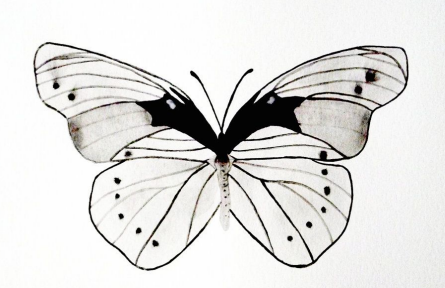
USTH 2024 – Project 1

Butterfly color evolution



How do colorations of butterflies emerge from predator-prey interactions and camouflage?

The colorful canvas of butterfly wings are examples of evolutionary innovation and adaptation. Starting in the 19th century, naturalists investigated the function of wing-color patterns in different butterfly species. The understanding of population genetics in the early 20th century led to associations between specific genes and color patterns, helping elucidate how and when they evolved. Recently, researchers have discovered that just a few genes are responsible for setting up the patterning throughout the wing.

The environmental conditions (dominant color in the surroundings) and predator avoidance through camouflage are key selective drivers of colorations. Observations of black and white colorations of closely related butterflies living in different habitats are examples of local adaptations and natural selection. For instance, peppered moths are displaying three morphs: a white morph, a black morph, and different intermediate shades of gray.

A research question is to evaluate how predatory selection in a gradient of environmental conditions (black to white) can allow the emergence of distinct populations with different colors. Create an agent-based model describing the butterfly population, its reproduction at a fixed rate, with coloration dependent on a simple transmission system (each parents transmit black or white depending on its color: white butterflies only transmit white, black only black and gray ones have 50% of chance to transmit either color), predation pressure (modeling a predator population that feeds on butterflies but can be tricked by their camouflage) and an abrupt or gradual transition in local environmental colors to explore under which conditions distinct morphs can emerge.

Extension 1: Modify the model by considering that predators prefer to hunt the most represented color of the moth population.

Extension 2: Modify the model to include dynamic environmental transitions, where the colors of the environmental patches can change at a given speed. Investigate how the variability in this change rate influences the emergence and stability of distinct morphs in butterfly populations.

Extension 3: Explore the impact of varying predation intensity within the model. Adjust the predation pressure on butterfly populations, introducing scenarios with high and low predation rates. Examine how predation intensity influences the selection and persistence of different color morphs.