Registering An Exceptional Lunar Phenomenon in

The Demoticpapyrus Carlsberg 9

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Abstract

Over the past century, the discussion of Egyptian calendars intensely occupied the minds of Egyptologists.Portions of texts referring to temple offerings from the reigns of Sahure and Neuserre;and the calendar of feasts from the Old Kingdom appear to be the oldest extant evidence of calendars (el- Sabban, 2000), although no calendars from the Middle Kingdom period have been found, materials in Illahun archive, however, "give some idea of the range of feasts which would have featured in a Middle Kingdom calendar, if any of this kind had survived".From the Eighteenth Dynasty to the Greco-Roman period, a number of calendar depictions have survived, other than festival calendars.(Spalinger, 2002)

Apart from the complexities of the ancient Egyptian calendars, the article analyzes the double date calendric systemto shed light onan exceptional Lunar phenomenon;the "Blue Moon"(*)that was documented inthe Demoticpapyrus Carlsberg 9.

Keywords: Blue moon, Lunar phenomena, Papyrus Carlsberg9, Lunar calendar

What is a Blue Moon?

A "Blue Moon" is a fairly infrequent phenomenon involving the appearance of a second moon within a single calendar month (a civil month with two Moons),it varies by time zone, and is not the same worldwide. (Sharp, 2018;Hocken, 2020)

Most of "Blue Moons" are dull gray and white, indistinguishable from any other moon:pressing a second moon in a calendar month doesn't change the physical properties of the moon itself, so the color remains the same,if the moon appears blue, it is due to dust in the atmosphere. (Gibbs, 1997)

When does a Blue Moon occur and how often?

There are approximately 29.5 days between successive moons, which makes it unusual for two moons to fit into a 29 or 30 day-long month,(Sharp, 2018)accordingly, when two occur in the same month, the first of these two moons is always on the first or second day of the month.

On average, a "Blue Moon" appears once every 33 months or full moons, which is 41 times per century, or about seven times every 19 years. Even rarer is the occurrence of two "Blue Moons" in the same calendar year, which occurs about four times per century. (Long, 2010)

The Egyptian calendar system

To organize civil life, religious rituals, historical and scientific purposes,the ancient Egyptians usedcalendars; a calendar is any system of dividing time over extended periods, such as days, months, or years, and arranging these divisions in a specific order(**). (Wiesenberg, 2019)

In acomplexmethod the Egyptian calendar satisfactorily draws into one system the dates of religious festivals based on the phases of the Moon and seasonal activities determined by the movement of the Sun.(Wiesenberg, 2019)

Although the basic unit of calculation on the calendar is the day, it is to understand the role and importance of the "Blue Moon" phenomenon in the luni-solar Egyptian calendar, what matters here is the month as a unit of time measurement.

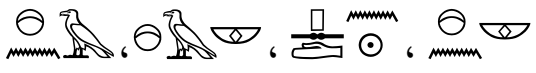
The month that was determined from the phases of the Moon and represents the basic time unit of the lunar calendar is called "the synodic" month(***), it measures 29.53059 days, 12 synodic months amounting to 354.36706 days, almost 11 days shorter than the tropical (solar) year. In order to compile any calendar in line with the phases of the moon or with the seasons, it is necessary to enter days at appropriate intervals; the "intercalations". In primitive Egyptian lunar calendar, intercalation was often achieved by taking alternately months of 29 and 30 days, but after the adoption of the civil calendar(****) an intercalary month was added, every time the first day of the lunar year came before the first day of the civil year. (Wells, 1994; Tetley, 2014;Wiesenberg, 2019)

Note that the presence of 13 moons in one year does not mean that the "Great year - aAtrnpt" is longer than the ordinary year, but rather the purpose is to bring about a compatibility between the two calendars, as the lunar month tend to be a little longer around the autumnal equinox, and a little shorter around the vernal equinox.The additional 13th month was intercalated on average nearly every 2.7 years. (Neugebauer,Volten, 1938;Depuydt, 2017)

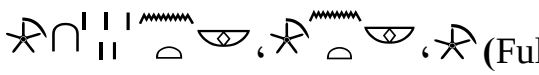
Although average solar years would have been 12 or 13lunar months long, they might sometimesinclude as many as 14 lunar cycles, note thattwelve lunar months (nearly 354 days) are about 11 days shorter than the solar year; but 13 lunar months (nearly 384 days) are about 19 days longer. (Belmonte, 2009;Depuydt, 2017)

The Lunar calendar: The lunar month is based on the "lunation" that period in which the Moon completes a cycle of its phases, which is easy to recognize; thus it had great significance and it was often the governing period of religious ceremonies, butit is not suitable for determining the seasons, which are solar, not lunar, phenomena.Accordingly,around 2600 B.C., hardly much earlier, the Egyptians invented what is now generally called the "Civil" calendar,which was Egypt's dominant calendar throughout history. (Depuydt, 2017;Wiesenberg, 2019)

For the ending of a lunar month and the beginning of another(by using the lunar calendar,the months began on the morning of the first invisibility of the old Moon, some other times on the first visibility of the new crescent) the ancient Egyptians used the following standards:first invisibility – first visibility.They used other standards that correspond with the phases of the Moon:


(New Moon)psDntyw

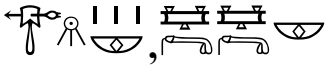

(Crescent**)** Abd


(Full Moon**)**smdt


(Full Moon or Great Moon**)**iaH-wr


(Quarter**)** dnit , Dnit

 (The fourteenth and seventeenth day)siAw

 (The eleventh day and the twenty-fifth day)sTt

The 25- year cycle: The 25-year cycle(*****)owes its entire existence tothe synchronous use of two calendars (the civil calendar andthe lunar calendar) and the need to relate them toone another.In this time cyclethe ancient Egyptians calculated that 309 lunar months were about 25 Egyptian civil years of 365 days long. They also discovered that out of these 309 lunar months, there must be 164 lunar months of 30 days, and 145 lunar months of 29 days. (Depuydt, 2017)

In the 4th century B.C.the Egyptians owned a table with which they could calculate the date of every new moonfell on each civil month in a 25-year cycle,when the first month began with a new moon on I 3ḫt 1. (Tetley, 2014)

R. Krauss points out that: "A lunar date repeats on the same calendar day: if 9125 days comprise 309 lunar months of which 164 are lunar months of 30 days and 145 are lunar months of 29 days: (164 × 30 days) + (145 × 29 days) = 4920 days + 4205 days = 9125 days". (Krauss, 2006)

If the first day of the first (lunar) month wouldhave begun before the 12th day after the heliacalrising of Sothis an intercalary month was added, a rule that wasinevitable to prevent the Sothic Rising from occurring outside the 12th month, the intercalary month usually falls on one of the epagomenal days(******). As a rule "whenever the first day of lunar Thoth would fall before the first day of civil Thoth the month is intercalary". (Parker, 1950 ;Wells, 1994)

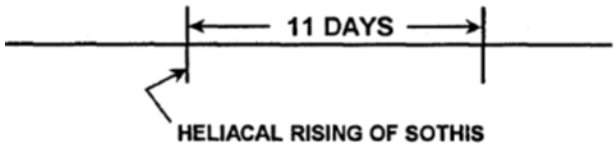
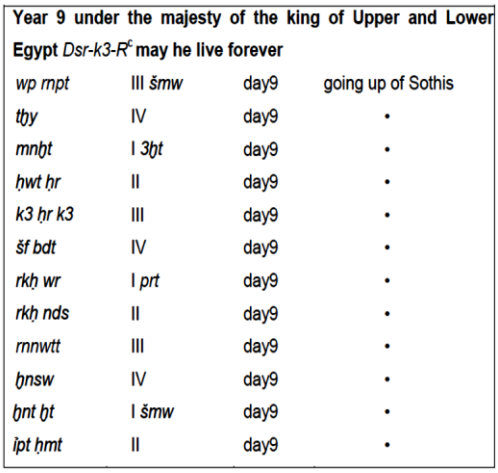


Fig.1 When the first lunar month begins in the given interval, including the ends,

it is intercalary (afterWells, 1994)



Year 9 under the majesty of the king of Upper and Lower Egypt *Dsr-k3-R*^{c} may he live forever			
wp rnpt	III *šmw*	day9	going up of Sothis
tbỉy	IV	day9	•
mnḫt	I *3ḫt*	day9	•
ḥwt ḥr	II	day9	•
k3 ḥr k3	III	day9	•
šf bdt	IV	day9	•
rkḥ wr	I *prt*	day9	•
rkḥ nds	II	day9	•
rnnwtt	III	day9	•
ḫnsw	IV	day9	•
ḫnt ḫt	I *šmw*	day9	•
ỉpt ḥmt	II	day9	•

Fig.2 The Ebers Calendar,is the latest evidence for the original Lunar calendar,

it dates to the 16th century B.C., asan example of the intercalation rule

(afterTetley, 2014)

Example: Given that I 3xt 4 = lunar day 18 of lunar month1, then day 1 of the second lunar month was on (civil) IV Smw 22. By the rules assumed by Parker for his second lunar calendar this is impossible; an intercalary month would have been inserted in the name ofwprnpt since the first lunar day lays within the first eleven days of the civil month. (Wells, 1994)

But how can a user of the Egyptian civil calendar tell when will the lunar months begin in the future?This is exactly where The Demotic papyrus Carlsberg 9 comes in.

The "Blue Moon" inThe Demotic papyrus Carlsberg 9

As the only truly mathematical astronomical Egyptian textwritten in Demotic yet published, the papyrus represents a true extension of the ancient Egyptian calendar without any influences from the calendars that the Greeks and Romans transferred to Egypt (the Alexandrian and the Julian calendars), it was found in Tebtunis - Fayyumdating to the middle of the 2ndcentury A.D..It conveys on one side a text of astronomical and calendar content.About 70% to 80% of the text is preserved divided on three columns.The papyrusprovides a certain method based upon the civil calendar to determine the beginning of certain lunar months over a 25-year cycle.(Parker, 1950 ;EAT,1968; Depuydt, 2016)

The Demotic text consists of the following:

1. (Column I) List of five regnal years of Romanemperors as rulers of Egypt.

2. (Column I) List of the zodiacal signs.

3. (Column I) List of numbers referring to the successive day

dates of lunar Day 1 in the civil calendar.

4. (Column II) List of the 25 years of the cycle.

5. (Column III) List of the included 9 "great" years and the 16 "small"

years.(Depuydt, 2016)

Names of five Roman emperors are listedin cartouches in the text because a 25year cycle begins in each of their regnal years; the earliest cycle began in the sixth year of Tiberius, (19 A.D.), then Vespasian I (69 A.D.), Domitian 14 (94 A.D.), Hadrian 3 (119 A.D.) while the latest in the seventh year of Antonius (114 A.D.). (Parker, 1950)

	3ḫt				*prt*				*šmw*			
Year	Months				Months				Months			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
1		1		30		29		28		27		26
2		20		19		18		17		16		15
3		9		8		7		6		5		4
4		28		27		26		25		24		23
5		18		17		16		15		14		13
6		7		6		5		4		3		2
7		26		25		24		23		22		21
8		15		14		13		12		11		10
9		4		3		2		1		30		29
10		24		23		22		21		20		19
11		13		12		11		10		9		8
12		2		1		30		29		28		27
13		21		20		19		18		17		16
14		10		9		8		7		6		5
15		30		29		28		27		26		25
16		19		18		17		16		15		14
17		8		7		6		5		4		3
18		27		26		25		24		23		22
19		16		15		14		13		12		11
20		6		5		4		3		2		1
21		25		24		23		22		21		20
22		14		13		12		11		10		9
23		3		2		1		30		29		28
24		22		21		20		19		18		17
25		12		11		10		9		8		7

Fig.3 The 25-year cycle as given inPapyrus Carlsberg 9

(after Parker, 1950)

As the previous table indicates, there are nine "Great Years" with 13 moons (13 lunar months) in one civil year, which are years 1, 3, 6, 9, 12, 14, 17, 20, 23, andthe remaining 16 years have 12 lunar months only:

-**In the first year:** the lunar month begins in the 2nd month of the Axt season twice during this civil month on the 1st and on the 30th.

-In the third year: the lunar month begins in the 4thmonth of the Smw season on the 4th of the civil month and on the 28th, since it is recorded that it begins in the following month on the 28th (in the 4thyear: the 1st month of the Axtseason).

Note: The five epagomenal days must be added to the end of the civil monthto complete 29 days.

-In the sixth year: the lunar month begins in the 4thmonth of the Smw season on the 2nd of the civil month and on the 26th, since it is recorded that it begins in the following month on the 26th (in the 7th year: the 1stmonth of the Axt season).

Note: The five epagomenal days must be added to the end of the civil monthto complete 29 days.

-In the ninth year: the lunar month begins in the 4th month of the prtseason twice during this civil month, on the 1stand on the 30th.

-In the twelfth year: the lunar month begins in the 4thmonth of theAxt season twice during this civil month,on the1stand on the 30th.

-In the fourteenth year: the lunar month begins in the 4thmonth of the Smw season, on the 5th of the civil month and on the 30th, since it was recorded that it begins in the following month on the 30th (in the 15th year: the 1st month of theAxt season).

Note: The five epagomenal days must be added to the end of the civil monthto complete 30 days.

-In the seventeenth year: the lunar month begins in the 4thmonth of the Smwseason, on the 3rd of the civil month and on the 27th, since it was recorded that it begins in thefollowing month on the 27th (in the 18th year: the 1st month of theAxtseason).

Note: The five epagomenal days must be added to the end of the civil monthto complete 29 days.

-In the twentieth year: the lunar month begins in the 4thmonth of the Smwseason on the 1st of the civil month and on the 25th, since it was recorded that it begins on the 25thof thefollowing month (in the 21styear: the 1st month of theAxtseason).

Note: The five epagomenal days must be added to the end of the civil monthto complete 29 days.

-In the twenty-third year: the lunar month begins in the 2nd month of the prt season twice during this civil month on the 1st and on the 30th.

There is a major importance concerning the structure of the 25- year cycle table that is the corrective unites (days – months) were placed in the Mesore – Thoth – Phaophi section of the calendar that covers late summer and early fall. (Clagett, 1989;Depuydt, 1998)

Accordingly, the papyrus presentsa tool that allows one to establish, early,civilmonths and day dates, or at least very close to which.Buthow does it operate?

When a lunar monthbegins on a certain day of a civil month, it will fall again on– or very close to – that day 25 civil years later.

With a simple division of the number of days in 25 Egyptian civil years (9125 days) by the length of one lunar month (29.53059 days) equals about 309.001615, that is, 309whole lunar months plus about 0.001615 of a lunar month.More precisely, the 25 civil years area little over an hour longer (Depuydt, 2017)

Conclusion

From what preceded it was provedthat the ancient Egyptians used the "Blue Moon" phenomenon, caused by the shortage of time between the Lunar calendar and the Civil one,and recorded it in their documents without a specific name, as early as 237 B.C.,thephenomenon became a calendar rule in The Demotic papyrus Carlsberg 9 by analyzing the double date calendric system.

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(*)The origin of this name goes back to the 16th century A.D., when the expression "Blue Moon" was used to denote the impossibility of something to happen: "once in a Blue Moon" came to mean rare rather than impossible, while the first use of this expression in astronomy appeared in the early 20th century A.D. (Long, 2010)

(**)The development of a calendar is vital to the study of chronology, since this relates to calculate time according to divisions or regular periods, and using these to date events. It

is also essential for any civilization that needs to measure periods for agricultural, commercial, household, or other reasons.(Wiesenberg, 2019)

(***) A synodic month is the average time period between two mean conjunctions of the sun and the moon, when these bodies are as close as possible in the sky, which is calculated as 29 days, 12 hours, 44 minutes 3 1/3 seconds. (Wiesenberg, 2019)

(****) The calendar that used the familiar Egyptian year of 365 days – 12 thirty days months – plus 5 extra (epagomenal) days – comprised of three seasons with 4 month each. (Parker, 1950)

(*****)The oldest surviving evidence for using the double date calendar (the lunar calendar and the civil calendar) dated to the year 237 B.C. – Ptolemy III, in the temple of Edfu. (Parker, 1950)

(******)Since the lunar calendar was governed by the rise of Sirius, its months correspond to the same season every year, whereas, the civil calendar, which was inventedaround 2600 BCE, would move during the seasons because the civil year was about a quarter of a day shorter than the solar year.Due to the discrepancy between these two calendars, the Egyptians created a second lunar calendar based on the civil year and not, as it had previously been, upon the rising of Sirius. Thus, the ancient Egyptians adopted three calendars, each with a different purpose, fordaily life, religion and agriculture. (Parker,1950 ;Wiesenberg, 2019)

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