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Evaluating the Effectiveness of an Electric Dispersal Barrier

The most recent invasive species threatening Illinois' aquatic ecosystems are the bighead and silver carps, two of four species commonly called Asian carps. These fish grow quickly to more than 50 lbs by consuming 30–50% of their body weight each day in small algae and other tiny organisms. They also reproduce quickly and migrate long distances to spawn. Currently, in the Mississippi and Illinois rivers, these Asian carp are spreading rapidly upriver toward the Chicago Sanitary and Ship Canal (CSSC) where they could enter Lake Michigan and affect the entire Great Lakes basin. Because of the immediate danger of Asian carps crossing into the Great Lakes basin through the CSSC and the more general and persistent threat of invasive fishes passing this artificial connection between the Great Lakes and Mississippi River drainages, an electric barrier to fish movement was constructed in the CSSC near Romeoville, approximately 28 miles downstream from Chicago Harbor. Currently, Asian carp have been found about 22 miles downstream of the dispersal barrier location in Romeoville.

This barrier creates a graded electric field that should repel fish as they sense the field, creat-

ing a nonlethal barrier. Because optimal barrier performance depends on current velocity, temperature, conductivity, etc., we are evaluating the performance of this dispersal barrier. One evaluation technique is a series of experiments being conducted under

liminary results suggest that big-head carp are very sensitive to the electric fields created by the electric barrier, making this barrier a promising technology for preventing further range expansion of this species. The integrated sound-bubble barrier and



Researchers track fish at electric dispersal barrier on the Illinois River. Photo by Dr. Scudder Mackey, Great Lakes Protection Fund

controlled conditions that evaluate a scale model barrier emulating the Romeoville barrier. We also are testing combined barrier technologies that focus on the efficacy of an integrated sound-bubble barrier and both technologies combined (electric and sound-bubble) in hatchery raceways at the Illinois Department of Natural Resources' Jake Wolf Memorial Hatchery. Our pre-

the combined technology barrier have also given good results by preventing over 90% of fish from moving through each barrier type. We continue to evaluate and modify these barriers to increase their effectiveness with the goal of stopping all attempts to move through each barrier type. Additionally, the com-

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Egg-powdering in Leafhoppers

Leafhoppers, one of the most diverse and abundant groups of plant-sucking insects, use plants not only as a food source but also as a repository for their developing eggs. Like their relatives the cicadas, leafhopper females use their swordlike ovipositors to cut the plant skin and inject the eggs underneath. Having done so, the female usually departs to feed and lay new eggs elsewhere, leaving behind nothing noticeable but a scar on the plant surface. A study, in which I collaborate with Daniela Takiya and Chris Dietrich, focuses on a significantly more complicated maternal behavior displayed by certain New World species from the xylem-feeding leafhopper lineage known as “sharpshooters.” Our research fills a gap in the knowledge of leafhopper biology and provides data that can be used in the biological control of pest species, such as the invasive glassy-winged sharpshooter in California. From a broader perspective, by reconstructing the evolution of the unique behavioral, physiological, and structural specializations related to egg-laying in sharpshooters we are seeking to better understand how complex biological innovations evolve.



Figure 1. A female *Oncometopia orbona* (F.), the largest and one of the most conspicuous leafhopper species in the eastern and central U.S., scrapes brochosomes from the white spots on its forewings to the lower surface of a compass plant leaf, under which it has inserted several eggs. Photo by Roman Rakitov, INHS Center for Biodiversity

This is how it works. All leafhoppers share a peculiar physiological trait—parts of their excretory system are modified as glands that produce myriads of tiny protein-lipid particles called brochosomes. After hatching and after each shedding of the old skin, leafhoppers use their legs to spread droplets of the brochosome suspension over the new epidermis. The layer of dry particles, hardly visible without a microscope, is water-repellent and protects leafhoppers from getting trapped in their copious liquid excrement, a filtered plant sap. Our study has found that approximately 200 species of sharpshooters also use brochosomes to powder their egg nests. When females of such species become gravid, their glands switch over to production of structurally modified brochosomes. When ready to lay eggs, the female places droplets containing these particles onto special areas of her forewings, covered with short hairs facilitating attachment of the material. Here brochosomes dry as a pair of conspicuous white masses (Fig. 1). Next, the leafhopper starts laying eggs, inserting them under the lower epidermis of a leaf, and scraping the brochosomes off the wings onto the plant with brushing strokes of its hind legs. A closer examination of the rows of spines on the female’s legs reveals that, in most such species, the spines that actually do the job of transferring brochosomes are elongate and curved, like the tines of a leaf rake. In males of these species and in both sexes of other leafhoppers, the legs bear only rows of short and straight spines, resembling the teeth of a garden rake. The completed egg nest, which can contain up to 30 eggs, is buried under a spot of white powder (Fig. 2). The function of this coat is not yet well understood. Experiments currently conducted by Walker Jones (USDA) in Texas indicate that it slows down the work of egg parasitoids—tiny wasps which inoculate leafhopper eggs with their own progeny—by making them waste additional time cleaning their body from adhering brochosomes. Other possible functions include protection of the



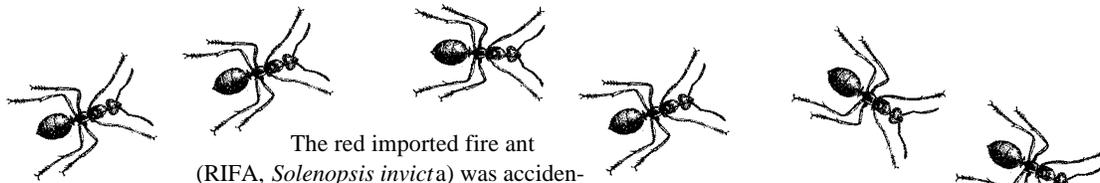
Figure 2. The completed leafhopper egg nest is coated with the white brochosome powder. Photo by Roman Rakitov, INHS Center for Biodiversity

wounded leaf from pathogens and facilitating respiration of the eggs.

By screening leafhopper collections of the world for presence of female sharpshooter specimens with brochosome masses on the wings (Fig. 3), we found that the powdering behavior, first described in 1936 and until recently reported in only a few species, is characteristic of 15 genera, of which the majority is confined to tropics of Central and South America and only three extend onto the territory of the U.S. Our analysis, in which we used DNA sequences to reconstruct the genealogical tree of sharpshooters, showed that these genera form a single branch, suggesting that powdering of eggs with brochosomes has been invented by their common ancestor. But how? We think that powdering is derived from the behavior known as grooming or preening, in which insects use their legs to brush contaminants off their bodies. If females of ancestral leafhoppers preened after the hard work of egg laying, brochosomes from the body could have accidentally gotten onto their fresh egg nest and, if such small amounts of ordinary brochosomes could confer even a minuscule increase to egg survival, natural selection might further amplify the efficiency of the process, leading to the evolution of the physiological and structural modifications and sophisticated powdering rituals we observe today. This hypothesis still needs to be supported by observations of the closest relatives of the “powdering” leafhoppers,

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Impact of Red Imported Fire Ants on the Black-capped Vireo, an Endangered Species



The red imported fire ant (RIFA, *Solenopsis invicta*) was accidentally introduced into the U.S. from South

America in the 1930s. This exotic species is established in the southern U.S., from Texas and Oklahoma to Florida and North Carolina, and its range is still expanding. Red imported fire ants are effective predators of many taxa, and they pose a serious threat to both terrestrial and aquatic communities. For example, some studies have shown that RIFA affect arthropod diversity and abundance. This finding, in turn, has led others to suggest that RIFA may negatively affect native bird species indirectly via competition for insect prey. More recently, laboratory studies suggest that RIFA may alter the behavior and decrease the survivorship and body mass of the Northern Bobwhite (*Colinus virginianus*). However, how RIFA affect wild birds is still controversial. Understanding how RIFA impact natural avian populations is essential for effective management. Here, we describe our research on the impact of RIFA on the reproductive ecology of a federally endangered bird species, the Black-capped Vireo (*Vireo atricapillus*).

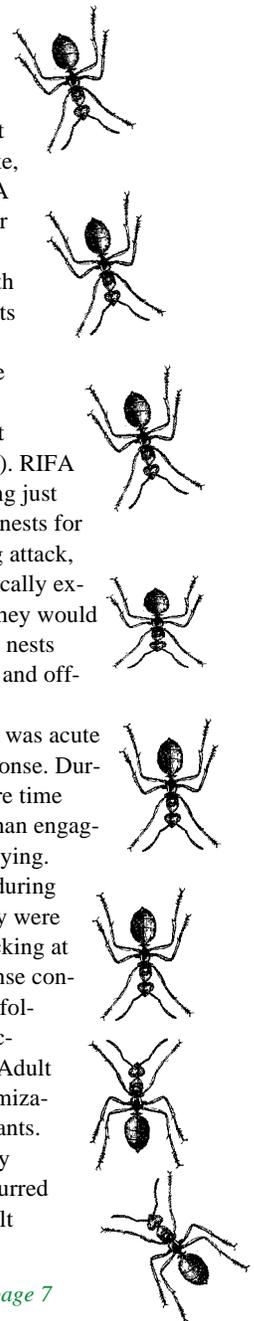
The Black-capped Vireo is a small, largely insectivorous bird that inhabits dense thickets of oak scrub habitat. Although it nests predominantly in oaks, many other plant species are also used. The bird's open cup nest is suspended from a forked branch 0.4–1.3 m above the ground. The species has been extirpated from most of its historic range, and breeding populations in the U.S. are now restricted to Oklahoma and Texas. Brood parasitism by the Brown-headed Cowbird (*Molothrus ater*), which lays its eggs in the nests of other bird species, coupled with habitat loss, caused the endangerment of the vireo. Recently the red imported fire ant has colonized the part of Texas that includes the 88,890-ha army base, Fort Hood, which currently contains the largest breeding population of the Black-capped Vireo. In an investigation of the reproductive ecology of the species, from 1998 to 2001, 139 vireo nests were monitored with infrared video cameras. We analyzed that video footage to determine the influence of predation, particularly that by red imported fire ants, on vireo behavior and nesting success.

Predation accounted for over two-thirds of nest failures in the study. RIFA was the leading predator, accounting for 38% of predation. The Texas rat snake (*Elaphe obsoleta lindheimeri*) was the second leading predator, causing 36% of nest failures. Birds (primarily the West-

ern Scrub Jay) and mammals (including raccoons and ringtails) accounted for the remaining predation. Two nests were visited by a second predator during RIFA activity. In the presence of RIFA, an eastern woodrat (*Neotoma floridana*) nicked one of the eggs but failed to depredate the clutch. A Texas rat snake, however, consumed all three nestlings while RIFA swarmed the nest. RIFA were present for four hours prior to snake predation and 15 minutes before the woodrat approached the nest. In both cases, adult vireos were actively defending nests against the RIFA attack. It is possible that the increased activity during this defense may have alerted secondary predators to the nest.

RIFA activity was independent of vireo nest height and substrate type (tree or shrub species). RIFA attacked vireo nests at night, typically beginning just after midnight. On average, RIFA remained at nests for at least 23 hours after the initial attack. During attack, adult vireos engaged in prolonged and energetically expensive defense against RIFA at a time when they would otherwise be sleeping. Ultimately, all attacked nests were abandoned, causing mortality of the eggs and offspring.

The initial response of adult vireos to RIFA was acute and had the appearance of a flight or fight response. During nest defense, vireos spent significantly more time pecking at and removing RIFA from the nest than engaging in brooding, alert perching, hopping, and flying. Adult vireos expended 2.4 times more energy during nest defense than would be expected while they were sleeping. Vireos expended the most energy pecking at ants and flying to and from the nest. Nest defense continued for hours through the night and into the following morning. No such prolonged defense occurred in the presence of vertebrate predators. Adult vireos likely received bites and stings (envenomization) while defending the nest from swarming ants. Such bites cause painful pustules and secondary infection for humans. Similar costs may be incurred by vireos. Despite their energetic defense, adult vireos never prevented nest failure when RIFA



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“Eat and Run:” Soybean Herbivory Influences Western Corn Rootworm Behavior and Egg-laying

The western corn rootworm, (WCR), *Diabrotica virgifera virgifera*, is a serious insect pest of corn. Before the mid-1990s, WCR adults displayed strong fidelity to cornfields as both feeding and egg-laying sites. This egg-laying fidelity and the re-

quired that larval WCR feed on corn roots during their development has long been exploited by pest managers through the practice of crop rotation. By annually alternating production of corn with a crop like soybean that does not support larval development, the WCR lifecycle can be interrupted.

applied at planting to protect corn roots from larval feeding injury. Over the years, enthusiastic adoption of crop rotation as a less costly (soil insecticides cost ca. \$15.00–17.00 per acre) and more environmentally benign alternative to insecticide, exerted a strong selection favoring female WCR with less fidelity to cornfields. Under a strict rotational scheme, only females that lay eggs in the rotated (noncorn) crop would have surviving offspring. By 1995, a “crop rotation-resistant” WCR population that circumvented rotation by laying eggs in rotated soybean fields caused devastating root injury to rotated corn in nine

Studying the effects of soybean herbivory on movement and egg-laying may help us understand the mechanisms of rotation resistance.

We studied the effects of mixed diets on WCR biology by providing beetles with corn and soybean diet on alternate days. One consequence of soybean herbivory was an increase in WCR activity; beetles are more likely to move or fly after feeding on soybean foliage than after eating corn tissue. Increased activity is a common insect response to nutritional stress. We also observed that beetles were more likely to lay eggs during days when they were exposed to soybean foliage than on days when corn was available. When the stress responses of rotation-susceptible and resistant beetles were compared, we learned that beetles from resistant populations were less responsive to the stresses associated with alternating diets and nutritional uncertainty than the rotation-susceptible insects.

We hypothesize that when an egg-laden female WCR from corn enters a soybean field, she experiences a stressful environment that can stimulate her to lay eggs. Greater sensitivity to soybean field stress among the rotation-susceptible population may rapidly drive them back into cornfields before accumulating stress can stimulate the problematic egg-laying in soybean fields that occurs in the resistant population. Continued observation, monitoring, and comparison of rotation-susceptible and resistant populations will improve our understanding of mechanisms at the “root” of WCR resistance to crop rotation.

Joseph L. Spencer and Eli Levine, Center for Economic Ecology; Timothy R. Mabry and Scott A. Isard, University of Illinois



Western corn rootworm beetles feeding on soybean foliage. Photo by Joseph Spencer, INHS Center for Economic Entomology



Tim Mabry, UIUC student in crop sciences, uses suction device to capture WCR in lab. Photo by Joseph Spencer, INHS Center for Economic Entomology

By not planting corn in the same field in successive years, excellent WCR control can be achieved. If corn is grown year after year on the same ground, soil insecticides can be

east-central Illinois counties. Since 1995, the region affected by the rotation-resistant WCR has expanded to more than 30 east-central and northern Illinois counties as well as the northern two-thirds of Indiana and parts of Ohio and southern Michigan.

Unlike rotation-susceptible WCR (found in western Illinois), beetles from the rotation-resistant population are common daily visitors to soybean fields where their consumption of soybean foliage can be conspicuous. Despite being a poor food (an exclusive soybean foliage diet is equivalent to starvation and kills most WCR in 4–5 days), over half of the beetles in soybean fields have soybean foliage in their gut contents. Beetles avoid the negative consequences of soybean herbivory by moving between corn and soybean fields and eating a mixed diet of corn and soybean tissue. The shared ability of beetles from either population to recover from brief exposure to poor nutrition by feeding in cornfields likely helps to insulate the adventurous egg-laying individuals from potentially fatal food choices.

Understanding the Public in Natural Resource Management

The Human Dimensions Research Program in the Center for Wildlife Ecology of the Illinois Natural History Survey conducts research on public attitudes related to natural resource policy and management. In 2003, we have conducted nine separate research projects, ranging from surveys of deer hunters and waterfowl hunters for the Illinois Department of Natural Resources to a study of public perceptions of water quality in Illinois for a private foundation. The following are summaries of two recent projects.

Perceptions of Chronic Wasting Disease Among Illinois Deer Hunters

A study of 2,683 (79% response) Illinois deer hunters' attitudes toward and understanding of Chronic Wasting Disease (CWD) in white-tailed deer in Illinois was conducted during spring 2003. Most hunters (96%) were aware of CWD, but fewer could state they were aware of CWD in a particular state, including Illinois (77%). Higher risk ratings were given to West Nile Disease (7%), Lyme's Disease (5%), or having a heart attack while hunting (5%) than CWD (3%). Hunters did perceive CWD to be a threat to the Illinois deer herd (33% were "very concerned"). Most hunters (63%) did not foresee any change in their hunting participation for the 2003 firearm season due to CWD, 15% thought they would hunt a CWD-free county. A majority of hunters (54%) expressed a degree of uncertainty as to the potential risk of CWD to humans, and 185 felt it could be contracted by eating meat from infected animals. Hunters expressed potential changes in behavior with increased infection rates of CWD in deer in the county where they hunted. Based on the responses to this study, approximately 5% of hunters can be expected to drop out of deer hunting if CWD is found in the county next to or in the county where they hunt.

Attitudes of East-central Illinois Residents Toward Tallgrass Prairie Restoration at Allerton Park

Homeowners in Champaign and Piatt counties feel prairies are a part of Illinois' heritage and support creating prairies on state-owned lands. Results of a recent mail survey of residents

in Champaign and Piatt counties show support for the pending sale of 1,300 acres of University of Illinois land at Allerton Park to the Illinois Department of Natural Resources (IDNR). The land in question will be restored to prairie by the IDNR if the land sale is completed.

When asked if they supported the land sale, almost half of all respondents (47%) supported the move, 27% were opposed, and 26% were undecided. Breakdown by counties showed 55% of Champaign County residents supported the sale, whereas 16% were opposed. In Piatt County 32% of residents supported the sale and 46% were opposed. Reasons for opposing the sale cited most often included: land should remain in agriculture (24%), displacement of tenant farmers (18%), and loss of taxes to area (14%).

Most respondents (65%) felt that preserving prairies provides future generations with a natural heritage. When asked if purchasing land for recreation and wildlife was a sound investment, 71% of respondents agreed and 13% disagreed. A majority of people (57%) felt that natural areas increase property values, whereas 18% disagreed. Residents were somewhat split on the statement that a sound

economy is more important than protecting wildlife: 45% agreed and 39% disagreed. When asked if they would visit the site if it was completed as planned, a majority of residents in both counties (74% in Champaign and 56% in Piatt) stated they would visit the site.

Most residents surveyed (82%) stated they supported the creation of natural areas and wildlife habitat on state-owned land in east-central Illinois, and a majority (80%) supported restoring prairies on state lands in the area.

When asked questions about landowners' ability to use their land, most residents (59%) supported a landowner's decisions to sell their land to IDNR, whereas 22% said they wouldn't care either way, and 18% objected to the idea. Most people (79%) felt that landowners should have more control over how their land is used, and most (70%) also believed a landowner had the right to use their land as they see fit.

Craig Miller, Center for Wildlife Ecology

Most residents surveyed (82%) stated they supported the creation of natural areas and wildlife habitat on state-owned land in east-central Illinois, and a majority (80%) supported restoring prairies on state lands in the area.

Announcing New INHS Publications

INHS Special Publication 24—*The Chewing Lice: World Checklist and Biological Overview*

By

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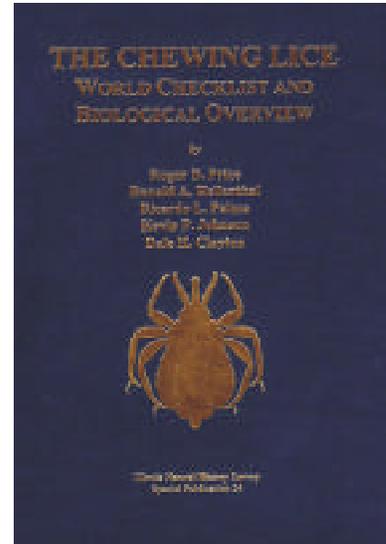
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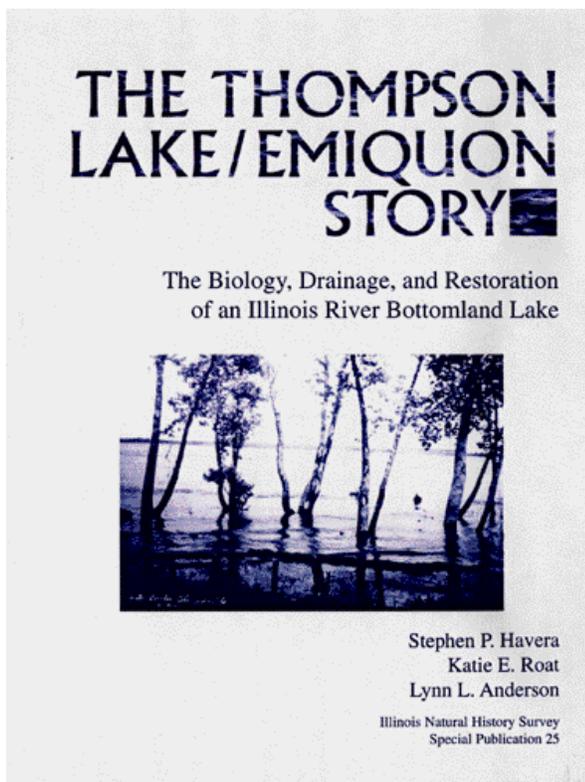
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By

Stephen P. Havera, Katie E. Roat, and
Lynn L. Anderson

Dimensions: 8.5 x 11 inches
iv + 40 pages, paperback
US ISSN—0888-9546

Cost: This publication is free of charge for those who pick it up at the Illinois Natural History Survey in Champaign, IL or the Forbes Biological Station in Havana, IL. Those who have it mailed will be charged first class postage (about \$1.50).

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Egg Powdering

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which may have retained the ancestral preening behaviors of females. Observing behaviors of these hard-to-collect tropical insects will be a challenge.

Another challenge is to explain why, if the selection worked to maximize the efficiency of powdering, there are among “powdering” species some with specialized brochosomes and wings but with ordinary legs, some with specialized legs and brochosomes but ordinary wings, some with specialized legs and wings but ordinary brochosomes, and finally some with only specialized brochosomes. One possibility is that modifications to these structures evolved independently and somewhat

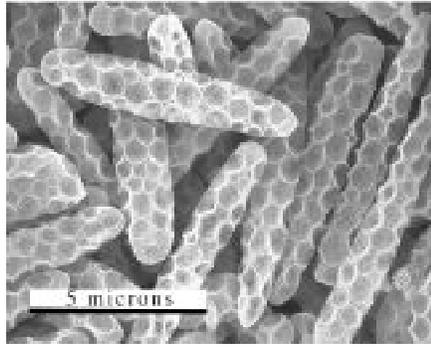


Figure 3. A scanning electron micrograph (SEM) of brochosomes. SEM courtesy of Roman Rakitov, INHS Center for Biodiversity

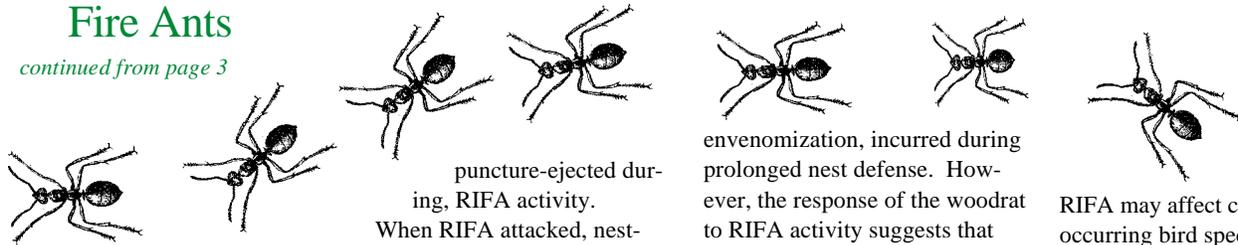
differently in different related lineages. Our results suggest an alternative scenario: multiple secondary losses of individual specializations (such as reversal to the ordinary leg structure) or the powdering behavior as a whole. For example,

within the North American grassland genus *Cuerna*, powdering has been lost independently no less than four times. The species that have lost the behavior can display vestigial elongation of the female leg spines or even vestigial powdering strokes during egg-laying but never produce specialized brochosomes nor place anything onto their wings. If powdering is an ingenious protective strategy, why does it get lost? Recent studies which traced evolution of various traits in different organisms indicate that losses are more common than was previously thought. The puzzling diversity of egg-laying specializations in sharpshooters can be used as a model to study the loss of a biological function in three dimensions: structure, physiology, and behavior.

R.A. Rakitov, Center for Biodiversity

Fire Ants

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swarmed nests. All nests with RIFA activity at either the egg (33%) or nestling (67%) stage of the nest cycle failed to fledge vireos. Adult vireos abandoned all nests with RIFA activity and all clutches subsequently failed to hatch, except for one. In this case, the eggs hatched while RIFA were still at the nest and RIFA depredated the hatchlings minutes after hatching. Eggs were incubated significantly less often while RIFA were at a nest than prior to attack. At one nest, an adult vireo grasp-ejected two cracked eggs out of her nest following nine hours of defense. We were unable to determine whether she punctured the eggs to eject them from the nest or did so inadvertently while pecking at ants. Regardless, eggs were in good condition prior to, and

puncture-ejected during, RIFA activity.

When RIFA attacked, nestlings responded by moving erratically in apparent distress within the nest until dead (motionless). The time for nestlings to die increased significantly with nestling age. Time until nestling mortality ranged from eight minutes (one-day-old nestling) to three and a half hours (nine-day-old nestling). At one nest, two of three nestlings were motionless (assumed dead) in response to RIFA, while the third ejected itself out of the nest. Vireos are known to fledge prematurely in response to predators.

These findings suggest that RIFA negatively impact Black-capped Vireos directly, via nest abandonment and mortality of eggs and nestlings. In addition, nest defense by adults leads to an acute and large increase in energy expenditure, coupled with

envenomization, incurred during prolonged nest defense. However, the response of the woodrat to RIFA activity suggests that RIFA may also indirectly benefit Black-capped Vireos. RIFA appeared to deter this small mammalian predator. Other studies indicate that RIFA shift foraging patterns and induce trap mortality of small mammals. Positive indirect effects of RIFA on Black-capped Vireos could arise via reductions in the population size of other predators (e.g., *Rattus* and other vertebrate predators). Positive indirect effects could also arise through changes in a predator's or a competitor's habitat selection and foraging ecology. While it seems unlikely that such positive indirect effects could outweigh the direct negative effects, these positive effects warrant investigation.

Our study found strong negative impacts of RIFA on the Black-capped Vireo. This in turn raises the possibility that

RIFA may affect co-occurring bird species similarly. With the predicted global range expansion of RIFA, management must be employed to deter the spread and future success of this invader.

Steven J. Taylor and Christopher J. Whelan, Center for Biodiversity; Jennifer E. Smith, Michigan State University; Michael L. Denight, Engineer Research and Development Center, U.S. Army Corps of Engineers, Champaign, IL; and Mike M. Stake, University of Missouri

Species Spotlight

American White Pelican Charlie Warwick

... Nothing else flies like that [White Pelicans], serene, untroubled, almost daring the air to throw them an updraft so that they can make a subtle, nearly invisible adjustment to their flight feathers and continue unperturbed. . . .
—Peter Cashwell, *The Verb 'To Bird'*

The American White Pelican (*Pelcanus erythrorhynchos*), the huge, majestic



American White Pelicans landing in an Illinois lake. Photo by Michael Jeffords, INHS Office of the Chief

flier described above is a member of the bird Order Pelecaniformes that contains six families, including Anhingas, Cormorants, Tropic Birds, Boobies, and Gannets. All birds in the Order are distinguished by having all four of their toes connected by webs, bills that are as long or longer than their heads, and expandable throat pouches for catching and holding prey.



American White Pelicans congregate to feed. Photo by Michael Jeffords, INHS Office of the Chief

American White Pelicans live on the coasts of the U.S. as well as lakes and rivers throughout the interior of the country. They are annual migrants in Illinois, usually arriving in the state in May and staying until September and October. Their autumn migration takes them to wintering grounds as far west as northern California and as far south as the island of Trinidad in the Caribbean. They are strong fliers who alternate flapping and gliding, and they can soar on thermals like hawks during migration at speeds up to 30 miles per hour. They migrate in “V” formation, often soaring to great heights. In Illinois, White Pelicans have been observed migrating in flocks that number in the hundreds to thousands.

Illinois American White Pelicans can be found along rivers and large inland lakes throughout the state. They seem to be more abundant in the western part of the state, especially along the Illinois and Mississippi rivers, but they have also been seen in the Chicago area, at Clinton Lake in east-central Illinois, at Carlyle Lake in southern Illinois, as well as at ponds and gravel pits. White pelicans may range up to 50 miles from their base when feeding.

These are large birds with bodies up to 5 feet in length, bills that reach 14 inches, wings that measure 22 inches from front to rear edges, and wing spans up to 9 feet. Their heads are white with distinctive throat pouches, the necks are long, and the wings are white with black tips. White Pelicans are a dramatic sight when making a low glide across the water. Writer Peter Cashwell, taking a bit of literary license with the large

stature of White Pelicans, states, “If pelicans were drivers, they’d own huge, rectangular American luxury cars with plush interiors; they would get into the interstate’s passing lane at the first opportunity and would set the cruise control at eighty, then lean against the headrest, drape one wrist over the top of the steering wheel, and look out at the traffic under heavy-lidded eyes, waiting for their destination to roll up over the horizon.”

White Pelicans usually build their nests in a depression on the ground, although some have been known to use trees. The females lay one to five cream or blue-white eggs that measure three and a half by two and a third inches. The eggs incubate in 28–30 days. The young are cared for by both parents who feed them out of their pouches. The baby birds almost disappear inside their parent’s throat pouches as they feed on a diet almost exclusively of fish.

Unlike their close relative the Brown Pelican, which dives to catch prey, adult White Pelicans either wade in shallow water or swim and submerge their pouches to scoop up a meal. If they are swimming when they feed, they act like dabbling ducks, tipping their heads under water to secure food in their bills. Pelicans will often work as a group to corral fish.

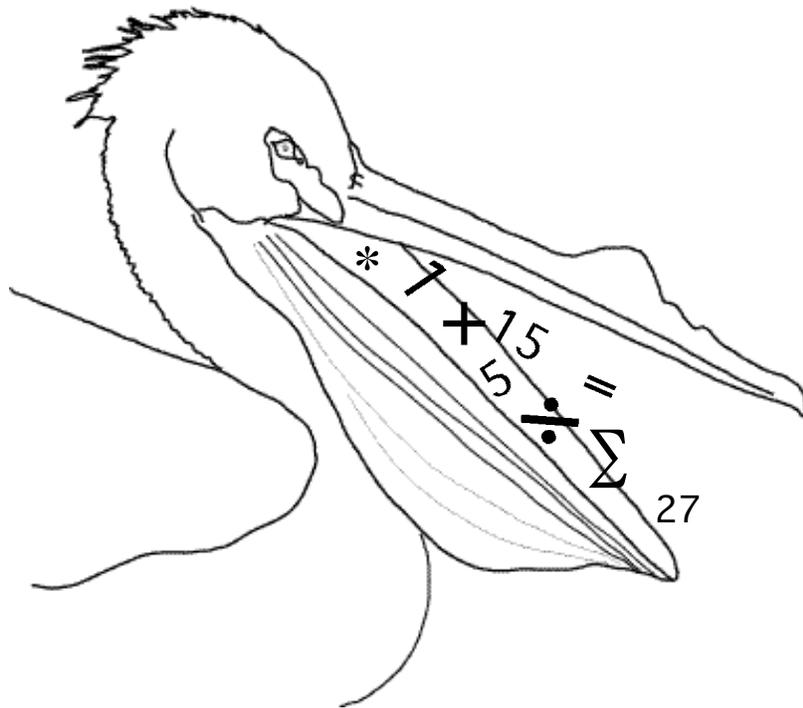
Only a couple of decades ago, White Pelicans were in danger of extinction because formation of their egg shells was being ruined by the pesticide DDT, which was ingested in their food. Since the use of DDT and other environmentally dangerous chemicals has been banned, the numbers of White Pelicans in Illinois have rebounded and are now among the highest recorded for the state.

Pelican Math

Using the pelican facts listed below, see if you can answer the following questions. (Hint: The answers to earlier questions may help you answer the later questions).

An adult American White Pelican weighs about 20 lbs and consumes 3 lbs of small fish, salamanders, frogs, and aquatic insects each day. It will live about 14 years. While its bill can hold 5 gallons, the stomach will hold only 2 gallons. A pelican can usually catch what it needs to eat in a day by 8:00 or 9:00 a.m. A female pelican usually lays two eggs, but often the parents are able to raise only one young. The chick stays in the nest for 25 days, during which it consumes about 150 lbs of food. The parents continue to feed their offspring until it is able to fly at about 10 weeks old. Parent birds often commute up to 50 miles between nesting grounds and feeding areas.

1. On average, how much does a pelican chick eat each day before it leaves the nest?
2. How many pounds of fish and other aquatic organisms must a pair of pelicans catch in one day when they have a chick in the nest?
3. If the pelicans are feeding on minnows that weigh 0.5 oz each, how many minnows must an adult Pelican eat in a day?
4. If a pelican chick will eat the same amount of food as an adult once it leaves the nest, how many pounds of fish must it eat from the time it hatches until it can fly?
5. How many 0.5-oz minnows would an American White Pelican eat in a lifetime?



Pelican Math Answers

1. 6 lbs ($150 \div 25$, or 6 lbs)
2. 12 lbs (each adult eats 3 lbs, and the chick eats 6 lbs)
3. 96 minnows (3 lbs of fish x 16 oz per lb, or 48 oz; $48 \div .5 = 96$)
4. 285 lbs (first 25 days it ate 150 lbs; 10 weeks = 70 days; 70 days - 25 days = 45 days; last 45 days it ate 3 lbs each day, or $45 \times 3 = 135$ lbs; 150 lbs + 135 lbs = 285 lbs)
5. 492,960 (14 years x 365 days per year = 5,110 days; 5,110 days - 25 = 5,085 days; first 25 days it ate 150 lbs; 150 lbs x 16 oz per lb = 2,400 oz; 2,400 oz \div .5 oz per minnow = 4,800 minnows; so it ate 4,800 minnows its first 25 days; it ate 96 minnows a day for the next 5,085 days, or $96 \times 5,085 = 488,160$ minnows; 4,800 minnows + 488,160 minnows = 492,960 minnows)

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Electric Barrier

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combined technologies barrier is an appealing approach because it provides redundancy in the event one or the other technologies physically fail or do not stop the movements of bighead carp or other undesirable species.

In the field, we have been following movements of common carp (a surrogate for the invasive carps) tagged with combined radio/acoustic transmitters in the vicinity of the dispersal barrier. To date, we have tagged 79 fish. We are following the common carp using a combination of fixed receivers immediately upstream and downstream of the dispersal barrier to detect any movement across the barrier, and using mobile tracking by boat. Since November 2002, we have detected 75 of the 79 tagged fish. One tagged fish crossed the barrier on

April 3, 2003. This fish was likely helped through the electric field by a commercial barge passing through the electric field at the same time as the fish crossed the barrier. This fish passage may be an indication that commercial navigation traffic can move fish across the field because of the strong propeller thrust from these barges and/or because the large steel hulls change the shape and strength of the electric field.

Since April, no other tagged common carp have passed through the barrier. We will continue to gauge the effectiveness of the dispersal barrier for the next two years. We expect that our work will provide the detailed information to maximize the effectiveness of the dispersal barrier before Asian carps move into close proximity of the dispersal barrier. An effective barrier will close down this avenue of expansion of the



A bighead carp attempting to move through the experimental electric barrier at Jake Wolf Memorial Fish Hatchery. Photo by Ronald Taylor

Asian carps into the Great Lakes and also keep future invasive fishes from crossing this artificial linkage between the Mississippi and Great Lakes drainage basins. The same technology, if effective in this demanding application, could be applied worldwide.

*John M. Dettmers and Mark A. Pegg,
Center for Aquatic Ecology*

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