ILLINOIS NATURAL HISTORY SURVEY

Reports

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Engineering Students Learn while Helping Bat and Bird Conservation at INHS

Migratory bats and birds sometimes fly at the same height as large commercial wind turbines. Because these flights take place at night high in the air, the danger to the flying wildlife posed by the spinning turbine blades is impossible to investigate by conventional wildlife techniques such as binoculars and leg bands. The animals come from far away, meaning that radio transmitters are not an option either. The one technique we have to observe flying animals at a great distance at night is radar, which can detect bats and birds while they are flying, without disturbing them.

Fortunately, the Illinois Natural History Survey operates two radar units devoted to conservation of migratory wildlife. The units are currently working on research contracts funded by the U.S. Department of the Interior and U.S. Department of Energy, both aimed at determining how bats and birds are killed at turbines.

Three ECE students and an engineer aim a mechanized platform they created to point a night-vision imager in three dimensions. Photo by Ron Larkin, INHS

Two UIUC Electrical and Computer Engineering students fine-tune the INHS Doppler radar unit. Photo by Ron Larkin, INHS

To help in keeping these specialized research instruments up to this task, teams of University of Illinois students in an Electrical and Computer Engineering (ECE) senior design class routinely work with INHS scientists to modify and augment the radar units. The students receive what is sometimes their first experience actually designing and building a complex piece of equipment and the Survey's ability to carry out sponsored research is strengthened.

One team of ECE students in spring semester 2010 built a circuit to accurately point the antenna of an old military radar so it can count flying animals more nimbly. Another team made a mechanized platform that will point a telescopic night-vision imager in three dimensions to permit biologists to look at what is flying by at night and begin to determine their identity beyond merely "radar targets."

Ron Larkin, Illinois Natural History Survey

Sweeter than Honey: Honey Bee Health

The European (or Western) honey bee was imported to North America by European settlers soon after colonization began and the importance of these bees for pollination services and production of honey in North America is undisputed. Honey bee husbandry represents an estimated $8–20 billion industry in the U.S. alone, and the successful production of many high-value crops would be compromised without the presence of this pollinator. Importing insect species to environments where they did not previously exist, however, whether intentional or accidental, and whether the imported species is beneficial (like the honey bee) or is a pest, generally raises many issues concerning the natural enemies—predators, parasites and pathogens—of the imported species.

The global trade of the European honey bee and the migratory nature of the honey bee pollination industry in the U.S. has resulted in increased exposure and transmission of parasites and pathogens, possibly including new disease organisms and increased prevalence of disease. In addition, the extent and intensity of human management of the honey bee adds to the potential for a variety of stresses that increase susceptibility to parasites and pathogens and may cause increasingly ill effects.

Honey bee drinking sugar water from pipette tip in laboratory experiments.

European honey bees (*A. mellifera*) are known to harbor a large number of species of disease-causing organisms that includes viruses, bacteria, and fungi. Perhaps more pathogen species have been described from honey bees than from other insects because of the intense agricultural/economic interest in this species. However, transmission and persistence of disease organisms are aided by highly dense host populations with, in the case of honey bees, similar genetic makeup and nests (hives, trees) that protect the bees but also protect the pathogens.

Postdoctoral research scientist Wei-Fone Huang feeding honey bees in laboratory experiments on the relationship between disease and temperature.

Two microorganisms that commonly infect honey bee colonies are *Nosema apis* and *Nosema ceranae*, members of the Microsporidia, a group of fungal pathogens that infect animals in all known classes. Although microsporidian infections tend to be chronic in nature, infection often results in harmful effects such as decreased egg-laying, shorter adult lifespans, lethargy and early death, effects that collectively can, and often do, severely reduce populations of their hosts. *Nosema apis* is a well-known and well-studied species and was thought to be the only microsporidian pathogen of honey bees, but it now appears that *Nosema ceranae* is more commonly found in North American honey bee populations.

It is possible that *Nosema ceranae* is an invader originating from the Asian honey bee, *Apis cerana*, as has been suggested, but it has been the dominant honey bee microsporidium in the U.S. since 1995, if not earlier. *Nosema ceranae* has been linked to Colony Collapse Disorder (CCD) in Spain, and we are currently studying the disease in North American honey bee populations to determine its effects on the honey bees and how it interacts with other honey bee disease organisms, particularly viruses. While our recent results showing lower than expected infectivity and mortality for *Nosema ceranae*, and information from other North American researchers with whom we collaborate do not suggest a direct connection with CCD, the presence of several disease organisms in most apiaries, in addition to other factors such as pesticides, habitat destruction, and changing climate, may result in synergistic effects, with honey bee colonies rendered unable to cope with the excessive stresses. By studying these interactions, we provide information on pathogen biology and efforts needed to develop better treatments for disease and beekeeping methods that reduce the loss of colonies.

Leellen Solter and Wei-Fone Huang, Illinois Natural History Survey

The Global Plant Initiative: A Unique Opportunity for the Herbaria of the University of Illinois

The three herbaria of the University of Illinois at Urbana-Champaign (UIUC) have joined with over 150 herbaria from 50 countries around the world to become part of the Global Plant Initiative (GPI). The GPI is a worldwide effort funded and organized by the Andrew W. Mellon Foundation to digitize and database herbarium type specimens from around the world and make them available via the World Wide Web (WWW).

An herbarium is a collection of preserved plant specimens. These specimens are made by collecting and drying plants (either whole plants or plant parts) and mounting them on herbarium sheets, each with a label containing information such as collector, date of collections, location collected from, etc., (see photo). A type specimen is the herbarium specimen "to which the name of a taxon is permanently attached." Each time a new plant species is described, a type specimen is designated and that specimen forever represents the name of that species. Plant systematists and taxonomists often find it necessary to consult type specimens as they conduct their research, but type specimens are located all over the world making their viewing difficult, as people must either travel to the herbaria where they are housed or request the specimens be shipped to them as loans. Many type specimens are very old and each time they are shipped there is the risk of damage or loss. Therefore making high-resolution scanned images of herbarium type specimens available on-line will greatly facilitate the research of many scientists and prevent the possible loss or damage of type specimens.

In 2009 scientists from the Illinois Natural History Survey (Mary Ann Feist, Rick Phillippe, and Brenda Molano-Flores) obtained a GPI grant to digitize and database 4,349 vascular plant type specimens from the three University of Illinois herbaria. According to Janelle Weatherford, Associate Director of University of Illinois Foundation Relations, this was the first grant awarded by the Authur W. Melon Foundation to anyone at the University of Illinois. Jenny Stratton, a recent graduate of the Plant Biology Department's Master's program, was hired to database and digitize the type specimens. She and Mary Ann Feist attended a weeklong training session in October 2009 at the New York Botanical Garden to learn about digitizing, databasing, and quality control. Since that time, Jenny has entered the label information from all of the type specimens into the type database and is now scanning the specimens using the Herb Scan, a special scanning device constructed at the Kew Royal Botanic Garden with an inverted high-resolution scanner and a cushioned platform for the type specimens.

The three UIUC herbaria involved in this project are: the University of Illinois Herbarium (ILL), the Illinois Natural History Survey Herbarium (ILLS), and the Crop Evolution Laboratory herbarium (CEL). Each of these herbaria is unique in its contribution to this project. Below we provide a brief history of each herbarium.

The collections at ILL date from 1869 and consist of about 520,000 specimens (430,000 plants and 90,000 fungi). They are worldwide in scope with particular strengths in Loranthaceae, Viscaceae, mimosoid Fabaceae, and Piperaceae. These collections include a large number of plant types, the majority of which are from Latin America (2894/4349). Over the years, ILL curators have acquired numerous collections from many renowned collectors and have actively added collections through gifts, purchases, and exchanges. Some of the unique vascular plant holdings include J.T. Buchholz's many types and other collections of southern hemisphere conifers, G.N. Jones's extensive collections of North American Salicaceae, A.G. Jones's Aster specimens, and D.S. Seigler's New World Acacia collections.

ILLS, founded in 1858, contains about 301,000 specimens (242,000 plants and 59,000 fungi) and is fully databased. ILLS specimens are primarily from the midwestern United States, especially Illinois. In recent years, however, the ILLS collections manager has made an effort to broaden the scope of the herbarium; significant collections have been added from Kyrgyzstan and Uzbekistan and a specimen exchange program was started with China in 2007. Eleven vascular plant type specimens are held at this herbarium.

Type specimen of Tripsacum bravum scanned by Jenny Stratton for the Global Plants Initiative project.

CEL houses about 30,000 specimens of cultivated grasses and legumes and their wild relatives. The collection is international in scope and includes specimens of many cultivated forms, including numerous land races and many documented hybrids. It is also rich in wild species, including rare endemics and many topotypes. CEL also holds a large collection of tropical cultivated species and their wild relatives. This is a truly unique collection that has value to systematists and agronomists, as well as to anthropologists and archeologists studying the origins of agriculture. Twenty plant type specimens are a part of the CEL collection.

Although these herbaria have been housed and managed separately, a new facility that is currently under construction will soon house all of them. This new facility will have a combined holding of over 850,000 specimens, making it about the 15th largest plant and fungus collection in the United States. Illinois Natural History Survey staff will manage the three herbaria. The GPI grant is the

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Extending the History of the Passenger Pigeon

"The Passenger Pigeon was no mere bird, he was a biological storm. He was lightning that played between two biotic poles of intolerable intensity: the fat of the land and his own zest for living. Yearly the feathered tempest roared up, down, and across the continent, sucking up the laden fruits of forest and prairie, burning them in a traveling blast of life. Like any other chain reaction, the pigeon could survive no diminution of his own furious intensity. Once the pigeoners had subtracted from his number, and once the settlers had chopped gaps in the continuity of his fuel, his flame guttered out with hardly a sputter or even a wisp of smoke." – Aldo Leopold, 1947, On a Monument to the Pigeon.

Perhaps no extinction in North America is more famous or more poignant than that of the Passenger Pigeon. The dramatic and tragic extinction of the Passenger Pigeon in 1914, when the famous last pigeon "Martha" died in the Cincinnati Zoo, was a hard lesson that humans could cause the loss of a species so abundant its extinction would seem unthinkable.

The Passenger Pigeon (*Ectopistes migratorius*) was no doubt the most abundant bird in North America, with an estimated 3 to 5 billion birds. Its success was a result of its remarkable ability to take advantage of superabundant tree seeds from oaks and beeches, widespread in eastern North American forests. These trees use a "mast" strategy of producing seeds in very large numbers synchronously with other trees in a local forest during only certain years. In this way these trees can overwhelm any local seed predators by concentrating their reproductive efforts.

Painting of the Passenger Pigeon by J.J. Audubon.

However, they could not overwhelm the Passenger Pigeon. The large nomadic flocks of these birds would seek out patches of forest where mast seed crop was being produced and set up a breeding colony to take advantage of this superabundant food. The Passenger Pigeons themselves were a "mast" species, able to satiate predators by their huge locally distributed flocks.

But, alas, one insatiable predator finally caught up with them—humans. Once a pigeon colony was discovered, people would come from miles around to slaughter them for market. These giant hunts disturbed the breeding colonies to such an extent, causing abandonment, that this species effectively did not reproduce for years on end. This constant slaughter and lack of reproduction eventually lead to steep declines in population size. Deforestation of vast tracts of eastern deciduous forest also took their toll on the pigeons' food supply. By the time humans noticed the coming demise of this species, it was too late. Because of its colonial breeding habits, the Passenger Pigeon lost any form of predator defense. Once its population size got too low, even if human hunting and deforestation had ceased, natural predators would have done the rest.

While many aspects of the biology of the Passenger Pigeon are well known, considerable speculation still exists regarding where it came from in the first place. Why is this species unique among pigeons and doves, being a monotypic genus, and what are its closest relatives? Based on morphological features, such as a long tail, many had suggested the Passenger Pigeon is closely related to the Mourning Dove (*Zenaida macroura*), another common avian species in North America. However, studies using DNA sequences from museum specimens by Dr. Kevin Johnson at the Illinois Natural History Survey with colleagues at the National

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Passenger Pigeon

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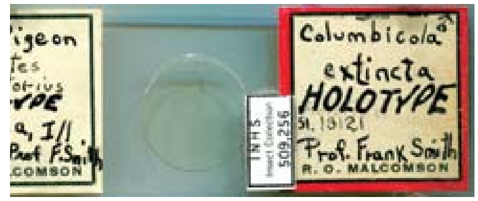
Museum of Natural History, California Academy of Sciences, and University of Utah have shed new light on this question. Gene sequences obtained from DNA extracted from the toe pad of a museum specimen of the Passenger Pigeon were compared to the same gene sequences from other pigeons and doves (Columbiformes). Methods for reconstructing evolutionary trees from these sequences reveal that in fact the Passenger Pigeon is not closely related to the smaller Mourning Dove, but rather is a true pigeon being a close relative of other large pigeons in the New World, including the Band-tailed Pigeon (*Patagioenas fasciata*) from western North America. Furthermore, more detailed reconstruction of the relatives of the Passenger Pigeon reveals this species might trace its lineage back to cuckoo-doves (*Macropygia*) of eastern Asia. Cuckoo-doves also have a long tail like the Passenger Pigeon, and juvenile Passenger Pigeons have a similar ruddy coloration of the wing feathers to that of cuckoo-doves. If the ancestors of the Passenger Pigeon did indeed cross the Pacific to reach North America, it would be one of few lineages of birds to have done so.

Further evidence of this history comes from studying the feather lice of these pigeons. Feather lice are wingless ectoparasitic insects found on most groups of birds. The Passenger Pigeon was host to a species of louse, *Columbicola extinctus*, described after its extinction in 1937 by R.O. Malcomson, a member of the Department of Entomology at the University of Illinois. The lice were removed from a museum skin of a Passenger Pigeon collected in Urbana, Illinois, in 1895. The type specimen of the louse, *Columbicola extinctus*, is housed in the Insect Collection of the Illinois Natural History Survey. Because feather lice are generally specific to a single species of host, this parasite was thought to have gone extinct at the same time as its host. However, recent taxonomic work on this genus revealed that the Band-tailed Pigeon also harbors *Columbicola extinctus*, resurrecting this parasite from extinction. Phylogenetic studies of pigeon lice also reveal that the lice of New World pigeons, including *Columbicola extinctus*, are closely related to those of cuckoo-doves, lending further support to the Pacific-crossing hypothesis.

While it is hard to know the full extent of how the extinction of the Passenger Pigeon affected the forest ecosystems of eastern North America, its demise might have been a factor in the rise of another parasite, *Borrelia burgdorferi*, the bacteria causing Lyme Disease. In forests that already have Lyme Disease present, the prevalence of the disease increases in years where forest trees produce mast seeds. This is because the primary reservoir for Lyme Dsease, mice and other small mammals, feed on this superabundant crop of seeds and their populations increase. It seems possible that the Passenger Pigeon, because of its amazing population sizes, might have competed with these rodents for these mast crops, preventing them from increasing their reproduction during mast years. This might have kept the prevalence of Lyme Disease at a much lower rate than is seen today in eastern forests. While this idea might be difficult to test, it might be possible to evaluate the prevalence of Lyme Disease in museum specimens before and after the extinction of the Passenger Pigeon. Such connections in ecosystems show how preserving biodiversity may be important in preventing the rise of infectious diseases, a recurrent theme in the study of emerging infectious diseases at the Illinois Natural History Survey.



The type specimen of the Passenger Pigeon louse, (Columbicola extinctus) *housed in the INHS Insect Collection.* Photo by Paul Tinerella, INHS

Kevin P. Johnson, Illinois Natural History Survey

A photomicrograph of the type specimen of the Passenger Pigeon louse. Image by Paul Tinerella, INHS

Species Spotlight

Luna Moth

Susan Post

Moonlight Tango
By Susan Post

On a Full Moon stage
Her heady perfume
Lures a partner

Shimmering lime, twisted
tails
Circling up and around
An "Abrazo" perfected

Dawn—dancers spent
Actias luna's twisted tango
Consummates a new
generation.

As an entomologist, if I had to choose, my favorite insect would be the Luna Moth. Growing up I remember early morning encounters in our lawn mower shed. The shed was near an outdoor light and the moths would be resting on the door or the sides of the small building. Their lime-green wings stood out in contrast to the faded white shed. Now grown, my encounters with Luna Moths have been less often. Usually I find a wing here and there, the luna victimized by a night-feeding bat. Last June during a black lighting adventure under a full moon, a female came to the light around 10:00 pm. When we turned the light off and packed the sheet to go home, she circled up to the sky, nothing but a shadow—gone. It was magical and inspired the above poem

The Luna Moth, *Actias luna*, is a large, lime-green silk moth (Family Saturniidae) with a wingspan of 3 to 4.5 inches. Like its Saturniid relatives, the Cecropia and Polyphemus moths, Luna Moths have eyespots on their wings. These eyespots are used to confuse potential predators. The moths rest with the hindwing eyespots covered, but when disturbed the wings open, revealing the eyespots and hopefully startling the predator, giving the moth time to escape. Unlike it's near relatives, Luna Moths possess elongated hindwing tails, which lend an air of aerodynamic elegance.

An adult luna moth perching on vegetation.
Photo by Michael Jeffords, INHS

Luna Moths occur from east of the Great Plains to the Atlantic Coast and from Nova Scotia to Florida and Ontario to Texas. They may be found throughout Illinois. The moths prefer a forest or woodland habitat, and in Illinois their principal larval hosts are walnuts, hickories, and persimmon.

In Illinois, the moth overwinters as a pupa, emerging during May and June. Adults emerge from their cocoons in the morning and begin to inflate their wings. Since their wings are soft, the moths climb to a safe spot where they are inactive until evening. Females will release a pheromone and the males will locate her by flying upwind toward the odor source. Mating usually takes place after midnight and may last until dusk of the following day. Females will mate only once, but males can mate each night of their short life. During their adult lifespan (7–10 days) the moths will never eat or drink as they have no mouthparts.

Once mated, the female begins to lay brownish eggs in small groups (4–7) on the underside of leaves—hickory, walnut, or persimmon. She will lay up to 300 eggs that will hatch in about a week. The larvae are lime-green caterpillars with magenta spots. They will undergo 5 molts before pupating. Each instar (period between molts) will take about a week to complete. To pupate, the fifth instar will spin a silk cocoon, incorporating a leaf from its food source. This unattached leaf will soon die and the leaf with the cocoon will fall to the ground where it will be hidden among the leaf litter under the tree. Within the cocoon, the pupa is active, as it will wiggle about. In Illinois, there are usually 2 generations of moths with adults flying in May throughearly June and again in late July through August.

I am not the only one given to descriptive prose when encountering a Luna Moth.

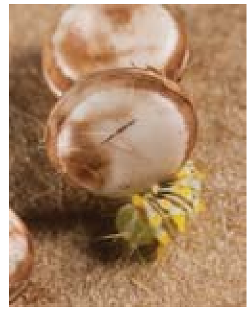
In 1876, Missouri's State Entomologist C.V. Riley wrote,
. . . Luna, our queen of the night, entire supremacy in grace, elegance and chasteness. No other North American insect can wing this distinction from her, the delicate green, relived by the eyespots and by the broad purple-brown or lilaceous anterior border, the soft downy hair of the body, and above all the graceful prolongation of the hind wing . . .

The Naturalist's Apprentice

Rearing Silk Moths

Michael Jeffords
and
Carolyn Nixon

Giant silk moths, such as Polyphemus or Cecropia, members of the family Saturniidae, can easily be reared in the home or classroom. Before you start, you will need to build a cage to rear your larvae. It should be at least 1ft x 1ft x 2ft tall, and should be covered with a fine mesh screen or cloth.



Hatching Polyphemus larva. Photo by Michel Jeffords, INHS

1. Find a female moth, usually at lights during summer nights. Place her in a brown paper bag and close it up by folding over the top and creasing it. Check her in the morning. If she was ready to lay eggs, there were be several clusters of eggs attached to the paper. Release the female outside. (note: male moths have large, feathery antennae; female moths have narrower antennae with large, fat abdomens.)

2. Eggs will hatch about two weeks after being laid by female moths. Watch them carefully so they do not starve! They need to feed shortly after hatching and are very tiny at this stage.

Polyphemus larva, first instar. Photo by Michael Jeffords, INHS

3. Collect twigs with several leaves from a nearby tree of the correct species, make a bouquet with water in a vase and place the leaf bouquet inside the cage. Cover the top of the vase with cloth or paper to keep the caterpillars from falling into the water and drowning. You will not need a lot of leaves while the larvae are still small. This WILL change as they grow. Appropriate leaves for Polyphemus are Apple, Black Cherry, Dogwood, Elm, Maple, or Oak. Cecropia larvae will feed on Apple, Birch, Box Elder, Dogwood, Silver Maple, and Wild Cherry. Once you start with a particular tree species, keep that same species throughout the rearing process.

Polyphemus larva, fifth instar. Photo by Michael Jeffords, INHS

4. Use a soft paintbrush to transfer the young larvae to the foliage in the cage. Be careful to not drop them or damage them in the move.

5. The larvae will settle down and eat, and eat, and eat . . .

6. When the leaves begin to wilt or dry or are all eaten, they must be changed. It’s best to create a new bouquet and just cut off the old leaves or stems that contain the larvae and clip them to the new foliage until they transfer over. This process will be repeated until they are full-grown and spin a cocoon.

Mature Polyphemus larva. Photo by Michael Jeffords, INHS

7. Polyphemus moths will emerge in a few weeks. Cecropia moths have one generation a year. Once your larvae pupate, put them in a mouse-proof wire cage, and keep them in an unheated porch or garage until spring. They should emerge as adult moths the next May, so bring them indoors where you can watch them in late April. Place a male and a female in a paper bag, let them mate, and begin the entire process again.

Alternately, if you find silk moth caterpillars (larvae), you can collect them and leaves from the tree they are feeding on, and proceed from #3.

To identify adult and larval silk-moths, and to see a list of plants which the caterpillars will feed on, see *Field Guide to Silkmoths of Illinois*, by John K. Bouseman and

Adult female Polyphemus moth. Photo by Michael Jeffords, INHS

Adult male Polyphemus moth. Photo by Michael Jeffords, INHS

Polyphemus pupa. Photo by Michael Jeffords, INHS

Institute of Natural Resource Sustainability

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Global Plant Initiative

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first joint project involving all three herbaria. A second proposal is currently being developed to obtain additional funding to digitize the approximately 4,800 fungal type specimens. Digital images and label data for all of the type specimens will be accessible through JSTOR's Plant Science Web page (http://plants.jstor.org/). In addition to the type specimens, other primary data sources relating to plant systematics, including books, manuscripts, letters, artifacts, and prints, will be available on this Web page.

Brenda Molano-Flores, Mary Ann Feist, and Rick Phillippe, Illinois Natural History Survey