



Biology Of the Monarch Butterfly

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INTRODUCTION

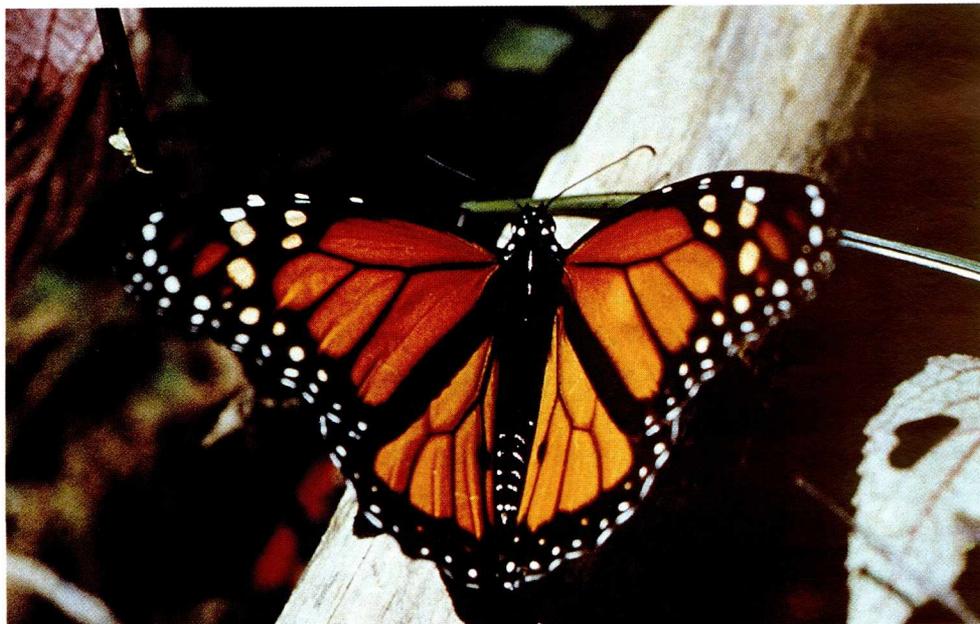
When we talk about the monarch butterfly, we touch on legend, mythology and the history of the species.

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The ancient Greeks thought that butterflies lived in the urn of the body. Christian theology positions them metaphorically in the three states of divinity: the caterpillar as a being of this world, the chrysalis as its tomb and the butterfly as the resurrection.

The pre-Columbian cultures considered them sacred. Their image can be

found in figures, vessels, ornaments and jewels. Butterflies were also used as tribute and offerings, and bread and sweets were even baked in their form. The Chichimecs called their mother goddess of sacrifices and wars Itzapapalotl, or the "obsidian butterfly." In Teotihuacan the great temple Quetzalpapalotl was built in her honor. The inhabitants of Texcoco, under



Photos by Arturo Píera

the reign of Acolmitzi Nezahualcōyotl, built the palace of Quetzalpapalotl on the shores of Lake Texcoco, where they did research on the sky, plants and animals.

Among the Aztecs, the butterfly, or *papalotl*, was a sacred being that symbolized death. It was butterflies who, in their flight, transported the souls of the fallen in battle.

The residents of Xochimilco represented their god Xochiquetzal, symbol of fire and the soul, with the body and wings of a butterfly: the representation of love and beauty, it was considered the protectress of plants, painters and artisans. Both the necklaces on the giant statues at Tula and the Aztec calendar depict the butterfly as a representation of fire.

The Mazahuas call them the daughters of the sun and, like the Otomis, Matlazincas and Mexicas, identify them today with the return of the spirits that come back year after year to visit them during the festivities of the Day of the Dead, around the end of October and the beginning of November, the season when the monarch butterfly arrives in Mexico.

THE MONARCH

The monarch butterfly (*Danaus plexippus*) is the best known of all the butterflies in Central Mexico. Its orange wings, outlined in black with white specks, dominate the winters in some parts of the dense forests on the border region between the states of Mexico and Michoacán.

An exceptional species, the monarch butterfly surprises with its astonishing biological adaptability which allows it to migrate with extreme precision every year.

The monarch butterfly's origins date back to more than 200 million years ago, when Africa and South America were a single continent.

With the separation of the continents and subsequent ice ages, the monarch migrated in search of the milkweed (*Asclepias sp.*), that it needed to feed its larvae.

Once established in the northern part of the hemisphere, when the temperatures dropped, the butterflies emigrated south to winter in Mexico in the temper-

Taxonomy of the Monarch Butterfly

Kingdom: *Animalia*
Phylum: *Anthropoda*
Class: *Insecta*
Order: *Lepidoptera*
Family: *Danaidae*
Genus: *Danaus*
Species: *D. Plexippus*

ate forests of the Transversal Volcanic Axis in what are now the states of Michoacán and Mexico, where they can enjoy broad biodiversity and a benign climate. This migration is reversed when the temperatures in the south increase.

Gauging by both traditional knowledge and scientific research, the monarch butterfly's migrations date from thousands of years ago.

DEVELOPMENT

The monarch butterfly is a diurnal, winged insect that belongs to the order of the *lepidoptera*, which are characterized by a sucking mouth in the form of a proboscis or tube that can be coiled spirally and a body and wings covered with scales. Hence, its name: *ptero* means wing and *lepidos* means scales.

The metamorphosis of the monarch butterfly broadly speaking takes it through four different stages.

Once impregnated, the females lay about 400 eggs the size of the head of a pin on the back of a leaf of the *Asclepias* plant. Between three and 12 days later the larvae hatch and the second stage begins. In its larval stage, the monarch feeds on the leaves where it hatched, multiplying its weight at birth 2,500 times and changing its tegulae, exuviae, or outer skin five times.

Two or three weeks later, during the last change of tegulae, the caterpillar hangs from a branch or leaf and weaves a bright green silk net around its body, becoming the chrysalis where its metamorphosis into a butterfly will take place. Ten days later the chrysalis becomes transparent and inside, the form and colors of the adult monarch butterfly can be distinguished.

The butterfly breaks through the chrysalis and in a few minutes its wings dry and harden. When conditions are favorable, the full cycle of the transformation from the egg to the adult insect takes an average of five weeks.

The egg. The female butterfly oviposits her fertilized eggs on the leaves. One by

one, she deposits about 400 oval-shaped, light green eggs very carefully, attaching them with a sticky substance she produces herself.

The shell has a micropore, a small orifice through which the male's spermatozoa enter the egg after entering the female monarch's abdomen. Through that same hole, the egg receives air and humidity.

Caterpillar or larva. From the egg, the larva is born, a yellow, black and white worm formed by a head and a body. The head has a powerful mandible with teeth that allow it to eat the leaves of the plants where the egg was originally deposited.

The body has no skeleton and is swollen like a balloon from the pressure of the hemolymph—functionally comparable to the blood of vertebrates—inside its body. It has thousands of muscles—proportionally four times more muscles than human beings—that allow it to move. The larvae grow very quickly; they devour leaves day and night, and they even eat the skin they slough off.

As they grow, their skin successively becomes too tight so they have to change it five times in this stage.

The larvae's main source of food are plants from the *Asclepiadaceae* family, which contain toxic substances that remain in the body until its adult phase, allowing it to repel the attacks of predators, among them insect-eating birds.

The chrysalis. The chrysalis is the intermediate stage between the caterpillar and the butterfly. During the last change of tegulae, the caterpillar hangs upside down and secretes a silky substance from its labia to form a web that eventually covers it completely. This is the beginning of the final stage of the monarch. During its metamorphosis, the chrysalis does not move; it does not eat; it does not drink; it only breathes through orifices called spiracles.

Initially, the chrysalis is a greenish blue color. Eight days later it darkens and the black, orange and white colors typical of the adult monarch appear. Later, it splits from the bottom up and the legs and

antennae appear first. The adult butterfly emerges with its wings humid, transparent and wrinkled. In a matter of minutes, however, the pressure of the hemolymph dries and hardens its wings, enabling it to take flight.

The adult butterfly. The monarch is covered with scales and morphologically consists of a head, a thorax and an abdomen. When examined through a microscope, the minute overlapping scales that cover its wings can be seen.

The head is black with white specks approximately two millimeters in size and contains the mouth, the eyes, the spirally coiled proboscis and its two antennae. With the exception of the size of their eyes, there is no difference whatsoever between the head of the male and that of the female.

The adult monarch has no mandibles, which is why it can only consume liquids like dew, nectar, and the juices and sap of plants. To suck them up the monarch needs its tube-shaped proboscis, which it keeps coiled when not in use. The proboscis is about 1.5 cm in length and when extended, it is as long as the thorax.

Its round eyes are compound and slightly larger in the males than in the females. The ocelli, or simple eye, are minute organs that perceive the intensity of light. The monarch's sense organs are its sensory palpi, which have both tactile and gustatory functions and allow it to perceive roughness and humidity in the area where they alight.



Monarch butterfly migrations date from thousands of years ago.

Their antennae have 43 segments placed one on top of the next, are about 2 cm long and have at their base the organ called the Johnston, formed by small ducts, that determines the animal's sense of direction. They also serve to regulate equilibrium in flight and when walking and are used for listening, smelling, perceiving the wind, humidity and the nearness of animals or objects.

The monarch's thorax has three segments, each with a pair of legs. Joined to the thorax are two pairs of wings, one on the second segment and the other on the third. The wings are rigid, without muscles or tendons, have few nerves and only slight hemolymphatic circulation.

In the males, the back wings have two black dots, one on each wing, which are actually glands to produce smells. When they are fluttered and rubbed together, they produce a stimulating odor that attracts the female butterflies.

The butterfly's six legs are attached in pairs. Each leg has three segments: they allow it to walk, hold on, perceive sound waves and clean its antennae and palpi. Their tiny hairs detect food with a system 2,000 times more sensitive than the human tongue that stimulates the proboscis which extends by reflex.

The digestive system consists of the proboscis, a pharynx, an esophagus, a maw, a stomach, an intestine and an anus that allow it to do everything from ingesting food to absorbing the nutrients and

discarding the non-usable waste materials.

The butterfly breathes through small holes in its skin called spiracles that send

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oxygen through its body via tiny tubes that make up the trachea. To avoid overheating, it has a ventilation system that keeps it cool during both flight and repose.

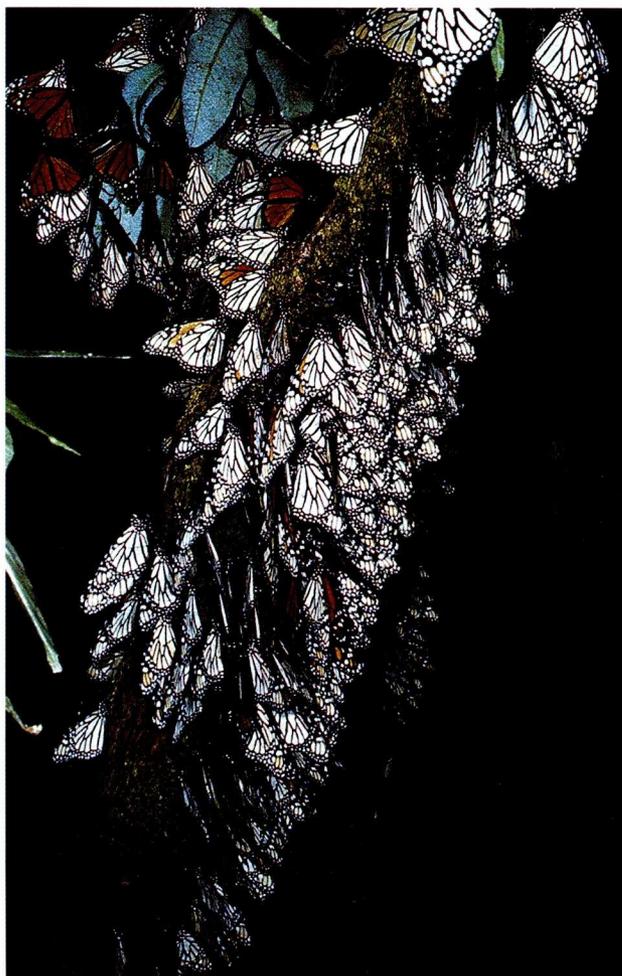
The circulatory system has neither arteries nor veins: the whole inside of its body is full of hemolymph. Its heart, shaped like a tube, lies along the entire length of the insect's body. This strange heart provides the body's organs and tissues with oxygen as it pulsates, pumping the hemolymph.

The nervous system has a cerebral ganglion connected to the entire body through nervous cords, ganglia and nerves. It also has external nerves that cover the surface of its body allowing it to perceive outside stimuli like the wind, rain

and humidity. The cerebral ganglion sends orders to the body through the antennae.

The reproductive system is very sexually dimorphic: that is, the male and the female are totally different. The female has two ovaries which produce eggs and a fertilization chamber where she stores those that have already been inseminated. The male has two testicles that produce the spermatozoa and a sexual organ called an aedeagus which at its end has claspers to hold the female during copulation.

To attract the female, the male rubs his odoriferous glands together secreting stimulating odors. If the female responds, the male takes the initiative by adhering himself to one end of the female's abdomen. Mating can take a long time, first dur-



ing flight, later on the ground, on trunks of trees or in the forest undergrowth.

During copulation, the male deposits his semen and the female keeps it in a receptacle called a spermatophore. When a spermatozoid fecundates an egg, the female adheres it to the back side of a leaf, initiating the cycle of reproduction.

PROTECTIVE COLORING

An interesting aspect of the monarch butterfly's conservation in winter is its protective coloring. To form its colonies for hibernation, it alights on trunks and branches of conifers and folds its wings to show their undersides and blend into the colors of the tree bark and foliage, thus avoiding its predators.

HABITAT

The monarch requires a healthy, undisturbed forest, with trees like fir, pine, evergreen oak and cedar, among other species, to be able to develop its biological functions and guarantee its survival.

The low brush of the forest undergrowth is also fundamental for retaining warmth during the night. A humid forest with moss and lichen, a variety of types of plants with nearby sunny areas, without noise or external disturbances make up a propitious habitat for the species.

The forests where the monarchs alight in Mexico have very specific microclimatic characteristics, appropriate for their habitat. Because of their altitude, from 2,700 to 3,400 meters above

sea level, these forests do not go through marked changes in temperature, with a mean of 15°C and 50 percent relative humidity. If the relative humidity were higher and the temperature lower, the monarchs would run the risk of freezing to death.

MIGRATION

During the summer and part of the autumn, the monarch lives in the forests of southern Canada and the northern United States. In mid- or late autumn, when climatic conditions become severe there, the monarchs begin their migration to the south, taking advantage of prevailing winds from the north.

Some scholars say that they take two routes: west of the Rocky Mountains toward California near Pacific Grove and Monterey, and east toward the forests of the states of Mexico and Michoacán.

The massive return trip that takes an average of two months goes in exactly the opposite direction when Mexico's temperate forests begin to heat up in spring.

The generation that migrates from north to south usually does not mature sexually until after its hibernation in the forests of Mexico. After hibernation, it begins reproduction with copulation in the forests of the Transversal Volcanic Axis.

It is important to point out that while scholars do not disagree about the way the monarch butterfly migrates south, there is a polemic regarding the characteristics of its northern migration. Some authors hold that, as a result of mating, the females of this generation oviposit

in the states of northern Mexico and after six weeks, the second generation is born, which is the one that travels further north, covering a large part of the states of southern and central United States.

This second generation in turn gives rise to a third generation that ends its life cycle in the south of Canada and the north of the United States, procreating a fourth generation that spends the summer and part of the autumn in short life cycles. Then, a fifth generation is born that will be the one which migrates south again and, in order to preserve the species, will not mature sexually—and therefore not reproduce—until finishing its hibernation in Mexico's coniferous forests.

Other scholars take a different view, saying that the butterfly migrates to the north of the hemisphere and arrives to the U.S. and Canadian forests, where four or five generations are born and die. It is the last generation that, instead of maturing sexually, prepares for its return to Mexico in the fall.

There are also several theories regarding the monarch butterflies' sense of direction on their migratory routes and in finding their colonies, given that it is different generations that migrate. One theory hypothesizes that they direct their flight by the sun; another says that they take their lead from the magnetic waves emanating from the Transversal Volcanic Axis.

Without underestimating the complexity of these theories, it seems logical and it is very possible that their actions stem from a genetic behavior pattern together with prevailing macro and microclimatic conditions. **MM**