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A Synthetic Approach in Maghribi and Ottoman Astronomical Traditions: The Example of an 18th-Century Ottoman Perpetual Calendar for the Latitude of Algiers*

Mağrib ve Osmanlı Astronomi Geleneğinde Sentetik Bir Yaklaşım: Cezayir Enlemi için Hazırlanan 18. Yüzyıl Osmanlı Daimî Takvim Örneği

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ABSTRACT

The lack of a systematic examination of the potential interactions between astronomical and maritime techniques in the Maghribi and Ottoman traditions has hindered the resolution of many issues in the history of science. In this context, an 18th-century Ottoman perpetual calendar prepared for the latitude of Algiers, which is the focus of this research, is significant in demonstrating the integration of the Maghribi-Andalusian astronomical tradition into Ottoman astronomy, particularly through the Magrib region. The critical data in the calendar provides information on astronomical applications on land and at sea, emphasizing the calendar maker's synthesis of sources from various cultures. Building on this foundation, our article aims to highlight the methodological and historical challenges in studying Ottoman perpetual calendars, as well as the importance and necessity of more in-depth research into the astronomy and maritime traditions among populations in the Maghrib and Ottoman regions.
Keywords: Ottoman astronomy, Algeria, perpetual calendar, nautical astronomy, astronomical instruments

ÖZ

Mağrib ve Osmanlı geleneğine ait astronomik ve denizcilik tekniklerindeki etkileşim olasılıklarının bugüne kadar sistematik olarak incelenmemiş olması, bilim tarihi açısından birçok sorunun çözülmesini zorlaştırmaktadır. Bu bağlamda, araştırmanın odak noktası olan Cezayir enlemi için hazırlanmış 18. yüzyıla ait bir Osmanlı daimî takvimi, özellikle Mağrib üzerinden Osmanlı astronomisine entegre olan Mağrib-Endülüs astronomi geleneğinin önemli bir örneğini teşkil etmektedir. Takvimdeki kritik veriler, karada ve denizde yapılan astronomi uygulamaları hakkında bilgi sağlamakta ve takvim derleyicisinin farklı kültürlerden gelen kaynakları birleştirdiğini vurgulamaktadır. Bu temel üzerine, makalemiz Osmanlı daimî takvimlerinin incelenmesindeki metodolojik ve tarihi zorlukları vurgulamanın yanı sıra, Mağrib ve Osmanlı bölgelerinde yaşayanların astronomi ve denizcilik geleneği bağlamında daha derinlemesine araştırmalarının önemini ve gerekliliğini ortaya koymayı hedeflemektedir.
Anahtar Kelimeler: Osmanlı astronomisi, Cezayir, daimî takvim, deniz astronomisi, astronomi aletleri

1. Introduction

The discipline of the history of science, while shaped by a prevailing consensus on scientific rationality and confidence in scientific progress until the 1960s, encountered a strong wave of criticism from the 1990s onwards. These influential debates created an environment that challenged almost the entire traditional historiography, revitalizing richly textured research and leading to the emergence and redefinition of a series of common concepts and methods, as well as thematic changes. In this context, historians of science moved beyond standard comparisons with predecessors or successors to embrace an environment dominated by methodological pluralism, such as microhistory, macrohistory, contextualization, and digital humanities. This shift not only strengthened the interaction of the field of history of science with various disciplines in the humanities, but also spurred researchers to formulate questions in the process of historicizing scientific practices towards a more inclusive model and expanding the areas that could be considered as science. Today, these developments are reflected among historians of science with an emphasis on the term "new approach" as a sign of maturity within the field.[1] In this context, historians of science, researching not only theoretical but also intuitive and practical knowledge, are attempting to analyze mechanisms for the production of "local knowledge" in time and space; to understand key moments between knowledge holders and patrons ensuring the historical continuity of this knowledge; to examine the processes of legitimizing or rejecting "foreign knowledge"; and to define hybrid knowledge and how it is reconceptualized from one culture to another. However, due to the complex and multifaceted nature of interactions between cultures, more than a single set of reasons is required to explain contextual elements. Because of this complexity, researchers working on the issue of cross-cultural knowledge exchange require a wide range of historical, linguistic, and advanced technical expertise to organize and interpret textual documents.

Today, the exciting atmosphere provided by the field of the history of science opens the door to questions about the theoretical and practical history of knowledge shaped by the interaction of various cultures brought together by the Ottomans, paving the way for a potential reshaping of historiography. Strong evidence of this potential emerges in Ottoman astronomical history, as the Ottoman Empire served as a stage for diverse cultural interactions. These interactions, shaped by time and space, facilitated the convergence of various beliefs, traditions, and scientific understandings, enriching the empire's multiethnic

1 In this context, it is beneficial to examine key studies within the existing literature. For just a few, see Sonja Brentjes-Alexander Fidora-Matthias M. Tischler, "Towards a New Approach to Medieval Cross-Cultural Exchanges", *Journal of Transcultural Medieval Studies*, I/1 (2014), p. 9-50; Sonja Brentjes, "Narratives of Knowledge in Islamic Societies: What do They Tell Us about Scholars and Their Contexts?," *Almagest*, IV/1 (2013), p. 75–95; Sonja Brentjes, "Research Foci in the History of Science in Past Islamicate Societies," *Historie*, issue 2, (2022), p. 270–87.

and multicultural fabric. In this context, the diversity of cultures and intellectual traditions fostered environments conducive to knowledge exchange and the exploration of various experiences in cultural pluralism.[2] The role of social diversity in enhancing artistic and scientific productivity has garnered significant scholarly interest. However, understanding how new knowledge was integrated into established intellectual frameworks presents considerable challenges, unravelling deeper layers shaped by various social, political, and economic dynamics.

The absence of a comprehensive modelling approach to explain these intricate relationships remains a fundamental obstacle in research, hindering in-depth exploration of cultural interactions within Ottoman geography. This gap leads to missed opportunities for grasping the complexities of this rich historical legacy. Conducting micro-level examinations may generate valuable data that can serve as case studies, contributing to a more comprehensive view of the broader historical and cultural framework. Building on this, such examinations will also significantly enhance our understanding of cultural interactions within the Ottoman territory.

Taking this perspective into account, our study aims to initiate a discourse on the findings of a case study focusing on an 18th-century perpetual Ottoman calendar at 36° 40´ latitude (Algeria). The analysis reveals that *Rūznāmah- i Jadīdah (*or simply *Rūznāmah)* reflects a rich tapestry of cultural interactions. Highlights of the distinctive features of this perpetual calendar as a significant historical artifact include its integration of the Maghribi astronomical tradition into Ottoman astronomy, its incorporation of crucial data concerning practical astronomy and the use of astronomical instruments on land and at sea, and its insights into the application of the Julian and Gregorian calendar systems. Besides, although the calendar was prepared according to the latitude of Algeria, the author's occasional emphasis on the Maghribi-Andalusian tradition implicitly reveals the relationship of astronomical practices with the Andalusian tradition. Moreover, it is noteworthy that, during its production period, the calendar's author adhered to certain preferences that originated in the Maghribi and

2 This cultural diversity can also be seen in the intellectual and knowledge exchanges between the Ottoman, Maghribi, and Andalusian traditions. In this framework, Khaled el-Rouayheb's *Islamic Intellectual History in the Seventeenth Century* is noteworthy for understanding how scholarly currents shaped the Ottoman Empire and the Maghrib in the 17th century. Additionally, Ekmeleddin İhsanoğlu's article, "Endülüs Menşeli Bazı Bilim Adamlarının Osmanlı Bilimine Katkıları," provides insights into the scientific heritage of the Andalusian influence on the Ottoman tradition. Furthermore, Edward S. Kennedy and David A. King's article, "Indian Astronomy in Fourteenth Century Fez: The Versified Zij of al-Qusuntini," summarizes the astronomical tradition in the Maghrib and, occasionally drawing connections to Ottoman practices, offers valuable context for understanding the exchanges of astronomical knowledge pertinent to our research focus. For more detail, see Khaled el-Rouayheb, *Islamic Intellectual History in the Seventeenth Century: Scholarly Currents in the Ottoman Empire and the Maghreb*, Cambridge University Press, New York 2015, 399; Ekmeleddin İhsanoğlu. "Endülüs Menşeli Bazı Bilim Adamlarının Osmanlı Bilimine Katkıları", Belleten, LVIII/223 (1994), p. 565-606; Edward S. Kennedy-David A. King, "Indian Astronomy in Fourteenth Century Fez: The Versified Zij of al-Qusuntini", *Journal for the History of Arabic Science,* VI (1982), p. 5-9.

Andalusian traditions rather than in Istanbul and Anatolia. For this reason, the *rūznāmah* is also important as an example of how these calendars interacted and how this interaction was reflected in practical applications.

On the other hand, the information on navigation in the calendar provides significant clues that astronomy was used in navigation techniques employed in the Mediterranean region in the 18th century. The description of how to determine latitude by measuring the altitude of the Sun above the horizon further strengthens this possibility. Furthermore, the notation that different instruments are recommended for use on land and at sea is noteworthy. Among the instruments commonly used on land that represent the Islamic tradition are the astrolabe, the sine quadrant, and the astrolabe quadrant, whereas the instrument recommended for use at sea is called a "*palastirilya,*" commonly known as a cross-staff, and more frequently used by European sailors. The calendar's preparation according to the latitude of Algiers and its inclusion of various maritime information suitable as a navigational guide for Ottoman sailors in the southern Mediterranean raise critical questions regarding the influence of these regional traditions on Ottoman navigation. The discovery, particularly the combined use of the Julian and Gregorian calendar systems and the mention of the cross-staff, an instrument from European maritime traditions, raises important questions about the calendar's connection to the Christian communities in the region.

Although a single example cannot fully encapsulate the broader processes of knowledge circulation, analyzing the specific astronomical concepts and instruments integrated within this calendar offers valuable insights into how these traditions may have been adapted within the Ottoman scientific framework. In this regard, our article highlights the methodological and historical challenges in studying Ottoman perpetual calendars, while also offering a preliminary exploration of how the integration of the Maghribi-Andalusian astronomical tradition may have influenced Ottoman practical applications and the transmission of knowledge through material objects. Additionally, it emphasizes the crucial need for deeper research into the astronomy and maritime traditions among populations in the Maghrib and Ottoman regions, as it raises important questions about their relevance in the context of Christian communities within the region.

2. General Features of '*Rūznāmah-i Jadīdah*'

Ottoman perpetual calendars represent a less explored type of calendar compared to annual calendars and merit special attention in historical studies. Comparative analyses of perpetual calendars from different periods reveal differences in their design and adaptation. The tables were updated according to the period of use, and occasionally, copiers inserted additional entries. When investigating Ottoman perpetual calendars, it is crucial to consider meticulously specific aspects such as the creators or copyists of these calendars, their production dates, structures, applications, and methods of replication. This critical evaluation is particularly relevant to the *Rūznāmah*.

The original manuscript remains unidentified up to now; however, three existing copies are documented in the literature. One of these copies, titled *Rûz-nâme* (*Rūznāmah*) and numbered 138/2, is held in the History of Science Collection at the Kandilli Observatory and Earthquake Research Institute Library (KOERIL). The other two copies are known as *Rūznāmah-i Jadīdah* (New Perpetual Calendar) and are located in the British Library (BL) and the National Library of Egypt (Ta'lat, Felek-Turkî Collection, ENL). Our research primarily relies on the KOERIL manuscript, with occasional reference to the *Catalogue of the Turkish Manuscripts in the British Museum* and the OALT introduction.

The *Rūznāmah* at the KOERIL comprises an introduction, four chapters, a *ghurrah-nāmah* table for determining the starting day of Arabic months, and a calendar covering 12 months. In this manuscript, the circular forms traditionally found in rūznāmah attributed to Sheikh Vefa, such as *Nawrūz-ı Sultānī* cycle and *rijāl al-ghaib (men of the unseen)*, are absent. Instead, the *ghurrah-nāmah* is presented as an extensive table distributed across multiple pages. In a marginal note on the calendar, it is explicitly stated that it was prepared in Algeria, and accordingly, the lengths of day and night in terms of hours and minutes were determined based on the latitude of 36° 40′.[3]

The calendar's sections are arranged according to the following topics:

1. *Miftāḥ-ı rūznāmah*: The first section provides information about the characteristics of the tables included in the calendar and their practical applications.

2. *'Āmm-ı 'Arabiyyah*: The second section contains information about the lunar year.

3. *'Āmm-ı Shamsiyyah*: The third section contains information about the solar year.

4. *Mayl al-shams wa 'urūḍ al-buldān*: The fourth section offers detailed instructions on how to determine the declination of the Sun and the latitude of a location, applicable both on land and at sea.

The approach used to estimate its production date was analyzing the *ghurrah-nāmah* tables included in the calendar, which are typically customized for the years they cover. The *ghurrah-nāmah* table in the KOERIL manuscript covers AH 1157-1212 (AD 1744-1798),[4]

3 Anonymous, *Rûz-nâme*, Kandilli Observatory and Earthquake Research Institute Library, History of Science Collections, MS 138/2, copied AH. XII. century, fol. 60v.

4 Ibid., fols. 61r- 66v.

while in the BL copy, it covers AH 1186-1267 (AD 1772/73-1850/51).[5] The copy in the ENL was transcribed around AH 1300 (AD 1882/1883).[6] This situation exemplifies how the copies of perpetual calendars were adapted and updated for different periods. Thus, it can be suggested that the KOERIL manuscript is the oldest extant copy of the surviving three.[7]

Further insights can be gleaned from examples provided in the third and fourth sections of the KOERIL *Rūznāmah*. The third section states that the date needed to determine latitude during sea voyages should be calculated according to the *tārīh-i Masīḥ ibn Maryam* (Anno Domini, AD). Consequently, individuals seeking to determine latitude using a different date system, such as Hijri, must convert to the corresponding AD date. For instance, the author/copyist illustrates this with the example of AH 1141 or AD 1729.[8] In the fourth section, the author/copyist uses the year AD 1732 as an example to elucidate methods for determining latitude. These examples, in conjunction with the *ghurrah-nāmah* tables, suggest that the original manuscript may have been compiled around the years AD 1729-1732. Subsequent copies were then adapted to suit the periods in which they were used, indicating potential updates made over the years.

3. Analysis and Evaluation of Sources Used in the Preparation of *Rūznāmah -i Jadīdah*

Time in Ottoman calendars is structured on theoretical foundations rooted in astronomical and mathematical principles. This theoretical framework has transformed over time into historical documents that mirror societal perceptions of time, particularly concerning daily routines like social events and religious practices. The content of these calendars varies, encompassing three main prominent types in Ottoman literature:[9] *taqwīm-i sāl* (annual calendar/almanac), *aḥkām-ı ṭāliʿ-i sāl* (prognostications of the ascendant for a year), and *taqwīm-i dāʼimī* (perpetual calendar).

Among these, *taqwīm-i sāl* and *aḥkām-ı ṭāliʿ-i sāl* stand out as the types for which we have the most information regarding the sources consulted during their preparation. Conversely, our knowledge of the sources used in Ottoman perpetual calendars is limited due to the lack

5 Charles Rieu, *Catalogue of the Turkish Manuscripts in the British Museum*, The British Museum, London 1888, p. 123.

6 Ekmeleddin İhsanoğlu-Ramazan Şeşen-Cevat İzgi-Cemil Akpınar-İhsan Fazlıoğlu, *Osmanlı Astronomi Literatürü Tarihi*, I, İstanbul 1997, p. 252-254.

7 *Rûz-nâme*, fols. 59r-60v.

8 Ibid., fol. 56r.

9 For more details on Ottoman calendars see Ahmed Tunç Şen, *Astrology in the Service of The Empire: Knowledge, Prognostication, and Politics at the Ottoman Court, 1450s-1550s*, The University of Chicago, Unpublished PhD Thesis, Chicago/Illinois 2016, p. 237-305; Gaye Danışan, "Osmanlı Takvimlerinin Analizinde Uygulanan Yöntemler ve Karşılaşılan Problemler Üzerine Bir Değerlendirme", *II. Uluslarası Prof. Dr. Fuat Sezgin İslam Bilim Tarihi Sempozyumu Bildiriler Kitabı*, ed. M. Cüneyt Kaya, Gürsel Aksoy, Nihal Özdemir, Istanbul University Press, Istanbul 2023, p. 178-189.

of systematic research on this topic. Specifying and elucidating the sources consulted in *Rūznāmah-i Jadīdah* can illuminate diverse traditions in calendar preparation and provide a detailed narrative on the circulation of these works within the Maghribi tradition in the Ottoman context.

In the introduction of the KOERIL manuscript, it is noted that the principles and rules of Sheikh Vefā's and Ayn 'Ali Efendi's perpetual calendars were consulted. Additionally, references are made to Ulugh Beg's *Zīj*, Sheikh 'Alī Dādisī al-Maghribī's treatise, Sheikh Ibn Sīnā's *Zīj*, and Sheikh Abū Miqra''s treatise. However, upon examining the catalogue information for the BL manuscript and the introduction of the ENL manuscript in the OALT, it becomes evident that different sources are referenced. While the BL manuscript does not mention Ibn Sīnā's *Zīj*, it refers to Ibn al-Bannā's *Zīj*; whereas the sources in the ENL manuscript include Sheikh 'Alī al-Maghribī and Ibn al-Bannā instead of Ibn Sīnā and Sheikh 'Alī Dādisī al-Maghribī. The reasons for these variations in sources are not entirely clear. Possible factors may include errors or omissions during the copying process or additions and alterations made by scribes based on the period in which they were copied.

3.1. Sheikh Vefā's and Ayn 'Ali Efendi's Perpetual Calendars and Ulugh Beg's *Zij*

In Ottoman literature, perpetual calendars known as *rūznāmah,*[10] *taqwīm-i dā'imī* (lit. perpetual calendar), or *taqwīm-i devr-i dā'imī* (lit. calendar of perpetual motion) were designed for long-term use, often taking the form of a scroll or a booklet consisting of 10-15 pages. The earliest known work indicating the use of such calendars is *Rūznāmah-i Sheikh Vefā* by Muṣliḥūddīn Muṣṭafā b. Aḥmad b. Vefā al-Ṣadrī al-Ḳonāvī, who was one of the sheikhs during the reign of Sultan Mehmet II and a founder of the Wafāiyya branch of the Zeyniyya Sūfī order.[11] The *rūznāmah* attributed to Sheikh Vefā, which enjoyed enduring popularity for several centuries in the Ottoman era and was extensively copied, represents a significant component of the Ottoman perpetual calendar tradition. It typically includes circular and/or tabular forms to determine dates for each year, such as the vernal equinox time when the day and night are equal, called "*Nawrūz-ı Sultānī*," and the first day of every lunar month, called "*ghurrah-nāmah*." Additionally, some of these calendars include tables related to the astronomical timekeeping (*'ilm al-mīqāt*) tradition and a circular diagram for the "men of unseen" (*rijāl al-ghaib*).[12] Finally, the calendar tables for 12 months are presented.

10 The term "*rūz-nāmah*" combines the Persian words "*rūz*" (day) and "*nāmah*" (writing or book). It has been used for various genres, including daily event notebooks, calendars, military expedition records, and daily accounts. For an example, see Mehmet Burak Çakın, "Klasik Edebiyatta çok bilinmeyen bir tür olarak rûz-nâme ve müellifi bilinmeyen bir örneği", Selçuk Türkiyat, issue 53, (December 2021), p. 207-229.

11 For more details on Sheikh Vefā see Reşat Öngören, "Muslihuddin Mustafa", DİA, XXXI, 2020, 269-271.

12 For more details on *Rijal Al-Ghaib* see Süleyman Uludağ, "Ricâlü'l-gayb", DİA, XXXV, 2008, 81-83.

Starting in the 17th century, the work of Ayn ‘Ali Efendi,[13] an Ottoman scholar and the head of the imperial register, titled *Sharh-i Rūznāmah-i Sheikh Vefā* (Commentary of Sheikh Vefā's *Rūznāmah*), became very famous. It was written at the request of Mehmed Pasha (d. 1619), the governor of Egypt, to explain the difficult and incomplete points in Sheikh Vefā's *rūznāmah*. In this work, Ayn ‘Ali Efendi addressed eight challenges encountered in Sheikh Vefā's perpetual calendar and provided tables starting from the year AH 1017 (AD 1608). This perpetual calendar was widely copied over time.[14]

We see a reflection of this process in the *Rūznāmah-i Jadīdah*, which forms the basis of our article. The principles laid down by Sheikh Vefā and the corrections made by Ayn ‘Ali with his commentary were taken into consideration while preparing the KOERIL calendar, emphasizing the importance of Sheikh Vefā's principles in the calendar-making process and their practical applications and effects.[15] Furthermore, the inclusion of these calendars in the preparation of the *Rūznāmah* underlines the unique features and techniques of the Ottoman perpetual calendar tradition and, shows how these techniques were effectively applied in the calendar-making process.

In contrast, among the sources, Ulugh Beg's *Zīj* serves as a source for tables containing observational data on the movements of the Sun, the Moon, and planets, as well as the durations of day and night. These tables acted as guides for astronomers conducting astronomical calculations and predictions.[16] Evidence from the Ottoman calendar tradition indicates that, with some exceptions, Ulugh Beg's *Zīj* was an essential foundational source for calendars.[17] Notably, it gained popularity in the 18th and 19th centuries, although there is no evidence to confirm its use in the Maghrib in the 17th century.[18] While the reasons for the increased use of Ulugh Beg's Zīj in the Maghrib are important, its inclusion in the context of this calendar is primarily due to its significance in Ottoman calendar preparation and its widespread use within the Ottoman astronomical tradition.

13 For more details on Ayn ‘Ali see Mehmet İpşirli, "Ayn Ali Efendi", DİA, IV, 1991, 258-259.

14 Ekmeleddin İhsanoğlu-Ramazan Şeşen-Cevat İzgi-Cemil Akpınar-İhsan Fazlıoğlu, Op. cit., p. 252-254.

15 *Rûz-nâme*, fol. 47r.

16 David King, Julio Samsó, "Astronomical Handbooks and Tables from the Islamic World (750-1900): An Interim Report," *Suhayl,* II, (2001), p. 14-15.

17 An example of exceptional cases, see anonymous, *983 senesine mahsus zâyiçeli takvim*, Istanbul University Rare Books Library, MS. TY 2000, fol. 25v.

18 Julio Samso discusses the historical context and significance of Ulugh Beg's Zīj within the Maghribi tradition in the following article. For further details on its impact and usage in the region, see Julio Samso, "An Outline of the History of Maghribī Zijes from the End of the Thirteenth Century", *Journal for the History of Astronomy*, XXIX/ 2 (1998), p. 96-97.

3.2. Ibn Sīnā's *Zīj*

Another significant source referenced in the preface of the *rūznāmah* is Ibn Sīnā's *Zīj*. Renowned for his contributions to philosophy and medicine, Ibn Sīnā (d. 1037) also made substantial advancements in astronomy and cosmology. He distinguished mathematical astronomy (*ʿilm al-hayʾa*; lit. science of the configuration of the entire universe) from astrology, considering the former integral to natural philosophy. His work played a pivotal role in redefining and categorizing astronomical knowledge.[19]

Ibn Sīnā's contributions included the calculation of *zījes* (astronomical tables), the design of astronomical instruments, and the determination of the direction of Mecca.[20] Sally Ragep categorizes Ibn Sīnā's nine astronomical works into four subjects: summaries of Ptolemy's *Almagest*, works on instruments and observational astronomy, philosophical and cosmological texts, and miscellaneous works.[21] Additionally, Ramesh Kapoor discusses Ibn Sīnā's engagement with observational astronomy in relation to contemporary *zījes*, exploring whether he observed the transit of Venus in AD 1032 according to the Julian calendar.[22]

While these studies illuminate various aspects of Ibn Sīnā's works, the reference to Ibn Sīnā's *Zīj* in the KOERIL manuscript remains ambiguous. It is unclear whether this refers to Ibn Sīnā's observational tables or a compilation of various *zījes*. Does this ambiguity perhaps stem from a misattribution or misunderstanding? Questions also arise about how the compiler of the *rūznāmah* accessed the work attributed to Ibn Sīnā, shedding light on the transmission of astronomical knowledge during this period. Understanding these uncertainties is crucial for contextualizing Ibn Sīnā's influence on later Ottoman astronomy. However, this question is beyond the immediate focus of this study. Therefore, for now, interpreting the nature of the *zīj* attributed to Ibn Sīnā in this context requires caution, particularly regarding its potential impact on the understanding of astronomical knowledge within the Ottoman tradition. Future research may benefit from exploring this issue in greater depth.

3.3. Sheikh ʻAlī Dādisī al-Maghribī and His Treatise

Another challenge arises in referencing the treatise of Sheikh ʻAlī Dādisī al-Maghribī's (full name: Alī b. Muḥammad al-Dādisī al-Maghribī). Limited information is available about him: He

19 F. Jamil Ragep, Alī al-Qūshjī, "Freeing Astronomy from Philosophy: An Aspect of Islamic Influence on Science", *Osiris,* XVI, (2001), 52-59; Sally Ragep, "Ibn Sīnā: Abū ʿAlī al-Ḥusayn ibn ʿAbdallāh ibn Sīnā" Hockey, T., *et al. The Biographical Encyclopedia of Astronomers*, Springer, New York 2007, p. 570-572. https://doi.org/10.1007/978-0-387-30400-7_694

20 Julio Samso, *On both sides of the Strait of Gibraltar. Studies in the history of medieval astronomy in the Iberian Peninsula and the Maghrib*, Brill, Leiden 2020, p. 497.

21 S.P. Ragep, Op. cit., p. 550-572.

22 Ramesh Kapoor, "Did Ibn Sīnā Observe the Transit of Venus 1032 AD?", *Indian Journal of History of Science*, XLVIII/3 (2013), p. 405-445; Samso, *On both sides of the Strait of Gibraltar*, p. 497.

lived in the 17th century and is mentioned as a *muwaqqit* (timekeeper) and astronomer in the OALT. He is associated with three works related to timekeeping: *Bidāyat al-Ṭullāb fī ʿİlm Waḳt al-Yawm bi al-Ḥisāb, al-Yawāḳīt li Mubtagī Maʿrifat al-Mawaḳit,* and *Fatḳ al-Muḳīt fī Sharh al-Yawākît*.[23]

It is pertinent to refer to the entry on ʻAlī b. Muḥammad al-Dādisī in the section on Andalusian and Maghribi authors in David King's biobibliographical study of Arabic, Persian, and Turkish manuscripts related to mathematics, astronomy, and astrology at the Egyptian National Library. His name is linked to the poem titled "*al-Yawāqīt li-mubtaghī maʿrifat al-mawāqīt*," which addresses timekeeping. Notably, three different copies of this poem contain variations of his name, including: *ʿAlī b. Aḥmad b. Muḥammad…, Muḥammad ʿAlī al-Dādisī,* and *Ahmad b. ʿAlī al-Dādisī.*[24]

Julio Samso's research on the copy of Ibn Abī l-Shukr al-Maghribī's (d. 1283) work *Tāj al-azyāj* at the Department of Arabic Philology, University of Barcelona (AFBU) are quite significant. While the date of this manuscript is uncertain, it contains a series of marginal notes that differ from the scribe's writing. Samso analyzes these marginal notes, suggesting that the manuscript circulated particularly in regions like Tlemcen (Algeria) and Marrakesh (Morocco), and may have remained in use until the 19th century. Among the tables contained in the manuscript, reference is also made to Ibn al-Bannā al-Marrākushī's work titled "*Minhāj al-ṭālib fī taʿdīl al-kawākib*". Notably, there is a note on the manuscript indicating that it belonged to the timekeeper ʻAbd Allāh al-Ṣanhājī al-Dādisī in Marrakesh. Samso notes that the handwriting of this note differs from that of the scribe and most of the marginal notes.[25]

Subsequently, Carlos Dorce, in his article discussing the calculation methods in Ibn Abī l-Shukr al-Maghribī's (d. 1283) treatise *Tāj al-azyāj*, again refers to the name ʻAbd Allāh al-Ṣanhājī al-Dādisī found in the AFBU manuscript examined by Samso. He also mentions David King's suggestion that ʻAlī b. Muḥammad al-Dādisī (d. 1683) could in fact be ʻAbd Allāh al-Ṣanhājī al-Dādisī. [26]

These findings may hold exciting implications for our study. However, due to the lack of access to the original manuscript of the *Rūznāmah* and the absence of a comparative analysis of the KOERIL copy and the aforementioned work, it remains ambiguous whether the Sheikh ʻAlī Dādisī al-Maghribī mentioned in our manuscript is the same individual that Samso and Dorce refer to in their studies. Nevertheless, future studies could re-evaluate this possibility by considering the following issues:

23 İhsanoğlu-Şeşen-İzgi-Akpınar-Fazlıoğlu, *Op. cit.*, I, p. 322-323.
24 David King, *A Survey of the Scientific Manuscripts in the Egyptian National Library,* Winona Lake IN (Eisenbrauns/The American Research Center in Egypt), Indiana 1986, p. 142-143.
25 Julio Samsó, *Op. cit.*, p. 814-816.
26 Carlos Dorce, "The Tāj al-azyāj of Muhyī al-Dīn al-Maghribī (d. 1283): methods of computation", *Suhayl*, III (2003), p. 193-212.

1. According to Samso's research, the manuscript in question circulated near Tlemcen and Marrakesh until the 19th century. Given that the *Rūznāmah* we examined was prepared based on the latitude of Algeria and the compiler consulted sources from the Andalusian and Maghribi traditions, it is plausible that one of the sources used could relate to the manuscript found at the University of Barcelona.

2. The absence of Sheikh ʻAlī Dādisī's name in the ENL, where he is replaced by Sheikh ʻAlī al-Maghribī among the sources, raises the possibility, albeit weak, that the two names may refer to the same scholar.

3.4. Sheikh Abū Miqraʻ's treatise

The name Sheikh Abū Miqraʻ (or Muqrīʿ) (fl.1320) mentioned among the sources in the *Rūznāmah* must have been a prominent figure in popular astronomy in the Maghrib during the 13th century. His teachings have been the subject of numerous commentaries, the most famous of which is summarized in a didactic poem titled "*al-Muqniʿ fī ikhtiṣār ʿilm Abī Muqrīʿ*," authored by the Moroccan astronomer Muhammad ibn Saʻīd al-Sūsī al-Marghīthī in the 17th century. Samso studied some of the many commentaries, summarizing their content concerning the discussion on lunar and solar calendars, including materials related to lunar mansions, as follows:[27]

1. Discussion on the birth dates of both the Prophets Mohammed and Christ;

2. Rules for calculating the day of the week corresponding to the beginning of each month in the Julian calendar;

3. Description of the lunar mansion occupied by the Sun throughout the year, along with monthly solar shadow diagrams for a gnomon of seven steps and the Indian rule for noon and afternoon prayers;[28]

4. Calculation of the seasonal hour of the day from sunrise or earlier by the Sun, including an explanation of how lunar mansions are used to calculate hours during sunset and throughout the night;

5. Introduction to astrology and a calculation rule, with information on the illuminated portion of the lunar disk for each day of the lunar month.

27 Samso, *Op. cit.*, p. 46-47.

28 For details, see David A. King, *In synchrony with the Heavens: Studies in Astronomical Timekeeping and Instrumentation in Medieval Islamic Civilization, The Call of the Muezzin*, Leiden & Boston, Brill 2004, p. 496-497.

While these items provide the necessary background information to understand better Sheikh Abū Miqraʿ's contributions to astronomy, the elements discussed in points 2, 3, and 4 are particularly significant in the context of the *Rūznāmah*, as they directly relate to calendar issues. This connection may offer valuable insights into the interaction between the Miqraʿ tradition and the calendar practices reflected in the *Rūznāmah*. However, to assess fully the influence of the Miqraʿ tradition on the *Rūznāmah*, future studies will need to conduct comparative technical analyses of both works. This will involve not only a content analysis to identify thematic connections and differences, but also a thorough examination of the methodologies and calculations used in each tradition. Such an approach is essential to draw definitive conclusions regarding the interplay between the Miqraʿ tradition and the calendar practices reflected in the *Rūznāmah*. The content presented here lays the groundwork for further research.

3.5. Ibn al-Bannā's *Zīj*

Ibn al-Bannāʾ al-Marrākushī (d.1321) is mentioned among the sources in the introductions of the BL and ENL editions, although he is not mentioned in the KOERIL manuscript. Ibn al-Bannā specialized in mathematics and astronomy and alongside *Minhāj al-ṭālib fī taʿdīl al-kawākib*, which was quite popular in the Maghrib and used until the 19th century, he wrote works such as *Risāla fī l-anwāʾ*, a book on pre-Islamic Arab calendar systems, and *Kitāb fī ʿilm al-awqāt bi l-ḥisāb*, addressing the measurement of time for Islamic worship without instruments.[29] Several of his works may relate to the calendar we are examining, but it is unclear which specific work is referenced in the BL and ENL editions. It is also unclear why these references are absent in the KOERIL copy. However, if the scribes copied from the original manuscripts, it is possible that the scribe of the KOERIL copy omitted references or that other scribes made corrections and additions. Notably, as discussed above, a manuscript in the Arabic Philology Department at the University of Barcelona indicates that the *muwaqqit* ʻAbd Allāh al-Ṣanhājī al-Dādisī holds a copy of Ibn Abī l-Shukr al-Maghribī's *Tāj al-azyāj* which included tables from Ibn al-Bannā's *Minhāj Zīj*. Therefore, an in-depth study of Ibn al-Bannāʾ's works and their transmission is necessary not only to clarify these ambiguities, but also to advance scholarly discourse and foster innovative research models in this field.

3.6. A Short Examination of Abū Miqraʿ's and Ibn al-Bannā's Traditions in Two Mediterranean Atlases

Before concluding the evaluation of the sources of the *Rūznāmah*, it is pertinent to highlight an intriguing example of the two traditions attributed to Abū Miqraʿ and Ibn al-

29 For details on his other works, see Julio Samsó, J., "Ibn al-Bannā': Abū al-'Abbās Aḥmad ibn Muḥammad ibn 'Uthmān al-Azdī al-Marrākushī", ed. Hockey, T., *et al. The Biographical Encyclopedia of Astronomers*, Springer, New York 2007, 551- 552. https://doi.org/10.1007/978-0-387-30400-7_675

Bannā found in the Mediterranean atlases prepared by ʿAlī bin Aḥmad al Sharafī al-Ṣafāqusī (d. 1579). Al-Ṣafāqusī created these atlases, suitable for both land and sea use, in 1551 and 1571,[30] and referenced authorities such as Abū Miqraʿ and Ibn al-Bannā regarding the rules for reconciling the Julian calendar, a solar calendar, with the lunar calendar.

His atlases provide detailed insights into calendars. The atlas prepared in 1551 provides insights into the calendar table for lunar mansions (2v); the circular table for shadow lengths (7v); and the monthly calendar from January to June and July to December, annotated with Julian, Syriac, and Coptic names (7r-8v)[31]. In the atlas prepared by Al-Ṣafāqusī's in 1571 added features include a *ghurrah-nāmah* calendar table (3r) to determine the day of the week at the start of Arabic months and years; a diagram for lunar phases (missing folio); a lunar mansion calendar (9r); a calendar to determine the day of the week at the start of Julian months and years (10v); a shadow length table (10r); and instructions for using the lunar mansions table and the Julian months/years week determination table (11r).[32]

Although references to Abū Miqraʿ and Ibn al-Bannā appear in al-Ṣafāqusī's atlases and Ottoman literature, the manner in which the author of the *Rūznāmah* incorporated these references into their sources remains unclear. Nonetheless, these atlases serve as significant primary sources for tracing the relationship between Ottoman and North African traditions, offering valuable insights into their usage and influence. These examples also highlight regional and traditional similarities, illuminating the connection of these sources within the context of the *Rūznāmah.*

4. The Content of the *Rūznāmah-i Jadīdah*

The second, third, and fourth sections of the calendar contain significant information pertaining not only to the practical application of the calendar but also to the contemporary tradition of applied astronomy. Evaluating these details alongside the sources provided in the author's preface could facilitate a clearer understanding of the specific purposes for

30 For a detailed discussion of the atlases in the context of maritime astronomical techniques, see Gaye Danışan Polat, *16. Yüzyılda Osmanlılarda Deniz Astronomisi ve Astronomi Aletleri*, Istanbul University, Social Science Institute, Department of the History of Science, Unpublished PhD Thesis, Istanbul 2016, p. 212-219, p. 239-247. Also see Mónica Herrera-Casais, "The Nautical Atlases of ʿAli al-Sharafi", *Suhayl*, *International Journal for the History of the Exact and Natural Sciences in Islamic Civilisation*, VIII (2008), p. 225- 226; Jeremy Francis Ledger, *Mapping Mediterranean Geographies: Geographic and Cartographic Encounters between the Islamic World and Europe, c. 1100-1600*, the University of Michigan, Unpublished PhD Thesis, USA 2016, p. 284-293.

31 For detailed information see Ahmed Shamima, *The Paris Copy of the Mediterranean Sea-Atlas of Ali ibn Ahmed ibn Muhammed al-Sharfi of Sfax, 958/ 1551*, Victoria University of Manchester, Unpublished Master Thesis, 1978.

32 For details see ʿAlī ibn Aḥmad al-Sharfī Safāqisī, *The Mediterranean Sea Atlas of ʿAli Ibn Ahmed Ibn Mohammed Al Sharfi Al Sfakasi: Dated H. 979, AD 1571 Held in the Bodleian Library the University of Oxford Ref. MS Marsh 294*, Ed. William C. Brice, Manchester 2003, p. 1-33.

which various works were consulted in future comparative textual analyses. This section underscores the focused examination of the data within the *Rūznāmah* toward this objective.

4.1. The Calendar's Key: Calendar Tables and Usage Instructions

The first section, called "*miftāḥ-ı rūznāmah*" (perpetual calendar key), contains information about the formal characteristics and usage instructions for the two types of tables in the calendar. The description of the tables begins with the calendar tables and continues with the *ghurrah-nāmah*. However, this order does not correspond to the sequence of the tables.

The tables provided for the *ghurrah-nāmah* are called "*miftāḥ-ı jadwal"* (table key).[33] While the first column of the *ghurrah-nāmah* table represents the years AH 1157-1212 (AD 1744-1798), the table is divided into four rows for each year. The first row provides information under the title "*ghurrah-ı shuhūr-ı rūmiyyah*" regarding which day of the week corresponds to the beginning of the Hijri month in the *Rūmi* calendar. The names of the 12 Arabic months are listed in the first row for each year, and the day of the week is given in Arabic alphanumeric (*abjad*) notation values from 1 to 7. In the second row (*shuhūr-ı rūmiyyah*), the names of the *Rūmi* months corresponding to the Hijri months are listed. The third row (*'adad*) indicates which day of the *Rūmi* month corresponds with the beginning of the Hijri month, and the last row provides the day of the week corresponding to the beginning of the Hijri month. Arabic alphanumeric notation is used, and since calendars in the Middle East typically standardize Sunday as the start of the week, the days are listed as follows starting from Sunday:[34]

ا *Ehad*, ب *isneyn*, ج *sülesâ*, د *erbi'â*, ه *hamîs*, و *cum'a*, ز *sebt*.

The calendar maker used Ulugh Beg's *Zīj* to indicate the days corresponding to the beginning of the Arabic months (*ghurrah*) and the Christian calendar (*sinīn-i īsā,* lit. the years of Jesus).

An illustrative example to clarify the usage of this table is as follows: in the first table, the first day of the month of Muharram in the year AH 1157 corresponds to the third day of February. This correlation is derived from the listing of the name "*Felvar*" (February) under the month of Muharram, with the numeral "3" found in the row titled '*adad* (lit. number). Additionally, it is understood from the *ghurrah-ı shuhūr-ı rūmiyyah* row that it corresponds to د (*yawm al-arba'a*, Wednesday) and from the *ghurrah-ı shuhūr-ı arabiyyah* row that it corresponds to و (*yawm al-cum'a*, Friday).[35]

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33 *Rûz-nâme*, fol. 47r.
34 Ibid., fols. 47r-48r.
35 Ibid., fols.47r-49r.

According to the author's statement, since the New Year in the Christian era begins in January, the corresponding year of the Christian era is written above each month of January (*Yanar*). It is a solar calendar that incorporates elements from both the Julian and Gregorian calendars, a feature that will be discussed in detail later. A leap year in this calendar is indicated by the symbol ك (*kāf)*. Similarly, the same symbol is used for leap years in the Hijri calendar as well. Additionally, the author has noted that if a Hijri month's *ghurrah* (beginning) does not fall within a month, the calendar repeats the month before it twice for that year, and subsequently skips the mentioned month to write the next one. For example, in the year AH 1160, the beginning of the month of January falls on *yawm al-khamis* (Thursday). January also ends on *yawm al-sabt* (Saturday), the 31st day. Therefore, in the year AH 1160, January and March are written twice, and February is omitted because there is no corresponding beginning of the Arabic month in that Gregorian month. Consequently, according to the calendar maker, anyone consulting the calendar should verify the year from the *ghurrah-nāmah* tables when performing related operations.[36]

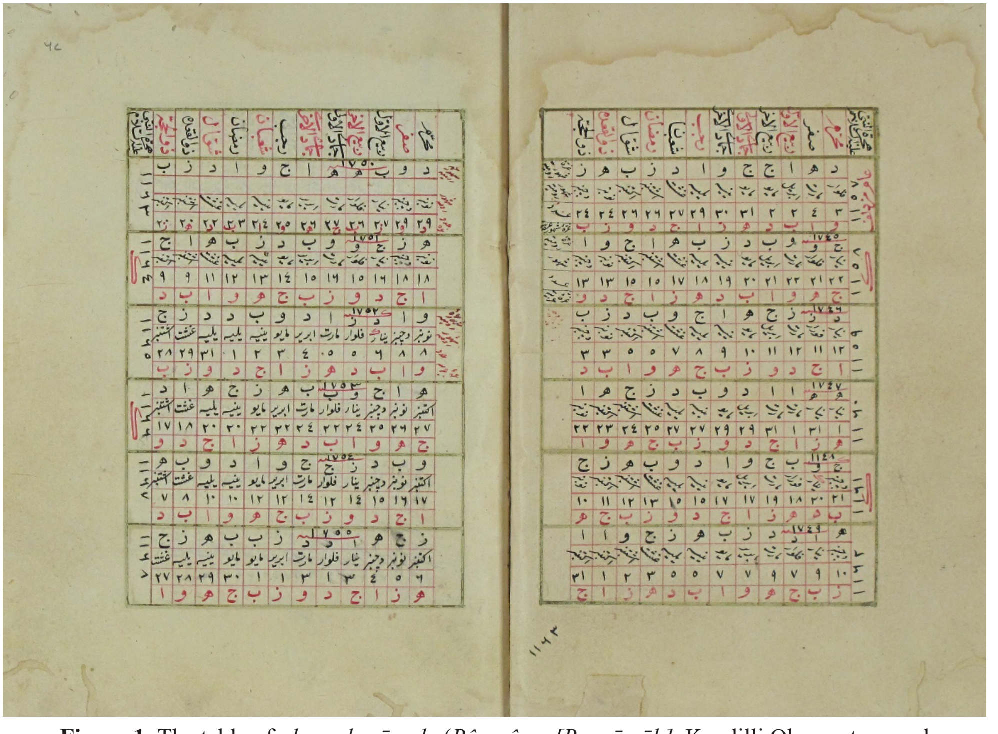


Figure 1. The table of *ghurrah-nāmah*. (*Rûz-nâme [Ruznāmāh]*, Kandilli Observatory and Earthquake Research Institute Library [KOERIL], MS. 138/2, folio: 61r-62v.)

36 Ibid., fols. 49r/61r.

The second set of tables represents the 12-month calendar, covering details on natural events, meteorology, nutrition, and health. These tables comprehensively address the correlations between months, the four seasons, and the four humors. Accordingly, spring was associated with blood, summer with yellow bile, autumn with black bile, and winter with phlegm.[37] However, unlike Ottoman perpetual calendars that typically begin in March, this calendar starts in January and ends in December.

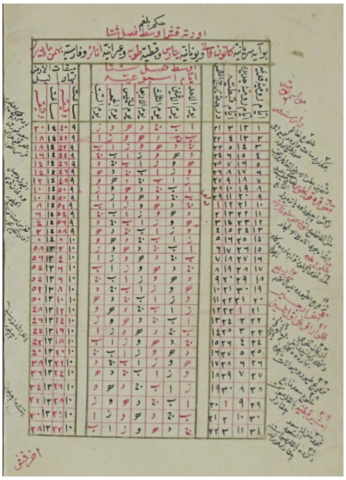
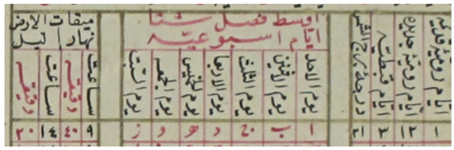
Each month is written with its equivalents in the Syriac, Greek, Coptic, Hebrew, and Persian languages. However, in October, an additional month name is given under the title *īsā* (Jesus). Below the section where the months are written, other columns of the table are present. The first four columns consist of *ayyām al-rūmiyyah al-qadīmah* (Julian calendar days), *ayyām al-rūmiyyah al-jadīdah* (Gregorian calendar days), *ayyām al-qıbtīyyah* (Coptic calendar days), and *darajat al-burj al-shams* (degree of the Sun's zodiac; longitude of the Sun).[38]

In the solar calendar, the calculation according to Anno Domini is determined in two ways: one corresponds to the Julian calendar, known as *al-rūmiyyah al-qadīmah,* and the other to the Gregorian calendar, known as *al-rūmiyyah al-jadīdah.* (Table 1) The author has organized the tables to include these two pieces of information, but has provided detailed explanations about them in the third section titled "*ʿĀmm-ı Shamsiyyah*." In the third section, the author has provided the names of the nations that follow these two methods.[39]

37 For details on Ottoman medical history studies in Ottoman calendars, see Gaye Danışan, "Osmanlı Tıp Tarihi Çalışmalarında Takvimlerin Kaynak Değeri Üzerine Tespitler (16.-17. Yüzyıl)", ed. Elif Gültekin, Türk-İslam Tıp Tarihi Araştırmalarında Kaynaklar*,* Türkiye Klinikleri, Ankara 2024, p. 47-52.

38 *Rûz-nâme*, fols. 68r-73v.

39 "*…ve dahi ehl-i İslâm ve Acem bi'l-cümle hisâb-ı kadîm üzre add iderler. Ve Kriks (قريق), Kazak ve Moskov ve Rus ve Leh ve Karaboğdan ve Dinmark ve İngiliz kefereleri bi'l-cümle hisâb-ı kadîm üzre add iderler. Amma Efrenc ve Fransız ve Tulyân ve İspanyol ve Portekiz ve Filemenk ve Dordeş ve Anberkiz ve Süveyd ve Ciniviz ve Venedik ve Nemse ve Sayvar ve Alagorniz ve Papa bi'l-cümle hisâb-ı cedîd üzre add iderler.*" Ibid., fols. 57r-57v.

<table>
<tr><td colspan="2">Table 1. An example of a calendar leaf for January (Rûz-nâme[rūznāmah], KOERIL, MS. 138/2, folio. 67r.)</td></tr>
<tr><td rowspan="2"></td><td></td></tr>
<tr><td>Example: According to table, January 1 in ayyām al-rūmiyyah al-qadīmah (Julian calendar days), corresponds to January 12 in ayyām al-rūmiyyah al-jadīdah (Gregorian calendar days), and January 3 in ayyām al-qıbtīyyah (Coptic calendar days). In Capricorn, it is the 21st day. In the Arabic month, it is Sunday. At this time, the duration of day and night is as follows: 9 hours and 40 minutes of daylight, and 14 hours and 20 minutes of night.

In addition, ayyām al-usbū’ consists of seven letters, each representing a day: ‘ا,ب, ج ,د,هـ,و,ز.’ This table does not include information regarding the year and week according to the Rūmi calendar; the author directs users to consult the ghurrah-nāmah for this purpose.</td></tr>
</table>

4.2. *Ghurrah-nāmah*: Methods of Determining the Beginning Day of Months in the Hijri Calendar

In Islamic astronomy, predicting the visibility of the new crescent moon on the evening following the conjunction of the Sun and the Moon in lunar calendars, based on lunar phases, holds special importance. However, there have been different approaches to determining this event, which marks the beginning of the new month. This topic is extensively discussed in the second part of the *Rūznāmah*.

In the *Āmm-ı ‘Arabiyyah* section of the *Rūznāmah*, the calendar maker states that there are three different methods to determine the beginning of lunar months in the Hijri calendar. The first method refers to the phase when the Moon and the Sun are in conjunction, specifically during the new moon phase when the Moon is not visible. The second method refers to the crescent phase when the Moon begins to reflect sunlight after separating from the Sun following their conjunction. During this time, the crescent Moon is visible on the western horizon after sunset. The day following the sighting of the crescent Moon is considered the beginning of the month. Finally, the third method involves determining the beginning of the month through calculation, which is also known as *ru’yat al-‘alamah*. According to this calculation method, the day when the Moon and the Sun separate from each other after conjunction is considered as the first day of the month. The author mentions that Christians (*Nasārā*), Western Europeans (*Efrenc*), and Jews used the first method, where the new moon phase is accepted as the beginning of the month, while Islamic legal scholars may prefer the second or third method. The author specifies that when preparing the *rūznāmah* tables, he relied on the third method.[40]

The author also explains the difference between the lunar and the solar year in this section. It is noted that there is an eleven-day difference between the lunar year and the solar year, and every 33 years, the two calendar systems coincide. This means that every 33 years, there is a leap year. It is stated that the year AH 1157 represents this coincidence. The Arabic months from *Muharram* to *Dhu al-Hijjah* are designed with varying lengths: six months have 29 days and six months have 30 days. During a leap year, an additional day is added to *Dhu al-Hijjah*.[41]

4.3. *'Âmm-ı Şemsiyye*: Solar Year

This section of the *rūznāmah* provides information about operations related to the solar year. It is stated that there is a need for the solar year/calendar to stabilize the solar calculation, to determine the seasons, and to identify agricultural seasons for the benefit of vineyards, gardens, and orchards.[42]

The solar year corresponds to 12 zodiac signs, with the Sun completing one circuit through each sign. For instance, the period from when the Sun starts at the first minute of Aries and returns to this sign is called "*'āmm al-awwal*," totaling 365 days and six hours. This period is named "*'āmm al-thani*" when it totals 365 days and 12 hours, and "*'āmm al-thālith*" when it amounts to 365 days and 18 hours in the subsequent years. The fourth year consists of 366 days, known as a leap year and referred to as "*'āmm- al-kabisa*." The calendar consists of 365 days annually, with every fourth year being a leap year, thereby totaling 366 days. This extra day is added to the month of *Felvar* (February). However, this practice varied across different traditions. According to the *rūznāmah*, in regions such as Egypt, Damascus, Aleppo, Baghdad, India, Yemen, and Persia an additional day was added to the month of February. In contrast, in Africa and Andalusia, the extra day was added at the end of December in accordance with the solar year. Therefore, in the latter case, since December was considered to have 31 days, in years with an additional day, December would be counted as having 32 days.[43]

Another important issue is the matter of the solar year's starting day, which is detailed in the manuscript. Information regarding the regions where various calendars are used and the starting days of the year provided in the manuscript are summarized in Table 2. The author has provided detailed information, particularly related to the equivalents of *Tūt*, which

40 Ibid., fols. 50r-51v.
41 Ibid., fols. 52r-54r.
42 Ibid., fol. 56v.
43 Ibid., fols. 56v-57r.

is accepted as the first month of the Coptic calendar listed in the table, in the Julian and Gregorian calendars. The Coptic calendar divides a year into 12 months of 30 days each, totaling 365 days with an additional 5 days added at the end. Every fourth year, a leap day is added, typically in August. For example, if it is not a leap year when 360 days are completed on August 23, five days are added, making August 28 the last day of the year. Thus, the first day of the next year, corresponding to the first day of *Tūt*, would be August 29. If it is a leap year, this would be August 30 instead. Moreover, the Coptic New Year falls in September in the Gregorian calendar. [44]

Another important feature of the *rūznāmah*, which distinguishes it from the Ottoman perpetual calendar tradition, is that the calendar tables are adjusted according to the *tārīh-i Masīḥ ibn Maryam.* Unlike the Ottoman perpetual calendar tradition, which usually begins in March, the *rūznāmah* prepared for the latitude of Algiers starts in January. Additionally, according to the author, various solar calendars were employed in different regions, each indicating the beginning of the year (Table 2).[45] What is more, according to the author, various solar calendars were employed in different regions, each indicating the beginning of the year (Table 2). This is evident in the inclusion of works popular in the Maghrib region among the calendar's sources, the preparation of the calendar tables according to the traditions of this region, and the adherence to the Maghribi and Andalusian traditions, despite also mentioning the Jalali calendar used in Istanbul and Anatolia for solar calendar applications. In light of this information, it is clear that the calendar in question diverges from the Istanbul-Anatolian tradition.[46]

The clear indication that the calendar scales were adjusted according to the *tārīh-i Masīḥ ibn Maryam.* and the fact that the starting points of the year varied according to different traditions underscores the importance of this calendar as a critical source that can be used in future in-depth comparative studies focusing on Maghribi and Andalusian traditions. Moreover, given the region's complex social structure, we should broaden our perspective by considering this tradition in a context that also includes the possibilities of cultural interaction not only with the Maghribi and Andalusian traditions but also with the Christian communities in the Ottoman territory.

44 Ibid.

45 Ibid.

46 For a general discussion on Ottoman calendrical tradition, Stephen P. Blake, *Time in Early Modern Islam: Calendar, Ceremony, and Chronology in the Safavid, Mughal and Ottoman Empires*, Cambridge University Press, USA 2013, p. 66-75.

Table 2. Solar calendars used in different regions and the starting times of the year in these calendars according to the author of *the rūznāmah*.

Regions where the solar calendar is used	**Type of solar calendar**	**Beginning of the year according to the solar calendar**
Ahl al-mashriq	*Tārîh-i İskender-i Rūmī*	*Tashrīn al-awwal*
Istanbul and Anatolia	*Tārīh-i Malik-Shāh Jalal al-Din* Seljuki	*ḥamel al-awwal; Nawrūz-ı Sultānī*
Persia, province of Ajem, Samarqand	*Tārīh-i Yazdegerd ibn Shahriyār*	*Hamel burcuna tahvili* (When the Sun enters the sign of Aries)
Egypt and Damascus	*Tārīh-i Dakyanīs / Tārīh-i qıbtī*	* *Tūt*
Maghrib and Andalusia	*tārīh-i Masīḥ ibn Maryam*	*Yanar*

4.4. Methods for Determining Latitude on Land and Sea Using the Sun's Declination and Altitude

The fourth section (*Mayl al-shams wa 'urūḍ al-buldān*) of the examined *rūznāmah* provides comprehensive insights into the declination of the Sun (*mayl al-shams*) and detailed instructions on how latitude determination should be conducted accordingly. The latitude of a location can be determined using astronomical methods in two ways. In the Northern Hemisphere, an observer measures the altitude of the pole star above the horizon, which directly correlates with the latitude of the observer's position. Another method involves measuring the altitude of the Sun at noon above the horizon. This method also requires knowledge of the declination of the Sun, known as its declination (δ). Thus, the observer needs to know the Sun's position in the ecliptic plane, determining the specific day on which the Sun's altitude is measured, known as its longitude (λ). At this point, the solar calendar becomes relevant. The *rūznāmah* fulfils this requirement and explains this second method in this section. To achieve this, the observer must measure the Sun's culmination altitude (*al-ghāya*), which denotes the Sun's altitude when it reaches the meridian. Hence, altitude measurements are taken at noon. The author also discusses the instruments used to measure the altitude of the Sun on land and at sea. For measurements conducted on land, the instruments mentioned are the astrolabe, the sine quadrant, and the astrolabe quadrant. These instruments hold significant importance in Ottoman astronomical literature.[47] If this measurement is to be

47 For an example study on the use of these instruments, see Gaye Danışan, "16th Century Ottoman Compendium of Astronomical Instruments: Admiral Seydi Ali Reis's Mir'at-ı Kainat", *Scientific Instruments Between East and West*, Ed. Neil Brown-Silke Ackermann-Feza Günergun, Leiden, Brill 2019, p.1-16.

conducted at sea, it is noted that an instrument called the "*palastirilya*" should be used.[48] No information is provided about the instrument's structure, making it unclear what it is. On the other hand, in an anonymous Ottoman treatise on navigation presumed to date back to the 19th century and written on maritime matters, this instrument is mentioned under the name "*palastire*." In this work, along with information about the usage of the instrument, there is also information about its structure. Based on this, it has been determined that the instrument referred to is the cross-staff, commonly used among European sailors.[49] Furthermore, the resemblance of the term "*palastirilya"* to the Italian word "*balestiriligia"* has raised the possibility that this information may have entered Ottoman literature through Italian sources and/or sailors.[50]

The author continues to discuss another important rule in determining latitude by measuring the Sun's altitude at noon. This involves knowing on which day and month the altitude of the Sun is measured, and which degree of zodiac sign the Sun is located, i.e., knowing the solar longitude (*darajat [al-buruj] al-shams*) which is provided in the calendar tables prepared for the 12 months in the *rūznāmah*. From this column, the movement of the Sun along the ecliptic plane throughout the year is tracked, divided into 30° segments corresponding to each of the 12 zodiac signs. This relationship is associated with the days corresponding to the solar calendar. Thus, depending on the month and day of observation, the observer can easily access the Sun's longitude information from the calendar. The details regarding the subject are clearly provided in the *rūznāmah*, supported by examples. Accordingly, there is no oblique when the Sun enters the signs of Aries and Libra because they coincide with the equinox times. After entering the sign of Aries, the Sun progresses through the signs of Taurus and Gemini, with the oblique increasing until it reaches the sign of Cancer. Then, the oblique begins to decrease as the Sun moves through the signs of Leo and Virgo, continuing this trend until it reaches Libra. According to the *rūznāmah*, the maximum value reached by the obliquity of the ecliptic is 23° 32′.[51] The value given for the

48 *Rûz-nâme*, fols. 58v-59v. This research topic is being carried out within the framework of the project titled "Portable Astronomical Instruments: The Processes of Adaptation and Diffusion of Medieval Islamic and European Examples in the Ottoman Geography (1500-1700)" supported by the TÜBA-Outstanding Young Scientists Awards program.

49 The description of the instrument named *"palastire"* mentioned in the treatise *Kitâbu'l-murûri'l-ubûr fî ilmi'l-berri ve'l-buhûr* aligns with the structures of the cross-staff and back-staff instruments. The author initially refers to these instruments collectively as "*palastire*" in the introduction section without differentiation, while later in the text providing a more detailed description, distinguishes them as *"yeke palastire"* for the cross-staff and "*çatal palastire*" for the back-staff. For more details, see Gaye Danışan Polat, "An Anonymous Ottoman Compendium on Nautical Instruments and Navigation: Kitâbu'l-murûri'l-ubûr fî ilmi'l-berri ve'l-buhûr", *Mediterranea-Ricerche Storiche*, issue 34, (August 2015), p. 379-381.

50 Crescenzio Bartolomeo Romano, *Nautica Mediterranea di Bartolomeo Cresntio Romano All'illustriss E Reverendiss. S. Card. Aldobrandino*, Italy 1602, p. 358; Broyner Willem Frederik Jacob Mörzer Bruyns, *The Cross-Staff: History and Development of a Navigational Instrument*, Walburg Press, Amsterdam 1994, p. 23.

51 *Rûz-nâme*, fol. 58r.

obliquity angle here is noteworthy because it is not commonly used. One of the astronomers in the Maghribi-Andalusian tradition who used this value is Ibn al-Raqqām (d.1315).[52] We currently lack sufficient evidence to interpret this further, but it serves as a clue for future research on the topic.

Additionally, the *rūznāmah* specifies that on March 9, the Sun will enter the sign of Aries, and on September 12, it will enter the sign of Libra. This corresponds to the spring and autumnal equinoxes, according to the Julian calendar. Therefore, it appears that the author adopts the Julian calendar, despite specifying a column for the Gregorian calendar in the *rūznāmah* tables.

The signs from Aries to Libra are known as the northern signs. Afterwards, the obliquity begins to increase again through the signs of Libra, Scorpio, and Sagittarius. When the Sun reaches the winter solstice in Capricorn, the obliquity reaches its maximum value (23° 32′). Then, it begins to decrease through the signs of Aquarius and Pisces, concluding the cycle in the sign of Aries. The signs of Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces are referred to as the southern signs.[53]

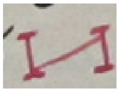
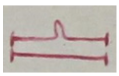
Following this information, the author explains the calculation necessary to determine the latitude of the location. If altitude measurements are taken on the equinox days, the obtained altitude value is subtracted from 90°, and the result value gives the latitude of the observer's location. In other cases, if there is an oblique and the Sun is in a northern constellation, the elevation value is subtracted from the zenith height and the remaining value is subtracted from 90°. If the Sun is in a southern constellation, the elevation value is added to the zenith height, and the result is subtracted from 90°. The resulting value gives the latitude of one's location. If the observer wishes to determine latitude at sea, certain special conditions and indicators must be considered. These are summarized based on the author's statements in Table 3.[54]

52 An Andalusian astronomer, mathematician, and physician Ibn al-Raqqām's full name is as follows: Abū ʿAbd Allāh Muḥammad ibn Ibrāhīm ibn ʿAlī ibn Aḥmad ibn Yūsuf al-Mursī al-Andalusī al-Tūnisī al-Awsī ibn al-Raqqām. His works suggest he lived in Tunis and Bijāya (in Algeria), as astronomical tables in *al-Zīj al-qawīm* are calculated for Tunis, while *al-Zīj al-shāmil* contains tables for Bijāya. A copy of *al-Zīj al-shāmil* (1280) is housed at the Kandilli Observatory Library (MS 249). Ibn al-Raqqām notes in the introduction of *al-Zīj al-shāmil* that he created the zīj to correct existing ones. He used value for an obliquity of the ecliptic of 23;32,40º. For details see Julio Samso, *On both sides of the Strait of Gibraltar: Studies in the history of medieval astronomy in the Iberian Peninsula and the Maghrib*, p. 65; Josep Casulleras, "Ibn al-Raqqām: Abū ʿAbd Allāh Muḥammad ibn Ibrāhīm ibn ʿAlī ibn Aḥmad ibn Yūsuf al-Mursī al-Andalusī al-Tūnisī al-Awsī ibn al-Raqqām", ed. Hockey, T., *et al.* , *The Biographical Encyclopedia of Astronomers*, New York, Springer 2007, p. 563-564.

53 *Rûz-nâme*, fols. 58r-58v.

54 Ibid. fols. 58v-60r.

Table 3. Procedures and symbols used by mariners for latitude determination

Celestial Event	**Date Range**	**Sign**	**The procedure for determining latitude**	**Example**
The moment when the Sun enters the sign of Aries, commonly known as the vernal equinox.	March 9		The Sun's altitude at the culmination provides the latitude.	-
The path of the Sun through the Zodiac from the spring equinox to the autumnal equinox.	From March 9 to September 12		Add the Sun's altitude value to the oblique. The result obtained will be the latitude of the location.	On April 1, AD 1732, we found the Sun's altitude to be 20 degrees [°]. We found the inclination from the table for that day [from a calendar]. In the year AD 1732, at the beginning of April, we found the oblique to be 4 degrees [°] and 45 minutes [′]. We added: 20° + 4° 45′=24° 45′ This is the latitude.
The moment when the Sun enters the sign of Libra, is known as the autumnal equinox.	September 12		The Sun's altitude at the culmination in Libra provides the latitude.	-
The path of the Sun through the Zodiac from the autumnal equinox to the spring equinox.	From September 12 to March 9.		The Sun's culmination altitude is subtracted from its oblique value to determine the latitude. The remaining result indicates the latitude. If the minutes of the Sun's altitude angle lower than the inclination angle, one degree is subtracted from the altitude value and added to the minutes. However, it should be noted that 1 degree equals 60 minutes of altitude.	We measured the altitude on the first day of November in AD 1732. The result is 57 degrees 10 minutes and the inclination is 14 degrees and 37 minutes. Result: 56° 70′ - 14° 37′= 42° 33′

5. Conclusion

The Ottoman Empire's cultural diversity was enriched by interactions influenced by temporal and spatial dynamics, alongside factors such as trade routes, political relations, and migrations. This contributed to the formation of a complex social fabric across the empire's vast geography. However, there is currently no single modelling approach to understand fully and analyze the process of incorporating new information into long-established knowledge repertoires. This complexity arises from the intricate structure of circulating channels, codes, and environments involved in the process. Therefore, theoretical approaches to understanding hybridization processes emphasize the significant role of case studies. In this context, our analysis of an 18th-century permanent calendar prepared according to the latitude of Algiers serves as such a case study. The findings highlight the integration of knowledge in fields such as navigation and astronomy by Ottoman and other Mediterranean inhabitants and offer significant insights into Ottoman approaches to measuring and organizing time.

The fact that the calendar was prepared in Ottoman Turkish, contains technical information related to navigation, and is tailored to the latitude of Algiers - thereby limiting its regional functionality - suggests that its primary audience was likely Ottoman residents of the Algiers region, particularly mariners. Additionally, the inclusion of works popular in the Maghrib region among the calendar's sources, the preparation of the calendar tables according to the traditions of this region, and the adherence to the Maghribi and Andalusian traditions, despite mentioning the Jalali calendar used in Istanbul and Anatolia for solar calendar applications, provide notable insights into the process of integrating the Maghribi-Andalusian astronomical tradition into Ottoman astronomy.

On the other hand, the content analysis of the *rūznāmah* has shown that traditional practices were combined with contemporary applications suitable for the conditions of the time. The best example of this is the preparation of the *ghurrah-nāmah* tables with two columns, corresponding to the Julian calendar as *al-rūmiyyah al-qadīmah* and the Gregorian calendar as *al-rūmiyyah al-jadīdah*. Furthermore, it has detailed which of these two calendars was preferred by specific European nations. This technical choice provides important insights into the calendar's user base and its widespread areas of use, while also reflecting the gathering of individuals from diverse cultural, religious, and linguistic backgrounds within Ottoman society to share knowledge and practices.

Another key point is the maritime information included in the calendar which has provided significant clues indicating the use of astronomy in navigation techniques employed in the Mediterranean region in the 18th century. Especially notable is the finding that the instrument used at sea, known as a *palastirilya*, is equivalent to the cross-staff commonly used by European sailors and its pronunciation is similar to the Italian nautical instrument *balestiriligia*.

On the other hand, the *rūznāmah*, aligned with Maghribi-Andalusian calendar traditions, functions as a practical guide rather than merely a theoretical treatise. Its composition in Ottoman Turkish suggests that its intended audience was the Ottoman people. Its content encourages us to consider the accessibility of foundational works of Ottoman astronomy to local populations in these regions, in light of the Ottoman Empire's presence in these areas. Although the calendar was prepared in Algeria from the Maghrib region, some points and sources regarding calendrical matters also reflect the Andalusian tradition and bear traces of cultural exchange within this geography. Furthermore, the presentation of information in the Julian and Gregorian calendar systems and knowledge about the cross-staff—widely used among European sailors—highlights the possibility that Christian communities in the region may have contributed to the Ottoman context alongside the Maghribi-Andalusian tradition. While these findings underscore the region's complex social structure, they also lead us to question how this information reached the Ottomans, both directly and indirectly, and what the processes of adaptation entailed.

Consequently, the following questions remain:

1. How did the complex social structure of the region impact the adaptation of astronomical traditions within the Ottoman context?

2. To what extent did local communities in the region contribute to the development and accessibility of foundational works of Ottoman astronomy alongside the established Maghribi-Andalusian traditions?

3. Did diverse maritime traditions across different regions influence Ottoman navigators?

4. To what extent did Ottoman sailors navigating the southern Mediterranean implement region-specific maritime techniques?

5. If region-specific techniques were indeed adopted, to what extent did nautical practices in the Maghrib shape Ottoman maritime practices?

The findings presented in this paper underscore the fact that various adaptations and updates of perpetual calendars were specifically adjusted to different periods. The data derived from the textual analysis, along with future comprehensive comparative studies and archival research, will enable a deeper understanding of the development, production, and adoption processes of Ottoman astronomical techniques.

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