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INSECTS—NATURE'S HIDDEN GEMS

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ASHIMA
AGE: 15

AVANI
AGE: 11

GIRL SCOUT TROOP 990
AGE: 13

RIA
AGE: 12

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SHAIVI
AGE: 11

Insects are the largest group of animals in the world—there are over a million species of insects, and they live just about everywhere! Insects provide essential services for us and for ecosystems, such as pollination, nutrient recycling, and pest control. Yet, most of us pay little attention to insects. Worryingly, insects also face many threats and, across the globe, their populations are at risk. Understanding insects, their importance in ecosystems, and the threats they face is vital for protecting these amazing creatures. In this article, we highlight our close relationships with insects, and the human activities that impact insect populations. We also present some of the current research efforts to better understand and protect insects and suggest some simple steps that each of us can do to support them.

INSECTA—THE COMPLEXITY OF A CLASS

Insects are everywhere and they come in a variety of shapes, sizes, and colors that allow them to live in almost every habitat on earth (Figures 1A–F). In the scheme that scientists use to group animals, insects belong to the class Insecta, the largest group of living organisms on Earth. There are over one million insect species described, and it is estimated that there are some 10 quintillion (10,000,000,000,000,000,000) individual insects alive at any time on our planet [1].

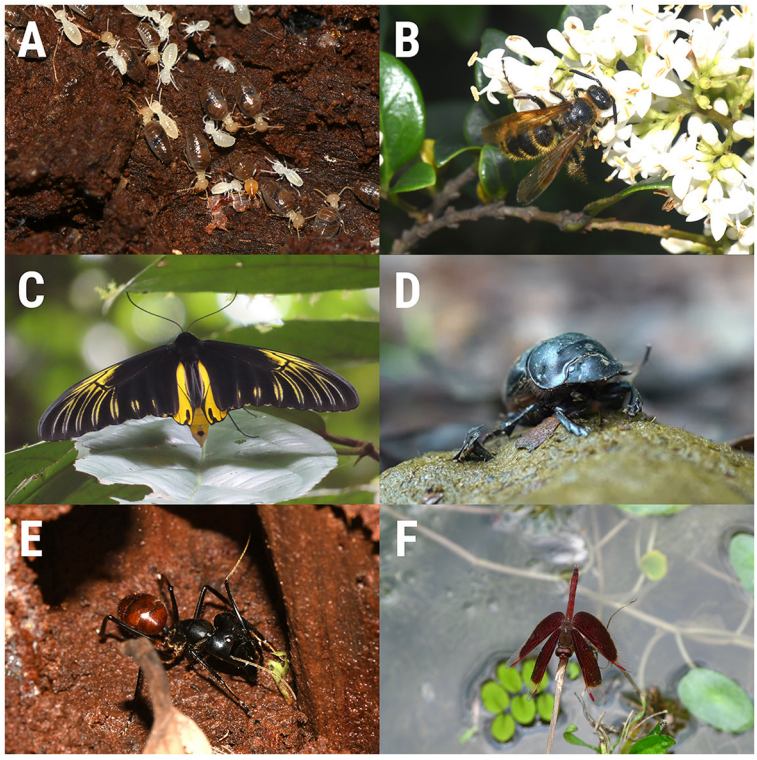

Figure 1

Insects are diverse and can be found nearly everywhere on the planet. **(A)** A trail of termites (*Nasutitermes* sp.) on a fallen tree. **(B)** A female scoliid wasp gathering pollen from flowers. **(C)** A Malay birdwing (*Troides amphrysus*) butterfly perching on a leaf. **(D)** A female *Catharsius dayacus* dung beetle on a dung pad. **(E)** A giant forest ant (*Dinomyrmex gigas*) foraging inside a decaying tree trunk. **(F)** A male common parasol (*Neurothermis fluctuans*) dragonfly guarding its territory from other males. [Photo credits: Calvin Leung **(A, B, E)**, Alexis Goh **(C)**, Marx Yim **(D)** and Xin Rui Ong **(F)**].

When the word "insects" is mentioned, you might think of those that are usually considered as pests, like mosquitoes and cockroaches. Most people are more aware of the few insects that cause problems to humans than they are of the majority of insects that benefit us and the rest of the natural world. The one million insect species that we know about is more than 15 times the number of all mammal, reptile, bird, amphibian, and fish species combined! Of the one million known species, 80% belong to the orders Coleoptera (beetles), Lepidoptera (butterflies and moths), Diptera (flies), and Hymenoptera (ants and bees); with the remaining 20% consisting of other insects such as grasshoppers, cockroaches, termites, cicadas, mantises, and more [2]. Still, scientists suggest that there may be as many as 5–10 million species still waiting to be discovered.

INSECTS AND THE ECOSYSTEM

Insects are important to our ecosystems, and we heavily depend on the **ecosystem services** that they provide (Figure 2). Do you enjoy eating kiwis, cranberries, melons, or cherries? Well, the next time you do, remember honeybees—the primary **pollinators** that enable us to eat all these tasty fruits. Bees, wasps, and butterflies help to pollinate many flowering and crop plant species, which provides us with fruits, flowers, vegetables, and other products such as silk, honey, and wax. Insects are a part of nearly every food chain, meaning that they are a source of food for many larger animals such as birds, fish, reptiles, and mammals—which are in turn eaten by other predators. Without insects, our food chain would collapse, and most animals would not survive. Insects also feed on living and dead matter, helping to break down wastes and speed up the recycling of nutrients in the environment. For example, dung beetles remove dung from the environment, bury it, and allow it to break down into nutrients that cycle through the ecosystem. Other insects act as pest controllers. Predatory ladybird beetles feed on agricultural pest species like mites and aphids, and by doing so they help farmers to increase their crop yields and reduce the use of toxic **pesticides**. **Ecosystem engineers**, like termites and ants, improve the amount of water and nutrients in the soil through their tunneling behavior, helping to transform infertile lands where nothing can grow into fertile ones [4].

ECOSYSTEM SERVICES

The benefits that the natural environment and its organisms provide to humans.

POLLINATORS

Agents of pollination, which is the act of transferring pollen between flowering plants. This process allows plants to reproduce and make seeds.

PESTICIDES

Chemical or biological substances that are used to remove pests.

ECOSYSTEM ENGINEERS

Species that change their surrounding environment so that it becomes better for them to live in.

WHAT KINDS OF THREATS DO INSECTS FACE?

Humans have changed the natural environment so much in the past few centuries that many insects today are struggling for survival. From the use of pesticides and artificial fertilizers to light pollution, noise pollution, and habitat destruction, the survival of insects presently hangs in the balance (Figure 2) [5]. Next, we will tell you about three major threats: agriculture (farming), habitat destruction, and climate change.

In terms of agriculture, humans have already transformed more than half of the Earth's land surface into farmland, to support our growing demand for food. This intensive agriculture has led to the heavy use of chemical pesticides and fertilizers, as well as **habitat fragmentation**, where large and connected habitats are split into small and separated ones. While agricultural techniques like genetically modified foods and chemical fertilizers have greatly benefited society, they often kill other insects, as well as the pest species that they are targeted to kill. Chemical pesticides get washed into soils and waterways, affecting many generations of insects to come.

Habitat destruction is an increasing threat to insects. Clearing land to build cities and other spaces for humans also results in less available habitats for insects to seek shelter, find food, and reproduce.

HABITAT FRAGMENTATION

The process of large and continuous habitats being split into small and separated patches.

Figure 2

Insects provide many benefits to humans and the environment, but at the same time they are threatened by many human activities. (Copyright: Alexis Goh, [3]).

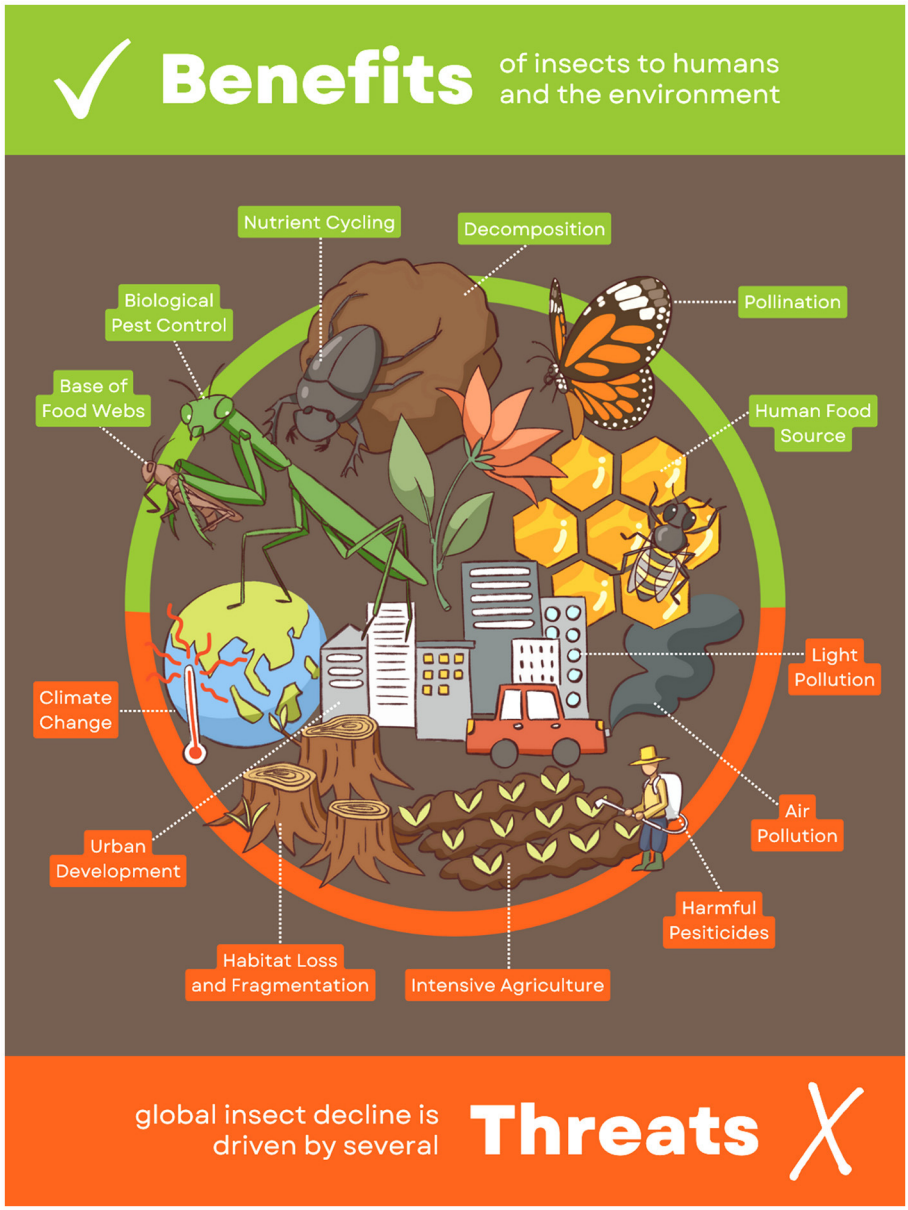

Figure 2

Pollinators are affected by the reduced numbers and diversity of plants that grow on cleared land, which impacts both the health of the pollinators and the survival of the plants that depend on them for reproduction. Decomposers like termites are affected by the loss of dead trees and by damaged soils, which impacts the recycling of nutrients in the ecosystem.

Climate change also affects insects. Plants are affected by changes in climate, which can then affect many of the helpful insects that are closely connected with those plants. For example, if spring flowers bloom earlier due to shorter winters—while pollinator insects are still in hibernation or immature—there will be no insects to pollinate the plants; and later, when the pollinators are ready to feed, their food will

no longer be available. The increased occurrence of extreme weather events, like hurricanes, droughts, and wildfires, is also a great risk to insect life.

ONGOING EFFORTS

The expansion of agriculture to support the increasing amount of food needed by the growing human population has caused large losses of natural habitats that insects live in. However, with a little work, insects can be welcomed into these farming areas as alternative habitats. Banning the use of harmful chemicals and research on bug-friendly pesticides have been steps in the positive direction. However, despite our increased awareness of insects' importance and knowledge of how to save them, scientists urge that more needs to be done on a global level—countries need to work together to preserve insect populations.

NATURAL HISTORY

The study of organisms, like animals, plants, and microbes, in their natural environments and their relationships with each other.

Unfortunately, fewer and fewer kids are learning about **natural history** in school. Natural history teaches us about the natural world and the organisms that live in its various environments. Partly because fewer people are learning about insects, the number of experts who describe and identify insects is decreasing, too. This means that insects are in a very vulnerable position—we may not know enough about them or how to protect or save them, and we may not even realize the existence of some species before they become extinct. This means that we are unable to properly conserve and protect already threatened insect species. Unfortunately, most animal conservation research so far has focused on protecting charismatic species, "cute" species, such as mammals and birds (read more in these Young Minds Articles here and here). If we only focus our studies on charismatic species and neglect the smaller, perhaps less "cute" species such as insects, we will not be able to develop effective conservation plans that consider the importance of insects in keeping ecosystems in balance [6].

HOW CAN YOU SUPPORT INSECTS?

Not all hope is lost—as the saying goes, the journey of a thousand miles begins with a single step. If *you* want to support insects, just remember these three simple steps (Figure 3)!

Step 1: Create Insect-friendly Places in Your Home

Do you think it is really cool to see bees and butterflies flying just outside your window? By creating some insect-friendly places in your home, you can discover the kinds of insects that live around your neighborhood. Try growing some insect-attracting native plants in your backyard or balcony garden. Native plants, which are plants that are naturally found in your area, can serve as food sources and nesting

Figure 3

Three simple ways that you can support insects.

Figure 3

sites for local insect species. Avoid using chemicals like pesticides and herbicides, as these will harm the insects. You can also build insect homes, such as bee hotels, that attract important pollinators like bees and wasps.

Step 2: Participate in Citizen Science Programmes About Insects

You can learn tons of information about insects and get to know fellow insect lovers by participating in **citizen science** programmes! These are programmes in which the community takes part in scientific research through collecting and sharing useful data. Information collected through citizen science programs can provide a wealth of information on insect diversity and population trends, helping us to spot and understand global insect declines. Some programmes are as simple as recording the insect species that you find indoors (Never Home Alone) or in your backyard (Bugs In Our Backyard). You can upload pictures of insects that you encounter on your own onto iNaturalist, and even help others to identify the insects around them.

CITIZEN SCIENCE

Programmes where the general public can take part in scientific research by collecting and sharing useful data.

Step 3: Become an Insect Ambassador

Best of all, be an Insect ambassador by sharing all the cool, fun, and important facts about insects with your family and friends. You can do this by posting amazing pictures and videos on your social media platforms, or you can make a picture collection of insects you encounter. Encourage your family and friends to

participate in citizen science programmes with you! As more people recognize how important insects are, they might choose to join in the insect conservation efforts and help to protect these amazing, important creatures.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ASHIMA, AGE: 15
Hi, I am Ashima. I like to read fiction books and swim. I love to study. My favorite subject is mathematics. Quadratic functions are my favorite topic in mathematics.

AVANI, AGE: 11
Hi, my name is Avani, I like to listen to music, swim and play with my dog. My favorite thing to do is to sing. When I grow up, I want to be a nature conservationist.

GIRL SCOUT TROOP 990, AGE: 13
We are Cadette Girl Scouts who enjoy lots of different sports (soccer, basketball, ice hockey, and gymnastics) and activities (music, crafts, and dance). We like different subjects including math and science. Every year we actively volunteer in our schools and community to make a difference.

RIA, AGE: 12
Hi, my name is Ria. I like to do Taekwondo, dance, and paint. My favorite subjects are science and math and like to make news shows.

RIMA, AGE: 13
Hi, my name is Rima. I like to swim, bake and read books. My favorite subjects are Math and Science and my dream job is computer engineer and astronomer.

SHAIVI, AGE: 11
Hi, I am Shaivi and I like science and math. My hobbies are swimming, arts and crafts, and experiments. My dream job is to become a scientist, probably.

AUTHORS

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Xin Rui is a Ph.D. candidate at the Asian School of the Environment in Nanyang Technological University. She graduated from the National University of Singapore with a B.Sc. in Life Sciences, specializing in Environmental Biology. Since her undergraduate years, Xin Rui has a soft spot for dung beetles and is now studying their diversity and interactions with mammal communities in Southeast Asia. She is also unraveling the status of insect records and research in Southeast Asia, which will help identify and address knowledge gaps that impede insect conservation efforts in the region. *ongxinru001@e.ntu.edu.sg

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Tharaka is a Ph.D. candidate at the Asian School of the Environment in Nanyang Technological University. He graduated from Guangxi University with a Master's degree in Ecology. His primary research interest is agroecology, which focuses on using ecological knowledge to promote sustainable farming practices. He works to identify economically attractive ways to boost biodiversity in agricultural ecosystems. Tharaka enjoys developing statistical models about different living things and their roles in ecosystems. He is also passionate about the taxonomy and conservation of wild orchids.

LI SI TAY

Li Si graduated from the Asian School of the Environment in the Nanyang Technological University and majored in Environmental Earth Systems Science (Ecology specialization). During his undergraduate years, he investigated the diversity of invertebrates living in the soil and leaf litter across forest patches of increasing disturbance. Using 3D-printing, he also designed field equipment to test if decomposition rates are different between these forest types. From this study, Li Si seeks to determine the importance of forest restoration efforts and whether they help in improving ecosystem functioning and the diversity of invertebrates living in the soil and leaf litter.

MARX WEN-HAN YIM

Marx is a project officer for the Tropical Ecology and Entomology Lab at the Asian School of the Environment in Nanyang Technological University. His primary goal is to encourage and enable the use of dung beetles as bioindicators for academic research and citizen science in Southeast Asia, where dung beetles can show how healthy or affected the environment is. Besides his scientific interests, Marx is also passionate about science communication and uses photography and videography to capture and share his personal experiences in scientific research. Additionally, he is keen on promoting the importance of natural history collections and to raise awareness on how these valuable collections contribute to scientific discoveries.

ALEXIS GOH

Alexis is a scientific officer in the Lee Kong Chian Natural History Museum, National University of Singapore. She graduated with a B.Sc. in Environmental Earth Systems Science (Ecology specialization) from the Asian School of the

Environment in Nanyang Technological University. During her undergraduate years, Alexis investigated the success of Singapore's nature ways as green corridors to help insect pollinators move between parks and reserves. She determined environmental factors that affected their success, documented butterfly species, and tracked their movements along the corridors using mark-release-recapture techniques. A skilled graphic artist, Alexis also designed our figure on insect benefits and the threats they face.

LOUISA MAY FUNG

Louisa is an environmental consultant in a private consulting firm. She graduated with a B.Sc. in Environmental Earth Systems Science (Ecology specialization) from the Asian School of the Environment in Nanyang Technological University. During her undergraduate years, Louisa investigated how flower traits may be driving feeding specialization in tropical butterflies, to help select suitable flowering plant species for landscape management targeted to butterfly conservation.

ELEANOR M. SLADE

Eleanor is an assistant professor at the Asian School of the Environment. She holds a B.Sc. in Zoology from the University of Leeds, a M.Sc. in Ecology from Aberdeen University, and a D.Phil. in Zoology from the University of Oxford. Eleanor is an ecologist whose research focuses on the conservation, management, and restoration of tropical forest landscapes and agricultural systems. She is particularly interested in invertebrates and has been studying dung beetles and their importance for healthy ecosystems for 20 years. Eleanor is also interested in using science to help inform policy and best practices in the oil palm industry.