AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 06 Issue: 04 April 2025 Article No: 24

The Migration of Monarch Butterfly

Hemanth Kumar K. J.,[1]* Sugeetha G.[2] and Sunil C. M.[3]

[1]PG Scholar, Department of Agricultural Entomology, College of Agriculture, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru, Karnataka.

[2]Asssistant Professor, Department of Agricultural Entomology, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru, Karnataka.

[3]Jr Agronomist, AICRP on Small Millets, ZARS, V.C. Farm, Mandya University of Agricultural Sciences, Bengaluru, Karnataka

SUMMARY

The monarch butterfly (Danaus plexippus) is one of the most well-known and studied insects in the world, primarily due to its extraordinary migration. Every year, millions of monarchs travel thousands of miles across North America to reach their overwintering sites in Mexico and California. The migration is unique among insects, as no single butterfly completes the round trip; instead, the journey spans multiple generations.The migration of butterflies is helpful in pollinating flowers along the migrating route and helps in detecting environmental health and it also boosts tourism activities, but The migration of butterflies is facing habitat destruction,climate change and ill effects of pesticides. Hence there is a urgent need to conserve these most exciting migration.

INTRODUCTION

The monarch butterfly (*Danaus plexippus*) belonging to the family Danaidae under the order lepidoptera is commonly known as the brush footed butterfly. The monarch butterfly is orange with black wing veins and bodies. The body is ringed with black, yellow, and white stripes. The wings feature an easily recognizable black, orange, and white pattern. The wingspan of the monarch butterfly is 8.9–10.2 cm (3.5–4.0 inch). The larvae feed only on milk weed plant . while adults are well known for their long migratory behaviour to the roosting sites .it is quite remarkable compare to other migration of other organisms because monarchs migration is multigenerational where 4 - 6 gernerations are involved in completion of one migratory cycle

Life Cycle of Monarch butterfly

Monarch Butterfly lay their eggs on milkweed plants and the biology is in synchrony with the biology of milkweed .They utilize most of the over 100 N.American Species (woodson 1954) in the milkweed family (Asclepiadaceae) which is the only group of plants that provide food for developing larvae.Female butterfly lays around 300-400 egys is wild and captive monarch butterfly average about 700 eggs / female over the period of 2 to 5 weeks and the egg hatches 4 days after laid and larva typically begin life by eating their eggshell, then move on to the milkweed leaves on which they were laid. The Larval stage lasts for 9 to 44 days with 5 larval instars. From hatching to pupation, they increase their body mass about 2000 times Both the egg and larva have slim chance of Reaching adulthood.Several precious studies documented mortality rates of over 90% during egg and larval stage.After pupal stage trasformations the adult stage is completed in about 9 to 15 days.Thus under normal temperature ,most of the physiological and morphological changes occurs during the larval stage. The wings and other adult organs develop in the pupal stage and most notable changes will occur after the involvement of a major reorganization of flight muscles in the thorax.Sperm will also mature during pupal stage although eggs do not mature until the adult eclosion.The primary goal during the adult stage is to mate reproduce and lay the eggs in order to produce the next generation. Adults in summer generation lives for 2 to 5 weeks, while those that migrate may live upto 9 months. This difference is due to the fact that overwintering monarchs are not reproductive and can thus funnel more energy in survival. In addition the cool conditions in the hibernation sites slow their metabolism allowing them to live longer.

Generational Migration of Monarch Butterfly:

1. **Spring Generation** –The spring generation consists of the first one or two generations of monarchs that emerge after overwintering in Mexico or California. These butterflies play a crucial role in recolonizing breeding grounds in North America.

Life Cycle and Migration Path:

Monarchs that overwinter in Mexico or coastal California begin their northward journey in early spring (March–April).As they migrate northward into Texas and the southern United States, they lay eggs on emerging milkweed plants (*Asclepias* spp.), which serve as the sole food source for monarch larvae. These eggs hatch into larvae, which undergo metamorphosis and become adult butterflies within 30–40 days.The spring generation butterflies continue migrating northward, laying eggs as they travel.

Key Characteristics:

A. Spring generation monarchs typically live for 2–6 weeks as adults and have short lifespan
B. The Primary role is Reproduction and migration for establishing new populations further north.
C. Unlike the overwintering generation, these monarchs do not accumulate large fat reserves because they do not need it to survive in the winter.

2.Summer Generations –The summer generations (typically two or more) occur from May to August. These butterflies emerge in breeding regions across the United States and southern Canada, producing successive waves of monarchs.

Life Cycle and Reproduction:

The first summer generation develops from the offspring of the spring migrants, maturing in late May to early June.A second summer generation emerges in July to August, sometimes followed by a third in regions with longer summers.

Each summer generation follows the typical monarch life cycle

A. Egg stage (3–5 days)
B. Larval stage (10–14 days) – Caterpillars feed on milkweed, storing energy for metamorphosis.
C. Pupal stage (chrysalis) (8–15 days) – Monarchs undergo metamorphosis.
D. Adult stage (2–6 weeks) – Butterflies mate and lay eggs for the next generation.

Key Characteristics:

A. Summer monarchs live for 2–6 weeks and die after reproducing which exhibits short life span
B. High reproductive output is seen where Each female lays hundreds of eggs, ensuring population growth.
C. The migratory behaviour is found where the generations remain in breeding areas, expanding the population.

3. Super Generation (Migratory Generation)

The super generation, or migratory generation, emerges in late summer (August–September). Unlike summer monarchs, these butterflies do not reproduce immediately. Instead, they migrate south to overwintering sites in Mexico or coastal California.

Life Cycle and Migration :

In August and September, environmental cues (cooler temperatures and shorter daylight hours) trigger changes in monarch development.Instead of becoming sexually mature, these monarchs enter reproductive diapause, delaying reproduction until spring (Brower *et al.*, 2011).They embark on a 3,000–5,000 km migration to overwintering sites, a journey that can take two months.Upon reaching Mexico or California, monarchs cluster in oyamel fir forests (Abies religiosa) or coastal groves, where they conserve energy for several months.In February–March, they emerge from diapause, mate, and begin their northward migration, restarting the cycle.

Key Characteristics:

A. Unlike other generations, super-generation monarchs live 6–9 months, surviving the entire winter exhibiting long life span.
B. Increased fat storage will accumulate lipid reserves from nectar sources, fueling their long migration (Alonso-Mejía et al., 1997).
C. Hormonal changes suppress reproduction until they return north in spring.
D. Since these monarchs rely on a combination of sun compass orientation and magnetic field detection to navigate their journey (Reppert et al., 2016).

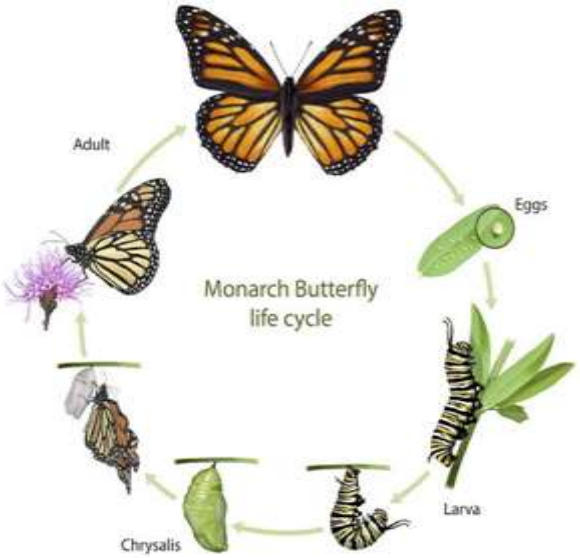

FIG.1 Life Cycle of Monarch Butterfly
Source: https://stock.adobe.com/in/images/monarch-butterfly-life-cycle/81277009

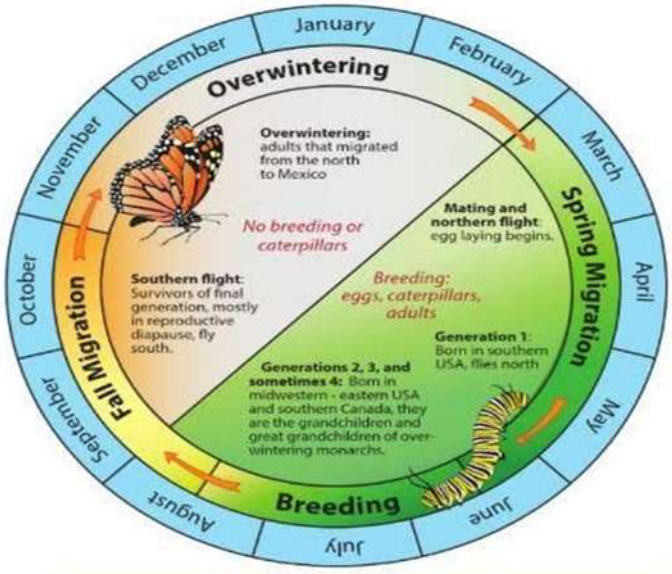

FIG.2 Seasonal Activity of Monarch Butterfly
Source:https://www.pinterest.com/pin/monarch-butterfly-life-cycle--48624870960660358

Migration Routes and Destinations

Monarch butterflies follow two primary migration routes in North America:

Eastern Population (Migrating to Mexico)

Butterflies east of the Rocky Mountains travel up to 3,000 miles from Canada and the United States to central Mexico. They overwinter in the oyamel fir forests of the Sierra Madre mountains in Mexico, where stable temperatures and humidity levels help them survive.

Western Population (Migrating to California)

Monarchs west of the Rocky Mountains migrate to coastal California. They spend the winter in eucalyptus and pine groves along the Pacific coast, with key sites in areas like Pacific Grove, Pismo Beach, and Santa Cruz. Upon arrival at their overwintering sites, monarchs enter a state of diapause, where they slow their metabolism to conserve energy. In early spring, they mate and begin their return journey northward.

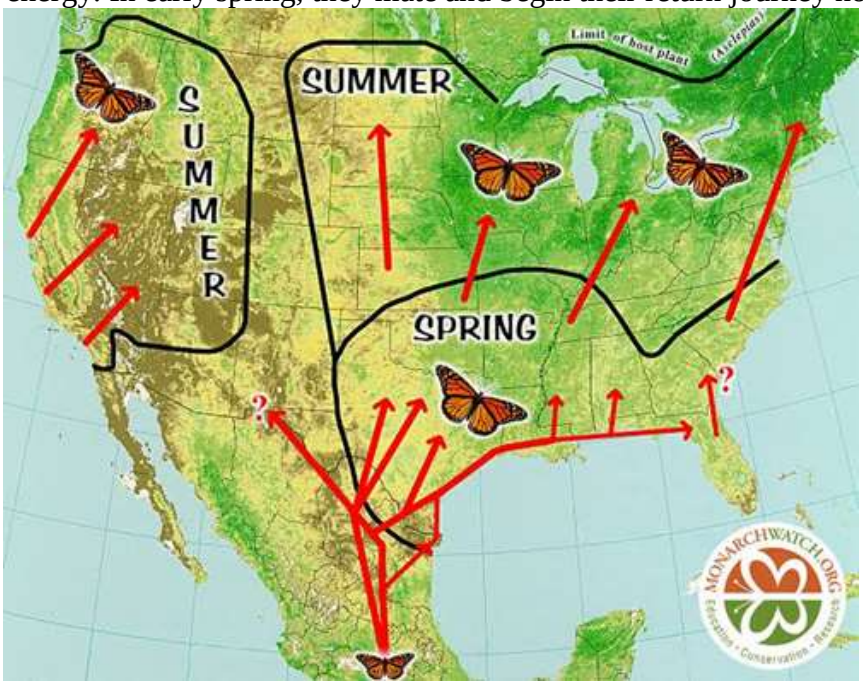

FIG. 3 Migration Routes and Destinations of Monarch Butterfly
Source: http://butterfly-lady.com/spring-migration

Navigation Abilities of Monarch Butterflies in Migration

One of the most remarkable aspects of migration is the monarch's ability to navigate with precision, despite never having travelled the route before. Unlike birds and mammals that rely on learned behavior or social guidance, monarch butterflies use innate navigational mechanisms to find their way Unlike birds, no single monarch completes the round trip. Instead, the journey is divided among multiple generations, yet each generation follows the correct path. This ability suggests that monarchs have sophisticated navigation mechanisms encoded in their biology.

Key Navigation Mechanisms in Monarch Butterflies

1. Sun Compass Navigation

One of the primary methods monarchs use to navigate is the sun compass, which helps them maintain a consistent flight direction based on the position of the sun. Monarchs have specialized photoreceptors in their eyes that detect sunlight. As the sun moves across the sky, they adjust their flight angle to maintain the correct direction. The circadian clock in their antennae helps them account for the time of the day, allowing them to correct their flight path. Researchers have conducted experiments where monarchs were kept in altered light conditions that shifted their internal clocks. These butterflies flew in the wrong direction when released, proving their dependence on the sun compass and circadian rhythm.

2. Earth's Magnetic Field as a Backup Compass

In addition to the sun, monarchs use the Earth's magnetic field to navigate, particularly on cloudy days when the sun is not visible. Monarchs have magnetite-based sensors in their bodies that detect magnetic fields. This internal magnetic compass helps them to orient themselves even when visual cues. Studies have shown that when monarchs were exposed to altered magnetic fields in laboratories, they changed their orientation, confirming their sensitivity to geomagnetic forces. Experiments using magnets placed on monarchs disrupted their ability to fly in the correct direction.

3. Polarized Light Detection

Polarized light, which scatters differently depending on the sun's position, serves as another navigation cue for monarchs. Monarchs can detect patterns of polarized light using special cells in their eyes. These patterns remain visible even on partially cloudy days, helping monarchs orient themselves. Researchers used polarized light filters in controlled environments and found that monarchs adjusted their flight paths accordingly, confirming their ability to use this visual cue.

4 .Wind and Thermal Air Currents

Monarchs also take advantage of wind patterns and thermal air currents to aid their migration. Monarchs use tailwinds to conserve energy during flight. They utilize thermal updrafts (rising warm air) to glide for long distances without excessive wing movement. They avoid strong headwinds that would slow them down.Studies showed that monarchs changes altitude and direction based on wind conditions, adjusting their flight path for efficiency.

5. Memory and Genetic Programming

Unlike birds, monarchs do not learn migration routes from previous generations. Instead, their navigation is based on genetic programming and instinct. Their migratory behaviour is encoded in their genes, allowing each generation to follow the same route without prior experience. When monarch caterpillars were raised in isolation without exposure to environmental cues, they still migrated correctly as adults, proving their ability is inherited.

Ecological Importance of Monarch Migration

The migration of monarch butterflies plays a significant role in ecosystems:

1. **Pollination** – As monarch butterflies migrate, they visit a variety of flowers to feed on nectar, transferring pollen between plants and flowers of diverse range in the ecosystem. Monarchs are effective pollinators due to their Furry bodies that pick up and transfer pollen between flowers and possess Long tube like proboscis which allows them to reach nectar deep within flowers and increasing the chances of pollen transfer.

2. Biodiversity Indicator –The presence and abundance of monarchs reflect the health of ecosystems, particularly grasslands and forests. Declines in their population often signal habitat loss, pesticide overuse, and climate change impacts. which helps the environmentalists to asses the health of the environment and acts as a indicator of the biodiversity.

3. Cultural and Economic Value – Monarch migration attracts ecotourism, especially in Mexico, where overwintering sanctuaries are the protected areas for these butterflies itself which enhances the aesthetic value of the surroundings.

Threats to Monarch Migration

Despite their resilience, monarch populations have declined significantly due to:

1. Habitat Loss

Since Monarchs rely on specific overwintering sites in Mexico and California.The process of deforestation, illegal logging, and climate variability has been threatening the habitats. According to Brower *et al*. (2012), deforestation in the Mexican overwintering sites has led to habitat fragmentation, affecting monarch survival rates. The decline in overwintering populations reflects broader conservation issues, emphasizing the need for habitat protection policies.Deforestation in Mexico reduces the availability of overwintering sites. Urbanization and agricultural expansion destroy milkweed plants which is the primary host for monarch caterpillars.

2. Climate Change

Monarchs are highly sensitive to climate changes, which makes them useful for tracking environmental shifts. Rising temperatures, changes in precipitation patterns, and extreme weather events disrupt their migration cycle. A study by Satterfield *et al*. (2015) highlighted how changing climate conditions impact monarch migration and survival rates, demonstrating their role in signaling broader ecological disruptions.Rising temperatures disrupt migration timing, causing monarchs to arrive too early or too late at their destinations. Extreme weather events, such as storms and droughts, threatening the monarch survival.

3. Pesticide and Herbicide Use

The widespread use of neonicotinoid pesticides and genetically modified crops has been linked to declining monarch populations. The loss of milkweed in agricultural landscapes due to herbicide-resistant crops has been a major factor in monarch decline. The study by Pleasants and Oberhauser (2013) demonstrated that glyphosate use in crop fields has eliminated milkweed, leading to a 90% decline in monarch numbers in some regions. This makes monarchs a critical indicator of sustainable agriculture and pesticide impacts on biodiversity.

Conservation Efforts

Efforts to conserve monarch butterflies include habitat restoration, milkweed planting initiatives, and reducing pesticide use. Organizations such as the Monarch Joint Venture and the World Wildlife Fund (WWF) promote conservation strategies to support monarch populations. The monarch's status as a biodiversity indicator underscores the need for ecosystem-wide conservation measures.

To protect monarch migration, conservation programs focus on:

Habitat Restoration – Planting milkweed plants and nectar-rich flowers along migration routes and in the breeding grounds of monarch butterfly.

Protected Areas – Establishing reserves like Mexico's Monarch Butterfly Biosphere Reserve. Avoiding tall structures along their natural migration routes. Reducing the spray of pesticides and herbicides.

Public Awareness and Citizen Science – Encouraging people to create butterfly-friendly gardens and report monarch sightings. Conservation groups and governments worldwide are working to ensure monarch butterflies continue their remarkable migration for future generations.

CONCLUSION

The migration of monarch butterflies is a natural wonder, showcasing the complexity of insect navigation and adaptation. It also reveals long evolutionary history and their adaptation to variable climatic conditions. Not only multigenerational migration even these insects also possess other behavioral adaptation to survive in the environment like feeding behavior to get rid of alkaloid present in milkweed plant and storage of toxic alkaloid in non-active form in body and used as a one of the defense against their predators. However, environmental challenges are threatening their survival. Thus by promoting conservation efforts and sustainable practices, we can help in preserving this incredible migration and the ecosystems it support.

REFERENCES

Brower, L. P., Fink, L. S., & Walford, P. (2006). Fueling the fall migration of the monarch butterfly. *Integrative and Comparative Biology, 46*(6), 1123-1142.

Flockhart, D. T. T., Pichancourt, J. B., Norris, D. R., & Martin, T. G. (2015). Unraveling the annual cycle in a migratory animal: breeding-season habitat loss drives population declines of monarch butterflies. *Journal of Animal Ecology, 84*(1), 155-165.

Malcolm, S. B. (2018). Anthropogenic impacts on mortality and population viability of the monarch butterfly. *Annual Review of Entomology, 63*, 277-302.

Oberhauser, K. S., & Solensky, M. J. (2004). *The Monarch Butterfly: Biology and Conservation.* Cornell University Press.

Reppert, S. M., Gegear, R. J., & Merlin, C. (2010). Navigational mechanisms of migrating monarch butterflies. *Trends in Neurosciences, 33*(9), 399-406.

Urquhart, F. A., & Urquhart, N. R. (1978). Autumnal migration routes of the eastern population of the monarch butterfly (Danaus p. plexippus L.; Danaidae; Lepidoptera) in North America to overwintering sites in Mexico. *Canadian Journal of Zoology, 56*(8), 1759-1764.

Vidal, O., López-García, J., & Rendón-Salinas, E. (2014). Trends in deforestation and forest degradation after a decade of monitoring in the Monarch Butterfly Biosphere Reserve in Mexico. *Conservation Biology, 28*(1), 177-186.