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Number 22.0

Title: Third Millennium BC Chronology and Clock-Time Correction

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Posted to web: 8 September 2021

Third Millennium BC Chronology and Clock-Time Correction

Peter J. Huber

Abstract.
The astronomical data available for fixing the third millennium BC chronology are precarious. But surprisingly, if taken at face value they yield unique coherent chronologies for the Dynasties of Akkad and Ur III (about 50 years higher than the conventional ones). Even more surprisingly, in conjunction with these chronologies three different sources (lunar eclipses, a solar eclipse and month-length data) yield tightly constrained coherent values for the clock-time correction ΔT valid in the late third millennium. In view of the precariousness of the data one may hesitate to accept these results without reservations. But in view of their internal coherence, one ought to keep them in mind at least as serious working hypotheses.

Keywords
Third Millennium chronology; Lunar eclipse omens; Akkad chronology; Ur III chronology; Dating by month-lengths; Clock-time correction.

1. Introduction.
Historical astronomical dating suffers from two basic uncertainties: the inaccurately known rotation of the earth, and the unreliability of ancient records.

The inaccurately known rotation of the earth is expressed by the poorly known difference ΔT = ET – UT between the uniform Ephemeris Time (ET) underlying the astronomical calculations and the somewhat irregular Universal Time (UT) based on the rotation of the earth that regulates the time of day. Because of tidal friction the rotation of the earth slows down, therefore ΔT increases quadratically with time, but it is subject to substantial random fluctuations. Extrapolation of ΔT to 2000 BC is affected by a standard error of about 60 minutes, conservatively estimated on the basis of a Brownian motion model with infinite relaxation time, see Huber (2006: 298). A more optimistic experimentally indistinguishable autoregressive model with 500 years relaxation time reduces the estimated standard error to 23 minutes. As a default ΔT I am taking a simple formula proposed by Morrison and Stephenson (1982): $\Delta T = c\, t^2$ seconds, with $c = 32.5$ and t measured in centuries since 1800 AD, and am using a value of –26.00" cy^{-2} for the lunar orbital tidal acceleration. Deviations from the default ΔT shall be denoted by dΔT. Near 700 BC the default agrees with the best estimate of ΔT within less than 2 minutes, see Huber and De Meis (2004: 26).

In Mesopotamia, systematic astronomical observations apparently started in the 8th century BC. From before that time we have (i) scattered observations of lunar eclipses and of the planet Venus, both preserved in the protases of celestial omens, (ii) a few literary records of solar eclipses, and (iii) contemporary records of month-lengths. The chronological value of such data has been doubted, but never convincingly refuted.

The lunar eclipse omen texts have been published by Rochberg-Halton (1988). Most of them appear to be schematic, not referring to identifiable events, and therefore useless for chronological purposes. On the other hand the omens of EAE Tablets 20 and 21 are so detailed and unsystematic that they appear to contain records of actual lunar eclipse observations preceding a change of reign in specified dynasties.

The present paper first summarizes relevant results from earlier paper and then adds a new study on the dependence of the recorded month-lengths on the clock-time correction. The results of that study crucially enforce the trust we can place on such month-length data.

2. Lunar eclipse omens and the Dynasty of Akkad.

Typical omen protases contain information about the month, the watch of the night and a crude entrance angle (north, east or south) of a lunar eclipse. On average, about four eclipses per century will match this information.

Thus, a single lunar eclipse omen is of little use for dating purposes. However, if multiple omens relate to transitions in a given dynasty with known lengths of reign, the number of good match-ups of omens with calculated eclipses is much reduced. This applies in particular to the Dynasty of Akkad. In the search described in Huber (1999/2000) I searched in a wide chronological range (namely assuming that Sargon's reign began between –2400 and –1950), and a wide ΔT range (namely assuming an uncertainty of ±0.4 watches of the night, that is about ±1.6 hours). It turned out that for two particular chronologies, with Sargon year 1 = –2380 or –2326, not only most transitions of reign were preceded by large lunar eclipses, but most of those eclipses were also matched by appropriate omens, see Huber (1999/2000: 66-67).

The difference of 54 years between the two chronologies is a well-known eclipse period. Later, it turned out that only the higher chronology is compatible with the solar eclipse from the time of Sargon, see Huber (2012: 726) and below. The listing given in Table 1 corresponds to that chronology.

Here I am following the traditional assumption that Sargon's reign lasted 56 years and Naramsin's 37 years. Recently, on the basis of a newer king list (USKL) different reign lengths of 40 and 56 years, respectively, have been favored, see in particular Steinkeller (2003) and Sallaberger and Schrakamp (2015: 108, 136). The length of Sargon's reign is irrelevant for my purposes, but for Naramsin I retained the 37 years of Jacobsen's list (1939) against the 56 years preferred by Sallaberger and Schrakamp, because the protasis of omen 20-I corresponds to two almost identical eclipses spaced 37 years. As illustrated in Table 1, this eclipse pair then is able to ominously presage the deaths of the two consecutive kings Maništusu and Naramsin.

The best match obtained by Huber (1999/2000) and (2012) for omens pertaining to the Dynasty of Akkad is listed in Table 1.

Kings of Akkad	Length of reign	First year of reign	Eclipse preceding the accession	Omen in EAE
Sargon	56	–2380		
Rimuš	9	–2324		
Maništusu	15	–2315		
Naramsin	37	–2300	–2301MAR09 –2301SEP02	20-I 21-VI
Šarkališarri	25	–2263	–2264MAR19	20-I
Igigi, Nanum, Imi, Elulu	3	–2238	–2239NOV04	21-VI?
Dudu	21	–2235	–2236MAR10 –2236SEP02	20-I 21-VI
Šu-DURUL	15	–2214	–2214JAN07	18-XI?
End of dynasty		–2199	–2200MAR31	21-I

Table 1. Dynasty of Akkad: Lunar omens and lunar eclipses. All eclipses are total. The lengths of reign are taken from king lists, see Jacobsen (1939: 177) and Sollberger (1954-1956: 45-46). For the omens see Rochberg-Halton (1988).

Outside support for this chronology is found in the Tell Leilan excavations. There, the post-Akkadian level IIc (i.e. post- Šarkališarri) is ^{14}C dated to the second half of the 23rd century, namely with 95% probability to 2252-2202 BC (Weiss et al. 2012: 175).

After seeing an early draft of Huber (2012) the late John Britton had wondered whether it would be possible to estimate ΔT from the lunar eclipse omens. Indeed, for the chronology shown in Table 1, if we accept the timings of the two omens EAE 20-I and 21-VI at face value, they yield tight bounds for ΔT: $-9 < d\Delta T < 31$ minutes, see Huber (2012: 721). (In view of the crudeness of ancient eclipse timings these bounds admittedly may be overly optimistic.)

3. The solar eclipse of Sargon.

A beautiful description of a total solar eclipse is contained in the Legends of the Kings of Akkade, see Westenholz (1997). It is discussed in Huber (2012: 723-725). Among the two best matches the eclipse of –2352JUN14 supports the chronology of Table 1. It implies a dΔT range of $-20 < d\Delta T < 7$ minutes, overlapping with the range just determined from lunar eclipse omens. The other well-matching eclipse (–2285APR25) would fit inside the range of the lower lunar chronology (Sargon reigning –2326 to –2271). I reject it, since it requires a high $d\Delta T > 80$, while for $d\Delta T > 54$ none of the three instances of EAE 20-I sets eclipsed, as required by that omen.

4. Lunar eclipse omens for the kings of Uruk and Ur.

Four lunar eclipse omens apparently refer to this period. Accepting them at face value, I matched them in Huber (1999/2000) as follows with transitions of reign.

Kings of Uruk and Ur	Length of reign	First year of reign	Eclipse preceding the accession	Omen in EAE
Utuḫegal (king of Uruk) Ur-Namma (governor of Ur)	10	–2159	–2159JUL24	21-IV
Ur-Namma (king of Ur)	8	–2149	–2149JUL04 –2149JAN08	20-IV 21-VIII?
Šulgi	48	–2141		
Amar-Sin	9	–2093	–2094JUL25	20-III, 20-IV
Šu-Sin	9	–2084		
Ibbi-Sin	24	–2075		
End of dynasty		–2051	–2052APR13	21-XII

Table 2. Third Dynasty of Ur: Lunar omens and lunar eclipses. The eclipses of –2159JUL24 and –2052APR13 have magnitudes 0.98 and 0.63 respectively, the others are total. The lengths of reign are taken from Sollberger (1954-1956: 45-46). The first years of Ur-Namma's reign in Ur (as governor) are known to have overlapped with Utuḫegal's kingship in Uruk.

The above date (–2093) for the accession of Amar-Sin had been determined disregarding the Venus chronologies. Back-reckoning from the Babylon I dynasty to that of Ur III is aasumed to be accurate within very few years, see Sallaberger and Schrakamp (2013: 5). The above Amar-Sin date is close to the date (–2099) obtained by back-reckoning from the High Venus chronology (Ammiṣaduqa year 1 = –1701). Thus the Ur III eclipse omens appear to favor the high Venus chronology.

5. Month-lengths of Ur III.

The lengths of the Mesopotamian months, that is the intervals between first visibilities of the lunar crescent, vary more or less randomly between 29 and 30 days. The disagreement- or miss-rate between (modern) calculations and (ancient) observations of 30-day months is about 10% for Late-Babylonian astronomical diaries, about 33% for Neo- and Late-Babylonian administrative texts. The rate of 33% need not apply to earlier texts, but if the dating practice bears any relation to the first visibility of the lunar crescent, we can expect a miss rate below the theoretical 47% applying for randomly wrong aligned months. With the currently available sample sizes, the difference between expected miss rates is too small to permit a statistically reliable dating on the basis of month-lengths alone.

The Ur III period has its peculiar problems. In different cities different calendars were in use, with different, possibly incompletely known intercalations. Modern synchronization errors do not necessarily invalidate the conclusions, but they impair the discrimination power of the data by raising the overall miss-count.

Sallaberger and Schrakamp (2015: 6[13]) comment about the high number of mismatches between 29- and 30-day-months of the Umma and Drehem calendars. Clearly, we need more data to elucidate what is going on here. However, a high number of mismatches is not surprising. As shown by differences in the intercalations, the two calendars are largely independent, and so we can assume that also the month-lengths were recorded independently. The discrepancies between recorded and calculated month-lengths seem to be essentially random. For the sake of the argument we shall assume them to amount to 33%. If we can assume that these 33% in the two calendars were occurring independently, the discrepancy rate between the recorded month-lengths of the two calendars will rise to about 44% – which is practically indistinguishable from the previously mentioned rate of 47% for random wrong alignments between recorded and calculated month-lengths.

By 1987 I had 228 useable Ur III month-length data, most of them supplied by Robert Whiting (see the Appendix). In the Amar-Sin to Ibbi-Sin range there were 126 data from Drehem, 60 from Umma, and in the Šulgi range there were 42 data from Drehem. Between –2150 and –1900 the best agreements (among over 3000) occurred if we date year 1 of Amar-Sin to –2093 or to –2005, with a tied miss rate of 83/228 = 36.4%, see Huber (1999/2000: 53-54). The agreement at –2093 is persuasive: it not only confirms the accession year of Amar-Sin we had found on the basis of lunar omens, but also the applicability of month-length data to chronological problems.

Later, I realized that the Šulgi segment of month-lengths has peculiar problems, cf. Sallaberger (1993: 5). Its month-lengths agree poorly with calculation, and if that segment is omitted, the miss-rate is lowered to 61/186 = 32.8%. In the remainder of this paper the Šulgi segment shall be ignored.

6. Estimating ΔT from the month-lengths?

In my contribution to the Festschrift for Lis Brack-Bernsen (Huber 2017) I had been varying the value of *c* in the formula $\Delta T = c\, t^2$ (see Section 1 for that formula) in order to check the sensitivity of the miss counts to ΔT. There I had been concerned with the Ammiditana-Ammiṣaduqa data. After reading my contribution, Lis persuaded me to overcome my initial reluctance and to apply the approach to the Ur III data, in order to check and possibly to improve the estimate of ΔT.

The approximate chronological ranges obtained by back-reckoning from the conventional four main Venus chronologies (i.e. within a back-reckoning error of ±10 years and assuming a New Year syzygy longitude between 310° and 50°) gave a total of 252 feasible alignments, of which at most one could be correct. Among these alignments I picked the four years giving the best month-length matches obtainable with the default value *c* = 32.5. For each of those four years I then varied *c* in steps of 0.25 from 27 to 38. For the period in question this range of *c* corresponds to a ΔT range of a little over ±2 hours, and the step-size of 0.25 changes ΔT by approximately 6 minutes.

The best matches for the Amar-Sin to Ibbi-Sin data are obtained for Amar-Sin year 1 = –2093, with an optimum centered near *c* = 32.75, clearly visible in Figure 1. For the sample size n=186, a theoretical calculation (based on a binomial distribution model and approximately checked by empirical alignments) yields that only about 1 in 10'000 random wrong alignments will reach a miss count of 62 or lower. (By the way, I repeated the calculations searching for the four best matches with *c* = 30.0 or 35.0 and obtained basically the same results: Amar-Sin year 1 = –2093 remained the only curve yielding any miss counts of 66 or lower.)

The location of the optimum suggests a narrowly constrained value of dΔT = +6 minutes in Ur III times, consistent with the ranges independently estimated from the Akkad lunar omens (–9 < dΔT < 31) and the Sargon solar eclipse (–20 < dΔT < 7). The singular importance of this month-length evidence is that it simultaneously verifies the Amar-Sin date derived from lunar eclipse omens and the clock-time correction derived from Akkad eclipses.

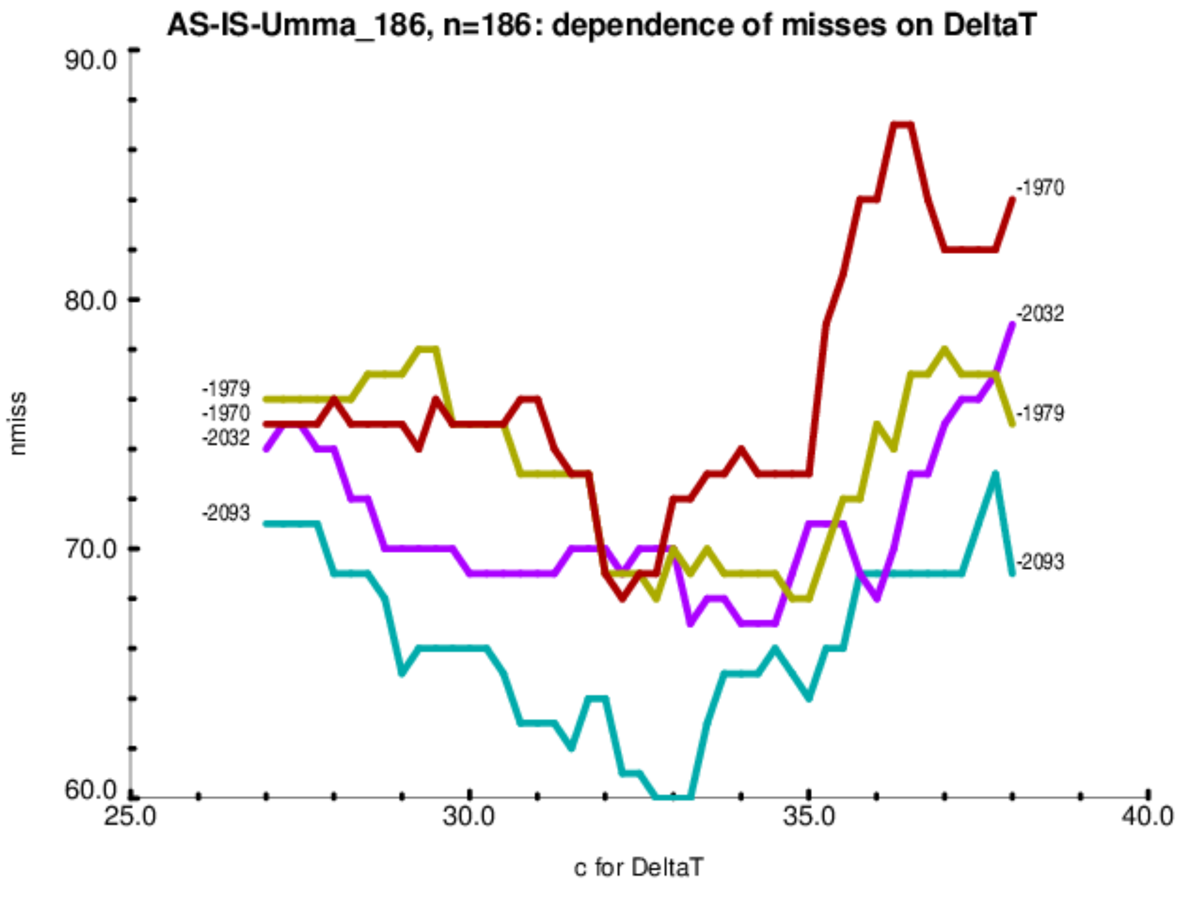

Figure 1. Sensitivity of miss count to ΔT. Amar-Sin to Ibbi-Sin data from Drehem+Umma; n=186.

7. Summary and conclusions.

Three distinct kinds of data are potentially relevant for the astronomical dating of the late 3rd millennium BC: lunar omens pertaining to the dynasties of Akkad and Ur III, a literary solar eclipse from the reign of Sargon, and Ur III month-length records. The data are precarious, and taken singly, their chronological reliability can be, and has been, questioned. But taken in conjunction, they persuasively yield unique, coherent chronologies for the dynasties concerned (Tables 1 and 2), and they are supported by ^{14}C dates from Tell Leilan. Moreover, the Akkad lunar eclipse omens, the Sargon solar eclipse and the Ur III month-lengths unexpectedly yield narrowly constrained independent values for the clock-time correction ΔT. In particular, the newly determined results from the Ur III month-lengths (Figure 1) removed my earlier misgivings about the chronological value of the Ur III month-lengths. in my opinion they now give an almost decisive confirmation of both the clock-time corrections and the proposed chronologies for the late 3rd millennium.

I am concerned here with the 3rd Millennium chronology, but I should add a few remarks on the following period. The currently accepted chronology of the 2nd millennium BC is based primarily on dendro-chronological and ^{14}C data from Anatolia, see Barjamovic, Hertel and Larsen (2012) and the discussion by Sallaberger and Schrakamp (2015: 5-11). It is compatible with the Middle Venus chronologies (Ammiṣaduqa year 1 = –1645 or –1637), but not with the High and Low Venus chronologies (–1701, –1581). Undoubtedly, the Anatolian evidence favoring the range of the Middle chronologies is very strong. On the other hand one should keep in mind that the latter are poorly supported by astronomy. The Venus Tablet favors the High and Low Chronologies over the Middle ones, and depending on one's interpretation of the data, its evidence may even be strong enough to reject the middle two with statistical significance. This was pointed out by van der Waerden (1965: 47) and later elaborated by Huber et al. (1982: 23). In addition, the Ammiṣaduqa month-length evidence favors the High Venus chronology, see the detailed discussion in Huber (2017), in particular Figure 4 and Table 7.

Sallaberger and Schrakamp fix the chronology of the 3rd millennium through back-reckoning from Ammiṣaduqa year 1 = –1645; they obtain Ur-Namma year 1 = –2109 (ibid. p. 5 and 136). Thus, their chronology for the 3rd millennium is 50 years lower than the one proposed here. One of the three pillars supporting the two chronologies thus must be off by these 50 years: either my astronomical chronology for the 3rd millennium, or the dendro-chronological chronology for the 2nd millennium, or the back-reckoning. In order to settle the problem, rather than to waste ink on opinionated fruitless discussions, we need more data, and it appears that the only pertinent materials currently available are month-length data.

How should we go on from here? First of all, we should use new month-length data to check the validity of the precise but fragile results described in this paper. I hope that the potential usefulness of the month-length data – they might enable us to determine the absolute chronology of the late 3rd millennium within an accuracy of one day – will animate some Sumerologists to dig into the enormously increased Ur III data basis we have by now and to extract trustworthy month-length information. I am not up to such a task. It is necessary but delicate to cleanly separate the month-length data according to local calendars and to pay attention to their synchronization. In particular, one should take a close look at lists of regular daily deliveries, since they give reliable actual month-lengths – 29 or 30 days –, more reliable than texts dated on day 30.

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Appendix: Ur III month-length data

DREHEM MONTH-LENGTHS (WHITING 1986)

K	Y	M	D	Syz#	Type	Source
Sh	39	6	30	883	2	CST 47
Sh	40	5	30	894	1	JCS 24 64
Sh	40	8	30	897	1	CST 51
Sh	40	10	29	-899	2	AnOr 7 66
Sh	41A	1	30	902	2	TRU 274
Sh	41A	8	30	909	1	POL 19 162 (19)
Sh	42	2	30	916	2	CST 467
Sh	42	12	30	926	1	MVN 11 210 UMMA? cf BIN 5 22 = AS 6?
Sh	43	2	30	928	1	RT 37 p 136a +
Sh	43	2	30		1	OLP 8 p 7 no 2 +
Sh	43	9	30	935	1+3	ASJ 4 p 134 Kelsey 89203 +
Sh	43	9	30		3	PDT 30
Sh	43	11	30	937	1	RO 11 p 96 no 1
Sh	44A	1	30*	939	1	MVN 3 200
Sh	44A	1 min	29*		2	MVN 10 169
Sh	44A	3	30	941	3	TS 69 Needs collation
Sh	44A	4 min	29		2	PDT 460
Sh	44A	7	30	945	2	CST 76 +:
Sh	44A	7	30		3	CST 70 +
Sh	44A	13	30	951	1	MVN 2 169
Sh	45	1	30	952	4	TRU.278
Sh	45	6	29*		2	Nik 2 496 +
Sh	45	6	30*		1	MVN 13 517 + mu-DU A2-ki-ti; different month?
Sh	45	7	29	-958	2	MVN 13 224 +
Sh	45	7	29		4	TS 177 + Needs collation
Sh	45	8	30	959	1	MVN 13 127 +
Sh	45	8	30		3	TRU 276 +
Sh	45	9	30	960	1	RA 9 SA 17 +
Sh	45	9	30		1	AnOr 7 74 +
Sh	45	9	30		2	BIN 3 496 +
Sh	46	2	30	965	1	TCL 2 5516 +
Sh	46	2	30		3	TS 120 + Needs collation
Sh	46	3	30	966	1	STD 12
Sh	46	4	30	967	1	TRU 262 +
Sh	46	4	30		1	MVN 11 149 +
Sh	46	4	30		3	TCL 2 5510 + Needs collation
Sh	46	5	29	-968	2	RO 5 p 5 no 4
Sh	46	6	30	969	4	CST 115
Sh	46	7	30	970	1	HVN 11 141
Sh	46	10	30	973	2	PDT 414 +
Sh	46	10	30		2	BIN 3 10 +
Sh	46	10	30		2	JCS 24 29 +
Sh	46	11	30	974	1	TRU 270 +
Sh	46	11	30		2	CST 150 +
Sh	46	11	30		3	HVN 13 512 + Needs collation
Sh	46	12	30	975	2	SRD 10
Sh	47A	1	30	976	1	DC 1 289 +
Sh	47A	1	30		3	Aegyptus 19 p 228 + Needs collation
Sh	47A	2	30	977	3	MVN 8 102
Sh	47A	5	30	980	2	OrAn 11 p 273
Sh	47A	7	30	982	1	TRU 114 +

K	Y	M	D	Syz#	Type	Source
Sh	47A	7	30		1	Nik 2 450 +
Sh	47A	7	30		1	AAS 212+ Needs collation
Sh	47A	7	30		1	AUCT 1 896 +
Sh	47A	7	30		3	AUCT 1 376 + Needs collation
Sh	47A	8	29	-983	3	POL 19 321 (4*)
Sh	47A	9	30	984	1	SETDA 97 +
Sh	47A	9	30		4	STD 13 +
Sh	47A	10	30	985	1	Bab 7 p 78 no 14
Sh	47A	11	30	986	1	CST 194 +
Sh	47A	11	30		1	JCS 24 6 +
Sh	47A	11	30		1+3	MVN 13 429 +
Sh	47A	11	30		3	Aegyptus 19 p 227 no 1 +
Sh	47A	13	29	-988	2	UCP 9 p 182 no 31
Sh	48	3	30	991	4	JCS 31 p 172f "c" HSM 911.3.93
Sh	48	8	30	996	1	POL 19 156 (13)
Sh	48	9	29	-997	3	MVN 2 160
Sh	48	10	29	-998	5	RA 9 SA 56 ?
Sh	48	11	30*	999	2	PDT 343 +
Sh	48	11	28*		3	AUCT 1 331 + Needs collation
AS	1	1	30	1001	1	TCL 2 5563 +
AS	1	1	30		1	SET 29 +
AS	1	2	29	-1002	4	RA 9 SA 60
AS	1	3	30	1003	1	CST 222
AS	1	4	30	1004	1	CST 227 +
AS	1	4	30		1	TLB 3 130 +
AS	1	6	30	1006	1	MVN 10 146 + year uncertain
AS	1	6	30		5	Or 47-49 8 +
AS	1	7	30	1007	1	AUCT 1 101
AS	1	10	30	1010	1	AUCT 1 25
AS	2	1	30	1013	1	CT 32 pl 48b
AS	2	3	30	1015	1	PDT 171 +
AS	2	3	30		1	TS 108 +
AS	2	3	30		1	Or 47-49 10 +
AS	2	5	30	1017	1	Or 47-49 65 +
AS	2	5	30		1	Or 47-49 71+
AS	2	5	30		1	JCS 14 p 108 YBC 12560 +
AS	2	5	30		3	POL 19 345 (Bab 12) +
AS	2	5	30		4	SRD 15 +
AS	2	7	30	1019	1	AUCT 2 365
AS	2	11	30	1023	1	BIN 3 44 +
AS	2	11	30		1	AUCT 1 808 +
AS	2	11	30		2	RA 9 SA 92 +
AS	2	12	30	1024	1	TCL 2 5498
AS	3A	3	30	1027	1	TRU 43 +
AS	3A	3	30		3	MVN 11 184 +
AS	3A	4	30	1028	1	BIN 3 527
AS	3A	6	30	1030	1	TRU 318 +
AS	3A	6	30		1	BRM 3 72 +
AS	3A	6	30		1	AnOr 1 11 +
AS	3A	6	30		1	Or 47-49 24 +
AS	3A	6	30		2	PDT 537 +
AS	3A	7	30	1031	4	SETDA 144
AS	3A	9	30	1033	1	CST 282
AS	3A	10	30	1034	1+3	BIN 3 368
AS	3A	11	30	1035	1	MVN 13 443 +
AS	3A	11	30		1	MVN 13 446 +
AS	3A	12	29	-1036	6	PDT 150 +

K	Y	M	D	Syz#	Type	Source
AS	3A	12	29		6	Or 47-49 74 +
AS	3A	13	30*		1	BIN 3 67 +
AS	3A	13	29*		3	TRU 330 +
AS	4A	1	30	1038	1	UCP 9 p 242 no 45
AS	4A	2	30	1039	1+6	PDT 211
AS	4A	3	30	1040	1	BIN 3 79
AS	4A	4	29	-1041	6	AJSL 38 p 141
AS	4A	5	30	1042	1	AUCT 1 700
AS	4A	6	30	1043	1	TAD 11
AS	4A	7	29	-1044	4	SETDA 152
AS	4A	8	30	1045	1	TRU 326 +
AS	4A	8	30		1	RA 10 p 210 BM 103413 +
AS	4A	8	30		1	AUCT 1 134 +
AS	4A	10	30	1047	1	AUCT 2 126
AS	4A	11	30	1048	1	AUCT 1 242
AS	4A	12	29	-1049	2	RA 9 SA 129
AS	4A	13	29	-1050	3	St.Louis B3 cited in M.Cooper (diss.) p 48
AS	5	1	30	1051	1	SET 15 +
AS	5	1	30		1	SET 16 +
AS	5	1	30		4	SET 62 +
AS	5	2	30	1052	1	PDT 62 +
AS	5	2	30		1	CST 306 +
AS	5	2	30		2	MVN 5 112 +
AS	5	3	29	-1053	3	PDT 439
AS	5	4	30	1054	1	PDT 74 +
AS	5	4	30		1	CST 314 +
AS	5	5	30	1055	1	PDT 118 +
AS	5	5	30		1	SA XLVI +
AS	5	5	30		2	RA 9 p 50 SA 143 + no copy
AS	5	6	30	1056	1	CST 323 +
AS	5	6	30		1	ASJ 7 P 122 no 7 +
AS	5	7	30	1057	3	PDT 584
AS	5	8	30	1058	1	DC 1 256 +
AS	5	8	30		1	DC 1 311 +
AS	5	8	30		3	PDT 584 +
AS	5	9	30	1059	1	CST 333 +
AS	5	9	30		3	PDT 584 +
AS	5	10	30	1060	1	Nik 2 512
AS	6	2	30	1064	1	MVN 8 57
AS	6	3	29	-1065	3	MVN 13 49 Needs collation
AS	6	4	30	1066	1	JANES 9 p 21 no 4
AS	6	8	30	1070	1	SETDA 158 +
AS	6	8	30	1071	1	AUCT 1 827 +
AS	6	8	30		1	MVN 13 838 +
AS	6	8	30		1	JCS 14 p 112 NBCT 1556 +
AS	6	9	30	1072	1	AUCT 1 253 +
AS	6	9	30		1	AUCT 2 65 +
AS	6	9	30		1	Or 47-49 94 +
AS	6	9	30		1+3	TRU 283 +
AS	6	10	30		6	SET 22 ?
AS	7	1	29	-1075	3	AUCT 2 89 +
AS	7	1	29		6	UDT 125 +
AS	7	2	30	1076	1	SET 101 +
AS	7	2	30		1	HVN 8 80 +
AS	7	2	30		1+6	Or 47-49 104 +
AS	7	3	29	-1077	6	AUCT 1 125
AS	7	4	30*		1	JCS 14 p 109 MLC 84 +

K	Y	M	D	Syz#	Type	Source
AS	7	4	30*		2	MVN 13 694 +
AS	7	4	29*		3	RA 9 SA 168 + Needs collation
AS	7	5	30	1079	1	CT 32 pl 28-29 +
AS	7	5	30		2	TRU 346 +
AS	7	5	30		4	AUCT 1 694 +
AS	7	7	30	1081	1	Or 47-49 55 +
AS	7	7	30		1+6	AUCT 2 375 + year broken
AS	7	8	30	1082	1	TCL 2 5590 +
AS	7	8	30		1	AnOr 1 15 +
AS	7	9	30	1083	1	TRU 13 +
AS	7	9	30		1	AueT 1 711 +
AS	7	9	30		1	Or 47-49 110 +
AS	7	12	30	1986	1	BRM 3 71 +
AS	7	12	30		3	TRU 333 +
AS	8	2	30	1088	1	AUCT 1 801
AS	8	4	30	1090	1+6	AUCT 1 923
AS	8	6	30	1092	1	JCS 23 30
AS	8	7	30	1093	1	Sigrist p 5 +
AS	8	7	30		4	AUCT 1 263 +
AS	8	8	30	1094	4	AUCT 2 176 +
AS	8	8	30		6	MVN 13 568 +
AS	8	9	30	1095	1	BIN 3 186 +
AS	8	9	30		1	AUCT 1 266 +
AS	8	9	30		1	AUCT 1 891 +
AS	8	10	29	-1096	2	POL 19 248 (012)
AS	8	11	30	1097	1	SET 105 +
AS	8	11	30		1	AUCT 1 187 +
AS	8	12	30	1098	1+6	AUCT 1 97 +
AS	8	12	30		1+6	AUCT 1 221 +
AS	9A	1	28*		6	AUCT 1 398 Needs collation
AS	9A	6	30	1104	1	AUCT 1 900
AS	9A	9	30	1107	4	JCS 31 p 173 "E" ASM 12078
AS	9A	10	29	-1108	2	POL 19 152 (H37)
AS	9A	11	30	1109	1	PDT 384
SS	1A	2	30	1113	2	TCL 2 5527 +
SS	1A	2	30		2	BIN 3 218 +
SS	1A	3	30	1114	1	AUCT 1 559 +
SS	1A	3	30		1	AUCT 2 82 +
SS	1A	6	30	1117	1	PDT 298
SS	1A	8	30	1119	1	Or 47-49 122
SS	1A	9	30	1120	1	TS 93
SS	1A	12	29	-1123	2	RA 9 p 62 AM 13
SS	2A	3	30	1127	1	BIN 3 222
SS	2A	4	30	1128	1	MVN 3 247
SS	2A	6	30	1130	2	BIN 3 221
SS	2A	8	30	1132	1	Brooklyn Museum 74.71.17 Owen copy
SS	2A	9	30	1133	4	PDT 573 collated OrAn 14
SS	2A	10	29	-1134	4	BIN 3 558
SS	2A	12	29	-1136	4	Bab 7 p 78 no 12
SS	3	3	30	1140	1	RA 9 SA 209 +
SS	3	3	30		1	Sigrist p 18 +
SS	3	6	30	1143	1	TS 169
SS	3	12	29	-1149	2	CT 32 pl 12
SS	4	3	30*		1	MVN 8 135 +
SS	4	3	30*		1	Sigrist p 32 +
SS	4	3	29*		2	Nik 2 480 +
SS	4	8	30	1157	1	AUCT 1 284 +

K	Y	M	D	Syz#	Type	Source
SS	4	8	30		1	UM not accessioned + Owen copy
SS	4	9	29	-1158	2	POL 19 50 (E5) +
SS	4	9	29		5	PDT 514 +
SS	4	10	29	-1159	2	AUCT 2 244
SS	4	12	30	1161	1	SRD 24
SS	5A	3	30	1164	2	SETDA 174
SS	5A	5	30	1166	4	AUCT 2 372
SS	5A	8	30	1169	1	MVN ll 148
SS	5A	11	30	1172	1	MVN 13 692
SS	5A	12	30	1173	1	MVN 13 427 ?
SS	6A	2	30	1176	1+4	CTC 7
SS	6A	3	29	-1177	4	CST 436
SS	6A	4	30	1178	1	TRU 253
SS	6A	11	30*		1	TRU 357 +
SS	6A	11	29*		2	PDT 564 +
SS	6A	13	30	1187	1	TRU 4 +
SS	6A	13	30		1	Jones AV (Cadorini 4) +
SS	7	1	29	-1188	3	MVN 13 422 +
SS	7	1	29		3	TLB 3 34 +
SS	7	7	29	-1194	3	AUCT 2 15
SS	7	8	30	1195	3	AUCT 2 15
SS	7	9	30	1196	1	MVN 13 484 +
SS	7	9	30		3	AUCT 2 15 +
SS	7	9	30		4	MVN 13 646 +
SS	7	10	30	1197	3	AUCT 2 15
SS	8	1	30	1200	1	PDT 526 +
SS	8	1	30		3	Aegyptus 19 p 230 no 5 + Needs collation
SS	8	6	30	1205	3	PDT 409
SS	8	7	29	-1206	5	YOS 4 245 +
SS	8	7	29		3	SETDA 178 +
SS	8	8	30	1207	5	YOS 4 245
SS	8	9	29	-1208	5	Y0S 4 245
SS	8	10	30	1209	5	YOS 4 245 +
SS	8	10	30		3	AUCT 1 543 +
SS	8	11	30	1210	5	YOS 4 245
SS	8	12	30	1211	5	YOS 4 245 +
SS	8	12	30		2	MVN 13 115 +
SS	8	12	30		3	MVN 13 89 +
SS	9	4	30	1215	1	SET 87 Chart
SS	9	6	29	-1217	3	SET 87 xii 596-98
SS	9	7	30	1218	1	SET 87 + Chart
SS	9	7	30		1	AUCT 1 715 +
SS	9	7	30		3	SET 87 xii 599-601 +
SS	9	7	30		3	UDT 171 +
SS	9	9	29	-1220	3	PDT 7
SS	9	10	30	1221	1	SET 87 + Chart
SS	9	10	30		1	AnOr 7 108 +
SS	9	10	30		3	SET 87 xii 608-10 +
SS	9	10	30		3	TSDU 94 +
SS	9	10	30		3	AUCT 1 224 +
SS	9	11	30	1222	1	SET 87 + Chart
SS	9	11	30		3	SET 87 xii 613-15 +
SS	9	12	30	1223	3	SET 87 xii 614-16
IS	1A	1	30	1224	4	AUCT 1 443 +
IS	1A	1	30		5	CT 32 pl 47a +
IS	1A	4	30	1227	1	OrAn 14 p 16
IS	1A	8	29	-1231	5	YOS 4 302

K	Y	M	D	Syz#	Type	Source
IS	1A	12	30	1235	2	BIN 3 260
IS	1A	13	29	-1236	2	TENS 63
IS	2A	1	29	-1237	3	TCL 2 5507
IS	2A	4	30	1240	1	BIN 3 618

Intercalary years are indicated by A after the number of the year.

Syzygy numbers (Syz#) are arbitrarily based at AS 1 1 = 1001. Months recorded as hollow are given a minus sign. If several months have the same recorded length, only one is considered. Questionable data are omitted (e.g. AS 6 10), also conflicting lengths are omitted (eg. AS 3 13).

Type:
1 = UD.30.KAM (or equivalent expression)
2 = New moon text
3 = Regular deliveries for Gula and/or the dogs
4 = Other regular deliveries for a month
5 = Unique-text type or information
6 = Terminated(?) regular deliveries

UMMA MONTH-LENGTHS (FROM HUBER et al. 1982)

K	Y	M	D	Syz#	Type	Source
AS	1	2	30	1002		
AS	2A					
AS	3	1	29	-1026		
AS	3	4	30	1029		
AS	3	11	30	1036		
AS	4A					
AS	5	4	30	1054		
AS	5	7	30	1057		
AS	5	8	30	1058		
AS	5	9	29	-1059		
AS	5	10	30	1060		
AS	5	11	29	-1061		
AS	6A	1	30	1063		
AS	6A	3	29	-1065		
AS	6A	7	30	1069		
AS	6A	12	30	1074		
AS	7	5	29	-1080		
AS	7	6	30	1081		
AS	7	8	29	-1083		
AS	7	11	29	-1086		
AS	8	7	30	1094		
AS	8	10	30	1097		
AS	9					
SS	1A	4	30	1115		
SS	1A	13	30	1124		
SS	2	2	29	-1126		
SS	2	4	30	1128		
SS	2	5	29	-1129		
SS	2	6	30	1130		
SS	2	7	30	1131		
SS	2	8	30	1132		
SS	2	12	29	-1136		
SS	3A	4	30	1140		
SS	3A	6	30	1142		B
SS	3A	9	29	-1145		
SS	3A	10	30	1146		
SS	3A	11	29	-1147		
SS	3A	12	30	1148		
SS	3A	13	30	1149		B
SS	4	1	29	-1150		
SS	4	3	30	1152		
SS	4	6	30	1155		
SS	4	7	30	1156		
SS	4	8	30	1157		
SS	4	9	30(29)			
SS	4	10	30	1159		
SS	4	11	29	-1160		
SS	4	12	30	1161		
SS	5	1	29	-1162		
SS	5	3	29	-1164		
SS	5	5	30	1166		B
SS	5	11	30	1172		B
SS	6A	3	29	-1176		
SS	6A	7	29	-1180		
SS	7A					

K	Y	M	D	Syz#	Type	Source
SS	8	9	29	-1208		
SS	9	5	30	1216		
SS	9	8	30	1219		
SS	9	12	30	1223		
IS	1A	8	30	1231		
IS	2A	3	29	-1239		
IS	2A	5	29	-1241		
IS	2A	9	29	-1245		
IS	2A	10	29	-1246		
IS	2A	12	29	-1248		
IS	3	4	30	1253		
IS	3	7	30	1256		
IS	3	9	29	-1258		
IS	3	10	30	1259		

The raw data (which included the Type and the Source) unfortunately were lost. A few entries were added after the monograph had been printed (marked B in the Source field; they were ignored in the later analysis).

The first four columns give King, Year, Month and Day.

Intercalary years (some of them conjectural) are indicated by A after the number of the year.

Syzygy numbers (Syz#) are arbitrarily based at AS 1 1 = 1001. Months recorded as hollow are given a minus sign. If several months have the same recorded length, only one is considered. Questionable data are omitted.