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The Historical Astronomic Observatory and Calendar of the Village of Graw, Northern Iraq

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The astronomic observatory of Graw Village is located on Mount Dari Lolikan, facing the village. Graw is located in the foothills of Mount Ser-i-Rash, 25 km northeast of Erbil Governorate, Iraq. This study attempts to clarify the foundations of this observatory, its components, as well as the founder and the date of its establishment. The study made efforts to clarify the benefits of this calendar to local residents in their daily lives. The database for this study is based on direct observation of the observatory station. The observation included the recording date and position of sunset and the appearance of stars throughout the year. Observation and documentation for both sunset and stars were performed over several years due to weather conditions since observation was not possible on foggy and rainy days and nights. Each observation took five to ten minutes depending on the clarity of the sky. The observatory consists of a group of stone cones. Each cone was built by stones in a specific location after careful and long observation of the sunset. Efforts were made to observe the disappearance and reappearance of the stars based on the change in the position of the Earth in relation to the sun. Graw's calendar helped to recognize important times of the year, such as the winter and summer forties, which were very important, especially when snow covered the roads, transportation stopped, crops spoiled, and pets stayed in their barn. The most important features of the winter forties are the memories, experiences, and minds of the villagers' ancestors. The forties were associated with the arrival of cold and heavier rain throughout the year, which is consistent with modern science, as the angle at which the Earth rotates

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increases the number and activity of weather depressions that affect the study area during this period. This observatory has a close connection with the daily life of the villagers, especially in the past centuries. It helped the people of the area in their appointments to carry out their work in the field of agriculture. The observatory was also of great importance in the field of education in the past centuries, especially in traditional religious schools. It also appears from this research that the calendar has ancient roots, which extend back thousands of years, as evidenced by the Ezidis who follow an ancient religion whose roots extend back thousands of years and who fast during both the winter and summer forties annually, with the participation of people in various regions of the world. It is not known who made this astronomic observatory but most of the oral information that has been passed down to us by word of mouth agrees on both Mullah Abdullah Al-Kurdi and Mullah Omar. Likely, this astronomic observatory was built around the late 17th and early 18th centuries.

Keywords: astronomic observatory, Chilay zistan (winter forty), cone, Graw Village, zodiac

Introduction

An observatory is a site used to observe terrestrial, sea, or celestial events and is used in astronomy, climatology, and meteorology, the most common of which is the astronomic observatory. An astronomic observatory is a place to observe environmental phenomena on Earth or in space. Meteorological observatories work to monitor the weather. Scientists work in astronomic observatories to monitor the part of the visible universe outside the Earth.

Astronomy in the regions of Central Asia (and other regions of the Islamic world) was greatly influenced by the Greeks and Indians, who were considered the main references. In ancient Iran, scholars translated astronomy books written in Greek and, through these translations, Muslim scholars translated them into Arabic (Al-Samarayee 1984). As for the influence coming from India, it can be observed in some astronomic treaties and agreements dating back to the 5th century during the period of Sasanian rule in the ancient Kingdom of Iran (from the 2nd to the 7th century CE). This shared knowledge and experience, which interactions between different regions and exchanges of science and knowledge along the Silk Road countries contributed to developing, led to the development of astronomic tools and the emergence of many innovative creations that helped to achieve a better understanding of the universe and became the foundations of modern astronomy (UNESCO 2023).

Furthermore, astronomy is considered one of the oldest sciences known to ancient man. It arose under the influence of the agricultural environment. With man's knowledge of agriculture, astronomy became parallel to it, developed, and adapted to it (Al-Naimi 2006, 7). As the stars and their formations were luminous and shiny bodies, their appearance and disappearance became a guide for agriculture in terms of plowing dates, seeds, and harvests. Most likely, the clear sky on most days of the year and its bright stars, especially in the central and northern parts of Mesopotamia, were among the reasons that justify thinking about it and its movements, absence, and appearance (Al-Turkey and Doski 2006, 16-18).

Kurdistan Regional Climate

Climate is used to determine the changes that occur in the long term and their relationship and impact on the environment, oceans, plants, animal production, human health, population distribution, architecture, industry, air transportation methods, maritime navigation, and other matters that affect the lives of various organisms on earth. Since this study is related to weather, therefore, it is worth to show the general situation in the region and to show how the astronomic and observatory station aligned with general scientific evidences regarding the climate.

Climate denotes the mean atmospheric conditions that cover a certain region over a long period of time—whether a place is commonly cold and wet or hot and dry. Since the weather refers to short-term atmospheric circumstances—the temperature and precipitation on a certain day, thus, it would be easier to understand and expect the changes that occur in the short term if the climate is known. The climate in the northern part of Iraq is noticeable by cold rainy winters and dry hot summers. The rains are carried in partially by cyclonical turbulences from the Mediterranean and partially by flow around an anticyclone adjusted in winter over the Arabian Peninsula (Hama et al. 2014, 1-11). The provincial rainfall rises with elevation in the mountains and is between 300 mm/yr in the exterior foothills to more than 1,000 mm in the high areas of the country, the Halgurd and Sakran highlands. The maximum precipitation occurs in the mountain region due to the high elevation of the mountains and also due to the tendency of the ranges to swing from east to southeast. The storms that track the exterior side of the range from the Mediterranean Sea eastward are forced to increase over the mountains or to be pushed abruptly to the southeast (Wright 1962, 131-164; Hughes 2018, 15-45). Temperatures are high at the Piedmont, with daily extremes commonly surpassing 35 °C from May to October. In areas higher than 1,000 m, summer heat is less forceful and nights are cool. The great discrepancy in average temperature between July and January (around 25 °C) is a consequence of the basic inland climate (Wright 1962, 131-164). There are no weather stations in high mountains in Iraq. The only temperature data obtainable is by Tali et al. (2016, 16-26), which is based on synoptic data from Khana (Piranshahr) station in Iran, east of Haji Omaran, for the period between 1995 and 2012. The meteorological data display that the mean annual temperature is 11.9 °C with a high-temperature oscillation in mountainous areas. They stated that the average minimum temperature is 4.1 °C and that the maximum is 14.4 °C. Also, the maximum temperature is 39 °C and the minimum is 28.6 °C in the region (Tali et al. 2016, 16-26).

Literature Review

Astronomy flourished in the Middle Ages like many other sciences in the East and many scholars made their names in this field and played an influential role in the development and utilization of this science, e.g., Mohammad Ibin Adam Balak wrote 11 books on this topic (Ismael 1977, 471-473). The existence, operation, and following of the astronomic observatory and calendar in a mountainous area shows the level and degree of development and engagement of the people of this area at that time and their participation and efforts to use the laws of nature for human welfare.

There are many calendars and astronomic observatories in Kurdistan (Figure 1). The Barê calendar is one of them and was built by Mullah Nabi in the middle of the 16th century on a mountain opposite the small village of Barê at the foot of the Surkêw Mountain range in the Sewêl Region. Also, on the other side of the Surkêw Mountains in Iranian Kurdistan, the villages of Cham Paraw and Garmawan contain something of a calendar (Yousif 1985, 242-277). In the village of Kêla Shin in the mountains of Kalikhan, located northwest of Bana, there is a calendar that is more famous than all other Kurdish calendars. In Sharbazhêr Region, Shêikh Ali Kosa composed a calendar on the wall of the mosque of Dol Pamu Village in the 18th century and in Kuradawê, in the same area, there is a calendar made of stone cones. In the village of Glazarda, Shêikh Hassan Glazarda made a calendar on the wall of the mosque in the 18th century. Moreover, there is a stone cone record in the village of Girdeh Sur in the Lajan Region of Iranian Kurdistan. In the Marga Region and the village of Kani Tu, the calendar has been made on Hêlana Qal Mountain (Yousif 1985, 242-277). In the village of Mamandawa in the Bitwên Plain, Hamadi Fatma made some calculations for the year by using some stone cones. In Raniya and Qaladiza, in general, and in the Qandil Plain and Sllê Village, in particular, until recently they used to share water among themselves at night based on the stars to irrigate their gardens.

In the Erbil region, the most famous calendars and observatories are the astronomic observatory of Graw Village, the calculation of Dashti Kandinawa and Qaraj, the Baranati calendar, the astronomic sign of the mosque of Tutma Village, and the calculation of Bêllnga in Hiran region. Hiran calculation was created by Bakr Beg Hirani who died about seventy years ago (Yousif 1985, 242-277). Both Baranati and Kandinawa are similar in many aspects, e.g., length of season and they differ in starting the winter season (Rash 2006, 17; Bahirkayee 2016, 32). The coldest days in the winter season that were indicated by Kaka (1984, 69) were not in agreement with the highest and lowest temperatures in the Erbil area, according to Abdulla (2019, 2732-2733). Further research concerning astronomic knowledge includes Sharaza (1985, 108-110) who documented some of Naseeh Haidary's memories in which he mentioned the names of some students who studied in Graw's school. Also, Sharaza (1979, 80-81) in his study entitled "Bearnda Feast" included this feast within the winter forties. Finally, under the title of discovery of a Kurdish stellar perspective in the village of Graw, Yousif (1985, 242-277) exposed several aspects of this star viewpoint.

The Middle East contains very significant historical astronomic observatories all over north-western Iran and northern Iraq owing to the high contribution to this field by residents in the past. Little published information exists; therefore, to expand our knowledge about interactions and influences between different regions along the Silk Road, this study will try to show one of the examples of the many astronomic observatories in Southwest Asia. Thus, this study is devoted to the astronomic observatory in the village of Graw and it highlights the principles, components, usages, founder, and date of foundation. In addition, the study tries to investigate the usages of this astronomic observatory and calendar and how they are related to the daily lives of the residents of the village. In the end, some folk oral literature related to weather will be briefly mentioned. The knowledge and experience in this region as a part of Central Asia most likely contributed to its development and it led to the development of astronomic tools and the appearance of many pioneering conceptions that assisted to attain a better perspective of the world and space and take them as the basics of modern astronomy.

Study Area

Graw village is located within the Pirmam Subdistrict at the foot of Ser-i-Rash Mountain, which has an elevation of 1316 m above sea level and is 25 kilometers northeast of Erbil, the capital city of the Kurdistan Regional Government, Iraq (Figure 1). This observatory place is located on the mountain of Dari Lolikan with coordinates: 36°20'44" N and 44°14'47" E, opposite the village of Graw (Figures 2 and 3). The name of this mountain comes from a tree that is on this mountain and it is in the same line with cones that belong to the stellar perspective. In spring, when the sun reaches this tree and the villagers have nothing left to cook, they have to make lolik (flour soup). The name of the village originated from the Graw Spring (Figure 4), which is an interesting site in the village. It is a famous spring and people believe that washing the body with this water is good for treating itchy skin.

Research Methods

This calendar was in use until recent years. The study started by collecting information from residents of the village of Graw, especially from those who devoted their time and gathered experience. Several people devoted themselves to explaining the astronomic observatory and calendar of Graw, e.g., Haji Smael Hamad Babakir Wsuwayee, Hassan Turshiyan Hamashirnan, and Haji Hamadamin Taha Ameen. Their explanations were recorded through interviews by recording device and compared to each other to highlight differences and to double check with them through additional investigation. Furthermore, all the data collected through interviews by recording and writing were testified by collecting data through direct observation of the astronomic site.

The length of the observatory was measured and illustrated. The local names of each cone were documented. The exact time of sunset at different points throughout the astronomic observatory was documented. The time of stars out and their position were observed by using the naked eye after sunset throughout the entire year. The observation and documentation for both sunset and stars out were performed over several years due to weather conditions, since observation was not possible on foggy and rainy days and nights. Each observation took five to ten minutes depending on the clarity of the sky.

The observatory's main focus site was the door of Graw's mosque in the village (Figure 5). The door measured 75 x 160 cm. Currently, the mosque has collapsed but traces of the walls and doors remain, thus, it is possible to rebuild it. Before sunset, dusk was observed at the entrance of Graw's mosque and its location was determined. When the sunset is observed on the mountain of Dari Lolikan, there is still about three-quarters of an hour left until the sundown is complete. Finally, this astronomic observatory and calendar were compared with other popular astronomic and annual calendars that are known in neighboring areas and around the world.

Discussion of Results

As mentioned above, this astronomic observatory is located on the mountain of Dari Lolikan (Figure 2). This station consists of stone cones with an average height of 1.20 m (Figure 6). A stone cone (*qucha bard* in Kurdish) is a three-dimensional geometric shape made by stacking rock pieces without using any binding material (Khal 1974, 42). The cones were set in specific locations, after much effort to observe the sunset and many nights to observe the rise or set of several stars, by the founder of this observatory based on the change of the Earth's position according to the Sun.

Stone Cone Types

Graw's observatory stone cones can be divided into two categories (Figure 7) based on their role within the station. The first group includes three cones. They are considered basic cones because the year is divided into four seasons according to their position. The first cone is the Winter Start Cone located in the south of the mountain. This cone makes the left end of the observatory and the last point where the sun reaches. When we say the sun reaches that place, we mean the Earth reaches that place as a result of its rotation. When the sun sets over this cone, it will be the last day of autumn and the day before winter. The other end of the astronomic observatory is represented by Summer Start Cone and is located north of the mountain. When the sun sets on this cone, this day will be the last day of spring, which is a sign that the next day is the first day of summer. The third cone is called Tarazu (Nawroz) and is located between the two other cones, Winter Start and Summer Start cones, this cone is considered the heart of the observatory and marks the beginning of spring and autumn.

The second group includes five subgroup stone cones (eight stone cones), which are called non-basic cones. They are used for different signs. The first cone is the sign of the constellation of Sirius (α Canis Majoris) and the sign of the middle of winter and autumn because the sun sets on February 4th and November 6th on this cone. It is called Galaweazh (Sirius) Cone. Both Summer Start and Winter Start cones, in addition to their sign for the beginning of winter and summer, also indicate the setting of the star Pleiades (Seven Sisters). When the sun sets on the cone of Winter Start, the star of Pleiades sets on the cone of Summer Start. That is the only night which it disappears, but appears in the sky all the other nights. The Pleiades are a prominent sight in winter and are easily visible. The third cone is a sign of the coming of the trimming tree season. It is called Razbrenan or Bahar Cone (Trimming Tree or Spring). Yousif (1985, 242-277) says "This cone is a sign of the beginning of spring in: (1) Garmian regions of Kurdistan which are located between the Zagros Mountain and the Tigris River" such as the Hawlêr, Kirkuk, Hamrin, and Khanaqin plains; (2) the mountainous Bêll Dar area behind the Qaradakh Mountain to the Kifri, Taza Khurmatu, Daquq; and (3) Kurdish plains below the mountain range of Taurus and the west of the Tigris River and the north of the Euphrates River such as Jizira Botan, Nusseibin, Mardin, Urfa, Diyar Bakir, Idyaman, Intab, and Marash, which have a warm climate in contrast to the mountainous regions of Kurdistan (Yousif 1985, 242-277). The fourth subgroup includes three cones and is called Tarazu (Nawroz) Cones (Figure 7). They are a sign of the setting of the stars of Ram and Balance and these are a sign of the battle between the Sun (duration of day and night) and Balance. The last subgroup includes only one cone and is called the Bazbaran (sheep jump) Cone. When the sun reaches this point, the sun cuts as far as the sheep's jump and is a sign for the Fishes and Scorpion constellations.

Occurrence of the Four Seasons

The Earth has several movements in the solar system, the most important of which is its revolution around its axis and the sun's axis. The first revolution takes 24 hours in the systematic repetition from west to east, thus, day and night occur (Al-Sanawi et al. 1979, 28). The second orbit is 365 days, 5 hours, 49 minutes, and 12 seconds (it becomes 23° 16' 48" in four years) (Al-Sanawi et al. 1979, 418). It revolves in an orbit called the Earth's orbit, which is oval-shaped and 939 million km long, so sometimes it approaches the sun to be 147 X 10^6 km away and sometimes it moves away 152 X 10^6 km and consequently four seasons occur (Lourens and Tuenter 2009, 103-123). So only twice a year, on March 21st and September 23rd, the Earth's axis slants at an angle of 23.5° to the Earth's orbit, making the Sun columnar on the equator. Both are called the time of cooling of the weather; one is the cooling of spring because it precedes spring and the other is the cooling of autumn because it heads to autumn. However, on June 21st, the Earth's axis is slanted towards the Sun, when the Sun's waves become columnar on a latitude circle of 23.5°—the orbit of Cancer—in the upper half of the Earth, so the night and day become shorter and longer, respectively. On December 21st, the Earth's axis will again be slanted towards the Sun, when the Sun's waves become columnar on a circle of latitude 23.5°—the orbit of the Capricorn—the lower half of the equator; thus, nights are longer and the days are shorter (Lourens and Tuenter 2009, 103-123). In Erbil, the longest day of the year is June 30th, which is 14 hours and 28 minutes. However, the shortest days of the year are December 17th and 20th, which are 9 hours and 42 minutes. For more information about the change in day length according to latitude, see Table 1.

According to Graw's calendar, the year is divided into four seasons. The sun will set on the evening of December 20th on the Winter Start Cone, so December 21st will be the first day of winter. Just as the sun sets on the third cone of Tarazu (Spring Start Cone) on the evening of March 20th, which will be the last day of winter. Accordingly, March 21st will be the first day of spring and the first day of the Kurdish Year. As the sun sets on the evening of June 20th on the Summer Start Cone, accordingly, June 20th will be the last day of spring. This half-cycle—from early winter to early summer—takes 182 or 183 days. Then, as a result of the Earth's rotation, the same process is repeated for another half-cycle. On September 22nd, the sun will set in the third cone of Tarazu (Autumn Start Cone), so September 22nd will be the last day of summer and September 23rd will be the first day of autumn. Just as the sun sets on the Winter Start Cone on December 20th, therefore, this day will be the last day of autumn. Thus, the Earth completes the other half of the cycle in 183 days (Figure 7).

Latitude	Length of Day
5.0°	12 hours
30.0°	13 hours and 56 minutes
40.0°	14 hours and 51 minutes
50.0°	16 hours and 9 minutes
60.0°	18 hours and 30 minutes
66.5°	24 hours
90.0°	6 months

Table 1. Change of day length according to latitudes.

Battle Between the Sun and Balance

It has been stated that three of the cones are known as the cones of the Tarazu or Newroz (Ram and Balance). When the sun sets on the first cone until sunset on the third cone or vice versa, the period is known as the Battle between the Sun and Balance when the duration of day and night tries to become the same (Figure 8). When the sun sets on the second cone, the middle cone, the length of day and night will be the same on the next day. That is, the night and day will be 12 hours each. The times of sunrise and sunset and the length of the day during the battle of the sun and balance are shown in Table 2 (Abdulla 2019, 2732-2741).

Day	Sunrise time	Sunset time	Day length
March 14	6° 21'	6° 14'	11° 53'
March 15	6° 20'	6° 15'	11° 55'
March 16	6° 19'	6° 16'	11° 57'
March 17	6° 18'	6° 16'	11° 58'
March 18	6° 17'	6° 17'	12° 00'
March 19	6° 16'	6° 18'	12° 02'
March 20	6° 15'	6° 19'	12° 04'
September 22	5° 58'	6° 05'	12° 07'
September 23	5° 58'	6° 03'	12° 05'
September 24	5° 59'	6° 02'	12° 03'
September 25	5° 59'	6° 01'	12° 02'
September 26	6° 00'	6° 00'	12° 00'
September 27	6° 01'	5° 58'	11° 57'
September 28	6° 02'	5° 57'	11° 55'

Table 2. The sunrise time, sunset time, and day length during the battle of Sun and Balance.

Winter Forty and Summer Forty

In the Middle East, generally, the forty consecutive days during winter and summer are the time periods that receive much attention. These two forties are called, in Kurdish, *Chilay zistan* (winter forty) and *Chilay hawin* (summer forty). These forty days are almost in the middle of winter and summer (Mardokhi 1972, 107). Determining the exact time of the start and end of the winter forty and summer forty is of great importance in the Kurdish calendar, regarding the geographical location of Kurdistan, the nature of the country, and its weather (Figure 9). The path of weather depressions becomes suitable for the region to be more affected by them, as the forties period witnesses the lowest temperature rates throughout the year and the highest rainfall rates. It is the most suitable period for the arrival of polar air masses, due to the stability of the winter systems. In terms of rain, this period constitutes 30%–40% of the total rainy season, the forties of winter is an important and critical period, especially for farmers and agricultural lands, due to the high chances of frost and freezes occurring, which cause spoilage of agricultural crops.

In Kurdish calendars, there are two winter and summer forties, the big forty and the small forty; the first is forty days (great forty) at the beginning of winter (Mardokhi 1972, 108) and the second is forty days (small forty) at the end of winter (Mardokhi 1972, 107). Obviously, because the name suggests that the great forty is colder, therefore, it becomes more common. In most areas, only the great forty is used. The migration of birds such as stork, goose, crane, swallow (*Hirundo*), and sandgrouse (*Pterocles*) is linked to the cold and hot weather, e.g., when storks arrive in the area indicating the end of winter forty.

Winter forty begins in the Levant and most Arab countries on December 21/22 of each year. As for the forty in the Arabian Peninsula, it comes after the season of marking and the time of its entry varies from one account to another, but it is in the first ten days of December for most of the people of the desert in the Arabian Peninsula and the deserts of the Levant and Iraq (Al-Haj 2022). They divide the winter season into two parts. The first section is the forty days of the first days of winter starting from December 22 until the morning of February 1st and the second section, which is called "Al-Khamsaniyyah," is the sector of the remaining winter season and is also known by its name because it lasts for 50 days (Ibrahim 2023).

Winter and Summer Forties Based on Graw's Calendar

Winter forty begins 12 days after the beginning of the winter season. The people of Graw say that January 2nd is the first day of winter forty. Another thing that is worth explaining is that the winter forty must be forty days, so the five days of last week, Palos, will be within the winter forty. In this study, the start and end of each week of the winter forty are determined and all weeks are counted as seven days except Palos as five days (Table 3).

Week names	Starting date of the week		Ending date of the week	
	Solar calendar	Kurdish calendar	Solar calendar	Kurdish calendar
Bênda	January 2	Bafranbar 12	January 8	Bafranbar 18
Bênderkha	January 9	Bafranbar 19	January 15	Bafranbar 25
Mêram	January 16	Bafranbar 26	January 22	Rêbandan 2
Oghan	January 23	Rêbandan 3	January 29	Rêbandan 9
Peet	January 30	Rêbandan 10	February 5	Rêbandan 16
Palos	February 6	Rêbandan 17	February 10	Rêbandan 21

Table 3. Start and end dates of each week of the winter forty according to Graw's calendar.

This calculation is in agreement with what is documented by Mardokhi (1972, 121) in the *Dictionary of Agriculture*, that the great forty is forty days at the beginning of winter. Again, it agrees with Sharaza's (1979, 78-84) thinking, who says that his father, Sharaza's father, was well versed in the calculation of the seasons, months, and weeks of the Kurdish calendar and who considered January 2nd as a beginning of the week Bidlkha or Bênda. This is in line with the temperature in the months that winter forty is within because the lowest temperatures are in Bafranbar (December 21 to January 19) and Rêbandan (January 20 to February 18). Table 4 shows the highest and lowest temperatures in Celsius for each month of the year in the Erbil area (Kaka 1984, 67-77).

Name of the Month	Highest temperature (°C)	Lowest temperature (°C)
Nawroz	17.90	7.00
Gulan	25.10	11.35
Jozardan	32.00	16.00
Pushpar	37.05	20.90
Kharmanan	39.00	22.90
Galawêzh	37.05	21.15
Razbar	32.55	16.75
Galarêzan	23.75	10.75
Sarmawaz	13.50	4.20
Bafranbar	9.10	0.20
Rêbandan	8.85	- 1.25
Rashama	11.75	1.25

Table 4. Maximum and minimum temperatures for each month of the year in Celsius, Erbil area.

According to Yousif (1985, 142-177), the beginning of the winter forty is January 15th and February 23rd is the end. Consequently, the six days at the beginning and four days at the end of winter forty fall in Bafranbar and Rashama, respectively. The temperature change from 8.8 °C to 7.1 °C in Rêbandan is not so dramatic. The temperature should be much higher than 8.8 °C in the last days of Rêbandan. If we put Bafranbar 12th as the start day of the winter forty and Rêbandan 21st as the end day, it appears much more reasonable according to the climate of the country. It is not clear what sources or experiments Yousif (1985, 142-177) and Kaka (1984, 67-77) relied on to determine the location of the winter forty in the Kurdish calendar. Apparently, the traditional calculation, which reflects the trial of hundreds of years of experience and adaptation is more acceptable.

The start and end day of winter forty according to Graw's observatory and Graw's Calendar are not the same as the Kandinawa and Baranaty calendars as documented by Rash (2006, 15-22) and Bahirkayee (2016, 32), respectively. The first week after the winter forty is called Khidr and Ellyas. Kurdish people say that Khidr and Ellyas are free from winter because with the end of the winter forty, the weather will become warmer and the cold weather of winter will decrease. The summer forty is counted in the same way as the winter forty, hence, it starts 12 days after the beginning of the summer season. Therefore, the 13th day, July 3rd, of summer will be the first day of summer forty. Table 5 displays the starting and ending dates of each week of the summer forty.

Week names	Starting date of the week		Ending date of the week	
	Solar calendar	Kurdish calendar	Solar calendar	Kurdish calendar
Bênda	July 3	Pushpar 12	July 9	Pushpar 18
Bênderkha	July 10	Pushpar 19	July 16	Pushpar 25
Mêram	July 17	Pushpar 26	July 23	Kharmanan 1
Oghan	July 24	Kharmanan 2	July 30	Kharmanan 8
Peet	July 31	Kharmanan 9	August 6	Kharmanan 15
Palos	August 7	Kharmanan 16	August 11	Kharmanan 20

Table 5. Starting and ending dates of summer forty's weeks according to Graw's calendar.

The Belt of Zodiac

In order to understand whether there is a relationship between the astronomic observatory of Graw and the zodiac, it is necessary to mention some information about a belt-fashioned expanse of the sky. The belt is separated into twelve symbols, each inhabiting 30° of spiritual longitude and unevenly equivalent to the star constellations (Figure 10).

The belt means that the sun moves around the constellations and cuts a constellation once a month. The constellation year is 360 days. The constellations opposite to the sun rotate from west to east. When the constellation falls on the equator, then the beginning of the Ram falls on the west point and the sun falls on the equator at the cooling point of spring on March 21st, which is the first day of spring. The circle of the eclipses breaks along this line and gradually moves away from it and the sun revolves around the eclipses and moves away from the cooling point until it reaches its peak, which is no longer the turning point of summer and the beginning of the Crab, and crosses three spring constellations (Ram, Bull, and Twins) at this distance. The sun returns at the beginning of summer until it reaches the equator at the cooling point of autumn, on September 23rd, which is the first day of autumn, and reaches the Balance constellation—the sun crosses three summer constellations (Crab, Lion, and Virgin). Then the sun breaks in the line until December 22nd and reaches the winter turning point and the beginning of the Goat constellation. The sun crosses three autumn constellations (Balance, Scorpion, and Archer). The sun does not go beyond the winter turning point but returns until it reaches the equator on March 21st, which is the first day of spring and, at that distance, it crosses the three winter constellations (Goat, Water Bearer, and Fish) (Yousif 1985, 142-177; Kurtik 2021, 53-66).

Graw's Astronomic Observatory versus the Zodiac

The relationship between Graw's astronomic observatory and the zodiac is obvious. All cones are lining up with constellations except the Winter Start Cone. The Winter Start Cone is one day apart from the Goat constellation. The sun will set on the evening of December 20th on the Winter Start Cone, which means that December 21st is the first day of winter. However, the cycle of Goat starts on December 22nd (Fletcher 2009, 105-128). Conversely, the Bazbaran Cone is exactly lined up with the Fishes constellation (February 19th) and on the way back, the Bazbaran Cone lines up with the Scorpion constellation (October 23rd). In the same way, the third cone of the Tarazu (Newroz) exactly contests the Ram constellation (March 21st). At the time of the return of the sun, the third cone of the Tarazu (Nawroz) is exactly lined up with the Balance constellation (September 23rd). Finally, the Summer Start Cone matches the Crab constellation (June 21st).

The Baranati and Kandinawa Calendars

The other calendars that are used by Kurdish people in Erbil Province are the Baranati and Kandinawa calendars. Both are used by people in the Baranati, Kandinawa, Dashty Hawler, Shamamik, and Qaraj plains.

The Baranati or the Eastern Roman calendar (Julian) is one of the most popular calendars that has been used until recent years in the Kurdistan Region of Iraq. It starts 13 days after the Gregorian calendar because the Orthodox sect believes that the Prophet Jesus was born on the seventh of January. They consider that the Western calendar preceded this event by 13 days and therefore the Eastern calendar appears 13 days after the Western calendar, i.e., the fourteenth day of each month, which is considered the first day of the month (Hocken 2023). The winter season consists of 90 full days (for leap year 91 days). December 14th to December 23rd is considered the beginning of winter and it is 10 days. From the 24th of December to the 1st of February is called the great winter forty and it is forty days. The day from February 2nd to March 13th is considered the small winter forty, which is also forty days. Winter ends on the 13th of March. Among thirteen weeks of winter, eight of them have been named. The names are Bênda, Bênderkha, Mêram, Oghan, Peet, Palos, Khidr and Ellyas, and Sardi Perazhin. There are seven days called the Battle of the Balance. Three days of this week fall in the winter season, namely 11, 12, and 13 of March, while four days fall in the spring season, and they are 14, 15, 16, and 17 of March.

The Kandinawa or Kandinawa and Qaraj calendar is a common almanac in the southern part of Erbil Province, the Kandinawa and Qaraj plains. According to the Kandinawa calendar, winter begins on December 14th and lasts 90 days. The winter forty begins 25 days after the winter begins. There is one winter forty and it is located in the middle of the season, that is, between 25 days at the beginning and 25 days at the end (the winter forty begins on the 7th of January and ends on the 16th of February). Among thirteen weeks of winter, nine of them have been named. The names of the weeks are the same as Baranati's week names except the eighth week, Khidr and Ellyas, is considered two weeks in the Kandinawa calendar.

Graw's Astronomic Observatory versus the Baranati and Kandinawa

Graw's astronomic observatory is similar to both Baranati and Kandinawa in many aspects, e.g., length of season, winter forty, week names, and some specific days. It differs from them with starting the winter season, starting winter forty, and exact times of specific days. According to Graw's calendar, the winter begins on December 21st while it starts on December 14th based on both other calendars. Furthermore, the winter forty starts on January 2nd in Graw's calendar but it starts on December 24th and January 7th in the Baranati and Kandinawa calendars, respectively. According to both the Graw and Baranati calendars, the dog prefers shady places in week Palos while Kandinawa indicated the week of Peet for when dogs stay in shady spots, however, the starting and ending days for these two weeks are different from one calendar to another calendar. According to the Baranati calendar, the night of the 13th to the 14th of February was the night in which Braim (Ibraheem or Abraham) Mulla Zindinan was expelled from the region. The night was considered a very cold night. He was covered while he was on the horeses back with snow, and he froze to death. This night is on January 14th based on the Kandinawa calendar and is from the 19th to the 20th of February based on Graw's calendar. One major difference between the Baranati calendar and both the Graw and Kandinawa calendars is that the Baranati calendar has two winter forties, while others have only one.

Kurdish Calendar

The Kurdish calendar year is a solar year, according to the Earth's revolution around the sun, and consists of four seasons, each of which consists of three months. The first six months of the year have 31 days each and the last five months have 30 days each. The last month of the year, Rashama, has 29 days, and in leap years the last month, Rashama, has 30 days. The main date of the Kurdish calendar dates back to the twenty-first day of March of the year six hundred and twelve BCE with the battle of "Nineveh" as well as the invasions of the Assyrians and this was before both the Babylonians and the Medes. Those invasions are considered remarkable events in the history of the Kurds.

It is mentioned that the days of the months that make up the spring and summer seasons reach thirty-one days, at a time when the days that make up the months that fall in the fall and winter seasons reach thirty days, and we find that there is a month that is excluded from the previous rule, which is that the last month of the winter season works according to the leap year, meaning that its days range between twenty-nine and thirty days. It is also noticeable that the names of the months that make up the Kurdish calendar are derived from the events of the community (Table 4), e.g., Gullan is likely derived from the Kurdish word "*Gul*" meaning flower, Gelawêzh is named after the "*Gelawêzh*" (Sirius) star that becomes visible in this month, Khermanan is likely derived from the Kurdish word "*Kherm*" meaning warm, and Bafranbar is likely derived from the word "*Bafr*" meaning snow.

The Usage and Application of Graw's Calendar

This astronomic observatory has several benefits. The most important advantage to the local people was knowing the annual climatic changes that occur and dividing the year into four seasons. Finally, linking the calendar to the economy and some important days in the year, which are mainly related to agriculture, including vine cutting based on Razbrenan Cone (February 23rd), grapes changing color, which occurs on the 1st day of Bênda (July 3rd), and figs ripening during the Oghan week (July 24th to July 30th). In the past, students also benefited from this astronomic observatory while they studied in traditional religious schools in the area to master the science of astronomy by recognizing some stars and their movement. The existence of hundreds of illustrations and classical books in the field of astronomy is clear proof of using this kind of observatory station for the sake of this purpose.

Significance of Graw Village's Astronomic Observatory

The Graw stellar perspective and the annual calendar are unique in the region because they are exceptional in their characteristics among the calendars in the region. This observatory divides the year into four seasons and indicates the winter forty. Furthermore, it is concerned with the summer forty as well. Moreover, it contains indications for observing the stars by having a specific geographic location, not just an annual calendar. This observatory has a close connection with the daily life of the villagers, especially in the past centuries. It helped the people of the area in their appointments to carry out their work in the field of agriculture. The calendar has ancient origins that range back thousands of years, as verified by the Ezidis, who follow an ancient religion by fasting during both winter and summer forties annually with the participation of people in various regions of the world.

The Founder of Graw's Astronomic Observatory

Although it is not known who made this perspective, according to most oral information and the information that has been passed down to us by word of mouth, two people can be selected. They are Mullah Abdullah Al-Kurdi and Mullah Omar (Umar). According to the information mentioned, this astronomic observatory was built around the end of the 17th and the start of the 18th centuries.

Mullah Abdullah Al-Kurdi is known as Mullah Abdullah the Great; he is the son of Ali's son, Yusuf. He lived for 120 years and was the teacher of Maulana Khalid Naqshbandi. Maulana Khalidi Naqshbandi was born in 1777 and died in 1826. When Maulana studied under him, he was very old and Maulana was young (Yousif 1985, 142-177; Sharaza 1985, 106-111). Some handmade things, e.g., an ashtray and pen holder by Maulana Khalid Naqishbandi still remain in the small cave, which is called Koshkoray Faqêyan within Ser-i-Rash Mountain (Figure 11). If we consider Mullah Abdullah's old age as 75 years and Maulana's youth as 25 years, we can say that Mullah Abdullah was born around 1727. On the other hand, Mullah Abdullah is the father of Mullah Ahmad who is a contemporary of Daud Pasha who became the governor of Baghdad in 1816. Mullah Ahmad was the Qazi (judge) of Soran during the reign of Mir Mohammed who was the ruler of Soran between 1813 and 1836 (Jalil 1987, 185). The same Mullah Ahmad published a book on rhetoric about which Dhiya Al-Din Hayder Al-Kurdi in 1853 published a book entitled "Sharh Rasala, Ilm Al-Bayan lil Maula Ahmad Al-Grawi" to explain (Al-Azawi 1962, 161-162). On the other hand, Mullah Omar (Umar) was the son of Yusuf, the uncle and teacher of Mullah Abdullah. He is the ancestor of Mulla Ahmed Rasul. This Mulla was a student of Mulla Abdullah and the teacher of Ibrahim Fasih Haidari (Al-Mudars 1983, 56) who was born in 1820 and died in 1883 (Al-Azawi 1962, 58).

Folk Oral Literature Related to Weather

Mêram and Oghan

It has been said that Mêram (Maryam) went to take a bath in a lake or a river but she began to freeze and she started shouting. Later her aunt, Oghan, went to look for Mêram (Mary) and there she sprinkled hot water on her to restore her vitality and saved her from death.

A'antar Days

Five days within the Oghan are called A'antar. A person of Arab origin went to Kurdistan to sell salt but the weather took a turn and rain and snow fell. There was no solution but to slaughter the camel that carried the salt. The person entered the skin of the animal for five days until the temperature rose and thus he saved himself from death.

Birth to Goats

Livestock owners in Kurdistan, especially those who lived in the plains, tried to give birth to goats during this period, the middle of February, thinking that the weather was favorable and that was why they mixed buck or billy with their does or nanny during the month of August.

Wishes Come True

The week that begins on the 24th of February to the 2nd of March (according to the Baranati calendar, it starts on February 11th to February 17th) was referred to as Khidr and Elyass. This is attributed to Khidr who is someone mentioned in the holy book Qur'an in Surat Al-Kahf as a scholar without his name being explicitly mentioned. The people of Erbil put sweets on the rooftops of the buildings, thinking that a wandering person would eat them, and accordingly their wishes would come true.

The Turning Night to Spring

In Kurdish folklore, the night of March 20th to March 21st, which is the last night of winter is mentioned in the following poem.
When the Sultana Newroz is coming
Sheep are not worrying anymore about infants
After this day
Take a baby in a cradle
It to the roof
Cover it with a piece of linen
Leave it there until the day after
No maliciousness will reach his/her body

The Night of Braim Mulla Zindinan

In the old days, it is narrated that there were two brothers by the names of Mir Sheikh and Mir Yazdin. A man named Braim (Ibraheem or Abraham) Mulla Zindinan used to work for them. They say that Mir Sheikh got sick and Braim helped him for seven years until he recovered from the disease. As a reward for his toil, Mir Sheikh agreed to marry his sister, Khatu Pari, and performed the marriage contract. After that, Mir Sheikh departed to a remote mountainous place. One day Mir Yazdin noticed that his sister and Braim were together and, for this reason, Sheikh Yazdin became intolerant of Braim because this meeting between them before marriage is considered hostile to tribal customs. Mir Yazdin told him I will not punish you but I will expel you from the region on the coldest night.

Braim was expelled on the 19th of February (13th of February and 14th of January based on Baranati and Kandinawa calendars, respectively) in the afternoon. Braim went to the area where Mir Sheikh lived, believing he was a man who loved him very much and had not forgotten his virtue. The snow began on that day and the area was about ten hours away. Snow covered his whole body and because of the cold he lost consciousness but the horse continued down the road and took him to the village where Mir Sheikh lived. Mir Sheikh dreamed that Braim would come. Mir Sheikh had three wives, so he sent them to check on Braim one after the other. One of the wives reported that there were signs of Braim's arrival. After taking him into the house, Braim regained consciousness and Mir Sheikh understood the situation. After the climatic conditions calmed down, he went personally to the village where his sister lived brought her with him and married her to Braim

Sarmay Pereazhn

The sarmay pereazhn "old lady's cold" occurs at the end of February and its last days witness strong winds and cold after a period of warmth, during which people think that winter has pulled its travels and accepted warmth, but without warning the cold surprises the atmosphere and those days are known as "selling his garments" as a metaphor about the one who sold his cloak thinking that the time of the cold had ended or the "days of decisiveness," which are decisive between cold and heat.

It was mentioned in the inheritance that the old lady's cold is attributed to an old lady who expected the cold to return after the advent of warmth in such a period and advised her people not to shear the sheep's wool yet, and not many listened to her, so their livestock perished with the advent of the cold, and they said it is the old lady's cold or the cold that the old lady spoke of after the arrival of warmth. The old lady's cold means the winter's deficiency or that it is at its end, and it consists of eight days at the end of February and the first of March and may extend to the 10th of March, due to the period from February 25 to March 10. This period is characterized by the advent of a cold wave that may be accompanied by the activity of cold winds, which is the last cold wind during the winter. It is a dry cold, rarely accompanied by rain. A fox and a jackal go into their holes or nests. This period is usually preceded by a rise in temperature, but it is a "deceptive and temporary" rise, as some people think. The cold is over but it is attacking again, accompanied by cold northwesterly or northeasterly winds.

Forty Fasting for the Ezidis

Followers of the Ezidi sect in the Kurdistan region and the rest of the world fast in what they call the "summer forty" for a period of 40 days, fasting from dawn until sunset. A number of religious men and women fast but this fast is not considered obligatory for the general followers of the Ezidi religion. The forty fasting for the Ezidis takes place twice a year, where there is the summer forty and the winter forty, considering that this issue has ancient roots in the religious history of the Ezidis. Usually, on the first night, the Baba Sheikh, the Pishmam, Sheikh Al-Wazir, and a group of Kawajk (ascetics) and religious Ezidis go to Lalish Temple. Some religious ceremonies are held there, with the Baba, the sheikh of this group, accompanied by a number of religious women who have given themselves to worship, about 50 km southeast of Dohuk, which is the only temple for the Ezidis in Kurdistan. The members of this procession take some of the sacred soil to seek blessings from it, pointing out that every person who takes from this soil considers that he has decided to fast in the forty of winter. The ceremonies of entry and exit from Chla Khana are with religious hymns and when the procession returns to Baba Sheikh, the night is spent reciting some supplications and religious texts until sunrise and they eat Suhoor (breakfast) at the allotted time (Shengali 2013).

Usually, a number of religious Ezidis from the regions of Sinjar, Bashiqa, and Khatara, in addition to the people of nearby regions such as Sheikhan and Baathra, participate. On the second day, they return to their regions to fast the rest of the days with their families. Also, some religious people from the Sinjar fast the forty in some caves and hollows located in the valley Karsê in Mount Sinjar. The fast of the forty is an obligation of the Baba Sheikh and his council, in addition to some religious people who vow themselves to fast voluntarily. After the end of the forty, on the last day, there is a festival called Jezhna Chla Havini (the summer forty festival). On the first Wednesday of April, the Ezidis celebrate the holiday (Figure 12 and 13) for three days by gathering in the "Lalesh" temple, which is located in a mountainous area near the city of "Ain Sifni" in northern Iraq, to commemorate the holiday and practice its rituals. According to researchers, the Ezidi is a monotheistic ethnic religion and is one of the ancient Kurdish religions, as all the religious texts are recited in the Kurdish language (Kurmanji dialect) on Ezidi religious occasions and rituals (Shengali 2013).

Conclusions

This Kurdish stellar perspective and the annual calendar are unique in the region because they are exceptional in their characteristics among the calendars in the region. It is based on the naked eye observation without using any instrument. The existence and usage of the astronomic observatory of the village of Graw in northern Iraq, which was likely built around the end of the 17th and the start of the 18th centuries reflect the level of knowledge of ancestors in this area to utilize natural facts for the sake of arranging their daily life schedule. This region, as a part of Central Asia, probably contributed to the development and progress of the astronomic concepts of many revolutionary commencements that aided in achieving a better consideration of the world and its surroundings, which became the fundamentals of modern astronomy. The observatory has similarities with the zodiac calendar with only a minor difference and it has similarities with the calendar of the Eastern Church with differences at the beginning and end of the winter season and the winter forty. These similarities reflect the level of interaction between different regions' experiences and knowledge.

This observatory divides the year into four seasons and indicates the winter forty. Furthermore, it is concerned with the summer forty as well. Moreover, it contains indications for observing the stars by having a specific geographic location, not just an annual calendar. This observatory has a close connection with the daily life of the villagers, especially in the past centuries. It helped the people of the area in their appointments to carry out their work in the field of agriculture. The observatory was also of great importance in the field of education in the past centuries, especially in traditional religious schools. It appears from this research that the calendar has ancient roots that extend back thousands of years as evidenced by the Ezidis who follow an ancient religion whose roots also extend back thousands of years and which includes annual fasting during both the winter and summer forties with the participation of people in various regions of the world.

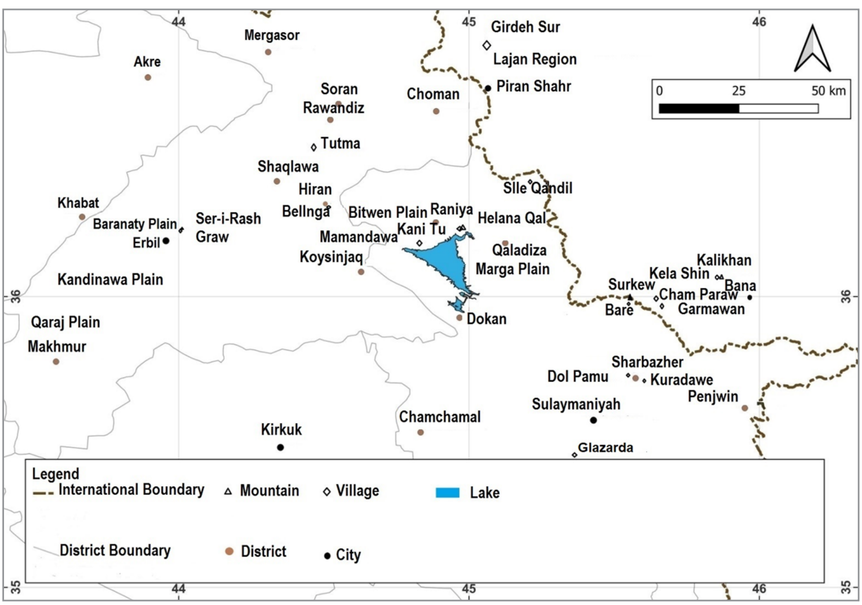

Figure 1. The location of Graw Village.

Figure 2. The google image shows the location of Dari Lolikan Mountain, Ser-i-Rash Mountain, and the village of Graw.

Figure 3. Image of Dari Lolikan Mountain, which is located opposite of the village of Graw.

Figure 4. Graw spring, which is located in the east of the village.

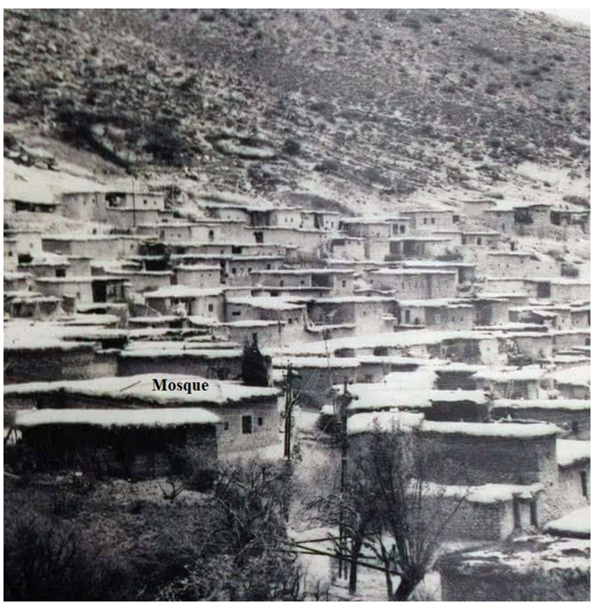

Figure 5. The image of the village of Graw in 1984, which shows the Mosque before it collapsed.

Figure 6. Shows the stone cone, which is made of stacked stones without using any binding material.

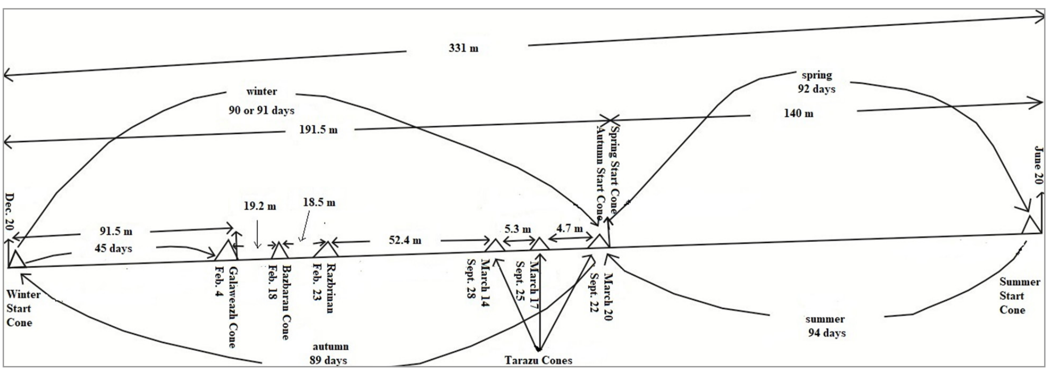

Figure 7. Location of basic and non-basic cones.

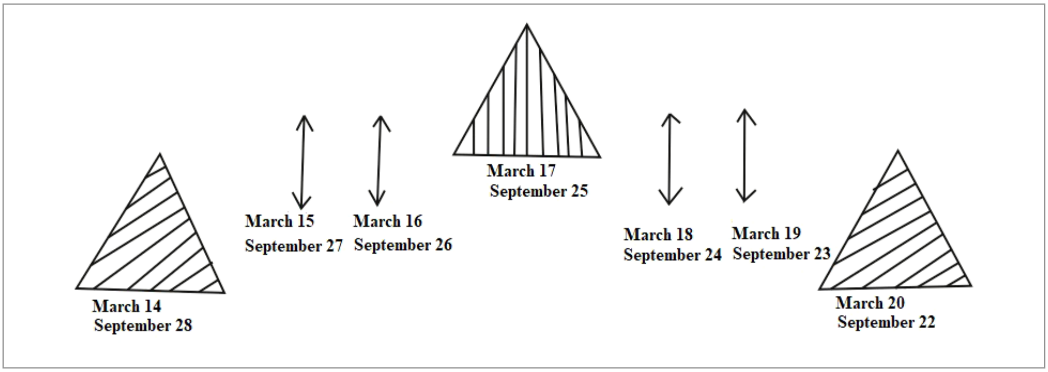

Figure 8. The Tarazu cones and the sunset dates on them.

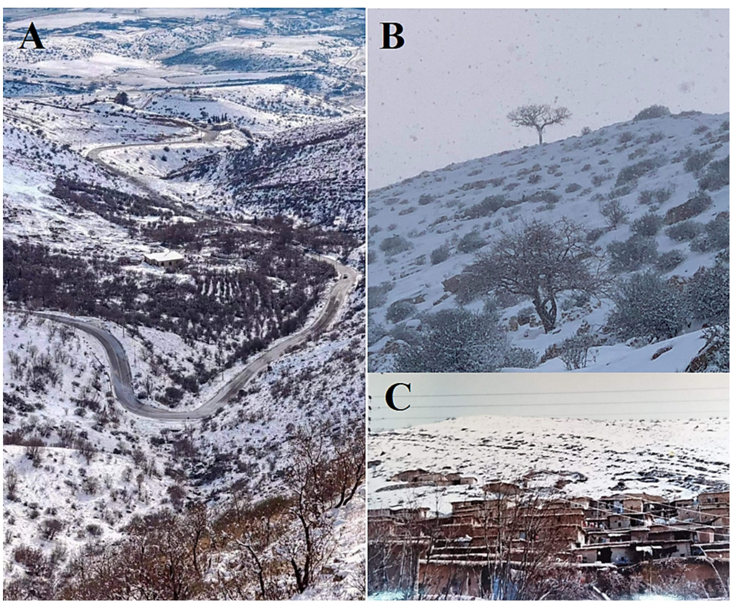

Figure 9. Images of the village of Graw during winter season. (A) image of the village that shows the location of village between two mountains; (B) shows the image of Mount Dari Lolikan and Dari Lolikan tree, which is located on the top of the mountain; and (C) shows architecture of the houses in the village.

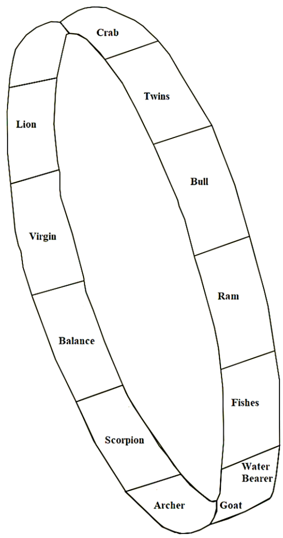

Figure 10. The zodiac is divided into twelve constellations (Al-Samarayee 1984, 24; Fletcher 2009, 105-128).

Figure 11. Shows the location of Koshkoray Faqêyan within the Ser-i-Rash Mountain.

Figure 12. Shows Ezidi woman while celebrating Chila Zistan (Winter Forty). Lighting candles and lanterns is an important part of the celebration as the sun sets on the last day of the old year and the New Year begins (Adnan 2023).

Figure 13. Shows Ezidi temples and people on the first Wednesday of April, so "Red Wednesday" was described as the day of creation and end of winter forty (Adnan 2023).

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