

Wandering Wings

Random foraging may explain complex Monarch migration

As I rode my bike around this spring, the barreling orange wings that usually dart into my face were sadly absent.

Austin is known to host more than 170 species of butterflies, most notably the Monarch, which has seen a significant decline in numbers over the past thirty years. Droughts and drastic temperatures have led to food shortages and habitat losses, resulting in major die-offs in monarch populations.

Graham Toal, a computer scientist at the University of Texas-Pan American (UTPA) has been using the Longhorn visualization system at the Texas Advanced Computing Center (TACC) to test a hypothesis: that certain random populations of butterflies have genes which permit them to wander to different locations therefore allowing them to survive. Toal's simulation is exploring the possibility that this diaspora enables butterflies to recuperate their population.

The monarch's usual life cycle takes it south to Mexico in the winter and back up north towards the US-Canada border in the spring. Butterflies that stay in roughly the same place die of starvation, as neither region produces enough food to allow them to survive a year. These assumptions about butterfly migrations are only applicable if



Monarch Butterflies wintering in the Monarch Grove Sanctuary in Pacific Grove, California.

weather conditions are ideal and the food supply is sufficient, which has not been the case in recent years.

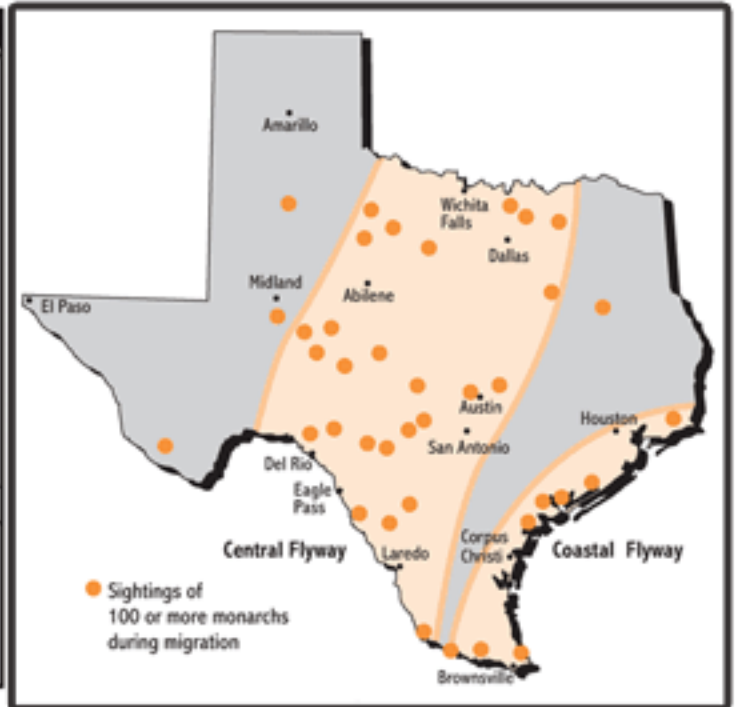
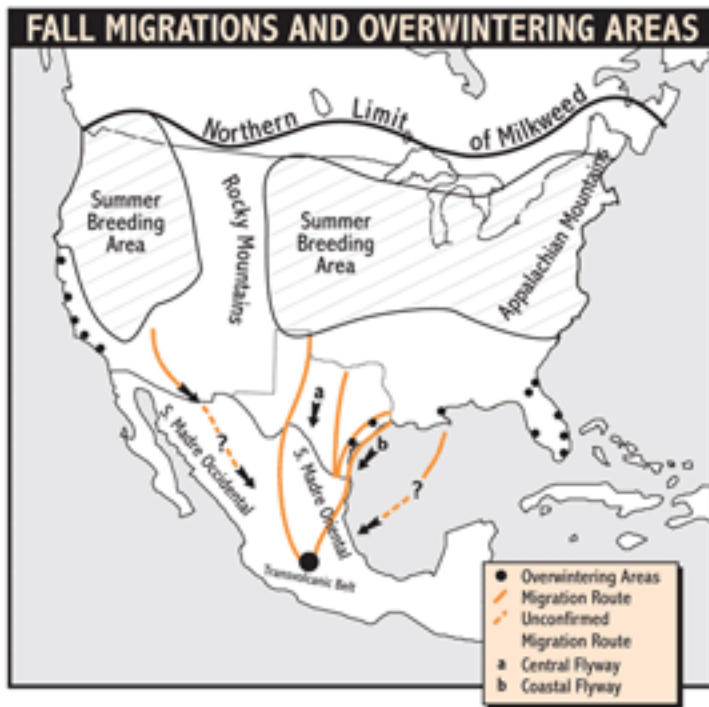
Toal holds a number of assumptions in his simulation, one being that butterflies in a certain gene pool act on instinctive or innate behavior based on current environmental factors, which effectively allows them to survive over others. This notion is not to be confused with Lamarckism, or the "inheritance of acquired traits", meaning that characteristics that an organism may develop during its lifetime are genetic and can be passed on to its offspring.

Read more: [Lamarckism - Genetic, Evolution, Fixed, Individuals, Individual, and Inheritance](#)

The hypothesis also assumes that butterflies will stay in a region where there is food, but will forage in random directions for random distances when there is no food. To test his ideas, Toal performed a virtual experiment with a population of creatures that resemble the Monarch butterfly.

As long as each butterfly heads in a particular direction consistently when it encounters the same environmental conditions, evolution will eventually breed out those butterflies for which the random direction leads to fatal outcomes and will set up a stable population when the random choices lead to a feeding ground, a breeding area with available milkweed, and an overwintering area.

The model starts with an initial population of 10 million butterflies, where the life of each and every individual is updated once per hour, over a simulated period of 8000 days. A few simple rules govern the virtual butterflies' lives:



Paths that migrating birds or butterflies follow are called “flyways”. North American monarchs migrate south in the fall to California, Mexico or Florida. On the way north in the spring they lay eggs. The young produced by those and the next generation’s eggs that return all the way north and start south again (left). Monarchs’ migration path can change slightly each year. The dots represent sighting reports sent in from citizens (right).

Butterflies which do not eat enough eventually die of poor health.
 Butterflies eventually die of old age.
 Butterflies can eat in the Northeast region during the summer season (the area shows as blue when it is a source of food).
 Butterflies can eat in the Mexico region (green when food is available).
 Butterflies can breed when in the Mexico region when food is available.
 When in either of these regions, they don't fly out of them.
 Toal's simulation shows that after the initial scattering some butterflies randomly disperse from those regions when they are no longer hospitable; however, some butterflies happen to forage in directions that lead them back to the original feeding regions when they are suitable again. If they or their offspring in turn randomly manage to return to the original food-producing region in time, they live long enough to reproduce.

“The descendants of the butterflies which randomly succeeded in establishing a cyclic route have the same genes, and therefore follow roughly the same route,” explained Toal.

The experiment is a proof of concept carried out using a small startup allocation available to researchers in the University of Texas system. The allocations are part of a continuing engagement with the UT system, most recently through the University of Texas Research Cyberinfrastructure Initiative. The work was done under the auspices of the Division of Information Technology at the University of Texas-Pan American as a demonstration project showing UTPA researchers how to add visualization to their HPC research projects.

In the current, simplified model the butterflies have no genetic variation and are effectively clones, so they are not likely to adapt well to changes in the environment. Toal intends to apply for a larger allocation in order to refine the model with details taken from the real behavior of Monarch butterflies.

“A more detailed model would take into account all the inputs available to a butterfly, such as the temperature, the winds and the food supply,” continued Toal.

While the simulation is too crude to use to make predictions, it does succeed in showing that a cyclic migration loop is a plausible behavior that can emerge from a much simpler mechanism.

This means there is hope yet for seeing these creatures again—they are currently in a recovery phase.

Said Toal: “Butterflies have been in this pattern long enough to have adapted to these changes in the weather, and boom and bust years are part of their natural cycle now.”

August 3, 2011

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