# BIRDS' CELESTIAL NAVIGATION

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How birds find their way through the skies has been the object of much current research, and has resulted in several interesting and sometimes startling hypotheses, theories and, to our mind, premature conclusions. As with theories on migration, there is no one avian navigation theory that stands by itself and of which we can state: this is it! this is the "how" of it in the whole bird creation. Whatever has been proved can be disproved; and the dedicated scientific mind with its intense "need to know" moves on to another more hopeful hypothesis.

Probably the most controversial supposition seriously defended by capable scientists is that of orientation by celestial guide posts. Convincing as its proponents may be, thoughtful analysis will not support it in its complete application. The following thoughts occur in its connection.

It has been postulated recently that birds determine their orientation in migration by using celestial bodies — sun, stars, constellations — as guides, even though it is well-known that migration very frequently takes place when the celestial bodies are obscured by cloud barriers. Experiments have been performed which apparently prove both that birds do use the heavenly units for orientation, and that they do not use them. It has also been postulated — and a good case has been made — that the bird relying on the heavens for finding its way must be endowed with a "built-in" clock, a means of measuring elevation and azimuth, and a memory!

Let us look at a few facts. How does a man, who is not endowed with these inherent physiological structures, locate his position on the face of the earth by means of celestial navigation? To simplify things, let us first assume that the earth's rotational axis is perpendicular to the radius from the sun to the earth, and that it rotates once in 24 hours, the circumference being 24,000 miles. Under these conditions there would be no seasons, and 12 hours of daylight would prevail at any latitude.

Suppose, now, a man is adrift on a raft on a smooth sea at a location unknown to him, and he wants to find out just where he is. He erects a mast three feet high, and with an improvised plumb bob makes it perpendicular to the earth's surface. He has with him an accurate clock or chronometer, and notes that at 12:00 noon the mast has no shadow; and on the following day the shadow disappears at 12:01. From this he deduces that (1) since the mast shadow will disappear completely only along the equator, he is on the equator; and (2) since the peripheral speed of the earth is 24,000 miles in 24 hours, or 1000 miles in one hour, or 16.6 miles in one minute, he has therefore drifted 16.6 miles in one day in a westerly direction. If his clock was adjusted to 0:00 hour at some previously fixed point on earth, such as Greenwich, then he would know that he was 180 degrees west of Greenwich.

Suppose that the mast is accidentally moved out of plumb by one-quarter of an inch in its three-foot length, between successive days, perhaps by a shift in the cargo. Suppose this displacement is on the east-west line with the top a quarter-inch off the true perpendicular westwardly. The shadow disappearance time will then be in error. The angle between ¼″ and 36″ is: *Tan* .25/36, or *Tan* .00695, or .397 degrees. On the earth at the equator, 24,000 miles is 360 degrees or 66.6 miles per degree. The slightly out-of-plumb mast thus has produced an error of .397 times 66.6, or 26.4 miles in the man's computed position.

If the raft is north or south of the equator the shadow will not disappear completely; it will have a minimum length (except at the poles), and the latitude would be calculated as: inverse *Tan* (minimum shadow length) / (mast height).

Since the earth's axis is at an angle of about 23.5 degrees from the perpendicular to the earth-sun radius, our man on the raft would require to know the day of the year and be equipped with a solar ephemeris (correction chart). This correction changes most rapidly toward the end of March and September, and neglecting it would create a position error of about 25 miles a day.

The purpose of all these figures is to show the accuracy demanded of a bird's "built-in" time-piece, its inherent leveling mechanism, and its prior knowledge of the daily change in the sun's trajectory. Leveling, for navigational purposes, has to be made against a line passing through the center of the earth and the bird's position. It is necessary to measure the angle between this earth radial line and the sun's position to an accuracy of five-tenths of a degree for an allowable error of thirty miles! To illustrate the smallness of five-tenths of a degree: the minute hand of a watch moves five-tenths of a degree while the second hand moves five seconds.

How does a bird know which way is down? Tests on man's sense of leveling are inconclusive because some individuals will average errors of twenty to fifty-two degrees in determining it. That's why the drunk staggers, he doesn't know which way is down. And how can the bird sight on the sun with out damaging its eyesight? Although the bird may well possess physiological senses not inherent in man, there is no evidence yet of its possession of the highly-developed senses required for celestial navigation.

Absolute measurement is required here. A man measures or senses things by their contrast with the environment. If his eyes measured absolute light intensity, he wouldn't need a photo light meter. If his ears measured absolute sound levels, he would not keep his neighbors awake with his loud TV set. We know that bats use sound radar, and that there is a fish that senses objects by distortion of an electromagnetic field which it creates; these are relative measurements.

Birds have undoubtedly been endowed by the creator with something beyond our immediate ken, but as for celestial navigation, — this requires absolute measurement of an angle, and we strongly doubt the bird's capacity in this area despite the apparent findings by sincere scientists with *some* birds.

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## HUMMINGBIRD FLIGHT TRAINING

A critical period in the life of a fledgling Ruby-throated Hummingbird — learning to fly — was observed and described to me by Cecil Bowers of Palmyra, New Jersey. The little bird, ready to go out into the world, would beat its wings faster and faster until it was lifted just above the level of the top of the nest. The adult female hovered close above with legs extended, and would gently push the youngster down, alternately letting the learner rise and fall in a bobbing motion. This training period and test of flight strength was performed one afternoon, and the next day the young bird had left the nest.

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