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Internal maps help fruit bats navigate

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Asaf Tsoar of the Hebrew University of Jerusalem and the daughter of Prof. Ran Nathan hold one of the bats used in the study of how these mammals are able to "home in" on their designated target sites even from great distances. Credit: The Hebrew University of Jerusalem

GPS technology can make our travels easier and more efficient. But for many animals, the ability to successfully navigate a landscape is not just a matter of convenience – their very survival depends on it.

Egyptian fruit bats, for instance, fly dozens of kilometers each night to feed on specific fruit trees, making the return trip the same night. To understand how the bats locate individual trees night after night, scientists attached tiny GPS devices to the bats in the first-ever comprehensive GPS-based field study of mammal navigation.

The results of this study showed that the bats carry around an internal, cognitive map of their home range, based on visual landmarks, such as lights or hills, but the study also suggests an additional,, large-scale navigational mechanism. The study, which appears August 15 in the *Proceedings of the National Academy of Sciences* (PNAS), reveals for the first time how free-ranging mammals find their way around their natural environment.

Many researchers have investigated the navigational skills of other creatures – birds, fish, insects, lobsters, turtles, etc. – but studies of mammalian navigation have been confined to the laboratory. Unfortunately, lab studies cannot duplicate the large, complex landscapes an animal must navigate in the natural world.

The new GPS-based method gives researchers the best of both worlds. This new approach to studying bat navigation was developed by a group of researchers from several institutions and disciplines: ecologists studying movements of animals in the wild: Ph.D. student Asaf Tsoar from the Movement Ecology Lab and his supervisor Prof. Ran Nathan from the Hebrew University of Jerusalem; a neurobiologist studying the neural basis of navigation: Dr. Nachum Ulanovsky of the Weizmann Institute, in collaboration with Giacomo Dell'Omo of Ornis Italica, Italy, and Alexei Vyssotski of ETH Zurich, Switzerland.

In this collaborative effort, the team developed miniaturized GPS devices – each weighing around 10 grams and containing tiny GPS receivers, in addition to a memory logger and battery. They used the devices to track the movements of Egyptian fruit bats (Rousettus aegyptiacus) over several consecutive nights.

At first, the researchers collected data as the bats took flight each night from a cave near the Israeli city of Beit Shemesh. These bats flew in a straight line at speeds of 40 km an hour and more and at elevations of hundreds of meters to trees that were about 12 to 25 km from their cave.

They went to the same trees, night after night, even bypassing apparently identical trees that were nearer to home. The data showed that bats' navigational abilities rival those of homing pigeons.

The fact that the bats bypassed similar fruit trees to get to their favorite feeding site ruled out smell as their main navigational aid, while an analysis of the data suggested that the bats were not simply "beaconing" on any visual or other individual cue.

To investigate further, the scientists took some of the bats to a new area in the desert, 44 kilometers south of their normal range. Some bats were released at dusk; others were fed in the new area and released just before dawn. Those released first had no trouble navigating to their favorite fruit trees, returning straight back to their caves afterward. Those who were fed first simply made a beeline back to the cave once they were released.

Based on a spatial model analysis, and after discussions with pilots, it appeared, though, that the bats could have seen some familiar visual landmarks – hills or the lights of human settlements – from this release site near Beersheba in southern Israel.

To prevent the bats from using visual landmarks to guide them, the researchers removed the bats even further south, to a natural depression that limited their field of vision: the Large Crater, located some 84 km south of their cave. Here, some of the bats were released from a hilltop at the edge of the crater and others were let go at the crater's bottom.

Despite the distance, those flying from the hilltop oriented themselves right away and flew back to the cave. The bats inside the crater, however, appeared disoriented, wandering for quite a while before finding their way out of the crater and back to the cave. This confirmed the idea that bats use visual information from a "bird's eye view" to construct a cognitive map of a wide area. Navigational cues include these distant landmarks, and the scientists believe that the bats most likely compute their own location by employing a form of triangulation based on the different azimuths to known distant landmarks.

Because most of the bats released in the crater, when they finally left, exited to the north (the direction of home), Tsoar, Nathan and Ulanovsky believe that the bats may have an additional, back-up navigational mechanism to help when landmarks are unreliable. This mechanism might involve sensing the magnetic fields or directional odors carried on the sea breeze from the Mediterranean to the Negev Desert.

Although lab experiments based on distances of a meter or two had hinted at the existence of an internal map for navigation, this study is the first to show that such mammals as fruit bats use these maps to find their way around areas 100 km in size.

Provided by Hebrew University of Jerusalem