ILLINOIS NATURAL HISTORY SURVEY

Reports

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Institute for Natural Resource Sustainability

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Winter 2010
No. 402

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Publications Sales Specials

Aedes triseriatus—*eastern treehole mosquito (adult).* Photo courtesy of Alex Wild, 2009

Interspecific Interactions between Invasive and Native Mosquitoes

Aedes triseriatus—*eastern treehole mosquito (larvae).* Photo courtesy of Alex Wild, 2009

The Asian rock pool mosquito, *Aedes japonicus,* whose native range includes Japan, China, Korea, and Taiwan has recently spread to several new areas in the world. In the continental United States, this invasive species was discovered in 1998 in Connecticut, New York, and New Jersey. The arrival of this species in the U.S. was most likely attributable to the used tire trade. *Aedes japonicus* has now spread throughout the East Coast, midwestern states, and a few states in the western U.S. The Illinois Natural History Survey Medical Entomology staff discovered the Asian rock pool mosquito in Urbana, Illinois, during the summer of 2006, representing the first state record. Surveillance by our local Champaign-Urbana Encephalitis Prevention Program has documented continued range expansion of *Ae. japonicus*. The immature stages of this species inhabit natural and artificial containers, some of which are also occupied by the native treehole mosquito *Aedes triseriatus*, the primary vector of LaCrosse Encephalitis Virus.

The distribution of *Ae. japonicus* and *Ae. triseriatus* overlap, which suggests that interspecific interactions, especially among the larval stages, should be common. Competition within and between larval mosquito species is common and plays an important role in determining individual mosquito life history traits and community structure. Several studies have demonstrated that the success of invasive species is, in part, due to their superior competitive abilities over native species. Also, larval competition may have important consequences for disease transmission. Previous studies have shown that competitively stressed and smaller adult mosquitoes have higher rates of infection and dissemination of arthropod-borne viruses. Competition-induced alterations in a mosquito's phenotype may also contribute to parasite transmission in other ways. The extrinsic incubation period is the time from initial acquisition of a parasite until the vector is capable of transmitting the parasite. The probability of transmission of a parasite is reduced as the adult life span (longevity) approaches the extrinsic incubation period.

A laboratory experiment was used to examine intraspecific (between individuals of the same species) and interspecific (among individuals of different species) effects of larval density and resources on interactions between these mosquito species. The goal of this study was

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Islands as Models for Biodiversity Studies

Although the Hawaiian Islands are just 1/10 the size of Illinois and only 5 million years old, they are home to more than 6,000 endemic plants and animals. The extraordinary endemicity on the islands has arisen so rapidly and in such a small area that Hawaii is an ideal place to investigate some fundamental biological questions. Why are there so many species on Hawaii? How and why did they diversify so rapidly?

The Hawaiian Islands are the most isolated major island chain in the world. Each island has emerged as lava from a volcanic hotspot that accumulated on the ocean floor. The islands are arranged in linear order by age: Kauai, at about 5 million years is at the western extreme and the Big Island of Hawaii at only 0.5 million years is at the eastern extreme. At emergence, the islands were barren rocks void of any life. They presented a rich variety of unoccupied habitats for organisms that were able to make the journey from elsewhere. The endemic fauna of Hawaii is dominated by animals that are good dispersers, such as birds, insects, and spiders. Aside from a single bat species, there are no mammals, reptiles, or amphibians native to Hawaii. The classic model of colonization of the islands (the stepping-stone model) predicts that organisms colonized the oldest island first, then moved down the chain as new islands arose (Fig. 1).

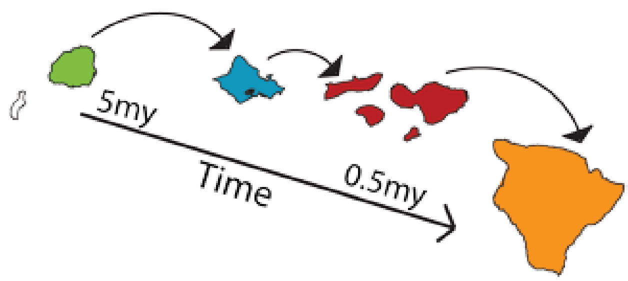

Figure 1. "Stepping stone" hypothesis. Oldest-to-youngest colonization mode for the Hawaiian Islands. A colonizing organism establishes on the oldest island; its progeny move down the chain as new islands become available.

Research by Emilie Bess and Kevin Johnson at the Illinois Natural History Survey (INHS) addresses fundamental questions on the origin and diversification of a group of understudied endemic Hawaiian insects—bark lice (Psocoptera). These studies are using taxonomy and phylogenies to understand how these insects speciated in the Hawaiian Islands and how fast new species can evolve. The endemic Hawaiian bark lice in the genus *Ptycta* are very diverse and are an excellent model for these questions. *Ptycta* is a large genus of about 170 species distributed worldwide, with 51 species described from Hawaii, although recent collections suggest that there are 100–150 species of *Ptycta* in Hawaii. These small insects (3–9 mm in length) live on tree bark and eat the fungi, algae, and lichens that grow on the bark (Fig. 2). Bark lice do not harm the tree, but they can be found in large numbers on damaged trees that have abundant fungal growth. They are among the most abundant insects in the Hawaiian forest ecosystem.

Figure 2. Bark lice from the genus Ptycta *that live off of fungi, lichens, and algae on trees in Hawaii.*

With funding from the National Science Foundation (NSF) and the University of Illinois Research Board, *Ptycta* bark lice were collected from the islands of Kauai, Ohau, Molokai, Lanai, Maui, and the Big Island of Hawaii during four collecting trips during 2006–2008. Sampling focused on as many unique sites as possible. Two dominant endemic trees, *Metrosideros polymorpha* and *Acacia koa*, are reliable hosts for the bark lice, although bark lice were found on more than a dozen endemic tree species. After four months of collecting, more than 7,000 new specimens of *Ptycta* were used in the molecular and morphological study. This number more than doubled the existing specimens of this genus from Hawaii across insect collections worldwide.

Using DNA sequences from two nuclear and three mitochondrial genes, phylogenetic trees were reconstructed, and these show some unexpected pat-

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Can Riparian Forests Help Improve Stream Communities in Illinois Agricultural Watersheds?

Many stream ecosystems in the midwestern United States have been greatly degraded by agricultural land use, particularly in Illinois where agriculture covers more than 76% of the state's total area. An estimated one-third of Illinois streams have been altered by channelization for drainage or irrigation of farmlands. Riparian areas comprise a significant portion of the remaining forested vegetation in Illinois, but are generally confined to the lower reaches of the watersheds. Removal of riparian vegetation in agricultural areas increases the severity and magnitude of flooding and creates higher loads of sediment and nutrients entering streams. These physical and chemical alterations have significant consequences for stream ecosystems and may be linked to declines in species diversity, alterations of trophic structure, and loss of ecosystem integrity.

Forested riparian buffers, typically 30–50 m wide alongside streams, are an accepted management practice to mitigate the impact of agriculture or other nonpoint sources of pollution. Studies have shown that forested buffers can improve stream water quality by reducing soil erosion and filtering fertilizers and pesticides out of runoff before it enters a stream. In addition, forested riparian zones provide important inputs of organic matter and can moderate stream water temperature through shading. While previous studies have addressed the size and width of riparian buffers needed to reduce pollutants, scientists at the Illinois Natural History Survey (INHS) are investigating how much riparian vegetation is sufficient to ameliorate the effects of agricultural activities on stream biota.

We are examining the influence of riparian forest and watershed agriculture on headwater stream community structure and ecosystem metabolism. Most studies of stream condition focus only on descriptive variables, such as water chemistry or biological community structure. However, functional measures such as metabolism are beginning to be used in stream assessments to gain a more complete picture of ecosystem condition. Stream ecosystem metabolism reflects the balance between autotrophic (primary production) and heterotrophic (respiration) processes. Since primary production and respiration respond to variables influenced by watershed disturbance (e.g., light, nutrients), they are ideal measures of stream condition. Therefore, in addition to evaluating community structure, we are measuring stream metabolism in order to provide a more comprehensive assessment of ecosystem condition.

(L–R) Edward Bates, Eden Effert, and Lorraine Chow use backpack electrofishing to collect stream fish. Photo by Hannah Grant

Methods. We examined nine agricultural streams with a gradient of riparian forest (16%–92%) to determine the effect of riparian and watershed land use on macroinvertebrate and fish communities in Illinois streams. All sites are second and third order streams located in the Embarras River watershed in east-central Illinois. Land use within the watershed is dominated by row-crop and small grain agriculture (73.5%). The study reaches were selected to have similar channel width, depth, and watershed area (range 27–39 km^2) to minimize differences unrelated to land use. Sampling was conducted seasonally (spring, summer, fall) over three years to explore temporal patterns in macroinvertebrate and fish assemblages related to land use, in-stream habitat, and water quality parameters. We compared species compositions and ecosystem metabolism among streams to identify patterns and influential factors related to riparian forest and agricultural land use.

Preliminary Results. While there were significant seasonal and annual differences, relationships among streams with different land use type were relatively consistent. Streams with low percent forest buffer had higher nitrate nitrogen levels, higher primary productivity, and higher densities of macroinvertebrates and fish. Though there were higher abundances in streams with low forest buffer, macroinvertebrate and fish assemblages were dominated by pollution-tolerant taxa such as chironomids (midge larvae) and green sunfish. Streams with the highest percent forest buffer and lowest percent watershed agriculture had the highest biotic integrity, greatest abundance of pollution-sensitive species, and the most complex trophic structure. Streams with high forest buffer had more top predators, such as grass pickerel and largemouth bass, indicating a more balanced, trophically diverse ecosystem.

Next Step. We are currently performing stable isotope analyses to examine trophic interactions and energy flow within each stream. These analyses will allow us to determine how land use changes affect in-stream food web interactions. Results of our study will provide information on the influence of riparian forest on Illinois stream communities and have implications for managing and restoring riparian areas in agricultural watersheds.

Eden L. Effert and David H. Wahl, Illinois Natural History Survey

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Ecosystem-scale Evaluation of Sound Bubble Barrier Technologies to Prevent Range Expansions of Asian Carps

Invasive Asian carps, collectively bighead (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*), have expanded their range upstream in the Illinois River and efforts have been increased to prevent them from entering Lake Michigan through the Chicago Shipping and Sanitary Canal (CSSC), which links the Illinois to Lake Michigan. Invading bighead and silver carps in the Illinois River have negatively influenced native fish populations by competing with them for habitat and food resources. Because Asian carps have been detected less than one river mile downstream of the CSSC Electric Barrier at Romeoville, these invasive species pose an imminent threat to the Lake Michigan ecosystem. Asian carps are very efficient planktivores. Therefore, resource managers are concerned that Asian carps will further contribute to the increased negative ecological effects observed in recent years due to numerous aquatic invasives entering Lake Michigan. In an attempt to slow the range expansion of Asian carps, Sound Projector Array Bio-acoustic Fish Fence (i.e. sound-bubble strobe light barriers) technologies have been tested to determine their effectiveness as potential deterrents. This type of system was chosen because Asian carps are sensitive to high sound frequencies, in the range of 750–1500 Hz. In a 2005 study, sound-bubble barrier technologies were shown to be 95% effective at deterring adult bighead carp passage through hatchery raceways. Because this technology is effective at deterring Asian carps in a mesocosm setting, researchers at the Illinois River Biological Station (IRBS) at Havana are conducting an ecosystem-scale evaluation of sound-bubble barrier technologies to determine their effectiveness at an appropriate scale for management and implementation.

Anthony Erickson (left) and Blake Ruebush after installing a bubble barrier in Quiver Creek near Havana, Illinois. Photo by Michelle Horath, INHS

Blake Ruebush (left) measures and tags a captured fish. Photo by Blake Bushman, INHS

In July 2009, field staff from the IRBS installed a sound-bubble strobe light barrier system in Quiver Creek (a tributary to the Illinois River) in order to test its effectiveness in deterring Asian carps and to investigate associated effects on native fishes. The upstream portion of Quiver Creek above the barrier is blocked by a lowhead dam, which prevents fishes from moving further upstream, making this an ideal location for this type of study. With assistance from Fish Guidance Systems, Ltd. and EIMCO Water Technologies, the sound-bubble strobe light barrier was fully functional by August 26 and operated continually until October 7. During this testing period, 1,240 fish were captured upstream of the barrier, measured, floy-tagged, and released downstream of the sound-bubble strobe light barrier. Fish were collected upstream of the barrier using

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Islands

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terns. Rather than supporting the classic oldest-to-youngest island colonization pattern, *Ptycta* seems to have colonized the islands in the reverse order, from youngest-to-oldest. The Hawaiian *Ptycta* also cluster into two distinct groups in the phylogenies, suggesting either that the genus colonized the islands twice or that a very early divergence occurred among the Hawaiian species (Fig. 3). These initial results have exciting implications for the evolutionary history of Hawaiian bark lice. The youngest-to-oldest pattern of colonization suggests that the diversification of Hawaiian *Ptycta* was extraordinarily rapid, possibly the most rapid rate yet seen in any insects. Ongoing work is aimed at documenting the number of species on the Hawaiian Islands and describing the many new species that were collected. The phylogenies will be refined and used to understand in more detail how the remarkable diversity of these insects on the Hawaiian Islands came to be. Information on the biodiversity of these insects will be used to document areas of endemism for these insects, which will be important for conservation of existing habitat.

Emilie Bess and Kevin Johnson, Illinois Natural History Survey

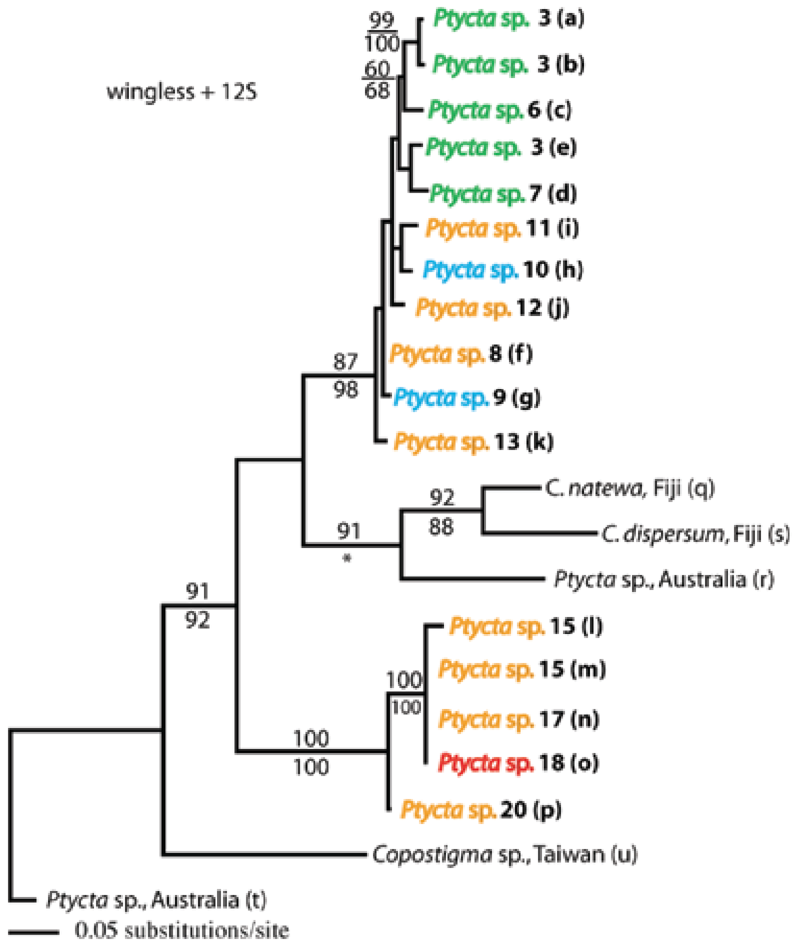

Figure 3. Phylogenies of Hawaiian bark lice of the genus Ptycta.

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Bubble Barrier

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a backpack electrofisher, hoop nets, and by angling. In addition, silver carp were captured from the mainstem Illinois River using a boat electrofisher and were transplanted below the sound-bubble strobe light barrier. In total, 34 fish species were captured and tagged in the first field season of this study.

Preliminary results from the first field season suggest that the barrier technologies are 97% effective at repelling upstream passage of the fish species tested. Barrier effectiveness was determined by upstream recaptures. Of the 141 silver carp that were captured and tagged in this study, none were recaptured upstream of the sound-bubble-strobe light barrier system. Species that did challenge and pass the barrier included bluegill (*Lepomis macrochirus*), common carp (*Cyprinus carpio*), green sunfish (*Lepomis cyanellus*), and largemouth bass (*Micropterus salmoides*). Bluegill were the most commonly recaptured species. This study will continue next spring and into the fall of 2010. Due to high water levels and the possibility of increased damage to the barrier during winter months, it will be removed from Quiver Creek to eliminate this risk. If this system proves to be an effective method of deterring Asian carps after a second field season, it could be used in concert with the CSSC Electric Barriers and in other areas where Asian carps pose a threat. This study was funded by the NOAA National Sea Grant College Program.

Blake C. Ruebush and Greg G. Sass, Illinois Natural History Survey

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Species Spotlight

Brown Recluse Spider

Susan Post

"Just received word the University of Illinois is planning some pest management monitoring here at the Forbes Natural History Building for brown recluse spiders. They will be placing a few monitoring stations here in the building this next couple of business days (and may knock on your door for access)."

E-mail message from Cathy Bialeschki (INHS), Friday November 13, 2009

Cathy's e-mail message piqued my curiosity, especially when a few days later a black rectangular spider trap was placed under my desk. What do these spiders look like? Would they really be in my office? Should I be concerned?

Photos by Michael Jeffords, INHS

The brown recluse spider, *Loxosceles reclusa*, is found throughout the south-central and midwestern United States. These spiders are rare outside of their range and are widely over reported. They may be transported to a non-native area in boxes or furnishings, but infestations seldom become established.

Only one-half inch or less in length, this spider is easily overlooked, especially in dark corners. They may be brown, gray, or deep yellow in color and have long, thin legs that lack conspicuous spines. Their cephalothoraxes (unlike insects, spiders only have two body parts—the cephalothorax and the abdomen) have the eyes, fangs, and legs attached. The dorsal markings resemble violins with the neck of the violin pointing to the rear of the spider. This mark, while less obvious in young spiders, has led to the common names of fiddleback spider, brown fiddler, or violin spider.

The eye pattern of recluse spiders is the definitive diagnostic feature, but most people will need a hand lens to see it! They have six eyes arranged in pairs; most other spiders have eight eyes. Even with this many eyes they have limited vision and rely mainly on touch.

During the day brown recluse spiders usually seek refuge in dim, secluded areas. These refuges are lined with dark, irregular webbing. Outdoors (their natural habitat) the webs may be built under rocks, logs, woodpiles, and debris. Rotting tree bark is a favorite habitat. Yet these spiders have adapted to living indoors with us, hiding in cracks and corners of our homes. Indoors they seem to favor cardboard and are able to persist many months without food and water. Females seldom venture far from their retreat, while males and juveniles tend to wander, ending up in shoes, clothing, or bedding where they may become trapped against someone's skin.

Unlike most web weavers, they leave their webs at night to hunt, seeking insect prey, either dead or alive.

From May through July the female will deposit 40–50 eggs in an off-white, silken sac. These sacs are 2/3 of an inch in diameter. Spiderlings (which resemble tiny versions of a fully grown adult) emerge from the sac in about a month and will molt up to eight times before becoming adults. It takes about a year for the spiders to mature. These spiders have an annual life cycle, but may live up to three years in captivity. A female will produce up to five egg sacs during her lifetime.

Most spiders have poison glands, which they use to paralyze their prey (any creature that happens to wander into their web or near the spider). The brown recluse is one of only four spiders in the United States whose venom poses a danger to humans. The black widow, hobo, and yellow sac spiders are the others.

As the name suggests, the brown recluse is not terribly aggressive. Bites, while rare, usually occur when a person inadvertently trespasses on a spider's turf. Most bites happen in response to body pressure, when a spider is inadvertently trapped against bare skin. These spiders have small fangs and cannot bite through clothing. The spider's venom is cytotoxic, meaning it kills cell tissue. The initial bite is usually painless. Several hours later the bite site may become red and swollen. Most bites remain localized and will heal within three weeks.

So far the spider trap under my desk remains empty. But there is no need for me to worry. These tiny arachnids are more inclined to avoid me, as much as I am them. Whether we encounter each other or not, we seem to have achieved a very natural and peaceful coexistence.

Handy references

A Guide to the Common Spiders of Illinois. Bennet Moulder. 1992. Illinois State Museum Popular Science Series, Vol. X.

A Golden Guide to Spiders and Their Kin. Herbert W. Levi and Lorna R. Levi. 1968. Golden Press.

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The Naturalist's Apprentice

Illinois Spiders

Carolyn Nixon

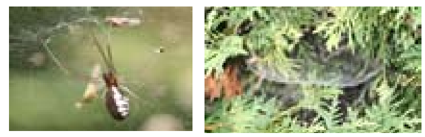
More than 500 species of spiders live in Illinois. While all spiders have venom, most spiders are harmless to humans because their fangs are too small to puncture the skin. Most alleged cases of spider bites are likely insect bites or other small injuries that have become infected by bacteria. Spiders are generally not aggressive towards humans and are actually beneficial predators. They are fascinating creatures to observe, especially once you learn to recognize the different types. Learn to recognize the two dangerous types and then enjoy the rest.

Here are some of the more commonly encountered groups of spiders. When you find a spider, try to determine which group it belongs to.

Orb web made by black and yellow argiope spider (left). Photos by Phil Nixon, UIUC

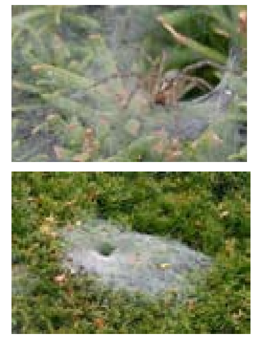
Web building spiders (spider webs are often easiest to view in early morning, when they are covered with dew).

• Orb weavers—these spiders spin very intricately designed webs attached to plants and structures. The webs are usually vertical, with strands of silk radiating out from the center and sticky cross-strands circling the center.



Sheet web with spider (left). Photos by Phil Nixon, UIUC

• Sheet web—these spiders spin small, sheetlike platform webs in plants, such as grass and branches of trees and shrubs. They often go unnoticed until they are covered with dew.



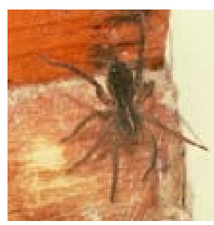
Funnel web with spider (above). Photos by Phil Nixon, UIUC

• Funnel web—these spiders spin sheetlike webs with a funnel-like tunnel at one end.

Cobweb spider (above). Photo by Phil Nixon, UIUC

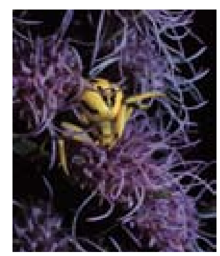
• Cobweb spider—these spiders spin a loose tangle of silk, often most noticeable inside structures such as houses.

Spiders without webs



Wolf spider (left). Photo by Phil Nixon, UIUC

• Wolf spider—these often large, somewhat hairy spiders roam the ground and low foliage as they hunt for prey. Some species are quite large. They can be easily seen at night with a head-lamp. (See "The Naturalist's Apprentice, Shining for Spiders," *INHS Reports,* Autumn, 2007 at http://www.inhs.uiuc.edu/resources/inhsreports/



Crab spider. Photo by Michael Jeffords, INHS

• Crab spider—these crab-shaped spiders sit and wait to ambush prey. They are often camouflaged, matching the color of a flower or leaf. They are often only noticed once the observer sees the prey insect dangling from its fangs.

Jumping spider. Photo by Phil Nixon, UIUC

• Jumping spider—these stocky, short legged, quick moving, hairy spiders are recognizable by their jerky movements. They hunt down their prey and jump onto it. They often have interesting markings and have large, forward-looking eyes.

Fishing spider. Photo by Michael Jeffords, INHS

• Fishing spider—these spiders closely resemble wolf spiders, but are found near, and often on water surfaces. They can dive underwater where they catch small fish or tadpoles.

Venomous spiders

Brown recluse spider. Photo by Michael Jeffords, INHS

• Brown recluses—(*Loxosceles reclusa*) make loose, messy webs, but are often seen away from the web. These are brown spiders with long, thin legs. There are no spots or stripes on the abdomen or legs. Their legs have no spines and are never dark brown. They have a light-colored cephalothorax (the head area) with a distinct, dark brown violin-shaped marking. They are neither hairy nor shiny.

Black widow spider. Photo by Phil Nixon, UIUC

• Black widow—is an orb weaver that is glossy black with a red, hourglass-shaped marking on the underside of the abdomen. Many similar looking spiders have red markings on the top of their abdomens. These are NOT black widows. Two species of black widow occur in Illinois (*Latrodectus mactans*—southern black widow, and *L. various*—northern black widow). The northern black widow is seldom found around human habitation, but the southern black widow was once common in outhouses, where people were often bitten.

"The Naturalist's Apprentice" presents educational activities for middle school students. Teachers are invited to photocopy this page for classroom use.

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Institute of Natural Resource Sustainability
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INHS Reports is edited by Charlie Warwick and printed on recycled and recyclable paper. Design by Otto-Walker Communications.

Mosquitoes

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to determine whether: 1) the invasive mosquito *Ae. japonicus* is the superior larval competitor over native *Ae. triseriatus*; 2) competitive stress at the larval stage and body size alter adult longevity. Competitive treatments showed similar effects of intraspecific and interspecific competition on survivorship to adulthood and a composite index of population performance which estimates the realized per capita rate of population change. Similar results were observed for development times to adulthood for *Ae. triseriatus*. However, *Ae. japonicus* development times for both males and females were significantly reduced when in the presence of *Ae. triseriatus* relative to *Ae. japonicus*, an indication of improved performance. Although development times suggest competitive asymmetry between these two species, other important life history and population level responses suggest that these species may be acting as ecological equivalents as larval competitors and neither species has a competitive superiority over the other species. Additional studies will be necessary to determine whether results from the current laboratory research translate similarly under field conditions.

The second objective was to determine whether competitive stress at the larval stage and adult body size alter mosquito longevity. For both mosquito species, low larval resources were associated with reduced adult female longevity. Similarly, competitively stressed and smaller mosquitoes had reduced longevity relative to larger and less stressed individuals. Similar observations for both species suggest a generalizable effect of resource and competitive stress, which may be applicable to other mosquito species. These observations strongly suggest that larval conditions may continue to adulthood and alter parameters (life span) that determine transmission of vector-borne diseases. This research was supported by the Illinois Waste Tire and Emergency Public Health Funds.

Barry Alto, Illinois Natural History Survey

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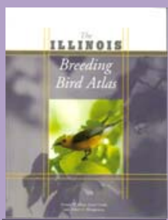

Regular price $26 - Sale price $13:

This publication presents a comprehensive summary of information about birds that currently breed in the state. As the word “atlas” implies, the book includes maps that illustrate the distribution of breeding bird species in Illinois, but it also includes information on their ranges, abundance, habitats, life histories, historical status and recent population trends.

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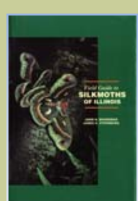

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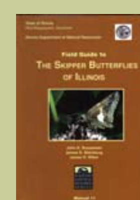

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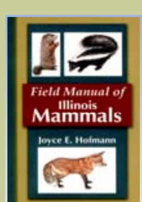

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