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Review of Crescent Visibility: The Role of Islamic Astronomy in Determining the Hijri Calendar

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ABSTRACT

The visibility of the lunar crescent (hilal) is a fundamental aspect in determining the beginning of months in the Hijri calendar. Differences in determining the beginning of lunar months among Muslim communities often arise due to variations in criteria and methods used to observe the crescent moon. This study aims to re-examine the concept of lunar crescent visibility from the perspective of Islamic astronomy and analyze its role in determining the Hijri calendar. This research uses a qualitative approach with a literature review method by examining classical Islamic astronomy texts and contemporary astronomical studies related to crescent visibility. The results show that Islamic astronomy provides a strong scientific foundation in predicting the possibility of hilal visibility through astronomical calculations. However, observational verification remains important in confirming these predictions. The re-examination of hilal visibility criteria indicates that the integration between traditional Islamic scholarship and modern astronomy can contribute to the development of more accurate and scientifically based Hijri calendar determination. This research contributes to the theoretical development of Islamic astronomy and provides insights for improving the methodology of lunar month determination in Muslim societies.

ABSTRAK

Visibilitas hilal merupakan aspek fundamental dalam penentuan awal bulan pada kalender Hijriyah. Perbedaan dalam penentuan awal bulan qamariyah di kalangan umat Islam sering terjadi akibat perbedaan kriteria dan metode yang digunakan dalam pengamatan hilal. Penelitian ini bertujuan untuk mengkaji ulang konsep visibilitas hilal dalam perspektif astronomi Islam serta menganalisis perannya dalam penentuan kalender Hijriyah. Penelitian ini menggunakan pendekatan kualitatif dengan metode studi literatur melalui kajian terhadap kitab-kitab klasik ilmu falak serta penelitian astronomi modern yang berkaitan dengan visibilitas hilal. Hasil penelitian menunjukkan bahwa astronomi Islam memberikan dasar ilmiah yang kuat dalam memprediksi kemungkinan terlihatnya hilal melalui perhitungan astronomi. Namun demikian, verifikasi melalui pengamatan langsung tetap memiliki peran penting dalam memastikan kebenaran prediksi tersebut. Kajian ulang terhadap kriteria visibilitas hilal menunjukkan bahwa integrasi antara tradisi keilmuan Islam dan astronomi modern dapat berkontribusi pada pengembangan sistem penentuan kalender Hijriyah yang lebih akurat dan ilmiah. Penelitian ini memberikan kontribusi teoritis bagi pengembangan kajian astronomi Islam serta memberikan perspektif baru dalam metodologi penentuan awal bulan qamariyah.

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INTRODUCTION

Islamic astronomy or astronomy is one of the branches of science that has developed in the Islamic intellectual tradition since classical times. This science studies the movement of celestial bodies such as the sun, moon, and stars which are closely related to the implementation of Muslim worship (Ridwan, 2022). In religious practice, astronomy has an important function in determining prayer times, qibla directions, and determining the Hijri calendar used in various worship such as Ramadan, Eid al-Fitr, and Eid al-Adha (Azhari, 2007).

The Hijri calendar is a calendar system based on the circulation of the moon around the earth (Anwar, 2016). Every month in the Hijri calendar begins with the appearance of the hilal, which is the first crescent moon seen after the conjunction or ijtimak between the sun and the moon (Al-Mostafa, 2005). Therefore, the visibility of the new moon is a very important aspect in determining the beginning of the month of qamariyah.

In practice, determining the visibility of the hilal often causes differences among Muslims (Aini, 2017). This difference arises because of the difference in the method used in determining the beginning of the Hijri month, namely the hisab method based on astronomical calculations and the rukyat method based on direct observation of the hilal (Susiknan Azhari, 2006a). Some people emphasize the importance of astronomical calculations because they are considered more accurate and predictable, while others emphasize the importance of direct observation as the basis for determining the beginning of the month (Azhari & Wardan, 2007).

The development of modern astronomy has made a great contribution to understanding the phenomenon of moon visibility. Various studies have been conducted to develop criteria for the visibility of the moon based on certain astronomical parameters such as the height of the moon above the horizon, the elongation between the sun and the moon, and the age of the moon after the conjunction (Thomas Djamaluddin, 2005). These parameters are used to predict the likelihood of the appearance of the new moon in various locations on the earth's surface.

However, differences in the determination of the beginning of the Hijri month still often occur in various Muslim countries (Sakirman, 2018). This shows that studies on the visibility of the moon still need further development in order to produce more comprehensive criteria that can be widely accepted by various Muslim communities (Sakirman, 2023).

A review of the concept of hilal visibility is important to look back at how classical astronomy and modern astronomy can complement each other in determining the Hijri calendar. The integration between the two approaches is expected to provide a deeper understanding of the factors that affect the visibility of the new moon.

Based on this background, this study aims to review the concept of hilal visibility from an Islamic astronomical perspective and analyze the role of Islamic astronomy in determining the Hijri calendar. Thus, this research is expected to contribute to the development of a more scientific and comprehensive methodology for determining the beginning of the month of qamariyah.

METHOD

This study uses a qualitative approach with the type of library *research* (Adlini et al., 2022). This approach is used to analyze various literature related to Islamic astronomy and the visibility of the new moon in determining the Hijri calendar.

The data sources in this study consist of primary sources and secondary sources (Kalu et al., 2021). Primary sources are obtained from classical books on astronomy as well as scientific works that discuss the theory of moon movement and moon visibility (Ahmed, 2018). Meanwhile, secondary sources are obtained from scientific journal articles, academic books, and research reports that discuss the development of modern astronomy and its application in determining the Islamic calendar (Lewis, 2018).

The data collection technique is carried out through the documentation method, namely by identifying, collecting, and reviewing various literature sources relevant to the research topic (Aguilar, 2012). The literature studied includes discussions of the concept of the new moon, the visibility criteria for the new moon, the method of hisab and rukyat, as well as the development of astronomical theories related to the observation of the crescent moon.

The data analysis in this study uses content analysis techniques. The data that has been collected is then classified based on certain themes such as the concept of hilal visibility, the development of astronomical criteria, and the integration between hisab and rukyat methods. Through the analysis process, it is hoped that a comprehensive understanding of the role of Islamic astronomy in determining the Hijri calendar can be obtained.

To understand the role of Islamic astronomy in determining the Hijri calendar, this research was carried out through several systematic stages. The stage starts with understanding the basic concepts of Islamic astronomy, followed by the collection of relevant literature, as well as the analysis of data obtained from various scientific sources. This research process aims to obtain a comprehensive overview of the concept of hilal visibility and its role in determining the beginning of the Hijri month.

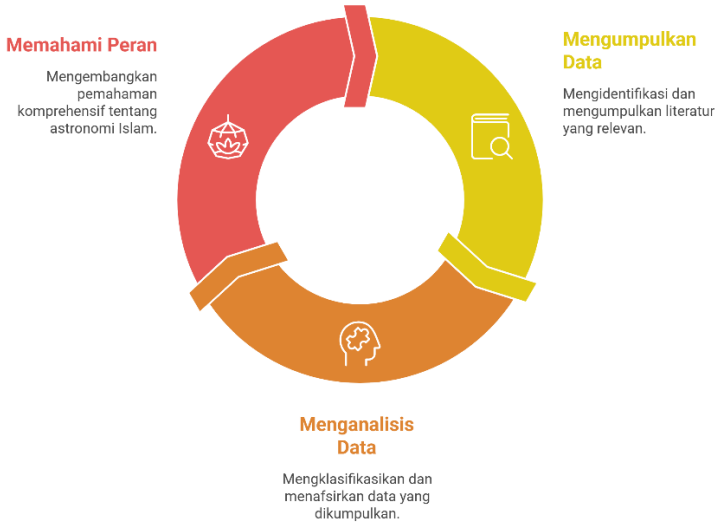


Figure 1. Islamic astronomy research cycle

Based on the image above, the research stage begins with understanding the role of Islamic astronomy as the conceptual foundation of research. Furthermore, the

data collection process is carried out through a literature review from various sources that are relevant to the topic of hilal visibility and the Hijri calendar. The last stage is data analysis, which is classifying and interpreting the data that has been collected to gain a deeper understanding of the relationship between Islamic astronomy and the determination of the Hijri calendar.

RESULTS AND DISCUSSION

Theoretical Framework

Lunar visibility is an astronomical phenomenon related to the ability of humans to observe the first crescent moon after the conjunction (*ijtima'*) (Alrefay et al., 2018), which is when the sun and moon are at almost the same ecliptic longitude. In astronomy, the visibility of the moon is not only understood as a purely optical phenomenon, but also as a result of the interaction of various astronomical parameters and atmospheric conditions that affect the possibility of seeing the crescent moon from the earth's surface (Ahmed & Aziz, n.d.).

In general, the visibility of the moon is influenced by several main parameters, including the height of the moon above the horizon at sunset, the angular distance between the sun and the moon (*elongation*), the age of the moon since the conjunction occurred, and atmospheric conditions and observation locations (Almadhidi & Mohammed, 2021). The moon's sufficient height above the horizon provides a greater chance for moonlight to be visible to observers (Ghanbari et al., 2013). Meanwhile, elongation indicates how far away the moon is from the sun so that the part of the moon that receives the light can appear as a thin crescent.

Astronomically, the elongation between the sun and the moon can be expressed in the form of the following equation:

$$E = \lambda \mathrm{m} - \lambda \mathrm{s}$$

where E is the elongation of the moon, λm is the longitude of the lunar ecliptic, and λs is the longitude of the solar ecliptic. This elongation value shows the angular distance between the sun and the moon which is one of the important indicators in determining the possibility of seeing the moon (Aguilar, 2012). The greater the elongation value, the larger the part of the moon's surface that receives sunlight and has the potential to be seen from the earth.

However, elongation is not the only factor that determines the visibility of the new moon. In the practice of astronomical observation, a large elongation value does not necessarily guarantee that the moon can be seen if the moon's height is still too low or atmospheric conditions are not favorable (Sakunov et al., 1990). Therefore, astronomers have developed various criteria for the visibility of the moon that consider a combination of several parameters at once, such as the Danjon criterion (Fatoohi et al., 1998), the Yallop criterion (Fatoohi et al., 1998), and the imkan rukyat criterion used in various Muslim countries.

From the perspective of contemporary astronomy, the study of the visibility of the new moon shows that modern astronomical approaches can provide more accurate predictions about the possibility of the appearance of the moon (Sakirman, 2020). Astronomical calculations allow the precise determination of the position of the moon so that it can estimate the best time and location to observe the moon (Alrefay et al., 2018). This shows that astronomy not only has a religious dimension, but also has a strong scientific foundation in understanding the phenomenon of the movement of celestial bodies.

Thus, the theoretical framework regarding the visibility of the moon shows that the phenomenon is the result of a complex interaction between astronomical parameters, atmospheric conditions, and human observation capabilities (Judhistira et al., 2016). Understanding these parameters is very important in an effort to develop a method of determining the beginning of the Hijri month that is more accurate and widely accepted in the Muslim community.

Conceptual Framework

In the context of determining the Hijri calendar, the concept of hilal visibility is not only understood as an astronomical phenomenon, but also has a normative dimension in Islamic religious practice (Izzuddin, 2007). The determination of the beginning of the month of qamariyah is directly related to the implementation of certain worship such as fasting Ramadan, Eid al-Fitr, and Eid al-Adha (Thomas Djamaluddin, 2005). Therefore, the approach used in determining the beginning of the month does not only consider the scientific aspect, but must also pay attention to the religious legitimacy accepted by the Muslim community (Aini, 2017). This condition makes the determination of the Hijri calendar at the intersection between scientific approaches and religious authorities.

Conceptually, the method of determining the beginning of the month of qamariyah develops in two main approaches, namely the hisab method and the rukyat method. The hisab method uses mathematical and astronomical calculations to determine the position of the moon precisely based on astronomical parameters such as conjunction, moon height, and elongation (Azhari & Wardan, 2007). The advantage of this method lies in its ability to provide systematic and calculable predictions long before the occurrence of the astronomical phenomenon. With the development of modern astronomical technology, the hisab method is able to produce very accurate data on the position of the moon and the possibility of moon visibility in various geographical areas (Mikhail et al., 1995).

On the other hand, the rukyat method is based on direct observation of the new moon after sunset at the end of the full moon (Ridwan, 2022). This approach has a strong foundation in religious tradition because the practice of observing the moon has been carried out since the early days of Islam (Azhari, 2005). Rukyat not only serves as an observation method, but also as a form of empirical verification of the astronomically predicted visibility of the moon (Al-Rajab et al., 2023). However, this

method has limitations because it is greatly influenced by external factors such as weather conditions, light pollution, and the ability and experience of observers.

In the development of modern astronomical studies, the relationship between hisab and rukyat is no longer seen as two opposing approaches, but as two complementary methods (Susiknan Azhari, 2006b). Hisab functions as a predictive instrument that provides information about the possibility of the occurrence of the new moon, while rukyat acts as an observational confirmation process for the prediction (Sakirman, 2017). This integrative approach allows the process of determining the beginning of the month to be carried out in a more rational manner while still maintaining the religious legitimacy inherent in the practice of rukyat.

Furthermore, the integration between hisab and rukyat also opens up space for the development of more objective and standardized hilal visibility criteria (Allawi, 2022). By utilizing accurate astronomical data and continuous observational experiences, astronomers can formulate more consistent and widely applicable lunar visibility parameters. Within this framework, Islamic astronomy acts as an epistemological bridge that connects the classical scientific tradition with the development of modern astronomy (Azhari, 2018).

Thus, the conceptual framework of this research places the visibility of the hilal as a meeting point between scientific approaches and religious practices (Ridwan, 2020). The integrative approach between hisab and rukyat not only provides a stronger scientific basis in determining the Hijri calendar, but also has the potential to encourage the creation of uniformity in the determination of the beginning of the month of qamariyah in various Muslim communities.

Research Findings

A review of various literature shows that the visibility of the moon is influenced by a number of astronomical parameters that are interrelated and determine the likelihood of the first crescent moon being seen after the conjunction. The first factor that is very decisive is the height of the moon above the horizon at sunset (Arumaningtyas & Raharto, 2010). The height of the moon has a direct effect on how long the moon is above the horizon after sunset. The higher the moon's position, the longer the moon stays in the sky after sunset, so the opportunity to observe the new moon becomes greater. On the other hand, if the moon's position is too low near the horizon, the moonlight will be easily reduced by atmospheric scattering and twilight light, making it difficult or even impossible to see.

The second factor is the elongation between the sun and the moon which shows the angular distance between the two in the sky (Djamaluddin, 2023). Elongation plays an important role because it determines how much of the moon's surface receives and reflects sunlight towards the earth. In the context of moon observation, the small elongation causes the illuminated part of the moon to be very thin so that the reflected light is not strong enough to be seen by observers. On the other hand, the greater the elongation value, the wider the part of the moon that is

illuminated, increasing the chances of moon visibility. Nevertheless, the astronomical literature shows that there is a certain minimum limit of elongation that practically allows the moon to be visible, so this parameter is often used as the basis for various moon visibility criteria developed by astronomers.

The third factor that affects the visibility of the new moon is the age of the moon since the conjunction (Li, 2019). The age of the moon is related to the process of increasing illumination or illumination on the surface of the moon facing the earth. The longer the time that passes after the conjunction, the larger the part of the moon that receives sunlight and reflects it back to the earth. However, the age of the moon is not always directly proportional to the visibility of the new moon because this parameter must still be associated with the moon's geometric position to the sun and observers on earth.

In addition to astronomical factors, literature reviews also show that atmospheric conditions and geographic locations of observations have a significant influence on the success of moon observations. Atmospheric thickness, air humidity levels, cloud presence, and light pollution can reduce the contrast between the light of the moon and the background of the twilight sky (Hj Wan Yussof et al., 2022). In addition, differences in latitude and geographical longitude cause differences in viewpoints on the positions of the moon and sun, so that the new moon that may be seen in one region may not necessarily be visible in other regions at the same time. This explains why rukyat reports often show different results at different observation sites.

Analysis of the various criteria for the visibility of the new moon that has developed in the astronomical literature shows that a single parameter-based approach is not enough to comprehensively explain the phenomenon of the visibility of the new moon. Therefore, astronomical researchers developed a criterion model that considers a combination of several parameters at once. This multidimensional approach allows for a more realistic assessment of the likelihood of the appearance of the hilal under different observation conditions.

In this context, the integration of modern astronomical calculations and the rukyat method is becoming an increasingly relevant approach in determining the beginning of the Hijri month (Alfirdaus Putra, 2023). Astronomical calculations provide a strong predictive basis for the possibility of moon visibility based on geometric parameters that can be calculated precisely. Meanwhile, rukyat still has an important role as an empirical verification of these predictions. The relationship between the two shows that the observation of the new moon does not only depend on the experience of the observer, but can also be supported by systematic astronomical analysis (S Azhari, 2006).

Furthermore, the findings of this study show that the use of modern astronomical technology such as telescopes, high-resolution digital cameras, and image processing devices can significantly increase the sensitivity of moon observation (Fitri, 2012). This technology allows the detection of the hilal that was

previously difficult to observe with the naked eye. Thus, the development of observation technology provides new opportunities in strengthening the accuracy of the rukyat process while enriching an empirical database that can be used to improve the visibility criteria of the new moon in the future.

Based on these findings, it can be understood that the visibility of the moon is a complex phenomenon and is influenced by various astronomical, atmospheric, and technological factors. Therefore, an approach that combines modern astronomical analysis with field observation practices is a strategic step in an effort to improve the accuracy of determining the beginning of the Hijri month and reduce the potential for differences in calendar determination among Muslims.

CONCLUSION

This study shows that the visibility of the new moon is an important factor in determining the beginning of the month on the Hijri calendar. The development of modern astronomy allows the prediction of the appearance of the moon to be carried out more accurately through astronomical parameters such as the moon's height, elongation, and moon's age. The use of these parameters provides a stronger scientific basis in understanding the possibility of the appearance of the new moon at a certain time and location.

The integration of the hisab and rukyat methods is a relevant approach in determining the beginning of the month of qamariyah. The hisab method provides precise astronomical predictions about the position of the moon, while rukyat serves as an empirical verification of the possible visibility of the moon. This integrative approach not only strengthens the scientific aspect of determining the Hijri calendar, but also has the potential to reduce differences in the determination of the beginning of the month among Muslims.

Theoretically, this research contributes to strengthening the study of Islamic astronomy by placing the visibility of the new moon as a phenomenon that can be analyzed through a scientific approach while considering the religious dimension. However, this study still has limitations because it only uses a literature study approach without being supported by direct field observation data. Therefore, further research is recommended to conduct empirical observations and more in-depth astronomical analysis to develop more accurate and applicable hilal visibility criteria.

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