



INSECTS AS CLUES: WHAT CAN BUTTERFLIES TELL US ABOUT ENVIRONMENTAL HEALTH?

Giselle Martins Lourenço^{1,2*}, Domingos Jesus Rodrigues^{1,2} and Thadeu Sobral-Souza³

¹Programa de Pós-Graduação em Ciências Ambientais, Instituto Ciências Naturais, Humanas e Sociais, Acervo Biológico da Amazônia Meridional, Universidade Federal de Mato Grosso, Sinop, MT, Brazil

²Núcleo de estudo da Biodiversidade da Amazônia Mato-grossense, Instituto Ciências Naturais, Humanas e Sociais, Acervo Biológico da Amazônia Meridional, Universidade Federal de Mato Grosso, Sinop, MT, Brazil

³Laboratório de Macroecologia e Conservação da Biodiversidade, Instituto de Biociências, Departamento de Botânica e Ecologia, Universidade Federal de Mato Grosso, Cuiabá, MT, Brazil

YOUNG REVIEWERS:



KAYCEE

AGE: 13



OWEN

AGE: 10

Butterflies can quickly inform us about the health of the environment—they are like perfect clues used by detectives when solving mysteries! Why? First, because butterflies can be found practically everywhere. Second, because butterfly communities are sensitive to very small changes in the environment. By investigating the butterflies in a certain location, researchers can learn about the current health of the environment and see evidence of things humans may have done in the past to impact the area. Cutting down forests, for example, changes to the types of butterfly species living in an area and can lead to the extinction of some species. In this way, studying butterflies helps us understand the effect of human impacts on the environment. Based on what they learn from butterflies, researchers can propose conservation actions to protect certain species—and the whole environment. So, the next time you look at a butterfly,

maybe it will make you consider the health of the environment around you.

HUMANS IMPACT THE ENVIRONMENT

Human beings live in all regions of the world. Humans need many resources, including water, food, houses, parks, and technologies. Humans have changed the natural environment to collect or create the resources that they need to live their lives. However, sometimes the effects on the environment are severe and can damage forests, savannas, and other **biomes**. Damage to the environment caused by humans is the main reason that Earth's **biodiversity** (the variety of animal and plants) is threatened [1].

Biodiversity is related to the amount of resources available for humans. Animals and plants are involved in the processes that provide us with water, food, and clean air. For example, many animals help with pollination by carrying pollen between flowering plants, which allows those plants to produce fruits, seeds, and new plants. Humans eat fruit, vegetables, and seeds produced through pollination. So, the **human impacts** to the environment can affect these processes and ultimately harm human lives.

Worldwide, researchers are investigating the effects of human impacts on the environment. To do so, they are looking for **biological indicators**, which are animals or plants that can quickly inform us about environmental changes, giving us clues about environmental health and human impacts that have happened in the past. Researchers act like detectives gathering these biological clues, which can provide excellent evidence about an environmental crisis. Many researchers have used butterflies as biological indicators [2].

ALL ABOUT BUTTERFLIES

Butterflies are insects that can be found practically everywhere—in both natural environments and human-made environments such as cities. Currently, researchers know of 18,768 butterfly species all over the world [2]. The distribution of butterflies varies. For example, there are more butterfly species in forests than in other environments. Forests have more food resources as well as temperature and humidity conditions that support butterflies' development. However, there are many regions of the Earth that still have not been investigated. When these areas are studied, it is likely that many new butterfly species will be discovered.

The life cycle of butterflies has four distinct stages (Figure 1). It starts with the female laying eggs on a plant (generally, each species eats a specific group of plants). After a few days or weeks, the eggs hatch and

BIOMES

Regions of the world classified according to similar conditions, such as climate (temperature, weather, humidity), soil type, animals, and plants.

BIODIVERSITY

Diverse kinds of living things in a given area and the interactions between them.

HUMAN IMPACTS

Effects or changes caused by human activities, such as deforestation, agriculture, cattle farming, or build cities.

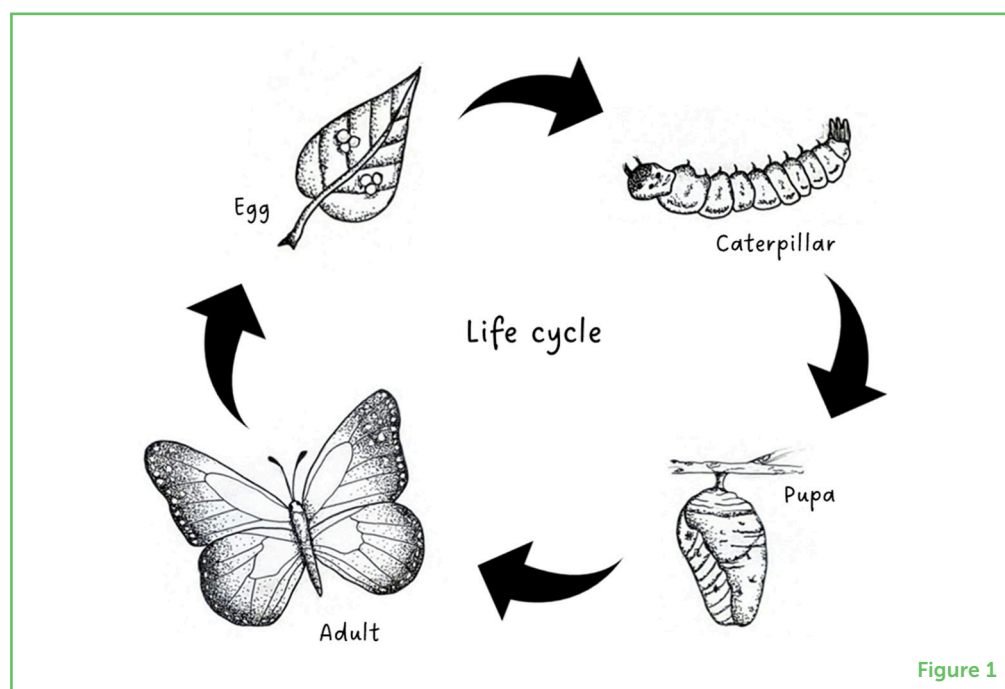
BIOLOGICAL INDICATORS

Organisms that help researchers understand the health of the environment.

caterpillars (larvae) emerge. After feeding on the plant and growing a lot, each caterpillar builds a cocoon called a pupa. Inside the pupa, the great transformation begins. This process can last a few weeks depending on the species. Eventually, an adult butterfly emerges from the pupa. Adult butterflies fly in search of food, to get the energy needed to explore the environment and to reproduce. Once butterflies mate, the cycle starts again.

Figure 1

The life cycle of butterflies has four stages: egg, caterpillar, pupa, adult. Illustrations by Bárbara Dolabela.



Butterflies can be separated into two groups (Figure 2): those that feed mainly on the nectar of flowers (nectar-feeding butterflies), and those that feed on organic matter such as decomposing fruits, feces, and sap (fruit-feeding butterflies). You may have seen butterflies perched on riverbanks or puddles of water. This happens because several butterfly species complement their diets by drinking salt-rich water.

INVESTIGATING THE CLUES: CATCHING BUTTERFLIES

There are several ways to collect butterflies to study them [3]. Have you ever seen researchers running around with an insect net in their hands (Figures 3A, B)? An insect net is the best method to capture nectar-feeding butterflies. However, the success of the capture depends on the researcher's ability, where they search, and how long they search for. The more practice researchers have, the more successful they will be.

To collect fruit-feeding butterflies, we usually use traps (Figures 3C, D). Inside the traps we place a bait that attracts butterflies, made of a mixture of banana and sugarcane juice. Bait traps are left in the environment for a few days, and researchers check daily to see

Figure 2

(A–C) Nectar-feeding butterflies; (D–F) fruit-feeding butterflies.

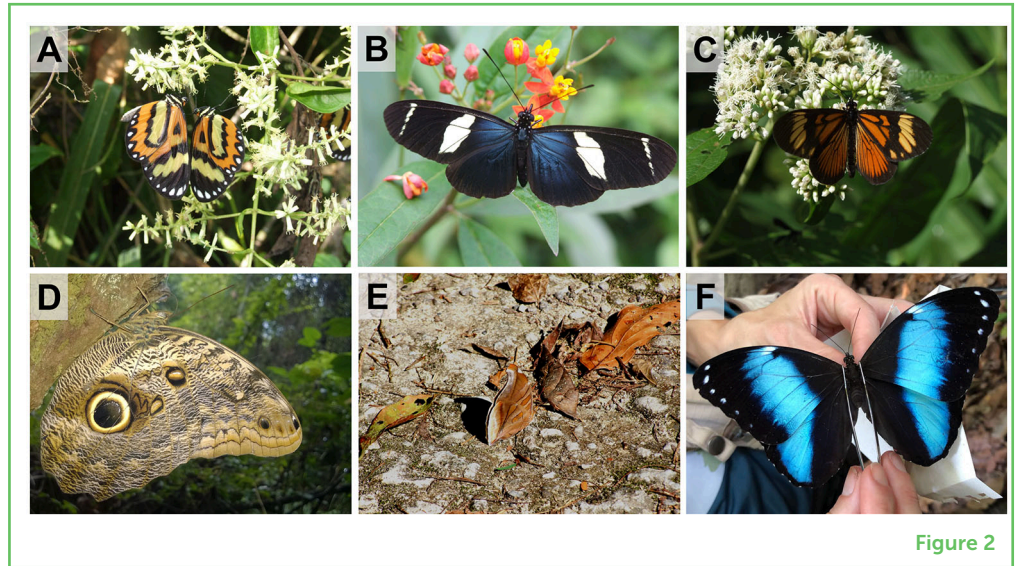


Figure 2

Figure 3

Ways to catch butterflies for scientific studies: (A, B) Insect nets can be used to collect nectar-feeding species (Photo credit: Prof. Dr. Ronaldo Bastos Francini). (C, D) Bait traps can be used to collect fruit-feeding species.

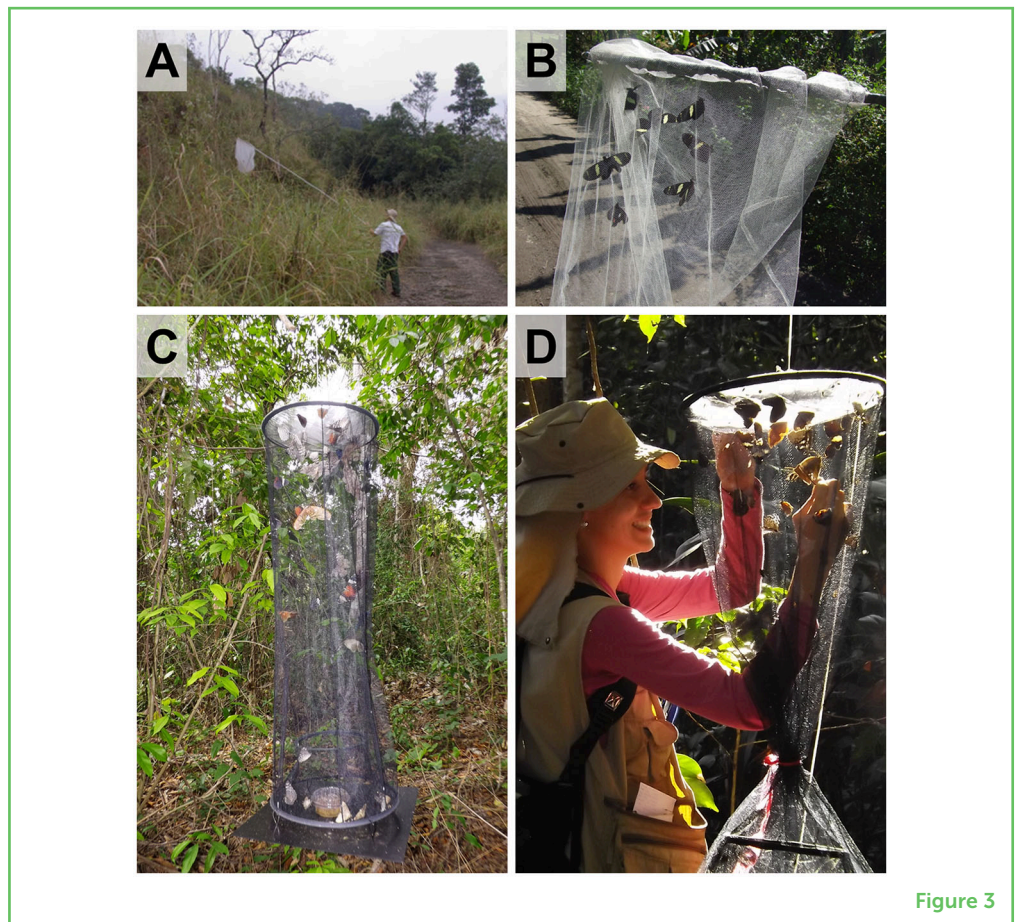


Figure 3

which species were captured. But we must be careful because bait traps can also attract other animals interested in eating the bait, the butterflies, or both. We can find ants, spiders, wasps, bees, and even amphibians in bait traps. Traps are widely used to monitor biodiversity because the success of the capture does not depend

on the researcher's ability. Thus, collections carried out in different locations can be compared.

In forest environments, bait traps can be set at different heights. When bait traps are placed 1–1.5 m above the ground, we catch lower-flying butterflies. When traps are placed 1–3 m below the treetops (canopy), we catch high-flying butterflies. Thus, we can get to know practically the entire butterfly community in a location. Typically, researchers use both insect nets and bait traps to discover as many butterfly species as possible. Then they can create a local list of butterfly species!

WHAT DO BUTTERFLY CLUES TELL US?

Butterflies have a close relationship with their surroundings. They are sensitive to climate variations and also to human impacts. So, changes in butterfly populations can often mirror small changes that occur in their environments, including changes that our eyes cannot easily detect. Thus, butterflies are considered excellent biological indicators that can give us clues about the health of the environment [4, 5].

Changes in the environment, such as **deforestation** to make room for farming or to build cities and other developments, are reflected in the disappearance of many sensitive butterflies. On the other hand, some changes to the environment can cause an increase in the number of **generalist species** that can live in many types of environments and have a varied diet. In this way, the presence or absence of specific butterfly species show us local changes resulting from human impacts. For example, you may have already noticed that, in many cities, there are almost no butterflies. The same has happened in some forests. Why? Things that humans do result in many changes in environments. Changes in vegetation, temperature, humidity, or availability of food, for example, can affect butterfly development (eggs, caterpillars, and adults). Studies have shown that forests that exist as fragmented, patchy areas favor butterfly species that are tolerant of sunlight and drought, while larger, well-connected forests tend to favor forest-specialist species that prefer shade and moist conditions. Recent studies have shown that the fragmentation of the Amazon rainforest is also leading to the loss of colorful species. Similarly, brown butterflies with larger wings are more common in preserved forest areas, while brown butterflies with small wings are commonly observed in fragmented forest areas.

Thus, studying butterflies helps us to detect imbalances and to understand the sensitivity of environments. This information is essential to help us predict the kinds of changes we will have to face as humans continue to affect Earth's climate. Prediction of future human impacts can help us propose conservation actions, so that we can preserve individual species and protect environments all over the world.

DEFORESTATION

Clearing, or cutting down, of forest environments, by humans who want to use the land for other purposes, like farming, or building houses.

GENERALIST SPECIES

Species that can live in many types of environments, use a variety of resources, and generally have a varied diet.

CONCLUSION

Butterflies are like clues used by detectives when they are solving mysteries. They provide important evidence of what is happening in the environment, helping us to understand how human actions are affecting nature. So, the next time you look at a butterfly, maybe it will make you think about the health of the environment and how the state of the environment ultimately impacts human wellbeing.

ACKNOWLEDGMENTS

The authors thank the young reviewers for reviewing the submitted version. Researcher Bárbara Dolabela for friendly providing us with incredible illustrations of the life cycle of butterflies. TS-S thanks Prof. Dr. Ronaldo Bastos Francini. GL thanks the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES) for the research fellowship (linked to the Project No. 88887.692955/2022-00). DR thanks the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for a fellowship.

REFERENCES

1. Dirzo, R., Young, H. S., Galetti, M., Ceballos, G., Isaac, N. J. B., Collen B. et al. 2014. Defaunation in the anthropocene. *Science* 345:401–406. doi: 10.1126/science.1251817
2. Mitter, C., Davis, D. R., and Cummings, M. P. 2017. Phylogeny and evolution of Lepidoptera. *Annu. Rev. Entomol.* 62:265–283. doi: 10.1146/annurev-ento-031616-035125
3. Freitas, A. V. L., Santos, J. P., Rosa, A. H. B., Iserhard, C. A., Richter, A., Siewert, R., et al. 2021. "Sampling methods for butterflies (Lepidoptera)," in *Measuring Arthropod Biodiversity*, eds. J. C. Santos, and G. W. Fernandes (Cham: Springer). p. 101–123. doi: 10.1007/978-3-030-53226-0_5
4. Brown, K. S. Jr., and Freitas, A. V. L. 2000. Atlantic forest butterflies: indicators for landscape conservation. *Biotropica* 32:934–956. doi: 10.1111/j.1744-7429.2000.tb00631.x
5. Uehara-Prado, M., Brown, K. S. Jr., and Freitas, A. V. L. 2007. Species richness, composition and abundance of fruit-feeding butterflies in the Brazilian Atlantic Forest: comparison between a fragmented and a continuous landscape. *Glob. Ecol. Biogeogr.* 16:43–54. doi: 10.1111/j.1466-8238.2006.00267.x

SUBMITTED: 06 April 2023; **ACCEPTED:** 07 November 2023;

PUBLISHED ONLINE: 24 November 2023.

EDITOR: [Becky Louize Thomas](#), University of London, United Kingdom

SCIENCE MENTORS: [Kristen Welsh](#) and [Lea A. Rempel](#)

CITATION: Lourenço GM, Rodrigues DJ and Sobral-Souza T (2023) Insects as Clues: What Can Butterflies Tell Us About Environmental Health? *Front. Young Minds* 11:1152488. doi: 10.3389/frym.2023.1152488

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.

COPYRIGHT © 2023 Lourenço, Rodrigues and Sobral-Souza. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

YOUNG REVIEWERS



KAYCEE, AGE: 13

I am an avid science enthusiast who participates in regional and state science fairs. My interests in science ranges from behavioral based to environmental/conservation science. I am just as passionate about rodeo as I am about science. I participate in state and youth rodeo associations. My main events are goat tying and calf breakaway. I even met my FYM mentor through our state rodeo association.



OWEN, AGE: 10

I am 10 years old, and I am interested in chemistry, synthetic biology, and environmental chemistry. I love animals and, in fact, I keep chickens as pets! One of my favorite things to do is to read. I am interested in developing an alternative to plastics and helping the environment.

AUTHORS



GISELLE MARTINS LOURENÇO

Hi, I am Giselle. I work as a postdoctoral researcher at the Federal University of Mato Grosso, Brazil. I am mainly interested in understanding the distribution and movement of insects, especially butterflies, in space and time, and how environmental changes and climate change influence them. I love butterflies not only because they are beautiful, but because they tell us important things that we cannot easily see any other way! Besides research, I also love spending my free time with my family, dancing samba, traveling, and practicing yoga. *gisambio@hotmail.com



DOMINGOS JESUS RODRIGUES

Hello, I am Domingos. I am a professor at the Federal University of Mato Grosso in Brazil. I am interested in the biodiversity of the Amazon and the factors that organize plant and animal communities, like butterflies. I love nature, the smell of the forest, and hearing about the mystic and unknown world of the Amazon. I love listening to

music and especially the voices of the forest that speak to us through birds, crickets, amphibians, rain, etc.



THADEU SOBRAL-SOUZA

Hi, I am Thadeu. I am a professor at the Federal University of Mato Grosso, Brazil. I have an interest in conservation of all animals without bias, but I love butterflies. I have three favorite hobbies: (i) surfing, (ii) listening to reggae music, and (iii) observing nature. When I listen to reggae music, I automatically observe nature and contemplate its beauty. These personal experiences guide my paths as a researcher and teacher.