Birthplace breeders: Look homeward, turtle

Green turtle lays her eggs at Costa Rican breeding site.

It might seem a simple task to track a reptile's journey from birthplace to mating site. But not when the creature is the green turtle, which doesn't start breeding until age 30. Researchers have tried to monitor its meanderings by tagging it with metal disks or wires, but the turtle's dramatic growth over the decades – from 4-inch infancy to 4-foot adulthood – has stymied efforts to keep the tags in place.

So Brian W. Bowen, an evolutionary geneticist at the University of Georgia in Athens, turned instead to natural markers, analyzing mitochondrial DNA from eggs and hatchlings at four green-turtle breeding sites in the Atlantic and Caribbean. In the May 11 SCIENCE, he and his co-workers report that turtles from the four breeding sites tended to differ slightly in genetic sequence. The researchers note that genetically distinct populations of green turtles would complicate efforts to preserve this endangered species, since each subgroup would be unique and irreplaceable.

They say their finding lends credence to the "natal homing" theory, proposed in the 1960s, which holds that while turtles born in different regions may share common feeding grounds away from home, the animals part company at breeding time, each swimming hundreds or thousands of miles to breed and nest at its own birthplace. At the same time, the new work undercuts a competing theory, known as the social facilitation model, which contends that virgin female turtles randomly follow experienced breeders to a nesting site regardless of their birthplace. Such "social mixing" must be rare in green turtles, Bowen concludes, because widespread interbreeding of diverse turtle groups at each nesting area would have long ago smoothed out the genetic differences he and his colleagues detected.

Bowen, with co-workers John C. Avise of the University of Georgia and Anne B. Meylan of the Florida Marine Research Institute in St. Petersburg, offer several caveats to the interpretation of their findings. They note that turtles from two of the nesting sites – Florida's Hutchinson Island and Costa Rica's Tortuguero sanctuary – had indistinguishable mitochondrial DNA sequences, a possible indication that some social mixing might have occurred between these two groups, or that the DNA assay was not sensitive enough to detect extremely subtle differences. In addition, they report that one of eight study turtles from Aves Island, off Venezuela, showed the same genetic pattern as the Tortuguero and Hutchinson turtles in their sample. And because turtles from the fourth breeding site, the remote Ascension Island in the South Atlantic, are not known to share feeding grounds with other animals, their distinct DNA pattern may reflect habitat isolation rather than an inherent avoidance of social mixing.

Zoologist David W. Owens of Texas A&M University in College Station, who helped develop the social facilitation model in 1982, observes that while the new study does not conclusively rule out his hypothesis, it does "seem to indicate there may be three distinct green turtle populations, even within the Atlantic-Caribbean regions."

A more recent study by Bowen's group strengthens that finding and broadens its geographic scope, Meylan told SCIENCE NEWS. Their preliminary analysis of a worldwide survey appears to indicate that most regional populations of green turtles are genetically distinct and return to the birthplace at nesting time, she says.

Such knowledge may influence future conservation efforts, Meylan asserts. "People think it's no big deal if one population of green turtles is wiped out, because it can be replenished by a neighboring rookery up the coast," she explains. "We're saying you can't expect that to happen. Biologists now think of the green turtle as one species, but there may be a number of different entities."

– R. Cowen

Straightening the magnetic tilts of planets

The axis of Earth's magnetic field tilts about 11° off line from the axis on which the planet rotates. Studying other planets, scientists have interpreted data from the Voyager and Pioneer spacecraft as indicating that the difference between the axis of rotation and the magnetic field axis is about 10° at Jupiter, 1° at Saturn, 60° at Uranus and 47° at Neptune.

But why should planetary magnetic fields tilt at all?

Two scientists now propose an explanation that they say may account for all the observed tilts in magnetic fields. Syun-Ichi Akasofu of the University of Alaska in Fairbanks and Takao Saito of Tohoku University in Sendai, Japan, suggest that inside these planets, as well as in any others that produce their own magnetic fields, the rotational and magnetic-field axes are actually aligned. Only above a planet's surface, which is where passing spacecraft make their measurements, do the two axes diverge.

The researchers base their theory – which they plan to present in detail May 30 at a meeting of the American Geophysical Union in Baltimore – on the magnetic behavior of the sun.

The basic magnetic fields of the sun and planets are called dipoles, essentially resembling a bar magnet that has a north pole at one end and a south pole at the other. Instruments on Earth can measure the tilt of the axis of the sun's magnetic field not only far from the sun but also at the photosphere, its visible surface.

Such observations have shown that the sun's rotation axis and its magnetic axis coincide, both in the photosphere and above it, Akasofu and Saito note. In addition, other dipoles occur in the photosphere. But beyond a distance of about 2.5 solar radii, the axis of the solar magnetic field changes throughout the 11-year cycle of solar activity.

The researchers liken the photosphere's multiple dipoles to what may exist within planets. Planetary magnetic fields also look like dipoles as measured at the region above the surface, but Akasofu says there is no way to measure the magnetic field of the interior.

At present, Akasofu says, scientists have only one surviving theory for the origin of planetary magnetic fields. Called the dynamo theory, it evokes a comparison between a planet's magnetic axis and the shaft of an electric motor. Akasofu notes, however, that since a planet's rotation is such an important source of energy for its dynamo, the observed large tilts of planetary magnetic fields with respect to their rotation axes pose "a great puzzle."

There are at least two possible ways to explain those tilts, the researchers say. One is that the main dipole field is indeed tilted, which would mean that the dynamo theory needs marked revision to explain the tilts already observed at the planets of the solar system. On the other hand, although the main dipole may be aligned with the inner portion of the rotation axis, there may be other dipolar fields within a planet that result in a large dipole tilt as measured from outside.

Akasofu and Saito propose that the magnetic field as measured outside a planet may arise from two components. One is the central dipole, which goes through the planet's core and aligns with the rotation axis. The other consists of a few other dipolar fields at the outermost portion of the core. The combined field of the central dipole and of the core-surface dipoles, they say, may produce a field outside the planet that shows a large tilt.

– J. Eberhart