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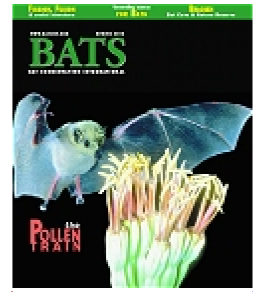

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Fission-Fusion
Discovering order among chaotic Canadian bats
Craig K. R. Willis et al

By Craig K. R. Willis, Kristen E. Kolar, Jackie D. Metheny & R. Mark Brigham.

Big brown bats seem to lead a chaotic life in Saskatchewan's Cypress Hills, their social order marked by tenuous loyalties and shifting alliances. They abandon perfectly good tree roosts every few days and move into new ones. They form small groups that move together from roost to roost, then abruptly split apart. This looks like very peculiar behavior. How could such fickle bats possibly constitute a colony? There is, it turns out, a likely and logical explanation to this apparent bedlam, one that would increase both the size of the colony and loyalty of its members. But it took us three long, sometimes-frustrating and often-freezing summers to find it.

After my first 37 nights of mist-netting, I (Craig Willis, rookie Ph.D. student) was beginning to worry that we had selected the wrong study site. My goal was to study the roosting behavior and ecology of the big brown bat (*Eptesicus fuscus*) in an area where they roost exclusively in trees. Assuming I could find some bats, I hoped to determine the relative influence of social relationships and thermal constraints on roost selection.

The Cypress Hills, which straddle the Alberta-Saskatchewan border 60 miles (100 kilometers) north of Montana and stretch some 90 miles (150 kilometers) east-west, seemed ideal for my research. The hills reach elevations of nearly 5,000 feet (1,400 meters) and boast intact forests of lodgepole pine, trembling aspen and white spruce. This vast array of potential roosting sites should be irresistible to bats, especially compared to the sea of prairie that stretches off in all directions around the hills.

So the dearth of bats was disheartening. One thing that kept us going was the work of Matina Kalcounis-Rüppell, a former student in Mark Brigham's lab at the University of Regina, who caught and radiotracked big browns in the Cypress Hills in 1993-4. She reported spending more than two months of her first summer without catching a single bat. Eventually, however, her mist nets paid off and data piled up.

She found that female big browns roost – in groups ranging from one or two bats to as many as 45 – inside hollow, but healthy, aspens in the Cypress Hills. The bats sometimes get into the cavities through woodpecker holes but mostly use holes resulting from fungal heart rot.

Large, old trees provide usable roosts. The presence of heart rot makes such trees hard to age accurately, but they typically reach a diameter at chest height of about 14 inches (36 centimeters) – very big for an aspen in our part of the world.

Kalcounis-Rüppell's work added to evidence that cavity-roosting bats switch among different trees every few days, a puzzling behavior given that the trees apparently remain usable for a much longer time. Roost switching is relatively rare among bats that live in groups in caves, mines or buildings.

Finally, one night in June, two female big brown bats found their way into our nets. We attached radio transmitters to their backs with nontoxic adhesive and released them. The transmitters emit pulsed signals that let us find and track the bats. Although the bats were released about an hour apart, they ended up using the same roost, more than 11?4 miles (2 kilometers) from where they were caught. When we monitored the roost at sunset that night, 23 bats emerged. Two days later, our tagged bats switched trees, along with most of their roostmates.
After that first success, things improved dramatically. Over the rest of that summer and the two that followed, we kept tabs on radio-tagged bats as they moved from tree to tree and netted at roost sites about every three weeks to replace transmitters as their batteries wore down. We captured only females, finding no males in these maternity roosts.

When we located a new roost, we climbed up to it and placed temperature data-loggers inside the cavities so we could compare temperature conditions in different trees. We also recorded skin temperatures of the tagged bats with the radio transmitters, which beep faster when warm and slower as temperatures fall.

Just as Kalcounis-Rüppell had reported, the bats we tracked switched roosts every two days or so, sometimes even reusing the same trees she had identified nearly 10 years earlier. Occasionally, a few bats in a roost tree would switch while others would wait a day or two more before leaving. Some pairs or subgroups of bats would switch roosts together several times, then split up and switch roosts at different times. Sometimes bats would leave a tree for a few days and then return to it.

Why didn't all the bats switch trees together? Did some individuals tend to roost together more often than others? Why were the bats switching roosts in the first place? How could we define the "bat colony" if the bats didn't stay -together? This behavior was definitely confusing, but the fact that some individuals stuck together when they switched trees suggested that there might be some sort of order in the chaos.

By the end of summer 2002, we had followed 61 females over a total of 361 tracking days. We were beginning to discern hints about what was going on. First, although bats switched between individual aspen trees regularly, they remained loyal to distinct patches of forest three-fourths of a square mile (two square kilometers) in area. We identified three of these "roosting areas" within 381?2 square miles (100 square kilometers) of forest.

Within these roosting areas, the radio-tagged bats used numerous trees, but never roosted outside their area. This "rule" applied not only for each summer season but also over the entire three years of our study. The bats we tracked more than one year remained loyal to their initial roosting area in subsequent seasons. Although roosting groups were continually breaking apart, the big browns showed strong loyalty to other bats in their roosting area.

We tested these clues statistically in comparison with random behavior. Throughout the study, we tried to ensure that we always had at least two to eight bats carrying radio transmitters. We assigned the bats that were being simultaneously tracked into pairs. We then compared the percentage of time that both members of a pair shared the same tree to what we would expect if roost trees and roostmates were chosen randomly.

There was some variation among pairs, as some bats were more likely to be found together than others. But every pair of bats from the same roosting area was significantly more

likely than chance would indicate to be found in the same roosts. The bats also shared roosts with the other bats in their roosting area more often than would be expected by chance alone. Simply put: These big brown bats seemed to like being with their friends.

Our conclusions about bats' loyalty for their roosting area were reinforced by a simple experiment. We captured eight bats as they emerged at dusk from the same roost. After outfitting all eight with transmitters, we moved four of the bats about six miles (10 kilometers) away and released them in another roosting area. The other four were released at precisely the same time, but near the tree where they were caught. Amazingly, the next morning all eight were in the same roost. We found them sharing a tree about 165 feet (50 meters) from the roost where we had originally captured them. However, none of these eight bats spent all of the subsequent days (on which we tracked them) together except for that first day.

Our data suggest that bats in the same patch of forest tend to stick together, even though no two individuals spend all their time together. This pattern of behavior is consistent with what is known as a fission-fusion social structure.

Fission-fusion was first des-cribed in some toothed whales and primates, but has also been reported by the Uni-versity of Zurich's Gerald Kerth and colleagues among Bech-stein's myotis (*Myotis bechsteinii*) roosting in bat boxes in Germany. Fission-fusion has also been observed in other populations of forest bats as far-flung as New Zealand and Mich-igan. We reasoned that it might apply to our big brown bat system, as well.

Among big browns, the "fused" colony includes all individuals in one roosting area. The entire colony probably comprises more bats than could fit into the cavity of a single tree, so the fused colony comprises a number of subgroups. The "fission" part of fission-fusion structure occurs during roost switching, when subgroups break apart and mix, with the bats ending up in different trees and often with different roostmates.

Given enough time, each bat would likely end up roosting with most, if not all, of the other individuals in the roosting area, allowing them to expand their social network and, in effect, increase their colony size without gathering all the bats in one place.

This could also help explain why roost switching occurs much less often in more spacious roosts, such as caves, mines and buildings. Bats in these structures may be free to move around inside the roost during the day and interact with many different colony mates. Bats roosting in trees can interact socially with bats in other trees only while foraging at night or by periodically switching to other roost groups.

While our data were consistent with a -fission-fusion social structure, obvious questions remain: Why bother? Why don't the bats just restrict their colony size to the number of individuals that can fit in one tree? The answer is likely complex and could involve a number of benefits linked to living in a large colony.

One possibility is that large colonies reduce the risk that individual bats would find themselves without roostmates on a given night. This is where our data on roost temperatures added to the story. Based on the temperature dataloggers inside roosts, trees with bats in them are significantly warmer than trees without bats. We estimate that a bat in a group of 45 individuals could, as compared to roosting alone, save as much energy as it would get from eating about seven grams of insects on a 68-degree F (20-degree C) day.

That's almost half the body mass of the average female big brown! The savings come because bats in a group don't have to expend as much energy staying warm.

By maintaining a large colony of fluid groups spread among different trees, bats may increase their chances of finding a roostmate to snuggle with when they search for a roost each morning.

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More to Learn

Few things are ever as clear as they might seem in the world of bat biology. A case in point is the fission-fusion hypothesis that seems to explain the peculiar roosting behavior of big brown bats in Cypress Hills, Saskatchewan. The bats frequently switch roosts and roostmates, but seem to limit their social contacts to a specific roosting area.

Well, almost always.

Graduate student Kristen Kolar, of Mark Brigham's University of Regina lab, recently has been expanding on Craig Willis' Cypress Hills research by injecting bats with Passive Integrated Transponder (PIT) tags. The tags are tiny microchips, each about the size of a grain of rice. The tags give each animal a "bar code." This allows us to mark and monitor these animals in greater numbers and for longer time periods than radio transmitters. It's also less inconvenient for the bat.

The challenge is in the monitoring. We have to climb trees to roost openings as high as 50 feet (15 meters) to install antennas that read the bats' bar codes. And then there's the daily slog into the rugged country toting 11-pound (5-kilogram) batteries for each of the readers.

The radio-tagged bats have led us to a yet another roosting area, about 71⁄2 miles (11 kilometers) beyond the three previously identified. There, via PIT tags and readers, we discovered some rather unusual behavior. Unlike the previously recorded pattern of roosting-area loyalty, some bats in our new Area 4 came originally from the other areas, apparently joining the Area 4 bat group occasionally and, later in the summer, becoming loyal to it.

Bats, it seems, don't read the journals to learn what they are supposed to do and keep us biologists pondering an endless supply of new questions.

Another graduate student, Jackie Metheny, hopes to answer a question or two of her own about the big browns of Cypress Hills. She's exploring the genetic population structure of the colony to determine whether kinship plays a role in roosting groups: In other words, are sisters and mothers roosting together more often than unrelated bats?

Working with Matina Kalcounis-Rüppell, now at the University of North Carolina – Greensboro, Jackie is analyzing DNA extracted from tiny bits of tissue taken from bats in the colony. Combining that with Willis' and Kolar's behavioral data, Metheny hopes to assess whether pairs of bats that often hang out together are more closely related than pairs that spend little time together.

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Biology at the University of Regina. His research focuses on ecology, behavior and Â-torpor use by insectivorous bats and caprimulgid birds (nightjars).

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