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The Beginning of Protohaykian Calendar

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Abstract. From its foundation, studies in the field of history of Armenian astronomy and Armenian calendars were integral to astrophysical researches of the Byurakan Observatory. It is important to note the monographs and articles of H. Badalian and B. Toumanian in this field. As the result of our work in this field, beginning of the Haykian calendar (BC 2341) and the concept of Protohaykian calendar were established. In the present work an attempt is made to determine the beginning of the oldest Armenian calendar–the Protohaykian calendar. It is shown that Protohaykian calendar was originated when the heliacal rising of the star Spica (α Virgo) was observable from Armenia 8 days before summer solstice. Calculations made on this basis provide date of the beginning of this calendar as BC 9000 with an error not to exceed 80 years. This date is in correspondence with the date of observations of the Pleiades from Metsamor (about BC 9000), that was found a few years ago. Meanwhile, it also corresponds to the geological data, which prove, that the oldest lake (Araratian Sea) in the territory of modern Araratian valley was dried out at the same time. There is also good correlation with the time of cultivation of crops that was done in the territory of historical Armenia about 12000 years ago.

Traditionally, the calendar and its history has been subject of much interest in Armenia both among scholars and ordinary people. One of the most important disciplines taught in medieval universities of Armenia was calendar and interest in the calendar and its history continued during the Soviet period in as well. Since the founding of the Byurakan Observatory, research of Armenian calendars and their history were among the traditional areas of studies of the Observatory. Notable among the many scholarly works are the scientific articles and monographs of L. Simeonov, H. Badalian and B. Toumanian. This trend has continued since the independence of Armenia in 1992 in Byurakan Observatory with officially sanctioned theme on the study of old and ancient Armenian calendars [1].

Our research and studies in this field were started in 1983 and continue until now. The most important results obtained during these years were the calculated data of the beginning of the Haykian calendar and the structure (the concept) of so-called Protohaykian calendar.

Let first examine what we know about the Haykian calendar. This was a classic solar calendar with **12×30 days + 5 days = 365 days** structure. The year in this calendar consists of 12 months of 30 days each and thus contains only 360 days. After the 360 days of year, 5 additional days were added to complete the year cycle. As a result of shortness of the duration of the year cycle, the beginning of the year in this

[1]The head of the research team was the author of this research.

calendar was movable and makes a full cycle through year seasons during 1506 years ($1506 \times 365.2422 = 1507 \times 365$)[2]. Although the mobility of the beginning of the year, the most important holiday of the calendar year Nawasard (having the same name as the first month) has been fixed and the day of this feast was determined by observing the heliacal rising of the star α **Orionis–Betelgeuse**. For an observer from the territory of Armenia ($\varphi = 39°.5$), heliacal rising of that star in the period of interest to us takes place about 8 days before summer solstice (June 14 according to our modern calendar).

This calendar was used in Armenia without significant changes until the official adoption of Christianity in Armenia (301 AD). From the beginning of Christianity in Armenia general Christian calendars (in all probability for 95 years) were used to determine dates of religious holidays. From about 353 AD the 200-year paschal tables composed by Andreas the Byzantian were in use. After the end of these tables in 552 the first Armenian paschal tables composed by Athanas Taronatsi were used. These tables were composed using Armenian traditional months and unchanged structure of traditional Armenian Haykian calendar. As such, the days (in terms of this calendar) of solstices and equinoxes as well as the beginning of Armenian year were movable as it was in the past. This situation continued in Armenian calendar until the calendar reform of Anania Shirakouni in 667 AD. Thus, we observe, that the Haykian calendar with its traditional structure was in use even during the first centuries of Christian period of Armenian history.

In order to determine beginning of the Haykian calendar, we calculate when first day of first month Nawasardi coincides with the day of heliacal rising of α Orionis - Betelgeuse. Our calculations were carried out using well-known formulas of spherical trigonometry giving us the date 2341 BC. As such, we conclude that the Haykian calendar was established in the year 2341 BC[3]. We can summarize what we have about the Haykian calendar as follows:

1. Correction – none,
2. Beginning – 2341 BC,
3. Duration of the year – 360 days,
4. Duration of year cycle – 365 days,
5. Beginning of the year – movable,
6. Main feast – fixed to heliacal rising of star α Orionis.

We call the calendar used in Armenia before the Haykian calendar Protohaykian. The structure of this calendar was reconstructed by analysis of large volumes of data concerning Armenian calendars from mediaeval Armenian calendric and historical sources. This analysis demonstrates that the calendar preceding the Haykian one had **10 × 30 days + 70(65) days = 365.2422 days** structure. As such, the year in this calendar consists of only **10 months of 30 days each** and thus contains **300 days**. After the year

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[2]Here 365.2422 days is the exact duration of tropical year.

[3] Grigor Broutian, About Some Problems of Armenian Calendar: The Native Armenian Calendar, Etchmiatsin, 1985, I, pp. 51-57, II-III, pp. 72-80. See also Grigor Broutian, The Armenian Calendar, Mother See Holy Etchmiatsin, 1997, pp. 211 - 246 (in Armenian).

there was a period of 70 (or 65) days that was considered to be out of the year. (In fact 5 of the 70 days of this period were considered to belong both the 300-day year and the out of year period). This out of year period corresponds to the length of invisibility of the star Betelgeuse, while the year corresponds to the period of visibility of the same star. Thus, the correction of the beginning of the year was done automatically by the observations of the heliacal rising of the star that represents the heavenly image of the main god - the Supreme Being[4]. Existence of Protohaykian calendar is confirmed by a large amount of data from:

1. Mediaeval Armenian historical sources[5],
2. Armenian folklore sources[6],
3. Folklore of neighboring nations[7],
4. Calendars of some neighboring nations[8],
5. A ceramic vessel of XXXII c. BC from Keti (Shirak, Armenia, Figure 1)[9].

Thus, the following is known about the Protohaykian calendar:

1. Correction – automatically
2. Beginning – unknown
3. Duration of the year – 300 days
4. Duration of year cycle – 365.2422 days
5. Beginning of the year – fixed
6. Main feast – fixed to heliacal rising of star α Orionis.

However, all the above mentioned sources do not give us the tools to find out the beginnings of Protohaykian calendar. In order to find the beginnings of this calendar we have to take into account the following additional information.

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[4] Grigor Broutian, About some Problems of Armenian Calendar: The Structure of Protohaykian Calendar, Etchmiatsin, 1996, XII, pp. 135-164 (in Armenian).

[5] Grigor Broutian, The Oldest Armenian Calendar Conceptions According to the “History of Armenia” of Agathangelos, Etchmiatsin, 1998, VI, pp. 45-53 (in Armenian).

[6] Grigor Broutian, Some Calendar Relations in Armenian Fairy Tales: I, II, III, Etchmiatsin, 2008, II, pp. 49-70, Etchmiatsin, 2009, XII, pp. 62-83, Etchmiatsin, 2010, VI, pp. 22-44 (all in Armenian).

[7] Grigor Broutian, The Oldest Armenian Calendar Conceptions and Byzantine Epic Poem Vasil Digenis Acritas, Bazmavep, 2004, pp. 5-16 (in Armenian).

[8] Grigor Broutian, Armen deacon Khachatryan, Certain Issues Related to the Calendar in the Holy Bible, Bazmavep, 2008, pp. 83-100 (in Armenian).

[9] Grigor Broutian, The Oldest Armenian Calendar Concept According to the Analysis of the Ornaments of a Vessel from 28-27th c. B.C., Bazmavep, 2007, pp. 149-163 (in Armenian).

Figure 1. The ceramic vessel from Keti and its ornaments (XXXIIc. BC)

1. First we have to note that observations of heliacal risings of stars can guarantee stability of the detected day only during a limited period of time. Indeed, due to precession of the Earth and proper motions of stars, the equatorial coordinates of bright stars are noticeably changed during centuries and this, in turn, changes the conditions of their visibility. As a result, we have slow changes for days of heliacal risings (and settings as well) of bright stars relative to days of equinoxes and solstices. For example, in the case of Egyptian calendar we can calculate that the day of heliacal rising of Sirius, which was celebrated with great festivities, was not fixed. It moved relative to the day of summer solstice with a rate of about 1 day in every 128 years**.** Meanwhile, duration of the year checked by these observations was stable during more than 3000 years and was exactly 365.25 days[10]. Thus, in ancient Egypt the heliacal rising of Sirius was giving a fixed duration of year and not a fixed day in the tropic year.

2. It is important that the main holiday of both Haykian and Protohaykian calendars were closely correlated with the harvest of winter crops (wheat and barley). Furthermore, the observations of heliacal rising of the chosen star serves mainly to show the exact time of that harvest and this was 8 days before summer solstice.

3. A large volume of ethnographic data reinforces the fact that the main holiday of Haykian and Protohaykian calendars was closely associated with the cult of bread. This tradition is still alive in Armenia even in our days.

4. We also have data that indicate the division of the starry sky into constellations was carried on and covered in Armenia about 2800 BC[11]. It is notable that this conclusion was made on the basis of only astronomical and geographical data more than 100 years ago. During this period, additional archaeological data have confirmed and reinforced these results. On this basis, it is normal to expect the relationship between the constellations of the sky, and Protohaykian calendar. In addition, since the main holiday of this calendar is closely linked with the cult of bread, then there must be a connection between the constellations and the cultivation of grain. Indeed, we see at least 6 or 7 constellations relating to the cultivation of grain. These are the constellation of the Big and Little Dipper, Bootes, Virgo and Libra. Ursa Major in Armenian tradition was

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[10] Klimishin, I. A., Calendar and Chronology, Nauka, Moscow, 1985, pp. 144-153 (in Russian).

[11] William Tylor Olcott, Star Lore: Myths, Legends and Facts, Dover Publications., Mineola, New York, 2004, (originally published by G. P. Putnam's Sons, New York, 1911, p. 6-8).

named “Sayl” (Cart), while Ursa Minor was named “Miws Sayl” (The other Cart). We know that in ancient times two carts were used in the cultivation of grain: the first (the large one) for transfer of sheaves of wheat from the field to the barn and the second (the small one) was used for threshing. Bootes corresponds to the “Reaping worker” with a sickle in his hand in the Armenian tradition. Besides we have at least 7 Armenian constellation names from mediaeval manuscripts closely associated with grain cultivation that have not yet been identified with modern constellations. However, among all the constellations associated with the cultivation of bread the most significant is Virgo depicting the female figure holding in her hand an ear or a sheaf of wheat. Analysis of extant data on this constellation from different mythologies and their comparison with data from Armenian mythology and folklore show that it represents the image of the wife of the supreme deity performing the ritual offering of the first harvest of grain[12]. That is, in the face of the Virgin, we have the image of a figure carrying out the final stage of the cultivation of grain.

5. We have also to take into account the fact that according to recent knowledge cultivation of crops was made in the territory of Armenia[13] and was of special importance.

Taking into account points raised above, we can draw the following conclusions:

As the heliacal risings of stars cannot give exact fixed days in the tropic year, therefore we must conclude one of two things: either the star chosen for observations should be changed after a period of time, or that the day detected by these observations should slowly move in the tropical year. However, the second option should be excluded as we know that the time of the harvest depends on only the plant and the climate of the location. As both of these factors cannot be changed, it implies that the time of the harvest cannot be changed. Meanwhile we know that in case of Protohaykian calendar the day of the main holiday was closely associated with the winter crop harvest. As such, we have to conclude that **the star used in Protohaykian calendar should be changed in time**. The question then is which star should be used in this calendar before α Orionis? The best candidate for this role is the star α **Virgo** – **Spica** the name of which means **Ear of corn**.

As such, problem of finding the beginning of the Protohaykian calendar is reduced to calculating the historical period when the heliacal rising of the star Spica could be observed from Armenia 8 days before summer solstice. To facilitate our calculations we will change the summer solstice to the vernal equinox and the 8 days before summer solstice = 84 days after spring equinox. Transformations of the well-known equations of spherical trigonometry, results in a quadratic equation for the right ascension of Sun at the moment of heliacal rising of our star $\left(\cos^2 S * - \frac{\cos^2 z_0}{\cos^2\varphi_0}\right)\mathrm{ctg}^2\alpha +$ $2\cos S * (\sin S * + \mathrm{tg}\varphi_0\ \mathrm{tg}\varepsilon)\,\mathrm{ctg}\alpha + (\sin S * + \mathrm{tg}\varphi_0\ \mathrm{tg}\varepsilon)^2 - \left(1 + \mathrm{tg}^2\varepsilon\right)\frac{\cos^2 z_0}{\cos^2\varphi_0} = 0$);

where α is the right ascension of Sun at the moment of heliacal rising of the star, $z_0 = 105^\circ$, $\varphi_0 = 39^\circ.5$, $\varepsilon = 23^\circ\ 27'$ are constants, and S* is the siderial time of heliacal rising of the star. The equatorial coordinates of Spica are taken from the catalogue of

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[12] Richard Hinckly Allen, Star Names. Their Lore and Meaning, first publ. 1899, Dover Publications, New York, 1963. p. 460-473.

[13] N. I. Vavilov, The Origin and Geography of Cultivated Plants, Nauka, Leningrad, 1987, pp. 335, 343-344 (in Russian).

G. S. Hawkins, and S. K. Rosenthal[14]. The results are presented in the table below and Figure 2.

The year (T)	α right ascension of Sun at the moment of heliacal rising of star	Number of days from vernal equinox (N)
- 3000	153.925400232	159.06
- 3500	147.753733806	152.68
- 4000	141.573651326	146.29
- 4500	135.396372455	139.91
- 5000	129.225833469	133.53
- 5500	123.096006939	127.20
- 6000	116.994267274	120.89
- 6500	110.952841770	114.65
- 7000	104.970534972	108.47
- 7500	99.054262522	102.36
- 8000	93.176528224	96.28
- 8500	87.340953073	90.25
- 9000	81.500387800	84.21
- 9500	75.633008917	78.15
- 10000	69.673918610	72.00

From the data in the table of our calculated numbers, we derive a formula using the method of least squares.

N = 0.0125T + 196.83.

Here **N** is the number of days from vernal equinox until the heliacal rising of Spica, and **T** is the year (BC).

Thus, beginnings of Protohaykian calendar is determined to be 9000 BC. Possible error of this date is calculated as the period of time during which the day of heliacal rising of star will change by one day. For such a change we find the error value of 80 years.

As indirect confirmation of this date, we have determined it to have strong correlation with the time of astronomical observations carried on at Metsamor (about 9000 BC)[15]. We also have good correlation with geological data concerning the time of drying of so-called Araratian sea, the existing region of modern Araratian valley, from

[14]Gerald S. Hawkins, Shoshana K. Rosenthal, 5000- and 10000-Year Star Catalogs, Smithsonian Contributions to Astrophysics, 1967, v. 10, Nr 2, p. 174.

[15] Grigor Broutian, The Ancient Armenian Calendar's Connection with the Celestial Bodies, Relation of Astronomy to other Sciences, Culture and Society, XIII Annual Meeting of Armenian Astronomical Society, 7-10 Oct. 2014, ed. H. Harutyunian, A. Mickaelian, S. Farmanyan, NAS RA Gitutyun publ. House, Yerevan, 2015, p. 322-333 (in Armenian).

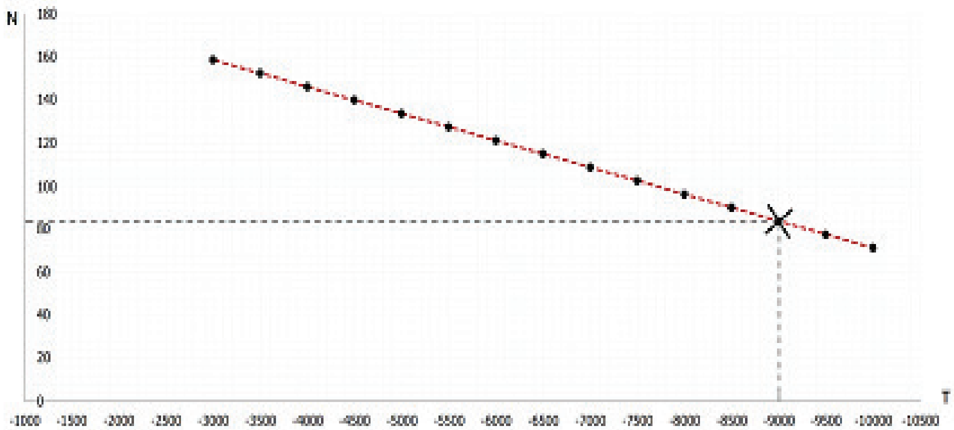

Figure 2. The dependence of the number of days from the vernal equinox until the heliacal rising of Spica, from the year of observations

780000 until 11000 - 9000 BC[16]. As final triangulation, this period also correlates with the period of cultivation of crops in Armenia about 12000 years ago[17].

Summarizing our results for the beginnings of Protohaykian calendar, we have:

1. Beginning – 9000 BC,
2. Possible error – 80 years,
3. Correlation with data obtained by analysis of observational platform of Metzamor (9000 BC),
4. Correlation with geological data concerning the time of drying of the so-called Araratian sea, existing in the region of modern Araratian valley, from 780000 until 11000-9000 BC,
5. Correlation with the time of cultivation of crops in Armenia about 12000 years ago.

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[16] U. V. Sayadian, The Newer Geological History of Armenia, NAS RA Gitutyun publ. House, Yerevan, 2009, p. 203-216 (in Russian).

[17] N. P. Goncharov, Domestication of Plants, Vavilov Journal of Genetics and Breeding, vol. 17, 2013, No. 4/2, p. 884 – 899.