2005JRASC..99...65D

EXPLORING THE ASTRONOMY OF ANCIENT EGYPT WITH SIMULATIONS II: SIRIUS AND THE DECANS

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The first paper of this series, hereinafter Paper I, included simulations to investigate Egyptian observations of the myth of *Nut* and the rebirth of *Ra,* winter solstices, the beginning of a lunar month, and the 25-year lunar cycle. Paper II includes simulations to investigate characteristics of the heliacal rise of Sirius, and the use of stars called the "decans," to mark the hours of the night.

The Heliacal Rise of Sirius

With a visual magnitude of −1.44[1] , Sirius is the brightest object in the sky after the Sun, the Moon, and the planets. The ancient Egyptians associated Sirius with the goddess Sopdet, or Sothis. The heliacal rise of Sirius in July marked the beginning of the season of flooding of the Nile River. The time between successive heliacal risings of Sirius is known as the Sothic year. Of course, observing the heliacal rise of Sirius did not mean that the Egyptians expected the Nile to start to rise the next day, anymore than the arrival of the winter solstice in Canada leads Canadians to expect a blizzard the next day. Still, there was an aura of mystery surrounding the rise of the Nile. The rains that caused the Nile to flood occurred thousands of miles to the south in the heart of Africa and were never seen in Egypt.

The heliacal rise of Sirius is easily predicted. Only a week or two of critical observations are required after the constellation of Orion is clearly visible in the early morning sky, in late June. The actual observational task would have been as simple as looking towards the east, roughly along an azimuth of 115°, just before dawn. If you *did not* see Sirius before sunrise then you would put another pebble-in-a-jar for the old Sothic year[2] . If you *did* see Sirius before sunrise you would announce that fact, and put a pebble-in-a-jar for the new Sothic year. As a refinement, you could also note the azimuth of Sirius as accurately as possible.

If counts of the number of days between heliacal risings of Sirius were kept over many years, then the Egyptians could have taken an average and obtained an accurate estimate for the length of the Sothic year. The Greek philosopher and astronomer, Hipparchus of Nicaea (*ca.* 150 BC), purportedly made use of Egyptian data on the azimuth of the heliacal rise of Sirius to aid in his estimate of the precession of the equinoxes.

A simple observational standard is needed to identify the date for a simulated heliacal rise of Sirius. Schaefer (2000) considered all the factors that might influence the observation of a real heliacal rise. He determined that for the heliacal rise of Sirius to be observed in Egypt, the difference in altitude between the Sun and Sirius would have to be about 11°. Table 1 provides the dates that Schaefer calculated for the heliacal rise of Sirius, and the corresponding dates obtained with simulations using *Starry Night.* Schaefer's dates include fractions of days and indicate the moment when the altitude difference reached 11°. The simulation dates correspond to the first morning when the altitude of Sirius was at least 11° greater than that of the Sun. Thus, the dates for the simulations tend to be one or two days later than Schaefer's. The correlation between these sets of results tends to confirm the efficacy of the simulation technique.

The date for the heliacal rise of Sirius also depends on the latitude of the observer. Schaefer found the date for the heliacal rise of Sirius to be about one day later for a one-degree increase in latitude. Changing the latitude of the observer in this simulation produces similar results. Egyptians at Aswan would have observed the heliacal rise of Sirius about 7 days before it could be observed in the Nile delta.

Simulation V: The Heliacal Rise of Sirius

On a given day, if the difference in altitude between the Sun and Sirius is less than 11°, then Sirius is judged to be too close to the Sun to been seen and the heliacal rise has not yet occurred. The first day on which the difference in altitudes is more than 11° is taken to be the date of the heliacal rising of Sirius. In 3000 BC at Luxor, latitude 26° N, Sirius would have advanced ahead of the Sun about 0.8° a day, so the date for the heliacal rise of Sirius can be readily obtained. An ambiguity of one day can occur when the difference in altitudes is very close to 11°.

Refer to the setup for Simulation V in the appendix. Step [forward] or [backward] in time until the Sun is just more than 6° below the horizon. In the simulation, at 6:20 a.m. on July 13, 3000 BC, the Sun is 6.0° below the horizon and at the same time Sirius is just 4.9° above the horizon. Since the Sun and Sirius were not separated by at least 11° in altitude, the heliacal rise of Sirius did not occur on this day. However, on the next day the Sun was 6.1° below the horizon while Sirius was 5.7° above the horizon. Thus, according to the simulation criteria, the heliacal rise of Sirius in 3000 BC occurred on July 14th.

In the simulation one has to be wary of subtracting the calendar dates and taking averages, because for every four years a leap day is automatically added. The Julian Date provides a simple count of days

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[1] *Observer's Handbook* 2004, p242

[2] The pebble-in-a-jar method was introduced in Paper I as a simple technique that could have been used by the Egyptians to count the number of days between repetitive celestial events.

and is ideal for estimating the length of the Sothic year. The decimal part of the Julian Date can be disregarded for this estimate. The mathematics is particularly simple for time intervals of 100 years. For example, the heliacal rise of Sirius at 26° N in 3000 BC occurred on JD 625867, and in 2900 BC on JD 662392. Subtracting the Julian Dates, one finds that 100 Sothic years correspond to 36,525 days, or an average of 365.25 days per year. Note that when the length of the Sothic year is estimated by averaging the number of days between successive heliacal risings, any observational errors tend to cancel.

To estimate the length of the Sothic year, the Egyptians would have had to observe the heliacal rise of Sirius and count pebbles every year, for several years. They would not have recorded fractions of days. If their method of observation was consistent and systematic, on average they would have recorded 3 years of 365 days followed by one year of 366 days. Table 2 provides a summary of data from simulations of the heliacal rise of Sirius over several centuries.

The Civil Calendar in Ancient Egypt

"Early in the third millennium, probably for administrative and fiscal purposes, a new calendar was invented" (Parker 1974). The "civil calendar," as it became known, was based on a year of precisely 365 days. It consisted of 12 months of 30 days plus 5 supplementary, or epagomenal days. Each month consisted of three 10-day "weeks" or decades. The civil calendar was the official calendar of the Egyptian government, was used to name months and number the days, and was used to set the dates of most festivals. The dates of new Moons, the winter solstice, and the heliacal rising of Sirius were still celebrated on the days that they actually occurred.

The civil calendar seems to have an obvious flaw. It slid ahead of the Sothic year by one day, every four years. In 40 years the difference would have been 10 days. In 400 years the difference would have been 100 days, and the seasons would have been totally out of step with the calendar. Once initiated, the civil calendar would not have matched the seasons and the Sothic year again, for another 1461 years[3]. Yet the Egyptians persisted in using the civil calendar for thousands of years. There is even a Greek reference by Aratus (*ca.* 240 BC) to an oath in the ceremony for "crowning" a new pharaoh that included the obligation to: "neither introduce a month nor even a day nor ever alter the date of a feast day, but would continue to measure the 365 days as decreed by the Ancients" (von Bomhard 1999). Apparently a new pharaoh had to swear not to "correct" the civil calendar.

Why did the Egyptians adopt such a calendar and refuse to correct an obvious weakness? The simple step of inserting an extra day every four years would have kept the civil calendar aligned with the seasons. The concept of inserting extra time units to keep a calendar synchronized with the seasons was a standard practice with lunar calendars. There are at least two important factors to consider.

First, the Egyptians seem to have regarded a calendar not as a means for measuring a continuous flow of time and marking the dates of historic events, but as a means for following the cycles of the gods. The 365-day cycle was an integral part of the 25-year lunar cycle, as explored in Paper I. The Egyptians were aware that year-by-year the heliacal rising of Sirius moved systematically through the days of the 365-day year. They recognized a Great Year of 1460 Sothic years. There is historical evidence that Great Years began in the years AD 139, 1321 BC, and possibly 2781 BC (O'Neil 1975). Thus, the 365-day civil year meshed with a 25-year lunar cycle, and a 1460-year Sothic cycle. Their calendar paid homage to the cycles of the immortals in the heavens. The very cyclic nature of their calendar also paid homage to the concept of an eternal Egyptian civilization.

Second, the Egyptians sought symbols to help consolidate the union of Upper and Lower Egypt. For example, one of the standard images of a pharaoh shows him wearing the "double crown," a combination of the tall "white crown" of Upper Egypt and the shorter "red crown" of Lower Egypt. The civil calendar may have served as an administrative and religious tool to advance the unification process. Before unification, Upper Egypt seems to have followed a lunar calendar in which the heliacal rising of Sirius marked the beginning of a new year. At the same time, Lower Egypt also seems to have followed a lunar calendar, but used the winter solstice to mark the beginning of a new year. The "new" civil calendar of 365 days (*ca.* 2800 BC) may have been designed to supplant these lunar calendars while still including a strong lunar component (the 25-year lunar cycle) and a strong Sothic component (the 1460-year Sothic cycle).

The great disadvantage of Egypt's civil calendar was that it was disconnected from the seasons. It would not be surprising if ancient Egyptians also made use of an unofficial calendar, somewhat analogous to a farmer's almanac, to keep track of seasonal events in a given year.

Simulations II to V demonstrate aspects of Egyptian calendars describing cycles-within-cycles. This cycles-within-cycles concept for Egyptian calendars is a simplified version of a model proposed by von Bomhard (1999). The brief summary of Egyptian calendars presented here does not do full justice to the work of Egyptian scholars who have spent the last century interpreting fragmentary archeological material. Many issues are still unresolved. For example, Leo Depuydt (1997) begins his academic treatise on the civil and lunar calendars in Egypt with a chapter entitled, "How many calendars were there in ancient Egypt?" indicating that even such a basic question is still worthy of serious discussion.

The Decans and the Hours of the Night

To measure the flow of time at night, you could select a circumpolar group of stars, such as the "Big Dipper" ("Leg of an Ox" to the Egyptians) and monitor its change of orientation during the course of a night. Or you could select a single star near the eastern horizon, just after sundown, and monitor its progress across the vault of the sky to measure the flow of time. The Egyptians selected a set of stars, now known as the "decans,"[4] and measured time as, one after another, these decans moved past a fixed reference point.

Before discussing any details, an initial question is often overlooked. Our sense of time and the practice of doling out hours, minutes, and seconds are relatively modern phenomena. Why would the ancient Egyptians have wanted to measure the hours of the night? A basic Egyptian myth involved the nightly journey of *Ra* and the spirit of a deceased pharaoh through 12 regions of the underworld, or Duat. Access to each region was controlled by a gate and guarded by a powerful demon. In order to gain passage through a particular gate, a spirit had to first recite the proper incantation. The incantations were complex and there was always the danger that a vital phrase might be forgotten. To assist the memory of a pharaoh's spirit, a scroll

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[3] Note that 365 × 1461 civil years = 533,265 days, and that 365.25 × 1460 Sothic years = 533,265 days.

[4] The term "decan" is used because these stars are used to mark the hours of the night for 10-day periods, or decades.

with all the instructions for this nightly journey was often placed in his coffin. Such scrolls became known as the "Book of the Dead"[5] and versions were often included in the coffins of anyone with hopes of joining the immortals after death. To further assist the spirit of a deceased pharaoh through the Duat, groups of priests chanted the appropriate incantation as the spirit was assumed to be approaching each gate. The desire to space these chants at regular intervals to match this nightly journey may have been the Egyptians' inspiration for developing the system of decans.[6]

The basic Egyptian system of decans used 36 brighter stars, or star groups, which were spread around the ecliptic. During any given 10-day week in the Egyptian calendar, a set of 12 decans was used to mark the hours of darkness. At the beginning of the next decade, to correct for the accumulated sidereal motion of the stars towards the west, the westernmost star was dropped from the set and a new one in the east was added. The progression of the sets of decans for a whole year was summarized in a "Decan Chart" with 12 rows (one row for each of the 12 stars to be used in a particular decade) and 37 columns (one column for each of the decades in the year, plus one column for the epagomenal days)[7].

It is thought that the sequence of decans began with Sirius and ended with the Orion group, but the identity of most of the decans is unknown. The Egyptians may have used different techniques, in different eras, to observe the decans. Choosing stars that were evenly spaced may have been more important than choosing the brightest stars.

Method I: The simplest technique is to monitor the setting of stars at the western horizon. The western horizon might have been preferred so that a setting star could carry the priests' message directly into the Duat. An early surveying instrument, called a *bay,* might have been used in such horizon observations. A *bay* is a short, notched staff used for sighting objects near the horizon.

Method II: According to Parker (1974), by the Twelfth Dynasty (*ca.* 1900 BC) decan observations were made on the meridian:

> "...two men sit facing one another on a north-south line. The northernmost would hold a sighting instrument like plumb bob...before him and would call out the hour when a [particular] star reached the meridian... as sighted against the target figure [of the second person]."

The frame for such a plumb bob was called a *merkhet*. The Egyptian Museum in Berlin has an example of a *bay* and a *merkhet* that once belonged to a priest named *Hor,* who was the Overseer of the Hour during the Twenty-sixth Dynasty (Wells 1999). A *bay* was probably held at arm's length (about 60 cm) while resting on a support. A line-of-sight would have been established through the *bay* towards an object of interest.

Simulation VI: Observing the Decans and the Hours of the Night

Imagine an Egyptian priest viewing the night sky and wondering how to space the incantations that would assist *Ra* and the spirit of the pharaoh through the 12 gates in the Duat. The stars could be seen to move uniformly across the sky. Why not select 12 evenly spaced stars, across the east-west vault of the sky, to use as time markers? As each of these stars set in the west, it would be time for the next incantation! Based on this scenario, the simplest approach is to simulate decan observations near the western horizon.

For Egyptian priests, the time of darkness extended from the end of twilight in the west (corresponding to the passage of *Ra* through the first gate of the Duat) to the beginning of morning twilight in the east (corresponding to the emergence of *Ra* from the twelfth region of the Duat). At Luxor, latitude 26° N, this time of darkness varies from about 12 hours and 40 minutes at the winter solstice, to 9 hours and 20 minutes at the summer solstice[8]. The corresponding average spacing for the decans varies with the seasons as shown in Table 3.

To become familiar with the decan concept, follow the setup for Simulation VI as described in the appendix, run time [forward], and watch the progression of bright stars over the western horizon as a few days and nights flow by. [Stop] the action with a bright star about 30° above the western horizon. Set the "Time Flow Rate" to 1 day, and [step forward] one day at a time. Note the day-by-day, sidereal progress of the star towards the western horizon.

To select potential-decans, reset the "Time and Date" to 7:20 p.m., April 15, 3000 BC. If DST is turned off, this time corresponds to the end of twilight. Then set the "Time Flow Rate" to 55 minutes, which is approximately one twelfth of the time of darkness at this time of year. The task is to locate 12 potential-decans that could have been used to divide the night of April 15/16, 3000 BC into 12 approximately equal segments. Search the region about 20° above the horizon, and within 40° of due west, for the brightest star that could have served as the first decan[9]. A bright star within an identifiable group would probably be preferable to an isolated star. Place the cursor over a selected star and push [control] to determine its name, altitude and magnitude. Record this information along with the time. Then [step forward] 55 minutes, and repeat the procedure. Continue until you reach morning twilight. Table 4 was produced using this procedure.

The starting point of April 15, 3000 BC at 7:20 p.m. at an altitude of 20° was somewhat arbitrary; however, 12 potential-decans were easily found. These potential-decans all had magnitudes brighter than 3.6, with 55-minute spacing, and all had altitudes within a few degrees of 20°. If this procedure were to be repeated again at both solstices, and the fall equinox, with appropriate changes in the "Time Flow Rate" as given in Table 3, then four lists would be produced with a total of 48 potential-decans. If all these stars were combined in a sequential list, and duplicates were eliminated, a list of potential-decans would be created that would be similar to the set of decans used by the ancient Egyptians. This list of stars could also be organized into a "Potential-Decan Table" with a structure corresponding to the structure of a "Decan Table" from ancient Egypt.

Observing the Decans: Practical Problems and Speculative Solutions

1. A decan system with 36 stars is conceptually neat and logical for a year consisting of thirty-six decades (10-day weeks). The five or six epagomenal days at the end of the Sothic cycle require

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[5] The papyrus of Ani, as presented in *The Egyptian Book of the Dead,* ed. von Dassaw (Chronicle Books, 1994) is one of the most complete and artistic examples.

[6] For example, Parker (1974) assumed that the Egyptians first identified the decans to divide the time of darkness into 12 portions, and only then divided the journey through the underworld into 12 sections. This assumption implies that the Egyptians were astronomers before they were religious practitioners. It may be more reasonable to assume that the mythical trip through the 12 divisions of the Duat is more ancient than the list of decans. The number "12" has a number of ancient mystic associations and may ultimately be related to the number of whole lunar months in a solar year.

[7] Photographic images of Decan Tables can be found at www.thebanmappingproject.com/sites. This site provides virtual tours of tombs in the Valley of the Kings along with hundreds of photographs. The tomb of Sety I (KV17) includes some of the best images of a Decan Chart (images #14, 22, 24, & 45).

[8] These times can be estimated by referring to "Twilight" (*Observer's Handbook 2004,* p 113) or by following the simulated Sun in 3000 BC from 6° below the western horizon, to 6° below the eastern horizon.

[9] According to Schaefer (2000), to be visible near the horizon an object should have an altitude of at least 5°. Since the stars advance about 1° per day and westernmost decan was observed for 10 days in a row, its initial altitude must have been at least 15°.

2005JRASC..99...65D

a 37th column in the Decan Chart. This column probably contained a selection of decans from the 1st and 36th columns.

2. Decans, when separated from each other by an average of 14°, or 55 minutes, create two basic concerns: i) only 26 stars are required to span the sky, and ii) during each 10-day period the stars advance about 10° towards the west, while the next column in the Decan Chart is based on advance of 14°. Thus the jumps from one column to the next in the Decan Chart are 4° too big. Unchecked, such an error would accumulate to 144° during a year. However, if every two or three decades, a column of the Decan Chart was simply a duplicate of the previous column, then the advance of the chart would be slowed to match the advance of the stars. A total of ten duplicate-columns per year would have kept the Decan Chart synchronized with the heavens[10]. If, in addition a duplicated column was marked by replacing one star with a new decan star, then a total of 36 decan stars would be required to complete the Decan Chart.
3. Based on Simulation VI, the spacing of the decans may have varied within a 5° range. Thus, the length of hours based on simple decan observations may have varied by up to 20 minutes. At some point the Egyptians seemed to have dealt with this problem by creating a supplemental chart to accompany the Decan Chart. Such a chart, and the figure of a kneeling man, is included in the inscriptions on the walls of the tomb of Ramses VII (*ca.* 1150 BC)[11]. The chart lists the decans with notations such as "opposite the heart," "on the right eye," "on the left ear," and "on the right shoulder." These instructions may have been used to refine the observations of decans by indicating how to adjust the line of sight by a few degrees. While Parker (1974) associates this chart only with meridian observations, similar charts may have also been used to correct horizon observations of unevenly spaced decans.
4. A clock based on the stars gradually shifts due to sidereal motion. A star passes a fixed sightline about four minutes earlier each day. Over the duration of a "decade" the sidereal shift would have amounted to about 40 minutes and the timing of incantations would have been disrupted. The Egyptians could have managed this difficulty simply by using a reference sightline based on the position of first (westernmost) decan each night, rather than the horizon or the meridian. This could have been accomplished in the following manner:
    - A short pillar was topped by a support for a *bay,* and the support was designed so that its height could be varied by several centimetres[12]. When held at a distance of 60 cm, raising or lowering a *bay* by 1 cm raises or lowers the line-of-sight by about 1°.
    - Each day, at sunset, the level of the support was set so that an observer's line-of-sight through a *bay,* was towards with the first decan.
    - The *bay,* at that platform height, was then used to observe the passage of the other eleven decans during the night.

The timing of the first incantation would have been determined by the onset of darkness, while the corresponding altitude of the first decan would have been used to establish the height of the *bay*. This technique would have the effect of resetting the decan clock to zero at the beginning of each night's observations and would automatically compensate for any sidereal shift.

Summary

Simulations have proved to be a useful tool for investigating the astronomical techniques and observations in ancient Egypt.

Working through a variety of simulations, relatively simple procedures have been designed that the Egyptians might have used to obtain the astronomical results that have been found in the archeological record.

It was demonstrated that observations of the heliacal rise of Sirius could be made to determine the beginning of any particular Sothic year, with an accuracy of one day. Averaged over a period of many years, at any time during the third millennium, the average length of a Sothic year was found to be 365.25 days.

The use of decans to divide the time of darkness into 12 equal parts may have been the most sophisticated Egyptian astronomical technique. To be effective over weeks and months, the technique required the construction of a Decan Chart with celestial spacing between the decans that depended on the season. An observational technique that depended on the position of the westernmost at sunset may have been used to "reset" the star clock each night. This resetting of the star clock would have avoided a number of systematic errors that would have occurred if observations had been based on the horizon, or the meridian.

I hope the six simulations presented in this two-part series have provided a useful hands-on introduction to the astronomy of ancient Egypt. For those who want to learn more about this topic, there is much more to be gleaned from the academic literature on the technology of ancient Egypt, and undoubtedly there will be more insights gained from future archeological discoveries.

Appendix

The following procedures have been designed to facilitate investigations of the astronomy of ancient Egypt using the computer program Starry Night (`www.starrynight.com`). "TOP TOOLS" refers to the horizontal tool bar across the top of the standard screen. "SIDE TOOLS" refers to the vertical tool bar at the side of the standard screen. Square brackets are used to indicate control buttons within the TIME window.

General Settings for Simulations in Ancient Egypt

The directions for creating the file called ANCIENT EGYPT can be found in the appendix to Paper I in this series.

Simulation V: The Heliacal Rise of Sirius

Open the file for ANCIENT EGYPT.
In the *Time Bar:*

- Set the date to July 13, 3000 BC. This date corresponds approximately

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[10] With 14° spacing and the duplication of ten columns, the 36 columns of the Decan Chart would have corresponded to a total advance of 26 × 14° = 364° per year.

[11] KV 1, image #15 at `www.thebanmappingproject.com/sites`.

[12] A support with a variable height could have been formed by carving a series of small steps in the edge of the support. Or, two wedges could have been stacked so their horizontal surfaces were parallel. Then the height of the top surface could then be changed, by sliding the top wedge horizontally. More simply, a series of flat boards could have been placed under the *bay.*

to the heliacal rise of Sirius.

- Set the time to 6:00 a.m. local (or 3:00 UT). At this time the Sun is about 6° below the horizon and Sirius has an altitude of about 5°.
- Recall the "Set Julian Day" option. Using this menu item you can obtain the current Julian Day value, and/or change it to another value.

From *Side Pane* use "Find" to locate and label Sirius, then select East again from the *Button Bar.* Use the "Hand" cursor to raise the horizon one third of the way up the screen.

Simulation VI: The Decans and the Hours of the Night

Open the file for ANCIENT EGYPT.
From the *Button Bar* select: West direction.
From the *Tool Bar* select Options > Stars > Star Options: Set the number of stars to fewer so only the brighter stars are shown.
In the *Time Bar* set:

- The "Time and Date" to 6:55 p.m. (Sun on the horizon) and April 15, 3000 BC (day of the vernal equinox).
- The "Time Flow Rate" to 5 minutes.

Use the "Hand" cursor to move the horizon to the bottom of the screen. The first gridline above the horizon marks +10° in altitude; the next gridline marks +30°. The intersection of green celestial equator with the red horizon marks the direction of west. The vertical gridlines mark 30° intervals in azimuth.

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TABLES

Table 1. The heliacal rise of Sirius at 30° N. A comparison of the Julian calendar dates calculated by Schaefer and those obtained with simulations using *Starry Night.*

Year	**Schaefer (2000)**	**Simulations**
3500 BC	July 16.4	July 19
3000 BC	July 16.9	July 19
2500 BC	July 16.6	July 19
2000 BC	July 17.3	July 19
1500 BC	July 17.8	July 19
1000 BC	July 17.2	July 19
500 BC	July 18.2	July 19
AD 1	July 18.3	July 20
AD 500	July 20.3	July 21

Table 2. Data from simulations of the heliacal rise of Sirius at 26°N.

Year (BC)	**Day (Julian Calendar)**	**Julian Date**	**No. of Days in 100 Sothic years**
3000	July 14	625867	N/A
2900	July 14	662392	36525
2800	July 14	698917	36525
2700	July 14	735442	36525
2600	July 14	771967	36525
2500	July 14	808492	36525
2400	July 14	845017	36525
2300	July 14	881542	36525
2200	July 14	918067	36525
2100	July 14	954592	36525
2000	July 14	991117	36525

Table 3. The time of darkness and average decan spacing at 26° N, in 3000 BC.

Time of Year	**Hours of Darkness**	**Average Spacing for 12 Decans**
Winter Solstice	12h 40m	63 min
Vernal Equinox	11h 5m	55 min
Summer Solstice	9h 20m	47 min
Fall Equinox	11h 5m	55 min

Table 4. Potential-decans for the Evening of April 15/16, 3000 BC.

Local Time	**Star**	**Altitude**	**Magnitude**
7:20 p.m.	Sirius	21.1	−1.47
8:15 p.m.	Castor	22.8	1.56
9:10 p.m.	Altarf	22.5	3.50
10:05 p.m.	Zeta Hydrae	20.0	3.09
11:00 p.m.	Omicron Leonis	18.8	3.50
11:55 p.m.	Nu Hydrae	22.7	3.09
12:50 a.m.	Gamma Centauri	22.6	2.81
1:45 a.m.	Kraz	20.8	2.62
2:40 a.m.	Menkent	22.7	2.03
3:35 a.m.	Gamma Lupi	20.9	2.96
4:30 a.m.	Sargus	21.8	1.84
5:25 a.m.	Arkab	21.5	3.09
6:20 a.m.	Morning twilight	—	—

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