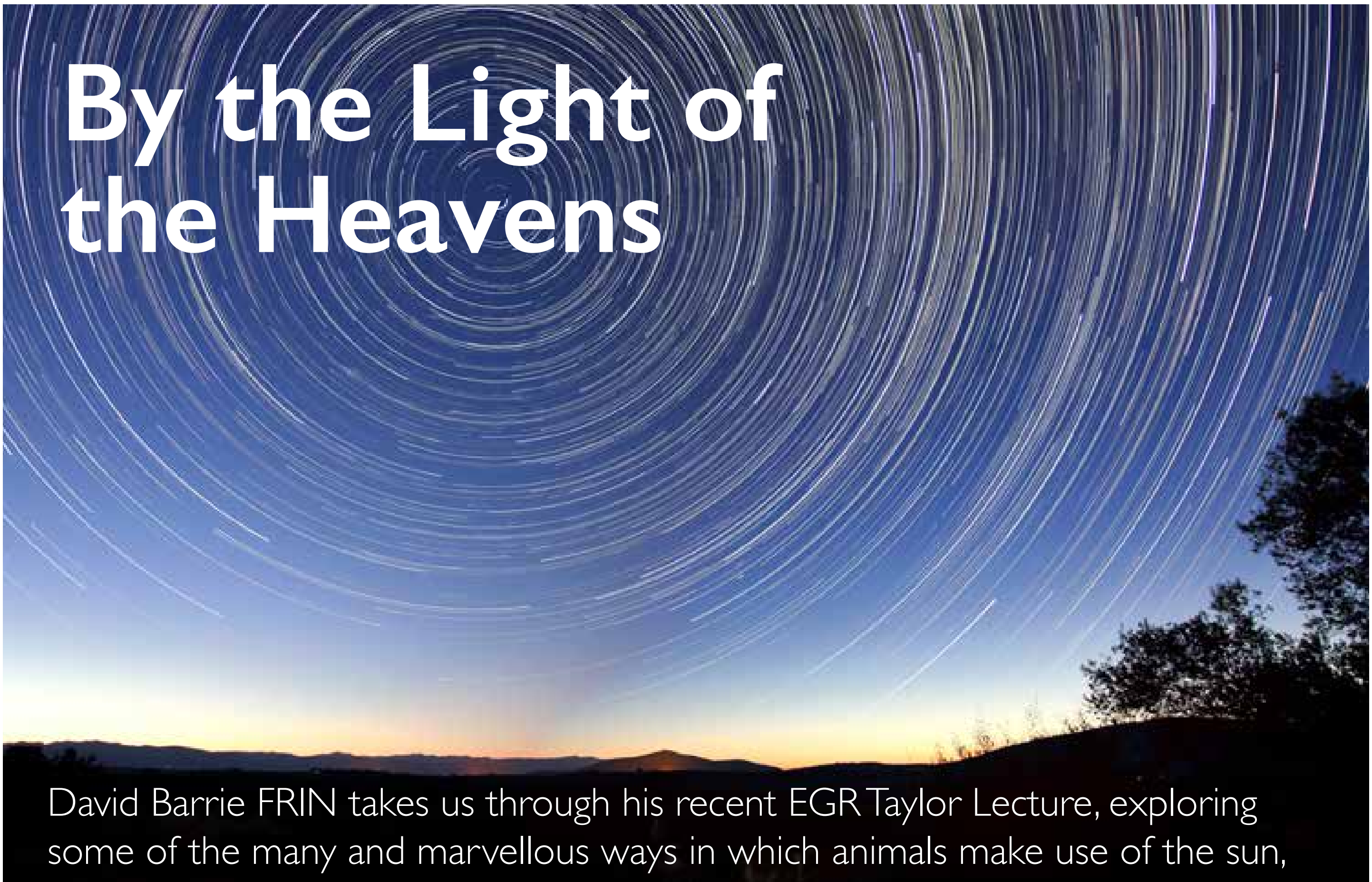


By the Light of the Heavens

David Barrie FRIN takes us through his recent EGR Taylor Lecture, exploring some of the many and marvellous ways in which animals make use of the sun, moon and stars to guide them.

What springs to mind when we think of navigation? Maps and compasses, and of course the marvel of GPS. But there's another kind of navigation - for which no tools are needed. And it's the oldest kind: animal navigation. I'm going to focus on just one aspect of it: how our fellow creatures use the light of the sun, moon and stars to find their way.

Among the best studied animal navigators are ants and bees.

In the early 1900s, Felix Santschi, a Swiss doctor working in Tunisia, noticed that the local desert ants went on long journeys, zigzagging around until they found some food to take back to their nest. Though the nest entrance is only a small hole in the ground, the ants could nevertheless head straight for it. How could they maintain such a steady course?

Santschi had the bright idea that they might be using the sun as a compass and conducted a simple experiment. First he hid the sun from the ants with a screen and then he showed them its image reflected in a mirror. Sure enough, the ants altered course accordingly.

This was the first clear evidence that any non-human animal employed a compass[1].

Later the Austrian biologist Karl von Frisch made an even more extraordinary discovery: honey bees could pass on information about the location of food to their nest mates using a strange dance 'language'.

At first he thought the dance just served to alert bees to the presence of food which they then located by following a scent trail.

But the truth turned out to be much more interesting. The dances conveyed information, not only about the existence of a food source, but also its bearing and distance from the hive.

Later von Frisch showed that the bees tracked the sun using patterns of polarised light in the sky. He then proved that they also had a 'clock' that enabled them to compensate for the sun's changing position[2].

Rüdiger Wehner and his wife and Collaborator, Sibylle

A German scientist called Rüdiger Wehner found that the homing abilities of desert ants also depended in part on their sensitivity to polarised light.

Wehner identified specialised cells in the ant's eye that were perfectly designed to respond to light of this kind. These cells proved to be the basis of a time-compensated sun compass very like that of honey bees[3].

Let me now turn to another truly extraordinary insect - the monarch butterfly.

These insects spend the winters clustered in vast numbers on trees in a tiny area of mountains in central Mexico.

When the days lengthen in the spring, the butterflies rise up in vast numbers. The females lay their eggs on milkweed plants in the southern US. A new generation of adults emerges and heads further north, where the same process is renewed - again and again.

At the end of the summer, as the days shorten, the last brood heads south to Mexico. They may fly as much as 3 600 kilometres, but they have never made the journey before.

Sandra Perez decided to find out whether the monarch too made use of a sun compass[4].

She kept a group of monarchs in a room, where the lights were turned on and off to simulate a day starting and finishing six hours later than the natural day - a process known as 'clock-shifting'.

Perez then released the butterflies and estimated their heading with the help of a compass while running alongside them. She found that the clock-shifted butterflies headed in a west-north-westerly direction, while the controls followed the normal south-westerly course. Exactly what was to be expected if the butterflies were using a sun compass .

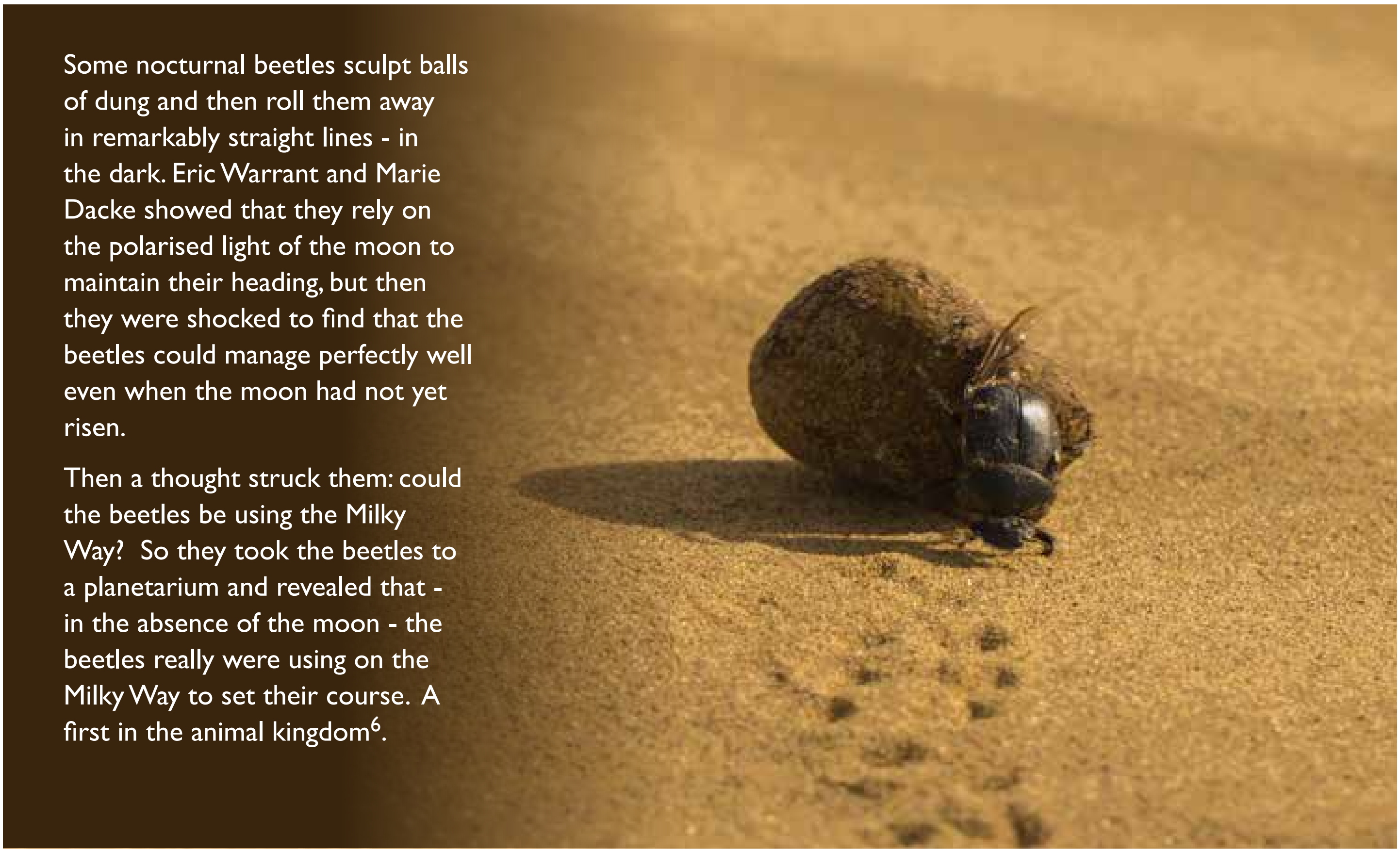
Steve Reppert and his colleagues have shown that the monarch is sensitive not only to the position of the sun, but also, like the honeybee and desert ant, to light polarisation. It has a clock built into its antennae[5]. It is even possible that the monarch may have a magnetic compass though that is disputed.

But it is still unclear how the butterflies pinpoint their overwintering sites in the Mexican mountains. In the closing stages of their journey, they may rely on their sense of smell.

Sophisticated tracking devices can tell us a great deal about where migratory birds go and when, but finding out how they find their way is much harder.

In the late 1950s, Franz Sauer showed that buntings used the stars to set their course. Later Stephen Emlen found that they learned to detect the rotational pattern of stars that marks the position of true north. Many other birds that migrate by night use this kind of star compass[7].

Marie Dacke and Eric Warrant



Some nocturnal beetles sculpt balls of dung and then roll them away in remarkably straight lines - in the dark. Eric Warrant and Marie Dacke showed that they rely on the polarised light of the moon to maintain their heading, but then they were shocked to find that the beetles could manage perfectly well even when the moon had not yet risen.

Then a thought struck them: could the beetles be using the Milky Way? So they took the beetles to a planetarium and revealed that - in the absence of the moon - the beetles really were using on the Milky Way to set their course. A first in the animal kingdom[6].


The Eurasian reed warbler.

It is also well established that many birds have a magnetic compass. And some migratory birds, notably Reed Warblers, can tell when they have been shifted east or west: they seem to have solved the longitude problem. These birds may be using a combination of celestial and magnetic cues to determine where they are[8].

One of the great mysteries is how birds (and other animals) detect the Earth's magnetic field - but that is another story!

David Barrie's new book, Incredible Journeys: Exploring the Wonders of Animal Navigation, will be published by Hodder & Stoughton on 4 April.

Meet David at the 10th RIN Conference on Animal Navigation in Royal Holloway from 10-12 April 2019.

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