Living Together

The social life of bats is a complex and multifaceted one of constant interaction between males and females, between females and their pups, and between rivals, relatives, and other bats. Bats can form lasting friendships, they groom each other, they alert each other to danger, they form a united front against inquisitive owls, they steal and share food, and they look after each other's young. The strategies of co-existence are almost as many as there are bat species. While some form stable, monogamous couples, others live in colonies of millions of individuals. Some live in small family groups or harems that stick together throughout the year (sometimes year after year), others change their groupings according to season.

Gathering in large colonies has, of course, both its advantages and disadvantages. On the positive side, it enables bats to cooperate—for example, in keeping warm or cool, depending on the season—and to develop sophisticated lasting forms of collaboration. It also provides safety in numbers from circling bird of prey when leaving the roost at dusk. Furthermore, while it is the mother bats' job to teach their pups, sometimes siblings and other relatives step in to help raise and protect them. Another benefit of group living is that it allows young, inexperienced members of the colony to learn where food sources and temporary resting places can be found and how to fly safely by accompanying their more experienced elders—even into adulthood. On the negative side, however, living in colonies exposes individuals to the risk of viral and parasitic infection and intensifies the competition for food.

The cave looks crowded and chaotic, but there is actually law and order. Each individual bat returns to its own little territory in the cave ceiling, sometimes occupying exactly the same spot year after year. Some individuals share the territory with others and sit tightly together. Perhaps they are sisters or mothers and young. It is important to use the same spot because the relationships with the neighbours are well established.

Social Life

There is, however, efficiency in numbers. It has been shown that suckling mothers and their young expend less energy in large colonies than in small, as the denser the group, the greater the insulation and the steadier the temperature. This probably is one of the main reasons why females congregate in nurseries in the spring. Another advantage is collaboration. Close relatives, often older siblings or half-siblings, help to raise a mother's young, and even unrelated individuals in the same colony are known to assist each other. An adult normally stays close to the pups when it is time for the colony to go out hunting, and in some cases, the pups are gathered together to facilitate their supervision—a crèche for bats, as it were. Even though a female can carry a relatively large pup on the breast, she usually leaves it behind—otherwise the pup attaches itself firmly to her nipples and clings onto her fur with its feet.

The males can seem less helpful when it comes to caring for the young. This is a typical feature of mammals and is simply due to the biology of suckling. Instead, the job of the males during the summer is to keep away from the females and their young so, as to minimise competition for food and the risk of infection. In some monogamous species, however, the males take active responsibility and, in smaller harems, defend both the living territory and hunting ground with demonstrations of flying prowess, aggressive calls, and scent marking.

J. Eklöf, J. Rydell, *Bats*, https://doi.org/10.1007/978-3-319-66538-2_9

Since bats live for a relative long time and often use the same roost year after year, they can form close bonds with their nearest kin, and larger colonies can contain sub-groups that provide security and a forum for exchanging information about successful hunts. It has been observed that species that relocate often do so with a few select individuals, commonly relatives, held together by the females, which make sure to include their daughters and granddaughters.

Bats often rub noses, possibly to learn each other's scent. Mutual grooming also helps the bonding process. We mentioned above that vampires share their food with less successful individuals; consequently, they keep a particularly close eye on each other, making mental notes of the altruistic members of the colony; while the selfish are immediately ostracised, the generous can count on being fed in reciprocation when in need themselves.

Communication

The more we learn about echolocation and social language, the more complicated it becomes. While much has already been learned about the sounds used in communication between females and their young and mating and territorial calls, more and more different communicative sounds are being discovered all the time. In recent years, it has been found that bats cannot only tell the members of their closest circle by their voices but can also hear the difference between those of different colonies, suggesting the possibility of dialects. One study carried out in Florida showed that free-tailed bats live in many respects as if in a musical and sing almost constantly, each song depending on the context and composed according to message, be it a warning, information, directions, or an invitation. The fact is that they use something akin to syntax and syllables in what is effectively a chiropteran language. The males sing a tune every time another bat passes their roost, an aggressive one for the males and a welcoming one for females. This can mean a great deal of singing for free-tailed bats since the colonies often comprise millions of individuals in different groups and permutations of harem, sex, and age.

Moreover, the roost as well as the size and composition of the colony vary with the season, which could also explain why such behaviour has evolved, the nature of the social context necessitating a flexible and complex communication system.

When humans listen to music while holding a conversation, the two hemispheres of the brain have their own tasks to perform, the right processing the music and the left the speech. It seems that the same is true for bats. So, while echolocating its surroundings and being bombarded with a constant influx of echoes, a bat can also listen to what its fellows are saying. Just like ours, the bat's right cerebral hemisphere is sensitive to small changes in frequency such as melody recognition, while the left deals with the more rhythmic hunting calls.

The disk-winged bats of Latin America that live in furled banana leaves relocate when the leaves open and become useless as living spaces. To keep the group together, they use special sonic signals to show their location. The other year, researchers found that the individuals sitting inside a rolled-up leaf use more complicated sounds than those flying outside because the leaf serves as a kind of megaphone. With no leaf to amplify its calls, a bat on the outside has to make more effort to be heard.

Vampire bats—and probably a great many other species—also use simple songs to keep track of each other and to navigate, the ensuing exchanges sounding a little like the duets performed by songbirds.

Competition

One disadvantage of living in a large colony is that it increases competition for food, and sometimes a bat will have to fly far from its colony,

Towards the end of the summer the maternity roosts become crowded, parasites become more prevalent and the females' responsibilities reduce as the pups grow. As soon as the young can fly the colonies start to disperse with the wind. The mouse-tailed bats travel in small groups, to find cooler roosts free from lice and flees. On the way, they find rest in the Roman ruins at Lake Galilee.

Greater mouse-tailed bat *Rhinopoma microphyllum*, Israel.

Sundevall's roundleaf bat *Hipposideros caffer*, Kenya.

to find undisturbed hunting grounds. Bats prefer to be alone when hunting and to not have other bats screeching in their ears, so many species have separate summer residences and hunt alone in their own environments. While the females hunt over lakes and beaches, the males stick to urban or cultivated areas. Ecologically, they behave like two separate species, which reduces the competition between them.

To hunt in peace, some bats establish temporary territories. Walk, for example, along a lit road in Sweden in the late summer, and the hunting territory of the northern bat is easy to spot. Staked out between street lamps, it is patrolled by the bat as it flies back and forth snapping up the moths attracted by the light. If the bat happens to encroach upon another's territory, an angry cry from its neighbour will soon send it back. And if it finds another bat aiming for the same prey, it can emit a sound that either scares the rival away or jams its echolocation signals.

Conversely, there are also examples of bats advertising to others where food may be found. Some leaf-nosed bats that normally live on fruit sometimes catch swarming ants, and when they do, they have been observed to call out to their friends to tell them where the insects are.

Parasites

Bats can share the same nook for decades, with several generations living side by side. But they are usually not alone. The walls are teeming with life after years of cohabitation, and bat bugs, fleas, lice, and parasitic flies thrive and spread from coat to coat. Mites are also very happy to settle on the naked skin of the face and ears, where superficial blood vessels are within easy reach. Parasites and bats have evolved together for millions of years, and most of the parasites confine themselves exclusively to bats, sometimes to just a single species.

There is usually no reason to cling on each other unless it is needed for thermoregulation. By maintaining a personal distance, fleas and other parasites cannot move as easily from fur to fur.

While the parasites are mostly harmless, they are, of course, extremely irritating, causing bats to spend much of their time grooming to rid themselves of them.

The rapidly growing multitude of skin parasites is one of the main reasons that bats often relocate from one roost to another, almost daily for some of the species that live in hollow trees. Those that live in larger spaces, such as buildings or caves, relocate to other parts as much as they are able. However, traces of parasitic activity, such as holes in the wings and blood clots on the skin, are common towards the end of the summer.

Infections

In a world full of viruses and germs, there is the ever-present risk of infection, especially in colonies containing hundreds of thousands of individuals. Bats are known for carrying a number of unpleasant diseases, to which they are sometimes resistant or immune.

The one disease that most people associate with bats is rabies, a viral disease that attacks the central nervous system. Rabies is found over large parts of the globe and in all kinds of mammals, although mostly in carnivores such as dogs, foxes, skunks, and raccoons. While bats, like other mammals, can carry classic rabies, in Europe, it is usually a specific chiropteran variety of the disease—the European bat lyssavirus. It was once thought that close to 10% of the world's bats were carriers, but it is now clear that this figure was a gross exaggeration and that it is way below 1%.

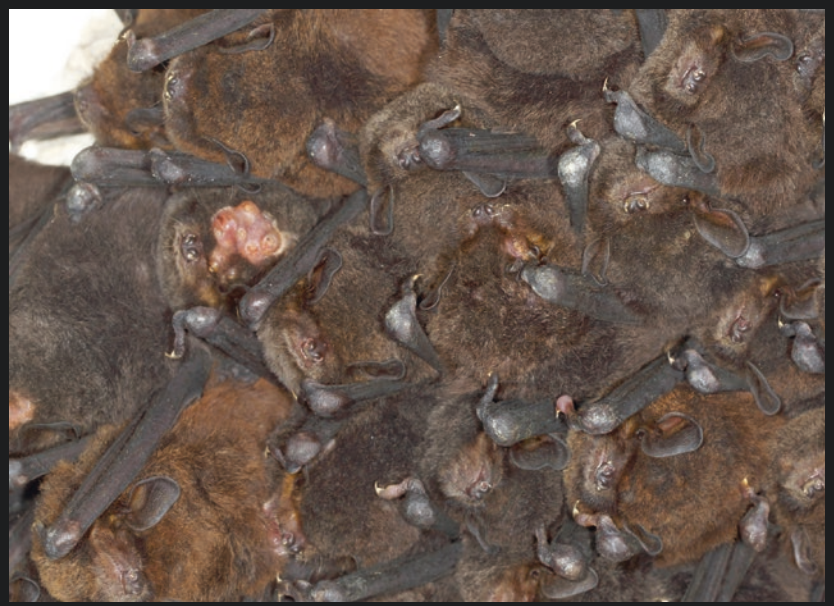
Compared with the danger posed to humans by rabid dogs, bats are a fairly insignificant problem, with the exception of South and Central America, where infected vampires can be a threat to livestock. The incidence of human infection has also risen in recent years in Latin America as forests are turned over to pastureland for beef cattle, making life easy for vampires by introducing a virtually ubiquitous abundance of food, on which vampire populations are thriving and proliferating. The strain of rabies carried by vampires is, however, not bat lyssavirus but classic rabies, a more infectious and therefore dangerous form, probably introduced by human activity through the

Bat wings often have hitch-hiking mites specialised for this somewhat unusual life style. In the fur live fleas, lice and bat-flies, sometimes also a special kind of bed-bug. All are wingless and feed on the bat's blood. The parasites are a constant pain for the host and one of the real drawbacks with the colonial life.

Daubenton's bat *Myotis daubentonii* with mite *Spinturnix* sp. and bat fly *Penicillidia* sp., Sweden.

Natal bent-winged bat *Miniopterus natalensis* with bat fly *Nycteribia* sp., Kenya.

Mediterranean horseshoe bat *Rhinolophus euryale* with bat fly *Stylidia* sp., Portugal.



Bent-winged bat *Miniopterus* sp. with bat flies *Ascodipteron* sp., Kenya.

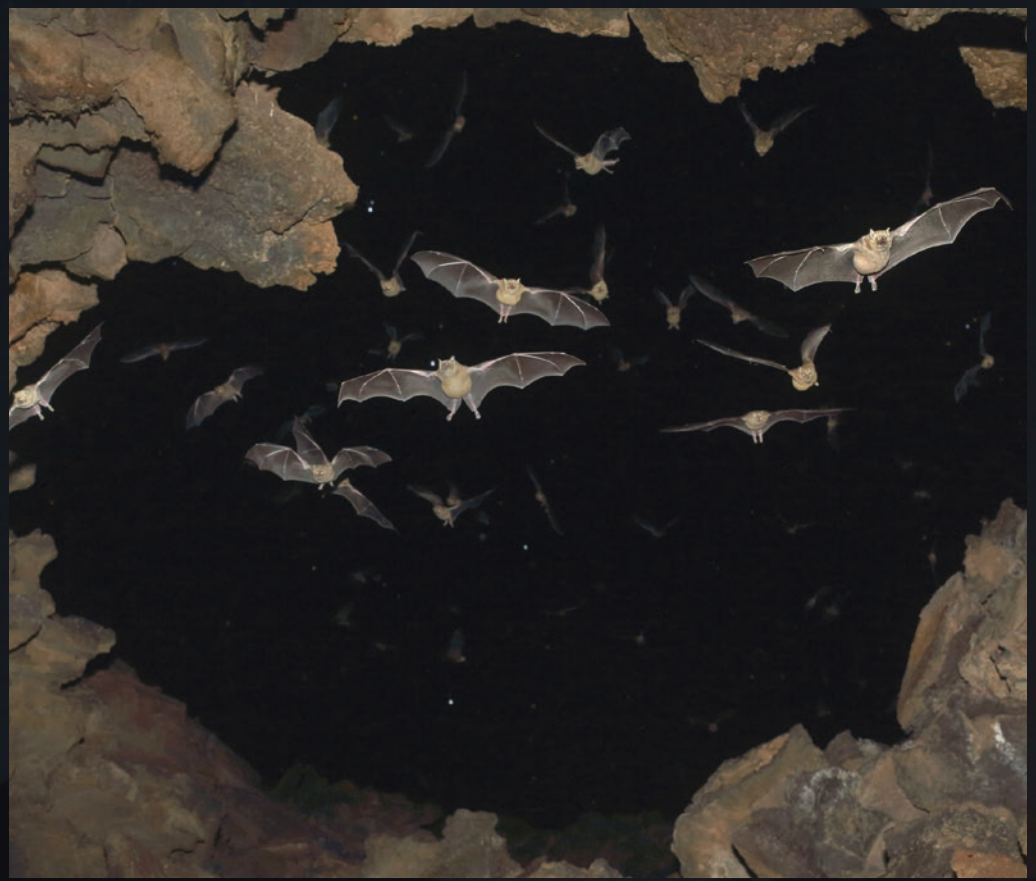
Greater dog-like bat *Peropteryx kappleri* with mites (Trombiculidae), Belize.

Bat-flies are highly specialised insects that live exclusively as parasites on bats. A particularly nasty one is *Ascodipteron*, which lives on bent-winged bats in Africa. The female fly enters the tear duct and moves under the skin towards the head, where she give birth to larvae, visible as swellings on some of the bats on the picture. The mature flies eventually emerge through the skin. The bats appear to be quite all right despite the parasites, surprisingly.

A hundred thousand mother bats return in the morning to the cave, where the newborn wait for milk. The females have filled their stomachs with nectar from the saguaro cacti, which flower in millions this time of the year.

These bats make long migratory flights across Mexico to track the flowering periods of different cacti and other plants. In early summer they arrive to this lava cave in the middle of the Sonoran desert, where they give birth and raise the young.

Lesser long-nosed bat *Leptonycteris yerbabuenae* and saguaro *Carniegia gigantea,* Mexico.



transportation of infected animals across the Atlantic. A number of misdirected interventions against vampires have merely aggravated the problem, and the poison and dynamite used to kill them off has only dispersed, rather than destroyed the colonies—with much collateral damage to many other species as well. In Mexico and some countries in South America, the problem has been overcome in many areas with the use of bovine rabies vaccines.

Bat rabies is, as noted, less infectious than classic rabies, and in some cases, the bats themselves are symptom-free. Yet the disease can still be transmitted to humans, so anyone handling bats—or any other wild mammal for that matter—should always put safety first and wear protective gloves. There are, however, effective vaccines that work even if taken several days after being bitten.

Even though there have been only a few incidents of humans being bitten by rabid bats, the fear and media fearmongering is widespread in Europe and North America. In 2014, however, articles about bat rabies were overshadowed by another virus, Ebola. The epidemic in West Africa is the hitherto most severe outbreak of this disease and is rumoured to have been started by a boy playing with an infected flying fox. Horseshoe bats living in a nearby tree were also blamed. The fact is, however, that no one knows if these bats were indeed infected. It has long been known that bats can act as a host to viruses able to cause different types of haemorrhagic fever such as Ebola, but it does not appear that the bats themselves are particularly susceptible to the disease, so it is hard to detect the presence of the virus.

Immunity and Resistance

Apart from Ebola and rabies, bats are more or less resistant to a wide range of parasitic and viral diseases, such as malaria, influenza, and the much written-about lung disease SARS. Some people argue that bats carry disproportionately many virus strains compared to other animals. In one species of flying fox, for instance, scientists have found 55 different virus types, 50 of which were previously unknown. While this is not unique for bats, and while similar finds can be made in many other mammalian groups, if one looks closely enough, there has been a strong focus on bats in recent times, which goes at least part way to explaining the many virus finds.

Whether or not bats carry an unusually rich viral flora, they are highly resistant to infection. There are also indications that bats rarely, if ever, develop cancer. Researchers recently examined mutations of 6000 genes and proteins during viral attack on bats and compared the results with human control cells. They found that the bat cells reacted much more quickly and effectively than the human, implying that their biochemical defence is simply superior to ours. The reason for this is a matter of speculation, but it could have something to do with their ability to fly. Active flight is extremely energy demanding and pushes the bat metabolism to levels way above resting. A number of by-products are thus formed in the body during flight, including DNA-damaging free radicals. Over the millions of years of bat evolution, their cell repair system has been fine-tuned to handle such damage as swiftly and effectively as possible. A fortunate side-effect of this could, then, be that other cellular damage is dealt with in a similarly efficacious manner. Perhaps, this is where we might also find the key to why bats live so long. It goes without saying that these properties of viral resistance, tumour prevention, and longevity are of great interest to humans and to medical research.

White-Nose Syndrome

One might be tempted to think that bats are immortal and that there is a possible grain of truth to all the myths, legends, and witches' brews claiming that bat blood can clean wounds and cure everything from blindness to a broken heart. There is, however, one disease that bats are powerless against, a fungal disease that affects the muzzle. It is called white-nose syndrome or WNS for short.

The disease was discovered in the late winter of 2006 in Albany, New York, by a speleologist who came upon a number of dead bats in a cave and took pictures of individuals that seemed to have a mysterious

Being alone can be advantageous in some cases. The risk for infections is kept to a minimum. Single males are much less affected by parasites than females in colonies.

Northern bat *Eptesicus nilssonii*, Norway.

white mass around their nose and mouth. The full extent of the discovery was only truly realised, however, when more such white-nosed bats were found in the area the following winter and a proper investigation was launched. Researchers then found hundreds of dead bats and observed peculiar behaviours. For example, the bats were not hibernating normally but waking up from their torpor and flying around both inside and outside their winter roosts, and not only at night. For a bat with a winter fat reserve, this is, of course, potentially fatal and many of the dead individuals had simply starved. Since then, the problem has quickly escalated. In 2008, the first cases were found outside New York State, in Vermont and Massachusetts, and there were reports the following year from four more states. The disease now exists from Canada to Mississippi and has claimed 7 million lives from a dozen different species to date. In Pennsylvania's vast hibernation caves, only droppings remain of the once enormous colonies that scientists estimate have now been decimated to just 10% of their original size.

WNS is caused by a fungus that thrives in cold, damp environments—the same conditions that bats seek for their winter roosts. The fungus works its way in under the skin and infects an area around the mouth, nose, and wings, causing fatal behavioural abnormalities during hibernation. Bats, which normally resist everything from malaria to Ebola, seem to have found their match in this resilient fungus. But there is hope. The first unaffected colonies have recently been found in Vermont in an otherwise heavily infected area.

As with rabies, the fungus was introduced to North America by humans, possibly via the dirty boots of some cave diver. Indeed, the fungus is found in caves and mines in northern Europe, but does not show the same symptoms, as the bats here seem to have evolved counterstrategies in a way that their North American cousins have failed to do. Perhaps, it is to reduce the risk of infection that European bats usually hibernate alone or in small clusters, rather than the enormous congregations found across the Atlantic.

African sheath-tailed bat *Coleura afra*, Kenya.

Ghosts and bats

In Kenya the ghosts are still alive. Some of them are found in caves and are connected with bats. Such things are taken seriously and are important aspects of rural life. Caves are used for religious purposes, for communication with the ghosts, but for this the bats are also needed and must therefore be protected. Typically, part of the cave is used for worship while the rest is left alone, so in some sense religion is the bats' best protection. In this crevice below the boulders, bats and villagers share the space. Even Jesus resides in a corner.

Kit Mikayi Rock near Kisumu, Kenya.

Ghost-faced bat *Mormoops megalophylla*, Mexico.