ScienceWatch-A Circle is the Shortest Straight Line for Migrating Birds
How birds migrate is a fascinating field of study for ornithologists. Laboratory investigations have provided various answers concerning the possible signals birds use to navigate. At any given time they may use a compass system based on the sun, stars, the earth's magnetic field or they may use landscape cues to guide them. The most popular theory is that birds use a magnetic compass, yet no one has found magnetoreceptive cells in the brain of any bird species. So, despite all the laboratory studies little is known about how birds orient themselves during actual migration.

A study performed by Swedish and Icelandic investigators, and published in the January 12, 2001 issue of *Science*, shows that migrating Arctic shorebirds birds match modern airline pilots in their navigational feats. Pilots know that the shortest distance between two points on the globe is not a straight line but rather an arc, known as a great circle. A great circle is any line that cuts through the center of the earth. Thomas Alerstam of Lund University in Sweden and his colleagues have discovered that migrating birds also fly close approximations of great circle routes. However, unlike airline pilots who are guided by a compass or a radio or satellite signal in order to make the numerous directional changes required, birds rely on the sun and their intrinsic biological clock.

Alerstam et al. used ship-borne and land-based radar to track flocks of migrating shorebirds such as American golden plovers (*Pluvialus dominica*), semipalmated sandpipers (*Calidris pusilla*) white-rumped sandpipers (*C. fuscicollis*), and pectoral sandpipers(*C. melanotos*). These species breed in the arctic during the summer and spend the winter in South America. They get there by following the Northwest Passage to the eastern United States and flying down the coast. The flight pattern near the pole was of greatest interest because here the birds could not rely on a magnetic compass due to field distortion, and the constant arctic summer daylight ruled out navigation by the stars. Moreover, since most of the trip is over water or featureless arctic tundra, guidance by local landmarks could also be ruled out. That meant the birds could only use the sun to get their bearing.

The radar tracks clearly showed that the birds were flying along a great circle (solid line) instead of the longer, unwavering compass heading (dotted line). However, simply orienting themselves by the position of the sun would not cause the birds to fly along a great circle. To do so they must use their biological clock and it must remain out of phase with local time in order for the sun compass to yield the shortest route. For example, a bird flying east across the arctic at noon will see the sun due south or 90^{o} to it's right on the first day. On subsequent days, however, the bird's clock is out of phase, and when it thinks noon has arrived, it is actually later. Thus, the sun would be somewhat west of due south and the bird would orient itself to fly south-southeast. This is exactly what happens. Mathematicians have discovered that sun-oriented travel across different time zones (longitude) will yield a great circle if the internal clock is not reset, and evidently, the birds have discovered this as well.

Laboratory studies have shown that it takes 3-6 days after a time shift for the birds to reset their clocks, whereas the non-stop east-west flights only take 1-2 days, which is not

enough time for the birds to reset their clocks. Maybe it's a lucky happenstance, but most likely it's an evolved adaptive response allowing them to get to the right place.

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