MATTER: International Journal of Science and Technology
ISSN 2454-5880

Salih Hamza Abuelyamen, 2023

Volume 9 Issue 1, 01-19

Received: 31st May 2022

Revised: 07th February 2023, 16th February 2023

Accepted: 17th February 2023

Date of Publication: 15th March 2023

DOI- https://doi.org/10.20319/mijst.2023.9.0119

This paper can be cited as: Abuelyamen, S. H. (2023). The Hijri Calendar and Its Conformance with the Gregorian Calendar by Mathematical Calculations. MATTER: International Journal of Science and Technology, 9(1), 01-19.

THE HIJIRI CALENDAR AND ITS CONFORMANCE WITH THE GREGORAIN CALENDAR BY MATHEMATICAL CALCULATIONS

Salih Hamza Abuelyamen
B.Sc., M. A., Retired from the Central Bureau of Statistics in Sudan, Association of Retired Staff from The Central Bureau of Statistics, Private Researcher, Sudan
salihabuelyamen@yahoo.co.uk

Abstract

The objective of this research is to develop a mathematical procedure to construct a Hijri calendar that is consistent with the Gregorian calendar. Our hypothesis was derived from the Quran Chapter, Alkahf verse (25), which states "They remained in their cave for three hundred years, adding nine". We understand this verse to mean "every 300 solar years equivalent exactly to 309 lunar years". The starting point was to locate the number of days for each month of each Hijri year. We found that the distribution of number of days per month coincided in the two rounds of the 309 Hijri years. Accordingly, we prepared a list of number of days per month for 1545 Hijri years. Hence, we constructed Hijri calendar starting consecutively from 1 Muharram 1AH to any Hijri Date. We considered the Gregorian Date consistent with the first of Ramadan 1442AH as a relevant reference versus the historical reference of the migration of Prophet Mohammed صلى الله عليه وسلم to Medina. Finally, we compared our results with previous official dates Therefore any Gregorian date corresponds to Hijri date could be known.

Keywords:

Lunar, Solar, Hijri, Gregorian, Astronomy, Calendar

1. Introduction

Arabs are the first to make use of the lunar system to know the starting and terminating of the month, and that by the appearance and disappearance of the crescent. The Arabs utilized this system to organize their trade and religion activities even before some centuries from the beginning of Islam (BBC). They continued to use this system after Islam up to the death of Prophet Mohammed (صلى الله عليه وسلم). After 17 years of the death of the Prophet (Aljazeera.net), the Caliph Omer Ebn-el-khattab established the Hijri date starting from the lunar system date of migration of Prophet Mohammed (صلى الله عليه وسلم) to Medina in 12 Rabi I, which corresponds to 27 September 622CE (Elmekafooree). According to these dates the first of Muharram 1AH would correspond to around 18 of July 622EC. As the number of days in the lunar month differs through time, and not yet known the dynamic of this behavior, an accurate perpetual Hijri calendar has not been established yet; the Islamic countries till now depend on physical observation of the crescent to fix the first day of the lunar month for undertaking their Islamic practices such as fasting in Ramadan or going to Hajj, except small number of countries that depend on astronomical forecasting.

As for the calendars based on the solar system it had been used by the Greece and other European countries before the 16^{th} century. The most famous of these calendars was the Greece one, which was being in use until they discovered an error in the number of days of the circulation of the earth around the sun. The Pope Gregorian the third corrected this error and established a calendar called Gregorian calendar, starting from the birth of Jesus (infoplease). It is now known as the European calendar.

This research aims to present a scientific study of constructing a Hijri calendar to the Islamic population on the basis of information from the Holy Quran. The research consists of five steps: First, finding the number of days in each month for each Hijri year starting from the first of Muharram the year one Hijri; Second, locating the Hijri Date by day, month and year for each Hijri day; Third, aligning the Hijri calendar with the Gregorian calendar for each Hijri day; Forth, developing programs to know the number of months' days in any Hijri year, and the Gregorian date that corresponds to any Hijri Date in the past or future; Fifth, working out examples to compare between our findings and the Gregorian Date of the first of Ramadan and other Islamic

occasions of previous years. Our results for the number of days of the Hijri months was production of a schedule of number of months' days whether 29 or 30 for 1545 Hijri years starting from 1/1/1AH. For the Hijri calendar and its correspondence to the Gregorian calendar we constructed Hijri calendar for 309 Hijri years conformed to Gregorian calendar. As for the knowledge of the number of days of the Hijri months in any Hijri year, and the Hijri dates conformed to any Gregorian date we developed programs to detect that on the basis of what we discovered about the cyclic nature of the lunar system dates.

2. The Objective

The objective of this research is to present a scientific study to the Islamic world by, firstly; finding out the number of days in each month of the Hijri years. Secondly; establishing a perpetual Hijri calendar and conforming it to the Gregorian calendar.

3. The Problem and Hypothesis

The problem of the research is that: first; the Islamic world depends mainly on physical sighting of the crescent to fulfill their religious commitments at its dates, especially fasting in Ramadan or going to Hajj; second; they depend mainly on the Gregorian date as reference to know the Hijri date. This is because a considerably perpetual and accurate Hijri calendar has not been established yet. Our hypothesis built on the verse number 25 of Surat Al-Kahf in the Holy Quran, which translated as "They stayed in their Cave Three hundred years, and add nine" (Ali). To our understanding this verse means that every 300 solar years equals exactly 309 lunar years.

4. The Importance of The Paper

The importance of this research can be summarized in the following:

- To provide a stable and acceptable Hijri calendar and conform it to the Gregorian calendar.
- To correct the Hijri dates of the past Islamic events and to know the Hijri dates for the future Islamic practices.
- To discover new information or facts that might be derived from the basic preliminary data of this research, for example more clues about the date of the Night of Power in Ramadan.

- To make use of the findings of the research for future researches in this field; either to develop it or to build on it new more accurate outcomes.

5. Scope of The Research

Theoretically, the research presents a method to construct Hijri calendar and conform it to the Gregorian calendar. Practically; a schedule of the numbers of days per month that covers 1545 Hijri years was prepared; and a Hijri calendar was constructed and conformed to the Gregorian calendar for 309 Hijri years starting from 1 Muharram, 1 AH. For other years out of this scope, programs were developed to know the number of days per month for any Hijri year, and the Gregorian date corresponds to any Hijri date in the past or future.

6. Literature Review

The studies on the establishment of Hijri Calendar and its conformance with the Gregorian's Calendar have not been paid considerable attention in research fields. Though the Islamic practices depend on Hijri dates, most of the Islamic countries up to now depend on physical sighting of the crescent to know the starting of the Hijri month; and they differ in that especially in the starting day of Ramadan. From the articles we found in the Web sides we knew that the ancient astronomers developed tables named Elaziaj that indicates the daily time of rise and set of the sun and the moon and the planets; but, on the lack of advanced forecasting instruments it was not at that level of accuracy (Marwa). Also, we knew from the same source that Saudi Arabia was the first Islamic country used Lunar Calendar known as Umelgura; but this calendar continued to be used only for 15 years from 1990 to 2005 because some errors had been discovered in it. At the present time we knew from the Net that there are tables indicates the time of rise and set of the sun and moon with very high accuracy. However, we could not be able to reach that. With more searching in the Net, we knew from the website of International Astronomy Center that there is a project called Islamic Center Crescents Project (ICOP) its members forecast the crescent from different places in the world and send their findings to the Center to be published (International A. C.). However, we did not find a permanent astronomical Hijri calendar that Muslims depend on it except the spontaneous reports from astronomers when the time of Ramadan or Shawwal months is being approaching. In addition to that there are several converting programs from Hijri to Gregorian and vice versa, for example The Intelligent Transformer (The intelligent transformer)

and The History Transformer (The history transformer); but no clarification about the procedures used to construct these programs was reported.

As for books and articles in the Net we found one of the famous ancient books in Arabic named as Alelhamat Eltofigeia by Mohammed Mokhtar Basha Elmasri (Basha); it consists of a schedule of Gregorian years versus Hijri years; but the methodology of this work was not explained. With respect to articles, we found in the Net two articles in English; in the first one the author proposed a preparation of permanent Hijri calendar depending on crescent sighting from a specific reference place. He proposed Holy Mecca to be the reference place (Ahmed). The second article is about development of mathematical relationship between the Tabular calendar and the Gregorian calendar (Odeh), but this theoretical relationship was not applied into practice to develop permanent Hijri calendar.

7. Definition of Concepts

***7.1. The Hijri Round*:** The Hijri round consists of 309 Hijri years. The first round starts from the first of Muharram the year 1AH up to last Zulu-Hajji 309AH, the second one starts from the first of Muharram 310AH up to last Zulu-Hajji 618AH, and so on.

***7.2. The Gregorian Round*:** The Gregorian round consists of 300 Gregorian years.

***7.3. The Hijri Cycle*:** The Hijri cycle is a different structure of the Hijri round. It consists of five series of Hijri years in which the distribution of number of days per month for the years in the first series, whether 30 or 29 days, overlaps with the following series.

8. The Methodology

The methodology consists of the following methods:

8.1. Method Of Allocation the Number of Months' Days in Hijri Years:

According to our hypothesis every 309 lunar years equals 300 solar years totally and exactly. By totally we mean that the equality tends to the last decimal point; and by exactly we mean that the accuracy is so high that the equality between the two rounds would be without a decimal point. We started to find out the number of days, whether 29 or 30 days, in the months of all lunar years as follows:

I. Firstly, we developed a standard figure "s" by calculation of the average number of the difference days between the month of 30 days and that of 29 days for the 309 lunar years; we found that to be 0.449029126213592. The standard figure is the base of our allocation of the number of months' days in the lunar years.

II. We accumulated the standard figure for all the number of months of the first 309 lunar years (3708 months) by multiplied it successively with numbers from 1 to 3708, starting from Muharram. Table 1 shows an example of the accumulated figures for 10 Hijri years from the first 309 Hijri years.

III. The last accumulated figure in the 3708^{th} month came as 1664.999999, for 6 decimal points rounded to 1665. But if was had considered 15 decimal points it would have been exactly 1665 (s*3708=1665).

IV. After comprehensive and thoroughly study across the accumulated figures we discovered that they tend to natural integers without decimal points after specific periods. These integers form a cycle of five series in the first 309 Hijri years. The length of the first four series found to be 68 years and 8 months; and that of the fifth one is 34 years and 4 months.

V. According to mathematical orientation we expected that the month with the accumulated figure's decimal point more than the standard figure its number of days would be 30 days, and that with the accumulated figure decimal point less than the standard figure its number of days would be 29 days. Table 2 presents an example of the allocated number of months' days in the 10 years of Table 1. As we see in the two tables, for the decimal point of the accumulated standard figures less than the standard figure in Table 1, the number of months' days located to be 29 days in Table 2 while for those more than the standard figure, the number of months' days located to be 30 in Table 2. To specify the number of days in the month, we needed only 3 decimal points of the accumulated standard figure, whereas we considered 10 decimal points in the accumulation operation.

VI. After continuing the same operation for the next 309 Hijri years we noticed that the cycle of series in the first 309 Hijri years round coincides with that of the next round with respect to the partitions and the lengths of the series as in Table 1; and to the number of months' days as in Table 2.

VII. After the separation of the five series in the two rounds, (1:309) & (310:618), we came with two coincided distributions of number of months' days within and across the cycles of the rounds.

VIII. Finally, we joined the five series of each round together to obtain two coincided rounds of the 309 Hijri years with respect to number of months' days in each year. Hence, we concluded that the Hijri months' days' distribution takes cyclic phenomena every 309 Hijri years.

IX. Accordingly, we copied the allocations of months' days in the first round Hijri years to five rounds starting from the first one, 1AH-309H, up to the fifth one, 1236:1545 that includes our current Hijri year.

8.2. Method Of Construction of Hijri Calendar and Its Conformance with Gregorian Calendar:

By knowing the number of months' days in each lunar year it is possible to construct Hijri calendar consecutively according to the beginning and end of each month, starting from the first of Muharram, 1AH to any day of any year. With respect to the conformance of Hijri calendar to the Gregorian calendar we ought to know first a Gregorian date reference point that is conformed to a specific Hijri date, then we start aligning from that point. This could be done by two references; either a historical reference which depends on past historian Hijri date corresponds to given Gregorian date or a standardized reference date of recent Hijri date aligned to a known Gregorian date. We did that by both references and considered the standard reference.

8.3. Method of Knowing or Detecting the Number of Days in The Hijri Year's Months and The Gregorian Date Conforms to Any Hijri Date:

As shown above we produced by the above-described methods a schedule of number of months' days of 1545 Hijri years; and a calendar of Hijri years conformed to Gregorian calendar for the first 309 Hijri years; so, the number of months' days and the Hijri date conformed to Gregorian date could be known from these schedules. For periods out of these ranges we developed programs to know the number of days in any Hijri month for any Hijri year; and the Gregorian date conforms to any Hijri date, taking advantage of the cyclic nature of the lunar date system that we discovered as we will see later.

Table 1: *The Accumulated Standard Figure For 10 Hijri Years*

Year/ Month	1	2	3	4	5	6	7	8	9	10

Muharram	0.449	5.837	11.226	16.614	22.002	27.391	32.779	38.167	43.556	48.944
Safar	0.898	6.286	11.675	17.063	22.451	27.840	33.228	38.617	44.005	49.393
Rabi I	1.347	6.735	12.124	17.512	22.900	28.289	33.677	39.066	44.454	49.842
Rabi II	1.796	7.184	12.573	17.961	23.350	28.738	34.126	39.515	44.903	50.291
Jumada I	2.245	7.633	13.022	18.410	23.799	29.187	34.575	39.964	45.352	50.740
Jumada II	2.694	8.083	13.471	18.859	24.248	29.636	35.024	40.413	45.801	51.189
Rajab	3.143	8.532	13.920	19.308	24.697	30.085	35.473	40.862	46.250	51.638
Shaban	3.592	8.981	14.369	19.757	25.146	30.534	35.922	41.311	46.699	52.087
Ramadan	4.041	9.430	14.818	20.206	25.595	30.983	36.371	41.760	47.148	52.536
Shawwal	4.490	9.879	15.267	20.655	26.044	31.432	36.820	42.209	47.597	52.985
Zulu-Qaeda	4.939	10.328	15.716	21.104	26.493	31.881	37.269	42.658	48.046	53.434
Zulu-Hajji	5.388	10.777	16.165	21.553	26.942	32.330	37.718	43.107	48.495	53.883

*(*Source*: Excel File of The Accumulated Standard Figure for Two 309 Year Rounds – At the Author's Disposal)*

Table 2: *Example of The Allocation of Months' Days for the 10 Hijri Years in Table 1*

Year/Month	1	2	3	4	5	6	7	8	9	10	--	-	69
Muharram	30	30	29	30	29	29	30	29	30	30	--	-	30
Safar	30	29	30	29	30	30	29	30	29	29	--	-	30
Rabi I	29	30	29	30	30	29	30	29	30	30	--	-	29
Rabi II	30	29	30	30	29	30	29	30	30	29	--	-	30
Jumada I	29	30	29	29	30	29	30	30	29	30	--	-	29
JumadaI	3	2	3	3	2	3	2	2	3	2	-	-	3
Rajab	29	30	30	29	30	29	30	30	29	30	--	-	29
Shaban	30	30	29	30	29	30	30	29	30	29	--	-	30

Ramadan	29	29	30	29	30	30	29	30	29	30	--	-	29
Shawwal	30	30	29	30	29	29	30	29	30	30	--	-	30
Zulu-Qaeda	30	29	30	29	30	30	29	30	29	29	--	-	30
Zulu-Hajji	29	30	29	30	30	29	30	29	30	30	--	-	29

(Source: Excel File of the Allocation of Moths' Days for Five 309 Rounds – At the Author's Disposal)

9. Results and Discussion

9.1. The Allocation of Months' Days In 1545 Hijri Years:

As the number of months' days in the first 309 Hijri years coincides with the following 309 Hijri rounds, we prepared a schedule of the number of months' days in 1545 Hijri years based on this round. The schedule consists of five rounds as follows:

1. The first round: from 1 AH to 309 AH
2. The second round: from 310AH to 618AH
3. The third round: from 619AH to 927AH
4. The fourth round from 928AH to 1236AH
5. The fifth round from 1237AH to 1545AH

The schedule of the five rounds is saved in an external file.

9.2. Construction Of the Hijri Calendar and Its Conformance to The Gregorian Calendar:

The Hijri calendar was constructed for the first 309 Hijri years according to the number of months' days in each year starting from first Muharram 1AH up to the last of Zulu-hajji 309AH. As for the conformance to the Gregorian calendar we found that the historical reference date based on the date of migration of the Prophet Mohammed (صلى الله عليه وسلم), which has been mostly adopted as reference in this respect, was not consistent with considerable number of dates that we checked; so, alternately we adopted a different standard reference which is the 20th of April 2020 that corresponds to the first of Ramadan 1441AH. The advantage of this reference is that the first of Ramadan is the Hijri month that Muslims in the world do their best to detect the Gregorian date that conforms to it, and the year 1441AH was the last year before starting writing this research which facilitates the check of level of its accuracy. We considered this date and derived from it the Gregorian date aligned with the first of Muharram 1AH which was found to be 9/8/622CE, with a

difference of 22 days ahead from the historical reference (18/7/622). Figure 1 shows a chart to clarify how the Hijri date is conformed to the Gregorian date; and Table 3 shows a module of part of the Hijri calendar of the first 309 Hijri years that we constructed, starting from 1 Muharram 1AH, and its conformance to the Gregorian calendar, starting from 9/8/622 CE. Thus, we could convert any Hijri year to the corresponding Gregorian year in this period. We saved the combined Hijri and Gregorian calendars for this round in an external file. For other rounds we could had done this operation by the same manner for all rounds; but as it is a tremendous work, we preferred to develop a program based on the first round to know any Hijri date in the past or future, and its conformance to the Gregorian date as we will see later.

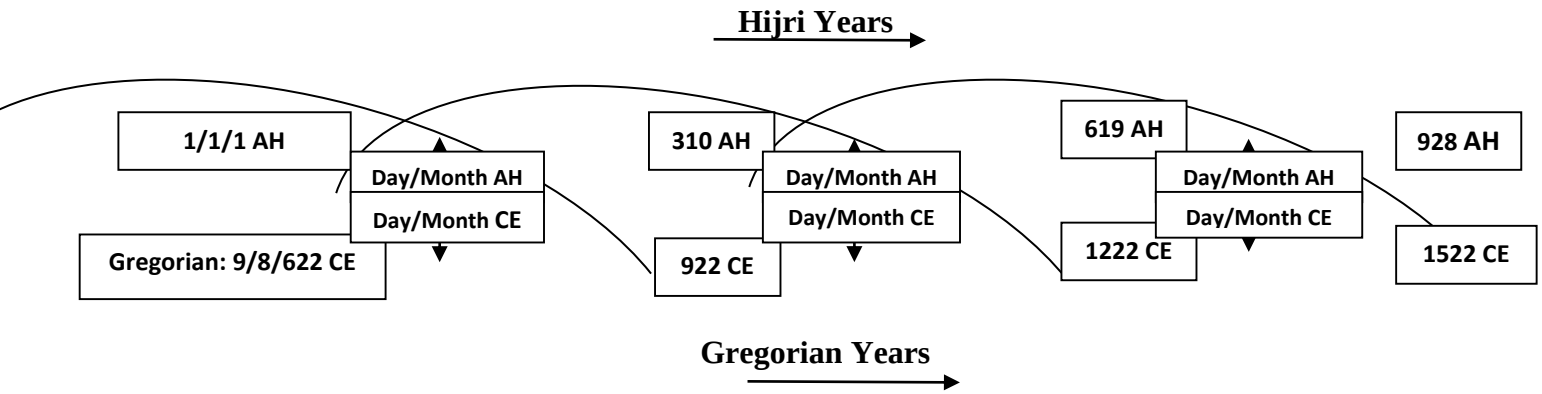

Figure 1: *Hijri Year's Rounds by Conformance with Gregorian Year's Rounds (Source: Self/Authors' Own illustration)*

9.3. The Five Series of the 309 First Hijri Years

As we noted earlier the Hijri round consists of five series and we used the structure of the series to detect the number of months' days in the Hijri years and the dates conform to the Gregorian date. The specification of these series is as follows:

1. The first one: from Muharram 1AH to Shaban 69AH
2. The second one: From Ramadan 69AH to Rabi II 138AH
3. The third one: From Jumada I 138AH to Zulu-Hajji 207AH
4. The fourth one: From Muharram 208AH to Shaban276 AH
5. The fifth one: From Ramadan 276AH to Zulu-Hajji 309AH

Figure 2 present a module of the five series and Figure 3 presents a module of three cycles of three periods of the first 309 Hijri year's round.

Table 3: *Part of The Hijri Calendar of The First 309 Hijri Years and Its Conformance to The Gregorian Calendar*

622 CE	622/8/ 9	622/8/ 10	622/8/ 11	622/8/ 12	622/8/ 13	622/8/ 14	622/8/ 15	622/8/ 16	622/8/ 17	
1 AH	Muharr am 1	Muharr am 2	Muharr am 3	Muharr am 4	Muharr am 5	Muharr am 6	Muharr am 7	Muharr am 8	Muharr am 9	
623 CE	622/11 /16	622/11 /17	622/11 /18	622/11 /19	622/11 /20	622/11 /21	622/11 /22	622/11 /23	622/11 /24	
1 AH	Rabi II 11	Rabi II 12	Rabi II 13	Rabi II 14	Rabi II 15	Rabi II 16	Rabi II 17	Rabi II 18	Rabi II 19	
623 CE	623/3/ 16	623/3/ 17	623/3/ 18	623/3/ 19	623/3/ 20	623/3/ 21	623/3/ 22	623/3/ 23	623/3/ 24	
1 AH	Shaban 13	Shaban 14	Shaban 15	Shaban 16	Shaban 17	Shaban 18	Shaban 19	Shaban 20	Shaban 21	
623 CE	623/7/ 17	623/7/ 18	623/7/ 19	623/7/ 20	623/7/ 21	623/7/ 22	623/7/ 23	623/7/ 24	623/7/ 25	⇨
1 – 2 AH	Zulu-Hajji 17	Zulu-Hajji 18	Zulu-Hajji 19	Zulu-Hajji 20	Zulu-Hajji 21	Zulu-Hajji 22	Zulu-Hajji 23	Zulu-Hajji 24	Zulu-Hajji 25	
624 CE	623/11 /16	623/11 /17	623/11 /18	623/11 /19	623/11 /20	623/11 /21	623/11 /22	623/11 /23	623/11 /24	
2 AH	Rabi II 21	Rabi II 22	Rabi II 23	Rabi II 24	Rabi II 25	Rabi II 26	Rabi II 27	Rabi II 28	Rabi II 29	
624 CE	624/3/ 16	624/3/ 17	624/3/ 18	624/3/ 19	624/3/ 20	624/3/ 21	624/3/ 22	624/3/ 23	624/3/ 24	
2 AH	Shaban 24	Shaban 25	Shaban 26	Shaban 27	Shaban 28	Shaban 29	Shaban 30	Ramad an 1	Ramad an 2	
624 CE	624/7/ 17	624/7/ 18	624/7/ 19	624/7/ 20	624/7/ 21	624/7/ 22	624/7/ 23	624/7/ 24	624/7/ 25	⇨
2 - 3 AH	Zulu-Hajji 29	Zulu-Hajji 30	Muharr am 1	Muharr am 2	Muharr am 3	Muharr am 4	Muharr am 5	Muharr am 6	Muharr am 7	
CE	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	
AH	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	
823 CE	823/2/ 24	823/2/ 25	823/2/ 26	823/2/ 27	823/2/ 28	823/3/ 1	823/3/ 2	823/3/ 3	823/3/ 4	
207 CE	Rajab 22	Rajab 23	Rajab 24	Rajab 25	Rajab 26	Rajab 27	Rajab 28	Rajab 29	Shaban 1	⇨
CE	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	
AH	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	
823 CE	823/3/ 26	823/3/ 27	823/3/ 28	823/3/ 29	823/3/ 30	823/3/ 31	823/4/ 1	823/4/ 2	823/4/ 3	
207 AH	Shaban 23	Shaban 24	Shaban 25	Shaban 26	Shaban 27	Shaban 28	Shaban 29	Shaban 30	Ramad an 1	
CE	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	
AH	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	
922 CE	922/7/ 17	922/7/ 18	922/7/ 19	922/7/ 20	922/7/ 21	922/7/ 22	922/7/ 23	922/7/ 24	922/7/ 25	
309 AH	Zulu-Hajji 7	Zulu-Hajji 8	Zulu-Hajji 9	Zulu-Hajji 10	Zulu-Hajji 11	Zulu-Hajji 12	Zulu-Hajji 13	Zulu-Hajji 14	Zulu-Hajji 15	
922 CE	922/7/ 27	922/7/ 28	922/7/ 29	922/7/ 30	922/7/ 31	922/8/ 1	922/8/ 2	922/8/ 3	922/8/ 4	
309 AH	Zulu-Hajji 17	Zulu-Hajji 18	Zulu-Hajji 1 9	Zulu-Hajji 20	Zulu-Hajji 21	Zulu-Hajji 22	Zulu-Hajji 23	Zulu-Hajji 224	Zulu-Hajji 25	
922 CE	922/8/ 6	922/8/ 7	922/8/ 8							
309 AH	Zulu-Hajji 27	Zulu-Hajji 28	Zulu-Hajji 2 9							

(Source: Excel File of The Hijri Calendar of The First 309 Hijri Years and Its Conformance to The Gregorian Calendar – At the Author's Disposa)

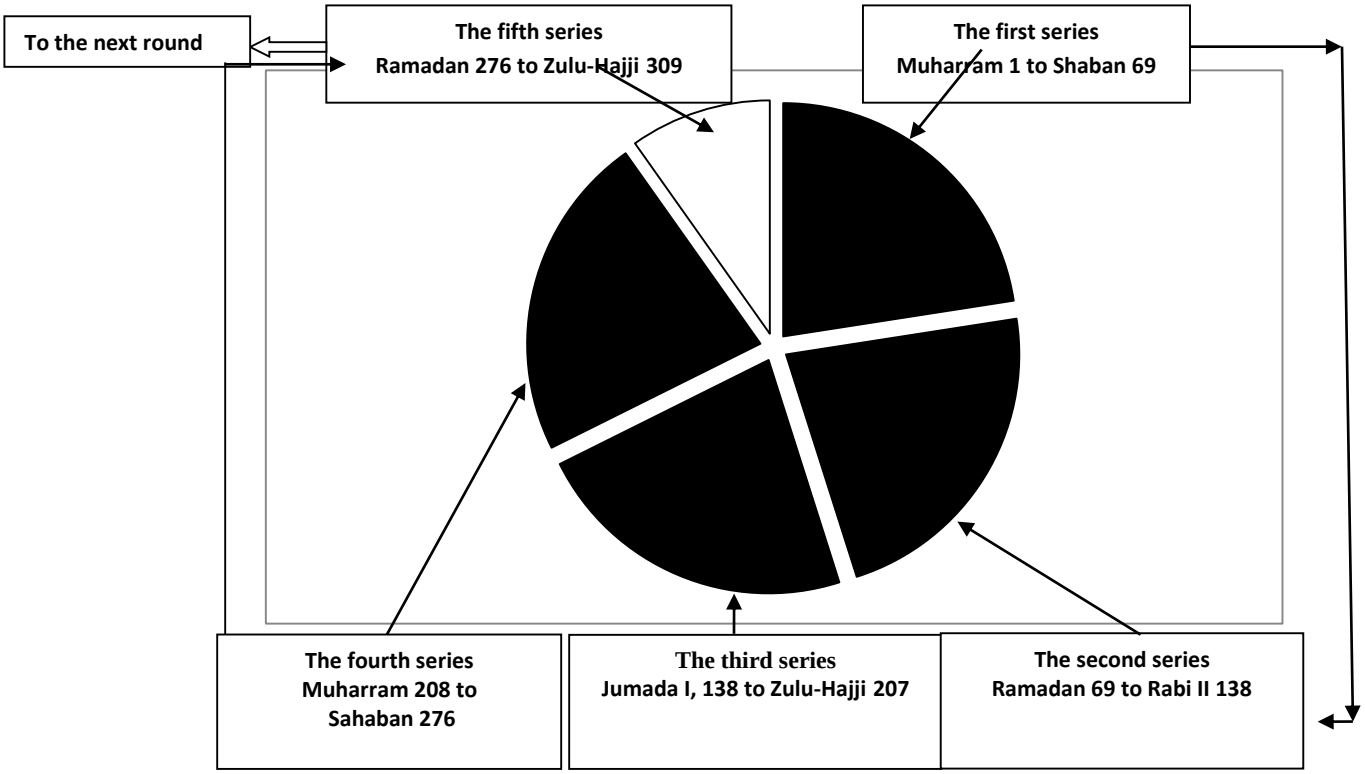

Figure 2: *A Module for The Five Series of The Cycle of The First 309 Hijri Year Round (Source: Self/Authors' Own illustration)*

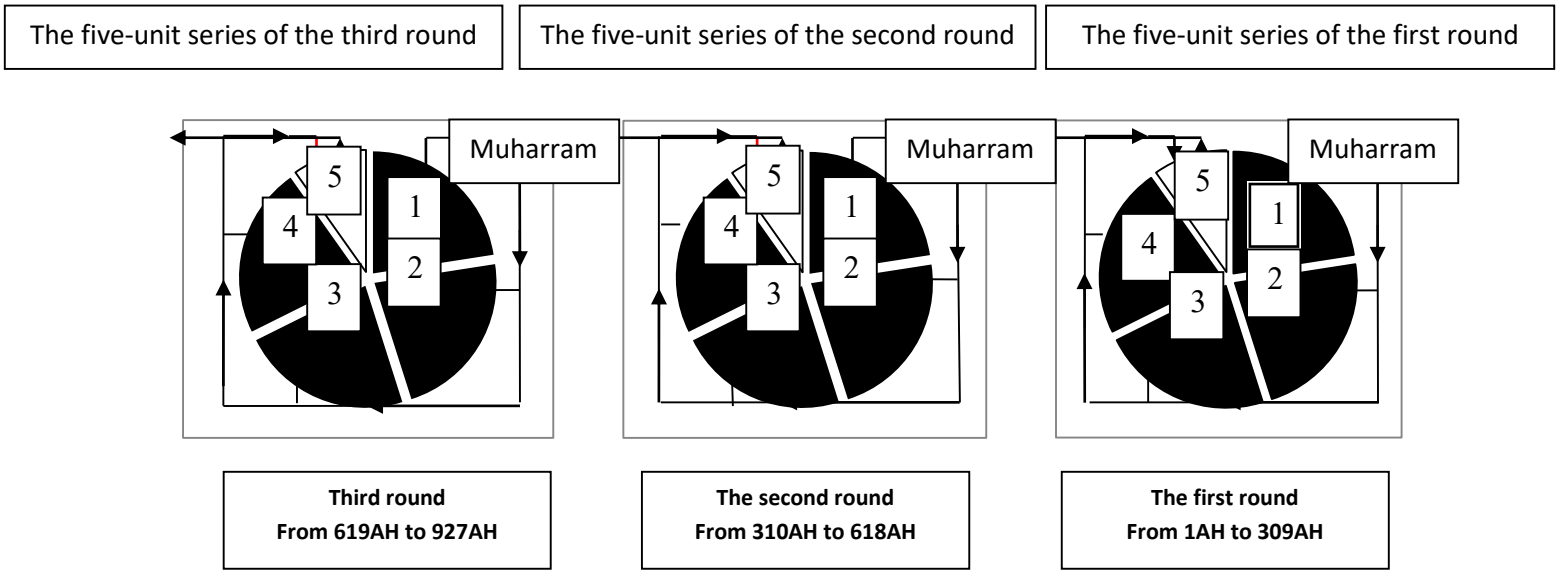

Figure 3: *Module of Three Cycles of Three Periods of the 309 Years Round (Source: Self/Authors' Own illustration)*

9.4. Structures Of Distribution of Months' Days of Hijri Years:

By a thoroughly studying the distribution of months' years in the first series of the first round we noticed that there are different types of structures of distribution of months' days across the Hijri years. These structures are repeated for some Hijri years. We found out that there are 15 types of structures. As the cycle of the first round coincides with that of other rounds, the structures of years in the cycle of the first round coincide also with cycles in all other rounds. Therefore, if we knew the type of structure to any of the years in the first series, we would know the type of structure of any year in other series aligned in position with that year. Figure 4 presents the structure type 1 of the 15 year's structure types by number of month's days and the accumulated figure. We notice in this Figure that the months with number of days equal 30 days their accumulated figure lies above the line represents the standard figure, while the months with the number of days equal 29 days their accumulated figures lie below this line. Table 4 shows all 15 types of structures in the first series of the first 309H round. We see that they are confined in the first 15 years of the round.

We note here that because the last Hijri years in the five series does not include all months of the year, the yearly structure does not necessarily valid for all months; thus, we developed what we call a monthly structure of the Hijri year which specifies the type of structure of a group of 4 or 6 months in the Hijri year. Table 5 presents the yearly/monthly structure of the Hijri years in the whole 309 year-round.

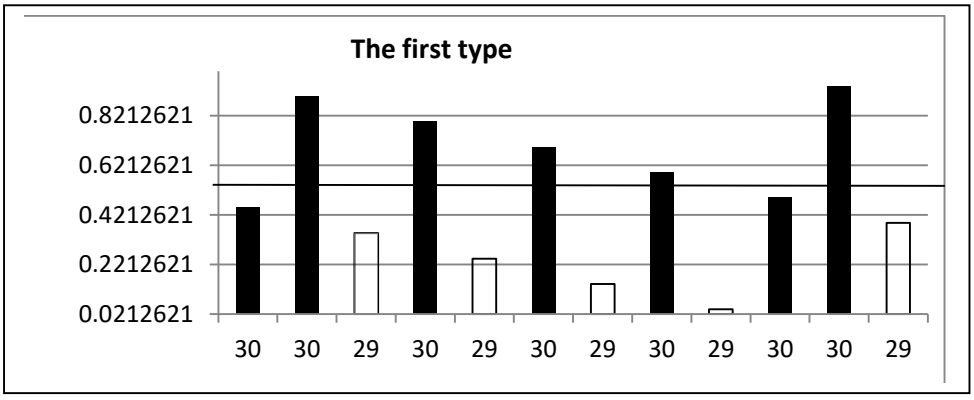

Figure 4: *Graph Of The First Type Of The Yearly Structure By Monthly Accumulated Figure (Source: Self/Authors' Own illustration)*

Table 4: *Number of Months' Days of Years in The First Series of The First Round By Structure Type And Hijri Year*

Month/ structure & year	1	2	3	4	5	6	7
Muharram	30	30	29	30	29	29	29
Safar	30	29	30	29	30	30	30
Rabi I	29	30	29	30	30	29	29
Rabi II	30	29	30	30	29	30	30
Jumada I	29	30	29	29	30	29	30
Jumada II	30	29	30	30	29	30	29
Rajab	29	30	30	29	30	29	30
Shaban	30	30	29	30	29	30	29
Ramadan	29	29	30	29	30	30	30
Shawwal	30	30	29	30	29	29	29
Zulu-Qaeda	30	29	30	29	30	30	30
Zulu-Hajji	29	30	29	30	30	29	29

(Source: Excel File of The of Months' Days of Years in The Five Series of The First 309 Year-Round -At Author's Disposal)

Table 4: *Continued…*

Month/ Structure & Year	8	9	10	11	12	13	14	15
Muharram	30	30	30	29	30	30	29	30
Safar	29	29	29	30	29	30	30	29
Rabi I	30	30	30	29	30	29	30	30
Rabi II	29	29	29	30	29	30	29	29
Jumada I	30	30	30	29	30	29	30	30
Jumada II	29	30	29	30	29	30	29	29
Rajab	30	29	30	29	30	29	30	30
Shaban	29	30	29	30	29	30	29	29
Ramadan	30	29	30	29	30	29	30	
Shawwal	30	30	30	30	29	30	29	
Zulu-Qaeda	29	29	29	30	30	29	30	
Zulu-Hajji	30	30	30	29	30	30	29	

Table 5: *The Type of Yearly/Monthly Structures of The Five Series of The First Round by Series and Month-Group*

Series	Years	Month-group	Type of structure in the first series
The first series	1 – 68 AH	Muharram – Zulu-Hajji	The same as the yearly structure
	69 AH	Muharram - Shaban	The yearly structure of 69 AH
	69 AH	Ramadan - Zulu-Hajji	The yearly structure of 1 AH

The second series	70 – 137 AH	Muharram - Shaban	The yearly structure of the coincided year in the first unit
	70 – 137 AH	Ramadan - Zulu-Hajji	The yearly structure of the (coincided year in the first unit+1)
	138 AH	Muharram – Rabi II	The yearly structure of 69AH
The third series	138 AH	Jumada I - Zulu-Hajji	The yearly structure of 1 AH
	139 – 206 AH	Muharram –Rabi II	The yearly structure of the coincided year in the first unit
	139 – 206 AH	Jumada I - Zulu-Hajji	The yearly structure of the (coincided year in the first unit+1)
	207 AH	Muharram – Rabi II	The yearly structure of 69AH
The fourth series	207 AH	Jumada I - Zulu-Hajji	The yearly structure of 1AH
	208 –275AH	Muharram – Zulu-Hajji	The yearly structure of the (coincided year in the first unit+1)
	276 AH	Muharram - Shaban	The yearly structure of 69AH
	276 AH	Ramadan - Zulu-Hajji	The yearly structure of the coincided year in the first unit
The fifth series	277 – 309 AH	Muharram - Shaban	The yearly structure of the coincided year in the first unit
	277 – 309 AH	Ramadan - Zulu-Hajji	The yearly structure of the (coincided year in the first unit+1)

(Source: Self/Authors' Own illustration)

9.5. Detecting the Number of Days in Hijri Years:

To know the number of months' days of any year between 1AH and 1575AH we go directly to the schedule that we prepared in the external file. In the case that this file is not at hand we developed a method to know the number of months' days for any requested Hijri year based on the knowledge of the round and series includes the required Hijri year; the aligned series and aligned year in the first round, and the yearly or monthly structure. As an example, the steps to know the number of days in Rajab, Shaban, Ramadan and Shawwal of the Hijri year 1443AH are as follows:

1. The round includes the year 1443AH is the round number 4
2. The aligned year in the first round = ((1443/309) – 4) *309 = 207AH ---------- (1)
3. From Table 5 we find that series 4 is the series which includes the of group of months of 207AH
4. From the same table we find that the structure of this group of months coincides with the year 1AH in the first series of the first round
5. From Table 4 and the structure of the 1AH the we find that the number of days of the required months in the year 1443AH equals 29, 30, 29 and 30 days for Rajab, Shaban, Ramadan and Shawwal respectively.

9.6. Detecting The Gregorian Date Corresponds to The Hijri Date:

To know the Hijri date and its conformance with the Gregorian date in the first 309 Hijri years we go directly to the combined two calendars we prepared in the external file. For any other date we constructed a method for that based on the structures of Hijri months' days in different years, the prepared combined calendars of the first 309 Hijri years, and the series in the first round that includes the required year. We developed a sub-program to facilitate this method attached to the 309 Hijri calendar in an external EXEL file. The key points of the method are to find first the Gregorian year aligned with the required Hijri year by a constructed equation, then to find the Gregorian day and month aligned with the required Hijri date from the yearly/monthly structure of the required year/month. The following is an example of how to find the Gregorian dates conform to the 27th of Rajab and the first of Ramadan of the Hijri year 1403:

1. The Gregorian year aligned with the Hijri year 1403AH:
   =1443 * (309/109575)/ (109575/300) + 621 = 2022 CE ---------- (2)
2. The round includes the required Hijri year 1443AH = 4 ---------- (3)
3. The Hijri year in the first round coincide with the Hijri year 1403AH
   = ((1443/309) – 4) *309 = 207 AH ---------- (4)
4. When we go to the first 309AH calendar conformed to the Gregorian calendar we find that: The 27th of Rajab of the year 207AH corresponds to the ***first of March*** of Gregorian calendar; and the first of Ramadan of the 207AH calendar corresponds to ***the third of April*** of Gregorian calendar (See Table 3).
5. Therefore, the Gregorian dates correspond the 27th of Rajab and the first of Ramadan of the Hijri year 1443 are as follows:

The Gregorian date conformed to 27 Rajab 1443 AH = 1 March 2022 CE ---------- (5)
The Gregorian date conformed to 1 Ramadan 1443 AH = 3 April 2022 CE ---------- (6)

9.7. Similarity Between Astronomical Forecast Measures and Concepts, And That of Our Research:

There is a similarity between our measures & concepts and that of the astronomical ones. This similarity is summarized as follows: The conjunction stage concept in the astronomical forecasting case resembles the case when the proportion of the accumulated sum of the standard figure would be around 0.45; in other words, more or less by infinitesimal proportion from the standard figure; the Age of Moon measure at this point according to the astronomical measure

would be zero. The Full Moon stage according to the astronomical concepts resembles the case when the proportion of the accumulated figure would be 0.2250 (0.45*0.5); in other words, around half of the standard figure. This proportion would be 0.1125 (0.45*0.25), around quarter of the standard figure, when the moon at its first quartile of age; and it would be 0.00045 (0.001*0.45) when the Age of Moon is at the end of the month. This point resembles the stage where astronomers try to find the ideal value of their measures by which they indicate the probability level of seeing the crescent by their instruments. For example, in the case of the astronomical elongation it would be impossible to see the crescent if this measure's value less than 6 degrees, hence the next day would not be the start of the new month. As for our research there is a clear-cut measure to detect the first day of the new month. The astronomical measures presented here were obtained from Odeh's paper (Odeh, M. S.).

9.8. Comparison Between the Gregorian Dates Conforms to The First Day of Ramadan for Recent Hijri Years and That of Our Findings:

The last three Hijri years previous to the Hijri year we started this research are: 1440AH, 1439AH and 1438AH (6). When we made a comparison between the Gregorian dates of the first of Raman of these years (Wikipedia) and our research results we found the following:

- Gregorian dates of the first day of Ramadan:
    - The first of Ramadan 1440AH: 5~~,6~~/5/2019CE
    - The first of Ramadan 1439AH: 16/5/2018CE
    - The first of Ramadan 1438AH: 27/5/2017CE
- Dates from the research
    - The first of Ramadan 1440AH: 4/5/2019CE
    - The first of Ramadan 1439AH: 15/5/2018CE
    - The first of Ramadan 1438AH: 26/5/2017CE

We notice from this comparison that the difference between the two dates in the first years is one or two days, and between the other two years only one day. Although there is small difference but this does not necessarily indicate that the dates of fasting in these years were more accurate than our findings.

10. Conclusion

The studies on the establishment of Hijri Calendar have not been paid considerable attention in research fields. There is no permanent astronomical Hijri calendar that Muslims depend on to practice their Islamic commitments. So, this paper aims to search in this field and to develop a Hijri calendar conformed to the Gregorian calendar. The basic hypothesis initiated from a verse in Holy Quran which the author believed to mean that every 300 solar year equivalent to 309 lunar years. Starting from this point, mathematical calculations based on this equivalency has been done which emerged a standard figure. The standard figure was used to detect the number of months' days in each 309 lunar years and hence to develop a Hijri calendar starting from the first of Muharram 1AH and to conform it to the Gregorian calendar.

This research can open a door for future researches, either to develop it for more accuracy or to use its findings to detect other Islamic controversial issues such as sighting the location of the Night of Gudr in Ramadan's nights. It can also be used to review the backward Islamic events' dates conformed to Gregorian calendar, for example the date of the conquest of Mecca and other Battles' events. In the mathematical field the cyclic phenomena of the distribution of months' days that we discovered can open a door also for mathematical researchers to study the characteristics of the cyclic series of incidents.

A self-evaluation of the correctness of this research is that, on the positive hand, the research findings is supported by methodological and religious indicators. An example of the first one is that the accumulated value of the standard figure at the last month of the 309 serial months (the month number 3708) came to be exactly 1665 without any decimal point (0.449029126213592*3708=1665) which supports the correctness of calculations and relevancy of the findings. For the second one it has been reported that the prophet Mohammed LPBUH said in the farewell pilgrimage that the time had rounded as its shape when God created the heavens and earth (Elfatwa); this statement simulates our findings of the cyclic nature of the lunar calendar system. As for the limitations of the research the basic one is that the starting Gregorian date conforms to the first of Muharram 1AH has not been fully confirmed although it was the best of our investigation. In addition to that the findings of this research need to be verified by Astronomers and scientists in related fields before being used in religious purposes.

REFERENCES

Ahmed D. (2006), Forman Christian College, Astronomy, moon sighting and Hijri calendar http://www.researchgate.net

Ali, A. Y. (1987). Test, Translation and Commentary of the Holy Quran, SURA XVIII, Verse 25, Tahrike Tarsile, Quran, INC, Page 736, New York.

Aljazeera.net (2022). The Hijri Calendar. http://www.Aljazeera.net

Basha M. M. (1983), Eltofeegat Elelaheeia (in Arabic), (First ed.) http://www.adchive.org

BBC, Facts from Lunar calendar before two hundred years from Islam http://www.BBC.com

Elfatwa, the roundness of the time. https://Isalmweb.net

Elmekafooree, S. (2006), Elraheeg Elmakhtuom (in Arabic), (First ed.), Page 138, Holy Mecca: Islamic World's association.

Gonzalez, W. S. (2000), Tabular Islamic Calendar http://www.researchgate.net

Infoplease.com (2021). The curious history of the Gregorian Calendar. https://www.infoplease.com

International Astronomical Center. Islamic Crescents Observation Project (ICOP). http://www.anstronomycenter.net

Marwa, Y. (1999). The science of astronomy and the beginning of lunar months (in Arabic) the cultural committee of the association of Lebanese scientists. http://www.nojumi.ir/arabic/research/bashir/yosefmarve.htm

Odeh, M. S. The difference between the births of the crescent and its scientific appearance. http://www.eajaz.org

The history transformer. http://www.al-eman.com

The intelligent transformer. http://www.un-web.com

Wikipedia, the beginning of Ramadan Month. https://ar.m.wikipedia.org