Journal of Astronomical History and Heritage, 22(3), 479–491 (2019).

THE CALENDARS OF SOUTHEAST ASIA. 6: CALENDRICAL RECORDS

Lars Gislén
Dala 7163, 24297 Hörby, Sweden.
Email: larsg@vasterstad.se

and

J.C. Eade
49 Foveaux St., Ainslie, ACT 2602, Australia.
Email: jceade@gmail.com

Abstract: Calendrical inscriptions and chronicles are an important source of information on the history and civilisation of Southeast Asia. Most of the records are horoscopes but there are also inscriptions commemorating the foundation of temples and other important buildings, and on Buddha images. Stone inscriptions are necessarily commemorative and the event celebrated is frequently of considerable social, political, and religious importance.

Keywords: History of astronomy, Southeast Asia, traditional calendars, inscriptions, chronicles

1 INTRODUCTION: COMPUTER TOOLS

Many of the calendrical records contain redundant data, something that is very useful for dating when part of a record has been eroded or damaged.[1] For the Mainland Southeast Asian records, the Burmese and Thai calendrical procedures[2] have been implemented in a Java application, SEAC (SouthEast Asian Calendars), which can be run on both Macintosh and Microsoft Windows platforms. The use of a computer application that emulates the calendars means that the dating of inscribed records is greatly facilitated. Computing a Burmese or Thai horoscope by hand can require six hours or more. Using a computer these calculations can easily be checked almost instantly. It is possible to enter several different eras, Chulasakarat, Mahasakarat, Buddhasakarat, and Anchansakarta, which are those used in Thai chronology. For Burmese records it is possible to enter the Arakanese, Makaranta and Thandeikta eras. There is also an option to enter Western dates, sexadecimal years and days, and compute *lagna* from time and *vice versa*, and also shadow lengths. Dates can be stepped up and down by years and days and there is an option to search for selected combinations of sexagesimal years and weekdays. The application calculates true longitudes of the planets, *tithi*, *naksatra* and *yoga*, as well as the cyclic day and year, and also the calendar fundamentals, *ahargana*, *kammacabala*, *uccabala*, *avoman* and *masaken*. There is also a graphical output (*zata*/*duang*) of the calculated positions of the planets in the zodiac. A typical output of the application is shown in Figure 1.

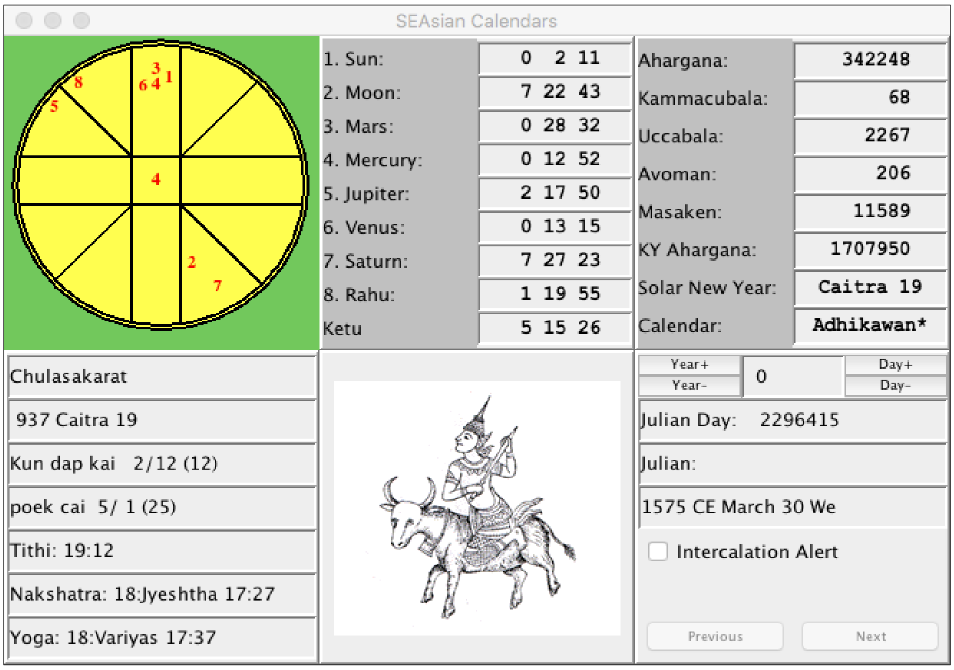
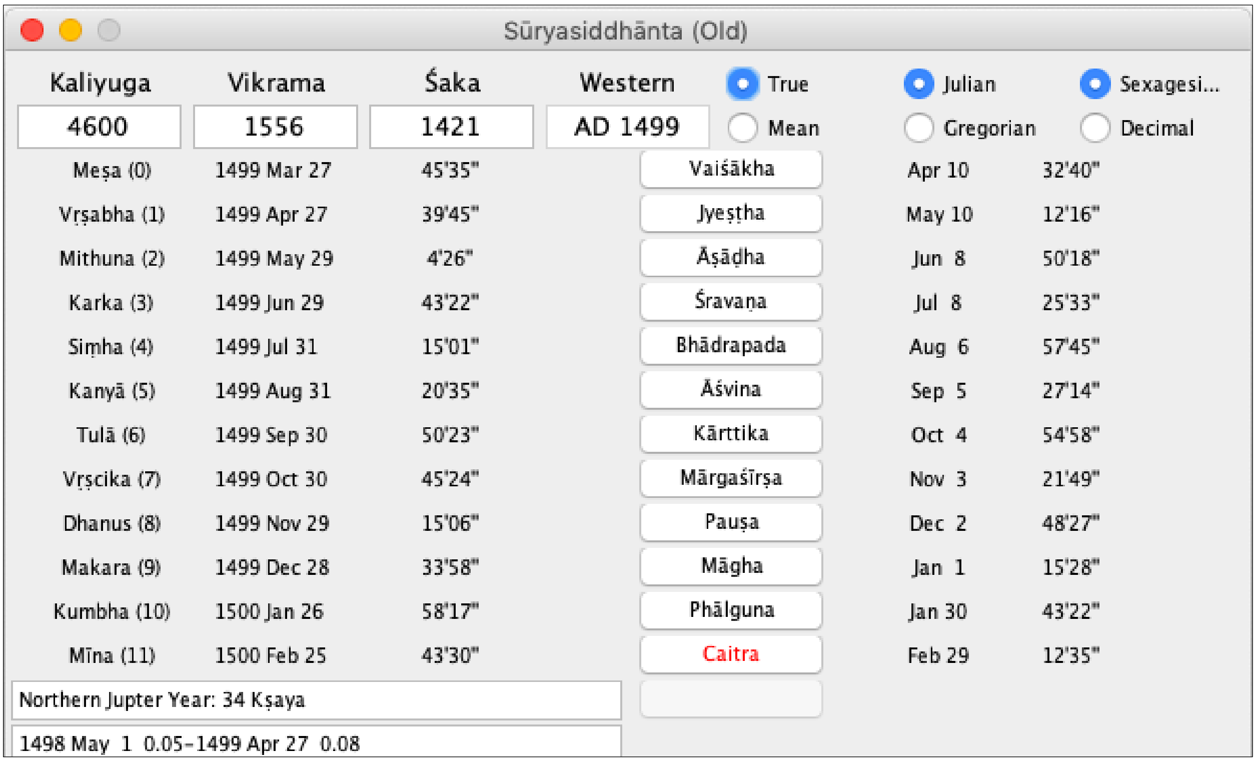


Figure 1: Application output of SEAC.



Sūryasiddhānta (Old)

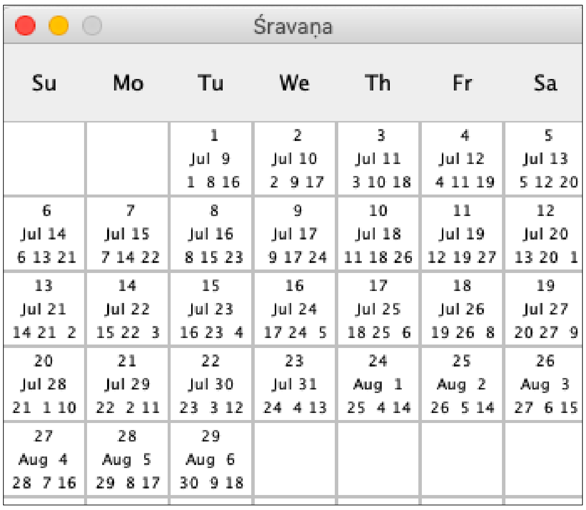
Kaliyuga	Vikrama	Śaka	Western	True	Julian	Sexagesi...
4600	1556	1421	AD 1499	Mean	Gregorian	Decimal
Meṣa (0)	1499 Mar 27	45'35"	Vaiśākha		Apr 10	32'40"
Vṛṣabha (1)	1499 Apr 27	39'45"	Jyeṣtha		May 10	12'16"
Mithuna (2)	1499 May 29	4'26"	Āṣāḍha		Jun 8	50'18"
Karka (3)	1499 Jun 29	43'22"	Śravaṇa		Jul 8	25'33"
Siṃha (4)	1499 Jul 31	15'01"	Bhādrapada		Aug 6	57'45"
Kanyā (5)	1499 Aug 31	20'35"	Āśvina		Sep 5	27'14"
Tulā (6)	1499 Sep 30	50'23"	Kārttika		Oct 4	54'58"
Vṛścika (7)	1499 Oct 30	45'24"	Mārgaśīrṣa		Nov 3	21'49"
Dhanus (8)	1499 Nov 29	15'06"	Pauṣa		Dec 2	48'27"
Makara (9)	1499 Dec 28	33'58"	Māgha		Jan 1	15'28"
Kumbha (10)	1500 Jan 26	58'17"	Phālguna		Jan 30	43'22"
Mīna (11)	1500 Feb 25	43'30"	Caitra		Feb 29	12'35"

Northern Jupter Year: 34 Kṣaya

1498 May 1 0.05-1499 Apr 27 0.08

Figure 2: Application output of HIC: Main window.

The top left panel shows a graphical layout of the position of the planets in the zodiac, the *zata* (Burmese) or *duang* (Thai) divided into twelve slots that represent the twelve zodiacal signs. The top slot is Aries, then follows, in anti-clockwise order, Taurus, Gemini and so on. The centre of the *duang* shows the weekday, in this case 4 = Wednesday. The top middle panel shows the true longitudes of the planets in format sign, degree, minutes of arc. The top right panel shows the calendar elements: *ahargana*, *kammacabala*, *uccabala*, *avoman*, and *masaken*, followed by the *ahargana* counted from the Kaliyuga epoch: 18 February 3202 BCE. Then follows the solar New Year date and the type of year, in this case it is a year with an intercalary day (*adhikawan*) and the asterisk indicates that the particular solar year is a leap year.



Śravaṇa

Su	Mo	Tu	We	Th	Fr	Sa
		1 Jul 9 1 8 16	2 Jul 10 2 9 17	3 Jul 11 3 10 18	4 Jul 12 4 11 19	5 Jul 13 5 12 20
6 Jul 14 6 13 21	7 Jul 15 7 14 22	8 Jul 16 8 15 23	9 Jul 17 9 17 24	10 Jul 18 11 18 26	11 Jul 19 12 19 27	12 Jul 20 13 20 1
13 Jul 21 14 21 2	14 Jul 22 15 22 3	15 Jul 23 16 23 4	16 Jul 24 17 24 5	17 Jul 25 18 25 6	18 Jul 26 19 26 8	19 Jul 27 20 27 9
20 Jul 28 21 1 10	21 Jul 29 22 2 11	22 Jul 30 23 3 12	23 Jul 31 24 4 13	24 Aug 1 25 4 14	25 Aug 2 26 5 14	26 Aug 3 27 6 15
27 Aug 4 28 7 16	28 Aug 5 29 8 17	29 Aug 6 30 9 18				

Figure 3: The HIC month window.

The bottom left panel shows the name of the era, the Southeast Asian date, the cyclic year, the cyclic day, the *tithi*, *naksatra*, and *yoga*. The *tithi* is numbered from 1 to 29/30 while the normal custom in Southeast Asia is to count the first half of the month as 1 to 15 waxing and the second half as 1 to 14/15 waning. The bottom central panel shows a picture taken from an illustration of the Khmer zodiac (Faraut, 1910: 186). The bottom right panel contains buttons for stepping year and day up and down and shows the *sutin* or the day number in the solar year. Then follow the Julian Day number (at noon) and the date in the Common Era, in this case showing the date in the Julian calendar. This will automatically switch to dates in the Gregorian calendar if the date is later than 4 October 1582 Julian, the inauguration date of this calendar. The bottom buttons are used for searches in the sexagesimal cycles. The menus of the application (not shown in the figure) allow different eras to be chosen as well as years, months, and days, among other things.

The Indonesian records are based on the Indian canons but can in practice sometimes have deviating intercalations. Here three Indian canons, the Aryabhata canon and the original as well as the modern *Sūryasiddhānta* canons have been implemented in the Java application HIC (Hindu Calendars) using the canonical Indian intercalation scheme. The Indonesian *wuku* calendar is also implemented. Figures 2–4 show typical outputs of the program.

At the top there are slots for entering the year in different eras. Below left are the solar months and the times when they start. On the right are the lunar months and their starting times, and top right are some radio buttons that govern the output format. The bottom left shows the information on the Jupiter sexagesimal cycle, although this is normally not used in the Southeast Asian chronology. A new window, the month window (Figure 3), is brought up by clicking on the relevant lunar month button.

The month window shows the layout of the days in the selected month. Each day is sequentially numbered, then the corresponding Western date is given, followed by the number triad of the *tithi*, *naksatra*, and *yoga*. By clicking on any day slot in this window, the day window is brought up (Figure 4).

The day window shows the positions of the *yoga*, *naksatra*, and *tithi* relative to the day as three parallel and horizontal lines that also show the times when they are in force. At the top are the two *karana* that are part of the *tithi* in force. Below the graphical display is the Indian date, the Western date, the *kaliyuga ahargana*, the *wuku* cyclical days and the *wuku* week and the following three buttons bring up some extra help windows. In the Indian calendar, there is sometimes a suppressed *tithi* and in order that the date be uniquely defined, the day is denoted by its civil day number preceded by a hash. The computer application should be seen as an Indian norm with which to compare the Indonesian records and discover possible structures in the intercalation schemes.

There is also a third small Java application, Pawukon Calendar, that implements the pawukon

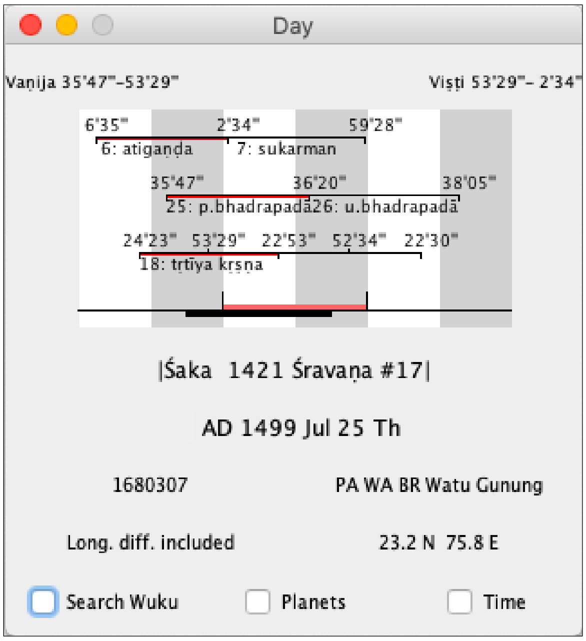


Figure 4: The HIC day window.

calendar. Any date in the Gregorian or Julian calendar can be entered (see Figure 5).

Finally, there is an application that implements the Pakkhakhanana calendar of King Rama IV (Mongkut) of Siam (see Figure 6).

These applications can be accessed freely and downloaded from the following website, http://home.thep.lu.se/~larsg/Site/SEATools.zip together with their manuals. There are versions for both the Windows and the Macintosh platforms.

The following sections show some typical calendrical records with comments. More than six hundred inscriptions and records analysed in

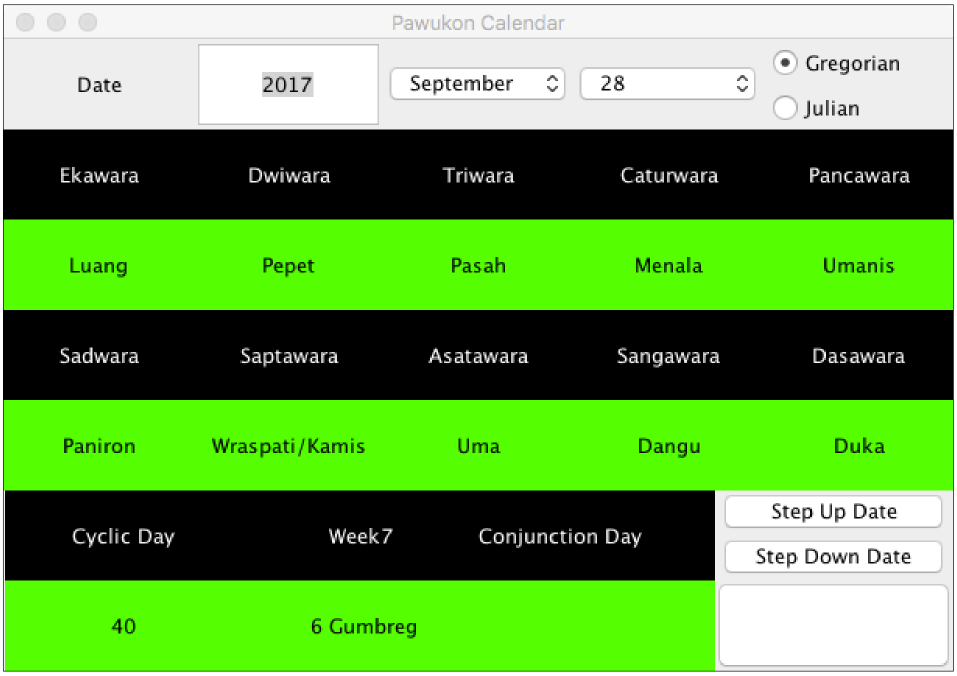


Figure 5: The Pawukon Calendar application.

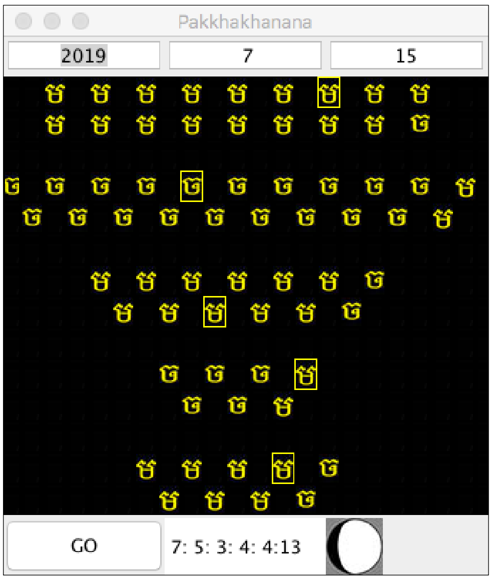


Figure 6: The Pakkhakhanana application.

detail can be found in Eade (1996) for Thailand; for Cambodia and Laos see Eade (1995); and for early Javanese inscriptions see Eade and Gislén (2000). While the selection of examples below will illustrate the typical structure of the records, we do not intend to present a deeper analysis of them here.

2 BURMA

The historical record of Burma has a particular distinction. As with Thailand and Cambodia there is a corpus of stone inscriptions recording political change, the founding of monasteries and the dedication of Buddha images. There is, however, another copious source of information—that provided by the many horoscopes on the walls of the temples of Pagan. This class of evidence has a title to be considered more fully in its own right. It presents many interesting problems and a wealth of data.

Predominantly they are horoscopes of individuals, and often they appear in clusters—the whole family, it seems, is represented. One has to assume that these *zata* were put in place either by persons making pilgrimage to Pagan or by locals, whose fortune in this life would be increased if their birth chart was set up in a holy place.

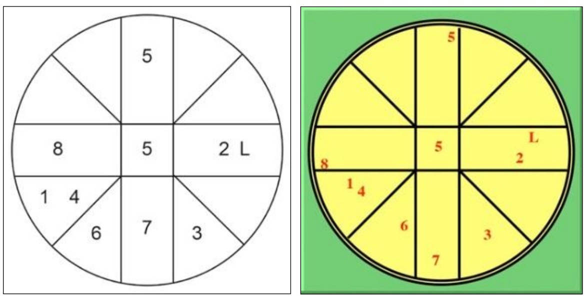


Figure 7: *Zata* from Hti-lo-min-lo (Pagan temple site 1812).

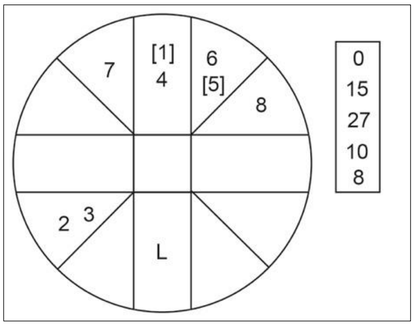
Whatever the motive and occasion, these memorials present the historian with enormously valuable information. The convention of using *zata* as a way of fortifying a historical record was also used widely in Northern Thailand, where many stone inscriptions exhibit a horoscope diagram at the apex of the stone. But in the entire Thai record there are only three instances where the horoscope is amplified by a table that also defines numerically, and hence in closer detail, the position of the planets at the moment commemorated. In the Pagan record there are dozens of such tables, and the information they present (sometimes legibly, sometimes recoverable with the exercise of a certain ingenuity) proves to be very largely correct.

One problem posed by the *zata* is where their purported age does not match their good condition. There are exceptions, such as site 1391, Kubyak-nge (Myinkaba) where some remarkably well-preserved *zata* appear nonetheless to be originals, but in some cases it seems that the *zata* have been recopied onto the walls after renovation, at a time when the originals were no longer easy to read. By contrast, the figures of these renovated *zata* do not match their purported dates. One also finds such mistakes as the appearance of a planetary numeral twice in the same diagram.

Figure 7 left shows a *zata* from Pagan temple site 1812; to the right is part of the computer output. The date is 14 Tawthalin 934 in the Burmese era = 21 August 1572. The numbers are 1 for the Sun, 2 for the Moon, 3 for Mars, 4 for Mercury, 5 for Jupiter, 6 for Venus, 7 for Saturn, and 8 for Rahu. The ordering is the same as the Western allocation of the planets to the weekdays. The position of the *lagna*, L, indicates a time of about 4 p.m. All the planets are in their correct positions. The number 5 in the middle of the *zata* gives the weekday 5 = Thursday, which is also correct.

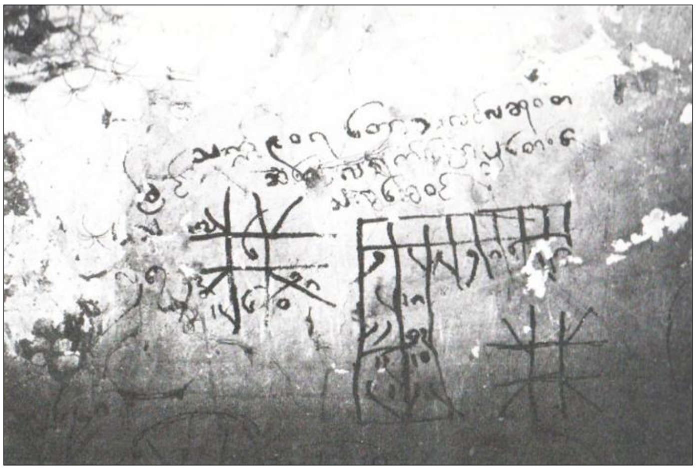
Figure 8 is a *zata* from the same place, that is partly illegible. However, it is accompanied by a table in which 0;15,27 and 10;8 can be read, the true longitude of the Sun and the *tithi*, respectively. The *tithis* can be converted into degrees 121° 36′ taking 30 *tithis* to correspond to 360°, which in turn gives the approximate longitude of the Moon as 15° 27′ + 121° 36′ = 137° 3′ = 4;17,3. It is now possible to reconstruct the date as Tuesday 23 April 1619 CE = 11 Kason 981 Burmese era. The computer output for the longitudes at midnight is shown to the right in the figure. Only Rahu (#8) is wrongly placed (in Aquarius, not in Capricorn). The *lagna* indicates a time of about 6 p.m. being opposite to the Sun.

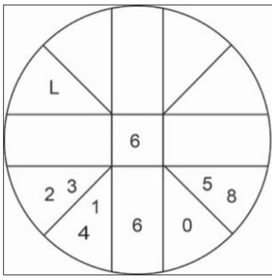
Many Burmese records (e.g. see Figure 9a–c) include a calculation of the longitudes of the planets. In this case only the longitudes of the



1. Sun:	0 15 27
2. Moon:	4 17 6
3. Mars:	4 27 18
4. Mercury:	0 8 43
5. Jupiter:	11 16 13
6. Venus:	11 2 21
7. Saturn:	1 13 36
8. Rahu:	9 7 44

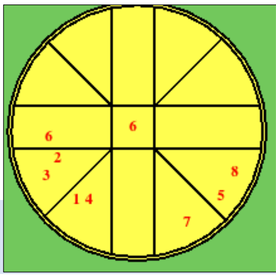
Figure 8: *Zata* from Pagan temple site 1812.





5	4	4	5	8	6	7	8

4	18
22	53
13	10
41	24



1. Sun:	5 4 21
2. Moon:	4 18 38
3. Mars:	4 21 25
4. Mercury:	5 3 4
5. Jupiter:	8 10 15
6. Venus:	3 18 22
7. Saturn:	7 16 1
8. Rahu:	8 22 3
Ketu	4 10 58

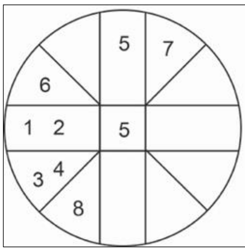
Figure 9a (above): *Zata* from Pagan temple site 2013: Mong-gu.
Figure 9b (right, top): Transliteration.
Figure 9c (right, bottom): Part of the computer output.

Sun and the Moon have been calculated completely with the *rasi*, or zodiacal sign, being given for the other planets. Venus, number 6, has *rasi* 6 in the table and in the *zata* but *rasi* 3 by the computer. Saturn, number 7, typically of many Burmese records, is denoted by 0, the reason perhaps being that in reckoning modulus seven, seven is the same as zero. The zodiacal positions of the planets except for Venus all agree with the computer output. The Burmese date is 29 (14 waning) Tawthalin 907 = 4 September 1545. The 6 in the centre answers to its being Friday, agreeing with the computer. However, the longitudes of the Sun and the Moon and the *lagna* fit a time slightly after midnight the next astronomical day, but is correct as the civil one.

Figure 10 shows a *zata* from site 1460 (just south of the city walls) that can be securely be dated to 2 Wagaung 1005 in the Burmese era = Thursday 16 July 1643. It contains a complete set of true longitudes for the planets as well as the *tithi* and *naksatra* (the two bottom numbers). The longitudes of the Moon and the Sun agree within a couple of arc minutes with the computer output. Also, the *tithi*, *nakshatra* and weekday are in place. The other planets do not agree very well. However, if the date is stepped back to 30 *Waso*, the end of the previous month, all are almost exactly reproduced.

It is a long and tedious procedure to calculate the true longitudes of the planets and obviously it was not done afresh for each horoscope but calculated for some specific dates and used for several records that were not too far away in time. As the planets, except for Mercury, move relatively slowly in longitude, the error would not be very large.

Figure 11 shows a *zata* from Wat Chiang Kham dating to 650 Kason 13 = 14 April 1288, and on the right is a transliteration. The *rasi* locations of the planets in the *zata* do not agree very well with the table but with the exception of Jupiter and Venus they do agree with the computer output. In the table and computer output Mars (3) is in *rasi* 5 but in the *zata* in *rasi* 4 and Jupiter (5) is in *rasi* 0 in the table but in *rasi* 11 in the *zata*. Only the table longitudes of the Moon and the Sun agree well with the computer, the other planets only



1	2	3	4	5	6	7	8
3	3	4	4	0	2	11	5
5	16	0	15	9	0	11	18
25	51	31	31	14	44	26	58

0	8
57	3

Figure 10: *Zata* at site 1460.

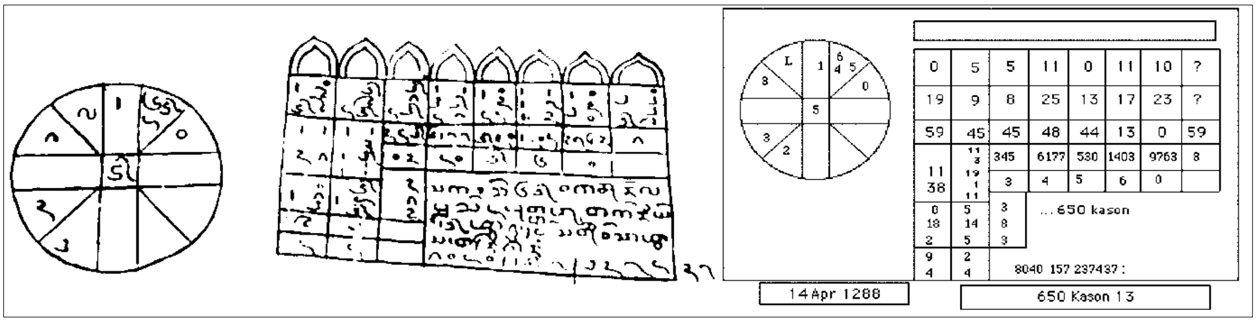


Figure 11: *Zata* from Wat Chiang Kham.

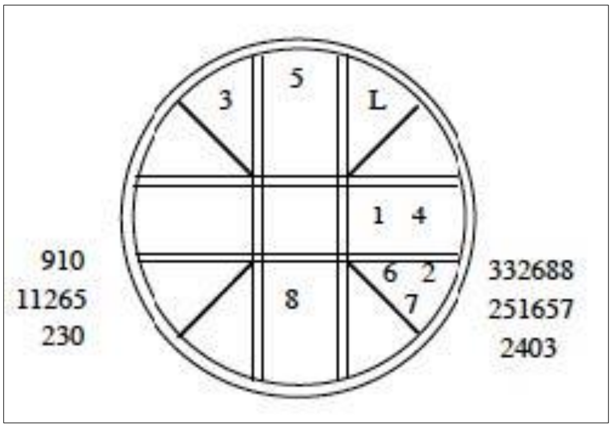


Figure 12: The Wat Chang Kam inscription (Prachum silacharuk, #74)

approximately. The *tithi* 11:38 agrees exactly with the computer output as do the mean longitudes of the Sun and the Moon, 0;18,2 and 5;14,5. Saturn as is common in Burmese records, is represented by number 0 instead of 7. The last item 0;22,59 is almost exactly opposite in the zodiac to the location of *Rahu* and could be interpreted as the location of the descending node. The precise longitudes of the Moon and the Sun are consistent with a time 0:12 after midnight on the following astronomical day, Kason 14; and the weekday 5 = Thursday in the centre of the *zata* is then correct. The line of numbers in the next to bottom line of the table is the ‘ages’ of the planets i.e. their mean longitudes expressed as days of their period. The line with numbers 8040, 157, and 237437 are the *masaken*, *avoman* and *ahargaṇa*, and they agree perfectly with the computer output.

3 THAILAND, LAOS AND CAMBODIA

The inscription in Figure 12 is from Wat Chang Kam in Thailand, and has a layout that is common for inscriptions from Thailand. A transliteration is given to the left in the figure. The body of the inscription reads:

> Chulasakarat 910, monkey, *pœk san*, month Magha … Thai month 5, waning 12; *mœng kai*, nearly noon, the Moon was *rœek* 19; Mula, *tithi* 27.

The cyclical year agrees with the computer output but the cyclic day should be *pœk si*. The top left number by alongside the *duang* is the Chulasakarat year 910. Top right is the *ahargana*, the elapsed days from the epoch 332688. The middle left number 11265 is the *masaken*, the number of elapsed lunar months since the epoch. The middle right number is the *kammacabala*, the bottom left number 230 is the *avoman*, and the bottom right number the *uccabala* 2403. Except for the *kammacabala* all the numbers and the positions in the *duang* are exactly reproduced by the computer. However, the *kammacabala* in the inscription, 251657, is 241657 by the computer. The digits 4 and 5 in Thai look rather similar and can easily be confused. The *lagna*, positioned in Pisces, gives the time as about 9:30 a.m. The date is 27 Magha 910 = Friday 25 January 1549.

The Wat Bang Sanuk inscription, Figure 13, is located at the mouth of the brook Huai Salok, on the west bank of the Yom River, in Ampho Wang Chin, Phra Province in northern Thailand at 17° 53′ N, 99° 35′ E. It is written to commemorate gifts from “… the ruler of Müang Tròk Salòp and Chæ Ngun …” (Wyatt, 2001) consisting of among others Buddha images. This was an occasion accompanied by music and festivities. The inscription is very interesting and unique because it is the oldest extant example of the Thai script. It uses the sexagesimal cycle for both the day and the year and can be uniquely dated. The dating part of the inscription is marked with red in Figure 13 and is transliterated

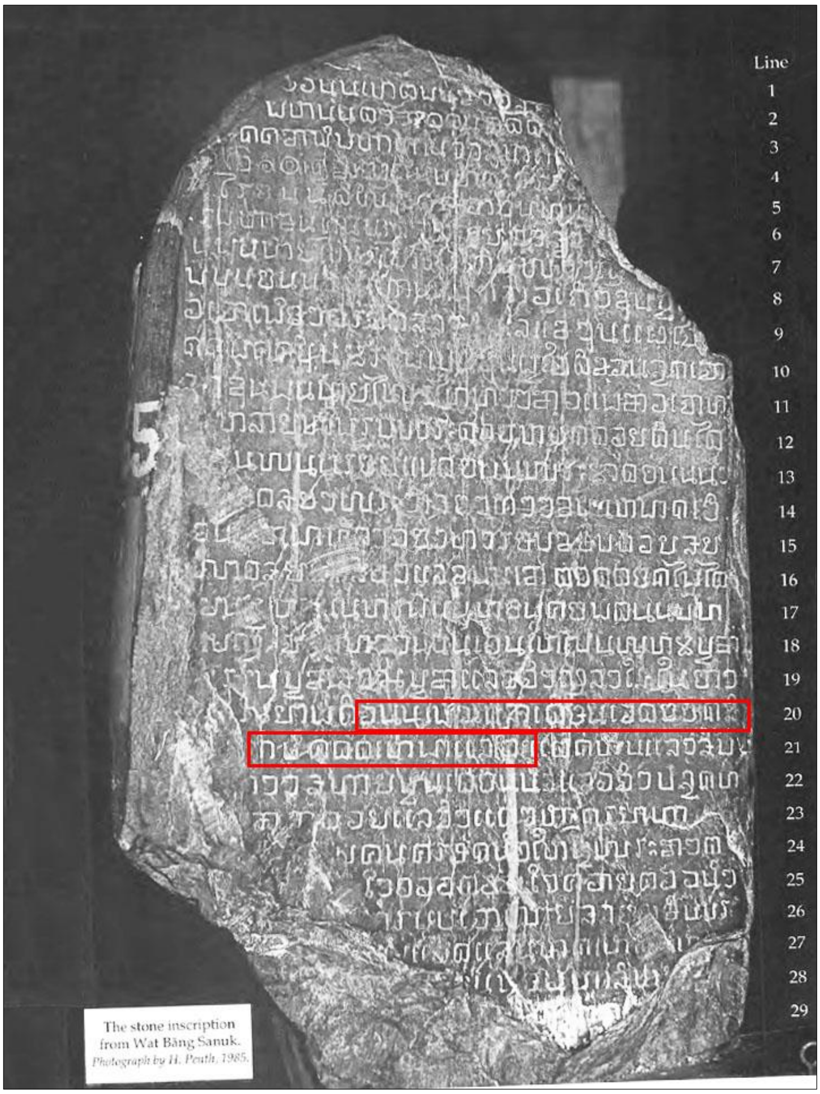


Figure 13: The Wat Bang Samuk inscription (after Wyatt, 2001).

ed into modern Thai script below:

(20) …วนน เมิง เปลา เดือน เจด ออก สิ… wann mœng plao düan cet òòk si
(21) [.]ํา ปี กดด เหมา แล โถะ …[p.kh]am pī katt hmao læ …

Translation: …day *mœng pao*, month seven, day 1[...] of the waxing Moon, year *kat mao* year of the hare…

An analysis (Penth, 1996) shows that the waxing day must be 11–15 and there are only two dates that fit the 60-day cycle data with an appropriate 60-year cycle. They differ in how the month number should be interpreted:

Chulasakarat *mœng pao* 11 Caitra 581 = Thursday 28 March 1219 (Chiang Mai style).
Chulasakarat *mœng pao* 12 Jyestha 581 = Monday 27 May 1219 (Sukhothai style).

Of these the first one is more probable, as the Thai words for the second one[3] could only fit into the space allocated on the stone with difficulty. The first date also occurs just one day after the New Year festival, which a day in Jyestha could not do. The year dating is critical because it challenges the earlier assumption that the earliest writing in Thai came from an inscription of King Ram Khamhæng of Sukhothai, dated CE 1292 and scholars have relied upon that inscription in their attempts to describe Siamese society at the end of the thirteenth century.

Figure 14 shows part of the inscription Wiang Kao at Phayao 12. The text with it reads:

Chulasakarat 875, cock, *ka rao*, month Citta according to the astronomers, Thai month 7, waning 8, *tithi* … *rœk* called Buppasat, Meng Thursday, Thai *tao* set.

All the calendrical data in the inscription agree with the computer and all the planets except Mercury (#4) are in their correct positions. The *lagna* gives a time of about 2:30 p.m. The date is 23 Caitra 875 Chulasakarat, the solar New Year = Tuesday 29 March 1513.

Sakarat 658, year *raway san* month Visakha waxing 8 nights, day 5. Thai day *mœng plao*, watch *trae rung* [3:00-4:30 a.m.], two *nadi* complete and two *pada*. The *lagna* is in a *nawang* of Jupiter in Mina *rasi* [Pisces].

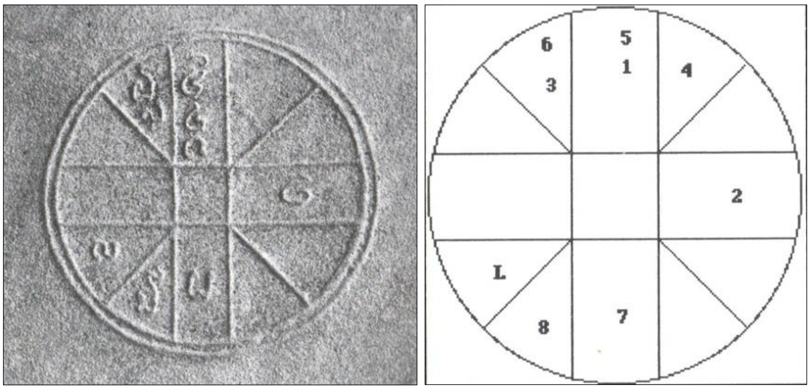
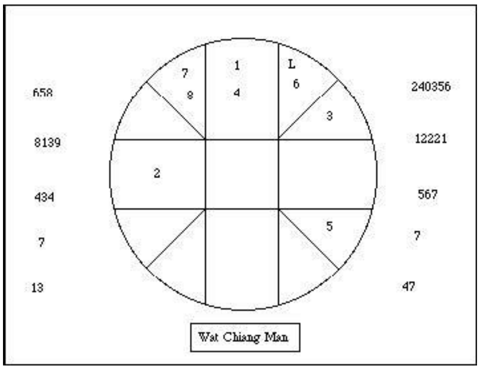


Figure 14: The Wiang Kao at Phayao 12 inscription (Prasert na Nagara, 1991: 129).



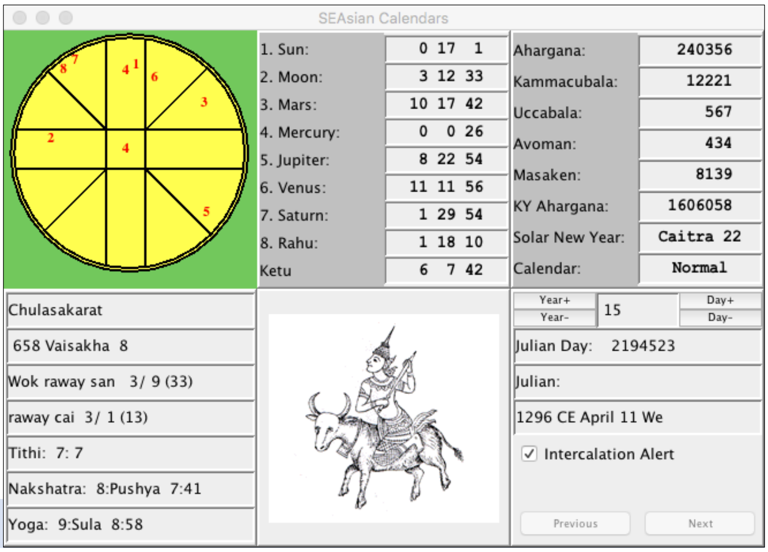


Figure 15a & b: The Wat Chang Man inscription, Chiang Mai (Prachum silacharuk #76).

The Chulasakarat date of the *duang* in Figure 15 is 8 Vaisakha 658 = Wednesday 11 April 1296. All the planets are in agreement with the computer as are the calendrical numbers. However, the *lagna*, *naksatra* and *tithi* all indicate a time of about 2:30 a.m. on the following morning. The watch given as *træ rung* is 3:00–4:30, which is also consistent with the cyclical day *mœng pao* of the record. This is one of the cases where the definitions of astronomical and civil day give different answers.

Some records date an event by counting the number of days since some important event in Buddha's life. These events are conventionally assumed to occur on the date of the full Moon of Vaisakha. Below are two examples that give an idea of the arithmetic involved in the reckoning.

Thai inscription 5 (Griswold, 1973: 159):

> ... on Wednesday, a ruang pao day in the Tai reckoning, in the naksatra of Punarvasu, towards evening, one thousand nine hundred and five years after our lord the Buddha entered Nirvana, [the king] was ordained. Counting by days from the Nirvana up to the day of his ordination, six hundred ninety-five thousand, six hundred and one days [695601] has elapsed.

The reckoning uses inclusive reckoning. As the year when Buddha entered Nirvana is 147 in the Achansakarat era (AS), the year of the king's ordination is 147 + 1904 = 2051 AS. The cyclical day, the weekday, and the *naksatra* determine uniquely the date as 22 Asvina 2051 AS = CE 22 September 1361. The date of Buddha entering the Nirvana is taken as 15 Vaisakha 147 AS.

By the beginning of 147 AS there had been 147·7/19 = 54 intercalary months since the epoch. By the end of 2051 AS (beginning of 2052) there had been 2052 × 7/19 = 756 intercalary months. Thus, in the years in between there were 756 – 54 = 702 intercalary months. In the interval to the end of 2051 AS were 1905 × 12 = 22860 normal lunar months, in total 22860 + 702 = 23562 lunar months.

From the beginning of the year 147 to the beginning of Vaisakha is one month and from the beginning of Asvina to the end of the year there are six months. Thus, there are 23562 – 7 = 23555 elapsed months between Vaisakha 147 and Asvina 2051. Each lunar month consists of 30 *tithis*. So, there are 23555 × 30 = 706650 *tithis* in the interval. Subtracting 14 *tithis* to reach Vaisakha 15 and adding 22 *tithis* to reach Asvina 22 we have 706650 – 14 + 22 = 706658 *tithis*. Remembering that one *tithi* corresponds to 692/703 civil days the number of civil days is (706658 × 692)/703 = 695600 days. Using inclusive reckoning this becomes 695601 days as stated in the inscription.

The cyclic day ruang pao is number 38 in the sexagenary cycle. The cyclic change in the interval is 695600 mod 60 = 20. The cyclic day of Buddha entering Nirvana is then 38 – 20 = 18 or *ruang sai*. The change in weekday is similarly 695600 mod = 3. The Starting week day is the Wednesday which minus 3 equals Sunday. Both these items agree perfectly with the computer calculation.

Thai inscription 3 (Griswold, 1973: 94, 96):

> Sakaraja (Mahasakarat) 1279 (2047 AS), year of the cock, eighth month (Ashada), fifth day of the waxing Moon, Friday, a kat rao day in the Tai reckoning, the Moon being in the naksatra of Purvaphalguni …
>
> If anyone asks, further, 'How long has it been from the day our lord attained Buddhahood under the srimahabodhi tree, up to the day this precious relic is being enshrined?', let the answer be given him: 'Counting the years, it is one thousand nine hundred and forty-six years; the year he reached Buddhahood was a year of the monkey. Counting by months, it is twenty-four thousand and sixty months; the month he reached Buddhahood was the sixth month (Vaisakha), on the day of the full Moon (tithi 15). Counting by days, it is seven hundred and ten thousand, four hundred and sixty-eight days [710468]; the day he reached Buddhahood was Wednesday, a tao yi in the Tai reckoning.

The date of the Buddhahood was assumed to be 15 Vaisakha 102 AS = CE 23 June 1357, the date of the enshrinement using the information above be can found to be 6 Ashada 2047 AS = 23 June 1357. Repeating the calculation and assuming inclusive reckoning we have:

The number of intercalary months up to the beginning of 102 AS is 37 and the intercalary months up to the beginning of 2048 is 754. In total, there are 717 intercalary months. The number of normal months is 1946 × 12 = 23352 months, in total 23352 + 717 = 23069 months. Subtracting one month for Caitra and nine months from the beginning of Ashada to the end of the year we are left with 23059 months or with inclusive reckoning 24060 months. The number of *tithis* is (24059 × 30) – 14 + 5 = 721761 moving 14 days forward to 15 Vaisakha and 5 days forward in Ashada. Converting the *tithis* to civil days 721761 × 692/703 = 710467 days, with inclusive reckoning 710468. The day *kat rao* is number 46 in the cycle, the change in cyclic number is 710467 mod 6 = 7 and the Buddha-hood cyclic day is then number 39, *tao yi*. The weekday change is 710467 mod 7 = 2: Friday – 2 = Wednesday. All the data agree with the inscription.

However, if we check the date using the computer we find that it corresponds to 15 Jyestha 102 AS, Wednesday, *tao yi*, and not 15 Vaisakha 102, Monday *tao san* as required. What has happened is that the year 102 AS is a year with an intercalary month that has been neglected in the count in the inscription.

The Wat Phra Dhatu Chæ Hæng inscription (Prasert naNagara, 1991: 62):

> Chulasakarat 948, year of the dog, Thai rawai set, month Maghna bright fortnight three, Thai month 5 waxing 3, weekday 1, Thai ka kai, the Moon in rœk 23 called 'tanisdata' (Danishta) in Mangkara (Capricorn) rasi. 2130 years past, nine months, eleven days, 2869 years to go, 2 months 19 days.

Table 1: Comparison of the inscription and the computer output.

	Inscription	Computed
Sun	9,03;09	9:02;57
Moon	9,28;20	9,28;16
Mars	5,11;42	5,05;36
Mercury	9,19;06	9,17;32
Jupiter	2,24;36	2,24;22
Venus	10,12;47	10,15;58
Saturn	0,02;21	0,00,59
Rahu	5,27;00	6,02,22
Tithi	02:05	02:06
Naksatra	22:22	22:22
Yoga	15:51	15:50

The date is 2 Magha 948 = 11 January 1587 agreeing with the cyclic day and year. The time past is normally given as the time from Vaisakha 15 but in this case from the New Year on Caitra 21, where Caitra 21 + 9 months 11 days = Magha 2. The sum of the times passed and to go is 2130 + 2869 = 4999 years, 9 + 2 = 11 months, and 11 + 19 = 30 days, equalling exactly 5000 years, as required.

The inscription in particularly interesting in that it is one of the very few Thai records that present planetary longitudes in addition to a *duang*. Table 1 shows a comparison between the inscription and the computer output for sunrise.

The differences in the true longitudes can perhaps be attributed to the complex process of converting mean positions to true positions. The *rœk* (*naksatra*) Danishta is number 23 in the *nakshatra* sequence starting with 1, 2, 3 …, but the 23rd *nakshatra* belongs to the interval 22–23.

4 AN EXAMPLE OF A DEVIATING THAI INTERCALATION

In this connection, it was useful to find in a Chinese academy report in the 1980s about the calendar used by the Dai in Southern China (Zhang and Chen, 1981), and also about the method adopted by two Northern Thai calendars-

Table 2: Deviating intercalation (years are in the Chulasakharat era).

(Year+1) mod 19	Year	Year Type	Year	Year Type	Year	Year Type	Year	Year Type
1			1254	A	1273	A*	1292	A
2			1255	C	1274	C	1293	C
3	[1237]	[A*]	1256	A	1275	A	1294	A*
4	[1238]	[B]	1257	B	1276	B*	1295	B*
5			1258	C	1277	C	1296	C
6			1259	A	1278	A	1297	A
7	[1241]	[B]	1260	A	1279	A*	1298	A*
8			1261	C	1280	C	1299	–
9			1262	B*	1281	B*	[1300]	[B*]
10	1244	C	1263	C	1282	C		
11	1245	A	1264	A*	1283	A		
12	1246	A	1265	A	1284	A*		
13	1247	C	1266	C	1285	C		
14	1248	B	1267	B*	1286	B*	[1305]	[B]
15	1249	A	1268	A*	1287	A		
16	1250	C	1269	–	1288	C		
17	1251	A	1270	–	1289	A*		
18	1252	C	1271	–	1290	C		
0/19	1253	B	1272	-	1291	B	[1310]	[B]

(Watthanatham, 1985) for the thirty years on either side of CE 1900 (1262 CS)—that only years 4 9 14 and 19 in each block of 19 years received an extra day. The years adopted by the two Lanna calendars are the same years as those identified by the Chinese for the Dai calendar of southern Yunnan, indicating a substantial spread of this practical solution to the intercalation problem. This confining of the extra-day years to a schematically-based position naturally gave rise to substantial differences from their theoretically-determined place. Each year displays a layout of the months and it is possible to infer the intercalation pattern of both months and days. In the Thai manuscripts the years are accompanied by a signature number in the interval 0–18 and a Thai word เศษ, *set*, meaning 'remainder'. It is easy to verify that the signature number is computed using the formula (year + 1) mod 19. Observing the intercalation pattern, it is obvious that some kind of cyclic intercalation has been used (see Table 2).

Table 2 is colour-coded so that A (in blue) represents normal lunar years of 354 days, B years (yellow) have an intercalary day of 355 days and C years (green) have an intercalary month of 384 days. The asterisks indicate for comparison those years where the B years are A years in the canonical reckoning or *vice versa*. Items in square brackets are interpolations, to fill in gaps in the coverage. We have changed the Lanna-Thai signature number 0 to 19. The arithmetic principle is that whereas each block of 19 years has seven C years in it, the distribution rate of B years would be eleven in fifty-seven (three blocks of nineteen). The Table indicates that as between the canonical scheme and the practice in Lanna and Yunnan there was disagreement about where the extra day should fall in six of the eleven cases from CS 1254 on—though of course by the end of the fifty-seven-year period the same total number of days had passed.

All the years with remainders of 2, 5, 8, 10, 13, 16 and 18 have been assigned an intercalary month, agreeing with the canonical scheme. Actually, it is possible to use such a quasi-Metonic intercalation also in the canonical scheme given that the intercalation sequence is changed now and then, presumably by directive from higher authorities.

Using such a fixed insertion scheme both for intercalary years and days would be a quite substantial simplification of the complicated original intercalation rules, and would save a lot of work for the calendarist. Some other intercalation deviations have been analysed by Eade (2007).

5 INDONESIA

The early Javanese horoscope records use the *pañcanga* system with several extra pieces of information being given, such that the record contains quite a lot of redundant information, useful as an aid to dating. The five *pañcanga* elements are:

(1) The *tithi*. The Moon's separation from the Sun. It is counted waxing (*śuklapakṣa*) from 1 to 15 and then waning (*kṛṣṇapakṣa*) 1 to 15 or 14. *Purnami*, the Full Moon day, is *tithi* 15 waxing. In the Javanese records the *tithi* is almost always synonymous with the number of the civil day in the month.
(2) The weekday. In most cases given as abbreviations for the 6-, 5- , and 7-day weekdays, and often with the added name of the *wuku's* seven-day week name.
(3) The *naksatra*. This is the Moon's position in longitude, given as the position in the zodiac divided into 27 parts.
(4) The *yoga*. The sum of the longitudes of the Sun and the Moon, given as the position in the zodiac divided into 30 parts.
(5) The *karaṇa*. Each *tithi* is divided into two

karana.

Inscription A23 (Eade and Gislén, 2000: 16) exhibits these five elements in order, interspersed with other technical elements whose principle of organisation has not yet been deciphered.

Year: 782; month: Kārtikka
Tīthi: 13 waxing
Day: ma (Maulu) pa (Paing) wṛ (Wraspati);
Week: Landep (#2)
Nakṣatra: Aśvīṇa (#1)
Yoga: Vyātipāti (#17)
Karaṇa: Taithila

The terms given here in brackets are the '*jyotisa* elements'; since it has not been possible to classify them systematically we will ignore them.

The partial computer output for the first of these records is shown in Figure 16, computed for the latitude 7.5° S and longitude 110° E of central Java. The top line shows the *yoga*, the next line the *naksatra*, and the next line the *tithi*. The red bottom line shows the extent of the civil day, sunrise to sunrise, the black line shows the extent of the astronomical day, midnight to midnight. In this case the *tithi* and the number of the civil day in the month coincide. All five *pañcanga* elements in the text are replicated by the computer program for the morning of CE 31 October 860.

The same close agreement is also manifest in inscription A151 (Eade and Gislén, 2000: 84):

Year: 1057; month: bhadrawāda (bhādrapadra)
Tithi: trayodaśi kṛṣṇapaksa (28)
Day: wu pa sa
Week: Wukir
Nakṣatra: māghā
Yoga: śubha
Karana: waṇija

This is the example shown in Figure 17 where the civil calendrical date of day 27 differs from the astronomical *tithi* 13 waning (28), and the astronomical *tithi* is used in the inscription. The hour is some time after sunset.

In the third example, inscription A61 (Eade and Gislén, 2000: 23; cf. Damais, 1945–1958), the relation is reversed, where it is civil 13 waxing on astronomical day 12 waxing, against the Indian 'rule' that the day's number was determined by the *tithi* in force at sunrise:

Year: 808; month: phālguna
Tithi: trayodaśi śuklapaksa (13)
Day: wurukung (wu) kaliwuan (ka)
bṛhaspatiwāra (br)
Nakṣatra: pusya
Yoga: śobhaṇa
Karana: —

Figure 18 shows this example where the calendrical day 13 is used but the astronomical *tithi*

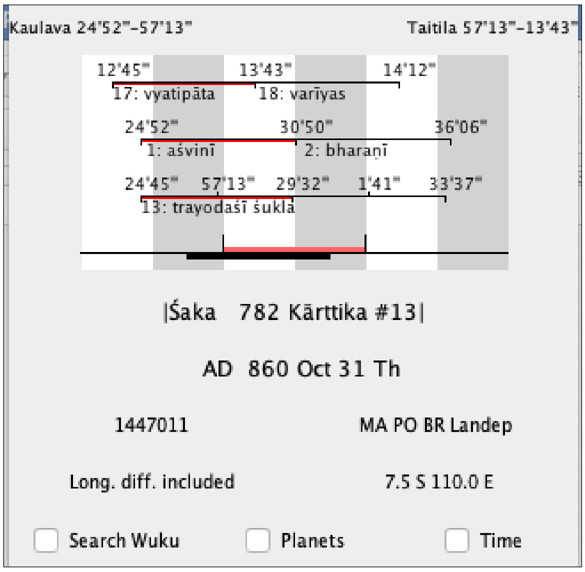


Figure 16: Computer calculation of the Javanese record.

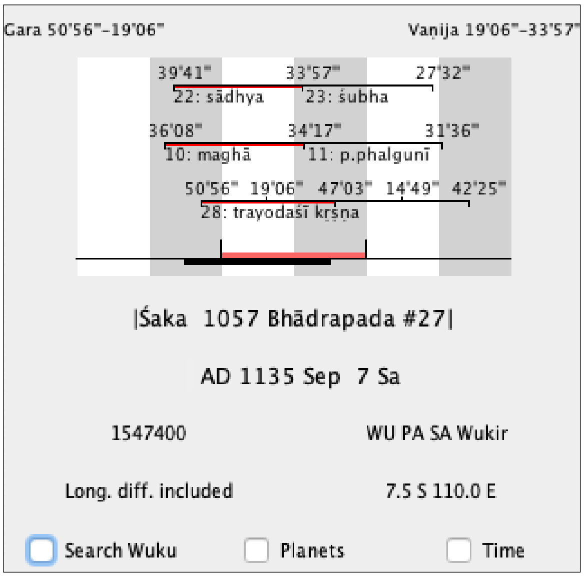


Figure 17: Computer calculation for inscription A151.

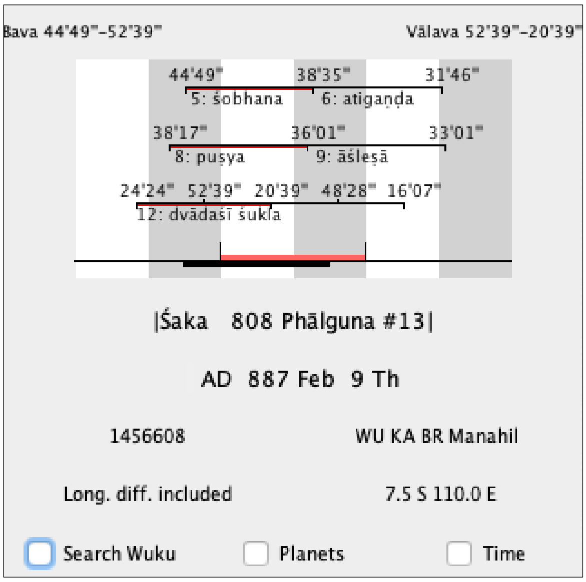


Figure 18: Computer calculation for inscription A61.

is 12 (*dvadasi sukla*). All the *pañcanga* elements are in place except the *karaṇa*, which is missing.

Figure 19 shows a month in a modern Balinese calendar. There are several calendars on simultaneous display. At the top is the Śaka year 1937, which equates in the Gregorian calendar with February 2016. The large numbers show the dates in this calendar. Each day also displays the pawukon weekdays, in this case, 8 February, the 1-day weekday is Luang, the 2-day weekday is Pepet, the 3-day weekday is Kajeng, the 4-day weekday Jaya, the 5-day weekday Pon, the 6-day weekday Maulu, the 8-day week-day Kala, the 9-day weekday Erangan, and the 10-day weekday Pati. The 7-day weekday Coma/Soma appears in the column to the left, together with the ordinary weekday name Senin. Kasanga is the name of a solar month here used for a lunar month, the red typeface of the Kasanga and the number 1 indicating that it is the first day of the waxing Moon. Top left are the calendar month and days of the Islamic (Javanese and arithmetic Muslim) calendars. Dungulan at the top of the column is the eleventh wuku week in the 210-day cycle.

7 CONCLUDING REMARKS

The combined picture of the calendrical records confirms the existence of a long and continuous tradition of rules for computation going back hundreds of years or even millennia. Although all the countries in Southeast Asia now officially use the Gregorian calendar, the traditional luni-solar calendars are still an extremely important part of religion and culture in the societies.

6 NOTES

1. This is the sixth and final paper in the series that discusses the traditional calendars of Southeast Asia. The first paper (Gislén and Eade, 2019a) provided an introduction to the series. Paper #2 (Gislén and Eade, 2019b) dealt with the calendars of Burma, Thailand, Laos and Cambodia; Paper #3 (Lân, 2019) with Vietnam; and Paper #4 (Gislén and Eade, 2019c) with Malaysia and Indonesia. Paper #5 Gislén and Eade, 2019d) mainly discussed Southeast Asian eclipse calculations.
2. Specialist terms used in this paper are listed in the Glossary, in Section 9.1 below.
3. In Thai eleven is สิบเอ็ด, *sip et*, while twelve is สิบสอง, *sip song*.

8 REFERENCES

Damais, L.-C. 1945–1958. Etudes d'épigraphie Indonésienne. *Bulletin de l'Ecole Française d'Extrême Orient*, 45–47, 49

Eade, J.C., 1995. *The Calendrical Systems of Mainland South-East Asia*. Leiden, Brill.

Eade, J.C., 1996. *The Thai Historical Record – A Computer Analysis*. Tokyo, The Centre for East Asian Studies for UNESCO.

Eade, J.C., and Gislén, L., 2000. *Early Javanese Inscriptions. A New Dating Method*. Leiden, Brill.

Eade, J.C., 2007. Irregular dating in Lan Na: an anomaly resolved. *Journal of the Siam Society*, 95, 111–122.

Faraut, F.G., 1910. *Astronomie Cambodgienne*. Saigon, F.H. Schneider (in French).

Gislén, L., and Eade, J.C., 2019a. The calendars of Southeast Asia. 1: Introduction. *Journal of Astronomical History and Heritage*, 22, 407–416.

Gislén, L., and Eade, J.C., 2019b. The calendars of

Figure 19: Example of a modern Balinese calendar (Gislén Collection).

Southeast Asia. 2: Burma, Thailand, Laos and Cambodia. *Journal of Astronomical History and Her-Heritage*, 22, 417–430.

Gislén, L., and Eade, J.C., 2019c. The calendars of Southeast Asia. 4: Malaysia and Indonesia. *Journal of Astronomical History and Heritage*, 22, 447–457.

Gislén, L., and Eade, J.C., 2019d. The calendars of Southeast Asia. 5: Eclipse calculations, and the longitudes of the Sun, Moon and planets in Burmese and Thai astronomy. *Journal of Astronomical History and Heritage*, 22, 458–478.

Griswold, A.B., and Prasert na Nagara, 1973. The epigraphy of Mahādharmarājā I of Sukhodaya. Epigraphal and historical studies No. 11 Part 1. *Journal of the Siam Society*, 61, 71–179.

Lân, T.L., 2019. The calendars of Southeast Asia. 3: Vietnam. *Journal of Astronomical History and Heritage*, 22, 431–446.

Penth, H., 1996. The date of the Wat Bāng Sanuk inscription. *Journal of the Siam Society*, 84(2), 5–26.

Prachum Silacharuk, *Seven Volumes*. Bangkok, Fine Arts Department (1924–1993).

Prasert na Nagara, 1991. *Lanna Inscriptions*. *Part I, Two Volumes*. Bangkok.

Watthanatham et al., 1985. Tamnān Phraya Indra, Patithin 100 pī Lānnā Thai (in Thai).

Wyatt, D.K., 2001. Relics, oaths and politics in thirteen-century Siam. *Journal of Southeast Asian Studies*, 32, 3–66.

Zhang, G., and Chen, J., 1981. Research on calendars of the Dai. In *Collected Articles on the History of Chinese Astronomy*. *Volume 2*. Beijing, Kexue chubanshe. Pp. 174–282 (in Chinese).

9 APPENDIX

9.1 Glossary

adhikamasa An indication as to whether or not a given year has an intercalary lunar month in it.

adhikawan An indication as to whether or not a given year has an intercalary day in it.

ahargaṇa The number of elapsed days since the epoch.

avoman The excess of lunar days over solar days in units of 1/692 of a lunar day modulus 692.

duang A graphical representation of the zodiac with the location of the planets.

kammacabala A quantity that gives the excess of solar days over whole solar days.

Ketu An artificial celestial body in Southeast Asian astronomy moving with ten times the speed of Rahu.

lagna An Indian term for the ascending zodiacal sign and used to give the time of the day.

masaken The number of elapsed lunar months since the epoch.

nakṣatra A measure of the Moon's longitude where the zodiac is divided into 27 parts, each of which covers 13° 20′.

pañcanga A set of five calendrical items attached to a calendrical day and used in Javanese records.

Rahu The entity known in the West as the "Dragon's Head". In Southeast Asian astronomy considered to be a separate planet.

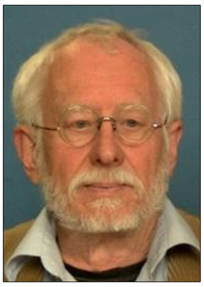
tithi It can refer to the lunar day number in a month and also the relative position of the Moon relative to the Sun.

uccabala A measure of the position of the Moon's apogee. It increases by one unit a day to a maximum of 3232.

wuku calendar Indonesian cyclic calendar based on a combination of 6-, 5- and 7-day weeks (in that order).

yoga An artificial quantity being the sum of the longitudes of the Sun and the Moon. It is expressed as the possible 360° divided into 27 parts, each spanning 13° 20′.

zata See *duang*.



Dr Lars Gislén is a former lector in the Department of Theoretical Physics at the University of Lund, Sweden, and retired in 2003. In 1970 and 1971 he studied for a Ph.D. in the Faculté des Sciences, at Orsay, France. He has been doing research in elementary particle physics, complex systems and applications of physics in biology and with atmospheric physics. During the past twenty years he has developed several computer programs and Excel spreadsheets implementing calendars and medieval astronomical models from Europe, India and Southeast Asia (see http://home.thep.lu.se/~larsg/).

Dr Chris Eade has an M.A. from St Andrews and a Ph.D. from the Australian National University. In 1986 he retired from the Australian National University, where he had been a Research Officer in the Humanities Research Centre before moving to an affiliation with the Asian Studies Faculty, in order to pursue his interest in Southeast Asian calendrical systems. In particular, research that he continued after retirement concerned dating in Thai inscriptional records, in the horoscope records of the temples of Pagan and in the published records of Cambodia and Campa.