Dung beetles use wind compass when the sun is high

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Credit: Chris Collingridge

Researchers have shown for the first time that an animal uses different directional sensors to achieve the highest possible navigational precision in different conditions. When the sun is high, dung beetles navigate

using the wind.

The discovery of the dung beetles' wind compass and how it complements the sun compass was made by an international research team comprising biologists from Sweden and South Africa.

"This is the first study that shows how an animal's biological compass can integrate different directional sensors, in this case wind and sun, in a flexible way. This enables the highest possible precision at all times," says Marie Dacke, professor of sensory biology at Lund University and leader of the research team.

The dung beetles cannot use the sun as a directional guide when it is cloudy, or when the sun is higher than 75 degrees above the horizon for a few hours in the middle of the day. A while later, when the sun is a little lower, they turn off the wind compass and again rely on the sun.

In the new study, the researchers investigated dung beetles both out in the field and in the laboratory. Using fans, to create wind they could select the wind direction. They changed the sun's position in the sky using a mirror.

The experiment shows that when the sun is at a low or medium elevation in the sky, the dung beetles change direction by 180 degrees if the sun's position is changed by 180 degrees. However, the dung beetles were not affected when the researchers changed the wind direction by 180 degrees when the sun was at these elevations.

When the sun was highest, the situation was reversed. The wind then showed the way, so the insects responded to a change in the wind direction of 180 degrees.

Credit: Chris Collingridge

The results show that directional information can be transferred from the wind compass to the sun compass and vice versa. In this way, the dung beetles can continue on in one direction when one of the compasses becomes less reliable.

The sensors that register wind direction are on the insect's antennae.

"The insect brain is definitely not pre-programmed to always follow the same set of actions. On the contrary, we can show that such small brains work according to very dynamic principles that adapt to the conditions prevailing at a given moment," says Marie Dacke.

The researchers had previously shown that, during the night, some dung beetles navigate by the Milky Way and polarised moonlight while rolling their dung balls in a straight line. Combined with the results from the new study, they show that the insect's compass works at all times of the day or night and probably under almost any conditions.

An experiment investigating how dung beetles use celestial cues like stars to orientate themselves during navigation. Credit: Chris Collinridge/Wits University

"Now we will go on to study whether they can also use the wind at night. Another aspect we are curious about is what guides them when there is no wind and it's cloudy," comments Marie Dacke.

The aim of the research is to fully understand how very small brains handle large amounts of information in order to make a relevant decision: is it appropriate to turn left or right, or continue straight on?

Marie Dacke believes that the results will be of direct benefit within a few years, in areas like robot development and artificial intelligence (AI). Just like dung beetles, robots must take large amounts of information into consideration in order to direct their next action.

"Developments in AI are happening at breath-taking speed and part of my research is directly aimed at creating a model of how networks function to integrate information in a smart way," she concludes.

More information: Multimodal cue integration in the dung beetle compass. *PNAS*, June 24, 2019, doi.org/10.1073/pnas.1904308116

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