggot feeds on a single paralyzed spider. For most sizes of spider there is a matching-sized spider wasp. The tarantula hawk of the southwest USA is a beautiful, huge metallic blue wasp with orange wings.
55. **Robber flies** Asilidae - More assassins than robbers, they sally out from a perch to catch flying prey and inject a neurotoxic saliva that quickly immobilizes the prey on the end of their beaks. The killer then returns to its perch and slurps out the juices of its prey. Some of these flies are furry black and yellow mimics of bumble bees, which are also their main prey.
56. **Argentine ants** *Linepithema humile* - Native to SE South America these tiny ants have invaded at least 15 countries including the USA. They have enormous colonies; one in California extends over 550 miles along the coast. They are aggressive to ants from other colonies, but not to nest-mates. Recent evidence suggests that the California colony is actually related to a similar huge colony in Japan and one in the Mediterranean.
57. **Leaf cutter ants** *Atta*, *Acromyrmex*, etc. - These ants are the original gardeners; they carry cut leaves back to their nest where they first disinfect them with antibiotics and then inoculate them with fungal spores in a symbiotic relationship. As the fungi grow, workers pull off pieces to feed the larvae. When new queens leave the colony they carry a bit of the fungus as their dowry.
58. **Termite** Isoptera (order Blattodea) - Soft-bodied termites, often called white ants, are social insects that chew through wood with hard-edged jaws. They use symbiotic microbes in their guts to digest the wood. In tropical forests, recycling dead wood is an important ecological service that termites provide, but in civilized areas the wood may be the wall or roof of a building and termites become pests.
59. **Ironclad beetle** *Zopherus* -These beetles have one of the hardest exoskeletons of any arthropod! They are very good at retaining water which is important because they live in the desert. To pin them you need to use a power drill and in Mexico they are glued to jewelry to make a living accessory.
60. **Red worms** *Chironomus* spp. - These half-inch long insects are not worms at all, but are the aquatic larvae of midges, relatives of mosquitos. They are sometimes called blood worms and are bright red because they are loaded with hemoglobin, which pulls oxygen from the surrounding water and allows the larva to colonize stagnant water unfit for many animals. These midge larvae and others are very useful as water quality indicators.
61. **Cactus moth** *Cactoblastis cactorum* - Caterpillars of this moth eat cacti and have been a successful biological control agent of invasive prickly pear cactus around the world. However this moth can also be a serious pest and is considered a dangerous invasive pest on native cacti in the USA.

## **BENEFICIAL BUGS – These are the Good Guys**

62. **Paper wasps** *Polistes* spp - Flying Pest Control. Paper wasps prey on herbivorous caterpillars which they kill by biting, not stinging. They feed caterpillar burgers to their larvae developing in the social nest. Paper wasps make water resistant nests with fibers from dead wood and plant stems mixed with saliva. These nests gave humans the idea how to make paper.
63. **Surgical maggots** *Lucilia sericata* - Debriding a wound with fly maggots may seem medieval, and indeed it was. Nevertheless, the use of maggots to clean wounds is making a comeback. For wounds in intricate parts of the body, such as hands, maggots are the only agents that get into small spaces, leave the healthy tissue and clean out only decaying flesh that could cause lethal infections, such as gangrene.
64. **Goldenrod gall fly** *Eurosta solidaginis* - Spherical galls in the stems of goldenrod plants contain a fly maggot that overwinters there. The maggot avoids freezing by secreting antifreeze, including the same compound we use in our cars. Studying how the maggots survive has shed light on preservation of human organs used for transplants.
65. **Oribatid mites** Orbatida - These are the world's most numerous arthropods living in soil and are very important for decomposition and nutrient cycling.
66. **Lady bugs, lady bird beetles, lady beetles** Coccinellidae - These brightly colored beetles and their larvae are mostly beneficial, eating thousands of insects that feed on plants, such as aphids. There can be too much of a good thing, however, as a single beetle in a batch of wine grapes can produce an off-taste.
67. **Dung beetles** Scarabaeidae - These beetles help reduce pests and disease among cattle in pastures and help recycle nutrients into the soil by burying and consuming dung. Several countries have introduced dung beetles to help control dung pests.
68. **Mayflies** Ephemeroptera – The aquatic larvae of mayflies are used as indicators of stream quality. Additionally these insects are important food for fish and many fly-fishing lures mimic the adult mayfly. Adults have no mouthparts and thus cannot eat. They can only survive as an adult long enough to mate and lay eggs, not much more than a day.
69. **Predatory Mites** Phytoseiidae – These mites are important biological control organisms of mites and other small insects.
70. **Trichogramma wasps** Trichogrammatidae- These tiny stingless wasps parasitize and grow up inside the eggs of other insects! They have been used extensively as biological control against destructive Lepidopteran pests. Mike Hoffmann's lab has worked on the use of these egg parasitoids for use against the European corn borer. Farmers can purchase these tiny wasps and release them into their corn fields.
71. **Aphid parasitoids** Braconidae - Tiny black wasps that lay an egg inside an aphid. The egg hatches into a wasp maggot that eats the aphid from the inside out, eventually killing the aphid and developing into an adult wasp.
72. **Housefly parasitoids** Pteromalidae - Tiny wasps that lay their eggs into the pupal stage of houseflies, killing the fly and producing an adult wasp. These wasps can be purchased by dairy or poultry farmers and released on farms for housefly management.
73. **Whitefly parasitoids** Aphelinidae - Tiny wasps that grow up inside tiny whitefly nymphs (small aphid-like insects), which are severe pests of many greenhouse crops and some outdoor vegetables and fruit crops. The use of the whitefly parasitoid *Encarsia formosa* rescued the greenhouse vegetable industry in Western Europe from pesticide-resistant whiteflies and is one of the famous examples of successful biological control!
74. **Caddisflies** Trichoptera - The aquatic larvae of caddisflies are used to monitor stream quality and health. A change in the abundance and/or the number of species of these larvae can indicate that the stream is being polluted! The larvae spin silk and use it to create hard cases from small rocks, twigs and other debris they find. There is even caddisfly jewelry which the larvae create when they are kept in a tank with semi-precious stones!

75. **Green lacewings** Chrysopidae - The larvae of these insects are ferocious aphid predators which are used worldwide as biological control agents. The larvae inject their prey with digestive enzymes and then suck out their guts. The adults have beautiful lacy green wings and the female lays her eggs on stalks to keep them above the reach of hungry predators.

### **PURPOSEFUL POLLINATORS – Keeping Food on Our Tables**

76. **Hover fly** Syrphidae - Adult flies are important plant pollinators worldwide and the larvae feed on small plant-feeding insects such as aphids.
77. **Honey bee** *Apis mellifera* - This bee is the most important commercial honeybee and is relied upon worldwide for pollination of many crops. Since ancient times humans have kept bees for their wax and honey and our current agricultural system is highly dependent on these pollinators.
78. **Bumble bee** *Bombus* - Excellent pollinators known for “Buzz pollination” in which they buzz to release the pollen from plants they visit. These bees are social but have much smaller hives than honey bees and only new queens will survive the winter. Raised commercially, these charismatic bees are particularly useful in pollinating greenhouse plants.
79. **Fig wasps** Agaonidae - If you have ever eaten a fig or a fig based product you have eaten a fig wasp! The female of this wasp pollinates the fig when she lays her eggs in the fig. The male wasps will never leave the fig because they die after mating inside the fig and helping chew a hole out of the fig for their female siblings. Some fig wasps are pests and do not pollinate the fig.
80. **Mason Bees** *Osmia* - These solitary native bees are good pollinators of fruit trees. They nest in small holes and tubes. Many fruit tree farmers build their own bee nesting sites using drilled wood, reeds or hollow tubes!
81. **Carpenter bee** *Xylocopa* spp. - These bees are called carpenter bees because the females bore tunnels into dry wood to form galleries in which to rear their offspring. The tunnels can cause structural damage to homes or other outdoor wood structures. These bees however are excellent pollinators of many vegetables and flowers.
82. **Stingless bees** Meliponines - These are important pollinators in the tropics. Although they have reduced stingers, they are known to give painful bites. These bees can be kept in artificial hives and used for small-scale honey production.
83. **Giant Asian honeybee** *Apis dorsata* - These large bees are found in South and Southeast Asia in forested regions where they form single comb colonies on rocky outcrops such as cliffs and smooth-barked trees. Indigenous peoples harvest the honey by climbing homemade rope ladders up to the cliffs where the nests hang.

### **CULTURED CREATURES – Art and Literature are Just Crawling with Bugs**

84. **Silk worm** *Bombyx mori* - Silk worms are one of two insects humans have managed to domesticate—they’ve become so reliant on human care that without intervention they cannot reproduce! After its discovery in ancient China, the silk-aking process became a highly-guarded secret and great boon to Chinese wealth. The Silk Road and subsequent exploration expanded economies to an intercontinental scale. Christian monks eventually absconded with silk worm larvae, supposedly hidden in hollow canes, and brought silk production to Europe. Silk comes from the cocoon of silk worm larvae which is boiled before being spun into fibers that can be used to make garments and other apparel.

85. **Spanish fly** *Lytta vesicatoria* - Despite its name, this is a beetle not a fly! This beetle protects itself with a bitter-tasting chemical called cantharidin which can also cause painful blistering. Cantharidin from ground-up beetles was used as an early aphrodisiac and poison.
86. **Spiders** Araneae - Arachnids are named after Arachne of Greek mythology. Arachne was a superb weaver who won a competition with the goddess Athena. In revenge Athena turned Arachne into a spider. Spiders are present in many cultures' mythology and are thought to be the inspiration for the discovery of many textile arts. To this day our fascination with spiders continues with spiders in films such as Lord of the Rings and Spider Man.
87. **Nabokov's blue butterflies** - Nabokov was a Russian literature professor at Cornell from 1948 to 1959; he is considered one of the great literary geniuses of the 20<sup>th</sup> century. He was also an avid lepidopterist who collected and studied butterflies. He described the Karner blue butterfly *Lyceoides melissa samuelis*.
88. **Insects in famous literature** - Metamorphosis by Franz Kafka: A seminal work of 20<sup>th</sup> century fiction in which a traveling salesman wakes up to discover he has transformed into an insect! The Very Hungry Caterpillar by Eric Carle: This book has sold over 38 million copies and features a hungry caterpillar that eats through all kinds of food before becoming a beautiful butterfly! Aesop's Fable, The Grasshopper and the Ant: Since ancient times this fable has been educating listeners about the virtues of hard work and planning for the future.
89. **Cricket** Gryllidae - Ancient Chinese kept crickets in cages because they enjoyed their song.
90. **Locusts** Acrididae - Locusts are the swarming phase of some species of grasshoppers. With the right conditions these grasshoppers reproduce rapidly, swarm and become migratory. Since ancient times locust plagues have devastated human agriculture and left starvation in their wake. The Rocky Mountain locust was a major pest the Western USA which went extinct because of human intervention! A locust plague is recounted in Laura Ingalls Wilder's book, A House on Plum Creek.
91. **Cochineal scale insect** *Kermes vermilio* - Cochineal insects are related to aphids and feed on cactus juices. If disturbed by predators, the insects exude a red droplet of toxic carminic acid. In Mexico, the Toltec culture in Oaxaca developed the cochineal dye around 800 AD and by 1500 AD the Aztec ruler Montezuma I taxed it heavily. Spanish conquistadors coveted the rich red colors and today cochineal dye remains popular with weavers and artists. Today, traditional Zapotec rugs are woven in a rural village in Oaxaca, Mexico. The weavers pride themselves on using only natural dyes.
92. **Scarab beetles** Scarabaeidae - Ubiquitous in Egyptian mythological symbols and hieroglyphics. Scarab amulets were hugely popular in Egypt from 2000 BCE until the end of the empire, presumably to aid in worshipping the god, Khepri, analogous to the Greek Apollo in his role as a solar deity. Scarabs today are now known to be a hugely diverse family of beetles with habits ranging from rolling dung to feeding on fruit and plant sugars.
93. **Eurois occulta** - A moth which feeds on a variety of herbaceous plants. It may be part of the reason that our official language is not Danish. It was possibly accidentally introduced by Vikings and a huge outbreak of this species coincides with the disappearance of Viking settlements in Greenland.
94. **Xerces blue butterfly** *Glaucopsyche xerces* - The Xerces blue is believed to be the first American butterfly species to become extinct as a result of loss of habitat caused by urban development. The extinction of this butterfly inspired the Xerces Society for the conservation of invertebrates.
95. **Woolly bear caterpillar** *Pyrrharctia isabella* - You may be familiar with these fuzzy, black caterpillars, especially in the fall and early winter season. The woolly bear is remarkable in that it literally freezes to withstand the winter, a task accomplished by antifreeze-like chemicals in its "blood." According to local folklore, the wider that middle brown section is, the milder the coming



winter will be. Conversely, a narrow brown band is said to predict a harsh winter. Is it true? Probably not. But don't let that dissuade your passion! There are at least seven Woolly Bear festivals held in the fall across the United States to help feed any budding obsession.

96. **African bombardier beetle** *Stenaptinus insignis* - Don't mess with these beetles! They can spray a nasty boiling-hot chemical in almost any direction including over their back! Thomas Eisner, a famous entomologist and former Cornell professor, studied these beetles and made many new discoveries about how these beetles defend themselves.
97. **Luna moth** *Actias luna* - This lime-green moth is common in North America and is famous for its unique wing structure. Unlike most moths, the Luna has long, tapered wings. They also have eye spots to fool their predators. This moth has a USA postage stamp in its honor, and can be seen in a Lunesta television commercial.
98. **Morpho butterfly** *Morpho* - The *Morpho* butterfly is a widely collected specimen. It was used as embellishment by indigenous tribes, and inspired the title of the film, "The Blue Butterfly." Limited to tropical areas, this beautiful butterfly is one of the best examples of iridescence in animals. Depending on the angle at which you view it, the *Morpho* will appear a different shade of blue, and even brown in the right lighting.

### **EDIBLE ENTOMOLOGY – Bugs so good you can eat 'em**

99. **Mealworm** *Tenebrio molitor* - Mealworms may be the protein of the future! Mealworm larvae are high in protein and have a carbon footprint that is just 1% of the carbon footprint of beef, this makes them an environmentally sustainable protein alternative. They are quite tasty when roasted and can be used in savory dishes or as an ice cream topping!
100. **Black soldier flies** *Hermetia illucens* - The larvae of these flies are good candidates for human entomophagy (eating insects) and animal feed because of their high calcium and protein content. Even better, these grubs feed on detritus and can be mass-reared.
101. **Grasshoppers, locusts, crickets** Orthoptera - Delicious jumping snacks. For centuries, Chapulines (or saltamontes), grasshoppers (*Sphenarium*) that are roasted with chili, lime, and salt, have been a favorite food. What's not to like!? They are very tasty, but the spines on the back legs can get stuck in your teeth.
102. **Moths and butterflies** Lepidoptera - Caterpillars of various species of moths and butterflies are consumed in many parts of the world and provide an important source of protein for many people. Some of the larvae which are eaten include Mopane worms, eaten by indigenous South Africans; Wicketty grubs, a historical staple food for indigenous Australians; and red maguey worms, which are a delicacy in Mexico.
103. **Tequila worm** *Hypopta agavis* - The pest of the *agave* plant, which is used to make tequila. The worm is also used in mescal liquor for flavor and marketing purposes; the last person to finish the tequila has to eat the worm.
104. **Mealybugs** Pseudococcidae – These small aphid-like insects known as scale insects feed on plants. The tamarisk manna scale, *Trabutina mannipara*, produces honeydew which solidifies into white cakes on plant tissues, thought by some to be the manna described in the Bible. The males and females look very different. The females completely sedentary on plants while the males have wings.
105. **Beetle grubs and larvae** Coleoptera - Many species of beetle grubs (larvae) are consumed in various parts of the world. The Sago Grub is a delicacy in many Malaysian tribes and other Southeast Asian countries where it is commonly called "Sago Delight" or "Fried Sago Worms." In New Guinea, sago worms are roasted on a spit to celebrate special occasions.

106. **Lake Flies** Chironomidae - In East African lakes on the new moon, millions of these flies emerge. Locals rush to collect them with large flat baskets. The flies are collected in baskets and the collectors boil and dry them to make *kungu* cakes. These patties, can contain up to 67% protein, making lake flies one of the most protein-rich edible insects.

## **AGRICULTURAL ANTAGONISTS – Cereal Killers and Other Crop Enemies**

107. **Spotted wing *Drosophila*** *Drosophila suzukii* - *What I do:* Attack soft fruit! *About me:* This small invasive fruit fly is a major pest of soft fruits. Unlike other *Drosophila* which only lay their eggs in rotting fruit, the spotted wing *Drosophila* attacks fruit that is still alive and ripe. The female has a distinctive, serrated ovipositor (egg layer) which she uses to puncture the skin of the fruit. Many Cornell entomologists are working to find solutions to this recently established fruit pest.
108. **Brown marmorated stink bug** *Halyomorpha halys* - *What I do:* Attack many crops! *About me:* This recently established invasive insect feeds on a wide variety of crops and can cause serious damage. It is also a nuisance pest because it is attracted to houses in the fall when the adults diapause (a type of insect hibernation).
109. **Kudzu bug** *Megacopta cribraria* – This pest of legumes is common in the southeastern United States. Like the stink bug, this insect emits a strong and unpleasant odor when disturbed.
110. **Western flower thrips** *Frankliniella occidentalis* - These tiny insects have a very wide host range, feed on many cultivated crops and ornamental plants. During feeding, they can vector a number of plant diseases, making them a scourge to growers. They are native to Western North America and can be found from sea level to all the way up to sub-alpine altitudes!
111. **Colorado potato beetle** *Leptinotarsa decemlineata* - Despite its name, the Colorado potato beetle is found across North America and Europe and feeds on many different plants. It is an incredibly successful pest, capable of completely wiping out crops. They can cause so much damage that during the Cold War it was hypothesized that the Colorado potato beetle could be used as a means of biological warfare to negatively impact Russia's agricultural industry. Due to their large effect on agriculture, this animal has a statue depicting it in Hedervar, Hungary.
112. **Varroa Mite** *Varroa destructor* - These mites are major pests of honey bee colonies and a serious contributor to Colony Collapse Disorder. The mites enter brood cells before they are sealed and feed on the developing bee. The mites feeding weaken the bee and will shorten its lifespan.
113. **Asian citrus psyllid** *Diaphorina citri* - This insect is a recent invasive pest of the citrus industry which transmits huanglongbing, the Citrus Greening Disease. It was first detected in Florida in 1998. The areas where this insect is found are quarantined and a variety of integrated pest management (IPM) techniques are being used to control this pest.
114. **Boll weevil** *Anthonomus grandis* - This beetle feeds on cotton buds and flowers. It came into the USA from Mexico and by the 1920s it had infested all USA cotton-growing areas, devastating the industry and the livelihoods of people working in the South. The Boll Weevil Eradication Program, established in 1978 has allowed full-scale cultivation to return in many regions.
115. **European corn borer** *Ostrinia nubilalis* – This major pest of corn was the first insect to cost the USA a billion dollars to control. In recent years *Bt* transgenic crops have controlled this pest. It has been used as a model organism for insect behavior, courtship, and pheromone communication. The sex pheromone was identified here at Cornell in 1975, and has remained the focus on ongoing research ever since.
116. **Red-banded leaf roller** *Argyrotaenia velutinana* - The red-banded leaf roller is a pest of apples and other fruit trees. The sex pheromone of this insect was identified right here at Cornell University! It has been used to monitor this pest ever since its discovery.

117. **Two-spotted spider mite** *Tetranychus urticae* - This tiny mite is the most serious agricultural pest mite pest in the world! It gets its name from its ability to produce silk. The mites feed on plant juice from a wide host range, blackberries to chrysanthemums, and their feeding can completely defoliate a plant if not caught in time.
118. **Apple maggot** *Rhagoletis pomonella* - This moth is a serious pest of apples. The apple feeding variant of this pest spontaneously emerged from a variant of moths which fed on hawthorns around 1800-1850 when apples were introduced into North America. Now the apple feeding variant of the moth does not normally feed on hawthorns and the hawthorn variant doesn't normally feed on apples! It is possible that this is an early step towards the emergence of a new species!
119. **Grape phylloxera** *Daktulosphaira vitifoliae* - This tiny aphid-like insect feeds on the roots of grape vines, weakening, and eventually killing them. This pest devastated the European wine industry in the mid to late 1800s, particularly in France. The entomologist C.V. Riley along with J.E. Planchon found that American grape rootstocks were resistant to the pest and promoted grafting European grapes onto these resistant rootstocks. This ended up saving the French wine industry!
120. **Corn rootworm** *Diabrotica* spp. - These beetles accost the USA a billion dollars to control. They attack the corn root system making them very difficult to control. Transgenic crops expressing *Bt* toxins were somewhat successful at controlling this pest but there are now reports of beetles that are resistant to these toxins.
121. **Diamondback moth** *Plutella xylostella* – This is the most important cruciferous (cauliflower, cabbage, broccoli, bok choy) pest and the most widely distributed pest moth species. The cost of controlling this pest is \$4-5 billion annually! It is the first agricultural pest to evolve resistance to DDT, *Bt* and other insecticides.
122. **Onion thrips** *Thrips tabaci* - These tiny 0.06 inch (1.5 mm) insects are the key pest in many onion production systems worldwide! Not only do these tiny creatures injure plants with their feeding but they can also transmit viral plant diseases.
123. **Oriental fruit moth** *Grapholita molesta* - This insect infests peaches, apples and nectarines. This insect was used for early studies on pheromones and sexual selection courtship behaviors.
124. **Whitefly** Aleyrodidae - A family of true bugs with over 1500 spp. Whiteflies in the genus *Bemisia* are the world's most invasive agricultural pests and currently devastate subsistence crops in Sub-Saharan Africa through superabundant populations that transmit plant viruses.
125. **Mormon cricket** *Anabrus simplex* - Actually not a cricket but a katydid! Although typically found at low densities, population explosions can occur that create huge swarms which can cause serious crop damage. They are named for the Mormon settlers who encountered them.
126. **June bugs** *Phyllophaga* spp. - A large genus of Scarab beetles, many different beetles in this genus are called June bugs, June beetles or May beetles. The adult beetles feed on plant foliage while the larvae feed on plant roots and can cause serious damage.
127. **Medfly (Mediterranean fruit fly)** *Ceratitis capitata* - One of the world's most destructive fruit pests and an invasive insect in the USA. So far it has not established in the USA because of the release of sterile male flies which prevent these insects from successfully reproducing.
128. **Japanese beetle** *Popillia japonica* – These beetles feed on a wide variety of plants and can cause serious damage. It was introduced into the USA from Japan. In Japan this insect is not a pest because it is controlled by natural predators.
129. **Chinch bug** *Blissus leucopterus* - This insect is a pest of turf grass but it can also attack corn and wheat. In the West it has forced farmers to switch to growing soy, which is not susceptible to chinch bugs.

130. **Cluster Fly** *Pollenia* spp. - Cluster flies are often a household nuisance when they spend the winter in window casings and come out into the house on warm days. The larvae are predators of earthworms.
131. **Cassava mealybug** *Phenacoccus manihotii* - A small, aphid-like insect that is covered with waxy-secretions. This little insect is a major pest of Cassava, which is a staple crop in many parts of Africa. Fortunately, entomologists have found a tiny wasp which parasitizes cassava mealybug and has been very successful in reducing the damage caused by this pest.
132. **Africanized bees** *Apis mellifera* -These aggressive bees are a cross between European honeybees and South African bees that were accidentally released in Brazil. They have since spread throughout the Americas. They aggressively defend their hives against intruders and outcompete the more docile European honeybees making them a serious concern for beekeepers in the USA.

### **FOREST FOES – Tree Huggers These Aren't**

133. **Emerald ash borer** *Agrilus planipennis* - *What I do:* Kill ash trees! *About me:* The emerald ash borer was introduced into the USA via cargo ships from Asia. Since then, it has been the perpetrator of the deaths of millions of ash trees. Watch out for this tree murderer as it has entered NY! *What you can do:* Don't move firewood and learn how to identify this invader!
134. **Hemlock wooly adelgid** *Adelges tsugae* - *What I do:* Kill hemlock trees! *About me:* This invasive sap-sucking, aphid-like insect feeds on the twigs of hemlock trees and can kill trees in 3-10 years depending on the region. *What you can do:* Don't move infected nursery stock, respect quarantine restrictions and learn how to identify this invader!
135. **Asian longhorned beetle** *Anoplophora glabripennis* - *What I do:* Feed on a wide variety of deciduous trees! *About me:* This invasive pest has been introduced into the USA via infested wood packing material. This beetle is currently under eradication and has the potential to cause major damage to a wide variety of deciduous trees. It is particularly a concern for the sugar maples industry and urban trees. *What you can do:* Don't move firewood and learn how to identify this invader!
136. **Gypsy moth** *Lymantria dispar* - This forest defoliator causes cycles of defoliation in eastern North American forests where it has been introduced. The fungal pathogen *Entomophaga maimaiga*, has dramatically reduced gypsy moth populations.
137. **Sirex woodwasps** *Sirex noctilio* - *What I do:* Kill pine trees! *About me:* This invasive woodwasp drills holes in suppressed or healthy pine trees and then injects eggs, toxic mucus and fungus into the tree! The mucus and fungus kill the tree creating a suitable environment for the wasp to develop. Ann Hajek's lab is studying how to use nematodes (parasitic worms) to control this pest.
138. **Eastern tent caterpillars** *Malacosoma americanum* - These caterpillars are social and will form a silk tent for protection and feed as a group for most of their larval lifespan. They feed on a variety of deciduous trees and can cause serious defoliation.
139. **Walnut twig beetle** *Pityophthorus juglandis* - *What I do:* transmit a disease which kills black walnut trees! *About me:* This tiny beetle transmits the Thousand Cankers Disease which is caused by the fungus *Geosmithia morbida*. This disease is a serious threat to black walnut in the USA. *What you can do:* Don't move black walnut wood! Even small logs can harbor thousands of beetles! Learn how to identify this serious pest and disease.

### **MODEL BEHAVIOR – These Insects are the Perfect Labmates**

140. **American cockroach** *Periplaneta americana* - Ever wondered why it is so hard to squish a cockroach? These insects can start running in 8.2 to 70.2 milliseconds after sensing a predator!

Although these roaches are serious pests they are not all bad news, because they are important model animals for researchers who have study them to understand how the nervous system functions.

141. **Tiger moths** Arctiinae – Many species in this family sequester toxic alkaloids when they are caterpillars. When *Utetheisa ornatrix*, one of the moths in this family, mate the male transfers some of the alkaloids he has stored to the female that uses them to protect her eggs. The females selectively mate with males that have stored a greater quantity of these alkaloids. Thomas Eisner studied these insects to understand parental investment and sexual selection.
142. **Cabbage looper** *Trichoplusia ni* - This moth is a pest on many plants and weeds particularly crucifers. It is an important insect used in pheromone research and a model for many other physiology/resistance studies. This is also the second pest to evolve resistance to *Bt* bio-insecticides in an agricultural setting.
143. **Cottony cushion scale** *Icerya purchasi* - This insect was a major pest of the citrus industry in the early 1880s before C.V. Riley imported the Vedalia beetle, a natural enemy of this insect. The Vedalia beetle saved the California citrus industry and is the earliest and most successful examples of Classical Biological Control (the importation of natural enemies from a pest's native habitat to its new habitat for its control).
144. **Drosophila melanogaster** - This tiny fly, which you may find around rotting fruit in your kitchen is one of the most important model animals for biology! It has been used as a model organism for almost a century to understand many aspects of animal biology and physiology including genetics, embryonic development and more recently the immune system.
145. **Hessian fly** *Mayetiola destructor* - This fly is a pest of cereal crops and is thought to have been introduced into North America during the American revolution in the straw bedding of Hessian (German) troops. This fly is a model organism because of its ability to overcome plant resistance and manipulate plant growth and phenology by forming galls. It is also used to study plant-insect interactions and genetics.
146. **Tobacco hornworm** *Manduca sexta* - These large caterpillars are important model animals for many branches of biology. They are easy to rear, very large and have a fast generation time. The adult form of this caterpillar, the sphinx moth, is very charismatic.
147. **Pea aphid** *Acyrtosiphon pisum* - These small, green insects feed on plant phloem which is low in many essential nutrients. Because of this these aphids depend on microbes to get the nutrients they lack. Their dependence on these microbes has led to their role as model organisms for understanding insect-microbe symbiosis. They are also serious pests on alfalfa, peas, and clover.
148. **Red flour beetle** *Tribolium castaneum* - This insect is a serious pest of stored grains and food products worldwide. It is also an important model animal and is used to study genetics, developmental biology, toxicology, immunity and comparative genomics.
149. **The greater wax moth** *Galleria melonella* - This moth is an apiculture (bee keeping) pest which feeds on the honeycomb. It is a popular model animal and has been used to study pathology, toxicology and the innate immune system.
150. **Cercropia moth** *Hyalophora cecropia* - This is one of North America's native silk moths and one of our largest moth species. Because of its large size this species was used for pioneering biochemical studies to elucidate the role of juvenile hormone, the substance that determines whether an insect will become another larval stage, a pupa, or an adult when it molts.