The House Mosquito *Culex pipiens*: A Threat in Your Backyard

The house mosquito (*Culex pipiens* Linnaeus) is the most widely distributed mosquito species in the world, and is encountered in all geographic regions except Antarctica. The name “house mosquito” comes from its close association with human settlements. Although *Culex pipiens* breeds in rural areas including marshlands, swamps, temporary ponds, and irrigation schemes, this mosquito thrives particularly well under urban conditions. Gravid females lay their eggs in the form of rafts primarily in polluted (high organic content or eutrophic) water in waste tires, abandoned cans, clogged roof gutters, barrels, birdbaths, or any place that can hold water long enough for eggs to hatch and the aquatic stages to complete development. This allows them to take advantage of habitats many mosquito species avoid. After emergence, adults will frequently enter houses and feed on humans during the night. The advent of air conditioning greatly reduced the presence of many mosquito species in modern homes, but species like *Culex pipiens* still remain near residential areas due to the abundance of urban larval habitats, including catchbasins. This species tends to feed within a couple hours after dusk and before dawn, although environmental conditions can shift the peak feeding until later at night.

*Culex pipiens* is so widespread in North America that it is difficult to believe that this mosquito species was unknown to the Americas in the pre-Columbian era. It was introduced to America from Africa and Europe on ships, probably on several occasions, during the slave trade and European colonization. In a short period of time, these mosquitoes were able to disperse throughout the entire New World.

*Culex pipiens* has been a difficult “nut to crack” for taxonomists and vector biologists. Early studies of the biology of this mosquito often resulted in conflicting conclusions. While some researchers described this mosquito as an annoying fierce man-biter, others viewed it as an insect with little or no interest in humans, describing it as primarily a bird feeder. Differences in feeding behavior and diapause capability of the northern form and southern form of this species led to the recognition of the group as a species complex (sibling species). Despite their ecological and behavioral differences, adult females and immature stages of the *Culex pipiens* complex cannot be reliably distinguished based upon their morphology alone. The only reliable morphological character that discriminates within the group is the DV/D ratio of male genitalia. This is an estimate of the distance between the tip of the dorsal (D) arm and the ventral arm (V) and the distance separating the two dorsal arms (D). (See photo on next page). The DV/D ratio is not useful for identifying adult females (see photo above), which is the only life stage that takes blood meals and thus can transmit diseases.

The northern house mosquito (*Culex pipiens pipiens* L.), and the southern house mosquito (*Culex pipiens quinquefasciatus* Say) are the most common forms of the complex. The northern house mosquito has a DV/D ratio <0.2, the southern house mosquito has a DV/D ratio >0.2.
feeds predominantly on birds, and is found in temperate regions. Inseminated females enter reproductive diapause during the winter. Another form morphologically indistinguishable from *Culex pipiens pippens* was named *Culex pipiens molestus* because it was found to “molest” people. Its distribution overlaps with that of *Culex pipiens pippens*. *Culex pipiens molestus* Forskal breeds all year around in underground structures and is known for the ability to mature its first set of eggs without a bloodmeal. *Culex pipiens quinquefasciatus* (DV/D ratio > 0.4) is the tropical form of the complex. This form does not undergo reproductive diapause and can also breed all year long in tropical areas. In 1957, Ralph Barr showed that in the United States only the northern house mosquito is found above 39˚N latitude. At latitudes below 36˚N, only the southern house mosquito is usually encountered. Hybrid forms (DV/D ratio between 0.2 and 0.4) have been recorded in nature. To date, much of the debate centers on whether the various members of the *Culex pipiens* complex are species or introgressed biological forms. The consequence of our inability to accurately identify these mosquitoes at the species level is a lack of knowledge of the biology and behavior of these vector mosquitoes. Thus, the debates on the taxonomy of *Culex pipiens* complex extend well beyond that of an academic exercise. Beside their nuisance, *Culex pipiens* mosquitoes act as vectors of debilitating diseases such as human lymphatic filariasis, dog heartworm, Rift Valley Fever, Saint Louis and West Nile Encephalides. It is well established that the feeding behavior of arthropod vectors determines their ability to transmit diseases to their hosts. Recent studies have suggested that hybridization within the *Culex pipiens* complex may have caused a shift in host feeding behavior, which contributed to the dissemination of West Nile Virus in North America. Therefore, the epidemiological implications of the complex as an enzootic (bird-to-bird transmission) and a bridge vector of diseases to mammals, including humans, require a means of easily identifying these species.

The medical entomology laboratory at the Illinois Natural History Survey has studied various aspects of the biology of the house mosquito in Illinois for many years, including attraction to various infusions used in traps, spatial and temporal abundance in tires and containers, seasonal population dynamics, and recently arbovirus infection rates. Unfortunately, the literature is full of studies pooling the species within the *Cx. pippens* complex as well as species morphologically similar (*Cx. restuans* and *Cx. salinarius*) during arbovirus surveillance programs. In order to improve our understanding of the role specific species play in the transmission of arboviruses, we developed a novel real-time polymerase chain reaction technique that allows the reliable identification of both male and female *Culex pippens* as well as *Cx. restuans*, *Cx. salinarius*, *Cx. tarsalis*, and *Cx. nigripalpus*. Using this technique, we detected a high frequency of hybrids between the northern and southern house mosquitoes in Champaign-Urbana (40.05˚N), thus demonstrating for the first time a northward expansion of the hybrid zone from the initial 39˚N upper boundary reported by Barr in 1957. This new tool will also help us to determine the species-specific contribution of the sibling species in the transmission of West Nile Virus. The key elements of arbovirus transmission include vector competency (ability to transmit an infective dose of pathogen), feeding rate on different vertebrates (including man), and vector abundance. In the long term, our laboratory seeks to elucidate the complex ecological and genetic factors that determine the ability of mosquitoes to transmit diseases as well as provide an ecological focus for vector abatement and mosquito-borne disease risk assessment.

*Yibayiri O. Sanogo and Richard Lampman, Division of Biodiversity and Ecological Entomology*
The stocking of predatory sport fishes for recreational purposes is a common fisheries management practice that has been utilized for over a century. Despite the frequency of sport fish stocking, little research has focused on the food web and community responses of increasing predator diversity and abundance. This is particularly true in lakes with existing predator populations because the majority of research on predator introductions has focused on effects in previously predator-free systems. Many questions remain regarding the ecological effects of stocking, including the prevalence of cascading trophic interactions, which alter community structure, and the possible effects of stocked fish on existing predator populations and fisheries.

Case studies and available theory dealing with trophic interactions and predator stocking suggest there are many possible effects on aquatic communities that receive stocked fish. Cascading effects such as changes in nutrient cycling, increased top-down control of primary production, changes in habitat coupling, and indirect effects due to behavioral responses of competitors or prey have been reported in the literature. Results of case studies dealing with the prevalence of trophic cascades have produced conflicting results and many theories about the mechanisms limiting these effects across differing freshwater ecosystems. Current theory cites nutrient loading rates, lake depth, and the presence of omnivores, which weaken links in the food web, as the primary factors limiting cascading responses. These hypotheses have not yet been rigorously tested across a range of lake types and this limits our ability to predict the likely effects of predator stocking in specific ecosystems.

Many lakes across the country and in Illinois receive routine stockings of predatory sport fish to supplement natural reproduction or to create new recreational opportunities. For example, many lakes receive supplemental stockings of largemouth bass to augment natural populations and muskellunge introductions to create trophy fishing opportunities. The number of lakes in Illinois stocked with muskellunge has risen from 8 to 34 since 1988, showing the increasing trend of introducing this predator species. By improving our understanding of the effects of stocking these popular sport fish species and their interactions with aquatic communities, we will enhance our ability to make sound management decisions and understand the possible consequences of such introductions. This is particularly important when stocking waters with established fisheries where ecological effects of stocking may cause economic harm to local fish communities.

Methods. We are examining the aquatic communities of multiple lakes in response to supplemental stocking of largemouth bass and muskellunge introductions. Response variables of size structure and abundance of several fish species, zooplankton composition and density, benthic macroinvertebrate density, chlorophyll abundance, total phosphorus, and water clarity are being measured across a series of stocked and control lakes before and after fish stocking to allow comparisons among systems. These lakes have been further divided into two groups based on the planktivorous fish community to examine differences in response between lakes with omnivorous (gizzard shad) and facultative (bluegill) planktivores. Examining the effects of sport fish stocking across lakes of varying depths, planktivore communities, and nutrient status will provide powerful tests of current theory on the prevalence of trophic cascades and community response in freshwater systems.

Preliminary Results. Responses to predator stocking appear to differ across planktivore and predator species. Supplemental stocking of largemouth bass appears to cause partial cascading responses in lakes dominated by bluegill sunfish (a facultative planktivore) but not in lakes dominated by an omnivorous planktivore/de-tritivore—the gizzard shad. In bluegill-dominated lakes these responses include increases in large bodied zooplankton density and a decline in planktivore abundance. Muskellunge introductions thus far have only been examined in gizzard shad-dominated systems and do not appear to influence the abundance of this prolific planktivore. Muskellunge do, however, appear to cause a shift in the size structure of gizzard shad possibly by increasing predation on smaller size classes.

Next Step. We are currently examining the variation in responses to largemouth bass stocking within bluegill-dominated systems to investigate other factors that may be influencing the magnitude of community response in these lakes. In addition, we are compiling data from 6 reservoirs that have received new introductions of muskellunge in the past 10 years to further investigate the possible effects of introducing this new predator type on existing aquatic communities and fisheries.

Corey S. DeBoom and David H. Wahl, Division of Ecology and Conservation Sciences
Soil Impoverishment and Prairie Plant Growth

Illinois, the “Prairie State,” once had approximately 22 million acres of prairie. Today 99.99% of the original prairie has been destroyed as the result of agriculture and urban development. This means that we have less than 2,500 acres of high-quality prairie remaining in Illinois. Most of this prairie can be found in small, isolated remnants in nature preserves, pioneer cemeteries, and along highway and railroad right of ways.

Prairie reconstruction provides a means to increase this habitat in Illinois. Most prairie reconstruction across the Midwest has occurred in former agricultural lands and Illinois is not an exception. Unfortunately these agricultural lands are very high in nitrogen, which encourages weed growth. The combination of high levels of nitrogen and weeds has hindered prairie reconstruction since the weeds can out-compete the prairie plants. Part of the reason is that prairie plants evolved in soil where available soil nitrogen was limited. However, one particular technique known as soil impoverishment could be the answer to this problem.

Soil impoverishment is the use of organic matter (i.e., carbon), such as sugar or sawdust in the soil, to immobilize plant-available nitrogen. The organic matter stimulates soil microbe activity and the soil microbes accumulate soil nitrogen in their biomass, making it unavailable to plants. Several studies have demonstrated that carbon soil amendments can reduce soil nitrogen levels during initial plant succession and reduce the number and biomass of weedy species.

Even though carbon soil amendments have been shown to be beneficial in reducing weeds, few studies have been conducted to determine if the reduction of nitrogen in the soil will have an effect on the growth (e.g., plant height, biomass) and reproduction (e.g., fruit and seed set) of prairie plants. For this reason we conducted a study to determine how five carbon soil amendments (i.e., sawdust and sugar, straw, soybean hulls, leaf mold, and brewery waste products) affect: 1) the growth and reproductive potential of a prairie plant species; 2) the nitrogen (nitrates and ammonia) levels in the soil; and 3) the establishment of native and non-native plant species.

We conducted this study at the Midewin National Tallgrass Prairie (MNTP, Will County, Illinois). The MNTP is one of the largest prairie reconstruction projects east of the Mississippi River and the bulk of the reconstructions at this site will be in former agricultural lands. Also, we decided to use *Rudbeckia hirta* L (black-eyed Susan, Asteraceae) as our focal prairie species because it is a common prairie plant and can be purchased at local nurseries. To conduct this study, 60 plots, half with *R. hirta* and half without, were assigned randomly to one of the five soil amendment treatments (i.e., sawdust and sugar, straw, soybean hulls, leaf mold, and brewery waste products) and a control (i.e., no soil amendment). Soil samples were collected before and after the soil amendment treatments were established to determine the levels of nitrogen in the soil. In addition, species richness and vegetation cover were determined for each plot. In the case of *Rudbeckia hirta* information on plant height, number of flower heads, and aboveground biomass was collected. Our preliminary results show that the sawdust and sugar soil amendment is reducing *Rudbeckia hirta* growth, vegetation cover, and nitrogen levels. Additional data analyses are needed to have a better picture of how each carbon soil amendment treatment compares to the others. These preliminary results suggest that adding organic matter in the soil could facilitate the reduction of the emergence of nitrogen-loving (i.e., nitrophilic) weeds in a former agricultural field, but it may also have a short-term negative impact on the growth of prairie plants.

*Study plots at the Midewin National Tallgrass Prairie, before and after the five carbon soil amendments were added.* Photos courtesy of H.J. Mlynarski, University of Illinois

*Brenda Molano-Flores, Division of Biodiversity and Ecological Entomology and Helen J. Mlynarski, University of Illinois*
Vegetation Structure and Composition of Arabuko-Sokoke Forest, Kenya

Arabuko-Sokoke Forest, a beautiful remnant of a once extensive coastal forest along Kenya’s east coast, is a tremendous repository of biological diversity. At just under 42,000 ha (103,740 acres), this forested tract contains 50 species of globally or nationally rare plant species, at least four endemic butterfly species, three globally threatened mammal species, and six globally threatened bird species, as well as many reptile and invertebrate species. Notable animals include the golden-rumped elephant shrew and Ader’s duiker; Clark’s Weaver and Amani Sunbird; Bunty’s dwarf toad and ornate tree frog.

The heart of the forest is Brachystegia woodland, growing on a band of white, infertile sand running through the interior of the forest. The Brachystegia forest type is rare and of high conservation priority. We investigated the composition and structure of disturbed and relatively undisturbed patches of Brachystegia woodland within the Arabuko-Sokoke Forest. The differences in disturbance level come from past legal and currently illegal logging activities.

Brachystegia spiciformis, the canopy dominant, is a graceful, fascinating tree. At Arabuko-Sokoke Forest, it attains a great height and breadth. The trunk generally begins branching close to the ground, and the multiple, curving trunks spread widely with increased height, often attaining heights and spreads of 24 m (79 feet) or more. This leguminous tree has small, pinnately compound leaves that intercept little light. The regularly spaced trees thus allow a patchy, but well-developed understory of shrubs, saplings, forbs, and grasses.

In 2003, we had the opportunity to conduct a quantitative investigation of the Arabuko-Sokoke Forest, allowing us to compare processes known to affect forest regeneration in Illinois with this unique and rare forest type in eastern Africa. We were interested in how past disturbances, like logging and fuelwood removal, affected the forest. Logging in the disturbed forest presumably removes large trees. Thus we expected mean diameter-at-breast height (dbh) to be higher in the undisturbed forest. Furthermore, species experiencing successful regeneration in the disturbed forest should have size distributions more skewed towards saplings and smaller trees than the same species within the undisturbed forest. Unsuccessfully regenerating species should either be unusually rare or lack smaller size classes of trees.

We found seven relatively abundant tree species in the undisturbed habitat, but only six of these in the disturbed habitat. Overall, tree species diversity was greater in the undisturbed than the disturbed habitats. The importance value, a composite index that combines the relative density, frequency of occurrence, and dominance of each species, was greater for Brachystegia spiciformis in the disturbed habitat than the undisturbed habitat and disturbed habitat. In the undisturbed habitat, adults were more abundant than juveniles, but in the disturbed habitat, juveniles exceeded adults. This suggests a mature canopy of trees in the intact forest with suppressed seedling establishment and/or sapling survivorship. B. spiciformis may depend upon light gaps for regeneration. Support for this perspective comes from the disturbed forest, where the past removal of canopy trees may be leading to many small and possibly recruiting B. spiciformis. The few yet extremely large B. spiciformis that we found in the disturbed habitat may have achieved unusual size through the removal of canopy competitors.

The Brachystegia portion of Arabuko-Sokoke Forest, though small in area, represents an important example of what may be a northern variant of Miombo woodland. Past selective logging has left an indelible signature through the removal of rarer species, leaving the forest unusually dominated by B. spiciformis. The disturbed site bears this out through its preponderance of unusually large (spared trees) and unusually small B. spiciformis (regeneration) relative to the undisturbed forest. Four tree species exhibit reduced abundance in the disturbed, but two of them are recovering there. J. magnistipulata has been completely depleted from the disturbed habitat, but remains abundant in the undisturbed habitat. Thus active management and restoration may be desirable for this species. For the remaining common tree species, active management may not be necessary. Continued protection promises to maintain this remnant forest, thus assuring its importance as one of the biological treasures of Africa’s east coast.

Joseph O. Oyugi, Wright College; Christopher J. Whelan, Division of Biodiversity and Ecological Entomology; Joel S. Brown, University of Illinois at Chicago
If I owned a paint store one of the colors I would offer would be prothonotary yellow. It is the color of the male Prothonotary Warbler’s head. It is the same color as the first dandelions of spring—orange-yellow centers that grade to bright yellow. This color lets you know there is spring and brightens the wet woods where the warbler occurs. One ornithologist eloquently described the bird as “an animate mote of golden sunlight moving through dark swamps.”

The Prothonotary Warbler, Protonotaria citrea, breeds across much of the eastern United States. From April to August in Illinois it is commonly found in the swamps of southern Illinois. By late September the warblers have migrated to the mangrove forests of Central and South America.

Prothonotary Warblers are heavy-bodied and short-tailed. They are approximately 14 cm (5.5 inches) long and weigh 15 g (about half an ounce). The male’s head, neck, and body are a rich saffron or orange-yellow, while females are bright yellow with no orange hues. Their black bills and eyes stand out against the plain yellowish heads. Bluish wings and tails complete the picture. Just as the cardinal gets its name from the red worn by Roman Catholic cardinals, the Prothonotary Warbler gets its name from the eighteenth century Louisiana Creoles who thought the bird’s plumage resembled the golden robes of the protonotarius (papal clerk), a Catholic Church official who advised the Pope. Its nickname is the golden swamp warbler, for its affinity for swamps and bottomland forests.

Prothonotary Warblers are found in deciduous swamps, backwater sloughs, wet woodlands without a dense understory, and along slowly moving rivers and streams. This attraction to water may be due to a higher number of decaying trees with nest cavities in flooded areas and the added benefit of lower predation by mammals when the nest site is located over water.

These birds are one of two warbler species that nest in cavities, and the availability of suitable nesting cavities is one of the most critical habitat requirements for them. While abandoned Downy Woodpecker holes are common nest sites, a variety of natural cavities are used, and the birds will readily use nest boxes, preferring those with a smaller internal volume than Bluebird boxes. Since 1994, hundreds of milk cartons have been used in a southern Illinois warbler study by the Illinois Natural History Survey.

Males establish territories around one or more suitable nest sites and place moss inside the cavities before the female arrives. The males display at each cavity and the female selects from among those available. The nest site is almost always over or within 5 m (16.4 feet) of standing water or in a low-lying easily flooded area. While the male initially places moss in potential nest sites, once a site is chosen the female constructs the remainder of the nest. Prothonotary Warblers are one of the few cavity-nesting species that use large amounts of moss in their nesting. The nests are a combination of moss, grass, sedges, and even fishing line.

After finishing the nest, the female lays 4–6 brown-spotted eggs which hatch after 12–14 days of incubation by the female. Primary predators of eggs and nestlings are rat snakes and raccoons. Ten days after hatching the young leave the nest (fledge), but the parents will continue to feed the birds for up to 35 days. While the nest’s proximity to water might deter predators, if the water rises and floods the nest, the hatchlings will drown. However, fledging birds can swim.

The warbler forages by hopping on branches, stumps, trees, and the ground, looking for a variety of insects and small mollusks. Caterpillars, flies, midges, spiders, and mayflies make up the bulk of their diet during breeding season.

To chase away the winter grays, head to the swamps of southern Illinois (Heron Pond or LaRue Pine Hills) during April and May for a glimpse of this feathered sunshine.

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Many animals, including insects, birds, and mammals, will use homes constructed for them by humans. If nesting places for these species are limited, people can construct artificial nest boxes or platforms. If these are close enough in design to the real thing, the animal may accept it. Conservationists construct nest boxes to help increase reproduction by a species. Many people put nest boxes up around their homes because they like to attract animals. If the animals are beneficial to humans, such as bees who pollinate flowers or Purple Martins who consume large numbers of insects, people construct homes to gain benefits from them. See if you can match the animal on the left with at least one home on the right. Some types of homes can be used by more than one type of animal, and some of the animals may use more than one type of home. Write the letter of matching animals on the blank lines under each image of an animal home.

- Honeybees, native to Europe, are kept in man-made hives constructed of stacked wooden boxes or in woven straw or wicker domes called skeps. 
- Leaf cutter bees and orchard mason bees lay their eggs in holes in logs. They will nest in logs or blocks of wood with holes drilled in them.
- Purple Martins nest in colonies of multiple compartment nest boxes or hanging gourds on top of a tall pole.
- Bats will roost in wooden boxes that are open at the bottom and mounted high on a building. They will enter through the bottom and cling to the inside walls of the box.
- Bluebirds will readily build their nests in wooden nest boxes that are placed on poles in open fields. A box with a steeply sloping top is less susceptible to predation by house cats.
- House Wrens will build their nests in any kind of nest box, either on a post or hanging from a chain. Smaller hanging boxes with small entrance holes are often provided for them as most other species will not use them.
- Wood ducks will nest in large wooden nest boxes placed near the water. Wood duck nest boxes have an oval hole, wider than tall.
- Toads will rest in toad houses that are often similar to an upside-down flower pot with an entrance hole near the ground.
- Robins will build their nests on wooden shelves.
- White-footed mice will build their nests in wooden nest boxes that are meant for small birds.
- Ospreys will build their nests on platforms on tall poles, usually placed over the water.

**Image Credits**
- Philip Nixon: honey bee, leaf cutter bee
- USDA photo: mason bee
- Michael Jeffords: toad, American Robin, white-footed mouse, Osprey
- Rhetta Jack: bat
- PGC Photo/Joe Kosack: House Wren, Eastern Bluebird
- Dover Clipart: Purple Martin, Wood Duck
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