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A Study of Monarch Butterfly (*Danaus plexippus* L.) Migration and Its Establishment

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Abstract

The fact that the monarch butterfly (*Danaus plexippus* L.) migrates from Canada to central Mexico is a well-known fact. Here, the migration of the Eastern and Western populations of monarchs is described. This article will not be a field study but an attempt to synthesize a theory of how this migration could originate in a young-Earth context, given that butterflies were created essentially as seen today or will be assumed to have originated this way. The Uvarov Phase Theory is discussed as it applies to desert locusts and its possible relation to the unique migratory generation of monarchs, that is, the larger size of the Fall migratory individuals, and the importance of diapause. The establishment of this interesting migratory pattern is discussed in terms of geography and topography and related to the unique flight abilities of these butterflies.

Key Words: design in nature, insect host plants, insect migration, instinctual reactions, monarch migration

Introduction

Monarch butterflies (*Danaus plexippus* L.) have an interesting life cycle in which the larvae feed upon several species of toxic milkweed. The plants are toxic due to high concentrations of cardenolides in their latex (Agrawal et al., 2015), but monarch larvae are able to tolerate and gain protection from predators by ingesting the milkweed contents (Figure 1). Milkweeds cannot grow in the cold winter, and the monarch itself has a frail constitution which needs warmer climates to survive (Dingle, 1996, p. 247). The eastern population of monarch butterflies follows various paths south in the Fall. Butterflies originating in Indiana or other Midwestern states follow a roughly-defined route south towards Oklahoma and then Texas. Butterflies from Eastern Canada or the eastern United States generally may follow the Appalachian Mountains, but others follow the shores of the Atlantic Ocean. Western monarchs find winter sanctuaries in coastal California.

The eastern population of monarch butterfly spends the winter in the mountains of central Mexico, seeming to prefer to flock together on fir trees on the sides of these mountains (Urquhart, 1976; Brower et al., 2009). Considering that these mountains may be the result of tectonic forces, possibly colliding plates or other Genesis Flood events,

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Figure 1. A monarch butterfly flying above a patch of common milkweed (*Asclepias syriaca*), a common happening during late Spring, Summer, and early Fall. Photo by Gene Chaffin.

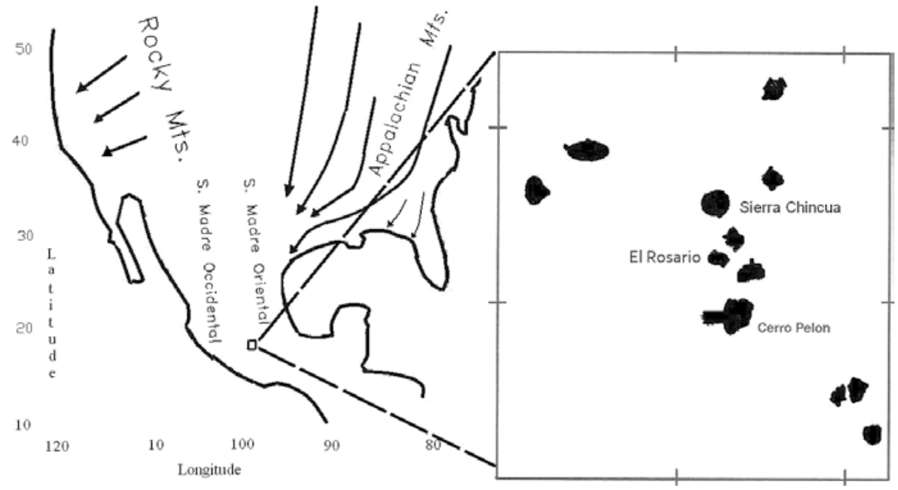

Figure 2. This map shows how the paths flown in Fall by the eastern population of monarchs are funneled towards the Transvolcanic Mountains of central Mexico by the Sierra Madre Oriental Mountains on the West and the shores of the Gulf of Mexico on the East. The black areas of the inset represent the sites in the Transvolcanic Mountains where the monarchs overwinter, although the exact shapes, monarch population densities, and locations vary from year to year. Drawn by Gene Chaffin.

we consider the monarch migration and how the monarch routes could become established on the post-Flood Earth. The Sierra Madre Oriental Mountains in Mexico, together with the Gulf Coast shores sort of form a "funnel" for directing the butterflies (Figure 2). Like sand falling through an hourglass, the monarchs are directed towards their winter home. However, when one considers the path that some of the monarchs must follow along the Gulf Coast starting from the southeastern United States, one is left wondering what directs them? Other species of butterflies besides monarchs migrate, including the cloudless sulphur (*Phoebis sennae*) (Walker, 1985), the painted lady (*Vanessa cardui*) (Abbot, 1951; Nesbit et al., 2009; Stefanescu et al., 2012), and red admiral (Brattström, et al., 2018). Gulf fritillaries (*Agraulis vanillae*) migrate, although over much shorter distances (Arbogast, 1966). However, monarchs are the marathon champions prominent in the minds of anyone who has ever paid any attention to butterflies. In recent years, biophysicists have been studying mathematical models to try to explain migratory movements. Vilk et al. (2022) tried to formulate a non-Markovian model to explain animal movement. "Markovian" in this context means that the behavior at each time interval is independent of the behavior at preceding intervals. But when an animal moves, its decisions are non-Markovian—its choice of direction and speed is balanced against its desire to seek a new foraging spot. Vilk et al. tried to insert input called "preferential returns" to take this into account.

Nearly a couple of decades ago, Dingle (1996, p. 391) wrote:

> In addition to conceptual models, there have also been attempts to generate some formal mathematical statements regarding insect movements. One approach is to assume a set of "rules" for movement and see if insect examples actually conform to those rules. Diffusion, random walk, and Markov chain models are of this sort and have been used effectively to describe within-patch foraging movements of insects, most notably by Peter Kareiva (1982, 1983a,b; Kareiva and Shigesada, 1983).

Kareiva and Shigesada (1983) considered a random walk process, a series of straight-line movements in which the future pattern of movement is not influenced by the pattern of movement that previously transpired. Although this process can result in dispersal away from a starting point, as when insects are seeking nectar from flowers, it does not move the majority of individuals toward a goal (Mexico).

The way monarchs or other butterflies fly is different from that of birds, bats, pterodactyls, locusts, dragonflies, mayflies, etc. Monarch wings are covered with tiny scales, about 100 micrometers in length. Experiments

Figure 3. Monarch butterflies roosting in an oak tree at Port Louisa National Wildlife Refuge in Iowa.

by Slegers et al., (2017) showed that butterflies' ability for climbing flight was decreased after scales were removed. Also, according to Lang (2023), the scales are of just the correct size to aid flight efficiency. Lang did not elaborate, but it appears that God has given a perfect design that enables butterflies to fly. It is difficult to imagine how slow changes in the genetics of scale size could lead to butterflies as observed, since decreased flight efficiency would not lead to viable individuals. The individual needs the perfect scale size.

For an insect to steadily move in a given direction, as for a monarch moving from Canada to central Mexico, it must be directed or attracted, perhaps by a God-given instinct. It also must be able to orient itself, perhaps using the polarization of sunlight (Chaffin, 2021) while soaring near the optimum height. But is there any way to explain how the route to Mexico was established? After all, the post-Flood butterflies had not been to Mexico before, and even today the individuals that return to Mexico are not the same individuals from the previous Spring.

Vilk et al. (2022) wrote:

> Notably, memory patterns must be properly balanced by the organisms with some level of behavioral plasticity to enhance flexibility and exploration (see, e.g., Ref. [14]). For all these reasons, correctly incorporating memory within stochastic models is an important research line for improving both predictive and descriptive tools of movement [6, 15–17].

Vilk et al.'s reference 14 was Krochmal et al. (2021), in which eastern painted turtles, *Chrysemys picta*, migrated the same routes based on memories of previous years, but juvenile individuals followed more varied routes. It would seem that perhaps the post-Flood monarchs were similar to the juvenile turtles in that the species had to learn the route.

In chaos theory one encounters an entity known as an "attractor state." One considers how a small change in an input parameter can cause a strategic change in a system's environment resulting in a branching from a critical point to a significantly different future trajectory. We could find that a new "attractor state" emerges, since from this critical point the trajectory can go in two different ways where each branch represents a trajectory into a new basin of attraction with a new regime and equilibrium.

Vilk et al. (2022) studied a "phase transition," occurring when their "preferential returns" got strong. In this case, a *phase transition* is defined as occurring when some smooth small change in a quantitative input variable that results in a qualitative change in the system's state. In the monarch, such a transition must occur when it is time for migration to begin.

Dingle (1996, p. 145) wrote:

> In many insects migration seems to involve a trade-off with reproduction. The frequently observed ontogenetic separation of migratory behavior from reproduction has been called an oogenesis-flight syndrome (above and Johnson 1969), and the assumption underlying the concept is that migration and reproduction are alternate physiological states.

Leong et al. (1991) studied the conditions, humidity, prevalent winds, temperatures, etc. at a site (San Luis Obispo County, California) where some monarchs of the western population overwinter. These conditions are attractive to monarchs. One might say that an "attractor state" exists at this site.

When an army gets ready to move, each soldier finds his place and each piece of equipment is moved as ordered. One might think of an attractor state being chosen as a stable configuration into which the army settles. As long as a soldier knows his orders and is close enough when the order comes, he finds this place (Figure 3).

In the central Mexico sites, the monarchs spend the winter gathering over and over either on the branches or the trunks of fir trees on the sides of mountains. The altitude is right for what the monarchs need. There are about a dozen known sites that the monarchs use, called El Rosario, Cerro Pelon, Sierra Chincua, etc., spread over two states (Figure 2). The trees, by holding heat, provide something to cling to and help control moisture conditions, and otherwise shelter the monarchs (Brower et al., 2009). The monarchs are normally not too hot or too cold. One might say that the sites would be "attractor states" due to these optimal conditions. Monarchs which reach these sites have a better chance of survival until Spring.

This does not explain every question about establishing migration, but perhaps it is a step in that direction. Another factor for the eastern population is the funneling, mentioned before, caused by the path of the butterflies as it leads between the Sierra Madre Oriental Mountains on the west and the Gulf of Mexico on the east (Figure 2). The monarchs avoid the great mountain heights to the west and the unforgiving gulf waters to the east, and flying in the generally southern direction end up in the Transvolcanic Mountains of central Mexico. At this new latitude, the mountains have an acceptable climate, at least most of the time. Occasional winter storms unfortunately kill off many monarchs. Also, recent reports reveal that small numbers of monarchs survive in coastal areas of northern Florida, Georgia, and South Carolina (Journey North, 2024), although not inland. Southern Florida, of course has a year-around population (Brower et al., 2009).

Phase Theory and Migration

The Russian/English entomologist, Uvarov (1889–1970), proposed the phase theory of desert locusts (Uvarov, 1921). It stated that the locusts could change physiologically and morphologically, between two extreme types or phases: *solitaria* which led a solitary, settled life and was produced when the individuals were more separated from others, and *gregaria* which was highly gregarious and active and was produced when the population was dense.

Uvarov had observed two phases of the Old World desert locust, now called *Schistocera gregaria.* The two phases differ in coloration, size, as well as relative proportions. Environmentally-induced changes seem to be due to humidity, temperature, and crowding of individuals. The word *polyphenism* is used for differences in physiological or behavioral differences within an insect species (Dingle, 1996, pp. 273–274; Pener and Simpson, 2009, p. 5). It has been noticed in social insects as well as in several species of grasshoppers and locusts. The modern day desert locust is associated with crop decimation in East Africa and the Middle East, similar to the episode in the Book of Exodus, Chapter 10. In 1938 to 1940, an episode of crop decimation occurred in the Dakotas, Wyoming, Montana, North-Central Colorado, and parts of southern Canada, due to the migratory grasshopper *Melanoplus sanguinipes*, then known as *Melanoplus mexicana* (Parker et al., 1955). It was thought to be due to an extremely gregarious phase of this species. Drought caused the decline of native grasses, the emergence of weeds, and soon swarms of this gregarious, migratory phase of insect were causing serious crop damage.

If our concern is the monarch butterfly, one soon wonders whether the migratory "super generation" (aka the "Methuselah generation") qualifies as a "phase." The wing size of the migratory Eastern population of monarch was reported by Altizer and Davis (2010, Table III) to be 51.44±0.19 mm for males and 51.18±0.19 mm for females, whereas South Florida, Puerto Rican, and Costa Rican individuals, not thought to be migratory, averaged a few millimeters less. Li et al. (2016) did not find a difference in wing shape (aspect ratio) between migratory and nonmigratory populations, but agreed with the conclusion that the migratory monarchs had larger wings: "Our study indicates that size may play a larger role than shape in long-distance migratory capability."

Davis et al. (2023) reported larger white spots on migratory monarchs, and speculated that this change in reflectance may aid aerodynamic efficiency.

The so-called "juvenile hormone" is connected with the induction of reproductive organ growth in both male and female monarchs. The migratory generation is in a state called diapause from August or early September to November for males while for females, diapause typically does not end until December (Herman, 1981, p. 89). In the diapause condition reproductive activity ceases, reserving energy for migratory flight.

Conclusion

Thus, the unique migratory generation of monarchs seems to be indicative of a phase designed by the Creator to enable these insects to survive the winter. Physiological and size factors have been discussed which play important roles. While other species of butterflies may survive by other means, monarchs are an example of a long-distance migratory solution.

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