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Analysis Data of the 22 Years of Observations on the Young Crescent Moon at Telok Kemang Observatory in Relation to the *Imkanur Rukyah* Criteria 1995

(Analisis Data 22 Tahun Cerapan Anak Bulan di Balai Cerap Telok Kemang Berdasarkan Kriteria Imkanur Rukyah 1995)

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ABSTRACT

The main challenge in the young crescent moon (YCM) observation is the ability to detect the appearance of the YCM, which has varying contrast due to the phenomenon of twilight. The advancement of technology in digital imaging helps the faint and thin image of the YCM to be detected and taken during observation. The techniques used in the observations of the YCM were naked eyes, telescope, and telescope with cameras. A digital imaging technique is also being used in the observations to assist in detecting and recording the image of the YCM more effectively. This paper presents the analysis of the YCM observation data recorded at Telok Kemang Observatory from 2000 to the present. A total of 275 observation sessions were conducted during this study, with 87 positive sightings successfully recorded. The studies found that the smallest elongation and the minimum altitude at sunset of the YCM successfully recorded were 6.81° and 5.40°, respectively. The moon was recorded at an altitude of 3.37°, while the sky is still bright with the sun at an altitude of –2.64° using the digital imaging technique. Based on the records, the YCM which has the minimum criteria of *Imkanur Rukyah,* i.e., altitude of 2° and elongation of 3° at sunset was never detected or recorded during the 22 years of observations. Therefore, this work suggests the need to change the visibility of *Imkanur Rukyah* criteria used since 1995 to a more potentially observable criterion. In other aspects, the lengthy observation activities have contributed to the development of a database system for *JAKIM* that other researchers can access.

Keywords: Digital imaging; *Imkanur Rukyah* criteria; Telok Kemang Observatory; young crescent moon sighting

ABSTRAK

Cabaran utama dalam cerapan anak bulan adalah keupayaan untuk mengesan kenampakan anak bulan dengan latar belakang langit yang mempunyai kontras yang berbeza-beza disebabkan fenomena senja. Kemajuan teknologi dalam pengimejan digital membantu imej anak bulan yang kabur dan tipis dikesan dan direkod semasa cerapan. Teknik yang digunakan dalam cerapan anak bulan adalah dengan mata kasar, teleskop dan teleskop yang disambungkan dengan kamera digital. Selain itu, teknik pengimejan digital juga digunakan dalam cerapan untuk mengesan dan merakam imej anak bulan dengan lebih berkesan. Artikel ini akan membentangkan analisis data cerapan anak bulan yang direkodkan di Balai Cerap Telok Kemang dari tahun 2000 hingga kini. Sebanyak 275 sesi cerapan telah dijalankan, dengan 87 kenampakan positif berjaya direkodkan. Kajian mendapati anak bulan telah dikesan dengan pemanjangan terkecil bulan-matahari dan altitud terendah bulan ketika matahari terbenam iaitu masing-masing adalah 6.81° dan 5.40°. Anak bulan tersebut telah direkodkan pada altitud 3.37° semasa keadaan langit masih lagi cerah dengan altitud matahari di bawah ufuk –2.64° menggunakan teknik pengimejan digital. Berdasarkan data yang direkodkan, anak bulan yang mempunyai nilai minimum Kriteria Imkanur Rukyah, iaitu ketinggian bulan 2° dan pemanjangan bulan-matahari 3° ketika matahari terbenam, tidak pernah dikesan atau direkodkan sepanjang 22 tahun cerapan dijalankan. Oleh itu, kajian ini mencadangkan keperluan untuk menukar nilai kriteria kenampakan anak bulan yang digunakan sejak 1995 kepada kenampakan yang lebih berpotensi untuk anak bulan kelihatan. Dalam aspek lain, aktiviti cerapan yang telah dijalankan dalam tempoh yang lama ini dapat menyumbang kepada pembangunan satu pangkalan data kenampakan kepada pihak JAKIM yang boleh diakses oleh penyelidik lain.

Kata kunci: Balai Cerap Telok Kemang; cerapan anak bulan; kriteria Imkanur Rukyah; pengimejan digital

Introduction

The moon takes in the ranges between 29.18 and 29.93 days to return to the next new moon phase, in which the position of the moon is in conjunction with the sun as seen from the earth. The light on the moon's surface is reflected towards the sun during the conjunction (Photinos 2015). Only after a few hours of conjunction, a portion of light from the moon's surface is reflected towards earth. If the smallest part of the moon, which reflects light towards the earth, can be seen, it is defined as the young crescent moon (YCM). This condition would result in a very thin and dim arc of light with a certain width as viewed from the earth. Several hours after the conjunction, the moon's position in the sky is just a few degrees above the sun when they become closer to the horizon. Therefore, if the conjunction has occurred on the evening 29th of the lunar month, the moon will set after sunset. The period for the YCM available above the horizon after sunset is not more than an hour before it sets. The visibility of YCM is expected if the geometrical parameters of the YCM fulfilled the visibility criteria, i.e., *Imkanur Rukyah* 1995 criteria in which the moon's altitude is not more than 2°, and the elongation of the moon-sun is not more than 3° at sunset, or the age of the YCM must not be less than 8 h after conjunctions (Nawawi et al. 2015). The position of the YCM is close to the western horizon, which is usually cloudy, and the bright sky background challenges the observers in detecting its earliest appearance. However, the development of science and technology has opened a new dimension to the encouraging progression of YCM visibility in digital images.

The Optical Astronomy Research Lab (MPAOP), University Malaya, and the Department of Islamic Development Malaysia (JAKIM) have conducted the YCM observations since 2000 at Baitul Hilal Telok Kemang, Port Dickson, Negeri Sembilan, now known as the Telok Kemang Observatory. The monthly observations activities also involve collaboration with various parties; the Department of Mufti Negeri Sembilan (JMKNNS) and the Department of Survey and Mapping Malaysia (JUPEM). Since that year, observation activities have been carried out every month using computerized mounted telescopes and film single-lens reflex (SLR) cameras to record the YCM (Bilal et al. 2013). The image of the YCM was recorded using a photographic film camera after it was successfully seen on a telescope. Therefore, the imaging of the YCM at that time was only intended to record the images of the YCM that were successfully observed.

Starting from June 2006, the film SLRs camera is replaced with the DSLRs camera for capturing the image of YCM. A digital camera allows images of the YCM, which are taken through a telescope, immediately displaying the image after exposure and can be reviewed for live public viewing (Schedler 2005). Furthermore, the application of digital camera imaging can help to hasten the time in detecting the thin and faint YCM behind the gaps of clouds that are not too thick for light penetration (Junaidi 2018). Therefore, this paper will present the digital imaging techniques in detecting the visibility of the YCM within the minimum criteria of *Imkanur Rukyah* and the findings of YCM visibility that have been successfully recorded throughout the 22 years of the observations.

Materials and Methods

The equipment and devices used in the observations are the 12-inch reflector and 101 mm refractor attached to a portable telescope with altazimuth mounting system, telescope accessories, and imaging digital cameras. The instrument setup for YCM observation was done before sunset, as shown in Figure 1.

Setting up the telescope and alignment must be done before sunset. For daytime alignment, the sun is the only celestial object used as the reference. If thick

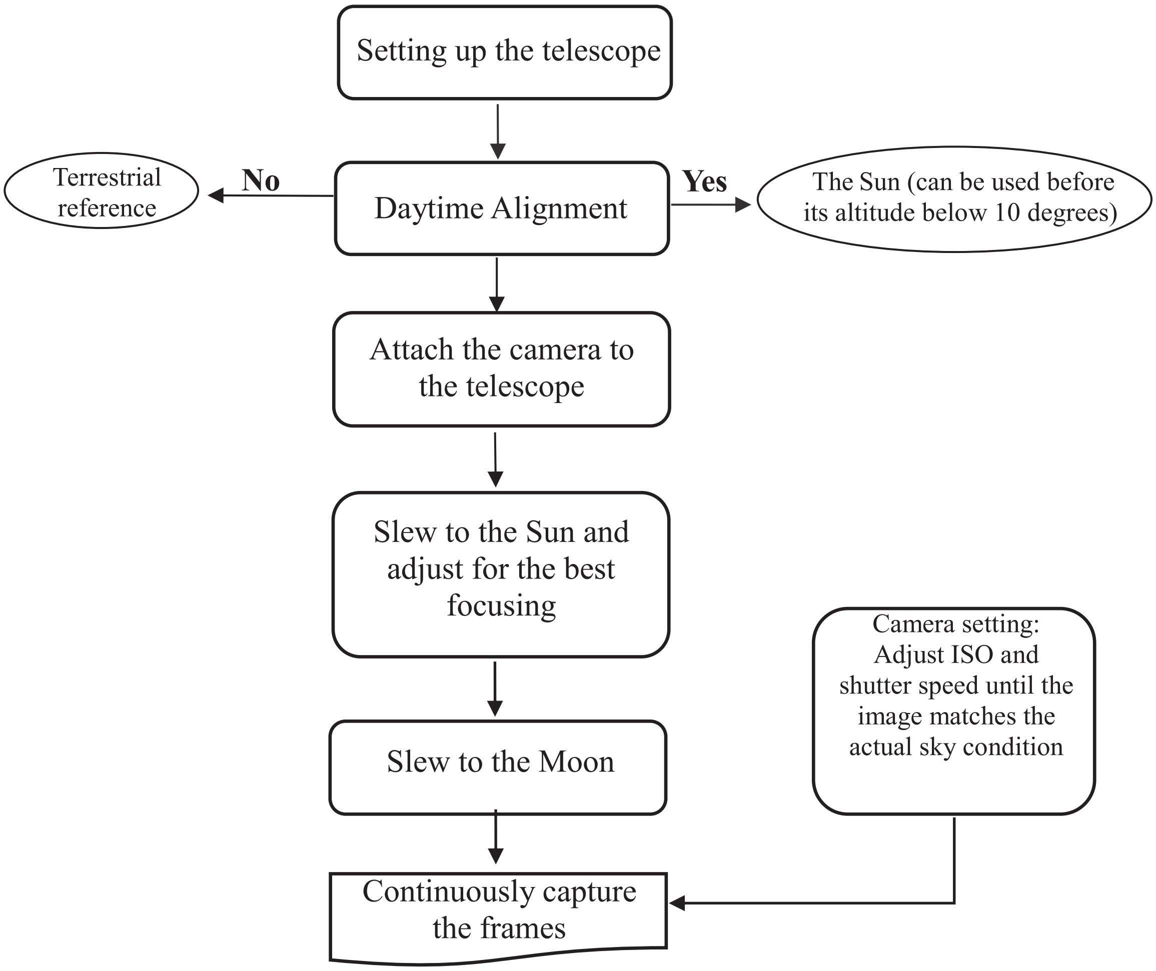


FIGURE 1. Flow chart of instrument setup for digital imaging technique

clouds cover the sun, then a terrestrial reference point with known coordinates will be used for the alignment process. The sun is also used in obtaining the best focusing point at the telescope (Kitchin 2013). The fine and dim arc of the YCM can be dissolved in the bright sky background if the image is not well focused. The telescope with a camera attached to it is then directed to the moon and begins the tracking while the camera continuously captures the frames of the image (Nizam et al. 2014). The settings of ISO and shutter speed of the camera can be changed to match the sky brightness level (Kitchin 2013). If they were matched, then the image captured in the frame should be the same as seen by the eyes. The digital camera allows an immediate review of the captured images (Busch 2007). Some basic features in digital images, such as brightness and background contrast, can be adjusted to enhance the foreground's image.

The camera is remotely controlled to reduce vibration when capturing the images, and the images were then enhanced using Digital Photo Professional 4 for adjusting the brightness and contrast levels of the images. The adjustments of the contrast background and foreground brightness are needed as the perfect ISO and shutter speed used for the camera that matched the sky brightness are hard to determine. By adjusting the brightness and contrast, the image will be enhanced to enable the YCM to appear if it exists in the frame (Bilal et al. 2013). For example, adjusting the tone curve has increased the contrast of the background image that enhanced the YCM's curve in the image frame recorded by the digital camera. Figure 2 shows the images of the YCM recorded by a DSLR. Some of the images were enhanced to increase the contrast of the YCM.

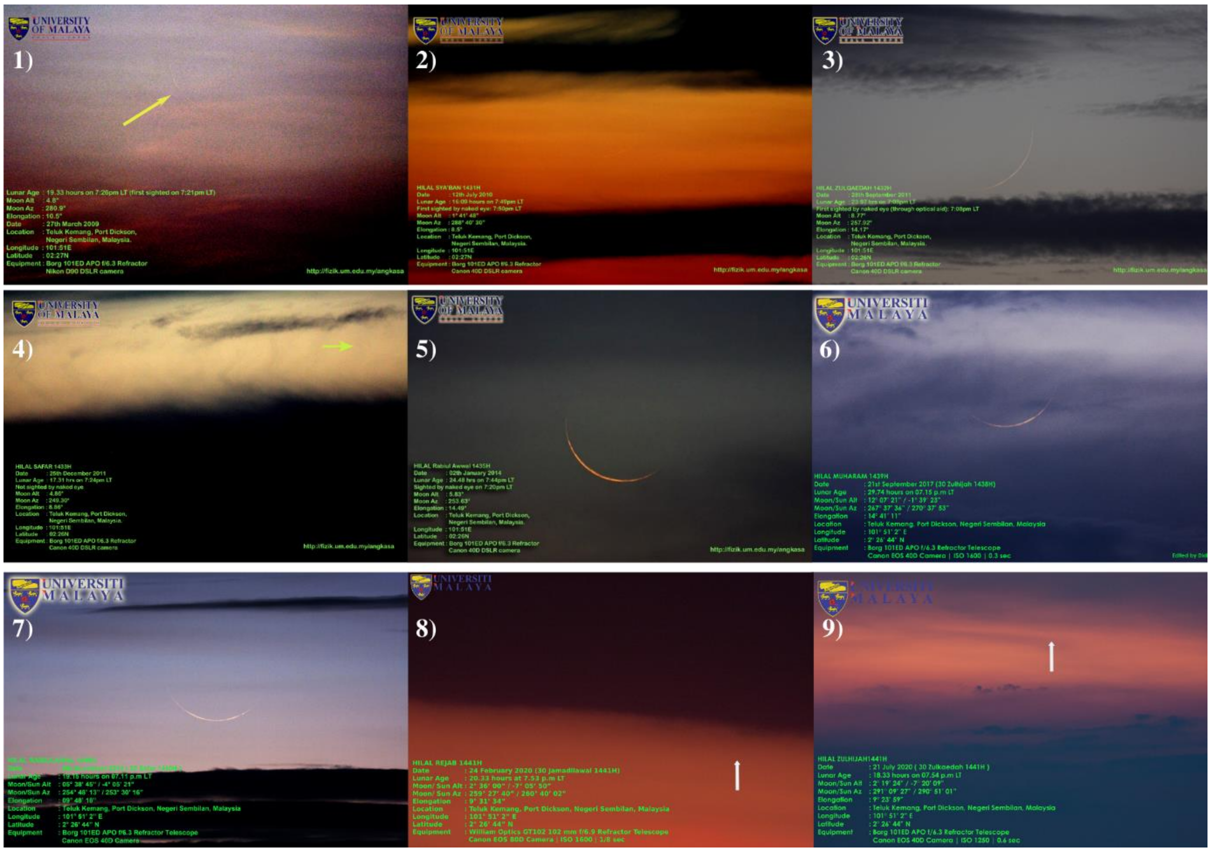


FIGURE 2. Images of the YCM were recorded by a DLSR camera attached to a telescope Images 2, 4, 8 and 9 were enhanced using Digital Photo Professional 4. The arrow in the image indicates the YCM. Courtesy from *JAKIM: Laporan Kajian Cerapan Hilal 1442H*

TABLE 1. The parameters of the YCM as shown in Figure 2

Image	Date	Alt- Moon,a_m (º)	Alt-Sun,a_s (º)	Elongation,e (º)	Moon age (h)
1	27 March 2009	4.8	-1.32	10.5	19.33
2	12 July 2010	1.69	-6.27	8.5	16.09
3	28 September 2011	8.77	-0.59	14.17	23.97
4	25 December 2011	4.86	-3.52	8.86	17.31
5	2 January 2014	5.83	-7.31	14.49	24.48
6	21 September 2017	12.12	-1.66	14.69	29.74
7	8 November 2018	5.65	-4.09	9.81	19.15
8	24 February 2020	2.6	-7.09	9.53	20.33
9	21 July 2020	2.32	-7.33	9.4	18.33

DATA COLLECTION AND ANALYSIS

Data on the visibility of the YCM in Telok Kemang Observatory were collected for 22 years, starting in March 2000 until the end of July 2021. The total observation activities were 275 observation sessions with 87 positive data. From 2000 until June 2009, the observations were carried out on the 29th, 30th, and 1st of the Hijr months. From August 2009 until now, the observations have been carried out consistently on each of the 29th or 30th Hijr months.

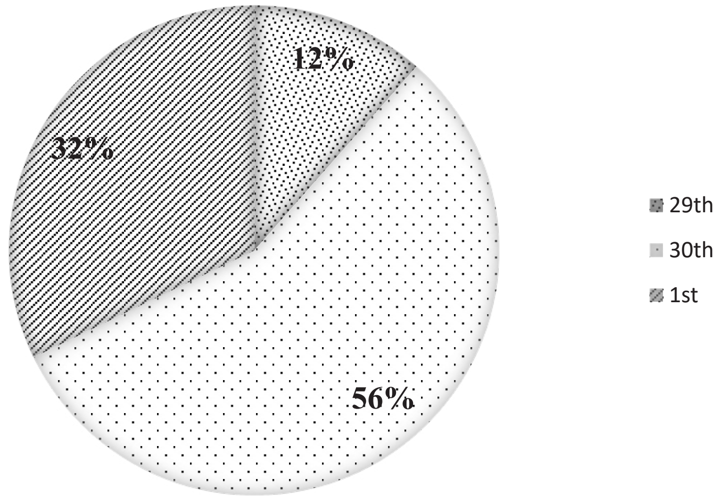


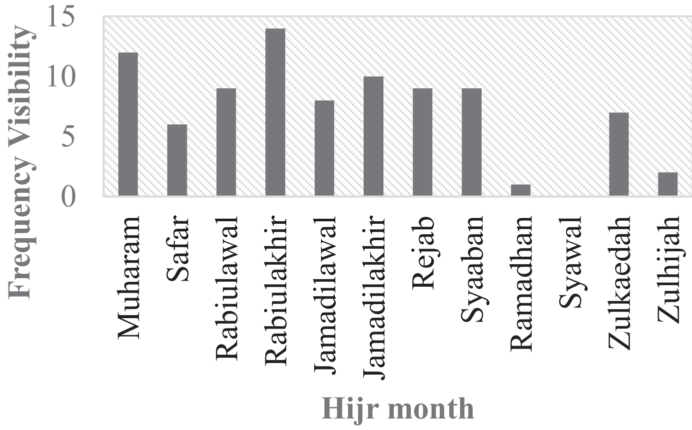
FIGURE 3. Percentage of the YCM visibility on the 29th, 30th and 1st month of Hijr for the 22 years of observations

Figure 3 shows the percentage of the YCM visibility on the 29th, 30th and 1st month of Hijr. From the pie chart, about half of the successful YCM observation (56%) was visible on the 30th because the width of the YCM is much bigger and brighter than the previous day allowing the YCM to be easily visible even before the sunsets when the sky still bright. In contrast, the positive sighting on the 29th is only 12% due to the very thin and dim moon's arc. In addition, its position is closer to the horizon that usually cloudy. A higher percentage of positive sighting (32%) on the 1st day of Hijr months was expected as the YCM can be seen directly by the naked eye, but the observations were conducted until June 2009.

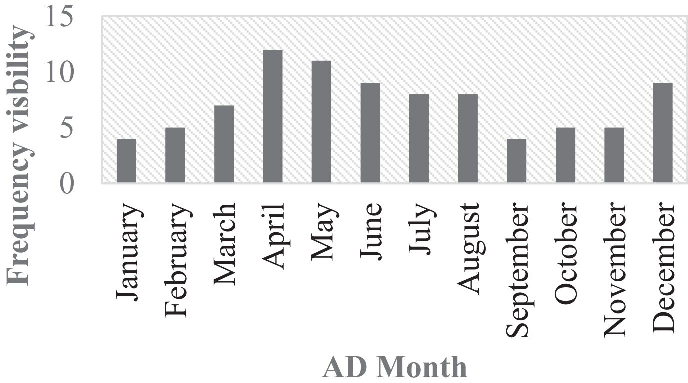
Based on the positive data, the number of visibilities is distributed over the AD months and Hijr months, as shown in Figure 4(a) and 4(b). It is evident from the bar chart that a higher frequency of visibility spans from April to August, which relates to pleasant weather and good sky conditions. The frequency of visibility was also relatively higher in December; however, most of them were seen on the 30th of Hijr months. On the other hand, the distribution over the Hijr months shows Rabiulawal has the highest number of visibilities. Most of the YCM observed on the 30th of Hijr months and none for Syawal caused no observation is carried out in Syawal for most of the years. The visibility of the YCM on the 29th and 30th of Hijr was also plotted by years and classified according to the observation technique as shown in Figure 5.

A telescope system attached with an SLR camera (film-based) used in the observation enables the image of the YCM to be recorded. However, it is still inefficient because the film needs to be processed and takes a lot of time to get the results. Therefore, starting from June 2006, the image of the YCM has been taken using a digital single-lens reflex camera (DSLR). By using a DSLR camera, the camera's setting can be adjusted lively to obtain the best quality images (Schroder & Luthen 2009), also the enhancement of contrast in the image can be done in real-time. Thus, the digital imaging technique indeed helps to hasten the process of detecting the appearance of the YCM compared to the naked eyes visibility (Wahid et al. 2019).

Based on the successful observations, the data have been categorized into three groups which are naked eye only – observed by the naked eye without using optical devices, telescope – observed through the eyepiece of a telescope, and telescope-digital camera – the image of



(a)



(b)

FIGURE 4. (a) The number of YCM visibility from 2000 until 2021 and b) The number of YCM visibility from 1420H until 1441H

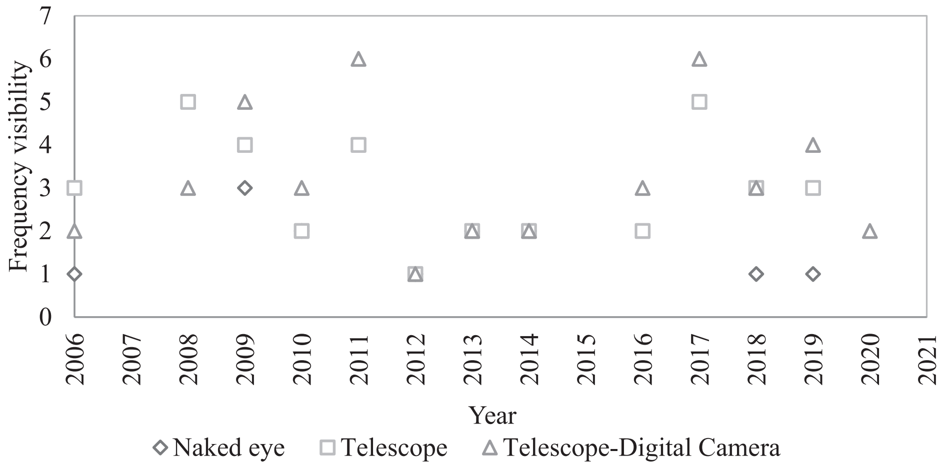


FIGURE 5. Distribution of YCM visibility from the year 2006 until 2021 based on the observing methods

YCM can be seen on a screen or display of a camera or computer. Some of the images need to undergo image processing procedures to detect the curve of YCM. The naked eye only method records the YCM seen on the 1st of Hijr, primarily for the data before 2009. Figure 5 illustrates the distribution of the YCM visibility over the years with the three observing methods. Most of the YCM that can be observed through the eyepiece of a telescope can also be recorded using digital cameras. However, some of the YCMs detected using digital cameras cannot be seen on the telescope eyepiece. In recent years, the implementation of digital cameras has significantly helped the detection of the YCM during the observation being conducted.

Results and Discussion

Based on the data and analysis carried out, three observing methods that can be used for sighting the YCM namely naked eyes, telescope aided, and telescope with a digital camera. All three methods exhibit the appearance of the YCM on different parameters. Table 2 summarizes the number of successful observations of the YCM on the 29th, 30th and 1st of Hijr according to the observing methods since 2000.

TABLE 2. Summary of the visibility numbers of the YCM for the 22 years of observations

Observing Date \ Observing methods	Naked eyes	Telescope	Telescope-Digital camera (Since June 2006)
29th	0	6	7*
30th	12	44	33#
1st	28	28	4

Note: * and # marks respectively indicate that 4 out of 7 images on the 29th and 6 out of 33 images on the 30th were detected by digital camera only

It is clear from Table 2 that the YCM on the 29th of Hijr was never visible by the naked eyes and only visible for the YCM on the 30th and 1st of Hijr, as it becomes brighter and appears at a higher altitude after sunset. In 22 years of observations, only 6 times the YCM was successfully detected on the 29th of Hijr by using a telescope and 4 of them were recorded using a film SLR camera (before June 2006). After June 2006, the YCM was detected 7 times, and 4 of them were detected by digital camera only, and the rest can also be observed through the telescope. As for the 30th of Hijr, most of the YCM was detected using all methods except for the 5 observing sessions as listed in Table 3.

TABLE 3. Parameters for YCM images detected through digital cameras only

	Date	Elongation,e (º)	Alt- Moon,a_m (º)	Alt-Sun,a_s (º)
1	30 Rabiulawal 1430 H (27 Mac 2009)	10.50	4.80	-1.32
2	29 Zulhijah 1431H (6 December 2010)	8.36	1.678	-6.98
3	30 Rabiulakhir 1432 H (4 April 2011)	9.96	1.07	-5.80
4	29 Muharam 1433H (25 Dec 2011)	8.85	4.92	-3.45
5	30 Rabiulakhir 1437 H (9 Feb 2016)	11.09	3.30	-6.68
6	29 Zulkaedah 1438 H (22 Aug 2017)	8.30	6.29	-1.08
7	29 Syaaban 1440H (5 May 2019) #	6.81	3.37	-2.64
8	30 Zulhijah 1440 H (31 Aug 2019)	14.57	9.94	-4.52
9	30 Jamadilakhir 1441H (24 Feb 2020)	9.53	2.6	-7.09
10	30 Zulkaedah 1441 H (21 July 2020)	9.40	2.32	-7.33

Note: # indicates that the image was taken using a mirrorless digital camera

Table 3 shows the parameters of the YCM that were successfully detected using digital cameras only. The values of the elongation and altitudes of the moon and the sun were generated from the MoonCalculator (MoonCalc) program based on the observed time. Four out of 10 data are the YCM on the 29th of Hijr and 6 on the 30th of Hijr. The YCM on the 30th should be visible by the naked eye or through a telescope, but due to the cloudy sky conditions, only the digital imaging method can detect them. From the analysis, the YCM on the 29th of Hijr had successfully been detected through a digital camera with the smallest elongation, e = 6.81° and the moon's altitude, a_m= 3.37° when the sun was below the horizon of 2.64°, which was approximately 11 min after sunset. These findings suggest that digital imaging can detect the YCM earlier after sunset. At the same time, the naked eyes have to wait several more minutes for the sky brightness to turn darker, and by that time, the YCM is getting closer to the horizon and the chance to see the YCM becomes harder. The data was also found to fulfil the new visibility criteria by Ramadhan et al. (2014), who proposed the new Hilal visibility criteria i.e., elongation greater than 5.4° and relative altitude greater than 3° by comparing the observational data from Indonesia and International.

CONCLUSION

Based on the analysis of 22 years of the YCM observations conducted, we found that none of the data or images of the YCM was recorded or observed at the minimum criteria of *Imkanur Rukyah* (moon's altitude is not less than 2˚, and the elongation of the moon-sun is not less than 3˚ at sunset). In addition, this work has been successfully detected through a digital camera only with the smallest elongation, e = 6.81° and the moon's altitude, a_m= 3.37° when the sun was below the horizon of 2.64°. Hence, the use of digital cameras improves the earliest detection of the YCM compared to the observation method using the naked eye and telescope, in which the best time for the YCM to be seen is when the sun is below the horizon 5°. This work also suggests the need to change the value of the visibility of *Imkanur Rukyah* criteria 1995 to a more potentially observable criterion.

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