

THE OSTRACON

THE JOURNAL OF THE EGYPTIAN STUDY SOCIETY

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Publication of The Ostrakon is supported by a grant from
THE PETTY FOUNDATION

Denver Museum of Nature and Science
 2001 Colorado Blvd.
 Denver, Colorado 80205



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The Inner Workings of the Egyptian Civil Calendar

James R. Lowdermilk

INTRODUCTION

IN 238 BCE Ptolemy III and his queen, Bernike, brought the highest priests of Egypt from temples throughout the land together in Canopus, near Alexandria. Here the foreign king and queen issued a decree intended to “correct” the Egyptian calendar, so the calendar would remain fixed according to the seasons of the year. Customarily the Egyptian calendar counted 365 days every year, ignoring what we call leap years. The *Decree of Canopus* was issued

in order that the seasons may all correspond to the ordinances of heaven at this time and so that feasts [originally] celebrated in the land in *Peret* [i.e., winter] shall not be celebrated at some time in *Shemu* [i.e., summer] as the result of the displacement of the Feast of Sothis one day [later] every four years (Claggett 1995:328).



The Egyptian’s 365-day civil calendar moves away from solar events—the solstices or equinoxes—or astronomical events such as the Sothic rising, being displaced by approximately one day every four years. For this reason festivals could occur one year in the calendar’s summer but over 700 years move toward the calendar’s winter. It is not the Sothic rising that moves across the year; the dates of this event move across the calendar (or the calendar moves in relation to this event). As the decree states, this situation was recognized by Greek scholars of the time, and their solution was to add one day to the calendar every fourth year, much as we do. The Egyptian priests rejected this obvious solution, and people from Greek philosophers to Roman Emperors to modern scholars have vilified them for not correcting what they viewed as a gross error.

The Egyptian priests had their own reasons to let the civil calendar continue to run at its established pace, however. After all, they had been using the calendar throughout pharaonic Egypt. From the Greek point of view, the Sothic Rising Festival would move one day on the calendar every fourth year, which meant it would move across the Egyptian 10-day week in 40 years. The creators of this calendar may have chosen 10-day weeks, which we call “decans,” because they understood that since this festival follows an astronomical event, it travels across 10 calendar days in almost exactly 39

years. The priests who rejected the *Decree of Canopus* may have understood that the proposed scheme would leave an error of $\frac{1}{4}$ day every 39 years, the equivalent of 9 minutes per year.¹

SOTHIC RISING

Understanding of this situation can be gained through investigation of the Sothic rising. Each star that rises and sets has times when that star resides too close to the sun and is not visible during any part of the night. One morning each year, each of these stars appears to move past the sun and becomes visible for the first time that year, on the eastern horizon. Since the star in question just moved past the sun, it is first visible just before the morning twilight. This is called a “heliacal” rising of a star. The heliacal rising of the brightest star in the sky, the one the ancient Egyptians called

 *spd.t* “Sopdet”—our Sirius and the Greeks’ Sothis—is what the Greeks dubbed the Sothic rising and the Egyptians  *pr.t spd.t* “the going forth of Sopdet.”

Observation of this astronomical event is greatly hindered by the morning twilight, a situation known to astronomers as the “arc of vision.” Atmospheric and weather conditions can influence the day when Sothis first becomes visible. Counting the number of days between these Sothic-rising observations would yield anywhere from 364 to 367 days, with no observable pattern.

This obstacle can be overcome by using a reference point as simple as a standing stone, a permanent wall, or a high ridge-line (Figure 1). With this observation taking place above the twilight, visibility of this star above the reference point regularly occurs in the days following the star’s first appearance of the year. Counting the number of days between these “adjusted” Sothic risings yields an interesting pattern. Most years one would count 365 days between these observations. This is why some authors, such as James Henry Breasted, claimed that the Egyptians chose to count 365 days in their calendar. Almost every four years this count would yield 366 days. This is the reasoning behind the *Decree of Canopus*—to add one day every fourth year. However, years of observations and accurate record keeping would reveal that every 39 years a 366-day count would occur on the third year of a cycle (Table 1).²

Table 1: Pattern by counting days observed in sidereal years³:

365, 365, 365, 366 days most years

365, 365, 366 days every 39 years

The Greek scholars responsible for the *Decree of Canopus* had not spent their time and energy perfecting these observations, because they did not understand this break in the one-day every four-year pattern.⁴ There is debate about whether the Egyptians understood exactly how inaccurately their calendar followed the seasons or the stars. If the Egyptians understood the error between their calendar and such observable events as the Sothic rising, they would have possessed a means to calculate on what dates certain events would occur. This calculation would be slightly more complex than just moving a festival based on astronomical events one day every four years.

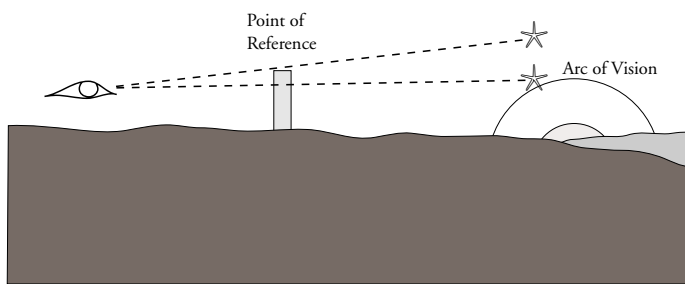


Figure 1

DECAN LISTS

The priests of ancient Egypt observed movements of the stars both through the sky and across their calendar by watching thirty-six stars variously listed in Dynasties IX–XII Decan lists. These thirty-six stars were listed in columns, each representing one decan or 10-day week. Each column contained twelve rows of stars representing the twelve decanal hours of the night, with one decanal hour being approximately 40 of our minutes in length.⁵ When a star representing the current decan rises, the row that star resides in tells the current hour of the night. Using the decan list, it is possible to track the movement of these stars down to the minute.

The Egyptian civil calendar contains 12 months of 30 days each with five additional days residing outside of any month, known as “epagomenal days.” Stars representing the five epagomenal days are tucked into the lower left-hand corner of the Decan lists. With thirty-six decans of 10 days each plus the five epagomenal days, the Decan lists account for 365 days per year. By definition, the initial year that a Decan list was employed, each star provided the correct time of night on the first day of its corresponding 10-day decan. On the second day the star would rise about four minutes later because of the daily motion of the stars. On the third day it would

rise about eight minutes late, and on the fourth day about 12 minutes late. After 10 days the star would rise approximately 40 minutes later than it rose on the first day, and the following day the star moved into the next decan, marking the next later hour.

The next year the Decan list is employed, each star would rise 1.01 minutes⁶ early on the first day of its 10-day week, hardly a noticeable difference even to a skilled observer. After four years each star would rise approximately four minutes early on its first day, and its rising would correctly begin the decanal hour of the second day of its decan. Four years later each star would yield the correct time on the third day of its decan, and as time progressed this change would become increasingly apparent. These lists account for 365 days every year and neglect leap years. Therefore, the stars are allowed to wander away from their original positions by the equivalent of about one day every fourth year. Continuing these observations over longer periods of time, one would observe that each star moves across its 10-day decan in only 39 years.

Many people, from Ptolemy III to the modern scholar Otto Neugebauer, have suggested that the Egyptian calendar moves away from observed events by the equivalent of about one day every fourth year. They believe this is accurate enough to warrant the use of a year with $365\frac{1}{4}$ days, or a “natural year,” for calculations ranging for more than forty years. Neugebauer has suggested that these decanal stars would move across each 10-day period in about 40 years. By actually observing these stars, the Egyptian priests must have known that they move 10 days across their 365-day calendar in almost exactly 39 years—knowledge that is incorporated in the design of the Decan lists by the choice of 10-day decans.


SOTHIC CYCLES

Another ancient scholar who bases his calculations of the Egyptian calendar on the “natural year” of $365\frac{1}{4}$ days was Censorinus, author of *De die natali*, written about 240 CE. He wrote that the Sothic rising coincided with the first day of the Egyptian civil calendar approximately 100 years earlier, in 139 CE. Using the assumed one-day-every-four-year movement of this calendar, he calculated that the Sothic rising should coincide with the first day of the Egyptian calendar every 1,461 Egyptian years (Clagett 1995:334). This calculation promulgated the error of using the one-day-every-four-year movement of the Egyptian calendar over great periods of time.

Since the appearance of astronomical events occurs in the Egyptian calendar approximately one day late every four years over short-term observations, many authors have erroneously extended this movement into the long term, when astronomical events follow behind the Egyptian calendar at the accurate rate of 10 days every 39 years. This calendar provides 36 decans and five epagomenal days, for a total of $36\frac{1}{2}$ decans, which requires 1,423.5 Egyptian years for an astronomical event and this calendar to realign. The Sothic Rising Festival is based upon observation of an astronomical event. Therefore 1,423.5 Egyptian years are required for this festival to be

celebrated on the first day of the first month of the Egyptian calendar, wander through the year and reoccur on the first day of the calendar again, in what is called a Sothic cycle.

THE BEGINNING OF THE EGYPTIAN CIVIL CALENDAR

It is commonly suggested that Egyptians began counting the 365 days of their civil calendar on the date they called  *wp.t* *mp.t* “Opening of the Year,” now known as the Sothic rising (Breasted 1906:1/26). Counting back Sothic cycles from the year 139 CE gives 2711 BCE and 4136 BCE as the only reasonable candidates for the approximate beginning of the Egyptian civil calendar. The first generally accepted reference to the civil calendar comes from the reign of Shepseskaf (Dynasty IV), beginning around 2472 BCE, but mention of the five epagomenal days in the pyramid texts gives the possibility of an earlier origin.

Recent excavations have uncovered megalithic stone circles with astronomical alignments at a Neolithic site in the Nabta Playa depression of southern Egypt. These standing stones could provide the unchanging points of reference necessary to accurately observe not only the Sothic rising but the rise times of other stars. Dates from sacrificial cattle burials (Malville 1998:488–491) show this site was active during dates spanning the 4136 BCE date for beginning the Egyptian calendar. The earliest inhabitation at Nabta Playa was only during the fall and winter. Later, large walk-in wells were constructed to enable some inhabitants to remain throughout the year (Wasylkowska 1997:933). These inhabitants then were available to observe the zenith sun passages three weeks before and after the summer solstice. The stones were erected not only with the ability to make astronomical observations, but also to mark the day of the zenith sun passage, when the sun passes directly overhead, casting no shadow at noon of that day.

CALENDRIAL MATHEMATICS

The number of days counted between successive spring or summer zenith passages is usually 365 days. As we might expect, almost every fourth year the zenith passage arrives one day late, or 366 days after the previous corresponding passage. However, usually every 33 years the zenith passage arrives one day late on the fifth year of a cycle, but sometimes it takes only 29 years.⁷ Thus, the zenith passage breaks its four-year cycle one year late on average every 32 years (Table 2). By comparison, the Sothic rising breaks its four-year cycle one year early every 39 years. Today, we understand that the year measured from the stars, the sidereal year, differs from the year measured by the sun, the solar year, and both years are measurable with naked-eye observation and accurate long-term record-keeping.

Table 2: Pattern by counting days observed in solar years:

365, 365, 365, 366	days most years
365, 365, 365, 365, 366	days on average every 32 years

Once the patterns in Tables 1 and 2 were established for the observations made on the stars and the sun, people who possessed this knowledge developed ways to interpret these patterns. A new method of division was invented to describe this data: unit fraction division. Using this method and modern notation, the stars cycle every $365 + \frac{1}{4} + 1/(4 \cdot 39)$ days, and the sun cycles every $365 + \frac{1}{4} - 1/(4 \cdot 32)$ days. In plain English these formulae translate to “the sidereal year is 365 days with one extra day every four years, gaining an extra quarter day every 39 years” and “the solar year is 365 days with one extra day every four years, losing a quarter day every 32 years.”

The cyclical patterns exhibited by counting the number of days between solar and stellar observations provide a paradigm for understanding unit fractions, and it may have been this paradigm that prompted the Egyptian priests to invent such fractions. The need for people to be able to perform calculations involving these formulae could explain why the Egyptians chose to use unit fraction division throughout Egypt’s ancient historical times. These formulae provide a basis for accurately predicting the dates of the Sothic rising or winter solstice, when the Sothic Rising Festival (*pr.t spd.t*) and Birth of Re Festival (*msu.t r*) were celebrated (Wells 1994:1). These formulae could have been used to announce the occurrence of the Sothic rising 22 days before this event occurred in Year 7 of (probably) Sen-Wasret III, as stated in Papyrus Berlin 10012 from Illahun (Clagett 1995:321).

The choice of a 365-day civil calendar year aids the computations necessary to identify the dates of solar and stellar events. The dates of festivals based on these events would generally move on the calendar one day every four years. For festivals based on stellar events, the extra day would come one year early, on the third year, every 39 years. For festivals based on solar events the extra day would come one year late, on the fifth year, on average every 32 years. These movements follow the patterns presented in Tables 1 and 2. The choice of 365 days also aids in computations necessary to identify the phases of the moon.

Papyrus Carlsberg 9, written about 144 CE, tells of the Egyptians’ knowledge at this late date of a lunar cycle, 25 civil years long, revolving around the 365-day calendar. The papyrus begins, “here is the procedure of enumerating the 25 years of the moon in order to make them known” (Clagett 1995:302). This procedure starts with the second lunar month in Civil Month 2 of *Akhet*, Day 1, a very auspicious date near the beginning of the civil calendar year. Nearly every 25 civil years, this coincidence repeats with a lunar month beginning with the same phase of the moon on the same date. This 25-year pattern repeats the phases of the moon 309 times almost every 25 civil years or 9,125 (=25*365) days.

It is clear that the Egyptians understood this 25 civil year lunar cycle during the Late Period, but there is debate about whether the priests had knowledge of this cycle at much earlier dates. When Richard Parker applied the 25-year cycle of Papyrus Carlsberg 9 to

the year 856 BCE, “the month starts in every case exactly one day before the morning of invisibility” (Parker 1950:17). Applied to times 500 years earlier, the lunar months would start two days early. For this reason many scholars, including Parker and Neugebauer, have claimed that the Egyptians had no knowledge of this procedure prior to 357 BCE, the earliest dates the procedure applies to accurately.

If the Egyptians noticed this 25-year pattern at a much earlier date, it would have been used to predict the future dates of the phases of the moon, “in order to make them known” (Clagett 1995:302). After 525 years these predictions would become incorrect by placing the moon one day ahead of its observed phases.⁸ Within 1,000 years the moon would be moving nearly two whole days away from its predicted cycle. The longer an incorrect calendar scheme is used the more error it accumulates, making its inaccuracies more apparent. Had this become apparent to the Egyptian priests, a calendar correction would have become necessary.

CALENDAR CORRECTIONS

A possible correction to the 25-year lunar cycle of the Egyptian civil calendar is to skip one day every 525 YEARS. This is equivalent to not counting one day every 21st lunar cycle and could be accomplished by counting only 364 days less than twice every millennium. The five epagomenal days of the calendar do not belong to any 30-day month, and one of these days could easily be skipped during the necessary year. The Egyptian unit fraction representation of this cycle in modern notation would show that the moon cycles 309 times every $25 \times 365 - \frac{1}{21}$ days. This formula could be used to calculate the year to skip the proper day in order to keep this cycle in line with the moon.

Neugebauer and Parker (1960–69) have suggested that the Egyptians had not noticed the 25-year patterns in the lunar cycles until the Late Period. In that case there is only a $\frac{1}{30}$ probability⁹ that the 25-civil-year lunar cycle would properly line up with the records given in Papyrus Carlsberg 9. This document begins its cycle on a very auspicious date. Had the aforementioned error not been accounted for, it is highly unlikely that the accumulated error would have placed this calendar date in line with the beginning of an observed lunar month. Therefore, since this lunar cycle was not currently in need of reform in 144 CE, the ancient Egyptian priests must have previously observed that this 25-year lunar cycle had a slight but correctable error. They must have already called for a calendar reform before the Late Period, correcting for this error and continuously keeping this cycle in check.

The Egyptians’ choice of 365 days per year with 10-day weeks provides a calendar system accurate to less than 30 seconds of the sidereal year. Ptolemy III and subsequently Julius Caesar proposed calendars loosely based on this system by adding one day every four years while introducing an error of 9 minutes per year. The Egyptian Hour-Watcher Priests understood this difference at least as early as the sixth century BCE. Instruments used by an astronomer priest

named Hor bear the inscription: “(I) knew the movements of the two disks [i.e., the sun and the moon] and of every star to its abode” (Clagett 1995:491). Although the Egyptian priests understood these movements, they were not fully understood by such luminaries as Ptolemy III, Julius Caesar, Censorinus, and Otto Neugebauer, which has led to more than 2,000 years of confusion regarding calculations involving the Egyptian calendar. These calculations can be rectified by realizing that this calendar of 365 days follows behind the actual movements of the stars by exactly 10 days every 39 years.

NOTES

¹*The Astronomical Almanac for the Year 1999* (Nautical Almanac Office 1999:C1) gives Sidereal Year = 365 days, 6 hours, 9 minutes, 9.8 seconds.

²*The Astronomical Almanac for the Year 1999* (Nautical Almanac Office 1999:C1) gives Sidereal Year = 365.256363 days = y_0 .

Counting the number of days per n^{th} year = $d_n = \text{TRUNC}(y_0 + r_{n-1})$, with the remainder of day in n^{th} year = $r_n = y_0 + r_{n-1} - \text{TRUNC}(y_0 + r_{n-1})$, where $r_0 = 0$, and $n = 1, 2, 3, \dots$

Lambeck (1980:3) gives the Length of Day increasing by 0.001 – 0.002 sec./100 yr. This means that 5,000 Years Before Present the Sidereal Year = 365.256074 days with negligible difference when used for y_0 .

³[A sidereal year is the time required for one complete revolution of the earth about the sun, relative to the fixed stars; see note 1 above—EDITOR]

⁴Claudius Ptolemy (1998:139)—no relation to Ptolemy III—in *The Almagest*, speaks of confusion between lengths of the year. Meton and Euktemon give 1 year = 365 + $\frac{1}{4}$ + $\frac{1}{6}$ days, Kallippos gives 1 year = 365 + $\frac{1}{4}$ days, and Hipparchus gives 1 year = 365 + $\frac{1}{4}$ – $\frac{1}{300}$ days.

⁵Neugebauer and Parker (1960–69:1/102) give decanal hours that are based on 10° intervals, and they vary from 27min, 12sec to 47min, 40sec. When based on 10-day intervals, the decanal hours are consistently about 40min with the stars appearing to move ahead of the sun by about 4min/day.

⁶If the Sidereal Year = 365.256363 days, then the Decan lists do not account for 0.256363 days each year. This error is spread equally through 365 days or 0.256363/365 day = 1.01min.

⁷*The Astronomical Almanac for the Year 1999* (Nautical Almanac Office 1999:C1) gives Tropical Year = 365.242190 days; same procedure as in note 6 with $y_0 = \text{Tropical Year}$. [A tropical year is the time interval between two successive passages of the sun through the vernal (spring) equinox—EDITOR]

⁸*The Astronomical Almanac for the Year 1999* (Nautical Almanac Office 1999:D1) gives synodic month = 29.530589 days. Therefore, 309 synodic months = 9,124.952001 days, which is $\frac{1}{21}$ days short of 9,125 days every 25 civil year cycle. [A synodic month is the average time between successive new or full moons—EDITOR]

⁹Only one day out of the month will make the two systems coincide with a probability of 1 day/29.53 days.

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