Bull. Astr. Soc. India (1998) **26**, 67-74

On the Pre-Siddhantic evolution of the Indian calendar

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Abstract. The oldest Indian (Vedic) calendar of 7000 BC was based on the northward and southward motions of the Sun during the year, known as *Uttarāyaṇa* and *Dakṣiṇāyana* respectively. It had 12 months of 30 civil days each with an intercalary month of 30 civil days after every 6 years giving rise to the idea of a 6-year yuga. The *nakṣatras* (the lunar asterisms) were discovered after 6000 BC giving rise to a lunisolar calendar. In the earlier days it was based on a five-year cycle with two intercalary lunar months in a 5-year yuga. It was modified around 3000 BC into a 30 year *Dakṣayaṇīya* sacrificial calendar with 11 intercalary months in a span of 30 years. It was further corrected by an Agnichayan Vidhi of 95 years. *Vedānga Jyotiṣ* was most probably composed by Lagadha around 1300 BC for giving a mathematical basis for these sacrificial calendars.

Key words : solar and luni-solar calendars, intercation, *Vedānga Jyotiṣ*.

1. Introduction

India has a hoary astronomical tradition, but it is difficult to trace its development from the earliest epoch due to the lack of any systematic historical records. So one has to interpret the stray astronomical references in the Vedic literature, which covers a long period of time, by using logical reasoning. We have used this method in the previous paper in this issue, where it is shown that the antiquity of the Vedic calendar can be traced as far back as 7000 BC. Here we propose to reconstruct the step by step evolution of the Indian calendaric astronomy from that remotest epoch.

A calendar is needed for regulating the civil and religious activities of societies. In the earliest days the people had to know beforehand the proper seasons for food gathering, hunting or fishing. In the later period, when agriculture became common, they had to know the proper times for ploughing and harvesting. The periods of northward and southward movements of the sun, i.e. the *Uttarāyaṇa* and *Dakṣiṇāyana*, respectively, provide the most natural way of marking the seasonal variations during the year. Even birds make use of this phenomenon for their annual migrations. So it is not surprising that the ancient people became aware of it at an early stage of civilization, and devised a calendar on that basis. The Vedic tradition of India is a testimony to this discovery

as it was used for devising their calendar with the help of an yearly sacrifice known as *saṃvatsarasatra*. We shall now see how the Vedic calendar evolved with the passage of time (see Abhyankar 1994). The aim of this evolution has been to have a year of seasons as stated in the aphorism : *Ṛtavah saṃvatsarah*; which means the seasons make the year.

2. The earliest vedic calendar

A detailed description of the earliest vedic calendar is given by the author elsewhere (Abhyankar 1993). We shall note here only the salient points of that system as it would be the starting point of our quest for the evolution of the calendar in India.

The observations of *Uttarāyaṇa* and *Dakṣiṇāyana* by means of a gnomon has indicated that the tropical year of seasons contains roughly 360 Ahoratras (civil days), or, 720 pairs of Ahas (days) and *Rātris* (nights together) Combining this with another observed fact that the lunar phases repeat after a period of about 30 days, it was simple and convenient to divide the year of 360 days into 12 months of 30 days each, which formed the earliest Vedic calendar. This is evident from *Ṛgveda* 1-164-11 and 14, as well as Taitiriya *Brāhmana* 7.17. The calendar was regulated by the yearly sacrifice, viz, the *saṃvatsarasatra,* which was started on the winter solstice day and was divided into two semesters of 6 months each, viz., *Uttarāyaṇa* and *Dakṣiṇāyana.* The month itself was further divided into five *Saḷahas* of six days each.

A 360 day year is the crudest, or, in mathematical language, the zeroth approximation of the tropical year which contains nearly 365.25 days. In fact a similar calendar was extant in other ancient civilizations of Egypt and Persia. In order to account for the difference of 5.25 days in the year, the Vedic Indians performed Atiratra (extra nights) sacrifices of 4, 5 or 6 days at the end of the *saṃvatsarasatra* so that the sacrifice, i.e. the year, could start on the winter solstice day. The extra days were also sometimes added in two steps of 2 or 3 days at the end of each semester, which were known as rathanantara- sāmans before the summer solstice and *bṛhad-sāmans* before the winter solstice. Taitiriya Saṃhitā 7.1.10 mentions a controversy about the number of days on which Atiratra sacrifices were to be performed. It says that 4 Atiratras make the year incomplete while 6 Atiratras make it swell, so 5 Atiratras are the best for obtaining agreement with the seasons.

Once it was realised that the year contained close to 365 days, Rohit (Atharvaveda 13.3.8) introduced the concept of introducing one *adhikamāsa* (intercalary month) of 30 civil days (Ahoratras) after every six years. It may be mentioned that the practice of adding five days at the end of the year continued in Egypt, while that of adding a 30-day intercalary month was taken up in Persia. The introduction of *adhikamāsa* by Rohit naturally gave rise to the concept of a 6-year yuga in which the successive years were named : *Saṃvatsara, Parivatsara, Idāvatsara,* Iduvatsara, *Idvarsara* and *Vatsara*, respectively. However there was still a gap of a quarter day per year; so occasionally one had to add the intercalary month after 5 years by dropping the "Vatsara" year in that yuga. The most natural way to do so comes out to be a longer cycle of 40 years divided into yugas 6, 6, 6, 5, 6, 6, and 5 years, which tallied with the heliacal rising of Venus with *Aśvinī*

nakṣatra. The Persians, however, had a cycle of 120 years, which would also take into account the periods of Jupiter and Saturn.

Being a tropical calendar, the Vedic months had seasonal names and they were grouped into three seasons of 4 months each. This is a special characteristic of the monsoon climate of India, the so called *ćāturmāsya* system. We have given evidence to show that the winter solstice was inferred from the heliacal rising of *Aśvinī nakṣatra* (α and β Ari). So the year began on the 25th of December on an average as explained by the author (Abhyankar 1993). So the first season from 25th December to 24th April approximately, which covered the cold period, was appropriately called the Agni *Ṛtu* (the fire season). The next four months from 24th April to 24th August approximately, were known as Surya *Ṛtu* (the sun season) because during this period one experienced the maximum power of the sun, first in the form of severe summer and then in the form of abundant rains. The last season, which covered the period from 25th August to 24th December approximately, was called the *Chandramā Ṛtu* (the moon season), because then we have the most beautiful full moons, partly due to the clear skies and partly due to the northern position of the full moon, because of which it was seen for a longer time.

3. Discovery of the *nakṣatras*

By about 6000 BC the heliacal rising of *Aśvini nakṣatras* no longer served as a marker of the winter solstice. But the nocturnal rising of the bright star *Chitrā* (α vir) after sunset was found to coincide with the beginning of *Uttarāyaṇa*. Further it was noticed that quite often there was a full moon near *Chitrā* at that instant. So the yearly *saṃvatsarasatra* was started on the Chaitri full moon according to Taitiriya *Saṃhitā* 7.4.8. Consequently the priests started observing the position of the full moon among the stars every month, and a little later its position on every day. This led to the identification of the 28 *nakṣatras* listed in the Vedic literature. There are two verses in *Mahābhārata* (5-108-14 & 15) which point to the observational aspect of this advance.

In this passage Garuda is telling Galava about the importance of the western direction. It is said that the sun reverses its motion at this point, i.e., it moves from west to east during the night after sunset instead of from east to west as in the day. Further, it says that the stars visible near the crescent moon after sunset on S2 (2nd day of the bright half of the lunar month) enter the solar orb and disappear in that direction due to the motion of the sun among the stars. After remaining invisible for 28 days due to the proximity of the sun, the same stars reappear in the east along with the crescent moon before sunrise after *śivarātri* on K 14 (14th day of the dark half of the lunar month). Thus the moon reaches the same position among the stars on the 29th day. Hence the priests identified one star group with the position of the moon on each day, these are the 28 *nakṣatras* (asterisms) along its path. This further led to the practice of naming the day after the *nakṣatras* in which the moon was found on that day. The original 28 *nakṣatra* have been identified by the author in Table IV of Abhyankar (1991).

In the beginning only the Chaitri full moon had the particular significance that it coincided

with the winter solstice. However, about 4000 BC the precession has shifted the winter solstice to the *Phālguni* full moon between δ and β Leonis. So the yearly sacrifice was started on that day vide *Śatapatha Brāhmaṇa* 6.2.2. and Gopatha *Brāhamaṇa* 6.19. Further it became necessary to name each lunar month according to the position of the full moon among the *nakṣatras*. But since there are 12 months in a year one had to choose only 12 out of the 28 *nakṣatras* for naming the months. The logical basis of this choice is related to some prescribed limits of the position of the full moon with the help of bright stars as indicated in Table II of Abhyankar (1991).

4. Introduction of the lunar months

After the identification of the *nakṣatras* the priests started using the lunar months instead of the earlier month of 30 civil days. The lunar month itself was divided into 30 parts which are now known as tithis. They were arranged into two *pakṣas* (sides) of the month, viz., *śuklapakṣa* (the bright half) and *Kṛṣṇapakṣa* (the dark half) . The tithis were denoted by S 1 to S 15 in the *śuklapakṣa* and by K1 to K 14 and K 30 in the *Kṛṣṇapakṣa*, S 15 being known as *paurṇimā* and K 30 as *amāvāsya*. The practice of dividing the month into *śalahas* of 6 days was continued, but occasionally a *śalaha* had to be reduced to 5 days by dropping a tithi as a *kṣayatithi* due to the shorter length of the lunar month, by about half a day.

It took some time to find that 12 lunar months contained about 354 days, which fell short of the tropical year by about 12 tithis. So they introduced the 12 day *Atirātra* sacrifice at the end of 12 lunar months for bringing the year into unison with the seasons. This discovery can be attributed to the three *Ṛbhus* vide *Ṛgveda* 4.33.7. From the same hymn 4.33.5 we see that the eldest *Ṛbhu*, named *Ṛbhavan*, continued to divide the year into two semesters - *Uttarāyaṇa* and *Dakṣiṇāyana* - as before and the second *Ṛbhu* named Vibhavan, divided the year into three seasons as before, while the youngest *Ṛbhu* named *Vājā*, divided it into four parts on the basis of the four cardinal points of winter solstice, vernal equinox, summer solstice and autumnal equinox. And another set of *Gavānām Ayanam* sacrifices called *Navagvās* and *Dashagvās* lasting for 9 and 10 months were introduced by the Angiras. They were started at the autumnal equinox so as to end at the beginning of the rainy season at the summer solstice. The practice of starting the civil year at the autumnal equinox was most probably started at this time.

As the tropical year was found to be roughly in excess of 12 lunar months by 12 tithis, the difference would amount to 36 tithis in three years. So an intercalary month (*adhikamāsa*) was added at the end of the third year. As the excess rose to 30 tithis during the next two years, another *adhikamāsa* was added at the end of the fifth year. So the earlier practice of using a 6 - year yuga was replaced by a 5-year yuga system by dropping the last year 'Vatsara' and renaming the fourth year as Anuvatsara. One can continue this process indefinitely but for the fact that one would be using one extra intercalary month in about 20 years. So it was necessary to drop one intercalary month as a *kṣaya* (dropped) month at an appropriate time. It was achieved by actually observing the solar as explained below.

We have seen in the previous paper that *Mahā śivarātri* festival coincided with the advent of *Uttārayaṇa* i.e winter solstice around 3000 BC. The purpose of introducing that festival was to determine by observation the solar *nakṣatra* at the beginning of the year. Now, we cannot determine the position of the sun among the *nakṣatras* by direct observations because the stars cannot be seen in the day. So one has to observe the lunar *nakṣatra* at the end of *śivarātri* on K 14 at sunrise, and again on the following S 2 after sunset. As the moon would be one *nakṣatra* behind the sun on K 14 and one *nakṣatra* ahead on S2, the mean of the two observations can give the position of the sun among the *nakṣatra*, on the new moon day. Around 3000 BC *Śatabhiṣag* was the solar *nakṣatras* at winter solstice. So the sun should be in that *nakṣatras* sometime during the first month of the year. This is established by introducing an *adhikamāsa* at the end of certain years in the 5-year cycle. Now, if in any particular year the introduction of the *adhikamāsa* took the sun one *nakṣatra* beyond *Śatanhiṣag*, then one had to drop the next month as *Kṣayamāsa*. This was done by calling the first half of the next month by its normal name and the second half by the name of the following month.

It appears that the deities of several *nakṣatras* were fixed at this epoch. As the full moon in *Śatabhiṣag nakṣatra* represented the beginning of the rainy season at the summer solstice, Varuna, the personification of waters was made the deity of that *nakṣatra*. Similarly since the full moon near *Jyeṣṭhā* coincided with the vernal equinox and the sun entered the *Devayāna* , the northern half of the ecliptic *Jyeṣṭharāja* i.e. *Bṛhaspati* or Ganesha was made the leader of the Devas (gods).

5. The calendar of the *Dākṣāyaṇīya* sacrifice

The continued observations of *Mahāśivarātri* brought to light that the tropical year exceeded 12 lunar months by 11 tithis instead of 12 tithis. Thus there were five extra tithis in the 5-year yuga and the excess amounted to 30 tithis in 30 years. So it became clear that one had to drop one *adhikamasa* in a span of 30 years, i.e. introduce a *kṣayamāsa* in that period. Alternatively one could drop one paksa of the lunar month in a span of 15 years. The *Dākṣāyaṇīya* sacrifice of 30 years described in the *Śatapatha Brāhmaṇa* (XI. 10 to 12) was most probably introduced by *Dākṣa - Prajāpat* for this purpose.

The *Dākṣāyaṇīya* calendar was made of 360 lunar *ahorātras* (civil days), each *ahorātra* being made of the *Śuklapakṣa* of the lunar month as day and the *Kṛṣṇapakṣa* of the lunar month as night. The *pakṣas* occurring in the *adhikamāsas* were not counted for this purpose. This was supposed to be the year of the *pitṛs* (the manes) who were considered to reside on the moon. This stands to reason, because one day on the moon is in fact equal to one lunar month.

In the first half of the 30 year cycle the year was started on S 1, i.e. the first day after the new moon. Intercalary months were introduced at the ends of the 3rd, 5th, 8th 10th and 13th years as in the five-year cycle. But the *Kṛṣnaypakṣa* (the dark half) of the intercalary month coming at the end of the 15th year was dropped as *Kṛṣnaypakṣa*. And then the second half of the 30 year cycle

was started on K 1, i.e. the first day after the full moon. Thus the months were *amānta* (new moon ending) during the first half, and *paurṇimānta* (full moon ending) in the second half of the 30 year cycle. Again after introducing *adhikamāsas* at the ends of the 18th, 20th, 23rd, 25th and 28th years, the *Śuklapakṣa* (the bright half) of the intercalary month coming at the end of the 30th year was dropped as a *Kṛṣnaypakṣa*. And the calendar was restarted after completing the 30 year sacrifice.

However it was found that three *Dākṣāyaṇīya* sacrificial cycles fell short of 90 tropical years by about 5 tithis. So it was decided to use one normal 5-year cycle of 1831 days after the third cycle, to bring the calendar into unison with the seasons. This was the basis of 95-year Agnichayana Vidhi to which attention has been drawn by S. Kak (1993). A new cycle of *Dākṣāyaṇīya* was started after the Agnichayana Vidhi.

6. The *Vedānga Jyotiṣ* calendar

It is most likely that *Vedānga Jyotiṣ* was composed by sage Lagadha for regulating these two sacrificial calendars when the winter solstice position of the sun had receded from *Śatabhiṣag* (α PsA) to *ne Dhaniṣṭhā* (β Del). It replaced a simple observational procedure by a mathematical device, the first and the oldest of its kind in the world. It involved the use of round numbers for describing the positions and the motions of the sun and the moon in the first approximation and giving rules for correcting them for better accuracy.

Firstly, the number of *nakṣatras* were reduced from 28 to 27 by dropping the Abhijit *nakṣatra*. Secondly the tropical year was assumed to contain 366 civil days and 372 tithis for the purpose of approximate calculations. Thus during one yuga of 5 years one had 1830 instead of 1831 days. During this period the sun was assumed to make 5 revolutions covering a total of 135 *nakṣatras*, and the moon was assumed to complete 1860 tithis, or 62 months = 124 *pakṣas*. This giving rise to two *adhikamāsas* during 5 years or one *adhikamāsa* after every 30 lunar months. Further, since the moon completes 62 + 5 = 67 revolutions, it covers 67 × 27 = 1809 *nakṣatras* during the yuga.

Now, since the sun covers 135 *nakṣatras* in 124 *pakṣas,* Lagadha divided one *nakṣatra* into 124 parts called Bhansas (Bh°) and he took the rate of solar motion as 135 Bh° per *pakṣa* or, which is the same thing as 9 Bh° per tithi. Similarly, since the moon covered 1809 *nakṣatras* in 1830 days, or, 603 *nakṣatras* in 610 days, Lagadha divided the day into 603 Kalas (K) and took the rate of lunar motion as 610 K for one *nakṣatra*. The ratio of the length of the tithi to the length of the day was presumed to be 1830/1860 = 61/62. The day was also divided into 124 parts so that the length of the tithi came out to be 122 parts.

The *Vedānga Jyotiṣ* text also specifies the corrections (vide *Ṛgjyotiṣ* verse 12) for both : (i) the extra one day length of 62 lunations, and (ii) one less tithi in the tropical year, which has close to 365 days. The first error is corrected by extending the length of each *pakṣa* , or parva, by

(1/124) th part of a day, which is ultimately taken care of by not dropping one of the specified tithis, e.g. the last tithi K 30 at the end of the fifth year. Thus one drops 29 tithis instead of 30 as required by the assumed numbers of days and tithis in the yuga. The second correction can be explained with the help of Table 1.

Table 1. Position of the sun and the moon at the beginning of successive yugas.

Yuga No.	Tithi	Sun	Moon
1Y	0 (new moon)	N = 0 + 0 Bh°	N = 0 ± 0 Bh°
2Y	0	0 + 45	0 + 45
3Y	0	0 + 90	0 + 90
4Y	0	1 + 11	1 + 11
4Y – 1P	15 (full moon)	0 + 0	13 + 62
5Y – 1P	15	0 + 45	13 + 107
6Y – 1P	15	0 + 90	14 + 28
7Y – 1P	15	1 + 11	14 + 73
7Y – 2P	0 (new moon)	0 ± 0	0 ± 0

Y = Yuga, P = *pakṣa*

The first yuga is started on S1. i.e. the day inmediately after the new moon when the sun and the moon are at the beginning of *Dhaniṣṭhā naksatra* with N = 0 + 0 Bh° as shown in the first row of the Table 1. As we have included 5 extra tithis in five years, the sun and the moon both reach 45 Bh° beyond the starting point, i.e. at N = 0 + 45 Bh° at the beginning of the second yuga as shown in the second row of the table. Continuing in this fashion we find that the sun would return to the starting point one *pakṣa* before the normal beginning of the 4th yuga as shown in the fifth row of the table. However, it is a full moon day with the moon's position at N = 13 + 62 Bh°. So the 16th year is started on K 1 after the full moon by dropping the dark half from the *adhikamāsa*. Similarly after dropping a second paksa viz. the bright half of the *adhikamāsa* at the end of the 6th yuga, we return to the original position of the sun and moon as shown in the last row of the table. This is exactly what is done in the *Dākṣāyaṇīya* sacrifice. And the Agnichayana Vidhi makes the final correction after three *Dākṣāyaṇīya* cycles.

In the article by P. V. Holay in this issue (see also Holay 1994) he has argued that *Vedānga Jyotiṣ* contains a calendar based on the 19th year Metonic cycle. But we are of the opinion that it is related to the two sacrifices mentioned by us for the following reasons :

1. Holay assumed that the first 18 years contained 371 tithis and the 19th year was a leap year with 372 tithis; but there is no such provision in the text.

2. Holay has correctly interpreted *Rgjyotiṣ* verse 14 as giving the lunar *nakṣatras* at the beginning of each semester with the rule that the moon goes ahead of the sun by five *nakṣatras* per semester very nearly. This would give at the end of 1st 15th year an excess of 150 *nakṣatras* , i.e. five revolutions and 15 *nakṣatras*. However, we see from the 5th row of Table 1 that the difference of

the true and approximate position of the moon has already become more than one *nakṣatra.* Hence there is no need to wait for 19 years to make the correction as suggested by him. *Ṛgjyotiṣ* verse can be applied again from the 16th year.

3. The difference between *Yājusjyotiṣ* verse 6 and *Ṛgjyotiṣ* verse 5 can be explained as follows. The former represents the beginning of the yuga in the first half of the 30-year cycle and the latter represents the beginning of the yuga in the second half.

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