

WINGS

ESSAYS ON INVERTEBRATE CONSERVATION



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Introduction

Scott Hoffman Black

In looking at the cover of this issue of *Wings* you might have noticed something different: a photograph of a plant rather than the customary invertebrate.

Plants and insects are inextricably linked; two essays in this issue explore this interaction. The first underscores the importance of native plants to the native insects that feed on them. The presence of non-native plants can significantly reduce the abundance of native insects, which in turn impacts the songbirds and other animals that eat them. The second looks at the astounding array of insects that use milkweeds, and the ways in which the Xerces Society and its partners are working to return milkweed to our landscapes and increase local supplies of milkweed seed.

We also have three articles about invertebrates that do not directly rely on plants. The purple marsh crab, living in West Africa, was rediscovered sixty years after the first—and only—specimen was collected. An essay about tiger beetles shows that not only are they amazing creatures in beauty and behavior, but they are useful in helping us to understand and manage the habitats in which they live. The last article delves into the little-known world of migratory dragonflies—some of which travel further than monarch butterflies—and discusses the newly formed Migratory Dragonfly Partnership, which is working to understand and protect these animals.

We hope you find this selection of essays informative and enjoyable.



This hickory horned devil will develop into a regal moth, *Citheronia regalis*, but only if it has adequate native plants to eat. Photograph by Douglas Tallamy.

Endangered Crab Found In West Africa's Shrinking Forests

Neil Cumberlidge and Piotr Naskrecki

We were camped in West Africa, on the westernmost fringe of the Upper Guinea forest, a vast area stretching from Guinea to Sierra Leone and Liberia. As part of an international team of scientists conducting a rapid assessment of this historically biodiversity-rich region, we had come to survey invertebrates, particularly freshwater crabs. At first sight these damaged forests and parched savannas, degraded by agriculture and industry, seemed an unlikely place to seek rare aquatic animals. But we were there because of the imminent threat of further industrial expansion and additional ecosystem disruption.

Our campsite was in disturbed land under intense agricultural management in northwest Guinea, but by sheer luck our tents were pitched just a few kilometers from a thriving colony of some of the continent's most elusive crustaceans—purple marsh crabs (*Afrithelphusa monodosa*). This species is truly an enigma, previously known only from a single specimen collected in 1947. Yet, amazingly, just a day after we began our survey, a local farmer walked right into our camp holding one!

Purple marsh crabs belong to a diverse group of decapod crustaceans colloquially known as river crabs or freshwater crabs, which are abundant in the rivers, streams, and lakes of inland waters throughout the tropics. Despite their large size, attractive colors, and

ubiquity in tropical aquatic ecosystems, the thirteen hundred or so species of freshwater crabs have somehow avoided the full attention of the scientific community. Interest in their biology and conservation is only now beginning to gain momentum.

The success of the world's marine land crabs—species that live in mangrove forests, on beaches, or further inland, but still need to return to the sea to breed—in the coastal fringes throughout the tropics is due to their well-developed abilities to breathe air, dig burrows, dehydrate slowly, and walk easily on land. These adaptations gave access to new food sources and living spaces in the coastal lands above the high-tide line, and this is where these animals now reign supreme.

Freshwater crabs evolved from marine crabs, but succeeded in breaking the connection to salt water with adaptations that enabled them to osmoregulate in low-salinity environments. These included ion pumps on their gills that move salts inward, antennal glands (kidney-like organs) that pump water out of their blood, and an impressively waterproof carapace. As a result, freshwater crabs complete their life cycle in fresh water and never need to return to sea water to breed.

Our newly rediscovered Guinean species was among the small subgroup of the freshwater crabs that we call fresh-

water land crabs, those species that can live and reproduce well away from permanent water sources.

Structural modifications in their gill chambers enable many species of freshwater crabs to breathe in air as well as underwater. Their gill chambers are so well adapted for aerial respiration that their ability to breathe is undiminished by being out of water. The bottom layer of each gill chamber has the usual set of gills that are seen in most crabs, which allow them to breathe under water. But it is in the upper layer above the gills where the truly remarkable adaptation is found. Here there is a spongy air-breathing organ, which is analogous to a vertebrate lung in function but structurally so different that it is known as a “pseudolung.”

In purple marsh crabs, this respiratory structure works so well that they actually prefer to breathe air rather than water. These crabs immerse themselves

in water only as a last resort, usually to avoid predators, and seem uninterested in using oxygen from water.

The abilities of the freshwater land crabs to breathe air, dig burrows, resist drying, and walk on land easily match those of marine land crabs. Freshwater crabs have a reproductive adaptation that opened up to them vast tracts of land in the inland tropical ecosystems of the world’s continents that even the well-adapted marine land crabs had not conquered. In contrast to marine crabs, which release their eggs into sea water and whose larvae spend several weeks in an un-crablike, planktonic stage floating with the currents, larval development in freshwater crabs is completed entirely inside the egg case, with each egg releasing a fully formed miniature crab. The evolution of larval direct development has had big ecological consequences for freshwater crabs. For one thing, it meant that these crustaceans could complete



Land crabs have adapted to life away from water, but most still need to return to breed. Blue land crab (*Cardisoma guanhumi*), at water’s edge, waiting to release her eggs. Photograph by Piotr Naskrecki.

their entire life cycle in their inland habitat, using fresh water for all of their needs. And it released female freshwater crabs from the need to spend valuable energy making migrations to the coast during the breeding season. This radical adaptation removed one of the last barriers to the colonization of land and gave them total independence from salt-water environments, which in turn led to the explosive radiation of freshwater crabs in the inland waters of the tropics around the world.

Today, these crabs are dominant inhabitants of warm fresh waters from tropical America to Australasia. Freshwater crabs have conquered not only more conventional freshwater ecosystems such as rivers and lakes, but some species, including the purple marsh crab, have colonized such marginal habitats as flood plains bordering rivers and streams, damp terrain in freshwater swamps and marshes, and dried-out river beds in parched savannas. In

humid rainforests, further adaptations such as small compact bodies and long slender walking legs have enabled freshwater crabs to move easily through vegetation and even to climb tree trunks, thereby equaling or surpassing the feats of most marine land crabs.

Marine land crabs found in coastal Guinea, such as the rainbow crab (*Cardisoma armata*), and air-breathing mangrove crabs, such as the fiddler crab *Uca tangeri*, each are widely distributed along hundreds of miles of the West African coast from Senegal to Angola. These wide distributions are a direct consequence of their developmental strategy, in that the currents carry the larvae long distances from their release points during the weeks spent drifting in the surface waters. In contrast, most freshwater crabs have a narrow distributional range—except perhaps where a major river system is involved. The lack of larval stages means that freshwater crab hatchlings do not stray far



The purple marsh crab (*Afrithelphusa monodosa*) was recently rediscovered in West Africa by the authors. Photograph by Piotr Naskrecki.



Purple marsh crabs live in swampy areas, which are increasingly under cultivation. Photograph by Piotr Naskrecki.

from the place where they were born, and only adult crabs disperse any distance; as a consequence, speciation is common and endemism is high. The smallest distributional ranges of all are seen in those species of freshwater land crabs that live in marginal habitats in isolated mountain streams, rainforests, swamps, marshes, and dry savannas far away from major aquatic systems.

Once back home in our laboratories, we used DNA analysis to confirm that the purple marsh crab indeed belongs to the African family Potamonautidae, and learned that it lies on an evolutionary branch separate from most freshwater crab species in that continent. We also described the habitat requirements and behavior of this species for the first time: it prefers marshy wetlands, many of which are now moist farmland on which bananas, pineapples, and cassava are grown. There crabs live underground in burrows partially filled with shallow, oxygen-depleted fresh water, easily overcoming any oxygen shortages by switching from water breathing to air breathing. During the long dry season crabs emerge from their burrows

in the colder nocturnal air, scavenging the nearby land for vegetable matter or the remains of plants and animals. The first storms of the wet season inundate the burrows and prompt the crabs to crawl onto land in the daylight hours, as well as the night. On the surface the air is cooler and more humid, and the new undergrowth provides both concealment from predators and shade from the sun. As the rains continue, extensive wetlands develop and crabs congregate in the muddy, shallow waters of the newly formed pools and marshes.

The secretive purple marsh crab of Guinea seems to lead a burrow-bound life in perennially marshy ground, a specialized niche that limits its population density and distributional range. Its inclusion as an endangered species on the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN) shows that its long-term survival is at risk. Indeed, it may be making its last stand in that small area of Guinean farmland, and the chances of this fragile species' survival are slim if its wetland habitat continues to be destroyed at the present rate.



Freshwater crabs have long legs and small bodies that make it easy for them to move through vegetation or climb trees. *Sylviocarcinus pictus*, photographed by Piotr Naskrecki.

Our chance rediscovery of the purple marsh crab gave us an opportunity to observe and learn about a little-known species from a fascinating lineage of terrestrial crustaceans. Freshwater land crabs such as *A. monodosa* and its red-listed relatives in Guinea, Sierra Leone, and Liberia live in the increasingly disturbed habitats of West Africa's Upper Guinea forest ecosystem—a biodiversity hotspot with an incredible richness of endemic plants and animals that makes it one of the world's priority conservation areas. Time is running short for that remarkable ecosystem and many of its unique species of flora and fauna—including its rare and barely studied freshwater land crabs—could be threatened with extinction. Unfortunately, should we return to the Upper Guinea forest, our campsite is increasingly less likely to be so fortuitously located.

Dr. Neil Cumberlidge is a professor in the biology department at Northern Michigan University, Marquette, where he works on the taxonomy, systematics, phylogeny, evolution, biogeography, and conservation of African and Madagascan freshwater crabs. He is chair of the Species Survival Commission's Freshwater Crabs and Crayfish Specialist Group of the IUCN.

Dr. Piotr Naskrecki is a research associate at the Museum of Comparative Zoology, Harvard University, where he works on the evolution and systematics of orthopterid insects. He is also involved in a number of invertebrate conservation projects, including the IUCN Red List assessment of African katydids and the development of internet-based resources for invertebrate biologists and conservation practitioners.

The authors thank Conservation International for the opportunity to once again get close to Africa's freshwater crabs.

Aliens

Douglas Tallamy

Although I chose entomology as a profession, I understand the thrill of growing exotic plants. In graduate school, I took a class in woody landscape plants from the noted horticulturist Robert Baker. I left that course with an intense desire to plant as many of the species I had just learned about as possible. The only thing that slowed me down was that, as an apartment dweller, I had no place to plant them. Still, I gathered seeds from many of the ornamentals on campus, germinated them in the greenhouse, and planted the seedlings all over the yards of my parents and relatives.

I now find it ironic that, at the same time that Professor Baker was turning me on to alien ornamentals, I was taking courses about interactions between

plants and insects. These were the classes that explained why most insect herbivores can eat only plants with which they share an evolutionary history. All of the information I needed to realize that covering the land with alien plant species might not be such a good idea had been neatly and simultaneously placed in my lap during those months in graduate school, but it was twenty years before I made the connection: the vast majority of our native insects cannot use plant species that evolved outside of their local food webs.

In 2000 my wife and I moved to ten acres in Pennsylvania. The area had been farmed for centuries, before being subdivided and sold to people like us who wanted a quiet rural setting close



Native trees—particularly oak, maple, and willow—are required food for caterpillars of the polyphemus moth (*Antheraea polyphemus*). Photograph by Douglas Tallamy.

to work. We got the rural setting we sought, but it was not the slice of nature we had hoped for. At least 35 percent of the vegetation on our property (yes, I measured it) consisted of aggressive plant species from other continents. We quickly agreed to make it a family goal to rid the property of alien plants and to replace them with species that had evolved within the eastern deciduous forests.

Early on in my assault on the aliens in our yard, I noticed a rather striking pattern. The alien plants that had taken over our land—multiflora rose, autumn olive, privet, oriental bittersweet, Japanese honeysuckle, Amur honeysuckle, Bradford pear, Norway maple—all had very little or no insect-caused leaf damage, while the red maples, black and pin oaks, black cherries, black gums, black walnuts, and black willows had obviously been eaten by many insects. This was alarming, because it suggested a consequence of the alien invasion occurring all over North America that was under the radar. If our native insect fauna cannot, or will not, use alien plants for food,

then insect populations in areas with many introduced plants will be smaller than those in areas with all natives. Because so many animals depend partially or entirely on insect protein for food, a land with fewer insects is a land with fewer forms of higher life. Birds would suffer most, because 96 percent of our terrestrial bird species rear their young on insects.

Ecologists suggest three reasons why most native insects do not eat introduced plants. First, many of the invasive plants that have succeeded in North America were imported specifically because of their unpalatability to insects. As Michael Dirr repeatedly emphasizes in his acclaimed books on ornamental plants, species that are “pest free” are favored by the ornamental industry. Unfortunately, 85 percent of the invasive woody plant species in the United States are escapees from our gardens!

The second reason is that it takes time—long evolutionary time spans, rather than short ecological periods—for most insects to adapt to the specific chemical mix that characterizes dif-



Like most songbirds, the white-eyed vireo (*Vireo griseus*) rears its young on insects. Photograph by Douglas Tallamy.

ferent plants. The literature is replete with evidence that the number of insect herbivores associated with transplanted aliens is only a small fraction of the number associated with these plants at home. In Europe, for example, *Phragmites* (the common reed) supports more than 170 species of phytophagous insects, while only five species of our native herbivores feed on this plant in North America. Similarly, since the introduction of melaleuca to Florida in the early 1900s, only eight species of arthropods have been recorded eating the leaves of this Australian native; in its home region, 409 species are known to eat it. Similarly, *Eucalyptus stellulata*, an introduced tree touted as supplying nectar for bees in California, supports forty-eight species of insect herbivores in Australia, but only one native insect herbivore in California. These examples demonstrate that adaptation to non-native plants by our native insects occurs, but is a slow process indeed.

The third reason that native insects shun aliens is that most phytophagous insects feed on plants with which they share an evolutionary history. Leaders in the field of plant/insect interactions such as Dan Janzen, Doug Futuyma, Fred Gould, and Elizabeth Bernays have all estimated that 90 percent of phytophagous insects have evolved associations with no more than a few plant lineages. (It is important to highlight that these predictions focus on how insect herbivores use plants. They are not predictions about pollinators, parasitoids, or predators that visit flowers for nectar or pollen.)

How do we know the actual extent to which our native insects are eating introduced plants? My students and I



Banded tussock moth (*Halysidota tessellaris*) caterpillars feed on a range of native trees from July to October. Photograph by Douglas Tallamy.

have been working to fill this gap in our knowledge. One of the first things we did was to compile information about Lepidoptera larvae collected from every plant genus—all 1,385 of them—in the mid-Atlantic states. We focused on Lepidoptera because host records for moths and butterflies are far more complete than those for other types of insect herbivores, and because caterpillars are disproportionately important food sources for birds. Two years and more than four hundred references later, we were able to rank mid-Atlantic plant genera, both natives and naturalized aliens, in terms of their ability to support the larvae of 2,909 Lepidoptera species.

We learned much from this effort. Even among natives there is tremendous variation in the ability to support cater-



The spun glass moth (*Isochaetes beutenmuelleri*) caterpillar is a specialist of oaks. Photograph by Douglas Tallamy.

pillars. Oaks supported the most species (534), followed by native cherries (456), willows (455), and birches (413), while there were some natives, such as sweet-spire (*Itea*) and yellowwood (*Cladastris*), on which no Lepidoptera were recorded. As predicted, favorite landscape plants that evolved elsewhere such as forsythia, golden raintree, *Zelkova*, and *Metasequoia*, supported few or no caterpillar species. All members of the thirty-eight most productive genera were native to the mid-Atlantic region, with the exception of pear (*Pyrus*), an agricultural genus. Among ornamental plants, natives supported on average seventy-four species of native Lepidoptera, while aliens supported fewer than five—just one-fifteenth as many.

These results have been supported by a large study in which we compared how well introduced plants support native insects. In a replicated common garden experiment, my students and I showed that alien plants significantly

reduce the abundance and diversity of both generalist and specialist Lepidoptera. Alien plants that are congeners—close relatives—of a common native species reduced Lepidoptera communities by 50 percent, while an alien plant that is not closely related to any local species reduced Lepidoptera abundance and diversity on average by 75 percent! We know that most bird populations are limited by the amount of food they can find, so if there are dramatically fewer caterpillars in neighborhoods dominated by introduced ornamentals, it is no wonder that our birds are struggling.

Many people justify the use of an introduced ornamental—or inaction against an invasive alien—by contending that it supports a particular butterfly, beetle, or bee. This approach, however, considers what is gained from a plant without considering what is lost through its presence. Kudzu provides an excellent example. When an acre in Virginia is overrun with kudzu, the silver-spotted skipper (*Epargyreus clarus*) can still find larval food because it is able to add kudzu to its list of leguminous host plants. But the meadow fritillary (*Boloria bellona*), variegated fritillary (*Euptoia claudia*), and great spangled fritillary (*Speyeria cybele*) would no longer be able to reproduce in that field because their violet host plants are lost. Similarly, monarch butterflies (*Danaus plexippus*) would lose their milkweed host plants, as the two hundred or more species of moths that feed on goldenrod and asters would lose theirs. Trees are not immune to kudzu, and the oaks, cherries, and willows that each support four or five hundred species of moths and butterflies would be smothered. Many more genera of native plants would be elimi-

nated on that acre, as would the hundreds of insect species they support.

We needn't limit this discussion to invasive species. We have replaced diverse native plant communities in thousands of square miles of suburbia with ornamental plants from Asia. Most of these plants are not currently invasive, yet if planted everywhere they have a similar impact on insect herbivores. Imagine a neighborhood in which native pines are replaced by Deodar cedars from the Himalayas. The pine white butterfly (*Neophasia menapia*) is able to develop on Deodar cedars, but more than two hundred other species of pine specialists would lose their host plants.



Great spangled fritillaries (*Speyeria cybele*) nectar on many flowers, but their caterpillars eat only violets. Photograph by Douglas Tallamy.

By favoring native plants over aliens in the suburban landscape and by working to minimize the abundance of invasive plants in our natural areas, we can do much to sustain the biodiversity that has been one of this country's richest assets. Native plants support and produce more insects than alien plants do, and therefore more numbers and species of other animals. Somehow we have come to expect an artificial perfection in our gardens and the greater landscape: the plastic quality of flowers is now seen as normal and healthy. It is neither. Instead, it is a clear sign of a garden that is no longer a living community; a garden in which any life form other than the desired plants is viewed as an enemy and quickly eliminated. In essence, we have demoted plants to mere decorations in our unnatural landscapes.

To sustain biodiversity we will ultimately need to improve the complexity and stability of insect-based food webs, both in our yards and in local natural areas. Although some insects can meet their needs with introduced plants, most cannot. This illustrates the real costs associated with replacing native plant communities with alien plants but also suggests ways to reverse the losses in biodiversity that have characterized our times.

Doug Tallamy is a professor and the chair of the Department of Entomology and Wildlife Ecology and director of the Center for Managed Ecosystems at the University of Delaware in Newark, where he has taught courses for thirty years and authored seventy-three research articles. This essay was adapted from his book Bringing Nature Home.

Milkweeds: Not Just for Monarchs

Brianna Borders and Matthew Shepherd

Standing in a field of milkweed plants, John Anderson watches a monarch butterfly search for a place to lay her eggs. This sight epitomizes most people's image of milkweed: food for monarch caterpillars. This, however, is no ordinary field of milkweed, and John is not most people. The co-owner of Hedge-row Farms near Winters, California, John is at the forefront of a movement to encourage the use of locally native milkweed in restoration projects. As the obligate host plants for monarch caterpillars, milkweeds play a vital role in the life cycle of the monarch butterfly (*Danaus plexippus*). They also provide food or shelter for a diverse array of other insects, including nectar-seeking bees, flies, and butterflies, and such specialist herbivores as seed bugs, longhorn beetles, and leaf beetles. Native milkweeds are clearly worthy of wider adoption.

More than a hundred species of milkweeds (*Asclepias*) are native to North America and they can be found in deserts, plains, valleys, foothills, open woods, and wetlands. Milkweeds also grow in disturbed environments including agricultural areas, livestock pastures, ditches, and roadsides; indeed, in some areas, these marginal habitats are the only places where milkweed is regularly seen.

Milkweed is named for its milky latex sap, which oozes from damaged leaves and stems. This sap contains alkaloids and cardenolides, complex chemicals that make the plants toxic to

animals. If eaten by livestock, milkweed typically causes depression or diarrhea, although it may be fatal. Fortunately, milkweed is bitter in flavor and unpalatable, and range animals will generally avoid eating it if sufficient forage is available; most milkweed poisoning results from hungry animals being concentrated in areas where milkweed is abundant.

The toxin-laden sap deters mammals, but insects have an amazing capacity to overcome the chemical defenses of plants, particularly those with which they have a shared evolution. In fact, a large number of insects eat milkweeds, often harvesting the toxins for use in their own defense; of the insects that do this, monarchs are the best known. Their caterpillars sequester the toxins and store them in their tissues, giving them a bitter taste. They have boldly colorful warning—aposematic—markings, which serve as a reminder to birds and other predators. Other milkweed-feeding insects, including milkweed bugs, milkweed longhorn beetles, and milkweed leaf beetles, sequester and store the milkweeds' toxic chemicals to aid their own defense, and like monarch caterpillars, generally have aposematic markings.

Large milkweed bugs (*Oncopeltus* spp.) feed only on milkweeds and closely related plants. Although these bugs will feed on young leaves, flowers, and developing pods, a seed diet provides for optimal growth and reproduction, and for

this reason adults lay their eggs close to developing pods. Small milkweed bugs (*Lygaeus* spp.) feed on seeds as nymphs but they can develop on plants other than milkweeds. As adults, they are not strictly herbivorous, and will scavenge insects trapped in milkweed flowers, feed on monarch butterfly pupae, and even engage in cannibalism.

Milkweed longhorn beetles (*Tetraopes* spp.), so-named for their prominent antennae, feed exclusively on milkweeds and close relatives. They are generally host-specific—there are thirteen species of milkweed longhorn beetles in the United States and each prefers a different species of milkweed.

The milkweed leaf beetle (*Labidomera clivicollis*) overcomes milkweed's defenses by biting through veins of the leaf. The sap drains from the outer part, and the beetle can feed in relative safety on the drained area beyond the cuts.

The relationship between milkweeds and insects is not one-sided. Milkweeds are entomophilous, meaning that they depend on insects for their pollina-

tion. Milkweed pollen does not occur as free grains, but instead is contained in pairs of waxy sacs—pollinia—that are located within vertical grooves on the flowers, called stigmatic slits. Each pollinium contains several hundred grains of pollen. An insect that visits a flower to obtain nectar may leave with a pair of pollinia affixed, the result of coming into contact with a corpusculum, a pollinia-bearing gland located at the top of a stigmatic slit. (Insects may accumulate strings of corpuscula and pollinia from repeated flower visits. In Robert Woodson's extensive monograph on the *Asclepias* species of North America, he reported an instance of a single honey bee carrying forty-five corpuscula!) Pollinia most commonly become attached to an insect's legs but they can also be borne on the mouthparts or on any barbed or hairy surface of an insect's body. Fertilization occurs when pollinia are transferred by the insect into the stigmatic slits of another milkweed flower.

Although milkweeds have a very specialized pollination mechanism,



Bright markings warn predators that the large milkweed bug (*Oncopeltus fasciatus*) tastes bad. Photograph by Bryan E. Reynolds.

they do not require specialist insects to activate it. Any insect that is large enough to remove and transport pollen can be an effective pollinator, and milkweeds are pollinated by a broad range of bees, wasps, butterflies, flies, and beetles, even true bugs. A review of milkweed pollination studies completed by Jeff Ollerton and Sigrid Leide revealed that whorled milkweed (*A. verticillata*) has 126 documented pollinators.

With their pollen enclosed within pollinia and inaccessible, milkweeds have only nectar with which to reward visitors. Even so, they attract a tremendous variety of insects with the abundant, high-quality nectar that is readily accessible in the hoods of their flowers. Many of the nectar-seeking insects inadvertently end up as pollinators, while others bring benefits in other ways. In a recent study by David James of Wash-

ington State University, milkweed—in this case, showy milkweed (*Asclepias speciosa*)—attracted the highest number of beneficial insects of any of the forty-three species of native flowers being studied.

Insects whose adults visit milkweeds for nectar include ichneumon, braconid, and mymarid wasps, all of which are parasitoids (meaning that they lay eggs on or in a host insect; once hatched, their offspring then consume the host), and thus natural predators of crop or garden pests. The closely related ichneumon and braconid wasps typically parasitize aphids or the soft-bodied larvae of such insects as butterflies, flies, and beetles, while mymarid wasps parasitize insect eggs. Syrphid flies are also attracted to milkweeds: the adults drink the nectar and their highly mobile larvae prey directly on aphids.



Milkweeds support a diverse community of insects that visit to drink nectar or feed on the plant itself—or on the other visitors. Photograph by Bryan E. Reynolds.



Fewer milkweed plants for its caterpillars to eat is one reason for declines in monarch butterfly (*Danaus plexippus*) populations. Photograph by Bryan E. Reynolds.

One conspicuous insect that can frequently be seen nectaring on milkweed in California and the desert Southwest is the tarantula hawk wasp (*Pepsis* spp.). As their name suggests, these wasps hunt tarantulas, not for themselves—as adults they eat only nectar—but to supply the nests of their offspring.

Like many native plant species, milkweed populations are being lost at a rapid rate due to urban and suburban development and agricultural intensification. Despite their native status, unique beauty, and value to the monarch butterfly as well as to a tremendous range of pollinators and other beneficial insects, milkweeds are often perceived as crop weeds or a threat to livestock and eradicated from agricultural areas, rangelands, and roadsides.

Loss of milkweeds is believed to be one of the factors (along with disturbance to and destruction of overwintering sites) that have led to the steep decline of the western population of monarchs. The butterflies spend the winter months in tree groves along the coast of California, the only U.S. state with large numbers of overwintering mon-

archs. Each spring, the butterflies leave the groves in search of milkweed on which to lay their eggs. Over the summer, successive generations spread out across North America west and south of the Rocky Mountains and as far north as British Columbia, with the last generation making the journey back to the California coast. Unfortunately, western monarchs are in trouble. Data collected by volunteers show that the number of overwintering monarchs has dropped by more than 90 percent since 1997.

In 2008 the Commission for Environmental Cooperation (a treaty organization of the United States, Canada, and Mexico) published the *North American Monarch Conservation Plan*, addressing the steady decline of the butterflies across their native range since population monitoring first began in 1976. Because of their migratory life-cycle (breeding in the United States and Canada, overwintering in Mexico and California), the most effective conservation strategies for monarchs are those that protect and restore habitat across their entire range. The plan cites broad national declines in milkweeds and



Butterfly weed (*Asclepias tuberosa*) has a wide distribution, but is not always the most appropriate milkweed for habitat projects. Photograph by Allen Casey.

recommends the planting of regionally appropriate native milkweed species to offset the loss and degradation of monarch breeding habitat.

Unfortunately, few commercial sources of native milkweed seed currently exist across the monarch's spring breeding range in the United States—California, the Southwest, Texas, and Florida—and, in these places, either no milkweeds are planted or those that are planted are species from outside of the region. Clearly, there is a need for sources of locally native milkweed seed. In 2010, with support from the Monarch Joint Venture and a Conservation Innovation Grant from the USDA Natural Resources Conservation Service (NRCS), the Xerces Society launched a multi-state initiative to increase the availability of native milkweed seed for monarch-habitat conservation efforts. Xerces is working with the native seed industry to develop new sources of regionally

appropriate native milkweed seed, and working with the NRCS to incorporate milkweeds into the agency's pollinator-habitat restoration projects.

As part of this effort, John Anderson has already produced seventy pounds of seed from narrow-leaved milkweed (*A. fascicularis*), which can be used in restoration across California. We hope that this is just the first batch of milkweed seed that will be planted to help stem the downward spiral of monarch butterflies, while at the same time sustaining the richness of insects required for a healthy environment.

Brianna Borders is a plant ecologist who leads the Xerces Society's effort to increase the availability of milkweed seed.

Matthew Shepherd is a senior conservation associate with Xerces. He has worked on pollinator conservation for a decade and edits the Society's publications.

Six-Legged Tigers

David L. Pearson

Tiger beetles are justifiably one of the most popular and most studied beetle groups in the world. With about twenty-seven hundred species described so far, there could be as many as another two hundred species awaiting discovery. Tiger beetles occur in a wide variety of biomes, from high-elevation alpine forests and high-latitude taiga (boreal) forests to tropical rain forests, from desert washes to ocean beaches. They are found in almost every part of the world except Antarctica, Tasmania, and smaller oceanic islands and atolls.

No matter where they reside, however, each species tends to occupy a narrow or highly specialized habitat. For example, in the Gran Chaco region of Brazil, Paraguay, Bolivia, and Argentina, the bicolored mound-dwelling tiger beetle (*Cheilonycha auripennis*) occurs only on

tall termite mounds, where the beetles feast on larval glow worms that live in tunnels on the outside of the mounds. (At night, the glow worms cause the mounds to glow eerily in the darkness.) Even adults of the most widespread species, such as the North American bronzed tiger beetle (*Cicindela repanda*), occupy relatively restricted habitats—in this case, sandy margins of rivers, lakes, and ponds.

Larvae of each species are even more restricted to microhabitats than are their adult stages. The larvae are also predatory, but they hunt using sit-and-wait techniques from the mouths of vertical tunnels in the soil. Some of these tunnels reach more than six feet (two meters) in depth, but most are only six to twelve inches (fifteen to thirty centimeters) deep. The larvae of some



Tiger beetles are alert, fast-running hunters. Big sand tiger beetle (*Cicindela formosa*), photographed by Bryan E. Reynolds.

tropical arboreal species construct their tunnels in decaying wood.

Although adults of many species are plain in appearance, with browns and blacks predominating, many are as colorful as spectacular jewels—emerald green, purple, orange, and eye-popping crimson. Upon closer inspection, even the apparently plainly colored ones are pointillistically covered with brightly reflecting microscopic pits. The various colored reflections from these pits blend through the physics of interference to produce the subdued but still attractive hues that are seen with the naked eye.

Adult tiger beetles can fly short distances to escape danger. They spend most of their time on the ground and among rocks, although a few tropical species patrol tree trunks and leaves. The beetles run rapidly on their long, thin legs and use their large, sickle-shaped mandibles to capture and dismember small, fleeing arthropods. Hudson's saline tiger beetle (*Rivacindela hudsoni*), a flightless species found only on huge saline lake beds in interior Australia, has been clocked running at 2.49 meters per second (5.57 miles per hour), so fast that collectors can rarely get close to them.

Largely because of the cooperative efforts between passionate amateurs and a few dedicated professionals over the past two centuries, the taxonomy of tiger beetles is relatively stable, even for species in such remote parts of the world as Sulawesi, Brazil, and the Sudan. These days, it is easier and faster for inexperienced helpers and students to learn to reliably census tiger beetles than it is for them to learn to census other taxa.

And the work itself is faster: students of tiger beetles can quite easily census an area during the season of adult activ-

ity and reliably find most of the species within a short time, even in such complex and species-rich habitats as tropical forests. At one site at Tambopata in southeastern Peru, ornithologists took almost five years of intensive work to document 90 percent of the bird species occurring there, while in the same area butterfly and dragonfly workers took two or three years to arrive at this level of knowledge for their respective taxa; those of us looking for tiger beetles found 90 percent of the fauna within the first fifty-five hours of searching.

Field identification guides for tiger beetles have been published for many countries, including Bolivia, Venezuela, Colombia, Thailand, and Madagascar, and these publications have encouraged amateurs in many countries to adopt tiger beetles as hobby organisms. The work of these enthusiasts quickly adds to the growing body of information on tiger beetle distribution and natural history in a cost-effective way.

It is no wonder, then, that tiger beetles lend themselves well to conservation efforts. Around the world they are among the few insect groups for which endangered species can be declared with certainty and placed on national red lists. In the United States, four species have been officially declared threatened or endangered by the U. S. Fish and Wildlife Service, and some experts claim that as many as 15 percent of the 225 named species and subspecies in the United States and Canada have fallen to such low levels that they should be considered for protection efforts. The Sacramento Valley tiger beetle (*Cicindela hirticollis abrupta*), for instance, evidently has gone extinct in the last thirty years, a victim of flood



The splendid tiger beetle (*Cicindela splendida*) displays spectacular iridescent colors. Photograph by Bryan E. Reynolds.

control and habitat destruction. In Bolivia, the beautiful Bolivian ornate tiger beetle (*Pometon bolivianus*) was first discovered and named in the early 1990s; although such a large and obvious species should be easy to find, it has not been seen since, even with extensive searching in the same areas in which it was originally found (most of which are now coffee plantations), and this species has been placed high on Bolivia's red list of endangered insect species. In Spain, the highly endemic Murcia tiger beetle (*Cephalota deserticoloides*) has been declared endangered. In Sweden, the most northern populations of the wide-ranging Eurasian tiger beetle (*Cicindela maritima*) have been declared threatened due to habitat destruction.

Those of us working in conservation cannot afford having to defend false claims of rarity, and the reliability of accurately censusing tiger beetles minimizes questions of detectability

that haunt conservationists who study the many other taxa that are harder to observe and easier to miss. By protecting threatened populations of tiger beetles we also secure habitat for many other species that also need protection—an umbrella effect.

We have strong evidence that, across the world, the species richness of tiger beetles is a good predictor of the species richness of other, harder-to-census taxa, such as butterflies and birds. And, because the number of species in a given locale can be so quickly determined, we can census hundreds of acres for tiger beetles in the time it would take to census one acre for birds or butterflies.

Tiger beetles thus make excellent bioindicators, and they have been used to monitor diversity in Amazonia and other less-well-studied areas of the world. With the aid of mathematical modeling we can examine a wide swath of habitat and generate broad estimates



Many tiger beetles have obvious markings, easing their identification. Oblique-lined tiger beetle (*Cicindela tranquebarica*), photographed by Bryan E. Reynolds.

of the quantitative patterns of tiger beetle species across vast areas such as the Indian subcontinent or South America. These patterns reveal areas of high and low species richness, which in turn can help determine priorities and boundaries for protected areas, as, for instance, in the case of Madagascar's recently declared Masoala National Park.

Bioindicators also have a role to play in the early detection of habitat degradation. Because tiger beetle adults and larvae are so specialized in habitat use, they tend to be highly sensitive to minor changes, functioning as barometers of degradation that might imperil them and their habitats. Collections made long ago are valuable aids in comparing the historic distributions of tiger beetle species with their current geographic ranges; tiger beetle records accumulated over the last century and a half in Europe have already documented habitat changes there that would not otherwise have been obvious.

Tiger beetles, employed as bioindicators to monitor habitat condition,

can even help to guide management decisions. In Venezuela, for example, conservation advocates have joined with lumber companies to maintain forest biodiversity while increasing profits, applying their knowledge of the habitat specialization of the local tiger beetles in planning a long-term rotation for harvesting smaller plots within a large forest concession. Although timing logging to maintain the forest for sustainable use is made difficult by local variations in drainage, soil fertility, and a host of other factors that render dependence on a rigid timetable impossible, the presence of particular species of tiger beetles provides a relatively accurate measure of when the forest is sufficiently mature for harvest. Succeeding patches of regenerated forest, from cleared to mature, have different tiger beetle species present, each adapted to differences in shade tolerance, temperature, and vegetation density. Now the companies monitor the presence of tiger beetles, and reharvest particular sections only when the complement of species is that known to

be typical of the mature forest community, thus maximizing the continuing complex diversity of the forest.

When Barry Knisley, Chuck Kazilek, and I first published our *Field Guide to the Tiger Beetles of the United States and Canada* in 2006, there were likely only a hundred or so tiger beetle aficionados in North America, most of them amateurs. Now, just a few years later, we can hardly keep up with the flood of new distribution records, natural-history observations, and innovative insights into the study and uses of tiger beetles that we receive from thousands of enthusiasts. With growing economies in China, India, and much of South America, the field guides and web sites that focus on tiger beetles attract a growing number of hobbyists who have the time and money to support their avocation.

The future of insect conservation is more and more in the hands of these professional amateurs, whose contributions should help guide future policy de-

isions and budget planning by professional biologists, politicians, legislators, and policy makers. This passion for tiger beetles illuminates the ways in which insects and their admirers can advance conservation policy everywhere in our threatened world.

David L. Pearson, a research professor in the School of Life Sciences at Arizona State University, has worked with birds and tiger beetles since he was a teenager in Minnesota. His research has spanned habitats from desert grasslands to tropical rain forests, and he has co-authored eight books ranging from insect field guides to wildlife guides for ecotourists.

For further information about tiger beetles, see Tiger Beetles: the Evolution, Ecology, and Diversity of the Cicindelids, by David L. Pearson and Alfred P. Vogler (Cornell University Press, 2001), and Arizona State University's "Ask A Biologist" web site.



Publication of excellent field guides has boosted interest in tiger beetles. Six-spotted tiger beetle (*Cicindela sexguttata*), photographed by Bryan E. Reynolds.

Watching the Devil's Horses Pass By

Celeste Mazzacano

The sun is burning off the dawn mist as we jolt down a pot-holed road on the Caribbean coast of Mexico. Cows gaze at us incuriously from wetland pasture on the left, while malachite (*Siproeta stelenes*), yellow-fronted owl (*Caligo telamonius*), and postman (*Heliconius erato*) butterflies are beginning to fly through the forested hill rising to our right. Traveling with Doug Taron of the Peggy Notebaert Nature Museum in Chicago, my destination this morning is a raptor-banding station at Cansaburo operated by Pronatura, a nonprofit organization dedicated to conserving Mexico's wildlife. Our companion on this trip is Elisa Peresbarbosa Rojas, a conservation assistant with Pronatura Veracruz, who draws our attention to a collection of hawks circling lazily in the

morning sky. These birds are just a few of the participants in the *Río de Rapaces* (River of Raptors), an annual migration of five million birds of prey—more than two dozen species—flying south over the state of Veracruz from late August to mid-November.

It is not, however, the spectacle of eagles and hawks that has drawn us here on this early-October day. Pronatura Veracruz has monitored this raptor migration since 1991 and, in the course of their counting, they consistently observe other annual migrants: darting swarms of thousands of dragonflies, known locally as *caballitos del Diablo*—the Devil's horses. These flights of dragonflies have also been observed at inland observatories in the cities of Cardel and Chichicaxtle.



The wandering glider (*Pantala flavescens*) holds the record for the longest migration—more than eleven thousand miles—by an insect. Photograph by Netta Smith.



Large, colorful, and easy to identify, the common green darner (*Anax junius*) lends itself well to monitoring by citizen-scientists. Photograph by John C. Abbott.

Migrating dragonflies may be a surprise to many people. The monarch butterfly (*Danaus plexippus*) is the best-known insect migrant, but the aptly named wandering glider (*Pantala flavescens*), a dragonfly found on every continent save Europe and Antarctica, easily dethrones the monarch as the insect long-distance champion. In North America the wandering glider migrates along the East Coast, but it is its flight across the Indian Ocean that is the most remarkable. Riding the monsoon winds, the glider island hops from India to east and southern Africa; subsequent generations return by following the continental coastline back to India. This round trip of more than eleven thousand miles (nearly eighteen thousand kilometers) is almost twice the maximum distance of the monarch's migration.

After negotiating the steep climb to the hilltop banding station, we find

ourselves eye-to-eye with a red-faced dragonlet (*Erythrodiplax fusca*) perched motionless on a leaf, its wings drooping forward in the characteristic pose of these small skimmers. A few common green darners (*Anax junius*) flash by, followed by a tandem pair of red saddlebags (*Tramea onusta*) heading south. Doug and I position ourselves in a small thatched blind, doing sets of timed counts to estimate numbers of passing dragonflies. For the first hour, our counts range from twenty-three to thirty-four dragonflies per three-minute interval—as many as 680 in an hour—a promising start to the day. But, as the morning progresses, the winds strengthen, the sky becomes overcast, and dragonfly activity ceases.

Unfortunately, this weather pattern persisted for the remainder of the week and we didn't see any further dragonfly migrations during our stay. This was



The band-winged dragonlet (*Erythrodiplax umbrata*) is one of eighteen dragonfly species in North America that regularly migrate. Photograph by Celeste Mazzacano.

frustrating but these flights are known to be sporadic and discontinuous, with large numbers moving in mass flights for a few days followed by gaps in which few to no migrants are observed, so even had the weather been perfect we still might have seen no dragonflies. Were the ones we counted that first day part of a true migratory cohort or simply a handful of residents moving south along the coast with the winds? This is a question we were unable to answer, and one that will require future study.

Dragonfly migration is not a newly recorded phenomenon; the first written reports of mass migration date back to the mid-nineteenth century. Migrations occur on every continent but Antarctica, and flights are often seen following such topographic edges as ridges, cliffs, coastlines, and lake shores. North America may have as many as eighteen migratory dragonfly species, including the

wandering glider; some engage in annual seasonal migrations and others are more sporadic. The best-known migrant dragonfly is the common green darner, which makes mass flights each fall in the thousands or millions, traveling from southern Canada and the northern United States down into the southern United States, northern Mexico, and parts of the West Indies. Midwesterners can follow clouds of migratory dragonflies along the shores of the Great Lakes, while residents of western states may see thousands of variegated meadowhawks (*Sympetrum corruptum*) sweeping south in the fall. Other North American dragonflies that are considered regular migrants are the band-winged dragonlet (*Erythrodiplax umbrata*), the spot-winged glider (*Pantala hymenaea*), and several species of saddlebags (*Tramea*).

Confirming a species as a true migrant is complicated, as dragonflies are strong fliers and may disperse over long distances if the habitat in which adults emerged becomes unsuitable. Furthermore, the magnitude of migration can differ from year to year—and from day to day within a given year—making it difficult to observe, and documentation of springtime’s smaller returning flights is sparse. Identifying the species in a mass flight can also be challenging, as individuals may fly well overhead; a glimpse from below of flashing wings and patterned abdomens may be all an observer has to go by.

Although dragonfly migration has been documented for well over a century, there is still much to be learned about this phenomenon. For example, we lack basic information, such as what environmental cues trigger migratory behavior and where the dragonfly overwintering

grounds are. We don't know details of how the dragonflies migrate: Do individuals that take wing in Canada alight in Mexico or do they routinely join and leave a migratory flight? How do they navigate along the flight path? Nor do we know whether the individuals that overwinter in the south fly north in the spring, or whether migrants mate and lay eggs at suitable habitats along their routes. In some respects we are in a position similar to that of biologists studying monarch butterflies forty years ago. Although we know there is a phenomenon, we know little about it.

In an attempt to answer these and other questions, dragonfly experts, conservationists, and federal agencies have spearheaded the formation of the Migratory Dragonfly Partnership, a collaboration aimed at better understanding and conservation of dragonflies and their migration. In December 2010 a meeting was held in Austin, Texas, to determine

the structure of the group and establish its working priorities. Scott Hoffman Black, executive director of the Xerces Society, was named chair of the new partnership, with John Abbott of the University of Texas at Austin as vice-chair. The author and her companions at Cansaburro, Doug Taron and Elisa Peresbarbosa Rojas, are members of the partnership, as are Jim Chu, Carol Lively, and Michael J. Rizo, U.S. Forest Service International Programs; Ralph Grunzel, U.S. Geological Survey; Matthew Jeffery, Audubon Society International Alliances Program; Colin Jones, Ontario Ministry of Natural Resources, Canada; Peter Marra and Colin Studds, Smithsonian Conservation Biology Institute; John Matthews, World Wildlife Fund Freshwater Program; Mike May, Rutgers University; and Dennis Paulson, Slater Museum of Natural History, retired.

The goal of the Migratory Dragonfly Partnership is to combine research and



The variegated meadowhawk (*Sympetrum corruptum*) migrates along the Pacific coast in the fall. Photograph by Dennis Paulson.

citizen science with education and outreach to gain better understanding of North America's migrating dragonflies and, in time, to promote conservation of the habitat on which they rely. The partnership will begin by focusing on two major initiatives. The first involves building a network of citizen-scientist monitors across Canada, Mexico, and the United States to track the spring and fall movement of the four most common migratory species in North America: the common green darner, variegated meadowhawk, wandering glider, and black saddlebags. The partnership hopes to develop the tools and resources needed to enable participants to monitor the timing, location, duration, and direction of travel of migratory dragonfly flights, and to identify the species involved. Regular monitoring and centralized reporting via the Odonata Central web site will facilitate identification of changes in species' ranges, increase public awareness of the importance of odonates (dragonflies and damselflies), and enable additional conservation attention to be focused on vulnerable species and habitats.

The second major initiative involves using isotopic signatures (also called isotopic fingerprints) to determine how far a migrating dragonfly has traveled from its point of origin, a technique that has been used in the study of migratory birds. Isotopes are different forms of a chemical element, each with a slightly different atomic structure; these differences vary characteristically with latitude. For dragonflies, an isotopic signature is the ratio between stable isotopes of hydrogen—a component of the water in the wetlands and streams in which the larvae live during develop-

ment—traces of which remain locked into the wing tissue of the adult following emergence. By comparing the ratio of hydrogen isotopes in its wings to that of the water body where the insect was captured, researchers can estimate how far a dragonfly has moved from its emergence site, measured in degrees of latitude. Such isotopic data will increase our understanding of the points of origin of dragonflies in a mass flight, better delineate southern and northern endpoints of migration, and help distinguish migratory individuals from residents.

North America's migrant dragonflies are not currently rare or endangered, but, with the mystery surrounding migratory cues, pathways, and overwintering grounds, we could put dragonfly migration at risk without detecting it until it was too late. Continuing threats to wetland habitats, coupled with the effects of global climate change, could alter environmental cues for migration, affect the timing of larval development and adult emergence, disrupt migratory corridors, or render overwintering habitat unsuitable. In finding answers to the many questions about dragonfly migration, we will better understand the role of this behavior in the survival of migratory species. This project will also help increase conservation of wetland habitat for all odonates, ubiquitous or rare, ensuring that dragonflies by the millions remain on the wing across North America for years to come.

Celeste Mazzacano is staff scientist and director of the Xerces Society's Aquatic Program, for which her work addresses invertebrates in streams, wetlands, bogs, and springs.

Thomas Eisner

It was with great sadness that we learned of the recent death of Dr. Thomas Eisner. Tom was president of the Xerces Society for many years, but his contributions to our knowledge of insects and their conservation go far beyond that role.

Many people know the work of Tom Eisner without realizing it was his. His photographs of a tethered bombardier beetle twisting its abdomen to squirt a boiling-hot chemical directly at its attacker have been widely published and are instantly recognizable. They also elegantly encapsulate his life: his acute observations of natural history led to the innovative design of an experiment to investigate the little-known subject of the ways insects use chemicals, and it was all captured with top-notch photography. The only thing that's missing is music. Tom was a concert-grade pianist,

and a piano was a permanent fixture in his Cornell University lab.

At Cornell, Tom's research crossed boundaries between disciplines as he pioneered the field of chemical ecology. He explored the ways in which insects use chemicals to communicate, mate, defend, and eat. When teaching, his lectures were standing-room only.

Tom believed that scientists had an ethical obligation to be conservationists. As a tireless advocate for invertebrates he spoke out on issues ranging from the protection of tropical forests to endangered species. He also was a gifted writer, with more than five hundred articles and books published.

"Once you fall in love with them, you can't fall out of love," he said of insects in an interview on National Public radio. "There's no end to the marvel."

Xerces Moves to Protect Cold-Water-Dependent Insects

Among the animals most threatened by climate change are those that depend upon cold-water habitats. They require cool, clear rivers and streams fed by glacial meltwater and snow melt, two sources that are becoming less dependable in the face of a warming climate and changing precipitation patterns.

It is vital that we ensure that the creeks these species live in are not further degraded by water diversion, grazing, extensive recreation, pollution, and other activities. The Xerces Society has asked for Endangered Species Act list-

ing for the most vulnerable cold-water invertebrates—the Arapahoe snowfly (*Capnia arapahoe*), the western glacier stonefly (*Zapada glacier*), the Gila mayfly (*Lachlania dencyanna*), the straight snowfly (*Capnia lineata*), and the Idaho snowfly (*Capnia zukeli*). ESA protection would mean that habitat of these insects would be protected and restored.

To date, the U.S. Fish and Wildlife Service has responded on just one of these species, the Arapahoe snowfly, determining that protection may be warranted and initiating a status review.

Xerces Ramps Up Efforts to Protect Bumble Bees

Recent work by the Xerces Society and leading bumble bee researchers has established that at least five species of formerly common North American bumble bees are declining and at least two species are now facing extinction. The Society is leading efforts to protect the most imperiled bumble bees and educate people about how they can help these animals.

A petition was submitted to the U. S. Department of Agriculture's Animal and Plant Health Inspection Service in early 2010 to request regulation of the interstate shipping of commercial bumble bees in order to protect wild bees from diseases carried by these shipments. This action was supported by many scientists, citizens, and farming and conservation groups. In addition, working with Dr. Robbin Thorp, we filed a petition to ask the U.S Fish and Wildlife Service to list Franklin's bumble bee

(*Bombus franklini*) as endangered under the Endangered Species Act.

In November 2010 a diverse group of researchers, conservation groups, commercial producers, and agencies gathered at the St. Louis Zoo to develop a conservation strategy for North American bumble bees. We worked with multiple partners to convene this meeting, including the Conservation Breeding Specialist Group of the International Union for Conservation of Nature (IUCN), the St. Louis Zoo, the USDA's Pollinating Insects Research Unit, and the University of Illinois. The meeting enabled unprecedented cooperation, which we hope will culminate in an effective conservation plan.

The Society also helped launch the IUCN Bumblebee Specialist Group, which will engage researchers to conduct a global status assessment of the world's approximately 250 species of



Rusty-patched bumble bee (*Bombus affinis*), photographed by citizen monitor Johanna James-Heinz in Peoria, Illinois.

bumble bees, in order to prioritize their conservation. The group is chaired by Dr. Paul Williams of the Natural History Museum in London; Sarina Jepsen, director of the Xerces Society's Endangered Species Program, is deputy chair.

Over the past three years, Xerces has engaged hundreds of citizens to search for bumble bees and submit their photographs to the Society. This project

has been highly successful at expanding our knowledge of where rare and declining species still occur. For example, the highly imperiled rusty-patched bumble bee (*Bombus affinis*) is known only from a few locations in six U.S. states and one Canadian province. Discoveries of this species in Massachusetts, Minnesota, and Pennsylvania were made by Xerces Society citizen monitors.

Advocacy Pushes County to Protect Rare Fender's Blue Butterfly

Fender's blue (*Icaricia icarioides fenderi*) is an endangered butterfly living in Oregon's Willamette Valley. The butterfly's host plant is Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*), which itself is threatened. Since 2001 the U.S. Fish and Wildlife Service has documented incidences in which Yamhill County's roadside-maintenance activities have harmed the lupine in violation of the Endangered Species Act. These activities impact the butterfly as well.

Recently, working with a coalition of local citizens and conservation groups, the Xerces Society sent the County a notice of intent to sue. As a direct result of this action, Yamhill County is developing a Habitat Conservation Plan to guide its road-maintenance efforts to avoid further harming the Fender's blue. Where disturbance cannot be avoided, the plan will specify ways in which the County can mitigate for the harm it has caused.

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THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION

4828 Southeast Hawthorne Boulevard, Portland, OR 97215

telephone 503-232-6639 fax 503-233-6794 info@xerces.org www.xerces.org



Residents of temperate areas may think of crabs as marine creatures, something to look for on beach trips, but, in warmer regions, some crabs—including this *Potamonautes* sp.—have adapted to life on land. Photographed in South Africa by Piotr Naskrecki.

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Our cover photograph is of a woollypod milkweed plant (*Asclepias eriocarpa*). With more than a hundred species in North America, milkweeds support a highly diverse community of insects. Photograph by Aaron Schusteff.