NAVIGATION BY BIRDS –

TIME BASED DETERMINATION OF LATITUDE

USING BRIGHT STARS

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Abstract : *It is shown that latitude can in principle be determined by timing the setting of certain combinations of bright stars.*

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INTRODUCTION

Latitude can in principle be approximately determined by measuring the dip angle of the Earth's magnetic field. Since we know that some birds at least can detect the Earth's magnetic field it is tempting to think that this might be an important latitude determinant. Dip angle has one great advantage in that any sort of mammal, fish or insect could avail itself of the data, given only that the animal possesses some sort of detector. Having noted this, I am going to put it one side and look at another method.

TIME BASED DETERMINATION OF LATITUDE

Latitude can be determined by observing the setting of bright stars. This can be illustrated by drawing maps of the night sky at different latitudes and advancing the time. See in the Appendix for tools with which to do this.

Consider an observer on the Greenwich meridian on the 21st of March at a point 60º North 0º West and that the sky is clear of clouds. The observer will see the sun set at 18:15 GMT. If he looks at the sky at 19:00 he will see a star pattern in which the few brightest stars make the pattern shown in Figure E (1). Then as time passes the stars will be seen to move towards the

western horizon (anticlockwise on the figures). At 21:00 their configuration is as shown in Figure E (2) and at 22:00 in E(3).Soon after this, some of the stars will set. Actually Rigel sets at 22:25, Sirius sets at 22:49 and Betelgeuse sets at 24:55. The intervals between settings are : Rigel to Sirius 24 minutes and Rigel to Betelgeuse 150 minutes.

If the observer continued making these observations on succeeding days, then the setting times would be different but the intervals between the setting of individual stars would remain the same.

Another observer located at 30ºN 0ºW, again on 21st March when the sun sets at 18:11, will see the same stars setting not only at different times, but with different intervals. Here, Rigel sets at 23:02, Sirius sets at 24:11 and Betelgeuse sets at 24:18. The intervals between settings are : Rigel to Sirius 69 minutes and Rigel to Betelgeuse 76 minutes.

At 10ºN where the sun sets at 18:10, we get the setting times of Rigel, Sirius and Betelgeuse as 23:14, 24:39 and 24:06 and the intervals as R-S=85 minutes and R-B as 52 minutes.

So what turns out from this is that the interval between settings of pairs of stars depends on latitude.

A human being, of course, would draw suitable graphs of the star setting interval vs the latitude. A less numerate animal, traveling roughly south, might content itself with noting that it must be getting more south because the time interval between Rigel setting and Sirius setting had increased.

We now need to consider the accuracy to which a bird has to measure time in order to make a useful latitude determination.

Consider a swallow *Hirundo rustica* arriving in the United Kingdom from Africa. The bird will end its flight in late March in all probability, and for the purposes of example we will assume that it actually crosses the southern coast on 21 March and alights to rest near Ilfracombe at 51ºN 4ºW. It will then feed and look at the star movements seeing the following :

Location : 51º North 4º West Date : 21st March			
	Sets	Intervals between settings (mins)	
Sun	18:29		
Rigel	22:57	Rigel-Sirius	44
Sirius	23:41	Rigel-Betelgeuse	117
Betelgeuse	24:55		

We know from observation that birds will sometimes, indeed often, return to a particular building to nest. Although the bird may make its last few kilometers by remembering features it encountered on its last visit, it has to fly to somewhere near by using other methods. Let us assume that the bird needs to get to within 30 km of its intended destination, before it can recognize the local landmarks. This means a square of about 60 km side. One degree of great circle arc is 111 km so the bird needs to know its latitude to about 0.6 degrees of arc

Suppose the bird wants to return to a stable close to the position 53º 46’ N 2º47’ W. At this location star movement would be as follows :

Location : 53º 46’ North 2º 47’ West Date : 21st March			
	Sets	Intervals between settings (mins)	
Sun	18:24		
Rigel	22:48	Rigel-Sirius	39

Sirius	23:27	Rigel-Betelgeuse	126
Betelgeuse	24:54		

Thus in flying northwards through 3.75 arc degrees a difference in star interval of 5 minutes of time would be seen for the Rigel-Sirius pair. A difference on one degree would cause the Rigel-Sirius interval to be about 1.33 minutes and so to determine position to 0.6 degrees of arc the bird needs to measure to about 0.8 minutes over a period of about 45 minutes. In round figures the bird has to be able to measure one hour to plus or minus half a minute.

CONCLUSIONS

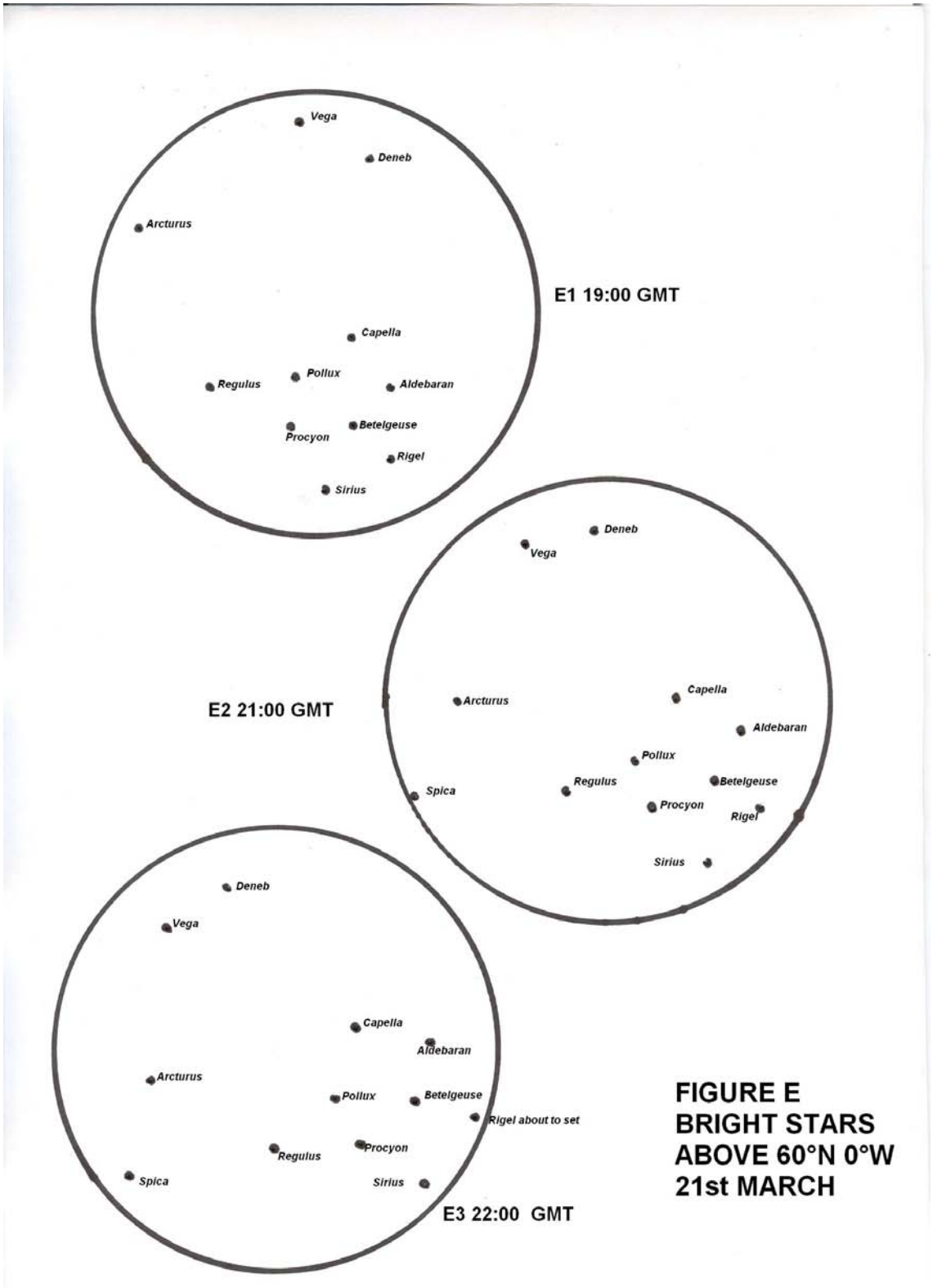
A bird does not know its latitude or longitude. Rather it follows a line of flight which instinct tells it will take it to the destination region. The bird infers how far it has traveled down the line by looking at star settings to determine its latitude. Finally it will search for known terrain if has done the journey previously.

APPENDIX

In order to carry out the calculations given in Section C two items are needed :

In order to reproduce the material of Section F is made, it is useful to have a tool which will draw selected features of the night sky on paper. There are several such tools;

I use the one at w.fourmilab.ch\yoursky and I set the controls to show only the stars brighter than magnitude 1.5. This tool gives a good idea of how the stars appear to move with time, but will only yield an approximate setting time, because of the vagaries of the graphical print out. To obtain accurate the star setting times, it is advisable to use the tool from w.alcyone.de, or something similar.


Vega
Deneb
Arcturus
E1 19:00 GMT
Capella
Pollux
Regulus
Aldebaran
Betelgeuse
Procyon
Rigel
Sirius
Deneb
Vega
E2 21:00 GMT
Arcturus
Capella
Aldebaran
Pollux
Regulus
Betelgeuse
Spica
Procyon
Rigel
Sirius
Deneb
Vega
Capella
Aldebaran
Arcturus
Pollux
Betelgeuse
Rigel about to set
Procyon
Regulus
Spica
Sirius
E3 22:00 GMT
FIGURE E
BRIGHT STARS
ABOVE 60°N 0°W
21st MARCH