LATITUDE DETERMINATION BY ANIMALS - C (a failed method)

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Context

This paper shows a way in principle for birds to discover their latitude. It also shows how what seem to be good ideas on paper can fail in practice.

Latitude by watching the sun set

Consider the following extract which I downloaded from the web site indicated

http://www.astro.uu.nl/~strous/AA/en/antwoorden/zonpositie.html#v240

12. Length of Sunrise and Sunset

The amount of time that passes between the moment when the bottom of the solar disk touches the horizon and when the top of the solar disk touches the horizon is not constant, but depends on your latitude, on the season, and on how quickly the conditions in the atmosphere change. We'll assume a quiet and unchanging atmosphere.

The fastest sunset (or sunrise) at any given latitude occurs at the equinoxes (near 21 March and 23 September). The sunset then lasts approximately `128/cos phi` *seconds, where* `phi` *is the latitude. The slowest sunset occurs at the solstices (near 21 June and 21 December). For latitudes up to 60 degrees, the sunset then lasts approximately* `142/cos(1.14 phi)` *seconds. For latitudes greater than 60 degrees, the length of the sunset rises steeply with latitude, until you get to the latitudes where there is a polar night or day, when the Sun doesn't rise or set at all for days or months. For arbitrary dates, there is no simple formula to calculate the length of sunset. The full procedure involves several of the formulas from the relevant Calculation Page.*

For example, at a latitude of 40 degrees (either North or South), the fastest sunset takes about `128/cos(40°) = 167` *seconds (2 minutes 47 seconds), and the slowest one about* `142/cos(1.14*40°) = 203` *seconds (3 minutes 23 seconds). At a latitude of 50 degrees, the sunset lasts approximately between 199 and 261 seoonds (3 minutes 19 seconds and 4 minutes 21 seconds). At the equator, the sunset lasts between about 128 and 142 seconds (2 minutes 8 seconds and 2 minutes 22 seconds).*

The duration of sunset and sunrise is independent of the refraction by the atmosphere that slightly lifts up things near the horizon so that they appear to be higher in the sky than they would have done without any refraction, because you compare two instants of time when different parts of the Sun are at the same *altitude in the sky. The same altitude means that the refraction is equally strong (except if the conditions of the atmosphere in that direction have changed in the meantime), so both instants are delayed by the same amount and their difference remains the same.*

In principle then a bird can get its latitude by measuring the time the sun takes to rise or set.

When the sun comes up in the morning, the first thing that happens is that “Astronomical Dawn” is reached. This point is when the sun is about 18 degrees below the horizon. The atmosphere refracts (bends) the suns light so that it starts bit by bit to reach the observer. The night is not so dark as it was, but the sun is not yet seen. Later, typically between one and two hours later, the upper tip of the sun’s disk comes over the horizon. This is position of formal sunrise. Then, a few minutes later the bottom of the sun’s disk comes over the horizon and the sun is fully visible.

The time between upper limb appearing and the lower limb appearing can be called the disk transit time dt.

For determining latitude by disk transit time, the worst case is near the equator. Here the sun’s disk transit time increases by only three time-seconds as you go from the equator to 10° North. So to be able to have the required accuracy the clock must be good to 3/20 second in 200. This is 150 milliseconds accuracy in 200 seconds, or about one minute a day.

At higher latitudes, the accuracy required is less. The suns disk-transit time increases by 49 seconds in going from 40° to 50°. So to get within the half-degree box the clock has to be good to 2.5 seconds in 300.

The bird has to be able to see something approximating the real geographical horizon, because the time for the suns disk to cross this horizon is not the same time for the disk to pass a horizontal line at, say, 15 degrees altitude. So a bird sitting on a tree in a city park and surrounded by buildings can’t determine latitude in the way suggested.

<u>Problems with disk transit time</u>

The disk transit time depends on date to some extent and this is a weakness. One is suggesting that the bird can compensate for the date. It’s nearly the same as saying carries a book of astronomical table. Not as bad, maybe, but still it’s a definite conceptual problem.

Also I saw straight away that to observe the time at which the lower limb appeared you would have to have been looking directly at the sun for some minutes. I bought dark glasses and assumed that birds could restrict their iris’s arbitrarily. Anything to make facts fit my theory.

<u>Experimental</u>

In calculating what I expected to see I took some months up to about January 2006. In the UK where I live, the spring was followed by an unusually long and bright summer. Cloudless day followed cloudless day from the middle of June until well into September.

I was also blessed with an excellent viewing place from which I could watch the sun fall into the sea in the evening. I would drive out there just before sunset every evening.

Without fail, a band of hazy cloud formed near the horizon a few minutes before the actual sunset and after forty more or less consecutive days I was unable to time the disk transit. This was a pretty serious blow. If I couldn't time the disk transit time, then neither could a bird.

All in all, it seemed to me that a bird probably could not use this method for latitude determination.