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A HISTORICAL REVIEW OF THE EGYPTIAN CALENDARS: THE DEVELOPMENT OF TIME MEASUREMENT IN ANCIENT EGYPT FROM NABTA PLAYA TO THE PTOLEMIES

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ABSTRACT

Chronology is the foundation of every archaeological research. Every single object, a text, or even the greatest monuments must be understood within their period of time. In certain occasions ancient authors have given a clear statement of the date of a piece but, even in these cases, we find ourselves with the task of translating ancient dates to our modern calendar system. To do that the first option that learned individuals should know is the history of the calendar itself.

The aim of this study is to review the chronological development of time reckoning and calculation systems or calendars in Ancient Egypt from the rather unknown predynastic time to the late antiquity. Scholars have been researching this same topic for many years and in fact there is a rich amount of Egyptian records from ostraka, papyri, as well as monumental inscriptions from all periods of Egyptian history that mention the application and use of calendars in Egypt. However, the opinion of the specialists is still very far from consensus and so there are different theories about how the Egyptian calendar worked and how exactly it was calculated. The three mayor theories are those regarding a Nile based calendar, a moon based calendar and a calendar based in the heliacal rising of Sirius, the so called "Egyptian civil calendar"

All these theories have been proposed and documented by research and in fact all can be proven by archaeological and historical evidence. A long lasting discussion regarding when each one of these calendars was in fact in use in Ancient Egypt can be enlightened by a new point of view that contemplates the development of all three systems throughout all Egyptian history succeeding one another as a "chain reaction" and making every system a step in a long evolution along the centuries.

KEYWORDS: Egyptian calendar, Sirius, heliacal rising, Nile, gnomon, archaeoastronomy.

1. THE CIRCLE OF NABTA PLAYA

The first recorded trial of a man made system to follow the rhythm of the Earth as well as the first "sort of calendar" in Egypt can be traced in the Western Desert (fig.1) Here a prehistoric circle of stones (fig.2) was created by groups of shepherds and gatherers. This stone construction, known as the circle of Nabta Playa, is formed by a total of 55 boulders aligned in circular series along with a second "interior" line (fig. 3) and it seems to be the first human attempt of construction following the alignment with the solstices and the rising of certain stars.

Figure 1. Map of Egypt with the situation of Nabta Playa

Figure 2. The circle of Nabta Playa

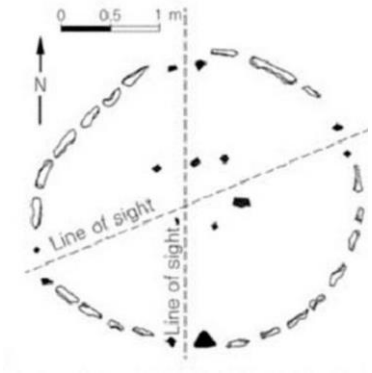


Figure 3. Model of the circle's orientation

The archaeoastronomer Kim Malville was part of the first team that first excavated the site. According to him some of the standing boulders of the circle were placed in the sand in purpose to be indicators of a calendar. He showed how this stones could reveal the phenomenon of the "zenith pass" on the Summer Solstice. By the fact that during that particular moment at the particular spot those stones wouldn't cast any shadow. This phenomenon will have later mayor importance in the creation and calculation of the Egyptian calendar, as we will see.

This "calendrical circle" as it's usually called, although its use as a calendar has never been really proven, has been dated applying the C14 method to different findings around the monument. The results show dating from 7.300 to 5.500 before present. Astronomically speaking and applying calculations done taking the chronology we just mentioned, the stones have shown a possible orientation to Dubhe (*a Ursae Majoris*) the Ancient Egyptian Meskhetyu and to Sirius (*a Canis Majoris*) the Ancient Egyptian Sopdet that was related to the goddess Isis and whose first appearance on heliacal rising was also a sort of announcement of the Nile flooding. Even after those observational facts we can not consider the stones of Nabta Playa as an exact system to calculate the passing of time but we must realize that the inhabitants of Nabta didn't need an exact calendar. Their nomadic way of life was based in recollection and the care of their flocks and all they actually needed was just a benchmark showing them the beginning of the rain season that would bring them the necessary for their sustenance. (Wilkinson 2002 & Lull 2006)

However, the evidence seems to show that, even at this remote spot of prehistory, the most important details of Egyptian cosmology had already captured the attention of the inhabitants. Astronomical details, like the observation of the heliacal rising of certain stars, that many centuries later would be the foundations of Egyptian calendrical systems.

2. THE NILOTIC CALENDAR

The first clearly attested calendar in Egypt was based in a natural phenomenon much closer to the ground. The Nilotic calendar is based on the rhythm of the Nile. A year, using this system, would be the period of time between two consecutive flooding periods of the river. This theory was first proposed by astronomy historian Otto Neugebauer. In 1942 he wrote: "*Every theory of the origin of the Egyptian Calendar which assumes an astronomical foundation is doomed to failure*" (quoted on Belmonte, 2012 (p. 39) As he was absolutely certain of this point of view so he created this Nile Calendar theory that really has nothing to do with astronomical phenomena.

We had left the inhabitants of Egypt in the time when they were mostly gatherers living a nomadic

or semi-nomadic way of life while caring of their flocks. This changed when these groups started to settle in stable places of dwelling and mutated their wandering way of life by adopting an organized agricultural activity. The cultivation of the land in Egypt has always been attached to a unique factor: the river Nile. The cyclical rhythm of the Nile dictated the rhythm of people's lives as well as the flooding of the river was absolutely necessary for their survival.

The Nile is the largest river in Africa. Its fonts are south from the Equatorial Line and it flows from south to north through the North-Eastern African continent and it finally leads in the Mediterranean shores. Every year the monsoon torrential rains in the Ethiopian highlands provoke the rise of the level of the river. By spring time the flooding arrives to Khartoum in today Sudan and from there they keep on going north until they reach the first cataract and traditional boundary with Egypt at the island of Elephantine (today Assuan) by the Summer Solstice.

The arrival of the waters in Egypt provoked what was called the "year flooding" After a while the water returned to its natural level leaving the shores of the Nile covered with rich mud that worked as a natural fertilizer. By that time people started to work the fields that had become fertile and after another period came the time for the gathering just before the arrival of a new flooding. That was the rhythm of the "Nile cycle". It is absolutely logical to think that Egyptians would have paid much more attention to the Nile than to the stars, Moon and Sun to organize their lives, since the yearly flooding was the foundation of Egyptian economy. We can assume that it was from that time that the starting moment of the flooding was the most important moment of the year as well as its beginning too. So we can recall on Neugebauer theory of an entirely non related to astronomy calendric system in the beginning of Egyptian history. (Neugebauer, 1942 & Belmonte 2012)

Proofs of this theory can be found in other elements related to the Egyptian calendars. The first of them would be the names of the seasons that remained the same throughout the entire Egyptian history. The seasons were three as were the changes in the state of the Nile and their names seem to show a direct relation with the cycle of the river. Akhet (Axt) Peret (prt) Shemou (Smw) (fig.s 4, 5 & 6) The first season is usually translated as "flooding", the second as "rising" and the third as "harvest" Names that are clearly related to the agricultural rhythm of the Egyptian life.

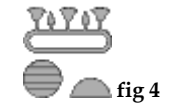


fig 4

Axt Akhet


fig 5

prt Peret


fig 6

Smw Shemu

A recent collaboration between professors Belmonte and Krauss (Belmonte 2009 & 2012) on the text of the Palermo stone has also contributed to add new proves on this Nilotic calendar theory. The Palermo stone is a black basalt stone dating from the 5th dynasty (2392 – 2283BC) whose larger fragment can be seen today in the museum of the Italian city of Palermo, hence its name. The stone contains a list of the of the Egyptian kings from the predynastic period to the Old Kingdom (Dyn 1st to 4th (3000-2125 BC) In the list the names of the kings are engraved together with the duration of their reigns and the level the water reached during each year's flooding. On the first series of kings, those of the 1st Dynasty, there is a mention of one year "shared" between two kings. Seemingly one succeeded the other during that year. (fig. 7)

Figure 7. The detail on the Palermo stone where the shared duration of a year between the reigns of two different kings can be seen for a year of 310 days.

The first king is noted with a period of 6 months and 7 days of the year while the second that succeeded him has duration of 4 months and 3 days. We know both kings share the same year because during the described period the symbol of just one flooding is recorded in total we have a year of 10 months and 10 days. That is too short of a moon year of twelve moons and even shorter for a solar year of 365 days. The period shown of 310 days fits very well in the

duration of a "Nile year" between two consecutive flooding periods of the river.

So, according to the scholars, we can assume that the most obvious calendar system for a first rural community whose existence depended on the river was based on the rhythm of the Nile and its yearly flooding.

3. THE MOON CALENDAR

The Moon phases have always been a clear reference for the calculation of periods lasting 29 or 30 days. The easiest way to divide the Nilotic year would have been clearly by counting the moons. A possible average of moons or months between two flooding periods could have been 12 or 13 moons.

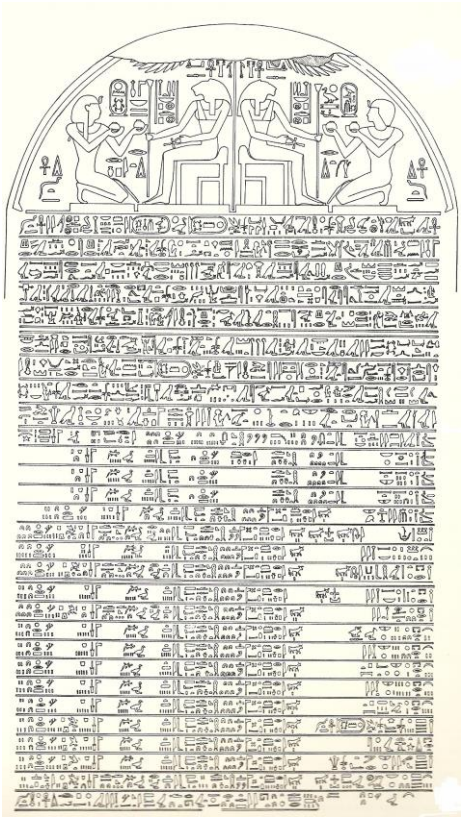
We also know that the moon was related to the calculation of the months thanks to the hieroglyph writing system. The Egyptian word for "month" has a lunar crescent as a determinative. In texts were the word must be written in short the crescent is the only symbol used to represent the entire word: 𓇼 (fig. 8). One example of this is in the lists of the Palermo Stone we just analyzed. This lunar symbol for the months applied by the Egyptian writing system as well as some other evidences lead us to the next step in the history of Egyptian calendars

Abd (Abed) = month (Faulkner 1962)

Figure 8

Festivals had a great importance throughout all the history of Ancient Egypt and to calculate the correct time for each celebration an organized calendar was required. Within a Nilotic calendar the first reason to celebrate as well as the beginning of the year itself was the start of the flooding. Other festivals were related to different theological reasons and during the New Kingdom the most important festival would give the name to the month itself.

Evidences regarding those festivals show that on its beginnings the Egyptian calendar seem to have been organized according to the moon. Many texts describing festivals use to have a double notation for the dates one according to the moon and a one according to the sun. Most of these texts are lists with offerings for the temples engraved in stone like stelae. One example with a very clear description of the offerings according to moon and civil dates is the "Stele of Bouto" (fig. 9 & 10) containing the lists of offerings ordered by Tutmose III (1479-1425 bC) for the festivals of the local goddess Wadjet. (Lull 2006 & Bomhard 1999)



Figs. 9 & 10 The Stele of Bouto and a copy of its inscription

In this stele, right after the first lines where Tutmose presents himself in front of the goddess, the king explains his desire of offer to wADyt nb(t) dp "Wadjed, mistress of Bouto" a big amount of offerings yearly. From the tenth line the first offerings are described with the exact dates:

Line 11: offerings for the psDntiw (New Moon) 150 breads, 10 jugs of bier, 1 jug of wine, 10 vegetables, 5 sweets, 5 birds, incense 10.
Line 12: offerings for the 6th day: 150 breads, 10 jugs of bier, 10 vegetables, 5 sweets, 5 birds, incense 10.
Line 13: offerings for the 15th day (Full Moon) 150 breads, 10 jugs of beer, 10 vegetables, 5 sweets, 5 birds, incense 10. (Lull 2006 & Bomhard 1999)

These offerings are organized following the Moon cycle. The first day mentioned is the first day of the New Moon phase (psDntiw), the second date on the 6th day corresponds to the first day of the First Crescent and the third date, on the 15th day corresponds to the Full Moon. After the 14th line of the text the dates of the offerings are given following the system of the civil calendar, which is the next step in the evolution of the Egyptian calendar systems.

Why does Tutmose use two different systems within the same text to define the dates of the offerings? One theory could be that the moon dates were more ancient in use and due to reasons related to the usual respect all peoples have towards traditions they kept on being calculated by the moon although the calendar in use by the time Tutmose was already based on the sun. We can put an example from our modern time. Today the calendar system globally applied is the Gregorian calendar which is a solar based calendar. Yet the countries where Christianity is the main religious stream choose the dates for all important religious festivals regarding the celebration of the Easter according to the Moon. However this does not mean that countries with a majority of Christian population use a moon based calendar.

To this point we have seen the creation of a Nilotic calendar organized by means of counting months by the moon. This calendar served well the early rural Egyptian culture and based on it some important festivals were organized throughout the year, and they kept on being calculated by the moon even later, when the Egyptian calendar changed to the civil calendar. The aim of this study is to find when all these changes did happen. Recalling the sources one important piece of information clearly states:

"When exactly the second, moon based year, was introduced, remains unclear. However the most plausible is that it happened after the moment in which the deviation between both forms of the year (civil and moon based) was clear. One good possibility would be putting that moment around 2.500bC. From that moment onwards the Egyptians would have three calendrical years, which would remain in use until the end of the pagan time of Egypt" (Parker 1950)

Professor Parker's work on Egyptian calendars has been for decades the major work on the topic. It's only rather after that new works have begun to propose points of view that differ from his proposed system of three simultaneous calendars. In fact, a system of three calendars is rather improbable as it would be extremely complicated to handle and it would lead to confusions and mistakes. However, it is possible to find more than one calendar system in use during periods of change. So we have to look for possible changes regarding the calendrical system by the times when major historical changes did happen in Egypt.

The first step consisting on a Nilotic calendar organized by the moon was certainly good enough for a local rural community but surely was not so practical when the Egyptian sphere became larger. After a long lasting process Upper Egypt managed to impose its rule over the Lower Egypt region. Yet both regions kept on having their own identity and since then we see how the pharaonic iconography and literature describe the rulers as kings "of the Double Land" By the time of Egyptian unification Upper and Lower Egypt became one land with two regions, under one ruler aiming to control the Nile valley from Abydos in the south to the Nile Delta on the Mediterranean. Certainly, applying the Nilotic calendar system in such a large region would have provoked some problems. The first and most important of them all would have been when to establish the beginning of the year itself, since the flooding of the Nile does not arrive to the entire country at the same time, and between its start in Abydos until the arrival of the waters to the Delta there can be a difference of an entire month. (Belmonte 2012)

Amongst the many other changes that came after the unification of Egypt one of the most necessary must have been the application of a new calendar system. As a new land, covering must larger latitudes, the local reference points were no longer practical, yet the observation of the heaven already had given the Egyptians another system to calculate the passing of time based on the Sun.

4. THE CIVIL CALENDAR

At the stones of Nabta Playa we had already seen how the position of the stones could serve as a proper reference for the observation of the Summer Solstice. This helped at the calculation of the beginning of the rain season that was so necessary for the inhabitants of the western desert at that time.

The calculation of the date of the Solstice could have resulted from the observation of a phenomenon that repeats itself every year in the zones of the Earth between the Tropics of Cancer and Capricorn, so

perfectly visible in southern Egypt. The best description of the phenomenon comes form a much later source regarding the experiments of Eratosthenes, the Greek scholar from the 3rd century BC, who first managed to measure the perimeter of the Earth. He did it by observing the following phenomenon: The fact was that during the Summer Solstice at noon the sun rays managed to light the deepest point of a profound well located in a town of the island Elephantine (Assuan) This happens because at that moment the sun is perfectly aligned with that particular point of the Earth. This phenomenon is known to astronomy as the "zenith pass"

"Zenith pass" can be observed as well by using a gnomon, a kind of scepter usually with a specific shape to cast a specific shadow (Isler 1991). Gnomons were used for measuring in Egypt from the most ancient times. In the case of Eratosthenes he also used one for his observations. Zenith Pass happens only on that exact day of the Summer Solstice and by the year 3000BC the most perfect alignment between Earth and Sun could be observed exactly at the point of Assuan and the island of Elephantine. The island has one of the most ancient temples in Egypt already in use by the 3200bC. Within the temple there is a rudimentary nilometer that in fact is a well of about 10m. depth (fig. 11).

Figure 11. The well and possible nilometer within the site of Elephantine

Either by following the pass of the sunrays over and "within" the well, either by applying a gnomon, Egyptians were certainly able to observe the phenomenon of zenith pass already from the remote predynastic times. After that, the observation of the same phenomenon year after year would have lead to calculate that the period between two consecutive "shadowless gnomon" days was 365 days, a solar year that could be calculated that way. (Belmonte 2009 & 2012, Lull 2006, Bomhardt 1999, Depuydt 1997, Parker 1950, Clagett 2004)

Another clue linking the use of a gnomon and its shadow for the calculation of the solar year comes again from the Egyptian hieroglyph system. The word "year" has as determinative a sort of scepter with some kind of handle and one curved edge. With the same symbol having just a small difference two different words can be written: The first one `nr(i)` (fig.12) means "year" having also the meaning, in several texts, of something that repeats itself. The second word `rnp.t` (fig.13) means clearly "year" (Faulkner 1962)

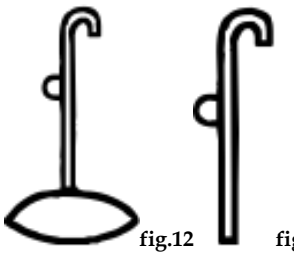


fig.12 **fig.13**

Figs. 12 & 13 Hieroglyphs for the words nr(i) & rnp.t Faulkner 1962

These two similar symbols can be related to the calculation of the zenith pass by the time of Summer Solstice. Egyptians used similar instruments of measurement to calculate time, as solar clocks, that appear countless times in Egyptian images and texts (Isler 1991, Bomhardt 1999, Neugebauer 1942, Parker 1950 & Clagett 2004). Usually gnomons are simply sceptres having just some kind of shape in one edge in order to cast a specific shadow. Yet the sceptre used to observe the zenith pass was expected to do exactly the contrary, that means that by using it NO shadow must be seen. As we can see in the plan proposed by Isler (fig. 14) a simple scepter or gnomon applied in this specific case could have given a problematic result because it would have been difficult to see clearly if the gnomon had a shadow itself or if it was cast by the hand or mean holding it. The solution was the use of a gnomon with a curved edge. By the moment of zenith pass this edge would have a shadow measuring exactly the same than its curved upper part (fig. 14) One strong possibility could be assuming that the determinative of the word "year" was the representation of the gnomon used to calculate the moment of the zenith pass by Summer Solstice.

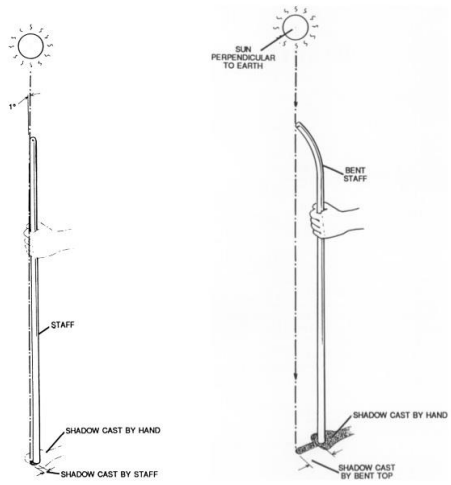


Figure 14. Use of a gnomon for the calculation of the zenith pass

The next step was to divide those days in a total of 12 months of 30 days each, divided in "weeks" of 10 days each. The Egyptian numerical system was based in the number 10 so this partition was seemingly the most useful. This division of time (12 months of 30 days) had a total of 360 days, so at the end of the year another 5 days dedicated to the 5 major gods of Egypt were added. This extra days were first called "small month" and later on, by the time of the Ptolemies, "*epagomenal*" in Greek (Lull 2006, Belmonte 2009 & 2012)

So, we have seen how a Nilotic calendar system calculated along with the moon phases changed to a new calendar system. This research aims to find when all these changes happened. We have already mentioned the unification of both Upper and Lower Egypt into one kingdom as a very possible reason for the search of a new calendar system since the flooding of the Nile wasn't a reliable reference to establish the dates for the whole new country. History sets the unification of Egypt during the reign of Narmer, who was responsible for the conquering of the north and the construction of a new capital in Memphis, on a spot chosen exactly at the boundary between the two kingdoms he had just united. (fig. 15)

The kingdom of Narmer and the foundation of Memphis are dated back to 3100BC. As already said the new geographical situation in united Egypt could have been the reason for the application of a civil calendar system but, yet a new problem arises when noticing that the zenith pass phenomenon in which the solar calendar seems to be based is NOT visible in the region of Memphis, neither in any of the former capitals or political centres of Upper Egypt, but exclusively at the region close to the Tropic of Cancer and more exactly at the island of Elephantine.

Figure 15. The city of Memphis at the boundary between Lower and Upper Egypt

All these details lead to the conclusion that the civil year of 365 days could have been applied by the time of Egyptian unification but it certainly must have been known from periods much earlier than that time. Several examples of this can be found. For instance: 1986 Hierakompolis. A series of carvings [1] dating from the 2nd half of the 4th millennium BC were discovered, the inscriptions showed the situation of the sun along the year, showing that already during the predynastic period the sun was observed and its different positioning seemed to be important at it was carefully recorded (Clagett 2005)

The knowledge of a solar based calendar was possibly moved as well from the south to the new capital of Egypt but as the phenomenon on which it is based is not visible far from Elephantine it seems difficult that the "new" calendar system could be applied immediately. Let us put it on a practical realistic situation. We must imagine the scholars of the time, most probably astronomers related to priesthood, who were aware of the measurements related to the observation of the sun at Elephantine, trying to propose the use of the new system to a population formed mainly by people without knowledge further than the necessary in their rural way of life. The most inhabitants of Egypt were the Nile workers whose lives were more linked to the river and the cycles of the moon. It seems difficult that they would have abandoned such evident ways of counting time in favor of an astronomical system calculated with instruments like the gnomon and, above all, based in a phenomenon that wasn't even visible in their geographic latitude.

Professor Parker was right when he proposed a system of three calendars although the chronological limit he proposes "*until the end of pagan Egypt*" (Parker 1950) is clearly exaggerated. However, three calendars could have been simultaneously in use. A Nilotic calculated along with the phases of the moon could have been kept in use by the major part of the population. While, at the same time, scholars and rulers began to apply the civil calendar that allowed calculating dates based in references as the Summer Solstice that were applicable to the whole country.

This period of the history of Egyptian calendars can be proposed by the time of Egyptian unification and during the Old Kingdom (3000BC – 2200BC) Evidence that the civil calendar was already in use during the Old Kingdom can be found again at the Palermo Stone. On the back side on the stone we have again a year "shared" between two pharaohs during the 4th dynasty. The first one, Menkaure reigns during 3 months and 24 days, while the second one, Sepseskaf, during 8 months and 11 days. The total of days for that year is 365. A solar year noted for the first time in an Egyptian text, which happens to be the same that showed the application of a Nilotic year as well (fig. 16)

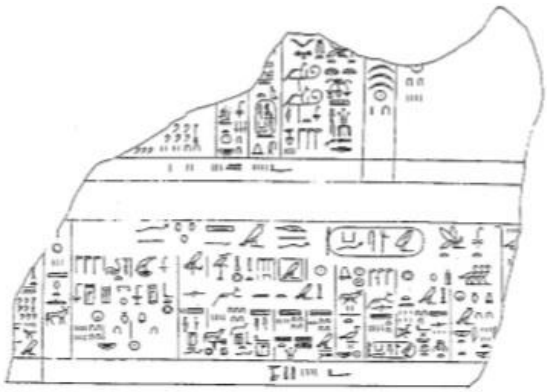


Figure 16. Back side of the Palermo Stone

The calendar system we propose for Old Kingdom Egypt was a multiple one but it doesn't seem to have remained like that further on. In fact there are no references of the use of a Nilotic calendar during the periods of Egyptian History that followed. Then, when did this multiple calendar system stop to be in use? And therefore, when did the Nile stopped to be a time reference for the Egyptians?

5. THE CIVIL CALENDAR AND THE GREAT YEAR OF SIRIUS

The reason can be related to climatology and evidences can be found in both ancient texts as well as in modern astronomical and geological research (Hassan 2007 & Parcak 2009)

The Old Kingdom finished in an abrupt way after the reign of pharaoh Pepi II (2246 – 2152BC) The period that followed is known as "First Intermediate Period" and it was a hard economical time characterized by the dissolution of the state and a general chaotic image. This situation has been analyzed many times and most experts usually agree that the 90 years reign of the last pharaoh of the Old Kingdom Pepi II was the cause of the problem. But, the fact is that, a long reign actually shows stability and even in the case that after Pepi's death the rivalries between his heirs would have started some kind of fight for the throne it would hardly have arrived to the edge of shredding the whole country. Before the reign of Pepi, during the Old Kingdom, there had been other cases of rivalries between heirs, as well as kings not so appreciated by the people but kingship itself and the central power of the monarch had never been challenged.

All this evidence leads us to think of some sort of natural disaster that found Egypt unprepared although by that time it was already a very well organized state. The sources from the time describe a chaotic situation of harsh economic and social crisis and many of the sources seem to agree, or at least mention, that the basic problem was the lack of water. Some of the better known sources describing the situation are "*The admonitions of Ipuwer*" [2] "*The lamentations of Khakehperre-Soneb*" [3] and "*The prophecy of Neferty*" [4]

Modern research has focused this phenomenon trying to prove the existence of a long lasting draught period. Remote satellite sensing has discovered migrations to the bigger branches of the Nile by this time. Showing that the lack of water on the smaller ones forced the people to leave the smaller towns in search of cultivable lands (Parcak 2009) Geology agrees as well. The analysis of the Egyptian subsoil coming from this period shows formations of wind blown sand. This fact was possible only after a very long period of draught, able to turn fertile lands into desert. (Hassan 2007) Finally also the climatologically research added evidences that showed how important changes in the atmosphere around the year 2150BC leaded to a lasting cold period able to interrupt the rainfalls in a large area. Amongst the affected zones were Ethiopia and the eastern shores of Africa and that lead to an interruption of the Nile's year flooding as well. (Hassan 2007)

Although the Nile never lost its divine role in Egyptian theology, when the river did no longer follow its former rhythm after years without the usual flooding, it certainly lost its role as calendar reference. Not being able to calculate the time by the rhythm of the river Egyptians finally relied only on

the other astronomical references they already knew but seemingly still hadn't been exclusively applied.

From the Middle Kingdom to the very latest periods references and sources mention the Egyptian calendar as having a solar duration (365days) but calculated by the stars. The best known reference comes from the Greek Herodotus, who mentions that *"Egyptians first discovered the length of the year […] and it's said they did so by observing the stars"* [5] Apart from Herodotus other sources like countless Egyptian texts and inscriptions mention the Great Year of Sopdet (Sirius) there are also many references from Greek Alexandrian astronomers [6] as well as Roman sources [7] that clearly relate the beginning of the Egyptian year to the Heliacal Rising of Sirius (α' Canis Major)

As already mentioned the "zenith pass" phenomenon wasn't visible but in a small part of Upper Egypt. This could have been the major problem when trying to apply the solar based calendar for the whole country. After the draught years when Egyptians realized that they couldn't rely on the Nile for the calculation of the calendar they had to find another phenomenon close to the Summer Solstice but perfectly visible in whole Egypt and this was the Heliacal rising of Sirius, the Egyptian Sopdet related to the goddess Isis.

The "heliacal rising" of a star happens the day the star can be first seen over the horizon a few moments before the sunrise after a period in which the star was not visible at all. In this first "rising" of the star it shines with an unusual intensity for a few minutes before the sunlight makes it fade. Sirius is one of the brightest stars and it appears immediately after Orion which happens to be one of the most easy to find constellations. The heliacal rising of Sirius was especially bright and visible all over the Egyptian geography and it comes to happen at the time of Summer Solstice.

It became the clearest reference for the announcing of the New Year as it was easily recognizable and perfectly visible for all the Egyptians. From that moment the well know system of three seasons with four months of 30 days each for a total of 365 days could have been easily applied as well. The phenomenon of the heliacal rising of Sirius was known and referred in sources older than the Middle Kingdom. As we mentioned at the beginning it could be observed even from the stones of Nabta, but its use as reference for the calculation of a calendar can be proposed by the beginning of Middle Kingdom (2050bC) and so it remained as the only system used in Egypt (except for some celebrations calculated by the moon probably as a form of respect towards more ancient systems of calculating the dates by the moon) until the very end of the Ptolemaic era.

Sources of that time refer how the new "foreign" rulers of the country were made to give an oath by the time of their enthronement that they would never attempt to change the calendar, neither would they add a month, or a day but they would keep on counting years of 365 days "*as the ancients had disposed*" [8]

6. THE ALEXANDRIAN CALENDAR

One detail regarding the oath that Germanicus mentions is that it probably should be given only by the time of the Ptolemies. This can be assumed by the place where the oath took place: the Temple of Isis. Egyptian Dynasties before the Ptolemies had their coronation ceremonies linked with the Temple of Amon without paying any special attention to Isis. So the oath scene described by Germanicus most probably took place at the Temple of Isis in Alexandria [9]. Apart of that it is also more logical that the Egyptian priesthood would ask from the Greek pharaoh an oath of respect towards the Egyptian traditions *"as the ancients had established"* rather than asking it from the local Egyptian kings that, in fact, wouldn't have had any reason to change anything. The election of the Temple of Isis as the place to host the oath regarding the calendar is also significant and it leads again to a reference to Sirius, the star that the Egyptians linked to this goddess.

This calendar oath mentioned by the Roman philosopher may have a historical starting point in the only known attempt of change ever recorded in the history of Egyptian calendar. In 238BC Ptolemy III Evergetes established by decree the addition of an extra day every fourth year so that the dates of the festivals could come on the right seasons of the year. This is the so called "Canopic decree" (fig. 17) and in fact it is the official invention of the leap-year. The long lasting Egyptian civil calendar actually had this defect. It lasted 365 days and that means that without adding the extra day required every four years within a relative period of time the dates wouldn't agree with the seasons.

By the time of Ptolemy III the problem was certainly visible as in the mentioned decree it is stated:

"Festivals that should be celebrated in the season of Peret are actually celebrated in the season of Shemu due to the change of the date of appearing of the divine Sothis by one day every four years"

In order to solve the problem Ptolemy decrees:

"This happens when there is a year composed by 360 days and another 5 days added at its end. It must be now established that a new feast day will be added every four years

before the festival of the New Year and announce to everyone that this small defect in the establishment of the seasons and the year has to do with the laws of knowledge of the ways of the heavens"

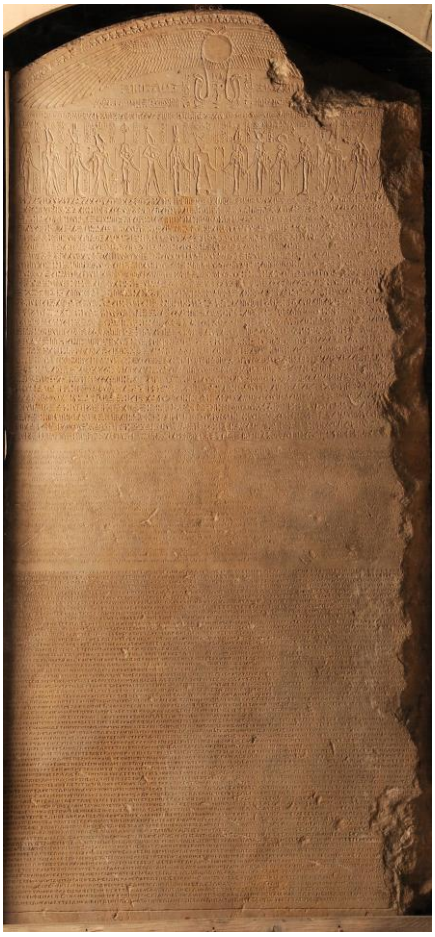


Figure 17. The Canopic decree

Although it is an important correction of a serious problem of the calendar regarding the accuracy of the dates in relation to the seasons the fact is that Ptolemy's decree was never applied and after that no other king of his dynasty ever tried to propose any change in the calendar. Back to Germanicus' text we could easily put all the information together and consider if this attempt was the reason why Ptolemies were asked to swear an oath before Isis of never try to add any more days to the calendar.

There can be several reasons for the failure of Ptolemy's idea. The fact is that we don't have any source explaining why this decree was never put to practice. We just know that Egyptian civil calendar of 365 days of length kept on being in use for centuries after the reign of Ptolemy III.

One possible reason could be the huge weight of the millennia that Egyptian tradition had gained. It would have been actually unthinkable for a foreign king to manage to change a system that had been in use for thousands of years before the arrival of his dynasty to the country. The key to success for every foreign leader in Egypt was always the adoption of Egyptian tradition. Alexander did understand this fact and showed a great respect towards the Egyptian sanctuaries and temples. Ptolemy I managed to acquire the power in Egypt and founded his own dynasty by doing the same while steadily he started to apply the Ptolemaic policy that identified the elements of Egyptian tradition with the Greek ones. His grandson seemingly made a mistake trying to change one of the oldest institutions, the civil calendar. This decree didn't seem to have any political cost for Ptolemy III but as it seems it was never put into practice.

Another theory (Stern 2012) proposes that maybe the decree that added an extra day every four years was meant to be applied but it just wasn't the right moment to do it. As Ptolemy himself mentions, by the year of his decree the festival of the heliacal rising of the divine "Sothis" (Sirius) was celebrated on the 1st day of the 2nd month of the season of Shemu. That's why the rest of festivals although they are supposed to be celebrated in summer come to be celebrated in winter. If Ptolemy's decree would have been applied on that year the rising of Sothis would have kept on coming on the 1st day of 2nd Shemu forever and so it would have happened that the rest of dates and festivals would have continued to be celebrated in the wrong seasons forever as well.

Calculating the date of the heliacal rising of Sirius within the duration of the cycle of the civil calendar we find that 1st day of 2nd Shemu comes 271 days after the first day of the year on the 1st day of 1st month of Akhet. We know that without leap-years the rising of Sothis moves by one day every four years so when it has changed its right date by 271 days we know that 1084 years have passed from the beginning of the Great Year of Sothis (271×4=1084)

The Great Year of Sothis is a cycle of 1460 years very well known and mentioned by many Egyptian and Greek-Roman sources. When leap-years are not applied it happens that the same phenomena come with a day of delay every four years. The natural correction of this problem comes when a total of 365 leap-years have been missed and then the phenomena happen again in their right dates. A total of 1460 years (365×4=1460) are needed for this adjustment that the Greek authors call *"apokatastasis"*

This is mentioned by one of the last Alexandrian philosophers Theon who lived on the 4th century AD. One of his texts contains the clearest description of the differences between the Egyptian and Alexandrian calendars:

"As the calendar that the Greeks or Alexandrians have given to us has 365¼ days while that of the Egyptians has only 365 it is clear that after four years the Egyptian year

overtakes the Alexandrian by one day. After 1460 years of 365 days have passed, that's an Egyptian year, Egyptians and Alexandrians celebrate the beginning of the year together […] This apokatastasis happens every 1460 years"

By knowing the date in which the heliacal rising of Sothis took place within a 365 days' year and multiplying by 4 we can calculate how many years have passed from the beginning of this cycle as well as how many years are missing until the next *apokatastasis* or beginning of the new cycle. It is tempting to think maybe Egyptian scholars could have used this system to calculate a chronology and maybe this is the reason they were so reluctant to change their calendrical system although they were perfectly aware that without an extra day every four years there was a problem of keeping the dates in harmony with the seasons. Maybe that problem was sought on purpose to calculate the path of time itself.

Egyptian chronology is actually based in the years of reign of every pharaoh which means that when a new monarch came to the throne they started to count the year first of his reign and kept on counting until a new king came and so a new year one started. This can be useful at a practical level since most Egyptians wouldn't see more than one or two kings during a lifetime but a scholar interested in having an accurate record about when did a fact happened or how long have it been from a certain moment in the past would have wanted another system to count. Let's put it with an example. An Egyptian scholar would want to know how many years before his time a certain fact had taken place. Think of the beginning of a monumental work, when a certain battle happened or when a treaty was signed. He would have to know how many kings had reigned from that moment, how long their reigns were and patiently add the years. If the same scholar had the date of the heliacal rising of Sirius for the year he was interested in and the date of the heliacal rising of the star in his own year he just needed to calculate the days between both dates and multiply by 4. In a practical example let's consider someone would want to know how many years before Ptolemy's Canopic Decree a certain fact had happened. The Sothis date that Ptolemy gives is 1st of 2nd Shemu in case we would want to know how many years before had happened something that took place the year when the heliacal rising of Sothis happened on 1st of 1st Shemu we would have to find that there are 30 days of difference between both dates so 30×4=120 years before.

Of course this is just a theory since any of the known sources can proof such a way of calculating a chronology but the fact is we do have many texts and inscriptions that mention the date of the year in which the heliacal rising of the divine Sothis took place. Some of them are: The Letter of Illahun, the Ebers calendar, the calendar from Elephantine, The T text in the Book of Nut within the cenotaph of Seti I, an inscription in the temple of Medinet Habu related to Ramses II, the inscription of Ptolemy IV Filopator in Assuan and the already mentioned Canopic Decree of Ptolemy III Evergetes. There is no source to prove that the lack of what we know as leap-years was made on purpose and therefore the application of the date of the heliacal rising of Sirius was a mean to calculate a chronology but it is still not known why Egyptians did record the date of the rising of the star for each year and at the same time they were so reluctant to change the year of 365 days by adding one extra day every fourth year.

Going back to the text of Theon who lived in Alexandria about 600 years after the Canopic Decree we realize that he describes two calendars: the Alexandrian or Greek and the Egyptian. By the durations he mentions for both we can understand that the calendar of 365 days is the ancient Egyptian civil calendar that was still in use in the 4th century AD but the other calendar he calls "Alexandrian" with years of 365¼ days seems to be the calendar that Ptolemy III proposed with the addition of a leap-year every fourth. Ptolemy's idea had no success in his time but it was applied centuries later by another leader who was seeking for the most exact way of measuring time.

In 47BC Julius Caesar arrived to Alexandria pursuing Pompey during the last events of the Roman Civil War. He was charmed by the intellectual life of the city and willing to find a solution to the problems that showed the old Roman Republican calendar he addressed the scholars of the Alexandrian Library. Pliny the Elder in his *Natural History* specifically mentions the collaboration of the astronomer Sosigenes:

"Who was very capable with this kind of knowledge and brought the separate years back into conformity with the course of the sun" [10]

We can not know if Sosigenes was aware of the contents of the Canopic Decree redacted two centuries earlier but in fact the solution he offered to Caesar was exactly the calendar described by Ptolemy III Evergetes. A sun based civil calendar of 365¼ days, which actually meant that after three years of 365 days a leap-year of 366 would follow. The new system was applied in 46BC that year actually lasted 445 days so that the new calendar would start in proper harmony with the seasons [11]. 45BC is actually the real first year of the new Julian calendar, so named after the roman leader who promoted the

change and it was in fact the system used to organize time in all occident until 1582 when the Gregorian reform took place.

However and due to the origins of Sosigenes for the inhabitants of his home town this new calendar was known as "alexandrian" and so it's called by Theon in the description already mentioned. In the same text we have also seen that Theon mentions the ancient Egyptian civil calendar most probably it continued to be in use until the rise of the new Christian faith and its leaders contributed to fade the last elements of the ancient Egyptian and Greco-Roman philosophy.

The Egyptian Civil Calendar had been the official calendrical system from the beginning of the Middle Kingdom (2050BC) although it was already known and documented by the time of the Old Kingdom (2500BC) It was still in use during the 4th century AD.

It had been almost three millennia for a system that had coexisted at the same time with others and had been through attempts of modification but still remained unchanged during all this long period. Stability and eternity are two of the most recurrent motifs in Egyptian culture and the calendar reflects exactly this. It remains really impressive to realize that pyramid builders and the scholars of Alexandria were separated by a huge gap of thousands of years. Years that had been counted with the same system along all that time.

FOOTNOTES

[1]The inscriptions have the code no. (Hierakompolis Hk-61D)
[2]Admonitions of Ipuwer, Papyrus Leiden 344 (Lichtheim 2006)
[3](BM 5645) (Lichtheim 2006)
[4]Prophecy of Neferty (Lichtheim 2006)
[5]Herodotus, "Histories" Book 2, 4.
[6]Manuscripts of Theon from Alexandria (4th century AD) (Bomhardt 1999 & Lull 2006)
[7]Censorino, "De die Natali" 239 AD (Bomhardt 1999 & Lull 2006)
[8]Germanicus, Aratea 285 quoted in Bomhard 1999 & Lull 2006
[9]Noted by Jean Yoyotte in Bomhard 1999
[10]Pliny «Natural history» 18 210-212
[11]Censorinus "de die Natali" 20.8-11 quoted on Hannah 2005

PLATE REFERENCES

All maps (figs. 1 & 15) created by Castro Martín B.
All hieroglyph inscriptions and pictures (figs. 4, 5, 6, 8, 9, 12, 13 & 17) www.projetrosette.info
Fig. 2 Belmonte 2012 (p.19 picture by Mosalam Shaltout)
Fig. 3 Wilkinson 2002 (p. 16)
Fig. 7 Belmonte 2009 (p. 90)
Fig. 10 Bomhardt 1999 p. 42
Fig. 11 Belmonte 2009 p. 92
Fig. 14 Isler 1991 p. 172
Fig. 16 Belmonte 2009 p. 89

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