Middle-East Journal of Scientific Research 22 (1): 115-120, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.22.01.21831

A Unified Islamic Calendar Proposal for the World

[1]Abdul Halim Abdul Aziz and [2]Ahmed Kamil Ahmed

[1]School of Physics, Universiti Sains Malaysia, 11800 USM Pulau Pinang, Malaysia
[2]Department of Astronomy and Space, College of Science, University of Baghdad, Baghdad, Iraq

Abstract: To date, there is no single global Islamic calendar for the community. Over the years, the computation of the Islamic calendar has become a subject of much debate. In this paper, we propose a unified global Islamic calendar (UGIC) based in the concept of "expected visibility", International Dateline and a single calendar for the whole world. We used a new sightability criterion to determine young crescent visibility that is based on eye-detectable contrast between the crescent illumination and sky background. We propose an unconventional reference for calendar construction that is based on a line instead of a point. We embraced the International Date Line as day (and month) separator. A three-year calendar has been produced based on the above method for evaluation.

Key words: Islamic Calendar · Unified Islamic Calendar · Time-keeping

INTRODUCTION

Apart from the Gregorian calendar, which serves as an international standard for civil time keeping, there are other calendars that are used for religious and cultural purposes. Unlike the Gregorian calendar, which is Solar-based, most others are lunar based, either purely lunar or luni-solar. The Islamic calendar is a purely lunar calendar. Islamic year consists of 12 lunar months without leap months. The lunar months are: Muharram, Safar, Rabiulawal, Rabiulakhir, Jamadilawal, Jamadilakhir, Rejab, Syaaban, Ramadan, Syawal, Zulkaedah and Zulhijjah respectively. The Islamic lunar calendar involves the astronomy of new moon's earliest visibility on local, regional and global scales [1]. It is a widely used time system. However, it has remained a localised system, with each region or country applying localised calculations and/or sightings. The methods of determining the crescent sightability also vary from region to region, resulting in a calendar that is not uniform on a global scale. The need for a global Islamic calendar is a requirement of modern times in response to rapid transportation and communication. In recent decades serious attempts have been made towards globalising the Islamic calendar by scholars like Ilyas [2]. Following his critical appraisal of the lunar visibility (prediction) criterion he went on to study its impact over the entire globe and discovered a systematic pattern of predictability when a uniform criterion is applied. This paved way for a unified calendar.

Most often in astronomy the instance of lunar conjunction is referred to as new moon. In the Islamic tradition, however, a new moon is only recognized after the first eye-sighting of a thin lunar crescent at the time of local sunset and, of course, before the moonset and after lunar conjunction. This usually happens approximately 12-30 hours after a lunar conjunction. In recent decade eye-sighting has included optically aided sighting. However, the actual crescent sightability of the new month cannot be predicted precisely because it depended on atmospheric conditions that accompany the sighting [3]. Hence, the central problem in preparing the Islamic calendar (in advance) is to formulate computational procedures for determining the youngest visible phase of the crescent [4]. For computing a global calendar these computations must then be applied to an agreed reference place on the surface of the Earth.

Traditionally, crescent visibility is important to a muslim society for determining the beginnings of special lunar months, which are Ramadan, Syawal and Zulhijjah. Crescent sighting activities are carried out on the 29th day of the previous month. It is more involved than just computing the times of conjunctions. There are several reasons that affect the new moon visibility. They can be divided into two categories:

Corresponding Author: Abdul Halim Abdul Aziz, School of Physics,
Universiti Sains Malaysia, 11800 USM Pulau Pinang, Malaysia.

Astronomical Reasons: The lack of contrast between the sky brightness (due to atmospheric scattering of the Sun's light) and the thin new crescent moon's brightness, which can be due to:

- The Moon being too young.
- Low altitude of the Moon during local sunset. With small angular separation from the Sun, the sky will appear bright for the period after sunset and before moonset.
- Location of the observer.
- Optical aid used (or not used).

Non-Astronomical Reasons:

- Weather and atmospheric conditions.
- Eyesight acuity of the observer.

Evolution of Calendar Construction: The process of time-keeping is almost as old as human civilization. For simplicity, all early civilizations started with the lunar calendar (e.g. Babylonians, Greeks, Jews, Egyptians, Chinese and Hindus) [9]. In modern studies, the first serious attempt to address the issue of the Islamic lunar calendar was made by a Malaysian astronomer named Mohammad Ilyas in the eighties and nineties of the last century. A new concept of International Lunar Date Line (ILDL) was introduced which divides the world more or less longitudinally into two regions. To the west of that line, the crescent will be visible in the night sky and the month will start at the local sunset. All regions lying to the east of the line would not be able to sight the crescent, thus the start of the month would be delayed by one day. It is important to realize that this line changes each month and has some margins of uncertainty [10]. The curved shape of the ILDL also changes between months. Guessoum, Alattabi and Meziane (1993, 1997) [11] have proposed Islamic lunar calendar based on the model developed by Schaefer [12] and by dividing the world into four regions as follows:

- From 180° to 75° E longitude (from Antemeridian to the eastern border of Pakistan).
- From 75° to 30° E longitude (Asia Minor).
- From 30° E to 15° W (Europe and Africa).
- From 15° to 180° W (Atlantic and American Continent).

Qureshi and Khan [13] compared computed calendars with actual observational calendar from 2000 to 2004 in Pakistan. They found that on average 95% observations were according to the Yallop's criterion [14]. The disagreement was due to either bad weather which prevented sighting (and, hence, the Lunar month began one day late), or due to optimistic claims of sighting (and, hence, the lunar month began one day earlier than predicted). On the other hand the disagreement between an arithmetic or fixed calendar (also sometimes referred as "istilahi" calendar) and the observational one was 54%. "Istilahi" calendar is simple and easy to apply. A month duration alternates between 29 and 30 days with occassional leap months applied based on a smiple formula. Odeh (2001, 2010) [11] introduced the Universal Hijri Calendar (UHC) by dividing the world into two zones, which were:

Eastern Zone: Extends from longitude 180° E to longitude 20° W and that includes all continents: Australia, Asia, Africa and Europe.

Western Zone: Extends from longitude 20° W to western parts of the two American Continents.

In this paper we propose a unified global Islamic calendar (UGIC) for the whole world.

MATERIALS AND METHODS

Sky brightness variations from sunset onwards were measured using a SQM-LU (Canada) sky photometer made by Unihedron between September 2012 and January 2013 intermittently at the Sheikh Tahir Observatory in Pantai Acheh, Pulau Pinang, Malaysia, latitude is 5° 25' N and longitude is 100° 12' E, at a height of 40 m above sea-level [5]. Observation dates were chosen based on moonless nights to exclude the influence of the moon on the sky brightness. The SQM-LU unit is fixed tilted at 5° from the horizon facing the Western sky. The sky brightness was recorded every five minutes for two hours. Crescent sighting data (visible and non-visible observations) were taken from Malaysia's observation archive at JAKIM [6] and Iran's archive at UGCS [7].

Positional software based on Xephem astrometry library were usedto compute the geometry of the Sun and Moon at the time of sunset as well as the Moon's percentage illumination. From these we derived a new crescent visibility criterion [8] and use this criterion to compute the proposed unified global Islamic calendar (UGIC).

Premises for the Construction of UGIC: The UGIC is constructed on the following premises:

1. There is a need for a single Islamic calendar for the whole globe.
2. As discovered by Ilyas [15] crescent sightability across the globe is systematic and has global patterns. These patterns are simple but vary from month to month.
3. Acknowledge and utilise the International Date Line (IDL) as day and month separator.
4. One positive sighting in any part of the globe is good for the whole globe. This idea may raise controversy amongst some Islamic jurists who hold the concept of matla' or common region. This often lead to proposals of 2 or more zones for the Islamic Calendar. While this is conciliatory it is also cumbersome to practice. There are, however, also jurists who accept a single global calendar solution that is based on one sighting for the whole globe. We favour this stand for our calendar construction. We do not dispute any ruling to locally verify the calendar dates with actual sighting for the special months of Ramadan, Shawal and Zulhijjah.
5. A calendar has to be constructed in advance, hence it is constructed based on known physical principles and computations. It is, therefore, possible to utilize the concept of one "expected sighting" to represent the whole globe.
6. A calendar must, therefore, be made based on the principle imkanur rukyah or 'expected sighting' so that it embraces the spirit of crescent sighting. This concept has been discussed internationally and agreed upon at the Calendar Commission held in Istanbul in 1978 [16].
7. Calendar constructed based on imkanur rukyah will, in turn, greatly benefit physical sighting of young crescent for the special months [16].
8. Preferably, no regular place on the globe should have to start a new month before lunar conjunction. A criterion must be chosen such that the Moon is already 'born' and have a positive age at the local sunset on any normal part of the globe that share a same day.
9. A sightability criterion and its location of test must be chosen so that it will not appear to negate other sightable areas on the globe. This is to avoid a situation where the calendar specifies the crescent as not sightable, but numerous people were able to physically sight the young Moon. This will generate distrust to the system. Hence, care has to be exercised not to impose a very lose criterion that often result in sightability in North America or land closer to the 180° W longitude.

Implementation of UGIC: With the above premises a criterion line (instead of a point) was chosen. This is to make the criterion more robust to the changing patterns of the global sightability distribution. The criterion line runs along the 60° W longitude and is in between latitudes 25° N and 25° S. At local sunset, at anywhere along the criterion line if the Moon's illumination is $\geq$ 0.39% [10] then a new month begins. The choice of 60° W line is a compromise between points 8 and 9 of the premises. There is an observational uncertainty of ±0.1% in the Moon's illumination criterion. That represents a sightability uncertainty of ±25% at the criterion line.

Table 1 shows an equivalent sightable Moon's age distribution that correspond to our criterion. Moon's age range from 12 to 30 hours with an average sightability age of 20 hours. Moon's age is defined as time between a lunar conjunction and the time of local sunset. The longitude difference from 180° E to 60°W is 240°. That represent a time difference of 16 hours. Taking an extreme case of lunar conjunction at exactly the time of local sunset at some location along the 180° E line (that experience regular days and nights) then there is a 10% probability that by the time any single location on the criterion line experience local sunset the crescent is sightable. On 90% of cases it will be unsightable. This is in line with premise number 8. However, we believe this situation is rare and on most occasion the global criterion is not met at the criterion line. A 10% probability estimate of new months occurring before conjunction at the 180° E line is well within our observational uncertainty. Table 1 shows 19 out of 173 computed crescent sighting occur at ages below16 hours.

Table 1: Shows a 173-month distribution of computed sightability according to our criterion expressed as Moon's age at Makkah, Saudi Arabia.

Moon's Age (h)	Incidence of Sighting
10	0
12	1
14	18
16	17
18	22
20	32
22	37
24	23
26	9
28	7
30	7
32	0

Construction of a Unified Global Islamic Calendar: We will introduce an algorithm for the construction of an Islamic calendar based on our criterion. The lunar sightability distribution algorithm is made as follows:

- Determine a date to evaluate the sightability of young crescent. This will be the 29th day of an Islamic Calendar month.
- Create a world 2-D coordinate grid for 180° W to 180° E in longitude at 10 ° interval and 40° N to 40° S at 5° interval.
- For every grid point on the specific date calculate the local sunset time.
- Then at that local sunset time lunar sightability is evaluated.
- If the location fulfils our criterion a '+' is printed on the screen, otherwise a '.' is printed.
- Procedure 3 to 6 is repeated until calculation for the whole grid is complete.
- Criterion test sites are all points along the 60° W longitude between 25° N and 25° S. We call this the criterion line. If any part of the line fulfils the criterion i.e. receive a '+' on the grid, then we consider the young moon is representatively sightable for the globe and a new month commences at any local sunset that share the same day. Otherwise, the new month begin one day later Note that an Islamic day begins at sunset.
- The process is repeated for remaining months.

Figure 1 in appendix A shows an example of global visibility distribution for 31 Jan 2014 using the above method. In this distribution we see that the moon is sightable along the 60° W longitude between latitudes 25° N and 25° S (marked as red '+'). Incidently, the latitude range chosen for the criterion was based on an approximation of the tropics where majority of the world Muslim population reside. It is also well within the range of regular days and nights throughout the year.

Calendar Comparison: We compare our computed calendar proposal with 4 published calendars, namely calendars of Malaysia, Saudi Arabia, Iran and Iraq for 2 consecutive years, shown in Table 2. We also show our proposed computed calendar for the next 3 years (36 months) from 1436 to 1438 AH in Table 3.

DISCUSSION

Of the countries chosen, Saudi Arabia and Malaysia show small average deviations from their existing calendars (8% and 17% respectively). The average deviation is calculated by taking the total number of deviated days divided by the total number of months, without taking into account whether the deviations are earlier or later. Iran and Iraq show greater deviations of 33% and 44% respectively. In all cases each monthly deviation do not exceed 1 day. These discrepancies are more likely due to different sightability criteria employed.

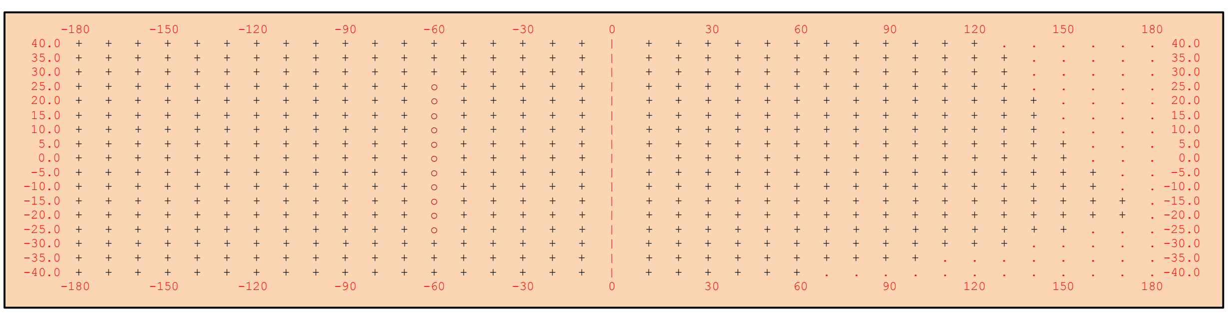

Fig. 1: Shows an example the global lunar sightability diagram based on the moon's illumination = 0.39% at local sunset on 31st January 2014 or the 29th day of the month of Rabiulawal 1435 AH. The horizontal axis represents the longitude, and the vertical represents the latitude on the Earth. The prime meridian, 0º, is represented by '?'. The sightability of new moon is represented by '+' whereas non-sightability is represented by '.' In this diagram the global sightability criterion is met because the '+'s are present at the criterion line, i.e. the line marked red 'o' along longitude 60o W between latitude 25o N and 25o S. Therefore, a new Islamic month begins at local sunset of the day. Note that the shape and orientation of the curve (seen at the interface between the '.' and '+') vary from month to month. There can also be months where the curve barely touches the criterion line, and also months where the curve is outside the criterion line. If the curve is outside the criterion line (i.e. the '+' are outside the criterion line) then the month begins at the local sunset the following day. If the curve include the criterion line or touches any part of the line then the month begin at local sunset of the same day.

Table 2: A comparison between our proposed calendar versus published Saudi Arabia, Malaysia, Iran and Iraq calendars for 1434 and 1435 AH

Hijri Month	Our Date	Our Month Dunation (d)	Saudi Date	Saudi Month Duration (d)	Our Date - Saudi Date (d)	Malaysia Date	Malaysia month duration (d)	Our Date - Malaysia Date (d)	Iran Date	Iran Month duration (d)	Our Date -Iran Date (d)	Iraq Date	Iraq Month duration (d)	Our Date - Iraq Date (d)
Muharram 1434	2012-11-15	29	2012-11-15	29	0	2012-11-15	29	0	2012-11-16	30	-1	2012-11-16	29	-1
Safar	2012-12-14	29	2012-12-14	29	0	2012-12-15	30	-1	2012-12-15	29	-1	2012-12-15	29	-1
Rabiulawal	2013-01-13	30	2013-01-13	30	0	2013-01-13	29	0	2013-01-13	29	0	2013-01-13	29	0
Rabiulakhir	2013-02-11	29	2013-02-11	29	0	2013-02-12	30	-1	2013-02-12	30	-1	2013-02-12	30	-1
Jamadilawal	2013-03-13	30	2013-03-13	30	0	2013-03-13	29	0	2013-03-13	29	0	2013-03-13	29	0
Jamadilakhir	2013-04-12	30	2013-04-12	30	0	2013-04-12	30	0	2013-04-12	30	0	2013-04-12	30	0
Rejab	2013-05-11	29	2013-05-11	29	0	2013-05-11	29	0	2013-05-12	30	-1	2013-05-12	30	-1
Syaaban	2013-06-10	30	2013-06-10	30	0	2013-06-10	30	0	2013-06-10	29	0	2013-06-11	30	-1
Ramadan	2013-07-09	29	2013-07-10	30	-1	2013-07-10	30	-1	2013-07-10	30	-1	2013-07-10	29	-1
Syawal	2013-08-08	30	2013-08-08	29	0	2013-08-08	29	0	2013-08-09	30	-1	2013-08-09	30	-1
Zulkaedah	2013-09-07	30	2013-09-07	30	0	2013-09-07	30	0	2013-09-07	29	0	2013-09-08	30	-1
Zulhijjah	2013-10-06	29	2013-10-06	29	0	2013-10-06	29	0	2013-10-07	30	-1	2013-10-07	29	-1
Muharram 1435	2013-11-05	30	2013-11-05	30	0	2013-11-05	30	0	2013-11-05	29	0	2013-11-05	29	0
Safar	2013-12-04	29	2013-12-04	29	0	2013-12-04	29	0	2013-12-04	29	0	2013-12-05	30	-1
Rabiulawal	2014-01-02	29	2014-01-02	29	0	2014-01-03	30	-1	2014-01-03	30	-1	2014-01-03	29	-1
Rabiulakhir	2014-02-01	30	2014-02-01	30	0	2014-02-01	29	0	2014-02-01	29	0	2014-02-01	29	0
Jamadilawal	2014-03-02	29	2014-03-02	29	0	2014-03-03	30	-1	2014-03-03	30	-1	2014-03-03	30	-1
Jamadilakhir	2014-04-01	30	2014-04-01	30	0	2014-04-01	29	0	2014-04-01	29	0	2014-04-01	29	0
Rejab	2014-04-30	29	2014-05-01	30	-1	2014-05-01	30	-1	2014-05-01	30	-1	2014-05-01	30	-1
Syaaban	2014-05-30	30	2014-05-30	29	0	2014-05-30	29	0	2014-05-30	29	0	2014-05-31	30	-1
Ramadan	2014-06-29	30	2014-06-29	30	0	2014-06-29	30	0	2014-06-29	30	0	2014-06-29	29	0
Syawal	2014-07-28	29	2014-07-28	29	0	2014-07-28	29	0	2014-07-29	30	-1	2014-07-29	30	-1
Zulkaedah	2014-08-27	30	2014-08-27	30	0	2014-08-27	30	0	2014-08-28	30	-1	2014-08-28	30	-1
Zulhijjah	2014-09-26	30	2014-09-25	29	1	2014-09-26	30	0	2014-09-26	29	0	2014-09-26	29	0
Averages		29.54		29.5	0.08		29.54	0.17		29.54	0.33		29.5	0.44

Table 3: Represent the results of unified global Islamic calendar (UGIC) for years 1436 to 1438 AH

	1436		1437		1438	
Hijri Month	Expected Date	Month Duration (d)	Expected Date	Month Duration (d)	Expected Date	Month Duration (d)
Muharram	2014-10-25	29	2015-10-14	29	2016-10-02	29
Safar	2014-11-24	30	2015-11-13	30	2016-11-01	30
Rabiulawal	2014-12-23	29	2015-12-12	29	2016-12-01	30
Rabiulakhir	2015-01-21	29	2016-01-11	30	2016-12-30	29
Jamadilawal	2015-02-20	30	2016-02-10	30	2017-01-29	30
Jamadilakhir	2015-03-22	30	2016-03-10	29	2017-02-28	30
Rejab	2015-04-20	29	2016-04-09	30	2017-03-29	29
Syaaban	2015-05-19	29	2016-05-08	29	2017-04-28	30
Ramadan	2015-06-18	30	2016-06-06	29	2017-05-27	29
Syawal	2015-07-17	29	2016-07-05	29	2017-06-25	29
Zulkaedah	2015-08-16	30	2016-08-04	30	2017-07-25	30
Zulhijjah	2015-09-15	30	2016-09-03	30	2017-08-23	29

However, we hope these discrepancies will not become a permanent deterrent to the adoption of a unified global Islamic calendar.

Longitude 60° W cover most of South America but a little of North America. This represents our critical choice. If our criterion line does not fulfil the criterion, but the rest of North America whose longitudes lie west of the criterion line does, then we may create a confidence issue.

In North America, there is a region of land that lie in between our criterion line and 120° W. This represent 4 hours of time difference. Using table 1, a young Moon whose age is <12 hours at the criterion line is deemed unsightable. However, at the 120° W the Moon's age will reach 16 hours and there will be a 10% sightability probability. Studying table 1 we see that the probability of sighting at 120°W is better than at 60° W due to the 4-hour age increase. We worked out the increase in probability for young Moon's ages 12, 14, 16, 18 and 20 hours and find the increased probability at 120° W longitude as 10%, 10%, 25%, 30% and 40% respectively. Up to the age of 16 hours the increased probability is within our observational error. At above 18 hours the extra chance of sighting appear significant. However, a cursory examination of the global sightability distribution pattern showed a seasonal skew at higher latitudes where the northern and southern hemispheres do not experience equal probability. We are inclined to believe that the probability values given above will be halved at higher latitudes due to the effect of season on the global sightability distribution. This analysis merit further scrutiny.

Another way to tackle this issue is by shifting the criterion line from 60° W to 120° W. However, in doing so we will increase the probability for places near longitude 180° E to experience a new month before lunar conjunction from 10% to 34%. This will also be a significant increase when compared to our observational uncertainty of 25%. Hence, we are inclined to recommend our criterion line location as appropriate. A longer term study may refine this position.

CONCLUSION

We have proposed a unified global Islamic calendar (UGIC) system based on a threshold percentage crescent illumination criterion of 0.39% tested at local sunset along a longitude line 60° W between latitudes 25° N and 25° S. This calendar was tested against existing calendars in Malaysia, Saudi Arabia, Iran and Iraq for a period of 2 years and found to have a discrepancy of less than 50% and maximum monthly deviation of not more than 1 day. We have constructed a future 3-year calendar based on this method in the hope that it will be evaluated by the community.

ACKNOWLEDGEMENTS

This work supported by Universiti Sains Malaysia (USM) through research grant award number (1001/PFIZIK/846078) titled "Photometric Data of Young Moon and Visibility Criterion for the Islamic Calendar", and the Ministry of Higher Education and Scientific Research, Iraq.

REFERENCES

1. Ilyas, M., 1994. Lunar Crescent Visibility and Islamic Calendar. Quarterly Journal of the Royal Astronomical Society, 35: 425-461.
2. Ilyas, M., 1991. Hijrah Day Number, Islamic Day Number and Islamic Lunation Number: New Parameters for Exacting the Islamic Calendar, Journal of British Astronomical Association, 101(3): 175.
3. Guessoum, N. and K. Meziane, 2001. Visibility of the Thin Lunar Crescent: The Sociology of an Astronomical Problem (A Case Study), Journal of Astronomical History and Heritag, 4(1): 1-14.
4. Abdali, S.K., 1979. On the Crescent's Visibility, this is an expanded version of a paper presented to the Conference on Community Development, MCC Chicago, March 1978, Courtesy Al-Ittihad, 16: 1-6.
5. Abdul Aziz, H. and A.K. Ahmed, 2013. Study of Young Crescent Visibility Based on Contrast Brightness Using Observed Data from Malaysia and Iran, 5th Conference on Lunar Crescent Visibility and Calendar, 26 June, Tehran, Iran.
6. Jabatan Kemajuan Islam Malaysia, Available from World Wide Web: http://apps.islam.gov.my/efalak/?q=en/erhk-laporan-baru.
7. Hasanzadeh, A., 2012. Study of Danjon Limit in Moon Crescent Sighting. Astrophys Space Sci., 339: 211-221.
8. Ahmed, A.K. and A.H. Abdul Aziz, 2014. Young Moon Visibility Criterion Based on Crescent Illumination and Sky Brightness Contrast Model, Middle-East Journal of Scientific Research, 21(9): 1641-1644.
9. Ilyas, M., 1986. Lunar Calendars: The Missing Date-Lines. Journal of the Royal Astronomical Society of Canada, 80(6): 328-335.
10. Guessoum, N., 2010. New Moon on the Horizon: An Astronomer's Guide to Solving the Start of Ramadan [Online], Available from World Wide Web: http://www.nature.com/nmiddleeast/2010/100809/.
11. Available from World Wide Web: http://www.icoproject.org/.
12. Schaefer, B.E., 1988. Visibility of the Lunar Crescent, Quarterly Journal of the Royal Astronomical Society, 29: 511-523.
13. Qureshi, M.S. and N. Khan, 2006, A Comparative Study of Arithmetic, Observational and Predicted Lunar Calendar for Pakistan for Years 2000-2004, Journal of Basic & Applied Sciences, 2(2).
14. Yallop, B.D., 1998. A Method for Predicting the First Sighting of New Moon. Technical Note No. 69, HM Nautical Almanac Office, Royal Greenwich Observatory, Cambridge, UK. NAO.
15. Ilyas, M., 1984, A modern Guide to Astronomical Calculations of Islamic Calendar, Times & Qibla. Kuala Lumpur: Berita Publishing Sdn Bhd.
16. Ilyas, M., 1988. Limiting Altitude Separation in the Moon's First Visibility Criterion, Astronomy Astrophysics, 206: 133-135.