By Terry L. Erwin and Kjell Sandved

Chirp and rattle, dart and glitter!

A world of exotic creatures that achieve success through diversity is captured alive in the Smithsonian's new Insect Zoo

First you hear them, like the sounds of a warm summer day along the Appalachian Trail. Then you see them: creatures with piercing chirps and loud rattles, bizarre shapes and brilliant colors, penetrating eyes and darting movements. It's all part of the new Insect Zoo at the Smithsonian's National Museum of Natural History.

But don't stop at the entrance, don't be *entomophobic* (deathly afraid of insects). If you are entomophobic, the Insect Zoo will help you learn there is little reason to be frightened. Insects and their relatives are friends of Earth in many ways, and most of them are harmless (especially in the Insect Zoo, where they are all behind Plexiglas).

In 1974, Porter M. Kier, director of the National Museum of Natural History, and his scientific staff decided it was time to establish a new exhibit hall devoted solely to insects and their relatives. Why? No hall had ever before been given over to "bugs." And the public is coming to realize that eight out of every ten species on Earth are insects or their relatives, and that there are more than a million species of insects. We are now more aware than ever how much these creatures affect our lives: that more than ten percent of our crops are destroyed each year by insects; that more than 98,000 tons of delicious honey are made in the United States by bees each year; that millions of tons of the world's decomposing garbage are cleanly processed by scavenging "bugs"; and that without butterflies flitting in sunny meadows and crickets singing in the humid evenings, human life would be quite dull.

Upon entering the Insect Zoo, you are immediately drawn to the Arthropod Bizarre, a bazaar of bizarre living giants among modern day arthropods. You realize, then, that there is more to the exhibit hall than "insects." There are five common classes of arthropods: insects; spiders and scorpions; centipeds; millipeds; and crustaceans (such as crabs and sowbugs). Arthropods are animals with a segmented body, jointed legs and an external skeleton. Many kinds are on display in the Insect Zoo. A careful reading of the printed matter surrounding the Arthropod Bizarre gives perspective to the world of "bugs." The percentage of the world's animals that are arthropods (78 percent) is compared with other invertebrates such as snails, starfish and worms (16 percent), and with vertebrates such as frogs, snakes, monkeys and Man (six percent). A chart created by Beth Miles, the hall's designer, shows the length of time arthropods have been evolving on Earth (more than 500 million years).

With this knowledge, you are now ready to embark on an adventure through a living microworld of diversity—diversity in habitats, diversity in feeding techniques, diversity in life histories and diversity in structure, shape and color. The theme of the Insect Zoo is "success through diversity." Text and textbooks are provided in unique ways. While on your adventure you will come across not only printed text next to the animals and textbooks in a recessed library for your use, but also walking-talking "textbooks" in the form of volunteer docents. Zookeeper Sheila Mutchler recruits docent volunteers through the Museum's Office of Education, radio spots and the District of Columbia's "School without Walls." The docents tell visitors about the animals on display, and they feed the animals at scheduled times in view of the public. Zookeepers Lynda Richards and Bruce Daniels have chosen active, large arthropods for feeding demonstrations which stir great excitement among the visitors (and the volunteers who usually do the feeding).

With the repetitive rustling of the reddish rear wings of great lubber grasshoppers coming from across the room, you continue through the world beneath the surface of a marshy pond. Water beetles and damselfly naiads, immature dragonflies and water scorpions gracefully move in their watery world of suspended oxygen. Each has special ways of breathing: the water beetles capture bubbles of oxygen from the surface on specialized hairy patches or under their wing covers, the naiads have gills, and the water scorpions use a strawlike device reminiscent of James Bond hiding underwater breathing through a reed.

A curator in the department of entomology, Dr. Erwin doubles as adviser to the Insect Zoo.

Suddenly your eye catches movement on the nearby pond surface. You find yourself alongside a living ecological transect, some 50 feet long, with a pond at one end, a grassland in the middle, and a forest at the far end; a sign overhead says WHERE ARTHROPODS LIVE. Again your eye picks up movement on the pond surface. It's a whirligig beetle, another, a third; the pond is teeming with them! These strange beetles have two pairs of eyes, one pair modified for watching above in the air and the other for watching below in the water. Their legs are highly modified oar-like devices which allow the beetles to swim erratically and rapidly. Usually they are searching for food or mates and often compete for food with the familiar water striders, also seen on the pond surface. Up the slope and around a large stone lives a colony of ant-lion larvae or doodlebugs. These strange-looking creatures with long, tonglike jaws (mandibles) lie in wait for prey at the bottom of small conical pits made in sandy or dusty soil. Passing ants or other insects sometimes walk along the edge of the pit and lose their footing, tumbling to the bottom where they are impaled on the doodlebug jaws, then drained of their life fluids. Doodlebugs dig and maintain the cone-shaped pit with quick flips of the concave head as they turn in a circle. Sand and dust are cast up and out, evenly forming the symmetrical pit—an elaborately styled but simple pitfall trap of the sort now used by entomologists to catch ground-dwelling arthropods.

There is so much going on in the large habitat enclosure that visitors often sit for an hour or more watching nature—close up. Alongside is a series of clear plastic enclosures, each illustrating how insects and their relatives have adapted to Earth's newest and most dominant species—us. Arthropod genetic flexibility and short life cycles have allowed them great latitude in adaptations and made it possible for them to invade new habitats, especially those made by human beings. You see cockroaches under the sink, sowbugs in the basement, Colorado potato beetles in the garden and termites in wooden structures.

Another chance for honeybees

Beyond the habitat section are two signs: HOW ARTHROPODS GROW and HOW ARTHROPODS COOPERATE. No story of insects would be complete without *metamorphosis* and *honeybees.* Arthropod growth is accomplished by molting, or shedding the external skeleton, but different groups have different ways of doing this. The classic case of butterflies is familiar to almost everyone. The process begins with an egg hatching to a caterpillar, the caterpillar pupating to a chrysalis, and finally the beautiful adult butterfly emerging from the chrysalis. In

A young visitor holds a "hickory horned devil," the five-inch larva of the royal walnut or regal moth.

These regal moths pupate on the ground without forming a cocoon. The wingspan may reach six inches.

Photographs by Kjell Sandved

The prominent horns of male scarab beetle attract a crowd. The female dug herself in under rotten wood.

other groups, such as silverfish, the young and adults look almost exactly alike.

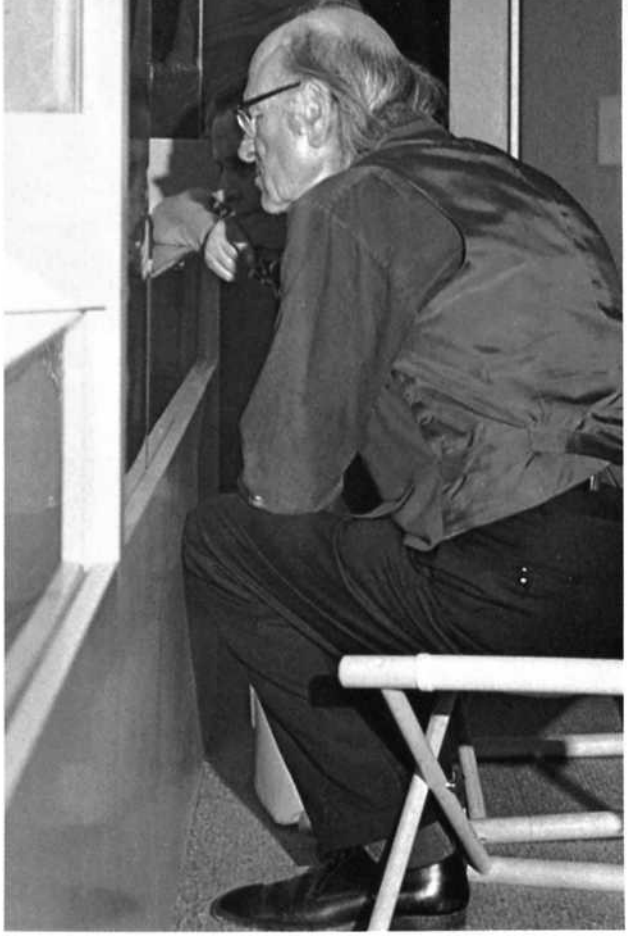
Near the metamorphosis display is one of the most popular exhibits in the Insect Zoo—the observation beehive with its four tiers of honeycomb, marked queen, and hundreds of busy worker bees. The Smithsonian began a display of honeybees in 1926 and the First Lady, at that time Mrs. Calvin Coolidge, was a frequent visitor to the beehive, often bringing her friends. One day the bees swarmed and settled—where else?—in the backyard at the White House. The bees were soon evicted, and Mrs. Coolidge's interest in them cooled. For years after that bees were not exhibited at the Smithsonian. When, later, another colony was installed, the bees swarmed to a nearby air-conditioner; later still, in 1963, the resident colony fell victim to a "silent spring" because of heavy doses of insecticide sprayed on the Mall. The present colony in the Insect Zoo is seemingly quite happy, however, and is busy gathering spilled soda pop from the Mall's tourists.

After a look at the beehive and the excitement of finding the queen, your attention is diverted by small pieces of green leaves and yellow blossoms moving through long transparent tubes. On close examination you see that each piece is being carried by a small reddish ant. You have now discovered the most fascinating story told in the Insect Zoo—the story of the leaf-cutter or fungus ants. As in the beehive and termite colonies, these ants have a strict caste system with a queen, male reproductives, and workers that act as soldiers, scouts, nursery attendants, guards, and garbage collectors.

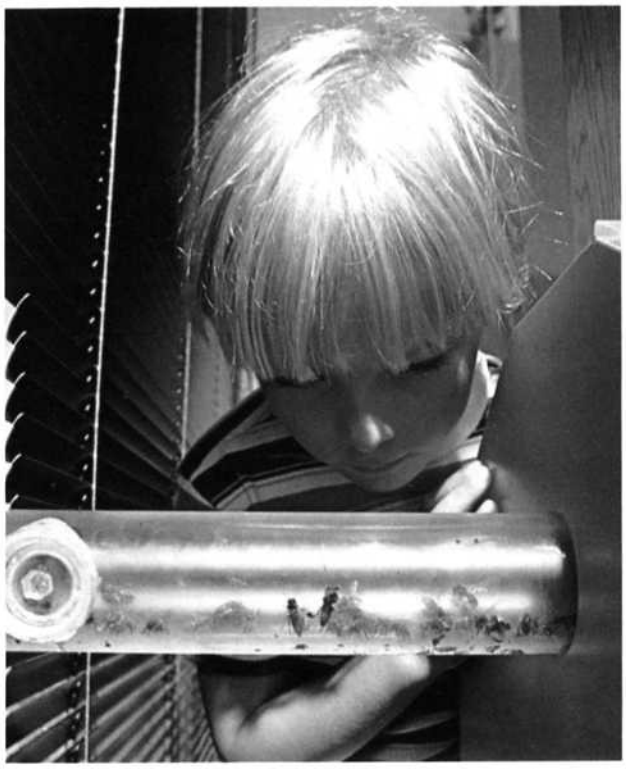
Each day fresh flowers and leaves are placed in a large enclosure connected to the ant nest by the transparent tubes. Scout ants discover the food source and make scented trails to the nest, where they "recruit" workers. At the food source, the workers cut pieces of petals or leaves and carry them back along the scented trail. The cut pieces are much larger than the ant, and would correspond to our carrying a 30-by-10-foot piece of wood board. Often small "police ants" ride on the cut pieces with their mandibles tilted, supposedly to attack enemies. The cut pieces are carried to a growth chamber which is temperature- and humidity-controlled by the ants themselves. Nursery-attendant ants "lick" each piece to protect it from growth of "unwanted" fungi; then the ants' own fungus is grown on the wilting pieces. By continually cutting the fungal filaments, the ants grow "Kohlrabi head," swellings of fungus rich in protein—their food.

As in any society, including our own, there is always leftover garbage. Among these ants, some workers are trash collectors. They usually dump the trash outside the nest in one place (unlike human litterbugs), which can be seen in the display at one corner of the food source enclosure.

Continuing through the zoo, you next come to a sign that says HOW ARTHROPODS EAT. Early in arthropod evolution, legs became mouthparts, and now, some 500 million years later, there is great diversity in use of these modified legs—chewing, sucking, filtering, sponging, rasping and slashing. Some highly specialized ocean-going forms do not even have mouth-



A couple reflects on butterfly mimicry and species that use it to deter would-be predators.



A colony of bees uses clear tube to get from their hive to flowers—and spilled soda—on the Mall.

parts; rather, they absorb nutrients through their skin. Each feeding method is described in filmed cartoons followed by filmed close-ups of arthropods actually feeding. Beside each film screen, the live chewers, suckers, filterers and others are seen doing their thing. With all these kinds of feeding behavior, there is scarcely any kind of organic matter that does not serve as food. There are even certain flies that live in jet fuel, and a beetle that bores holes in lead cables.

Next you see another sign, ARTHROPOD SIZE, SHAPE, AND COLOR; you are in the final section of the Insect Zoo. Curiosity draws you to a large black box labeled SIZE. Under movable magnifying glasses you see alive some of the world's smallest arthropods—mites, springtails and flour beetles. In front of you, there is a pyramid of mounted specimens ranging in size from beautiful beetles and bugs one-inch long to a three-foot spiny lobster. Press a button and the pyramid disappears as the ghostly image of a nine-foot Japanese spider crab, the largest living arthropod on Earth today, looms into view.

As with human beings, color plays an important role in the lives of insects. In the Insect Zoo you will see living displays of camouflage, disguise and mimicry. Monarch butterflies, so spectacularly colored with orange and black stripes, are almost perfectly mimicked by viceroy butterflies. Scientists have found that the monarch tastes bad to birds and frogs and other hungry animals. The viceroy gains protection because animals that have tasted a monarch will not, henceforth, touch anything with orange and black stripes.

Across from the monarchs and viceroys is another story of color, *cryptic coloration*. A yellow crab spider is poised in wait for prey on a yellow goldenrod. Visitors often need help to find the spider, the color blend is so good. Green katydids stand on green leaves and are equally difficult to find. A brownish rove beetle runs on soil of virtually its own color. These animals have evolved the coloration of their background, either to hide from predators or to hide from their prey. Nature puts simple principles to many uses.

Color is also used as a warning device. Reds, oranges, yellows and black are variously combined in rememberable patterns. These colors are usually combined with the arthropod's ability to sting (as with the Zoo's velvet ants) or bombard (as with the bombardier beetles which spray a toxic chemical at 212 degrees F, accompanied by a loud pop or hiss and a puff of white water vapor). Once a predator has experienced these nasty devices, it avoids certain colors and color patterns during food searches. Animals which adopt these colors and patterns are thus pro-