

BATS & BEDBUGS

Protecting bat caves conserves diverse ecosystems



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by Klaus Reinhardt and Steffen Roth

Steffan Roth examines the walls of a Texas bat cave for evidence of bedbugs or their eggs.

More than 1,260 bat species have paid a high collective price in destructive myths and widespread persecution because three of those species, all in Latin America, feed on blood (and only one on the blood of mammals). But few people realize that bats are themselves preferred victims of a blood-eating parasite: the bedbug.

What brought us from Europe to explore caves in Central Texas was not the bats but the bedbugs. Most of the roughly 100 species of bedbugs relish the blood of bats. Even the notorious common bedbug (*Cimex lectularius*) that occasionally dwells in our homes can, at least in Europe, still be found in bat colonies. Other species live in bat caves or tree roosts or in buildings used by bat colonies. They do not remain on the host animals after feeding.

We were after bedbugs of the species *Primicimex cavernis*. This apparently ancient species is much larger than the common bedbug, and it has been found only in caves inhabited by Mexican free-tailed bats (*Tadarida brasiliensis*). We hoped to collect a living specimen to study *Primicimex's* unique version of the



Caves used by bats typically host a rich diversity of invertebrates, as seen in this collection from one such cave. Conserving the bats will also protect these and many other organisms.

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bedbugs' bizarre mating habit, known as "traumatic mating" because it involves the male literally piercing the female's back or belly (see "*Traumatic Mating*").

Our search documented the remarkably rich ecosystems of invertebrates and other creatures that have adapted to caves dominated by roosting bats – the linchpins of these complex food chains. Protecting the bats also protects this panoply of organisms, many of

them found nowhere else. This, incidentally, validates the long-standing resistance to treating infected caves with fungicides to kill the fungus that causes White-nose Syndrome for fear of destroying whole ecosystems.

While millions of Mexican free-tailed bats roost in Central Texas, their associated bedbug is known from only six locations in the world: two each in Texas, Mexico and Guatemala. The

last published record was 43 years ago. Such rarity means that little is known about the biology of *Primicimex*.

It has been reported that *Primicimex* females glue their eggs to the cave walls. And the species very likely follows typical bedbug feeding behavior: approaching the host bat, often while it sleeps, and piercing the skin with a sharp, elongated proboscis. Just as vampire bats include an anticoagulant in their saliva – an enzyme that has become a treatment for human stroke victims – bedbugs inject three substances into the skin of their prey: a painkiller, an anti-clotting chemical to keep the blood flowing and a blood-vessel widener.

As entomologists, we were fascinated by this peculiar bedbug species, but we also suspected it might be extinct. Then we discovered that a museum, the University of Texas Insect Collection in Austin, harbored a *Primicimex* specimen collected in Texas in 2003. We promptly contacted its collector, Jim Kennedy of Bat Conservation International, who invited us to bring our search to Texas.

The cave system of Central Texas shelters hundreds of invertebrate species. But protecting that amazing biodiversity is uniquely challenging. Bat conservationists often note that their efforts are hampered by the dreadful and unwarranted public reputation of bats. You think bats have it tough? Try building a



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Entomologists Steffen Roth and Klaus Reinhardt suited up in full protective gear before braving the often-challenging conditions inside Texas bat caves.

coalition dedicated to protecting spiders, insects, scorpions and bedbugs.

Conserving these species, including “our” *Primicimex*, seems to require two things. First, we need to join ranks with “bat people,” since a side effect of protecting bat caves is the conservation

Traumatic Mating

All 100 or so species of bedbugs (the Cimicidae family) share a bizarre mating ritual known as “traumatic mating.”

Males drive a “mating dagger” through the exoskeleton of the female’s back or belly, causing a significant wound through which sperm enter and swim through the female’s body cavity to the ovaries.

The evolution of such a system is being studied extensively, but that is not the whole story.

At the site where females are penetrated, most bedbugs have evolved an organ (a sort of secondary genitalia; the primary is used for laying eggs) that limits damage from the wound. We have shown that this organ, among other things, provides immune functions that kill bacteria carried on the males’ mating daggers.

Primicimex is especially interesting because females of the species have not evolved this secondary organ. They seem to have other, apparently unique ways of dealing with the wounds inflicted during mating.

A female could, perhaps, ramp up the whole immune system inside her body to kill the microbes. But it’s not that simple with bedbugs: all cimicid species have beneficial microbes

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Primicimex cavernis

within their bodies that handle digestion of the blood they consume. Activating the immune system to kill the harmful bacteria would also kill these digestive microbes, and the bedbug would starve even with a stomach full of blood. Thus, bedbugs keep these microbes in little protective bags, so immune responses can’t reach them. All bedbugs use these bags – except *Primicimex*.

And that puzzle is why we came to Texas in a desperate – if ultimately futile – search for live individuals of this giant bedbug. Perhaps *Primicimex* doesn’t have these digestive microbes, in which case they must have evolved a novel way to digest blood. Or maybe they protect their pet microbes in some other way. Or males may not even transmit bacteria, which would require some special adaptation that prevents transmission. Or males, as we have found with the infamous common bedbug, may provide an antibiotic with the sperm and remove the need for females to protect themselves.

Any of these four possibilities, or perhaps something we haven’t thought of yet, would represent a novel and very cool discovery – and reason enough to crawl through Texas caves.

of invertebrates. And second, we need to identify and record the organisms living in the caves. Such caves can be difficult to reach and explore, so knowledge about their biodiversity is limited.

After a few lessons from Kennedy, an ardent caver, we were ready to begin our underground adventures. We were told to expect high temperatures, a stifling airless atmosphere, knee-deep bat guano, a piercing ammonia smell and showers of bat droppings, bat urine, fleas and mites raining down upon us. Two hectic weeks later, we had learned that all of this was true. In BCI's Bracken Cave, home of the world's largest bat colony, we counted 1,800 mites and 600 bat droppings landing in a box about 6x6 inches (15x15 centimeters) in just 15 minutes. That works out to a staggering 320,000 mites and 108,000 droppings per square meter (10.8 square feet) per hour raining down from the bats. And we usually spent two to three hours in each cave.

All together, we explored seven Central Texas caves and recorded almost 60 species of invertebrates, plus a few mammal, bird, snake and frog species. We found spiders, beetles, scorpions, cave crickets, fleas, whip spiders, flies, even moths, earthworms and a ladybug – an amazing ensemble of creatures that's now in the University of Texas collection. We found an average of about 18 species per cave.

In addition to Mexican free-tailed bats, we also encountered two tri-colored bats (*Perimyotis subflavus*) and cave myotis (*Myotis velifer*). If these seven sites were protected for just three bat species (and many of the sites are), that protection would be extended automatically to almost 60 species of invertebrates. And

many more species undoubtedly escaped detection during our brief visits.

And then there is the object of our desire: *Primicimex*. We spent 50 man-hours searching every square foot of cave walls; we sieved guano and examined invertebrates falling from the ceiling. Yet all we found of our target species was a single, dead individual. Its host, the Mexican free-tailed bat, was abundant, so the parasite must be very rare for other reasons.

In addition to establishing the seventh published record of *Primicimex*, our mini-expedition had two other outcomes. We have been converted to bat fans – we now like bats almost as much as insects. And we will also remember that destroying or damaging even a single cave is a threat to hundreds of invertebrates of dozens of species. We have learned just how important bats are as flagships to protect these unique ecosystems.

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A dense cluster of cave myotis (*Myotis velifer*) roosts on the walls of one of the seven Texas caves surveyed by the authors in their search for the oversized bedbug known as *Primicimex cavernis*.