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↑ A close-up of Wright's Happy Tube-nosed Fruit Bat (*Nyctimene wrightae*) shows the unusually shaped nostrils that define this group of bats.

↑ Tube-nosed Bats, such as this Queensland Tube-nosed Fruit Bat (*Nyctimene robinsoni*), can detect odors in each nostril separately while in flight, which helps them localize ripe fruit.

↑ Keast's Tube-nosed Fruit Bat (*Nyctimene keasti*) is readily identified by its bright yellow spots. Known only from three Indonesian islands, it is threatened by habitat loss.

MINIOPTERUS SCHREIBERSII

Schreibers's Long-fingered Bat

Long narrow wings

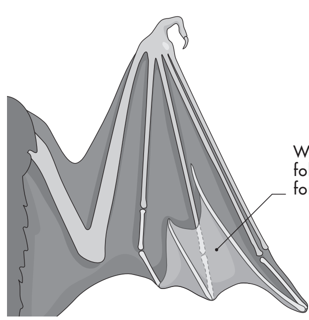
SCIENTIFIC NAME	*Miniopterus schreibersii*
FAMILY	Miniopteridae
DIET	Moths
HABITAT	Varied, semidesert steppes, Mediterranean scrub and forests
CONSERVATION STATUS	Vulnerable
WEIGHT	0.35–0.49 oz (10–14 g)
WINGSPAN	12 in (30 cm)

Schreibers's Long-fingered Bats are one of 41 species in the Old World family Miniopteridae, unique in their ability to fold back an exceptionally long third finger when not flying. As aerial hawkers, they hunt for flying insects, specializing in moths.

Long-fingered Bats, sometimes also called "Bent-wing Bats," are small to medium-sized bats with a simple muzzle, a tail enclosed in the wing membrane that stretches between the legs, and an extremely elongated third finger. This elongation, due to significant lengthening of the second phalanx of the third digit, results in some of the longest and narrowest wings within bats, supporting long-distance flight in open environments.

This species changes roosts several times per year and may migrate hundreds of miles. Schreibers's Long-fingered Bat was once thought to be widespread across Africa, Asia, and Australia. However, recent molecular studies have demonstrated that what was once considered *Miniopterus schreibersii* actually contains at least 11 different bent-wing bat species. This taxonomic splitting has refined our understanding of which bats from which locations are truly *M. schreibersii*, restricting it now to southwestern Europe and North Africa through the Middle East to the Caucasus.

Across its range, populations are declining due to habitat loss and disturbance, including that from ecotourism and from improperly designed cave "gates." These barriers, with multiple small gaps, allow bat access while limiting human entry. Unfortunately, bats will sometimes abandon caves if the gap spacing creates flight challenges. In the last 20 years, a number of mortality events have occurred, with mass die-offs of thousands of bats. While most are unexplained, those in Spain and Hungary were associated with the Lloviu virus, a relative of Ebola.



Long wing
The tip of the long wing of Long-fingered Bats folds forward to tuck out of the way, making climbing easier.

→ Schreibers's Long-fingered Bats forages mainly in open areas and is protected in most of its geographic range.

ASELLIA TRIDENS

Geoffroy's Trident Leaf-nosed Bat

Largest trident leaf-nosed bat

SCIENTIFIC NAME	*Asellia tridens*
FAMILY	Hipposideridae
DIET	Beetles, moths, flies, and grasshoppers
HABITAT	Varied, mostly desert and semidesert
CONSERVATION STATUS	Least Concern
WEIGHT	0.21–0.46 oz (6–13 g)
WINGSPAN	Not known

Geoffroy's Trident Leaf-nosed Bat is a member of the large Old World bat family Hipposideridae, a group of bats easily distinguished by the structure of their nose leaves, their broad and mobile ears, and their constant frequency (CF) echolocation calls.

Geoffroy's Trident Leaf-nosed Bat is a very common and widely distributed species in North Africa and parts of Asia. It can be found in a variety of habitats but is mostly associated with oases and dry riverbeds of desert and semidesert habitats. This gregarious species roosts in enclosed spaces, including caves, mines, and rock caverns, but also takes advantage of human-made structures such as underground irrigation channels, buildings, cellars, temples, and tombs. Although this species may roost in small numbers, up to 5,000 individuals have been reported from a single cave in Iran. It usually only roosts with bats of the same species but has been found to occasionally co-roost with the Persian Trident Bat (*Triaenops persicus*), mouse-tailed bats (*Rhinopoma* species), and the Egyptian Rousette (*Rousettus aegyptiacus*).

The name of this lineage of bats is derived from the large and distinctive nose leaf with three subtriangular projections, which form a trident. The muzzle of Geoffroy's Trident Leaf-nosed Bat is relatively short and its fur is brownish gray; it is darker on its back than on its front. The species is highly seasonal. Females roost together in maternity colonies and each gives birth to a single pup in June or July, which it nurses for approximately 40 days. This bat migrates between the summer and winter, putting on fat in the late fall just before migration.

→ Geoffroy's Trident Leaf-nosed Bat adeptly clings to the rock ceiling of a cave. Their highly mobile ears allow them to sense their surroundings.

NOCTILIO LEPORINUS

Greater Bulldog Bat

Huge feet

SCIENTIFIC NAME	*Noctilio leporinus*
FAMILY	Noctilionidae
DIET	Fish and occasionally aquatic arthropods
HABITAT	New World tropics
CONSERVATION STATUS	Least Concern
WEIGHT	1.8–3.2 oz (50–90 g)
WINGSPAN	Around 20 in (50 cm)

The handsome Greater Bulldog Bat is a common and well-studied species found in neotropical forests, always in proximity to bodies of water. Males are typically orange or yellow and have brighter colored fur than females.

Bulldog Bats are so named due to their large, floppy lips and cheeks, dominant on faces that are otherwise plain, without nose leaves or other adornments. In support of their fish-eating habit, their hind limbs are larger than most bats, with large feet and long, curved, and very sharp claws. Although they cannot detect fish under water, as soon as a surfacing or jumping fish disturbs the water, the bat's sensitive echolocation will pick it up. When surfacing fish are very abundant, the bat switches tactics and deploys a "random rake" strategy, dragging the tips of its feet through the water for up to 3 yards (10 m). When their toes hit a fish, the claws spear the fish and close around it, aided by a scooping action performed by the uropatagium. The bat then moves its legs up and its head down, transferring the fish to its strong jaws. Larger fish are carried back to a perch for easier processing.

Female Greater Bulldog Bats give birth to a single pup each year, with the timing linked to seasons of highest food availability. Both infant and adult Greater Bulldog Bats emit an array of communication calls, mostly in the ultrasonic range (above human hearing). These capable hunters also eavesdrop on other Greater Bulldog Bats by listening for feeding buzz echolocation calls, thus learning where the best foraging opportunities are.

→ A female Greater Bulldog Bat rakes the surface of a pool of water in search of fish. Some females are paler than males.

CNEPHAEUS NILSSONII

Northern Bat

Pushes northern limits

SCIENTIFIC NAME	*Cnephaeus nilssonii*
FAMILY	Vespertilionidae
DIET	Insectivorous, primarily small Diptera
HABITAT	Varied, including boreal and high mountain forests
CONSERVATION STATUS	Least Concern
WEIGHT	0.3–0.46 oz (9–13 g)
WINGSPAN	9.4–11.0 in (24–28 cm)

The Northern Bat is a fast-flying and widely distributed insectivorous species found in a diversity of habitats across the northern regions of Eurasia. Highly adaptable, it even lives north of the Arctic Circle in Norway, Sweden, and Finland.

The most northerly distributed bat, the Northern Bat is known for its long, luxurious, silky, and shaggy fur, which is dark brown to black with frosted gold-yellow tips on the back and lighter brown or beige fur on the front. Its ears and tragus (a cartilaginous projection at the base of the ear that plays a role in echolocation) are short and rounded. Like all bats in the family Vespertilionidae, their faces are plain, without any fleshy appendages or features. Their fast flight is supported by broad and long wings, and they hunt in open woodlands or forest edges. Naturally a tree-cavity and cave-roosting species, the Northern Bat readily adapts to human-made roosts, including houses and cellars. It is a frequent visitor to city parks and gardens. Although the Northern Bat will consume beetles and moths, its primary food sources are small Diptera, which include mosquitos, midges, and gnats.

Like other hibernating temperate species, female Northern Bats form maternity colonies, groups of reproductive females that roost together and give birth at roughly the same time in the summer. Females establish and defend small feeding territories that have abundant insects. Northern Bats in their highest ranges are faced with continuous midsummer daylight. Under these conditions, one might expect them to hunt during daytime hours when insects are more plentiful. However, bats feed primarily between 11 p.m. and 7 a.m., following their normal patterns in other locations.

→ The Northern Bat, with its distinctive fur, can sometimes be found roosting in and on human-made structures, like this concrete wall.

MYOTIS SODALIS

Indiana Myotis

A picky rooster

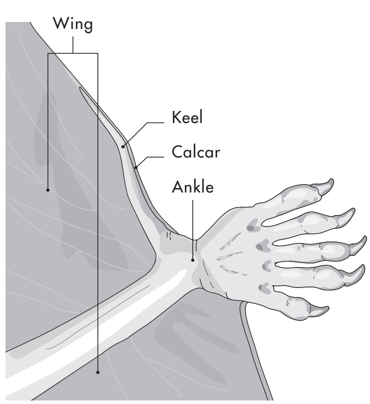
SCIENTIFIC NAME	*Myotis sodalis*
FAMILY	Vespertilionidae
DIET	Varied insects, including moths and Diptera
HABITAT	Wooded or semi-wooded upland forests
CONSERVATION STATUS	Endangered and declining
WEIGHT	0.18–0.35 oz (5–10 g)
WINGSPAN	9.4–10.6 in (24–27 cm)

This bat species, first described from Indiana, in the United States, is listed as "Near Threatened" by the International Union for the Conservation of Nature (IUCN) but "Endangered" by the US Endangered Species Act.

Indiana Myotis, a hibernating species, is found in forested areas in the eastern half of the United States. In both summer and winter, it has specific roosting requirements. Small groups of females form maternity colonies and each gives birth to a single pup in hollow dead trees or under the loose bark of dead or living trees. In the winter, both sexes hibernate in the coldest and most humid caves.

Approximately 85 percent of the total population hibernate in just nine sites. Such specific preferences place this species at risk when habitat loss and degradation, forest fragmentation, and winter cave disturbance occur. Urbanization and development have thus historically posed the greatest risk to this species. Since being listed as Endangered in the United States, populations have declined by 50 percent. Part of this decline is due to their susceptibility to the fungal pathogen that causes White-nose Syndrome (see page 222).

Light to grayish brown in color and with soft, dull fur, Indiana Myotis can be difficult to tell apart from the Little Brown Myotis (*Myotis lucifugus*), with which it shares much of its range. Careful examination distinguishes the Indiana Myotis by the presence of a keel, or bump, on the calcar. The presence of shorter hairs on the toes relative to Little Brown Myotis is also diagnostic, as is the pinkish-colored nose.



Cartilage spur

Most bats have a calcar, a spur of cartilage that connects to the ankle and helps to support the wing. The Indiana Myotis has a bump or keel on the calcar not present in the Little Brown Myotis.

→ The Indiana Myotis migrates between its summer roosts, in which it forms maternity colonies, and the caves in which they hibernate.

BAT ANATOMY

The bat body

The bat body is a marvel of evolution, built to support powered flight in a uniquely mammalian way. Beyond the wondrous wings, nearly every part of the bat body has evolved over time to meet the unique anatomical, physiological, and energetic requirements of being a flying mammal. These are especially pressing for female bats, who must fly while pregnant and carry their young pups as they forage.

The most obvious anatomical adaptation for flight in bats is the hand wing, which enables powered flight (see page 25). Composed of long, delicate bones across which a thin layer of living skin is stretched, this heavily modified mammalian feature is more than meets the eye. The skin of a bat wing (the patagium) is incredibly thin, delicate, and flexible, allowing it to stretch and move in ways that are essential for maneuverable flight.

The elasticity of the patagium allows bats to adjust the shape and curvature of their wings to support different speeds and flight maneuvers. Underlying this elasticity is an intricate network of blood vessels, muscles, and connective tissues. The rich supply of blood vessels maintains wing tissue integrity, facilitating the rapid healing of any injuries to the skin of the wing.

In some species, such as the Variegated Butterfly Bat (*Glauconycteris variegata*, page 84), the venation is part of the visible color patterns of the wings. The wing membrane is not simply a flap of skin but rather a living tissue that aids flight as well as gas exchange and thermoregulation. Since the blood vessels are so close to the surface, bats are able to bring in oxygen and expel carbon dioxide through the skin, increasing the efficiency of gas exchange during long, energetically expensive periods of flight. Through these wing blood vessels, they can also rapidly dissipate the body heat generated during flight and thus avoid heat stroke.

The long, delicate bones of the bat's fingers support the wing membrane. They are lightweight to save energy, but are under significant stress during powered flight. To compensate, bats have an extra bone at the elbow called the ulnar sesamoid. Formed when part of the triceps muscle ossifies, it functions to strengthen the joint. Similarly, for bats that have a wing membrane between the hind legs (a uropatagium), a spur of cartilage near the ankle, called the calcar, provides structural support for this unique bat structure. Interestingly, the skin of the uropatagium is thicker and more resilient than other parts of the wing membrane, which may help reduce damage from insect body parts when this structure is used as a scoop during prey capture. Although the bones of digits II through V of the hand wing are fully enclosed within the wing membrane, the thumb remains separate and typically has a claw, which may aid in climbing, roosting, and food handling.

↙↘ The Variegated Butterfly Bat is a well-known species from Sub-Saharan Africa. It is easily recognized for the reticulated patterning of its wings, formed by visible blood vessels and fibers of muscle and elastin. Like all other species in the family Vespertilionidae, it has a long tail that is fully enclosed in the uropatagium.

BATS IN FLIGHT AND AT REST

Myriad other skeletal, anatomical, and physiological modifications support the unique bat lifestyle. Bats in flight require approximately 12 times as much energy as bats at rest. To meet these needs they have a very efficient circulatory system, facilitated by oversized hearts and lungs housed within an enlarged rib cage and broad collarbones. Just as the human heart rate varies between exercise and rest, the bat heart rate during flight is significantly higher. In the well-studied Common Tent-making Bat (*Uroderma bilobatum*), the heart rate during flight can exceed 1,000 beats per minute, compared to around 200 beats per minute at rest. To support these exceptional cardiovascular needs, bat veins and arteries contract rhythmically to pump blood back to the heart. In other mammals, only the arteries do this.

To generate the power needed for flight, bats have exceptionally strong arm, back, and chest muscles. Similar to birds and pterosaurs, the chest muscles are supported by a keel on the sternum bone, providing more surface area for muscle attachment. Their enlarged chest, combined with a relatively small pelvis, gives them quite an exaggerated "body builder" appearance, especially compared to other mammals of similar size, such as rodents. In addition to the arm, back, and chest muscles, bats also have five muscles not found in other mammals, which control the tautness of the wing membranes and allow them to adjust the curvature of the airfoil during flight.

Bat bodies are not just modified for flight. There are also adaptations for extended periods of rest when bats are neither foraging nor migrating. The long, slender bones of the bat hind limb support these unique animals while they roost, hanging upside down. The arrangement of the tendons in the feet and the lower legs keeps their long and flexible toes firmly gripped on a branch or cave wall, with negligible energy required. This roosting position conserves energy and allows for rapid takeoff when needed.

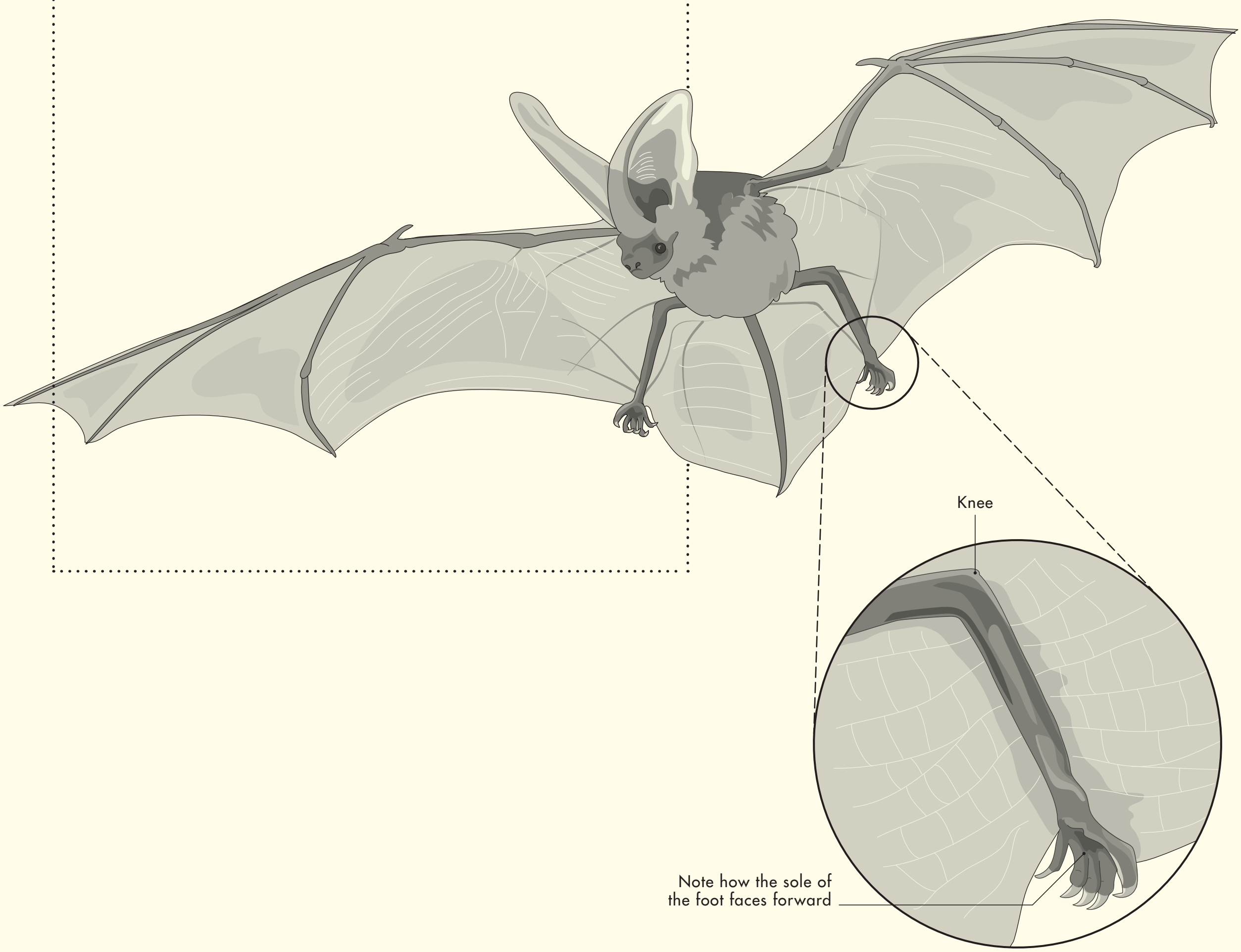
← Roosting bats, like this Common Sword-nosed Bat (*Lonchorhina aurita*), have resting heart rates significantly lower than bats in flight.

HIND LIMB POSITION

Perhaps the most surprising feature of the bat body is the rotation of the hind limbs at the pelvis, such that the sole of the foot faces forward. Accordingly, the bat knee flexes in the opposite direction compared to other terrestrial mammals. The position of the hind limbs contributes to the aerodynamic shape of the bat in flight, supports the uropatagium when present, and facilitates roosting, but it comes at a cost. Most bats, unlike birds, are not good at walking. Furthermore, although bats are highly skilled at taking off for flight, landing can be perilous. Some bats have four-point landings, touching down with hind feet and thumbs, while others land (somewhat awkwardly) on their feet. Amazingly, some bats do backward somersaults just before landing to direct their feet toward the substrate.

"Backward" leg

All bats have "backward" legs, rotated at the hip by 180°. Note the visible bending at the knee and the positioning of the foot such that the sole is visible when looking at a bat from the front. This shift in basic mammalian anatomy is often overlooked when we consider the many other amazing evolutionary changes present in bats.



← The New Zealand Lesser Short-tailed Bat (*Mystacina tuberculata*) is unusual in that it spends much of its time walking on the forest floor in chase of crawling rather than flying insects.

→ Spix's Disk-winged Bats are often found roosting in the small tube-like structures formed by the unfurled leaves of tropical plants.

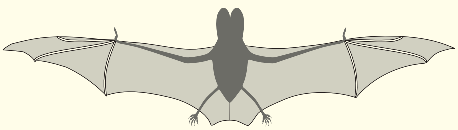
↓ Disk-like structures present on the wrists and ankles of Spix's Disk-winged Bats are a unique adaptation that helps them cling to the smooth and damp sides of these leaves.

VARYING APPEARANCE

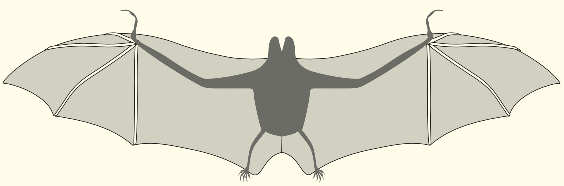
As we shall see throughout this book, because bats live in a remarkable variety of habitats and feed on many different food sources, they vary significantly in overall appearance and size. For example, wing shape varies according to lineage and niche, which is tied to flight differences. Likewise, the appearance of the bat head is strongly linked to both diet and echolocation patterns, with facial modifications for emitting echolocation calls and ear modifications for receiving their echoes. Some highly unusual bats have additional unique anatomical modifications, such as the sucker-footed bats of Madagascar (see the Eastern Sucker-footed Bat, *Myzopoda aurita*, page 82) and the disk-winged bats of South America, such as Spix's Disk-winged Bat (*Thyroptera tricolor*), which have skin at the wrists and ankles modified to form disk-like structures for clinging to smooth surfaces like unfurled leaves. Although the basics of the bat body are the same across all 1,482 species, the differences between bats reveal amazing evolutionary stories.

Wing shapes and flight

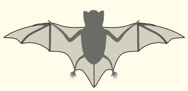
Every bat has "hand wings" and flies, but the size and shape of their wings vary significantly. Wing variation reflects differences in a bat's foraging ecology, including where it feeds, how it acquires its food, and what type of food it prefers.



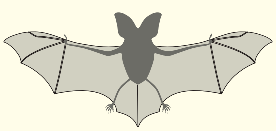
Large-eared Giant Mastiff Bat
(*Otomops martiensseni*)



Egyptian Rousette
(*Rousettus aegyptiacus*)



Moloney's Mimic Bat
(*Mimetillus moloneyi*)



Brown Long-eared Bat
(*Plecotus auritus*)

Wing shapes

Bats vary in overall body size and also in the shape of their wings. Some bats have short stubby wings while others have long narrow wings. Relative to their overall body size, bat wings can also be larger or smaller, as measured by their surface area.

Bat wings generally vary in two primary ways: size and shape. Wings can be smaller or larger relative to the overall size of the bat. This is measured by the surface area of the wing relative to the bat's weight, and is called "wing loading." Similarly, bat wings can vary in shape, ranging from short and broad to long and narrow. This is measured by the wingspan relative to the surface area of the wing and is called "aspect ratio." Bats within each of the 21 living bat families usually have similar wings, with notable exceptions tied to species differences in ecology.

Bats with a small wing surface area relative to their body size have high wing loading. They must work harder to generate the lift needed to stay airborne but are otherwise efficient fliers because the drag on their smaller wings in flight is less. Bats with high wing loading often also have long and narrow wings, with a high aspect ratio. These bats can fly very far and at very high speeds. They typically forage in open, uncluttered environments and catch their food on the wing. These modifications for speed and distance are advantageous when high speed and short migration time are needed, but they come at a cost, as these bats cannot turn tight circles and have less maneuverable flight in general. They are unable to forage in cluttered forests, nor to hover to gather food that does not move, like fruit and perched insects. They also have difficulty taking off and must roost in high-up locations so that they can drop down to build up airspeed before thrusting forward. Long, narrow wings are often found in long-distance migrating insectivorous bats like the free-tailed bats and the ultra-marathoner fruit bat, the African Straw-colored Fruit Bat (*Eidolon helvum*), as well as in fish-eating bats such as the Greater Bulldog Bat and the Fish-eating Myotis (*Myotis vivesi*)

↑ The Mauritian Tomb Bat (*Taphozous mauritanus*) has long, narrow wings (high aspect ratio) with a small surface area (high wing loading), which enables fast and energetically efficient flight.

→ The Indian Flying Fox can fly long distances, but also must be able to fly slowly and maneuver to land in trees. The compromise is wings that are quite long but have a large surface area.

that fly over open water with less need for tight turns. However, in this case they have wings with a relatively large surface area—that is, low wing loading—so that they can carry their heavy fish prey.

Bats with short and broad wings (low aspect ratio), like the Brown Long-eared Bat (*Plecotus auritus*), are the champions of flying and feeding in cluttered environments, even in the dense canopies of the tropical rainforest. They are agile fliers that are able to quickly adjust direction and speed. Although they are not typically long-distance or exceptionally fast fliers, they have extraordinary control during flight. Like other bats, they generate lift and thrust through the wingbeat cycle—the flapping of their wings. However, when needed, they can quickly fit through an opening barely larger than their body by tucking their wings in close to the body at just the right moment. Their ability to maneuver around obstacles is aided not just by their echolocation calls but also by small sensory hairs on the surface of their wings. These hairs allow the bat to sense changes in air pressure and speed over its wings and to adjust flight patterns accordingly. Bats with short and broad wings can either have wings with a relatively smaller surface area (high wing loading) or wings with a relatively greater surface area (low wing loading).

Species in the latter group are gleaners and hoverers, like the long-eared bats in the genus *Plecotus*. They select insect prey that is stationary, briefly hovering like a hummingbird, and have the wing

↖ The Lesser Long-nosed Bat (*Leptonycteris yerbabuenae*) is a nectarivore whose wing shape supports both hovering (short, broad wings) and fast flight (small surface area) between the patchily distributed flowers on which it feeds.

↑ The Brown Long-eared Bat has short, broad wings (low aspect ratio) with a large surface area (low wing loading), which allows them to hover and to carry off heavy prey items.

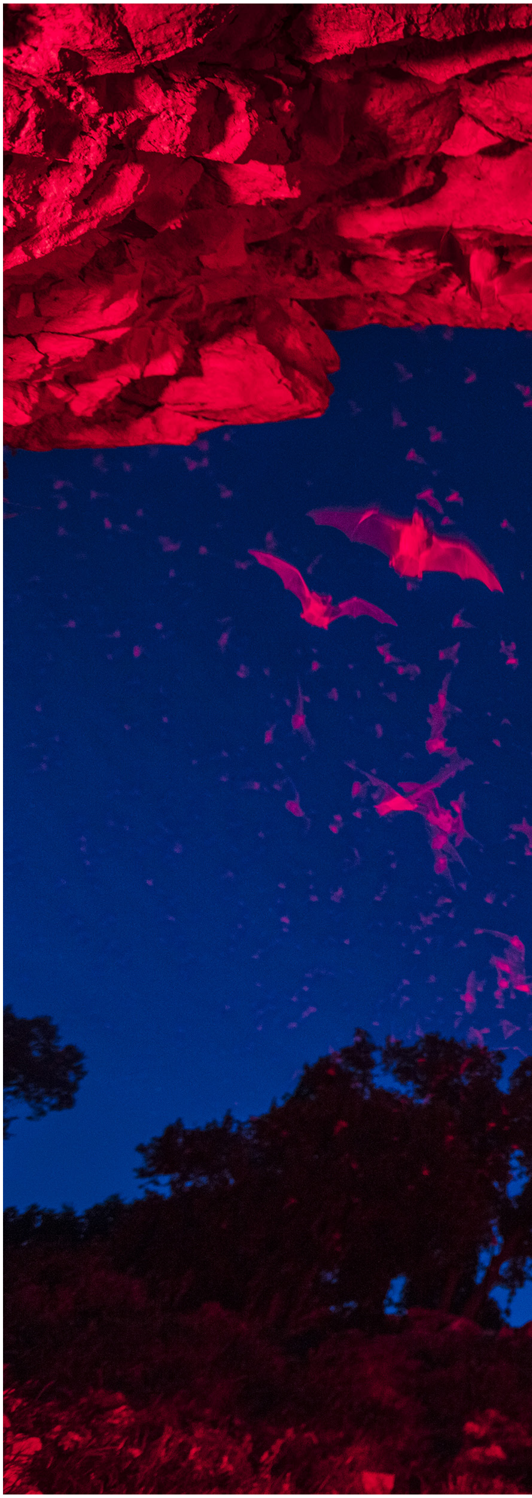
strength to carry off heavier food items. Gleaning bats will often carry their prey to a nearby perch where they can more easily manipulate them, leaving a pile of discarded insect body parts below.

Finally, bats may or may not have a well-developed uropatagium—a wing membrane between the hind limbs. This membrane, which may enclose the tail or part of it, can vary dramatically in shape. Potential roles for the uropatagium, beyond being used as a scoop for capturing prey, are not well understood, but it may aid in maneuvering during flight. Stretched between the hind limbs, it is functionally very different from a bird tail as its movements impact, and are impacted by, the rest of the bat wing.

How fast can bats fly?

Bats can reach speeds of up to 90 mph (144 km/h), but speed is highly species-specific. Some bats can hover like hummingbirds, extracting nectar from flowers, while others are able to achieve great flight speeds in search of faraway food sources.

The Brazilian Free-tailed Bat (*Tadarida brasiliensis*, page 274) is widely recognized as the fastest bat, at 90 mph (146 km/h), and one of the speediest flying animals in the world. This impressive speed is supported in part by high wing loading (small wing surface area relative to body size), long, narrow wings, enlarged pectoral muscles, and distinct air vortices created at the wingtip, which provide thrust. Free-tailed bats roost in exceptionally large numbers, ranging from hundreds to thousands to millions per site. At these high densities, bats emerge from their cave roosts as large columns of upwardly dispersing animals.



→ Brazilian Free-tailed Bats, shown here with thermal imagery, can congregate by the millions. They emerge nightly to feed from their roosts, which include caves and human-made structures like bridges.

As aerial pursuit predators of a variety of flying insects, each bat must separate itself sufficiently from its many roost mates in order to access food. Like pilots, bats can take advantage of the prevailing wind to increase their speed and to gain altitude for longer-distance travel.

Flight speed has only been measured in a few dozen other bat species, and not surprisingly varies by context. For example, Little Brown Myotis have been clocked at 5 mph (8 km/h) when flying over water (and potentially drinking), 11 mph (18 km/h) when hunting, and 18 mph (29 km/h) when approaching cave roosts (and not foraging).

For bats that roost and forage within cluttered forest environments, maneuverability rather than speed is the more important metric. At the lowest end of the bat speed continuum, hovering in place represents its own flight challenges but is energetically less costly than directional flight. Newer techniques that deploy

↖ Prior to nightly emergence, Brazilian Free-tailed Bats warm up by flying inside their cave roost for some time.

↑ To get a head start and distance themselves from their neighbors, some Brazilian Free-tailed Bats emerge from their day roosts before dusk to travel in search of food.

high-speed videography and the use of strategically placed sensors to analyze 3D kinematics are advancing our understanding of bat speed and other aspects of flight. Likewise, the increasing miniaturization of GPS tags allows for the georeferenced tracking of bat movements, including speed, across the landscape.

How far can bats fly?

Bat flight distances vary across species. Some bats find their nightly meal close to home while others can travel 60 miles (100 km) or more each night in search of food. Likewise, some bat species remain localized all year round, while others migrate great distances.

Nightly foraging patterns, including how far bats fly each night and which routes they take, are typically studied using radiotelemetry or GPS tracking. Not surprisingly, the fastest bats, with their specialized wings, forage the farthest and can migrate long distances. For the Brazilian Free-tailed Bat, individuals may fly 30–60 miles (50–100 km) per night and may reach altitudes of over 10,000 ft (3,000 m), where prey is abundant. While migrating, they might travel 220 miles (350 km) in a night, eventually covering 1,050 miles (1,700 km) from the southern United States to Mexico.

← Lightweight radiofrequency tags can be used to track bat flight patterns and distances. Pallas's Long-tongued Bat is a nectar feeder that follows the same route each night. The symmetrical holes in this bat's wings are from tissue biopsies taken to obtain a DNA sample. Bats have no issues flying with small holes or tears in their wings, which heal within two to three weeks.

↗ Bechstein's Myotis from Europe and Western Asia is a forest-dwelling species. Maternity colonies form each spring.

In contrast, the smallest bat in the world, the Hog-nosed Bat from Thailand and Myanmar, is believed to only forage within about half a mile (1 km) of its limestone cave roosts and may disperse no more than 1–3 miles (2–5 km) across its entire life span. The biggest bats, flying foxes such as the Large Flying Fox, are highly mobile and within a year can travel hundreds of miles between roosting sites, readily hopping between Southeast Asian island nations. Similarly, within Africa, the Straw-colored Fruit Bat smashes records with its cross-continental annual migration between Central Africa and Zambia—a distance of more than 1,500 miles (2,500 km).

Some bats readily explore new areas, but many are creatures of habit. In common with hummingbirds, nectar-feeding bats, such as Pallas's Long-tongued Bat (*Glossophaga soricina*), often display a nightly travel pattern called "traplining," in which they repeat the order in which they visit specific locations. Bat flight patterns and distances traveled often also vary by sex, with females of some species more likely to migrate than male bats. In addition to nightly flight patterns and migrations, which occur in regular daily or annual cycles, some bats undertake a once-in-a-lifetime dispersal when they are young, moving away from their natal group. For example, in the temperate bat species Bechstein's Myotis (*Myotis bechsteinii*), females typically remain near where they were born and often reside with their original birth colony, while males disperse to new geographic regions.

↑ The migratory Nathusius's Pipistrelle is widely distributed across Europe, typically following a northeastern-southwestern route.

MIGRATION FUEL

Although nightly foraging is generally fueled by food acquired each night, for those species that migrate, prolonged long-distance flight is mostly fueled by stored fat. Many species prepare for this marathon by weeks-long bouts of excessive eating and fat deposition. This is especially true for temperate bats like the 0.3 oz (8 g) Nathusius's Pipistrelle (*Pipistrellus nathusii*), which holds the record for small bat migration—with a journey of over 1,380 miles (2,224 km) from Latvia to Spain. The secrets of some migratory species, such as Nathusius's Pipistrelle, have been revealed by the ringing of bats, tracked over time by a host of international bat biologists.

(continued...)

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