Letter from the Desk of David Challinor
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As visitors exit the Zoo's Amazonia exhibit, they face an extraordinary display—hanging on the wall is a 3 ½' x 6 ½' panel depicting a Grant's stag beetle. On closer inspection, one sees the beetle image is constructed from more than a thousand pinned beetles of about 100 species. An actual Grant's stag beetle (3 ½" long) is mounted at the bottom of the panel for comparison. Within the animal world almost 300,000 species of beetles (order: Coleoptera) have been described and entomologists estimate that this number comprises only between a quarter to less than a tenth of beetle species still awaiting collection and identification. In comparison, only about 4,000 mammal species have been named and it is a rare event when a new one is found. With so many niches to fill, beetles have evolved into amazing congeries of different shapes, sizes and dazzling iridescent colors. This month's letter will delve into some examples of particularly novel forms of coleoptera that play important roles in our lives and in the world around us.

A childhood favorite is the handsomely marked ladybug of which there are about 4,000 species throughout the world. In the fall, when ladybugs often enter houses in search of overwintering sites, they delight children with their black-spotted, bright red elytra (the hard covering that protects the fragile wings folded underneath). When my siblings and I were children and they crawled on our hands, we used to sing "Ladybug, ladybug fly away home, your house is on fire and your children will burn." We would then thrust up our hands to launch them in flight.

Years later, I learned how valuable ladybugs are to farmers and home gardeners. The nymph or larval stage is a small, black, flattened, voracious predator of aphids and scale insects, two common garden pests. During the 1950's in Bermuda, large canisters of adult ladybugs were imported from California in a desperate attempt to control an accidentally introduced scale insect that had infested Bermuda's dominant tree—its cedar (*Juniperus bermudiana*). Cedar mortality was close to 90% and the archipelago was covered with bleached, rot-resistant dead cedars. Sadly, the ladybugs never took hold in large enough numbers to be effective control agents and most were blown out to sea by fall storms.

Besides ladybugs, children delight in fireflies or lightning bugs, as some call them. On mild August evenings, these courting beetles flash cold light from complex three-layered organs. The protoplasm of the innermost cellular layer is crammed with microscopic crystals of uric acid salt, whose surfaces reflect light outwards. The middle cell layer is the actual "light cells." The mitochondria of these cells are filled with rounded or elongated particles, which supply the energy to operate the flashing. A complex chemical system produces the light and controls the pulses. The third or outer layer is completely transparent and serves as a window through which the light shines.

In my childhood days, when milk came in glass bottles, I would race around the back lawn and adjacent hayfield of our summer home catching fireflies and carefully putting them in the milk bottles to light the dark when we were put to bed. I have often relived those happy times with my grandchildren on the same lawn and field.

There are over a thousand species of fireflies, most of which live in the tropics. In Costa Rica there is even a species that flashes synchronously to confuse predators. In most species the males flash in a species-specific pattern and are answered in a matched pattern of flashes by receptive females, who patiently sit on grass blades. In the North American species, the male looks for the responding flash to occur exactly two seconds after his at which time he flies to the female and checks her out with his antennae; she then checks him with hers to ensure that they are of the same species. Only when this ritual has been completed will the pair breed.

In the 1930's, the east coast was invaded by Japanese beetles. These iridescent blue-green insects attacked rose bushes and were particularly partial to linden tree foliage. I remember the sails of my boat often being covered with beetles when the wind was off-shore. The larvae overwintered in the soil, particularly under lawns, and in the spring the beetle grubs would feed on grass roots. Huge brown patches covered our lawns where the roots had been consumed and the interlocking dead grass foliage on the surface could be rolled up like a carpet. As children, we picked endless beetles from the flowers and dropped them in a can half-filled with kerosene. I have described this beetle invasion to illustrate how transitory such assaults can be. Within a few years scientists had isolated a fungus that attacked and killed Japanese beetle grubs in the soil. The fungus spores were sold in a powder form, which was broadcast on lawns. It was so effective that the invading beetle soon became rare; it has been years since I have seen one.

Less successful have been efforts to control the European elm bark beetle. During my lifetime, I have witnessed an impressive change in the tree composition of New England and mid-western towns. The towering deliquescent (wine glass-shaped) American elms once dominated the small town scene. New Haven was known as Elm City because of its giant elms on the green and along its streets. When I was there at graduate school in the 1950's, the big elms had started to die and today there are few if any of the giants left.

The elm bark beetle carries a fungus on its body, and when it bores through the elm bark, it makes galleries through the cambium layer of cells. These are the cells that produce xylem and phloem cells that transport nutrients up and down the stem and cause the tree to grow in diameter. When the fungus reaches the cambium, it sends its mycelia (hair-like "roots") through this crucial, single cell-wide layer. When the mycelia meet on the opposite side of the tree, the stem is girdled and the tree dies.

Although we blame the Dutch by naming this plague "the Dutch elm disease," we must remember that beetle traffic is two-way; European potato farmers still struggle with the Colorado potato beetle—a ladybug-sized beetle with horizontal yellow and black stripes. It consumes potato leaves, but with quarantines and new effective sprays, it is no longer the threat in Europe that it once was.

This letter's final beetle examples are the scarabs. This is a large family found in both the new and old world. They are remarkable for the iridescent elytra of many species. The February 2001 National Geographic published a beautifully illustrated article on spectacularly colored scarab beetles from Honduras. Their dazzling colors have long attracted attention in many cultures. The pharaohs of ancient Egypt, for example, used to be buried with life-size jade replicas of the local sacred scarab inserted between their toes. For years my father kept one of these jade scarabs, housed in a small gold case, on his watch chain. He bought it in Cairo in 1938, complete with official looking documents attesting to its authenticity. From my own experience with alleged Egyptian antiquities offered for sale, I think my dad "was had."

Although not as brightly colored as some of the iridescent scarabs, but for me more interesting behaviorally, are the coprophagous scarabaeids, better known as the dung beetles (which include the sacred scarab mentioned above). This group is found worldwide except in Australia, where efforts were made to introduce dung beetles safely to bury some of the accumulated droppings of non-native sheep, cattle and camels. Dung beetles first shape fresh mammal dung into a ball and by using their pair of hind legs, roll the ball backwards by pushing it with their two sets of front legs. You have to see these beetles in action to appreciate the effort and skill it takes to roll a dung ball to the nest hole. Once there, the beetle pushes the ball down the hole into an excavated brood chamber. Certain carefully selected balls are modified by the female, who selects the dung source, makes the ball and transports it. Once in the chamber, the female moulds the round ball into a pear shape and hollows a small cavity at the top of the "pear" into which she lays her egg. When the larva hatches, it feeds on its own pellet. Unmodified balls are stored underground as food for the adults. Females of some species actually remain with newly hatched larvae and provide maternal care and protection. Dung beetles often fight over balls and have developed effective tactics to defend them.

The sacred scarab (the one buried with the pharaohs) is an outstanding dung beetle in that its brood chamber is the size of a human fist. Its brood pellet is greater than two inches high (5-6cm) and can weigh up to 1 ½ oz (40g). This is impressive when the beetle itself weighs only about 2gms. The fertilizing effect of all this buried dung has yet to be calculated, but it must be significant.

Recently, Nature (2 September 2004) published a short article about burrowing owls and dung beetles. These owls (S*peotyto cunicularia*) live in southern Florida and the treeless west of the U.S. where they are relatively common. They typically stand by their burrow during the day and surround the entrance hole with mammal dung, a behavior perplexing to ethologists (scientists who study animal behavior). To gain understanding of this practice, a recent Florida experiment by Douglas Levey and colleagues found that when they removed the dung, the owls rapidly replaced it. The scientists tested one theory that the dung might hide the scent of eggs in the burrows from predators. They tested this hypothesis by digging 50 artificial burrows 50m apart and putting five quail eggs in each. Alternate burrows were surrounded by cow dung. The nest holes were checked every two days for 3 ½ weeks and they found that all but one nest had been consumed by predators. They concluded that the dung did not mask the scent of eggs.

They then tested whether the dung was used to attract dung beetles, a major owl prey item. They found that when dung was present, the owls ate ten times more dung beetles than when dung was absent from the burrow entrances. Although the title of the paper was "Use of dung as a tool by burrowing owls," semantically I think of dung as bait. Is bait a tool? From an ethologist's perspective it is, for they define a tool as 1) coming from an external source, 2) being manipulated and 3) conferring a benefit on the user. In this case, the owl may not even be aware of the connection between cow manure and dung beetles. The owl does not have to be conscious of the connection, but only that it is of benefit.

From beetles to owls is one big jump and from owls to animal cognition is another one. For me and most of my colleagues, that is the great appeal of science. Scientists keep asking questions and when a reasonable (not false) answer turns up, they conduct ever expanding inquiries and speculations. With luck and hard work, one may stumble on some unimagined insight into how the world works. The resulting elation from a successful quest when shared with colleagues is reward and incentive enough for most scientists. Perhaps this explains why so many keep active for so long: Charles Greely Abbot, the Smithsonian's sixth Secretary (101); Fred L. Whipple, the director of Smithsonian Astrophysical Observatory who died last month at 97; and the indefatigable Ernst Mayr, still going strong at Harvard after his centennial birthday. Just think how many more letters I can write; I am <u>only</u> 84 years old.

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