Bugs

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“The little things that run the world.”

E.O. Wilson

When we think of insects, we think of mosquitoes, flies, fleas and cockroaches – bugs we would rather do without; nuisances that buzz, bite, sting, make us itch, and carry diseases. Who needs ‘em? Let’s just get out the spray cans and get rid of ‘em! Their extinction would be a blessing.

This attitude is well justified by the harm insects cause us. A term “pest” is defined anthropocentrically as “an annoying thing; a nuisance; an injurious organism.” Thus, insects can be agricultural pests, especially herbivores that use the same resources as humans. Interestingly, in spite of the use of tens of millions of tons of pesticides over the past few decades, crop losses to insects have remained fairly constant. Insects are evolving resistance to these agents as quickly as new ones are being developed.

Insects also transmit deadly viruses, bacteria and protozoans from one person or animal to another. In this capacity, they are “vectors of disease.” Human diseases that are vectored by insects are numerous. The most important is probably malaria where a species of the protozoan, *Prasmodium*, causes the

disease. Female anopheline mosquitoes transmit the parasite from one person to another. Approximately 300 million people worldwide are affected by malaria, mostly in Africa, Asia and Latin America. Well over a million people die of malaria every year. Drug resistance of the parasite has become a serious problem in the last few years.

Other diseases vectored by insects include sleeping sickness (caused by *Trypanosomes* and carried by the Tsetse fly), plague (caused by a bacterium *Yersinia pestis* and carried by fleas), encephalitis (brain inflammation caused by a virus and vectored by mosquitoes), dengue (a fever causing virus that is also transmitted by mosquitoes), and Chaga’s disease (specifically caused by *Trypanosoma cruzi* that is transferred between hosts by “assassin bugs”). These human diseases inflict tremendous suffering and loss, particularly in the tropics. While we consequently consider these insects as terrible pests, they also play important roles in ecosystem maintenance.

As first pointed out to me by Professor Dave Holway, an insect ecologist at UCSD, bugs play central roles in most terrestrial ecosystems. Detritivores are decomposers that play a vital role in the survival of plants, and thus of all life, by recycling nutrients. Among their useful functions, insect detritivores scavenge in every conceivable terrestrial ecosystem, feeding on and recycling dead organic matter and animal excrement. They thereby accelerate processes of decay. Without bugs, our soils and waters would be buried in organic debris.

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Insects are a primary, or in some instances, the *only* source of nutrition for various vertebrates and invertebrates (spiders, birds, bats, etc.). If these source insects were to go extinct, the extinction of the prey organisms would quickly follow. Perhaps of even greater importance, insects function in conjunction with many plants, pollinating flowers, dispersing seeds, and providing chemical protection. Over 100 major crops benefit from bee pollination, and many are strictly dependent on bees for this purpose. Among these crops are almonds, apples, cranberries, blueberries, kiwis, and vine crops. Bees are estimated to be important to a 20 billion dollar agricultural effort in the U.S. alone. For every three bites of food we eat, one is dependent on insect pollination!

Insects serve mankind in numerous other ways. As predators and parasites, they provide biological control of other animal pests and unwanted plants. A single ladybug, for example, eats over 5,000 aphids in its short adult lifetime, but it also consumes other soft-bodied pest insects that feed on plants. Even the alligator-like larvae can eat over 50 aphids per day. Amazingly, there are over 5,000 species of ladybugs – more than all known species of mammals. It's a beetle of unusual beauty that at one time or another has commanded the delight of every child.

The silk moth, *Bombyx mori*, provides us with silk, a fine, strong, soft, lustrous fiber. It has been used in China for over 5,000 years and was exported to the Greek and Roman empires, a trade that brought China great wealth. The Chinese never gave away their secret on how silk was made, and only when Christian monks illegally smuggled silkworm eggs out of the country was China's monopoly broken.

In many cultures, especially in Asia, insects serve as delicacies in the non-western cuisines of the people. In fact, at least 10,000 years ago, our hunter and gatherer ancestors ate bugs to survive. Much later, the ancient Greeks and Romans described their preferences for insects. Aristotle wrote: "The larva of the cicada on attaining full size in the ground becomes a nymph; then it tastes best." And the Old Testament encouraged Jews to consume locusts, beetles and grasshoppers. Saint John the Baptist was said to have survived on locusts when in the desert. The Piute Indians in Nevada were recorded hunting and trapping hordes of crickets which they roasted and ate. Today bugs are traditional food in many cultures across Africa, Asia, Australia and Latin America.

Butterflies, moths, bees and beetles tickle people's aesthetic senses with their colorful exteriors. The ancient Egyptians and neighboring cultures revered species of dung scarab. In fact, they were of religious and symbolic importance as early as 2200 BC, and their religious significance lasted for over 1,000 years! Scarab imagery can be found in the objects of worship and funeral ceremony used by the people in these ancient cultures. Even today, the Chinese hold crickets and other musical Orthoptera in high esteem, while Japanese authors and artists describe and portray the beauty of insects in their works.

Insects (Hexapods) are fantastically diverse. There are over a million insect species described, and there may be as many as 30 million unidentified species. Fifty-six percent of all described species are insects. It is estimated that 64% of all "higher" multicellular organisms may prove to be insects.

Bugs belong to the phylum, *Arthropoda*, which also includes the Crustaceans (about 55,000 known species including lobsters, crayfish and shrimp), the Chelicerates (65,000 known species including spiders, scorpions, mites, ticks and horseshoe crabs), and Myriapods (13,000 species including centipedes and millipedes). Compare these numbers with those of known mammals (4,000) and birds (10,000), where almost all species on Earth are already described and named.

Organisms of the class, Insecta, share a number of relatively unique features as compared to other hexapods. (1) They have three characteristic body segments, the head, thorax and abdomen. (2) Most but not all insects have wings, an important feature for dispersal and escape from predators. (3) They fall into two developmental types. First, the hemimetabolous species have incomplete metamorphosis. This means that they exhibit gradual change throughout development without drastic changes in morphology. By contrast, Holometabolous species display a four stage metamorphosis where eggs hatch into feeding larva; these form resting cocoons or pupa, and the pupa hatch into the reproducing adults. (4) Their large compound eyes are among the best developed of the arthropods. (5) Gaseous exchange is mostly tracheal.

As noted above, there are far more described insect species than all other classes of animals and plants combined. For example, there are ~350,000 known species of beetles, ~125,000 species of flies,

~160,000 species of butterflies and moths, and ~100,000 species of ants, bees and wasps.

Why should insect species be much more numerous than other animal types? First are their small sizes and short life spans. Insects can divide an ecosystem finely, occupying many different niches. Second, insects have been on Earth for 250–300 million years, so they have had time to evolve into a much larger number of species than have more recently arising organismal classes. Third, the capability of most adult insects to fly allows them to disperse, escape predators, find mates and seek optimal conditions. Finally, insects derive benefit by associating with other organisms, particularly plants and other insects. Moreover, they can be

herbivores, parasites, or parasitoids (part parasites and part predators). This last lifestyle is specific to insects. It is possible that diversity begets diversity. It may also be that their four stage developmental cycle offers advantages not shared by creatures with other types of lifestyles.

Man-induced insect imperilment probably has the same causes as for other types of animals: (1) *habitat* loss or fragmentation, (2) *invasive* species introduction, (3) *pollution*, (4) *human overpopulation* and *sprawl*, and (5) *overkilling* (HIPPO). Since we and our biosphere depend so heavily on insects for maintenance, it is considered by many that insect conservation deserves a major effort. Without these little things, the world would not run right!