AN EGYPTIAN CHRONOLOGY FOR DYNASTIES XIII TO XXV

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METHODOLOGICAL REMARKS

Dead reckoning, checked by synchronisms, and by lunar and Sirius dates, is the standard procedure in Egyptian chronology. Egyptologists like Parker and his precursor Borchardt analysed pharaonic lunar and Sirius dates, utilizing the astronomical tables of P.V. Neugebauer. Both more often missed the historically correct chronology than hit it, since, for example, they did not realize how difficult it is to interpret recorded Sirius dates. Nowadays, experts do not agree about whether a pharaonic Sirius date refers to an actually observed heliacal rising or a schematically reckoned one. Another contentious issue is the geographical reference for the rising of the star: Memphis, Thebes or Aswan. The variability of these two factors alone can result in a difference of about 30 years for a Middle or New Kingdom Sirius date.

Specialists are also at odds concerning the value for the arcus visionis, the negative height of the sun at the moment when Sirius is at the horizon. On the basis of observations in Egypt Neugebauer arrived at an arcus visionis of 9°.[1] Decades later, in 1993, Pachner was able to correct the value slightly to 8.85° ± 0.15°, on the basis of new observations in Middle Europe.[2] Recently Schaefer, disregarding the observational values of 1929/1993, reckoned with an arcus visionis of 11° in accordance with his theory of visibility of stars during twilight.[3] This mandates a shift of a pharaonic Sirius date by +8 years over against those using the values of Neugebauer/Pachner. The possibility of an arcus visionis as low as 8.4°,[4] which would shift a pharaonic Sirius date by –4 years, was derived by Aubourg from the 1926/1993 observations. To avoid the difficulties inherent in the recent and earlier discussion of Sirius dates, I intend here to establish an Egyptian chronology based on lunar dates, i.e. without reference to traditional Sirius dates.[5]

According to Parker, the Egyptians reckoned the lunar month from the first calendar day of the moon's invisibility, i.e. the day after old or last crescent;[6] the calendar day began at dawn before sun rise.[7] A complete Egyptian lunar date is a double date consisting of a civil calendar date and a day in the lunar month. For example, the date of the Battle of Megiddo in the reign of Thutmose III is recorded as "Regnal year 23, first [month of the] Shemu [season], calendar day 21, day of pesedjentyw [1st day of the lunar month], exactly."[8]

Spalinger notes that "there are myriad challenges involved in sighting the moon";[9] doubtless his remarks are not based on myriad lunar observations. Any observer using the naked eye alone could recognize the first day of invisibility with certainty only when he had been able to see the crescent on the previous morning. Mistaken observations can occur on either day. Thus Egyptian lunar dates exhibit random qualities and therefore analysis of them mandates consideration of probabilities. I am aware that others have erred by neglecting to pay "close attention to the wording of all reasonings on questions of probability,"[10] yet I dare to analyse recorded Egyptian lunar dates in a probabilistic manner below. Parker asserted that "an Egyptian lunar date as given in the civil calendar and as calculated by modern tables may lack agreement by a day ... due to faulty observation or any other reason".[11] Did Parker mean that there is a 50% chance that a lunar date is correct or that it is more probable that a lunar date is correct than wrong? Until recently the accuracy of Egyptian lunar observation was thought to be the same as

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[1] NEUGEBAUER 1926, 445f; NEUGEBAUER 1929, 59.

[2] PACHNER 1998, 133.

[3] SCHAEFER 2000a, 151.

[4] AUBOURG 2000, 41f.

[5] For the time being see KRAUSS 2003a, 182–190, and Excursus 1 below.

[6] PARKER 1950, 9–13.

[7] KRAUSS 2003a, 193–195; KRAUSS 2004, in press.

[8] The tag '*r-mtr* (exactly)' is documented only in this date.

[9] SPALINGER 2002, 381.

[10] HERSCHEL 1866, 496.

[11] PARKER 1958, 211f.

lunar observation in Babylonia. In both cultures observations were made under similar meteorological conditions and by experienced observers.[12] The accuracy of Babylonian lunar observation was investigated by Schoch and Huber who concluded that at least 85% of the recorded lunar dates represent correct new crescent observations.[13] Fatoohi *et alii* have surmised that Schoch might have used not only observed crescents, but predicted ones as well;[14] Huber's data consist of observed crescents only.[15] Both relied on the same slightly outdated astronomical parameters and on Neugebauer's crescent visibility values, which ought to have resulted in some incorrect determinations of new crescents in both lists. Thus the 85% probability that a recorded Babylonian lunar date is correct, and by implication an Egyptian lunar date as well, is not really sound.

No modern series of observations provides a basis for extrapolating the quality of professional ancient Egyptian old crescent observations. Minimal criteria include a) consecutive old crescent observations over a period of at least one year; b) the observers ought to be the same experienced persons to simulate the situation of professional ancient observers; c) observations should be made at the same latitude and/or at least under comparable meteorological conditions as at Thebes and Illahun (the sites furnishing practically all pharaonic lunar dates). Recently Doggett and Schaefer organised 'moon watches' in North America to establish the Lunar Date Line for specific months.[16] Such moon watches do not constitute a model for old or new crescent observations by professional observers in ancient Egypt or Babylonia. In particular, the quotas for positive and negative errors are inapplicable. "A positive error occurs when an observer mistakenly claims to see the crescent; a negative error is when an observer mistakenly does not see the Moon."[17] The moon watches yielded one example of a positive error: 20 observers had no possibility of seeing the new crescent, because they were outside the zone of visibility, yet 3 apparently inexperienced observers reported sighting the moon.[18] To account for this error, Doggett and Schaefer proposed that "there are many objects in the sky (e.g., whisps of cloud or aircraft illuminated by the Sun) that can be taken for a crescent."[19] My own observations lead me to reject this explanation. Nor have I ever heard of an experienced observer believing he saw old crescent (sic) when it was not visible. Admittedly "honest observers may make honest mistakes," but it seems more likely to me that the three moon watchers were not honest. Regardless, the moon watches did not yield a rate of positive errors made by *experienced* observers. The ratio of negative errors among the moon watches is also not binding, as the commentary of Doggett and Schaefer implies. They report error rates of 1% and 2%, but "suspect the rate of negative error is greater (and probably much greater) than 1%."[20]

In the absence of adequate observational data I have attempted to establish the rate of error in observing old lunar crescent and first day of lunar invisibility from a theoretical model. By definition, an ancient lunar date is 'correct' if it is confirmed by modern astronomical computation.[21] Since the early 20th century old crescent visibility, as the lunar phase which is used today to determine such 'correct' lunar dates, has been calculated within the azimuth/altitude diagram introduced by Fotheringham:[22] For the moon to be considered visible it must have a minimal altitude (without parallax) which is dependent on the distance in azimuth of the sun and moon at the moment when the sun is in the mathematical horizon.[23] Especially Neugebauer improved upon the minimal altitudes of Fotheringham. Astronomers, Egyptologists and specialists in other disciplines have used Neugebauer's visibility criteria since the publication of his *Astronomische Chronologie* in 1929.[24]

In the late 1980's Schaefer developed a model for reckoning old/new lunar crescents which took the following factors into consideration: the physiology of the human eye, the brightness of the twilight sky, the surface brightness of the moon, the extinction in the atmosphere and the local observing conditions. From this model the minimal old/new crescent altitude h, relating to the azimuth-difference between sun and

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[12] For Egypt see Fissolo 2001, 15ff.

[13] Krauss 1986, 26.

[14] Fatoohi 1999, 64.

[15] Huber 1982, 25ff.

[16] Doggett and Schaefer 1994, 402; Schaefer 1996, 759f.

[17] Doggett and Schaefer 1994, 397.

[18] Doggett and Schaefer 1994, 397, 402.

[19] Doggett and Schaefer 1994, 398.

[20] Doggett and Schaefer 1994, 397.

[21] All astronomical calculations for this article were made with UraniaStar 1.1; for the program's reliability, see Firneis 2003, 48.

[22] Fotheringham 1910, 530 f; cf. Krauss 2003b, 53f.

[23] For a topocentric model see <http://www.saao.ac.za/~wgssa/as5/caldwell.html>.

[24] Neugebauer 1929, 79–82.

moon, can be determined, together with its mean deviation σ.[25] In Schaefer's model, the term h ± σ defines a zone of uncertainty. If the minimal altitude h of any computed old/new crescent falls within h ± σ, then visibility or invisibility of the crescent depends on extinction at the time of observation, a factor that cannot be predicted exactly.

According to Schaefer, there is a general shift from clear skies in winter to hazy skies in summer – in other words, in the northern hemisphere the minimal altitude is lower in winter and higher in summer. This rule does not seem to apply for all regions, but it is valid for Egypt.[26] Schaefer's and Neugebauer's minimal altitude values coincide in March and September, but they diverge for the other periods. According to Schaefer, low old crescents from October to February which Neugebauer thought might not be visible, might have been visible; conversely, low crescents from April to August which Neugebauer thought could be visible, might not be, according to Schaefer. Especially March through June and, to a lesser extent, in October it must be remembered that a sandstorm (*khamsin*) can affect extinction dramatically and thus the evaluation of recorded lunar dates.

According to a test made by Doggett and Schaefer, the latter's method is optimal: "The altitude/azimuth criteria by Fotheringham, Maunder, Ilyas, and Yallop proved to be reasonably accurate, with the particular implementation by Yallop being better than the other three. The model by Schaefer yielded significantly better predictions than any other algorithm."[27] Down to the present this claim has not been challenged. However, the possibility to check Schaefer's algorithm is limited since his software program LunarCal is no longer accessible.[28] Regardless Schaefer's model represents an improvement over Fotheringham-Neugebauer and so I have adopted his values h ± σ, despite some reservation, for determining whether recorded Egyptian lunar dates are correct or not. I reckon with three possible sources of error in Egyptian old crescent observation: a) the observer himself; b) observational difficulties when the crescent is in the zone of uncertainty; c) observational difficulties resulting from unfavorable weather conditions, i.e. haziness or overcast skies due to clouds or sandstorm.

A professional observer can err as far as recording the date is concerned. The tendency seems to be to give the date of the previous day, rather than that of the actual observation, which results in a negatively incorrect lunar date for old crescent observations.[29] Schaefer cites 7 such errors among 201 dated lunar observations,[30] but *none* for the day following the date of observation. For the present, I shall reckon with a 3% quota of negatively incorrect Egyptian lunar dates on this basis.

I cannot quantify how often a professional observer succumbs to the temptation to falsify data. Even when an observer conscientiously does his job, the observation can be hindered or rendered impossible. If extinction is high or the sky is overcast, the observation of old crescent may be impossible. If the sky is overcast, the invisibility of the moon on the day after old crescent cannot be determined. It is possible to quantify what conjectures an observer who stays in bed might make. If the sky is overcast on one day (e.g. on the day of old crescent), then it is likely that the sky will also be overcast on the following day.[31] I am unaware of any detailed statistics for cloudy days in the Nile valley; there are only statistics available for the average monthly level of cloudiness.[32] For the time being, the following commentary must suffice. If the yearly mean cloudiness is p %, then the sky is completely overcast at most on p % of 365 days. The maximum mean cloudiness in Upper and Middle Egypt occurs in December; during the summer cloudiness is minimal. At the entrance to the Fayum, and thus in Illahun, the yearly mean cloudiness is about 20.5%, or at most 75 days of totally overcast sky. Ideally, there could be 75 successive overcast days in winter, resulting in the impossibility of observing 2.5 old crescents.

If, towards the end of the lunar month on an overcast day, the observer presumes that the moon is visible or not, then there are in fact six possible situations. If it is astronomically the 29th day of the lunar month, then any assumption concerning the presence

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[25] I owe specific numerical values for h ± σ and the permission to use them in publications to a generous personal communication from Schaefer in November 1999; see also Krauss 2003a, 190–192.

[26] Shaltout 2001, 631–634; and personal communication from January 17, 2004.

[27] Doggett and Schaefer 1994, 402.

[28] See the slightly unfavorable review of Mosley 1990, 228.

[29] The result is a positively incorrect lunar date in the case of new crescent observation.

[30] Schaefer 1988, 512f.

[31] Schaefer 1992, S37.

[32] Griffiths 1972, 84–85, 126–128.

of the crescent is (a) correct, the opposite assumption (b) negatively incorrect. If it is a 30th day of the lunar month, then the assumption concerning the presence of the crescent is (a) correct, and the opposite assumption (b) negatively incorrect. If it is not the 30th but rather already the 1st day of the next lunar month, then the assumption that the crescent is present is (c) positively incorrect and the opposite assumption (d) correct. Consequently there are 6 possibilities: three correct, two negatively incorrect, and a single positively incorrect. If, as presumed, poor weather obtains in 20.5% of all cases, then the observer who stays in bed on these days will guess altogether 10.25% correct dates, 6.8% negatively incorrect and 3.4% positively incorrect dates.

To quantify errors resulting from variations in extinction, I calculated about 150 old crescents for the years between +2001 and +2013 at the latitude of Illahun. About 84% of them ought to have been visible without difficulty, whereas about 16% would have been situated within the zone of uncertainty. Because high and low extinction are equally possible, I expect that half of the uncertain cases or 8% will be correct sightings, and 8% negative errors; positive errors do not arise. In 290 days (i.e. 365 minus 75 days) or about 79.5% of all cases with good weather there would be 73.1% = 0.795 × (84% + 8%) correctly observable old crescents and thus correct first lunar month days. The result for negative sightings or minus one day falsely begun lunar months is about 6.4% = 0.795 × 8%. If I have made no gross error, then there would be in all 80.35% (= 73.1% + 10.25% – 3%) correct lunar dates and furthermore 16.2% (= 3% + 6.8% + 6.4%) negatively incorrect and 3.4% positively incorrect dates. Thus I suggest replacing Parker's general statement about an Egyptian lunar date being possibly wrong by one day, with the assertion that the probability p of an Egyptian lunar date being correct is p = 0.81; the probability that a lunar date is negatively incorrect is about 0.16 and that it is positively incorrect about 0.03. These values are to be understood as mean values which lie between those for Upper and Lower Egypt. With the aid of these probabilities I intend to determine which equivalents in absolute chronological terms are astronomically and historically correct for recorded lunar dates. There would be many different possible dates, if presumption of Egyptologists that a particular lunar day corresponds to the very same day in the civil calendar every 25 Egyptian years were correct.[33] This notion is erroneous; rather, for astronomical reasons there is only a 70% probability that an Egyptian lunar date repeats after a single 25 year shift (see Excursus 2).

An example are five lunar dates preserved from Dynasties 18 and 19: the Megiddo and Karnak dates, Piramesses date, and two feast-of-the-valley dates from 7 Tewosre and 7 Ramesses III. For these dates there are two possible correlations with the first years of the reign of Thutmose III and Ramesses II (see Table 10). If the first regnal years coincide with 1479/1279 BC, then 4 of the lunar dates are correct and only one is a day early (represented here by cccc–). If the first years coincide with 1504/1304 BC, then two of the five dates are correct while two fall a day too early and one a day too late (cc– –+). The comparative probabilities of cccc– and cc– –+ can be calculated assuming that about 3700 first lunar days occurred between the Megiddo date and the feast-of-the-valley date of 7 Ramesses III ; of these 3700 lunar dates 2997 (i.e. 81%) may be considered correct, 592 (i.e. 16%) negatively incorrect and 111 (i.e. 3%) positively incorrect. The probability P is defined as the ratio "number of favorable chances" ÷ "whole number of chances". In the example, the whole number of chances is the combination of 3700 lunar dates choose 5, i.e. C (3700,5) = (3700! ÷ 5!) × 3695! = 5.763×10^{15}. The number of favorable chances in the form cccc– is the product C(2997,4) × C(592,1) = 1.986×10^{15}, yielding $P_{cccc-} = (1.986 \times 10^{15}) \div (5.763 \times 10^{15}) = 0.344$, i.e. the probability that of five lunar dates exactly four are correct and exactly one is negatively incorrect. The number of favorable chances in the form cc– –+ is the product C(2997,2) × C(592,2) × C(111,1) = 6.681×10^{13}, yielding $P_{cc--+} = (6.681 \times 10^{13}) \div (5.763 \times 10^{13}) = 0.0151$, i.e. the probability that of five lunar dates exactly two are correct, two negatively incorrect and one positively incorrect. Accordingly, cccc– is approximately 23 times more probable than cc––+. Obviously, cccc– is much more likely to be historically correct than cc– –+. An alternative would be the use of the trinomial formula:[34]

$$P_{x,y,z} = (n! \div x! \times y! \times z!) \times 0.81^{x} \times 0.16^{y} \times 0.03^{z}$$

x is the number of correct lunar dates, y those nega-

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[33] E.g. Kitchen 1991, 204: "These moon-risings occur in the ancient calendar every twenty-five years."

[34] For this suggestion I am indebted to Sylvie Roelly, Lehrstuhl für Wahrscheinlichkeitstheorie, Institut für Mathematik, Universität Potsdam, who read and commented on a preliminary draft of this ms.

tively incorrect and z the positively incorrect ones, with n = x + y + z. Accordingly, the probability of cccc– works out to be:

$$P_{4,1,0} = (5! \div 4! \times 1! \times 0!) \times 0.81^4 \times 0.16^1 \times 0.03^0 = 0.344$$

Dynasties XXII to XXV

The reign of Psammetichus I began in February 664 BC and the reign of Taharqo in 690 BC. According to the Tang-i Var inscription, Shebitqo ruled from at least 707/706 BC.[35] The highest attested date for Shabaqo is year 15. Thus 1 Shabaqo corresponds to 722/721 BC at the latest. Shabaqo defeated Bocchoris as ruler of Memphis.

According to Vercoutter, a graffito in the burial chamber of the Apis that was buried in 6 Bocchoris mentions year 2 of Shabaqo. He states "the underground vaults of the Serapeum were opened only for the 70 days during which the body of Apis was being embalmed and for the actual burial."[36] The corresponding equation 6 Bocchoris = 2 Shabaqo has become the *communis opinio*.[37] In fact, Vercoutter paraphrased Boreux who wrote: "Pausanias nous apprend que l'intérieur du Sérapeum n'était ouvert que pendant les soixante-dix jours qui s'écoulent entre la mort d'un Hapi et son ensevelissement."[38] Pausanias however did not mention a 70-day period; rather, he noted that "neither foreigners nor even priests can enter there [Serapeum] before they bury Apis."[39] Whatever Pausanias reported in the 2nd century AD concerning contemporaneous practices at the Serapeum, is not pertinent for the 8th century BC. Furthermore Vercoutter's information about the Shabaqo graffito is incorrect. Actually Mariette wrote: "Une petite stèle grossièrement écrite à l'encre noire nous apprend qu'un Apis est mort l'an 2 de ce dernier prince [Shabaqo]. J'ai copié dans la chambre où la stèle précédente a été trouvée la fin d'une légende royale dont ce fragment de cartouche <///*kꜣw*> était lisible. Je n'ai pas osé, sur un document si incomplet, attribuer un Apis au règne de l'Éthiopien Schabatoka [*Djedkꜣwre*], successeur de Sabacon".[40] The chamber where Mariette found the stela mentioning a second year of Shabaqo is apparently not identical with that housing the burial of the Bocchoris-Apis: "Il est à noter d'ailleurs que l'Apis mort l'an 37 de Scheschonk IV [V]… et l'apis mort l'an 6 de Bocchoris, … furent ensevelis dans la même chambre, et que l'étude de la tombe prouve que ces deux Apis occupèrent successivement et sans intermédiare l'étable sacrée de Memphis."[41] Subsequently Mariette speaks of "… la porte même de la chambre sur les parois de laquelle les légendes de Bocchoris et de Scheschonk IV [V] ont été tracées."[42] These remarks cannot be reconciled with Mariette's plan of the Serapeum which Vercoutter published, which shows the Bocchoris-Apis (XXXIV) and that buried in 2 Shabaqo (XXXV) together in chamber S, while the Apis of 37 Sheshonq V (XXXIII) is in chamber R.[43] It would seem that Vercoutter overlooked this contradiction. Clearly, his reconstruction of the succession of the Apis bulls must be reconsidered, but for the time being it is preferable to date 6 Bocchoris earlier than 2 Shabaqo = 723/722 BC.

The Bocchoris Apis was the successor of the Apis that died in 37 Shoshenq V. According to the data concerning the three Apis bulls buried between 28 Shoshenq III and 37 Shoshenq V, and presuming that Pami's reign ended in a year 7,[44] 95 years lie between 1 Shoshenq III and 37 Shoshenq V (inclusive). If the Bocchoris-Apis was born very soon after the death of its predecessor[45] and had a life span of 26 years at most (the maximum life span attested),[46] the highest possible date for 1 Shoshenq III is 723/722 BC + 26 + 95 = 844/843 BC. This limit would need to be adjusted upwards if Shebitqo's reign began before 707/706 and/or Shabaqo occupied the throne longer than 15 years.

When reckoning the lower limit, it must be taken into consideration that Shepsesre Tefnakhte may or may not have ruled in Memphis as predecessor of Bocchoris for at least 7 full years.[47]

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[35] Frame 1999, 52–54.

[36] Vercoutter 1960, 66 n. 28.

[37] Vercoutter 1960, 65f; Kitchen 1973, 141 n. 247; Leclant 1984, 505 n. 9; Depuydt 1994, 23; Beckerath 1997, 91.

[38] Boreux 1932, 171.

[39] Pausanias I 18.4; see Levi 1971, 50.

[40] Mariette 1857, 26; Mariette 1904, 228. The present location of the stela is not known.

[41] Mariette 1857, 24; 1904, 215.

[42] Mariette 1857, 24; 1904, 223.

[43] Vercoutter 1960, fig. 1.

[44] Bickel 1998, 40.

[45] Vercoutter 1960, 64; Vercoutter 1958, 339–341.

[46] Vercoutter 1958, 340–342.

[47] Kitchen 1973, 141f; Beckerath 1997, 93, does not take a stand on this issue.

Tefnakhte's initial take-over of Memphis occurred at the earliest in the course of 38 Shoshenq V.[48] In his 20th (?) year Piye drove a non-royal Tefnakhte out of Memphis;[49] subsequently Shepsesre Tefnakhte and Bocchoris may have ruled for at least full 12 years (7+5) until the death of the Bocchoris Apis. Accordingly, the lower limit for Shoshenq III would be ca. 722 BC + 12 + 2 (?) + 95 = 831 BC or 722 BC + 5 + 2 (?) +95 = 824 BC, if Shepsesre Tefnakhte did not rule as king in Memphis.

Aston's conclusion that the rival kings Takelot II and Pedubaste I ruled Thebes when Shoshenq III reigned in Lower Egypt[50] seems self evident and has been widely accepted.[51] The following synchronisms are deducible or attested: 5 Takelot II = 1 Shoshenq III[52] and 5 Pedubaste I = 12 [Shoshenq III].[53] The resulting upper and lower limits are: 1 Shoshenq III : 844/824 BC, 1 Takelot II : 848/828 BC, 1 Pedubaste I : 833/813 BC. More specific dates can be derived by using the information provided by lunar feast dates. The five-day *Tepi Shemu* feast began at Karnak on lunar day 1. It is documented from the MK to the Saite Period; Parker analyzed an occurrence dated to 14 Psammetichus I.[54] According to Vernus and Kruchten the inductions of priests took place during the *Tepi Shemu* feast. Bubastide examples of the *Tepi Shemu feast[55] and/or of inductions are as follows:[56]

*(A) 11 Takelot II: I Shemu 11 = lunar day 1 to 5
(B) 7 Pedubaste I: I Shemu [1] = ditto
(C) 8 Pedubaste I: I Shemu 19 = ditto
*(D) 39 Shoshenq III: I Shemu 26 = ditto

Assuming that 11 Takelot II fell between ca. 838 and 818 BC, table 1 contains the lunar days which correspond to feast date A within that interval. Here and below, lunar days are counted forward as positive from lunar day 1 to 15; starting with the last lunar day, whether day 30 or 29, the lunar days are counted backward as negative down to lunar day 16. Since a lunar date can occasionally be wrong by minus one day and less often by plus one day, the lunar *Tepi Shemu* feast may have been celebrated in a given year on lunar days –1, 1, 2, 3 and 4 or on lunar days 2, 3, 4, 5 and 6, instead of the intended lunar days 1, 2, 3, 4 and 5. In general, we do not expect a lunar date to be off by more than a single day; accordingly no alternative with feast days earlier than lunar day –1 and later than lunar day 6 is acceptable. Between 838 and 818 BC these premises yield six possibilities for feast date A corresponding to a lunar day (LD) –1 to 6 (underlined).

11 Tak II	*LD*	*11 Tak II*	*LD*
838	–3	827	–5
837	8	826	7
836	–12	825	–11
835	–1	824	–1
834	11	823	10
833	–9	822	21
832	3	821	2
831	14	820	12
830	–6	819	22
829	5	818	4
828	15		

Table 1

Table 2 contains the acceptable and the nearest unacceptable possibilities which result when the lunar day equivalents of the feast dates of Shoshenq III and Pedubaste I are also computed and correlated with those of Takelot II within the limits for their first regnal years.[57]

	lunar day equivalents for dates			
1 Tak II	*A*	*B*	*C*	*D*
845	–1	5	4	1
842	3	7	7/8	3
839	5	11	10	6
834	–1	5	4	–1
831	2	7	6	3
828	4	9	9	5

Table 2

There are only two acceptable alternatives. Either 1 Takelot II corresponds to 845 or to 834 BC. In 834 BC two of four lunar dates would have been incorrect by minus one day (cc––), but in 845 BC there is only one error of this kind (ccc–); Table 3 lists the corresponding probabilities.

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[48] For year 38, see Beckerath 1995, 95.

[49] Piye ruled at least until a year 24. A year 30 (or 40) is by no means certain, see Kitchen 1973, 152 n. 292.

[50] Aston 1975, 139 ff.

[51] Except by Kitchen 1995, XXIII–XXV; 1996, 2.

[52] Beckerath 1995, 9f.

[53] Beckerath 1966, 51; Beckerath 1995, 9f.

[54] Parker 1962, 7f.

[55] Vernus 1975, 24; Kruchten 1989, 244 n. 3.

[56] Legrain 1913, 130: A; Kruchten 1989, 239f: B–D.

[57] There is a single case in which it cannot be decided whether a given date corresponds to a lunar day 7 or 8.

combination	*probability*
cccc	0.430
ccc–	0.340
cc– –	0.100
c– – –	0.013
– – – –	0.0006

Table 3

It is more probable that only exactly 1, instead of exactly 2, out of 4 lunar dates is incorrect by minus one day. Therefore 1 Takelot II is more probably 845 BC, than 834 BC and 1 Shoshenq III = 841 BC. Fragment 5b of the Karnak Priestly Annals allows an extension of the argument, for if I Shemu [1] of 14 Osorkon II is interpreted as a date of the *Tepi Shemu* feast,[58] then 1 Osorkon II = 872 BC[59] and *31 Osorkon II = 842 BC.[60] Current conventional estimates are slightly different. For example, Beckerath equates 1 Shoshenq III to ca. 837 BC.[61]

Dynasty XXI

According to Vernus, two of the priestly inductions known from Dynasty XXI occurred during the lunar *Tepi Shemu* feast:[62] (a) 2 Akheperre setepenre (Osochor/Osorkon) : I Shemu 20, induction of a father; (b) 17 Siamun : I Shemu [1], induction of a son. Assuming that the two inductions would have been separated by 20 to 30 years, i.e. a generation,[63] at least 21 years separate the dates, provided that both correspond to lunar days 1 to 5; other possibilities are 22, 24 and 32 years. The distance of 21 years is methodologically preferable, because it results in 6 regnal years for Akheperre Osochor as recorded in the Manethonian tradition. Upper and lower limits for the first years of Akheperre Osochor and Siamun, can be established by dead reckoning:

0 y	Shoshenq II (predecessor of Osorkon II)
14 y	Takelot I
33 y	Osorkon I
21 y	Shoshenq I
*19 y	Psusennes II
17[64] (*19) y	Siamun
6 y	Akheperre Osochor
sum = 112 (110) years	

It is likely that year 19 of Psusennes [II] is mentioned in the text of the Dakhleh stela from 5 Shoshenq [I]. The stela was originally attributed to Shoshenq I,[65] but susequently to Shoshenq III on the basis of the association of the title Pharao combined with a royal name (Psusennes or Shoshenq respectively) which is a feature of historically later texts.[66] But this is invalid, since '*Pharaoh Siamun*' is attested.[67] If Shoshenq III ruled Lower Egypt when Takelot II was in charge of Middle and Upper Egypt, Takelot II, rather than Shoshenq III, would have been the ruler who sent his representative from the 7th Upper Egyptian nome to Dakhleh. The text records a judgment on the ownership of a well in Dakhleh. According to Gardiner's understanding (sic), the mother of the claimant was mentioned as the owner in a document dated to year 19 of a king Psusennes.[68] Because at least 80 years separate 5 Shoshenq I and 19 Psusennes I, it is unlikely that the document was written in 19 Psusennes I, instead of Psusennes II.

If 112 (110) years are added to 1 Osorkon II = 872 BC, then year 2 of Akheperre Osochor corresponds to 984 (982) BC at the latest. Table 4 lists the acceptable and nearest unacceptable lunar day (LD) equivalents for the *Tepi Shemu* feast dates of Akheperre (a) and Siamun (b), together with the probabilities that exactly two of two lunar dates or only exactly one of two are correct and one is negatively incorrect; the table allows for an uncertainty of ca. 15 years.

2 Akheperre	*LD a*	*17 Sia*	*LD b*	*combin.*	*prob.*
990	5	970	2	cc	0.65
993	2	973	–1	c–	0.26
1001	5	981	3	cc	0.65

Table 4

Clearly, it is more probable that year 2 of Akheperre Osochor corresponds to either 990 or 1001 BC, rather than to 993 BC. Which alternative is preferable depends upon the results of the analysis of earlier New Kingdom chronology.

Early Dynasty XXI

At present there are two Egyptological models for the history and chronology of Dynasty XXI prior to

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[58] Kruchten 1989, 52.

[59] I Shemu [1] in 14 Osorkon III = November 21, 859 BC = lunar day 1 or 2.

[60] For years 29 and *30 see Beckerath 1997, 95.

[61] Beckerath 1997, 98.

[62] Kruchten 1989, 47f.

[63] Young 1963, 100f.

[64] For 19 years of Siamun see, for example, Beckerath 1997, 101.

[65] Gardiner 1933, 23; Kitchen 1973, 289.

[66] Jacquet-Gordon 1979, 180ff.

[67] Kruchten 1989, 47f.

[68] Gardiner 1933, 28.

Akheperre Osochor. Inscriptions with anonymous regnal years of early Dynasty XXI are found in Upper Egypt only. Traditionally, these regnal years have been interpreted as years of the kings who ruled in Lower Egypt. But Jansen-Winkeln proposes that they refer instead to the High Priests of Thebes in Upper Egypt who assumed royal prerogatives.[69] The traditional Manetho-based chronology reckons with 86 years between Smendes and Amenemope, or with 82 years, if Nepherkheres is considered a coregent: Amenemope 10 years + (Nepherkheres 4 y +) Psusennes I 46 y + Smendes 26 y = 86 years.

In Jansen-Winkeln's model, the attested series of anonymous regnal years should be attributed as follows: High Priest Menkheperre 49 y + HP Pinudjem I 26 y + HP Herihor 6 + x years = 81+x years. The possible synchronism [year x of king] Amenemope = year 49 [of the High Priest Menkheperre][70] would provide the link between the two chronologies. If Amenemope ruled only for 10 years, as is generally assumed, the overlap with Menkheperre amounts to between 1 and 9 years or a mean of 4.5 years. The difference of ca. 5 years between the two models is too small to affect the analysis of lunar dates. If Herihor counted at most 8 regnal years, the years of the High Priests add up to 87.5 or 88 years. Table 5 shows the resulting possibilities for the first year of Dynasty XXI:

2 Akheperre	*duration of early Dynasty XXI*	*resulting year 1 of Dynasty XXI*
991/990	88 y	1079/76
994/993	ditto	1082/79
1002/01	ditto	1090/87

Table 5

DYNASTIES XX AND XIX

The work of Beckerath, Ohlhafer and others appears to have securely established the chronology of Dynasty XX from the reign of Ramesses III onwards.[71] Debates continue about the transition from Tewosret to Sethnakhte and the position of Amenmesses at the end of Dynasty XIX. Both problems can be resolved by using lunar dates. Besides the explicit lunar date from 52 Ramesses II (Piramesses date),[72] there are several graffiti from Deir el Bahri (DB) referring to the lunar feast-of-the-valley.[73] According to the Medinet Habu calendar (and the DB graffiti), the feast began on a lunar day 1 in the second (or third) month of Shemu. On that day a cult statue of Amun crossed the Nile to spend the night in the funerary temple of the ruling king, returning to Karnak on lunar day 2. According to DB 3 and 10, Amun spent the night in the funerary temple of Tewosret and Ramesses III, respectively, thus furnishing the following lunar dates:

DB 3: year 7 of Tewosret, II Shemu 28 = lunar day 2 or 1
DB 10: year 7 of Ramesses III, III Shemu 9 = lunar day 2 or 1

The position of Amenmesses is deducible from the interval between the Piramesses date and DB 3. If Amenmesses was a usurper in control of Nubia and Upper Egypt between the middle of the first and the fifth regnal year of Sety II, then the interval between the two lunar dates amounts to 36 years +121 days = 13261 days = 449 mean lunar months + 2 days. This figure corresponds to the proper interval between a first lunar day and a lunar day 1–2 as a feast-of-the-valley date, either of which might be wrong by one day. Thus the reign of Amenmesses was contained within that of Sety II. If, by contrast, the interval between the two lunar dates is lengthened by a chronologically independent reign of Amenmesses of 4 or 5 years, then the feast-of-the-valley date DB 3 would fall far outside its proper time.[74]

Queen Tewosret is attested for about 412±15 days between DB 3 and year 8, IV [Shemu, day x] of oCG 25293.[75] Sethnakhte ruled into a year 3, so that his reign amounted to between 731 and 1095 days. 2234 days lie between Ramesses III's accession and DB 10. 3377 to 3741 days are accounted for between DB 3 and DB 10 which allows for their proper lunar minimal distance, i.e. 10 years + 11 days = 3661 days = 124 mean lunar months. There is no workable alternative, because *at least* 14 more years would be required for the next coincidence of the lunar dates of DB 3 and 10. Considering the wealth of dated material between the end of Dynasty XIX and the beginning of Dynasty XX, a gap of 14 unattested years is out of the question. Provided that the chronology of Dynasty XX between Ramesses III and XI is securely established, the interval between III Shemu 27 as the accession day of Ramesses II

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[69] JANSEN-WINKELN 1992, 34–37.
[70] KITCHEN 1973, 32; cf. JANSEN-WINKELN 1992, 37.
[71] BECKERATH 1997, 103–108.
[72] BECKERATH 1997, 51.
[73] MARCINIAK 1974.
[74] For details, see KRAUSS 1997a, 175–177.
[75] BECKERATH 1994, 74–76.

and the last attested date of Ramesses XI (I Shemu 25, year 10 of the era *wehem mesut* = regnal year 28) inclusive amounts to 199 years + 304 days ~ 200 years. By adding the latter figure to the alternatives for year 1 of Dynasty XXI, we arrive at three possibilities for 1 Ramesses II:

year 1 of Dynasty XXI	*interval between Ramesses II and XI*	*year 1 of Ramesses II*
1079/76	200 y	1279/76
1082/79	ditto	1282/79
1090/87	ditto	1290/87

Table 6

Table 7 lists the differences between recorded lunar dates and computed dates and the respective probabilities for the Piramesses-date in conjunction with the lunar dates of DB 3 and 10. The conventional alternative 1304 BC is included for the sake of traditionalists.

1 R II	*Pir difference rec.*	*DB3 minus com.*	*DB10 date*	*comb.*	*prob.*
1304	–1	0	–1	c– –	0.062
1290	+1	+1	0	c++	0.002
1282	–3	–1	–2	–	–
1279	–1	0	0	cc–	0.314

Table 7

1282 BC is not an acceptable alternative, because the indiviudal errors exceed 1 day. 1304 would be preferable to 1290 BC, but 1304 BC is incompatible with the chronology established for Dynasties XXI–XXII and it is far less probable than 1 Ramesses II = 1279 BC.

Mid- and Late Dynasty XVIII

The next step is to subject the lunar dates from the reign of Thutmose III to scrutiny: (a) year 23, I Shemu 21: lunar day 1; Battle of Megiddo; (b) year 24, III Peret 1: lunar day 1; foundation of the Akhmenu at Karnak. The possible correspondances for these dates depend on the time elapsed between the Megiddo date (alternatively the Karnak date) and the Piramesses lunar date which amounts to:

51 years + 215 days[76]
11y Sety I[77]
1y + ?m Ramesses I
27 [28] y Haremhab
4y + 1m Aya[78]
9y [10 y][79] Tutankhamun
?y Ankhetkheprure[80]
2y + ? m Smenkhkare[81]
16y + 9m Akhenaten
37y + 6(?)m Amenhotep III
7y + ?m or 9 y + 8 m Thutmose IV
25y + 10m[82] Amenhotep II
31y + 194 d[83] Thutmose III
sum = 227 years

Table 8

Thus a minimum interval of about 227 regnal years separates the Piramesses and the Megiddo date, corresponding to a minimum of 197 years between 1 Ramesses II and 1 Thutmose III. There are some indications that this minimum is smaller than the historically correct interval. To cite two examples, Manetho recorded 9y + 8m ~ 10 regnal years for Thutmose IV and Kitchen reckons with a year 28 of Haremhab which is not directly attested, although it may be deduced from extant sources.[84] The historically determined minimal distance between 1 Ramesses II and 1 Thutmose III amounts to 197+x years, corresponding to an interval of a) 261 years between the Piramesses and Megiddo lunar dates and b) 226 years between the DB 3 and Karnak lunar dates. Only the distances of 261+3 and 226+3 years, respectively, make up proper lunar distances, corresponding to an interval of 200 years between 1 Thutmose III and 1 Ramesses II. Table 9 contains the differences of the Megiddo and Karnak lunar dates as recorded first lunar days minus computed dates in relation to a generous range of possibilities for 1 Thutmose III.

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[76] Interval between day 1 of Ramesses II and the Piramesses date.

[77] Against the attribution of 15 years to Sety I, see Jansen-Winkeln 1993. Kitchen 1996,5, who attributes 15 years to Sety I, uses the debated coregencies of Akhenaten/Smenkhkare and Thutmose III/Amenhotep II to eliminate the 4 extra years.

[78] Krauss 1994, 74–78.

[79] A year 10 is attested by a wine jar from Tutankhamun's tomb which might belong to an earlier reign; cf. Tallet, 1986, 369–383.

[80] After some hesitation, scholars seem to have accepted the existence of this ruling queen, cf. Beckerath 1997, 112.

[81] Krauss 1997b, 225–250.

[82] Current arguments in favor of a coregency between Thutmose III and Amenhotep II are invalid, see Krauss 1995, 241–242.

[83] Distance between the end of the reign and the Megiddo date.

[84] Kitchen 1996, 5.

1 Th III	*Megiddo* *difference rec.*	*Karnak* *minus com.date*	*comb.*	*prob.*
1454	0	+1	c+	0.048
1465	+1	+2	–	–
1468	0	–1	c–	0.259
1476	+2	+2	–	–
1479	0	0	cc	0.656
1482	–2	–1	–	–
1490	+1	+2?	–	–
1493	–1	–1	– –	0.025
1504	+1	0	+c	0.048

Table 9

The years 1465, 1476, 1482 and 1490 BC are not acceptable as 1 Thutmose III, because they imply errors of more than 1 day. 1468 is more probable than 1454 and 1504, while 1493 BC is less probable than 1468, 1454 and 1504 BC. In sum, 1479 BC is by far the most probable alternative for 1 Thutmose III. The acceptable and some unacceptable possibilities for 1 Thutmose III and 1 Ramesses II are combined in Table 10 as five interrelated lunar dates.

1 Th III/R II	*M*	*K* *difference rec*	*Pir*	*DB 3* *minus com.date*	*DB10*	*comb.*	*prob.*
1504/1304	+1	0	–1	0	–1	cc– –+	0.015
1493/1293	–1	–1	–3	–1	–2	–	–
1479/1279	0	0	–1	0	0	cccc–	0.344

Table 10

Evidently 1 Thutmose III = 1479 is far more probable than 1504 BC. There is an additional historical argument in favor of 1 Thutmose III = 1479 BC. In the report concerning date M, it is explicitely stated that the battle occurred precisely (Egyptian: *r-mtr*) on the first lunar day, which suits only 1 Thutmose III = 1479, not, however, 1504 BC.[85] Thus 1 Thutmose III = 1479 and 1 Ramesses II = 1279 BC.

Consequences for the chronology of Dynasties XX–XXII

Since 1 Ramesses II = 1279 BC, 2 to 3 unattested years must be added to bridge the gap between 1077/76 BC, as the calculated year 1 of Dynasty XXI and February 1079 BC, as the last attested date of Ramesses XI. Adding these years to the reign of Ramesses XI would suit Wente's dating of a Late Ramesside Letter to year *XII of the era *wehem mesut* = year *30 of Ramesses XI.[86] Then the earliest possible equivalents for the lunar *Tepi Shemu* feast dates in 2 Akheperre Osochor and 17 Siamun would be January 990 and December 970 BC. Reckoning from 17 Siamun, 1 Shoshenq I would fall at the earliest in 948.5 BC = 969 BC – 2 – 18.5; alternatively, reckoning from 1 Osorkon II, the first year of Sheshonq I would correspond at the latest to 938.5 BC = 872 BC + 13.5 + 32.5 + 20.5; the mean lies at 943.5 BC. A likely lunar date corresponding to 1 Shoshenq I = 943.5 BC is that of the *weresh* procession on IV peret 25 in 5 Shoshenq [I], mentioned in the text of the Dakhleh stela.[87] If the procession occurred on a lunar day 1, then the reign of Shoshenq I began in 943 BC.[88] On this assumption there would be 5 unattested years between 6 Osochor and 1 Shoshenq I which implies a total of 134 years for Dynasty XXI. The unattested years may be distributed between Siamun and Psusennes II, or all attributed to Psusennes II.[89] If the 21 years and x month reign of Shoshenq I ended in 922 BC, then there are 49 full years before 1 Osorkon II = 872 BC. Of these 49 years, 46 are accounted for as mean values: 32.5 for Osorkon I + 13.5 for Takelot I. Thus about 3 unattested years remain to be distributed among Osorkon I, Takelot I, and Shoshenq II.

Early Dynasty XVIII

Manetho ascribes 13 years to Chebron < Akheperenre (Thutmose II). As Hornung noted, a 13-year reign does not suit the archaeological record for Thutmose II, whereas a 3 year rule would.[90] Kitchen concedes 3 years to Thutmose II and 12 years to Thutmose I, arriving at 1494 BC for the end of the 20y + 7m reign of Amenhotep I.[91] A comparison of the archaeological remains of Thutmose I/II and Hatshepsut supports the attribution of (4.1 + 10.2) years = 14.3 years to Thutmose II and I, resulting in 1 Thutmose II = 1483 BC and 1 Thutmose I = (March) 1493 BC. If then the reign of Amenhotep I began in III Shemu/July 1514 BC, the Manethonian 25y + 4m reign of Ahmose began in March 1539 BC.[92] Year 9 of

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[85] According to computation, old crescent occurred on –1481/5/14 = I Shemu 19, if 1 Thutmose III = 1504 BC; old crescent should have been visible on I Shemu 20 = May 15, if I Shemu 21 were a first lunar day.

[86] Wente 1967, 17.

[87] Cf. Krauss 1985, 165f.

[88] IV Peret 25, 943 BC = December 5th .

[89] The 14 regnal years ascribed to Psusennes II by Manetho-Africanus are conceivably a scribal error for *24.

[90] Hornung 1964, 32f.

[91] Kitchen 1996, 12.

[92] The highest contemporaneous date is year 22; the Manethonian figure of 25 y + 4 m is quite possible, but should not be taken for granted.

Amenhotep I corresponds to 1507 (according to Kitchen) or to 1506 BC. In 1506, a lunar day 1 coincided with III Shemu 9 as the Ebers calendar, according to Parker, indicates.[93] In this context, I shall not use this lunar date, but I encourage my colleagues to study the Ebers calendar under the assumption that 9 Amenhotep I corresponds to a particular year BC – in all likelihood 1506 BC.[94]

Dynasties XVI/XVII and XIII

Ryholt has shown that there are grounds for separating the Theban kings between the end of Dynasty XIII and the accession of Ahmose into two Dynasties (XVI and XVII).[95] But because the dividing line between them is unclear, I shall use the overall designation "Theban Dynasty" here. Presumably the Theban Dynasty began with the king whose name and regnal figure are lost in Turin Canon X 31. The names of nine kings are preserved in TC XI 1–9; about eight more are attested epigraphically, whereas the names of five kings in TC XI 10–14 are lost. In order to minimize the number of Theban kings, I presume that five of the epigraphically attested kings in the following list are those whose names are lost in TC XI 10–14; the sequence is tentative.

TC X 31: name lost, ? years
XI 1: Sekhemre///, 3 y
XI 2: Sekhemre-seusertaui, 16 y
XI 3: Sekhemre-se///, 1 y
XI 4: Se///re, 1 y
XI 5: Sewadjenre Nebiriau I, 26 y
XI 6: Nebiriau II, ? y
XI 7: Semenenre, ? y
XI 8: Seuserenre Bebiankh, 12 y
XI 9: Sekhemre-shed<waset>taui/Sebekemsaef I, ? y
[XI 10]: Sekhemre-wahkhau Rahotep, ? y
[XI 11]: Sekhemre-wadj-khau Sebekemsaef II, 7 y
[XI 12]: Sekhemre-up-maat Antef, ? y
[XI 13]: Nebukheperre Antef, 3 y
[XI 14]: Sekhemre-herhermaat Antef, ? y
Senakhtenre
Seqenienre
Kamose, 3 y

The figures attested for the reigns of nine kings in the Theban Dynasty add up to ca. 73.5 years; for at least 9 other Theban kings the regnal years are unknown.[96] It follows that the king of TC X 31 would have begun to rule *before* autumn 1613 BC = spring 1539 BC + 73.5 years. Ryholt argues that the Turin Canon originally listed at least 57 kings for Dynasty XIII.[97] Therefore the Manethonian figure of 60 kings might well be historically correct and will be used here as an upper limit. For 21 of these kings, a total of about 105 regnal years are attested: 83.5 years in TC and 21.5 years in contemporaneous sources. The 4.5 regnal years attested in pBoulaq 18 should be added, since this document belongs to one of the kings in TC VII 21–23 whose regnal figures are otherwise not known.[98] Thus about 109.5 regnal years for 22 Dynasty XIII kings are accounted for. If these 109.5 years are added to (autumn) 1613 BC as the lowest possible date for the last year of Dynasty XIII, we arrive at (spring of) 1722 BC as lowest possible date for the first year.

The regnal figures for at most 60–22 = 38 kings of Dynasty XIII are not preserved. It is methodologically sound to deal with the chronological uncertainties of Dynasty XIII by reference to an earlier fixed point which should yield a figure for the regnal total of the kings whose years are unattested. I do not intend to use the Sirius date from the Illahun archive to establish such a fixed point,[99] but shall rely instead solely on the 21 lunar dates from the same source as published by Luft.[100] These lunar dates span a period of 42 calendar years; the earliest, in 9 Sesostris III, the latest in 32 Amenemhet III. From an historical perspective the astronomical equivalents 1 Sesostris III = 1862/61, 1837/36 and 1812/11 BC are possible, but only 1 Sesostris III = 1837/36 BC is astronomically correct. The astronomically possible equivalents for the Illahun lunar dates can be expressed in relation to the last year of Dynasty XII, for example as 1 Sesostris III minus 77 years. The alternatives for the last year of Dynasty XII prior to (spring of) 1722 BC are 1735/34, 1760/59, 1785/84 BC and so forth, at intervals of 25 years. Of them, only 1760 BC, corresponding to 1 Sesostris III = 1837/36 BC is astronomically correct (see Excursus 2).

If Sobeknofru indeed ruled 2 m + 14 d of her fifth calendar year,[101] then Dynasty XII ended in mid-January, 1759 BC. It follows that the last year of Dynasty

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[93] Parker 1950, 42.
[94] For the present, see Krauss 2003a, 187–190.
[95] Ryholt 1997, 151.
[96] Ryholt 1997, 202, 204.
[97] Ryholt 1997, 72.
[98] Ryholt 1997, 193–194.
[99] See nevertheless Krauss 2003a, 186–187.
[100] Luft 1992; see the comments of Krauss 2003a, 175–178.
[101] Beckerath 1964, 218.

XIII would have been later than summer 1650 BC = January 1759 BC minus 109.5 years. The gap of 37.25 years between the summer of 1650 BC, as minimum last year of Dynasty XIII, and the autumn of 1613 BC, as minimum first year of the Theban Dynasty, is due to the loss of the regnal figures for a maximum of 38 + 15 = 53 kings and for a minimum of 35 + 9 = 44 kings of the Thirteenth and Theban Dynasties. It is methodologically sound to break up the 37.25 years proportionately into mean regnal lengths of the 44 to 53 SIP kings. The resulting interval for the end of Dynasty XIII/beginning of the Theban Dynasty is (the spring of) 1623 to 1620 BC.

A further correction is possible on the basis of the Sirius date from Gebel Tjauti:[102] "Regnal year 11 [of an unnamed king], II Shemu 20, observing *prt Spdt*". As Darnell realized, the date apparently refers to an actual observation of *prt Spdt* (heliacal rise of Sothis/ Sirius) on the territory of a king of the Theban Dynasty, so that II Shemu 20 should correspond to the Julian date of the heliacal rise of Sirius at Gebel Tjauti around 1600 BC. By contrast to other Sirius dates, the site where the observation was made is not at issue nor does the question arise whether the date could have been arrived at schematically. Darnell postulated a local arcus visionis of ß = 8.4° for 1600 BC and inferred that Sirius rose on II Shemu 20 = July 11 in the years 1593 to 1590 BC. There are two problems with this correlation: a) ß = 8.4° is smaller than any actually observed arcus visionis, although it may be just possible; b) on July 11 in 1592–1591–1590 BC the local arcus visionis would have reached only 8.24°, 8.02° and 7.81°. These values seem to be unworkably small, making the corresponding years very unlikely alternatives. Around 1600 BC a workable local arcus visionis of ß = 8.4° is computable for July 12 = II Shemu 20 in 1594–1595–1596–1597 BC. In all likelihood the Gebel Tjauti date refers to the years 1597 to 1594 BC and just possibly to 1593 BC. If Schaefer's theory about heliacal risings is applied, then the rising could not have occurred before July 14/13 which would shift the quadrennium to at least 1601/1598 BC.[103]

If only full years are reckoned, year 11 of Nebiriau I corresponds minimally to 1591/1588 BC = 1623/1620 BC – 32 years, whereas 11 Sekhemre-seusertaui corresponds minimally to 1609/1606 BC = 1623/1620 BC – 14 years. Thus the Gebel Tjauti date can only be ascribed to Nebiriau I. If 11 Nebiriau I includes July of 1597/1593 BC, the minimal date for his first year must be raised to include July of 1607/1603 BC. The correction mandates raising the beginning of the Theban Dynasty from 1623/1620 to 1628/1624 BC or the end of Dynasty XIII to 1626 BC as the mean year.

The 'stèle juridique' provides a possibility to check this result:[104] In 1 Merhetepre Ini of Dynasty XIII the visier Aya conferred the office of Hatj-a of El Kab on his son, the priest Aya. The latter's brother Iymeru inherited the office and passed it on to his own son Kebsi who sold it in 1 Nebiriau I. In minimal chronology, 1 Merhetepre Ini equates to 1662 BC = 1759 BC – 97 years, and there would be a difference of 55/59 years between 1 Merheptepre and 1 Nebiriau I = 1607/(1603) BC. In a second step one may correct 1 Merhetepre = 1662 BC, arguing that he had about 13 predecessors and at the most 25 successors within Dynasty XIII who ruled together for 34 to 38 years (1662 BC minus 1628/24 BC). If 34 to 38 years are apportioned equally to 38 kings, then about 11.5 to 13 years must be inserted between 1759 BC, as the first year of Dynasty XIII, and 1 Merhetepre Ini, which shifts 1 Merhetepre to about 1651/1650 BC. The resulting interval of 48 to 43 years between 1 Merhetepre Ini and 1 Nebiriau I is compatible with the time span of two generations when two brothers and the son of one of them held the office of Hatj-a in El Kab.

Excursus 1

Due to adverse atmospheric conditions, I was not able to observe the consecutive risings of Sirius in Abu Simbel, Aswan and Luxor in July 2003;[105] however, I did see old crescent on July 28 in Abu Simbel and new crescent in Luxor on July 30. I succeeded in observing the heliacal rising of Sirius (and, coincidentally old crescent) in the vicinity of Berlin at Caputh, (12° 59.3' E, 52° 20.44' N, 65 m above sea level) on August 26, in the company of Dr. Bernhard Gramsch, who suggested the observation site. We had no difficulty in seeing Sirius between 4h 21m and 4h 51m MET; the computed arcus visionis was 9.04°. This observation and those of 1926/1993 contradict Schaefer's theory insofar as it should not allow the equivalent of an arcus visionis of about 9°. Clearly, the theory must be corrected in view of the data obtained by observation.

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[102] Darnell 2002, 49–52.

[103] See note (3) above.

[104] Beckerath 1964, 182f.

At which minimum arcus visionis Sirius becomes observable at heliacal rising is a different problem altogether. Aubourg suggested that the arcus visionis of 9° from a modern urban area like Münster in Westfalia[106] implies a lower value for rural ancient Egypt with less air pollution. One may compare the following observed and *computed values for the arcus visionis within a 4 year cycle:[107] (Münster) year *1992: arcus visionis ß = 9.22°; 1993: 9.03°; *1994: 8.83°; *1995: 8.64° or 9.41°. (Minya)[108] *1924: 9.15°; *1925: 8.92; 1926: –8.7°, *1927: 8.47° or 9.37°.

Aubourg could argue that ß=9° in urban Münster implies the possibility of ß=8.5° in rural Minya. The problem is whether the rising in Minya is indeed observable under ß=8.5° or whether it is necessary to wait one more day to allow ß to increase to about 9.4°. The question can be resolved by making observations in the respective cycle years to come. Aubourg also presumes that the greater distance in azimuth between the sun and Sirius at heliacal rising in antiquity implies a smaller arcus visionis then now. On the basis of the 1926/1993 observations, Pachner could not confirm the expected relationship between the arcus visionis and the difference in azimuth.[109]

Excursus 2: Repetition of lunar dates

Figure 1 presents all astronomically possible sets of equations between the Illahun lunar dates and the years 2300 to 1200 BC, a total of 36 sets of 21 lunar dates each. All 756 cases of old crescent have been calculated; the solid lines in Fig. 1 indicate the percentage of those cases in which old crescent would have been observable without reasonable doubt; dashes signify the cases in which the calculated height of the crescent would have been within the zone of uncertainty. Thus Fig. 1 illustrates how the set of 21 Illahun lunar dates (actually the respective old crescent dates) repeats every 25 Egyptian years. This occurs because every 25 Egyptian years, the sun and the moon reach the approximate same distance from each other once again. The return of the moon to the same star occurs within the siderial month of

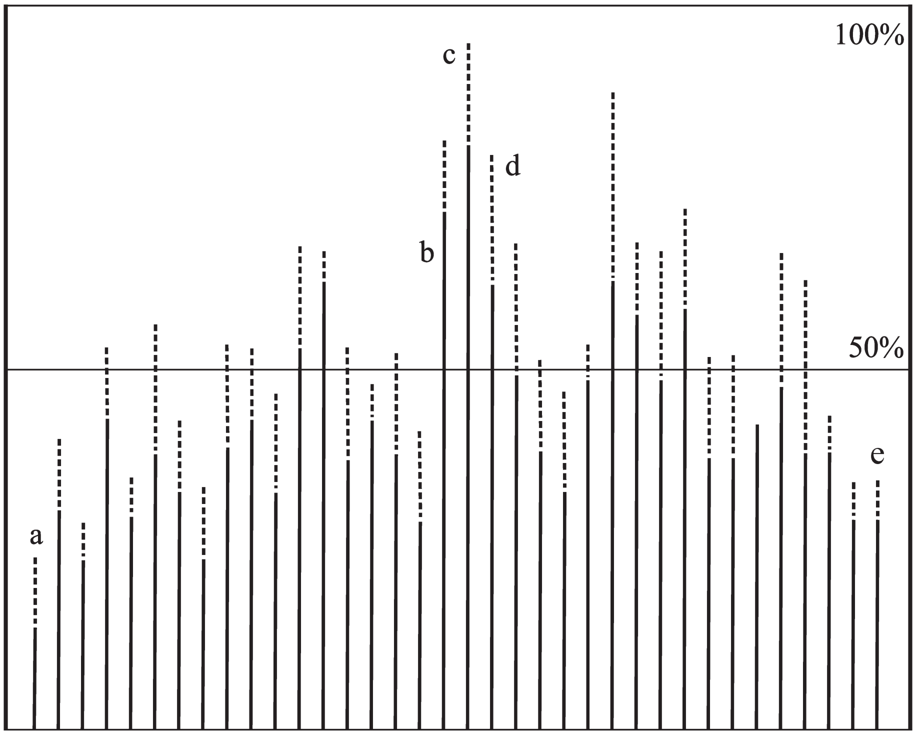

Fig. 1 Percentages of correct and uncertain Illahun lunar dates in 25-year shifts with 1 Sesostris III corresponding to a = 2286, b = 1862, c = 1837, d = 1812 and e = 1387 BC[110]

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[105] Residents told me that the haze prohibiting observation was extraordinary.

[106] Pachner 1998, 127.

[107] The figures refer to Sirius on the horizon, without refraction.

[108] Borchardt and Neugebauer 1927, 444.

[109] Pachner 1998, 134.

[110] In 2286 BC I Akhet 1 corresponds to March 18, and so forth.

27.32158 days. Because the sun also travels during the siderial month, it takes the moon additional time to reach the same distance to the sun again; the additional time is the difference between the synodic month of 29.53059 d and the siderial month. Within the siderial and synodic months the moon travels at a mean velocity of 13.176° per day. Within 25 Egyptian years = 24.982 siderial years, the sun travels in the mean 24 × 360° + 353.683°, whereas the moon travels 333 × 360° + 354.272°. In other words, in 25 Egyptian years the positions of sun and moon have decreased by about 6.317° and 5.728° respectively, whereas their original distance has decreased only by about 0.52°. The latter difference increases every 25-year shift resulting in a gradual decrease in repetitions of lunar dates.

The mean siderial and synodic movement also comprises (a) the anomalistic and (b) draconitic movement of the moon, which do not share a common period of 9125 days:

9125 days =
(a) 331 × 27.55455 d + 4.44 d =
(b) 335 × 27.21222 d + 8.91 d =
25 Egyptian years

Thus the mean anomalistic velocity is not the same after 25 years; the moon reaches the same velocity earlier or later. Furthermore, in ±25 years the mean draconitic movement results in a different latitude of the moon. The combination of these factors mean that Egyptian lunar dates do not repeat uniformly every 25 years.[111]

By computing 75 consecutive old crescents and their single ±25 year shift equivalents, I established that on the average only about 70% of a set of lunar dates repeat on the same day.[112] Those old crescents which do not repeat on the same civil calendar day shift by +1 or –1 day. Under these premises any large set of Egyptian lunar dates tends to have only one astronomically correct solution whereas its ± 25 years shifts are not correct. This is exemplified by the computational correlations for the Illahun dates of 1862, 1837 and 1812 BC, as 1 Sesostris III. As Table 11a shows, the three alternatives differ in the percentages of correct, doubtful and wrong dates. If half the doubtful dates are correct and half negatively incorrect, then the probabilities for each set in Table 11b can be calculated. The set '1 Sesostris III = 1837 BC' is about 25 times more probably correct than '1862' and about 6 times more probably correct than '1812'. These two alternatives can be interpreted as ±25 year shifts. They contain fewer correct dates, and display about the same rate of negative and positive errors. Presuming a shifting rate of 70% it is not possible to explain the alternative 1837 BC as the result of a 25-year-shift of either one of the two alternatives.

1 Ses. III	*correct*	*doubtful*	*wrong*	*neg.*	*pos.*
1862 BC	71.5%	9.5%	19.0%	1	3
1837 BC	81.0%	14.2%	4.7%	1	0
1812 BC	62.0%	19.0%	19.0%	2	2

1 Ses. III	*correct*	*neg.*	*pos.*	*prob.*
1862 BC	16	2	3	0.0048
1837 BC	18 (19)	3 (2)	0	0.122 (0.098)
1812 BC	15	4	2	0.0203

Table 11a.b

Shifts of 2 × 25, 3 × 25, 4 ×25 and 5 × 25 years, result in decreasing percentages of correct repetitions as can be inferred from Figure 1. There is an increase in the number of repeated lunar dates within 6 × 25 = 150 Egyptian years; lesser increases occur within (2, 3, 4 ...) × 150 Egyptian years. Apparently the increase is linked to the fact that (a) the mean siderial, (b) synodic, (c) anomalistic and (d) draconitic months have an approximate common period of 150 Egyptian years:

54750 days =
(a) 2004 × 27.32158 d – 2.44d =
(b) 1854 × 29.53059 d + 0.28 d =
(c) 1987 × 27.55455 d – 0.89 d =
(d) 2011 × 27.21222 d – 0.99 d =
150 Egyptian years

Thus the decisive components for a particular lunar phase recur within approximately 150 Egyptian years, resulting in a relatively high percentage of repeated lunar dates. A yet higher percentage is precluded by the fact that within 150 Egyptian years the mean distance between sun and moon at old crescent decreases by 5.53°.

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[111] For a specific example see Krauss 2003a, 190–192.

[112] Krauss 1985, 27; similarly Parker 1950, 25. The figures in Krauss 1985, 27, were based on Neugebauer's tables and his lunar visibility criteria. A recomputation with Uraniastar and Schaefer's visibility criteria resulted in the same figure of ca. 70%. I am aware that the 70% lies between the 3s–limits of about 54% and 82%.

Chronological results (dates with an * are liable to slight modifications)

Dynasty XXV	
Taharqo	690–664
Shebitqo	*706–691
Shabaqo	*722–707
Dynasty XXIV	
Bocchoris	*728–723
Tefnakhte	*736–729
Dynasty XXII	
Shoshenq V	783–746
Pami	790–784
Shoshenq III	841–(789)
Takelot II	845–821
Osorkon II	872–842
Shoshenq II	*873
Takelot I	*887–874
Osorkon I	*922–888
Shoshenq I	943–923
Dynasty XXI	
Psusennes II	*967–944
Siamun	986–968
Osochor	992–987
Amenemope	*1002–993
Amenemnisut	*1005–1002
Psusennes I	*1051–1006
Smendes	*1076–1052
Dynasty XX	
Ramesses XI	1106–1078
Ramesses X	1110–1107
Ramesses IX	1129–1111
Ramesses VIII	1130
Ramesses VII	1138–1131
Ramesses VI	1145–1139
Ramesses V	1149–1146
Ramesses IV	1156–1150
Ramesses II	1187–1157
Sethnakhte	1190–1188
Dynasty XIX	
Tewosret	1192–1191
Siptah	1197–1193
Sety II	1202–1198
Amenmesses	1202–1200
Merneptah	1213–1203
Ramesses II	1279–1213
Sety I	1290–1279
Ramesses I	1292–1291
Dynasty XVIII	
Haremhab	1319–1292
Aya	1323–1320
Tutankhamun	*1333–1324
Ankhetkheprure	1334/1333
Semenkhkare	1336–1334
Akhenaten	1353–1336
Amenhotep III	1390–1353
Thutmose IV	1400–1390
Amenhotep II	1425–1400
Thutmose III	1479–1426
Hatshepsut	1479–1458
Thutmose II	1482–1479
Thutmose I	1493–1483
Amenhotep I	1514–1494
Ahmose	1539–1515
Dynasty XVI/XVII	
Kamose	*1542–1540
Bebiankh	*1578–1566
Nebiriau	*1606 –1580
Sobekhotep VIII	*1622–1608
Dynasty XIII	
Merhetepre Ini	*1651–1650
Merneferre Aya	*1675–1651
Ibiau	*1686–1675
Khahotepre	*1691–1686
Sobekhotep VII	*1701–1692
Neferhotep I	*1712–1702
Khendjer	*1728–1724
Dynasty XII	
Sobeknofru	1763–1759
Amenemhet IV	1773–1764
Amenemhet III	1818–1772
Sesostris III	1837–1819
Sesostris II	1845–1837
Amenemhet II	1878–1843
Sesostris I	1920–1875
Amenemhet I	1939–1910

ADDENDUM

At the SCIEM2000 Workshop "Egypt&Time", Vienna 30 June–1 July 2005, Kim Ryholt demonstrated that John C. Darnell's reading of Gebel Tjauti Rock Inscription no. 11 as referring to an observation of Sothis in a regnal year 11 is not acceptable. Therfore my deductions in "Dynasties XVI/XVII and XIII" which are based on Darnell's reading should be disregarded.

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