Fake Leap Months in the Chinese Calendar:

From the Jesuits to 2033

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Abstract

In 1645 the Jesuits carried out a reform of the Chinese calendar. The key change was to use the "true sun" rather than the "mean sun". One consequence was that it was now possible to have "fake leap months", i.e., months without any *zhong qi*'s that are still not leap months. One of the reasons why the Jesuits made this change was to demonstrate their superiority over the Chinese and Muslim astronomers.

However, this plan backfired against them. The appearance of fake leap months in the calendar was one of the reasons why they were thrown into jail in 1664. Fake leap months is still causing controversy in the Chinese calendar. Up until the early 1990's all Chinese calendars had the wrong leap month for 2033!

Introduction

It is not my purpose to give a detailed discussion of the Chinese calendar or the history of the contribution of the Jesuits. I will just focus on one consequence of the reform of the Chinese calendar carried out by the Jesuits in 1645, namely the "fake leap months".

For details about the Chinese calendar see my paper ([As1]), the books by Dershowitz and Reingold ([DR]) and Tang ([Ta]), and the articles by Doggett ([Do]) and Sivin ([Si]). For details about the history of the contribution of the Jesuits see the article by Chu ([Ch]) and the book by Spence ([Sp]). For the computations in this paper I used the Mathematica version of the code from the book by Dershowitz and Reingold ([DR]).

Their astronomical functions are based on the book by Meeus ([Me1]). Robert C. McNally did the conversion from Lisp to Mathematica. Additional functions are in my Mathematica package ChineseCalendar ([As2]).

Fake leap months and the Jesuits

The calendar has always been very important in Chinese society. The Chinese emperor based his authority on being the "Son of Heaven". In that case, it is very embarrassing if the calendar is not in harmony with the heavens. Unfortunately, with a lunar or lunisolar calendar, errors are much more obvious than with a solar calendar. A solar calendar can be off by a couple of weeks without anybody noticing. The only reason why the Catholic Church had to reform the Julian calendar was because the rules for computing Easter had frozen the March equinox to be March 21. That meant that Easter was drifting noticeably towards summer. Otherwise, nobody would have noticed the drift of the March equinox. But with a lunar calendar, an error of even a couple of days is a serious problem. Every peasant could each month see that the new moon was visible near the end of the previous month or that the old moon was visible in the next month. Why should they pay taxes and serve in the army if the emperor didn't know the secrets of the heavens?

Since the fourth century B.C.E., Chinese astronomers knew that the motion of moon was not uniform, and by the sixth century C.E. they knew that the sun's motion was also irregular ([CJJ]). Before the Tang dynasty, they used mean values for the motion of the sun, *ping qi* (平气), and the moon, *ping shuo* (平朔). This means that they assumed that the time intervals between the 24 *jie qi*'s and the length of the synodic month were both constant. Leap months were determined using the *zhong qi* (中气) rule, saying that a month without any *zhong qi* was a leap month. This meant that leap months would come at regular intervals, and that each month was equally likely to have a leap month.

Chinese astronomers started using the true moon, *ding shuo* (定朔), in the calendars in 619 at the beginning of the Tang dynasty. The length of the synodic months used to be fixed at 29.53, but now it could range between 29.27 and 29.84. It was not until 1645, however, at the beginning of the Qing dynasty that the Jesuits introduced the true sun, *ding qi* (定气), into the Chinese calendar. In the old calendar, the time between two *zhong qi*'s was constant at 30.44 days, but under the new system, the time could range between 29.44 and 31.44 days, and the *zhong qi*'s were closer together during the winter.

The true sun caused serious changes in the calendar. Under the new system, leap months were more likely to occur during the summer. In exceptional cases, it was now possible to have two *zhong qi*'s in a month, and to have months without any *zhong qi*'s that were not the result of a "drift" of the *zhong qi*'s but just a compensation for a nearby month with two *zhong qi*'s.

Such cases require clear rules about which of the months without a *zhong qi* should be counted as a leap month. The modern rule is to consider the "astronomical year" from the new moon immediately before or on the same day as a December solstice to the new moon immediately before or on the same day as the next December solstice.

The solar year from one December solstice to the next is called the *sui* (岁) in Chinese astronomy, but for convenience, I will also call the astronomical year a *sui*. A *nian* (年), however, is the Chinese year from one Chinese New Year to the next.

Let me clarify some terminology. When I talk about the Chinese year 2033, I mean the *nian* from Chinese New Year 2033 to Chinese New Year 2034. The problem with this convention is that dates in the 11th or 12th months may fall in the following Gregorian year. For example, the 12th month of the Chinese year 2033 starts in January 2034. The *sui* 2033 is the *sui* from the new moon immediately before or on the same day as the December solstice in 2032 to the new moon immediately before or on the same day as the December solstice in 2033.

If the *sui* contains 13 months, I will call it a leap *sui*, and the first month without a *zhong qi* in it is the leap month. Any month without a *zhong qi* that is not a leap month is called a *fake leap month*. This is the modern rule as described by Liu and Stephenson ([LS1]). It is possible that the Jesuits used a variation of this rule.

I think it is important to try to understand why it took so long for the Chinese to introduce the true moon and the true sun into the calendar. First of all, there is a big difference between knowing that the motion is not uniform and knowing how to predict the motion. The ancient Chinese calendars were based on arithmetical resonance patterns, and the Tang reform came about because of Indian influences. As explained above, the need for introducing the true moon was more pressing than need for using the true sun, since using the mean moon created discrepancies that were noticeable to everybody, but the errors caused by using the mean sun were only noticeable to astronomers. Given the computational complexities associated with using the true sun, the Chinese astronomers choose to stay with the old method. The Jesuits, however, needed to demonstrate their superiority over the Chinese and Muslim astronomers. Changing the calendar by using the true sun was a way of asserting control over the calendar.

It is therefore somewhat ironic that this backfired on them. Many aspects of Chinese astrology were based on the mean sun, and months with three *jie qi*'s or fake leap months were very alien to Chinese scholars of the time. Part of the reason why they were thrown into jail in 1664 was because Yang Guang Xian (杨光先) and Wu Ming Xuan (吴明炫) accused them of having made an error because the 11th month in 1661 had three *jie qi*'s (including two *zhong qi*'s), something that was an obvious error in the old system. (Chu ([Ch]) says the 12th month, but this must be a typo. In fact, the last *zhong qi* should have been in the following month, because it occurred 39 minutes after midnight, but the Jesuits made an error.) Moreover, both the 7th and the 12th month had no *zhong qi*. The 7th was a leap month, but the 12th was a fake leap month. Fake leap months did not exist under the old system, so again Yang claimed that the Jesuits were obviously wrong. These were two of the complaints that Yang raised, and which eventually led to the 1664 calendar case in the Imperial Court ([Ch]).

The 2033 error in the Chinese calendar

Up until the early 1990's, all Chinese calendars had a leap month after the 7th month in 2033, while in fact is should follow the 11th month. In this section I will discuss this error in detail. Let us start by looking at the times for the *zhong qi*'s and new moons during the end of 2033. This is given in Table 1. I denote the n'th month (or the n'th new moon) by "Mn", and I denote the new moon after Mn by "Mn+" and the new moon after that by "Mn++". The reason is that before I have compared with the *zhong qi*'s, I cannot tell whether any of them are leap months or not. I denote a leap month after Mn by "Mn-leap". I will denote the n'th *zhong qi* by "Zn". (The December solstice is Z11.)

M7: 2033 7 26, 16h 11m	Z7: 2033 8 23, 3h 0m
M8: 2033 8 25, 5h 38m	Z8: 2033 9 23, 0h 50m
M9: 2033 9 23, 21h 38m	Z9: 2033 10 23, 10h 26m
M10: 2033 10 23, 15h 27m	Z10: 2033 11 22, 8h 14m
M11: 2033 11 22, 9h 38m	Z11: 2033 12 21, 21h 44m
M11+: 2033 12 22, 2h 45m	Z12: 2034 1 20, 8h 25m
M12: 2034 1 20, 18h 0m	

Table 1: *Zhong qi*'s and new moons during the winter of 2033/34

It is known that the *zhong qi*'s all occur between the 19th and 23rd of the month. The date of the new moon, however, more or less regresses through the Gregorian month. If you write out the Gregorian calendar with the months as columns, and mark the new moons and the *zhong qi*'s, you see that the *zhong qi*'s form a more or less horizontal line, while the date of the new moon climbs upwards until it reaches the top and jumps to the bottom and starts climbing again. Leap months occur when the new moon curve crosses the *zhong qi* curve. Most of the time you get a "clean" crossing, but sometimes the curves might get intertwined is complex ways. In 1998 (Table 2) the *zhong qi*'s fell before the new moon until June, in July they coincided, and from August on the *zhong qi*'s fell after the new moon. This clean crossing gave a "normal" leap year.

	June	July	August
19			
20			
21	Z5		
22			M7
23		Z6/M6	Z7
24	M4-leap		

Table 2: Position of the *zhong qi*'s and new moons in 1998

In 2033 (Table 3), however, the *zhong qi*'s fall before the new moon until August, and for 7 months between September and March they either coincide, or the *zhong qi* fall earlier. Not until April do the *zhong qi*'s fall after the new moon.

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr
18							Z1		
19							M1		M3
20						Z12/M12		Z2/M2	Z3
21					Z11				
22				Z10/M11	M11-leap				
23	Z7	Z8/M9	Z9/M10						
24									
25	M8								

Table 3: Position of the *zhong qi*'s and new moons in 2033/34

The number of *zhong qi*'s for the winter months of 2033/34 is given in Table 4.

2033 M8:	0
2033 M9:	1
2033 M10:	1
2033 M11:	2
2033 M11-leap:	0
2033 M12:	2
2034 M1:	0

Table 4: Number of *zhong qi*'s for the winter months of 2033/34

We see that the 9th month takes Z8, the 10th month takes Z9, and the 11th Month takes Z10. But the 11th month also holds on to the December solstice, Z11. The fact that the 8th month doesn't have a *zhong qi* is compensated for by the fact that the 11th month has two. Hence the *sui* 2033 has only 12 months, while the *sui* 2034 has 13 months. In other words, *sui* 2033 is not a leap *sui*, while *sui* 2034 is a leap sui. It follows that the month after the 7th month is not a leap month, because there's no room for a leap month in the *sui*. The 8th month is a "fake" leap month, in the sense that it doesn't contain any *zhong qi*, but is not a leap month.

Year	Leap year	Leap *sui*	Leap month	Month with 2 *zhong qi*'s	Fake leap month
1832	Yes	Yes	9-leap	11	
1833	No	No			1
1851	Yes	Yes	8-leap	12	
1852	No	No			2
1870	Yes	Yes	10-leap	11	12
1984	Yes	Yes	10-leap	11	
1985	No	No			1
2033	Yes	No	11-leap	11,12	8
2034	No	Yes			1

Table 5: Fake leap months

It is clear that fake leap months are closely related to months with two *zhong qi*'s. Table 5 shows all such months between 1800 and 2100. In 1832, 1851, 1870 and 1984, a month with two *zhong qi*'s caused a month with no *zhong qi* in the next *sui* (in 1870 in the same *nian*, in the other three cases in the next *nian*). In all these cases, the December solstice was early in the 11th month, making the year both a leap year and leap *sui*. But 2033 is unique in that the December solstice is the second *zhong qi* in the 11th month. Since there is a leap *sui* if M11+ falls within about 11 days of Z11, we see that this is the reason why 2034 is a leap *sui* while 1833, 1852, 1871 and 1985 are not. The fake leap month in 2034 is the first fake leap month in a leap *sui* since 1645. The next will occur in 2129.

It also follows that Chinese New Year is the third new moon after the December solstice in 2034. Notice also that 2033 contains two months with two *zhong qi*'s. It is interesting to observe that in the Indian calendar, a fake leap month is counted as a leap month, but when a month has two *zhong qi*'s they skip a month!

A month with two *zhong qi*'s will of course have three jie qi's. Sometimes there are months with three *jie qi*'s where one is a *zhong qi* and two are odd *jie qi*'s. This happened in the 10th month in 1999. They are not so interesting since they don't affect the leap months.

A year is said to have "double spring", *shuang chun* (双春), if it contains "beginning of spring", *li chun* (立春), at both its beginning and end. It is easy to see that this happens if and only if the year is a leap year. In the same way, a year is said to have "double spring, double rain", *shuang chun shuang yu* (双春双雨), if the *nian* contains both "beginning of spring", li chun, and "rain water", *yu shui* (雨水), at both its beginning and end. This is considered significant in Chinese astrology. Between 1645 and 2644, this happens only 15 times. It happened in 1699, 1832, 1851 and 1984, and will happen again in 2033 and 2053. We see that these years are almost the same as the exceptional years we have discussed earlier.

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