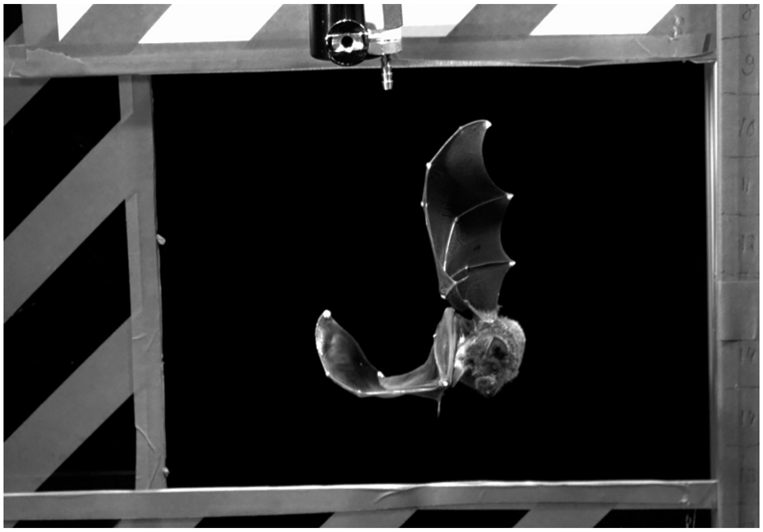
Recovering from a tumble and roosting bat style



A Seba's short-tailed bat (*Carollia perspicillata*) tumbling after its wing has been hit with a 2.5× bodyweight puff of air. Photo credit: David Boerma.

Evolution has had some fun with the limbs that we call arms. From weight-bearing forelimbs, to fins and flippers, the same skeletal structures keep turning up; albeit somewhat modified. When David Boerma from Brown University, USA, gazes at the wings of a bat, he says that he literally sees himself; 'from an anatomical perspective their wings aren't very different from my own arms and hands', he smiles. Having traded in their manual dexterity, bats mastered an airborne lifestyle, but Boerma wondered how the mammal's elegantly elongated limbs might contribute as they navigate natural gusts and squalls. Knowing that bat wings are relatively heavy, Boerma wondered whether the mammals could capitalize on the limbs' apparent weighty inertia to stabilise their manoeuvres when knocked off course by a gust of wind.

Working with Tim Treskatis, an intern from Westphalian University of Applied Sciences, Germany, to build a laser-triggered blast of air that would unbalance Seba's short-tailed bats (*Carollia perspicillata*) as they flew along a narrow corridor in the lab, Boerma filmed the bats' recoveries in 3D to reconstruct their manoeuvres. Remarkably, when Boerma, Treskatis, Kenneth Breuer and Sharon Swartz analysed the bats' movements they were amazed that the animals were able to recover from being thrust off course within a single wing beat.

Focusing on the bats that had been pitched upward when the 2.5× bodyweight puff of air hit their back end, the bats flung their wings wide at a point in the wing beat when they would normally pull them in; with the result that their wings were thrust forward, to counteract the jet of air and tip the body back down. However, when the jet glanced off one of the bats' wings – forcing it down and sending the animal into a spin – the bats swiftly extended the unperturbed wing as it rolled upward in a bid to counteract the rotation. Then they swept the perturbed wing all the way under the body as the bat righted itself ready to resume normal wing beats. 'By just shifting the weight of their wings around, bats can generate forces that rapidly reorient their bodies when recovering from aerial stumbles, similar to the way a gymnast or diver moves their arms and legs to spin in mid-air', says Boerma.

By this point, Boerma's appetite for research had been whetted; 'the experience left me yearning to work with bats in the field, where I might see first-hand the kinds of environmental challenges they face and learn how they respond', he recalls. Explaining that Spix's disk-winged bats (*Thyroptera tricolor*), which roost head-up inside furled *Heliconia* leaves in the rainforest, have evolved unconventional suction cups at the base of the thumb and at the ankle for attachment to smooth leaves, Boerma was curious how the minute mammals manage their inbound trajectory when coming in to land.

A Spix's disk-winged bat (*Thyroptera tricolor*) nestling inside a furled *Heliconia* leaf. Photo credit; Micheal Schöner.

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Travelling to the Hacienda Baru Biological Research Station, Costa Rica, and teaming up with José Pablo Barrantes from the Universidad de Costa Rica, the duo spent two weeks tracking down the tiny mammals in their rainforest home. Returning with them briefly to the research station, the pair quickly trained the bats to land on a force plate disguised as a leaf while filming the manoeuvre. And Boerma recalls how the bats were equally happy to land on the researchers as they were on the force plate: 'At one point José Pablo left the enclosure and I kept training the bat on my own. It flew around and then landed on my back where I couldn't reach it', he laughs.

Analysing movies of the bats landing on the force plate and within furled leaves, with the help of high-school student Charles Chung, Boerma realised that the bats fine-tune their approach by subtly adjusting their wing beats until just above the landing site. Then they pull in their wings, going into freefall as they reach forward with their thumb suction pads to latch onto the surface. Evaluating the force exerted on the force plate as the bat made contact, the duo also realised that the suction pad snaps into place as soon as it contacts the leaf.

'These kinds of studies help us to begin to apply what we learn about bat flight in the lab to understand the more complex flight they perform in their natural habitats', says Boerma. He is now eager to understand how reeling bats coordinate their deft manoeuvres; in addition to looking for connections between the landing styles of other species to learn how the mammals have adapted to roost sites ranging from tightly furled leaves to caves and trees.

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