Lunar and Solar Calendrical Systems[1]

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Abstract

This article discusses Lunar Calendrical System which forms the basis of Islamic Calendar that relies on visual sighting of the crescent. The articles also gives a brief description of the Solar Calendar as a way of comparing both calendrical systems.

INTRODUCTION

It is impossible to talk about crescent sighting without discussing the nature of lunar calendar. In addition, it is preferable to discuss the nature of solar calendar as comparison to lunar calendar.

These two calendars are the most widely used internationally. They are also mentioned in the Qur'an: And they stayed in their Cave three hundred years and to that they added nine[2].

According to *tafsir* scholars, among them Fakhr al-Dīn al-Rāzī, the three hundred years mentioned in the verse refer to solar calendar, and the additional nine years refer to the lunar calendar.

LUNAR CALENDAR

The Lunar Calendar is based on the orbit of Moon around Earth. Each orbit is called a month. Twelve of these orbits make a lunar year. Allah says: The number of months with Allah is twelve months by Allah's ordinance since the day when He created the heavens and Earth[3].

The period of Moon's orbit around Earth varies each month. This is due to the interplay of gravitational pull between Earth, Moon, Sun and other planets. This is one of the reasons for the varying number of days in a month. Some months have 29 days while others 30 days[4]. And a lunar year is either 354 or 355 days[5].

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[1] This article is the translation of Chapter 1 of the Master's thesis entitled *Ahādīth Ru'yah al-Hilāl wa Muḥāwalah Iktishāf al-Taṭawwur fī Mafhūmihā* (The Prophetic Sayings on Crescent Sighting and an Attempt on Revealing the Development in Their Understanding) submitted to International Islamic University Malaysia, Kuala Lumpur, Malaysia, in 2005. The Arabic version *Nabẓat Min al-Faṣli al-Awwal Min al-Baḥaṣ a-Mājistīr: Naẓm at-Taqwīm al-Qamarī* was published in Jurnal Dakwah 3 (December 2012), pg. 124-133.

[2] Al-Kahfi, 25.

[3] al-Tawbah, 36.

[4] According to astronomers, a lunar month is 29 days 12 hours 44 minutes. The differences in seconds occur each month. We cannot built lunar calendar around this odd numbers of hours and minutes. It is easier to assign lunar months with integer numbers of 29 or 30 days. A 29-days month is called deficient month, while 30-days month is called full month. Whether a month is deficient or full depends on the civilisations that use lunar calendar as their reference time-keeping. Indian and Chinese civilisations adopt the conjunction of Moon as the start of the month, while Muslim prefer visual sighting of the crescent on western horizon after conjunction as the basis for the start of the month.

[5] Among the contributions of Muslim scholars in the development of lunar calendrical system is the creation of Lunar Conventional Calendar. It is based on the interchange of months between 29 and 30 days disregarding the

Types of Lunar Calendar
There are various types of Lunar Calendar. Some of them depend on Moon's conjunction as the start of new month[6]. While others depend on either the path of Moon on pre-determined constellations every month or the visual sighting of the crescent.

Though the Islamic lunar calendar depends on visual sighting of the crescent, the Muslims were not the first to adopt it. Sighting of the crescent to mark the beginning of months has its roots in the Babylonian civilization some 3,000 years before Prophet Muhammad PBUH. The Babylonians also developed a criterion to distinguish between false and true sighting of the crescent[7].

Crescent Observation Factors
Sighting the crescent is unlike observing other celestial bodies. It is a difficult endeavor because the observation window opens up only after sunset and last till moonset. Observation must be done in usually in less than 30 minutes. Sometimes, once or twice a year, the window opens up for 40 minutes[8]. Within this small sliver of time, the observer has to track down the almost invisible crescent and distinguish it from other natural phenomena such as traces of white clouds or refraction of sun rays. To confound matters further, the observer has to contend with the still bright western horizon during sunset and that which only disappears about 50 minutes later.

Muayyid bin Bārak al-'Urḍi, the Syrian astronomer (d. 1265 CE), discussed the factors contributing towards positive sighting of the crescent. He differentiated those factors into inherent and external.

Inherent factors are the size of the visible part of the crescent, the period between sunset and moonset (lagtime) and the crescent's azimuthal distance (in degrees) from the centre of the Sun[9].

The external factors are the difference in latitude, openness of the horizon, clear sky, visual acuity and knowledge of the Moon's setting angle. In addition, Muayyid said, "It is incumbent on those who seek the crescent to observe these factors. If he does that, he will be

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crescent sighting factor. A year then is either 354 or 355 days. The former is called al-Basitah (Normal Year) and the later al-Kabisah (Leap Year). In every 30 years cycle, there are 11 leap years of which an additional 1 day is added to the 29-days Ẓulhijjah. The reason for those 11 leap years lies in the fact that a lunar month is 29.530 588 853 days. If we multiply that number by 12, we will get 354.367 066 2 days. This exceeds the 354-days leap year by 8 hours 48 minutes 35 seconds. This extra hours and minutes add up to 11 days in 30 years. These 11days caused the 11 leap years. These leap years occur on the 2nd, 5th, 7th, 10th, 13th, 16th, 18th, 21st, 24th, 26th and 29th year. The Lunar Conventional Calendar was used by many Islamic states in the past because it assists people in determining past and future dates, a process crucial for financial and other transactions. However, the three religious months of Ramaḍān, Shawwāl and Ẓulhijjah were of the exception. Visual sighting of the crescent were still employed to determine their beginnings, in accordance to the Prophetic teaching. See: Hassan Musa, *'Ilm al-Falak fī al-Turāth al-'Arabiy,* p. 185.

[6] There are many sub-types for this variation of Lunar Calendar. Determination of the new month depends on either conjunction before sunset of the last day of the month, or before midnight, or before dawn, or before midday.

[7] Richards, E.G., *Mapping Time Calendar and Its History*, p 146.

[8] Departemen Rukyat dan Hisab, *Kalendar Rukyat MABIMS 1996 – 2020*.

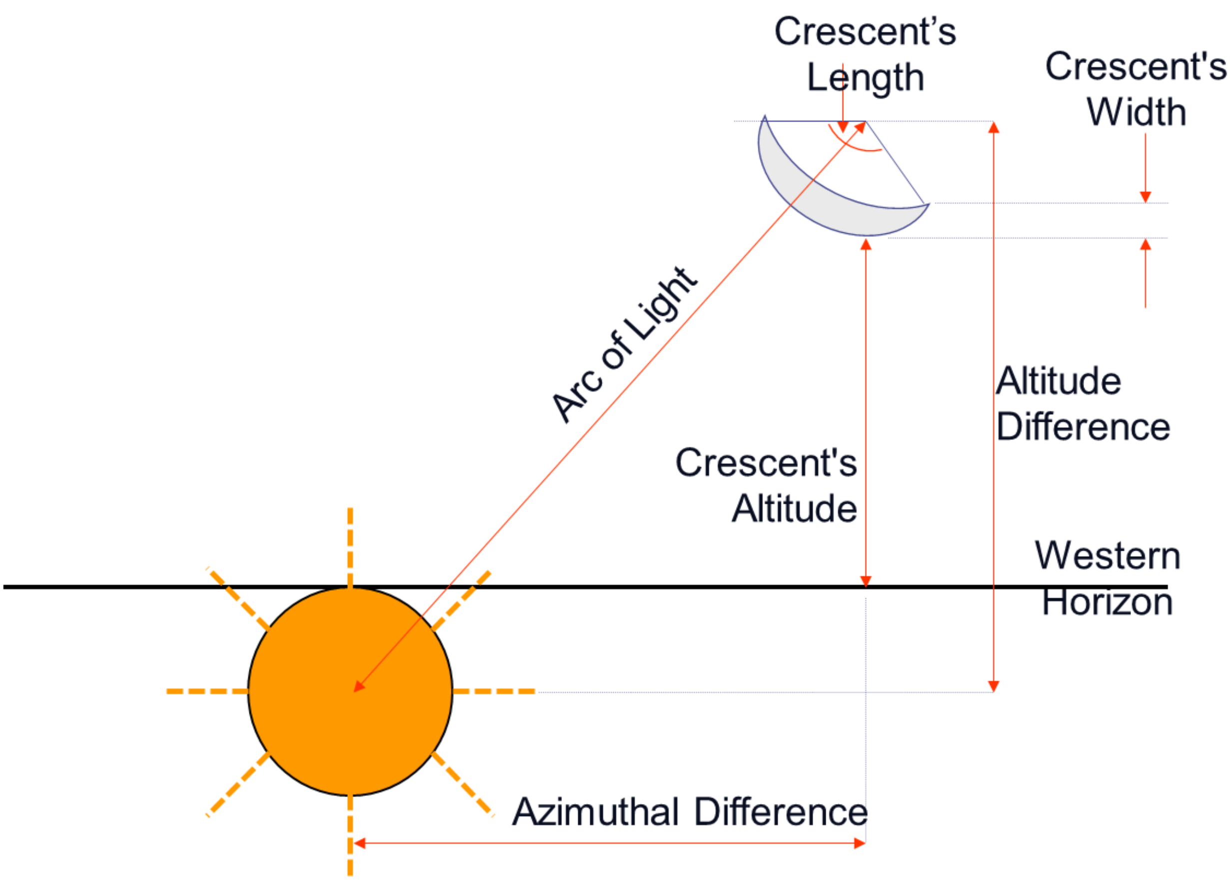
[9] Muayyid bin Bārak al-'Urḍi, *Kitab al-Hay'ah*, p 317.

able to see the crescent at conditions that usually permit such sightings without committing any mistake."[10]

Astronomers after him listed other contributing factors. I grouped these factors into three: inherent, external and psychological.

Inherent factors are those that concern the Moon. They are as follow:
1) Moon's age from conjunction to sunset
2) Crescent's width
3) Crescent's length
4) Moon's lagtime (time between sunset and moonset)
5) Azimuthal difference between centre of Sun and centre of Moon
6) Altitude difference between centre of Sun and centre of Moon
7) Moon's lower limb's altitude from the horizon
8) Arc of Light (angular distance from centre of Sun to centre of Moon)
9) Moon's mountains that might block the reflection of sun rays to the observer

The figure below shows these inherent factors:



External factors concern the environment and they include the following:
1) Open western horizon
2) Weather conditions such as clouds, temperature and air pressure
3) Air pollution

[10] Ibid.

4) Light pollution especially at the western horizon
5) Altitude of observer

Psychological factors play a major role in the observer. They are:
1) Visual acuity of the eye
2) Physiological preparedness, such as getting the eyes used to darkness before observation.
3) Spiritual preparedness, cleansing oneself of sins and beseeching Allah's help in observing the crescent.
4) Psychological preparedness so that the observer will not regard any atmospheric phenomena as the crescent.
5) Knowledge in the inherent factors above
6) Types of optical aid used

Crescent Sighting Criteria

Astronomers continuously develop and refine the criteria for earliest possible crescent sighting. Some of these criteria are:
1) Babylonian (586 – 74 BCE): Oldest criterion. The crescent is regarded as visible 24 hours after conjunction. However this criterion is not accurate[11].
2) Ibn Ṭāriq (d. 178H / 794M)[12]: Arc of descent is more than 10 degrees and arc of light during sunset (elongation) is more than 15 degrees[13].
3) al-Khawārizmī (d. 228H / 842M)[14]: Arc of descent is more than 10 degrees and crescent's width is more than 4.8 degrees.
4) al-Baṭṭānī (d. 307H / 919M)[15]: Sun's depression below horizon during Moon set is more than 8 or 10 degrees.
5) Fotheringham (1910M): His criterion came from 20 observations made by Schmidt at Athens between 1859 to 1867. It depends on crescent's altitude during sunset and elongation[16].
6) Ilyas (1988M)[17]: He presented three criteria. Criterion A depends on elongation and Moon's altitude. Criterion B depends on Moon's age and azimuthal difference. Criterion C, which is an improvement of Criterion A, depends on altitude and azimuthal difference[18]. In addition, his criterion depends on darkness of the sky and crescent's light strength[19].
7) Royal Greenwich Observatory: The criterion depends on the best observation time and place for positive sighting. The best time is when the azimuthal difference between Sun and Moon is zero degree and crescent's altitude of 10 degrees. The best place for

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11 Muhammad Shaukat Odeh, *al-Taqwīm al-Hijrī al-ʻĀlamī*, p 2.
12 He is Yaʻqūb bin Ṭāriq, a distinguished astronomer during the time of the Abbasid caliph al-Manṣūr. Among his works: Taqṭīʻ Kardajāt al-Jayb, Ma Irtafaʻ min Qaws Niṣf al-Nahār and al-Zayj Maḥlul fī al-Sind Hind li Darajah Darajah. The latter is actually two books: the first on astronomy and the second on state affairs. See: Ibn Nadim, Abu al-Faraj Muhammad bin Ishaq, *al-Fihris*, p 388.
13 Baharruddin bin Zainal, *Kriteria Kenampakan Anak Bulan di Malaysia*, p.9.
14 He is Muḥamamd bin Mūsā al-Khawārizmī, one of the astronomers during the reign of the Abbasid caliph al-Manṣūr. See Mohammad Yasin Owadally, *The Muslim Scientists*, p.2.
15 He is Muḥamamd bin Jābir al-Baṭṭānī. His book Ilm Falak was used as a standard textbook in astronomy in Europe till the 18th century. See Mohammad Yasin Owadally, *The Muslim Scientists*, p.6.
16 Dr Monzur Ahmad, *Documentation for Moon Calculator*, p. 18.
17 He is Muhammad Ilyas bin Shihabuddin. He is the founder of the Sheikh Tahir Centre for Astronomy, Penang.
18 Monzur Ahmad, *Documentation for Moon Calculator*, p. 18.
19 Baharruddin bin Zainal, *Kriteria Kenampakan Anak Bulan di Malaysia*, p. 10.

observation is an open flat horizon with clear sky. If the best time and place are achieved, then it is possible to sight the crescent with Sun's geocentric dip reach 5 degrees[20].

8) Shaukat[21]: Considered as one of the best criterion presently. It is based on more than 900 crescent observations worldwide for the last 150 years. The criterion is based on crescent's altitude at sunset must be greater than 3.4 degrees and (moon'saltitude/12.7) + (crescent width in arcmin/1.2) > 1[22].
9) Yallop (1997M): His criterion is also considered as one of the most accurate presently. It was developed by Bernard Yallop, previous director of Greenwich Observatory and head of Astronomical Tables Committee under International Astronomical Union (IAU). His criterion depends on the geocentric relative altitude and topocentric crescent width. The possibility of the crescent sighting depends on five conditions: First, possible to sight using telescope or binoculars only. Second, sighting might need telescope of binoculars. Third, possible to sight by naked eye when the sky is clear. Fourth, easy to sight by naked eye. Fifth, impossible to sight[23].
10) Istanbul (1978M)[24]: The criterion states that crescent's altitude during sunset must be more that 5.5 degrees and elongation more than 7.5 degrees, or Moon's age from conjunction to sunset must be more than 8 hours[25].
11) MABIMS (1991M)[26]: The criterion states that crescent's altitude during sunset must be more than 2 degrees and elongation more than 3 degrees. Or Moon's age from conjunction to sunset must be more than 8 hours[27].

These eleven criteria, though they differ among each other, generally they agree on the fact that sighting the crescent is impossible if crescent's altitude is less than 2 degrees during sunset, or its lagtime is less than 10 minutes[28].

Brief History of Islamic Lunar Calendar

The Islamic Lunar Calendar was introduced in 17 AH during the reign of Caliph ‘‘Umar bin al-Khaṭṭab. He officially instructed its use on Wednesday, 20 Jumadā al-Ākhirah, of that year. The Calendar came into being due to an incident involving a letter sent by Caliph ‘Umar to his governor in Basrah, Abu Mūsā al-Ash‘arī. The letter was dated with only the month it was written – Sha‘bān. So Abu Mūsā wrote back to Caliph ‘Umar: We received several letters from the Amīr al-Mu'minīn (the title ‘Umar carried as caliph) but we are not sure which one to prioritized since we also received a letter dated with only Sha‘bān in it. So we are not sure which Sha‘bān. Is the current month or the previous one?[29]

Upon receiving the letter from Abu Mūsā, Caliph ‘Umar realized that the Islamic state urgently needed a calendrical system. He formed a council of elder Companions and sought

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[20] Monzur Ahmad, *Documentation for Moon Calculator,* p. 18.

[21] He is Khalid bin Shaukat, an American engineer and consultant for Islamic Society of North America (ISNA). He is creator of the website www.moonsighting.com.

[22] Leong Wen Xin, *Lunar Visibility and the Islamic Calendar, A project paper for Undergraduate Research Opportunity Programme in Science*, National University of Singapore, Singapore, 2000, p. 22.

[23] Muhammad Shaukat Odeh, *al-Taqwīm al-Hijrī al-‘Ālamī*, p 3.

[24] The criterion was adopted during the Conference for Determination of the Start of Lunar Months at Istanbul on 27-30 November 1978 CE (26-29 Dzul Hijjah 1398 AH).

[25] Baharruddin bin Zainal, *Kriteria Kenampakan Anak Bulan di Malaysia,* p 12.

[26] MABIMS is an acronym for Unofficial Meeting of Religious Ministers of Brunei, Indonesia, Malaysia and Singapore. The Calendar and Crescent Sighting Technical Committee formed under MABIMS came out with the criterion in 1991.

[27] Baharruddin bin Zainal, *Kriteria Kenampakan Anak Bulan di Malaysia,* p. 13

[28] Departemen Rukyat dan Hisab, *Kalendar Rukyat MABIMS 1996 – 2020.*

[29] Muḥammad Muḥammad Fayyāḍ, *al-Taqāwīm*, p 62.

their advice. They concurred with him on the need for a calendar. But they disagreed on the event that should mark the start of such calendar. Some of them suggested the birth of the Prophet PBUH as the commencement of the Islamic calendar, similar to the Christian calendar that starts with the birth of Prophet ‘Īsā. Others suggested the year the Prophet PBUH received the first revelation. Still others, among them the Companion ‘Ali, suggested the year the Prophet PBUH arrived in Medina since that marked the beginning of Islamic ascendency. Furthermore, it was a well recorded event, witnessed by many and everyone agreed on the year. ‘Umar agreed with the latter suggestion and decided to adopt it[30].

Advantages and Disadvantages of Lunar Calendar

The advantages of Lunar Calendar are as follow:

1) The month coincides with the orbit of the Moon around Earth, either from conjunction or from first sighting of the crescent.
2) Determining the day of the month is relatively easy just from the shape of the Moon. If it is half-moon, a quarter of the month is gone. If it is full-moon, then it is middle of the month. If the Moon rises on the later part of the night, then the month is approaching its end.
3) The Lunar Calendar does not need corrections unlike the Solar Calendar. The reason being that the month in Lunar Calendar depends on the physical orbit of the Moon around Earth. Twelve of those orbits constitute a year. Since the number of days in each month depends on the physical movement of a celestial object – Moon, hence the number of days in a lunar year is automatically adjusted.
4) Unlike the Solar Calendar, there is no need to create artificial division of the year into units called month since the month in Lunar Calendar depends on physical orbit of Moon around Earth.
5) Natural phenomena follow the lunar cycle, such as menstruation.
6) Solar eclipse will always occur just before the start of a new lunar month, and lunar eclipse in the middle of the month. On the other hand, eclipses occur randomly in a solar month.

The disadvantages of the Lunar Calendar are as follow:

1) The Lunar Calendar is not in sync with the four seasons. This causes difficulty on farmers who depend on the correct time for planting and harvesting.
2) Difficulty in having a united international lunar calendar if the criterion depends on visual sighting of the crescent which differs from one place to another.
3) Difficult to determine past dates if the lunar calendar depends on visual sighting of crescent if there is no record of past sightings. Determination of future dates is impossible since future visual sighting cannot be determined beforehand.

SOLAR CALENDAR

The solar calendar is based on the orbit of Earth around Sun. One complete orbit is a solar year. The time taken for each orbit differs everytime. However, the difference is less than 1 second. Presently, the time taken for an orbit is 365 days 5 hours 48 minutes and about 45 seconds.

It is difficult to ask people to consider a year on the account of hours and minutes. Hence, a year is considered 365 days. The extra hours and minutes add up to a full day after three

[30] Ibid.

orbits. This extra day is then added to the fourth year making it 366 days long. The extra day changes a normal year into a leap year[31].

The solar year is not tied down to the orbit of Moon around Earth. Hence, there is a need to artificially divide the solar year into months. The early Roman Civilisation divided its solar year into 10 months until the time of Julius Ceaser who adopted the Egyption 12-months division, the system of which lasted until now.

The number of days in a month, however, varies between 28 and 31 days, depending on the whims of the Roman ruler.

Types of Solar Calendar

There is not much of a variety for Solar Calendar, unlike the Lunar Calendar. The reason being that the Solar Calendar was not widely used in the past as much as the Lunar Calendar. There were only two known civilisations who used the Solar Calendar: the Egyptian and the Roman Civilisations. The latter has very strong ties with the former.

The present calendar used worldwide presently, and of which is known as the Civil Calendar, has its roots in the Roman Calendar. It was originally called the Julian Calendar since it was introduced by Julius Ceaser in 46 BC. However, Julian Calendar is not exact. It was in need of corrections and updates so that it can stay in tune with Earth's orbit[32].

A correction and modification of the Julian Calendar was done during the time of Pope Gregory XIII in 1582 AD. He ordered 11 days to be dropped the Calendar and a day to be dropped at the start of every century that is a multiple of 400. These corrections synchronized back Julian Calendar to Earth's orbit. He then renamed the calendar the Gregorian Calendar. It is this calendar that is now being used internationally and now known as Civil Calendar.

Advantages and Disadvantages of Solar Calendar

The advantages of the Solar Calendar are as follow:

1) It is suitable to be used as an international calendar. This is because the start of the year is based on Earth's orbit which is the same worldwide.
2) The four seasons begin and end at the same time every year.
3) Easy to determine past and future dates.

The disadvantages of the Solar Calendar are as follow:

1) Differences in determining the start of solar month. This because it does not depend on Moon's orbit around Earth.
2) Determination of date in a month cannot depend on the lunar phases since the month does not start with the new lunar cycle.
3) Natural phenomena does not coincide with the solar months.
4) Earth's orbit around the Sun, which is 365 days 5 hours 48 minutes 45 seconds, is a very difficult number to assign for a calendrical unit. It thus needs corrections now and then. The first correction was done in 1582 AD after dropping 11 days from the

[31] If we multiply 5 hours 48 minutes 45 seconds by four, we get 23 hours 11 minutes. That is close to a day.

[32] The Julian Year is 364.25 days, or 364 days 6 hours. It exceeds the true orbit of Earth by 11 minutes 15 seconds. If we multiply it by 128, we will get almost 24 hours. Thus it is clear that a day needs to be dropped from the Julian Year after every 128 years.

Julian Calendar. The second correction will be done in the year 4782 CE with the addition of a day in that year[33].

REFERENCES

al-‘Urḍi, Muayyid bin Bārak. *Kitab al-Hay’ah*. Beirut: Markaz al-Dirasāt al-‘Arabiyah. 2001.

Departemen Rukyat dan Hisab. *Kalendar Rukyat MABIMS 1996 – 2020.* Jakarta: Departement Rukyat dan Hisab Indonesia. 1995.

Hassan Musa. *‘Ilm al-Falak fī al-Turāth al-‘Arabiy*. Damascus: al-Maṭba‘ah al-‘Ilmiyah. 2001.

Ibn Nadīm, Abu al-Faraj Muhammad bin Ishaq. *al-Fihris*. Beirut: Dār al-Ma‘rifah. 1978.

Baharruddin bin Zainal. *Kriteria Kenampakan Anak Bulan di Malaysia*. Kota Terengganu: Kolej Ugama Sultan Zainal Abidin. 2003.

Leong Wen Xin. *Lunar Visibility and the Islamic Calendar, A project paper for Undergraduate Research Opportunity Programme in Science*. Singapore: National University of Singapore. 2000.

Mohammad Yasin Owadally. *The Muslim Scientists*. Kuala Lumpur: A.S.Noordeen. 2003

Monzur Ahmad. Documentation for Moon Calculator. Birmingham: n.p. 2001.

Muḥammad Muḥammad Fayyāḍ. *al-Taqāwīm*. Cairo: Wizārah al-Awqāf wa al-Ta‘līm. n.d.

Muhammad Shaukat Odeh. *al-Taqwīm al-Hijrī al-‘Ālamī*. Jordan: n.p. 2002.

Richards, E.G. *Mapping Time Calendar and Its History*. New York: Oxford University Press. 1998.

[33] Gregorian year lag behind the true orbital period of Earth around Sun by 12 seconds. If we divide 24 hours by 12 seconds, the 12 seconds will become a day in 2300 years. If we add that number of 1582 AD, the next correction will be in the year 4782 CE.