PL ISSN 0860-6102
ACTA ASIATICA VARSOVIENSIA
No. 34, 2021

Calendrical Terminology in the Early Vedic Astronomical Treatises of the *Jyotiṣavedāṅga*

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Abstract: Knowledge of Vedic time reckoning was preserved in the *Ṛk*- and *Yajurveda* recensions of the *Jyotiṣavedāṅga*. Most of the verses of the two treatises convey the same meaning and provide a lecture on the measurement of time and its division. Some basic mathematical operations are also applied in order to calculate specific data important for the performance of Vedic ritual. This paper discusses some of the stanzas and examines the terminology applied for the sake of time reckoning.

Keywords: *jyotiṣa*, Vedic calendar, calendrical terminology, Vedic astronomy, *jyotiṣavedāṅga*, time reckoning

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1. Introduction

The oldest preserved treatises on *jyotiṣa* are two recensions, *Ṛgvedajyotiṣavedāṅga* (*ṚJV*) and *Yajurvedajyotiṣavedāṅga* (*YJV*), likely composed in the 5th–3rd centuries BC[1] and associated with *Ṛgveda* or *Yajurveda,* respectively. The first, considered older, is composed of 36 stanzas, and the latter of 43, but most of them are shared by both recensions.[2] A few of the shared stanzas differ in words but convey the same meaning. The authorship of both treatises is attributed to sage Lagadha or his disciple Śuci.[3]

[1] The absolute chronology of the *Jyotiṣavedāṅga* has been a bone of contention between European and Indian scholars. Sen, Weber, Pingree, and Müller agree that the work was composed before Common Era. Sen 1971: 78 dates *ṚJV* as not earlier than the 7th–6th cent. BC, Weber 1852: 222 places it in the 5th cent. BC, Pingree 1981: 10 in the 5th–4th cent. BC, and Müller 1862: 16 believes it was composed in the 3rd cent. BC. Filliozat considers it later, composed between the 4th cent. BC and the 2nd cent. AD (see Sen 1971: 78). Others recognise the work as much earlier. Narahari Achar 2000: 173 dates it back to the 18th cent. BC, while Sarma 1985: 13 and Dixit 1969: 87 to the 14th cent. BC.

[2] See Weber 1862: 2, cf. Narahari Achar 1997: 21.

[3] See Narahari Achar 1997: 21.

The content of the treatises is threefold and can be divided into the following categories: (1) socio-religious (praise of the deities, reference to ritual, social practices, and authorship of the text), (2) mathematical (units of time and their proportions, rudimentary calculations) and (3) astronomical (celestial phenomena, movement of the Sun and the Moon in the sky, sky topography, characteristics of the five-year lunisolar cycle, i.e. *yuga*). Although the astronomical knowledge recorded in both recensions is rudimentary, it conveys complex yet interesting concepts, like *nakṣatra* and *tithi*, presented later in the article.

According to the *ṚJV* 35[4] '*jyotiṣa* distinguishes itself among the limbs of the Veda, as do the crests of the peacocks [and] the jewels on the heads of the *nāga*s.'[5] This work belongs to the Vedāṅga text corpus and conveys knowledge of the Vedic period in the field of *jyotiṣavedāṅga*. However, its shade of meaning is fairly comprehensive, as *jyotiṣa* translates as 'the science of the movements of the heavenly bodies and divisions of time dependant thereon',[6] 'astronomical science',[7] 'astronomy'[8] or 'mathematical, astronomical, and astrological science, astronomy, astrology'.[9] Given its wide scope and development, *jyotiṣa* is divided into three minor branches (*skandha*s) in later astronomical works.[10] Varāhamihira, in his work *Bṛhatsaṃhitā*, introduces the following *skandha*s: *saṁhitā* ('connected with, agreeing with, conformable with' → study of omens), *horā* ('hour, horoscope' → divination, astrology), and *gaṇita* ('counted, calculated, reckoned' → astronomy).[11] Of these three sub-disciplines, only one can be considered *scientific*,[12] that is *gaṇita*. The other two are less precise and rely rather on guesswork, prediction, and interpretation of some events, despite the mathematical apparatus sometimes applied in such activities.[13] Although *ṚJV* 35 seems to refer to the overall term and hence to this broad scope of knowledge, the *YJV* specifies the character of the work as belonging to *gaṇita-skandha*, i.e. astronomy. In the *YJV* 4,[14] identical to the

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4 *ṚJV* 35: *yathā śikhā mayūrāṇāṃ nāgānāṃ maṇayo yathā /*
tad vad vedāṅgaśāstrāṇāṃ jyotiṣaṃ mūrdhani sthitam //.

5 Unless otherwise stated, all translations of the source texts were made by the author.

6 MONIER-WILLIAMS 1899: 427.

7 BENFEY 1866: 341, MACDONELL 1893: 103.

8 CAPPELLER 1891: 191.

9 WILSON 1832: 356.

10 PINGREE 1981: 1, cf. SUBBARAYAPPA and SARMA 1985: 2.

11 SUBRAHMANYA and BHAT 1946: 4.

12 *Scientific* as based on any investigation by systematic methods and principles of science.

13 See PINGREE 1981: 8.

14 *YJV* 4: *yathā śikhā mayūrāṇāṃ nāgānāṃ maṇayo yathā /*
tad vad vedāṅgaśāstrāṇāṃ gaṇitaṃ mūrdhani sthitam //.

ṚJV 35, the word *jyotiṣa* is replaced with *gaṇita* thus its astronomical character is emphasised. Probably the other *skandha*s developed later when *jyotiṣa* (at the early stage particularly *gaṇita*) had already established its own theories and primary research methodology. Its high position among the *vedāṅga*s presumably comes from the close relationship between Vedic ritual and setting the time of its performance. This relationship is emphasised in the *ṚJV* 3 and *ṚJV* 36:[15]

> I will proclaim in order the entire [knowledge of] the movements of heavenly bodies, highly respected by *brāhman*s, [composed] to establish the proper time of the ritual. […] For the Vedas were advanced for the sake of the ritual and the rites were arranged according to the time [of their performance], therefore he who knows *jyotiṣa*, the knowledge of the measurement of time, knows the sacrifice.

Jyotiṣa, as well as other *vedāṅga*s, is considered to form primary scientific knowledge.[16] As a scientific discipline, it should have its own terminology and methodology, although, considering the date of its composition, both could be quite rudimentary. Hence the aim of this paper is to establish whether Vedic astronomers introduced a *jargon* that formed the astronomical/calendrical lexicon of the early Vedic period. In order to provide the background for this discussion, the author performs textual analysis of chosen passages from the early *jyotiṣa* treatises. Translation of these passages is done by the author based on a philological approach. As a result, a primary astronomical/calendrical *lexis* is proposed and discussed in the section 'Calendrical Terminology'.

2. Elements of the Vedic Calendar

The elements of the Vedic calendar explained in both recensions of the *Jyotiṣavedāṅga* can be divided into two groups: (a) topographic, i.e. concerning sky topography and phenomena observable in the sky, and (b) calendrical, i.e. time reckoning resulting from the observation of the movement of celestial bodies.

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[15] *ṚJV* 3, 36: *jyotiṣām ayanaṃ kṛtsnaṃ pravakṣyāmy anupūrvaśaḥ /*
viprāṇāṃ sammataṃ loke yajñakālārthasiddhaye // [...]
vedā hi yajñārtham abhipravṛttāḥ kālānupurvyā vihitāś ca yajñāḥ /
tasmād idaṃ kālavidhānaśāstraṃ yo jyotiṣaṃ veda sa veda yajñāḥ //.
These stanzas are shared with the *YJV* 2, 3 with few differences. The *YJV* 2 has *puṇyaṃ* instead of *kṛtsnaṃ* in the first *pāda* and differs in the third *pāda* which is as follows: *sammataṃ brāhmaṇendrāṇāṃ*. The fourth *pāda* of the *YJV* 3 has *yajñam* instead of *yajñāḥ*.

[16] Kak 1997: 399.

2.1. The Sky Topography

Astronomical observations from Vedic times were limited to studying the movements of the Sun and the Moon along their paths; planetary movements were not then considered by astronomers.[17] Thus, the first group (a) includes the terms for the sky, stars, the Sun and the Moon with their orbits. Together, they form the sky topography.

The most general, yet fundamental list of the topographic elements of the Vedic sky is given in the *ṚJV* 30 (*YJV* 43):[18]

> ***somasūryastṛ****caritaṃ lokaṃ loke ca sammatim /*
> ***somasūryastṛ****caritaṃ vidvān vedavid aśnute //*
>
> Versed in the Vedas [and] skilled in [the knowledge of] the movements of **the Moon**, **the Sun**, and **stars** reaches the world in which **the Moon**, **the Sun**, and **stars** reside [and] is highly valued in the world.

These elements are the stars (*stṛ*), the Sun (*sūrya*), and the Moon (*soma*). The terms for the Sun and the Moon also serve as names of personified Vedic deities. Such an association with Vedic mythology and tradition may emphasise the importance of this *vedāṅga* and its close connection with ritual, especially given that this stanza praises astronomers (or *brāhman*s learned in *jyotiṣa*). Their positions in the sky were marked with a reference to the stars, and more specifically to *nakṣatra*s.[19] The term *nakṣatra* occurs in the *ṚJV* 28 (*YJV* 35) in a socio-religious context:

> ***nakṣatra****devatā etā etābhir yajñakarmaṇi /*
> *yajamānasya śāstrajñair nāma* ***nakṣatra****jaṃ smṛtam //*
>
> […] these are the residing deities [and beings] of the ***nakṣatra*s**. [It is said] by these learned in sacrificial rites that the sacrificer's name [should be] associated with the ***nakṣatra*** one was born under.

It introduces an important[20] custom according to which the names of newborns were associated with the *nakṣatra* or its deity. This stanza is preceded

[17] See ASHFAQUE 1977: 151.

[18] *ṚJV* 30 is identical to *YJV* 43 however the latter is slightly corrupted. They differ in the second *pāda* where in the *YJV* there is *santati* instead of *sammati*, which makes the meaning unclear.

[19] Indian astronomers divided a space of width determined by the arc measure of 13°20' along the ecliptic into 27 (or 28) equal parts and called them *nakṣatra*s. These were further divided into 124 smaller parts (*aṃśa*s). Together, they formed a conventional reference system used to determine positions of both the Sun and the Moon moving against the fixed background of the sky. See SEN 1971: 574 and BASHAM 1954: 492, cf. SUBBARAYAPPA and SARMA 1985: 104, and ASHFAQUE 1977: 151.

[20] The importance and significance of this tradition are testified by the continuity of its observance up to date. See SHARMA 2005: 36–40, cf. GATRAD et al. 2005: 1095–1096.

by enumeration of the names of the deities and class of beings residing over 27 *nakṣatra*s.[21] *Nakṣatra*s are listed in a prior stanza that is the *ṚJV* 14 (*YJV* 18):[22]

jau drā ghaḥ khe śve 'hī ro ṣā cin mū ṣa ṇyaḥ sū mā dhā ṇaḥ /
re mṛ ghrāḥ svā 'po 'jaḥ kṛ ṣyo ha jye ṣṭhā itt ***ṛkṣā*** *liṅgaiḥ //*

Aśvinī, Ārdrā, Pūrvaphalgunī, Viśākhā, Uttarāṣāḍhā, Uttarabhādrapadā, Rohiṇī, Āśleṣā, Citrā, Mūla, Śatabhiṣak, Bharaṇī, Punarvasū, Uttaraphalgunī, Anurādhā, Śravaṇa, Revatī, Mṛgaśīras, Maghā, Svātī, Pūrvāṣāḍhā, Pūrvabhādrapadā, Kṛttikā, Puṣya, Hasta, Jyeṣṭhā, Śraviṣṭhā– [these are] **the lunar mansions** with [their] signs.

The enumeration does not follow any order and is given only by the *designata*.[23] They are here referred to as lunar mansions (*ṛkṣa*). This highlights a close and clear connection between the stars (and consequently *nakṣatra*s) with the Moon, which moves against the fixed background of the sky, residing in successive *nakṣatra*s and reaching fullness in them recurrently.

A few more terms for the Sun (*sūryā*, *arka*) and the Moon (*soma*, *candramas*) are mentioned in the *ṚJV* 5–6 (*YJV* 6–7):

svar *ākramete* ***somārkau*** *yadā sākaṃ savāsavau /*
syāt tadādi ***yugaṃ*** *māghas tapaḥ* ***śuklo'yanaṃ*** *hy udak //*

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[21] The list is as follows: 'Agni, Prajāpati, Soma, Rudra, Aditi, Bṛhaspati, Sarpas, Pitṛs, Bhaga, Aryaman, Savitā, Tvaṣṭā, Vāyu, Indrāgnī, Mitra, Indra, Nirṛti, Āpas, Viśvedevas, Viṣṇu, Vasus, Varuṇa, Ajaekapād, Ahirbudhnya, Pūṣā, Aśvinas and Yama are residing deities of asterisms....' [*ṚJV* 25–27 (*YJV* 32–34): *agniḥ prajāpatiḥ somo rudro 'ditir bṛhaspatiḥ /*
sarpāś ca pitaraś caiva bhagaś caivāryamāpi ca //
savitā tvaṣṭātha vāyuś cendrāgnī mitra eva ca /
indro niṛrtir āpo vai viśve devās tathaiva ca //
viṣnur vasavo varuṇo 'ja ekapāt tathaiva ca /
ahirbudhnyas tathā pūṣā aśvinau yama eva ca //].

[22] Some *designata* are (mis)written in both recensions. Instead of *gaḥ* (Pūrvaphalgunī) and *ṇyaḥ* (Bharaṇī) given in the second *pāda* of the *ṚJV* 14, there are *ghaḥ* and *yaḥ*, respectively, in the *YJV* 18. In turn, there is *ghrāḥ* in the third *pāda* of the *ṚJV* 14 instead of *ghā* (Maghā) as in the *YJV* 18. There is probably a misspelling in *ittṛkṣā* (*ityṛkṣā* is correct). Cf. *YJV* 18:
jau drā ghaḥ khe śve hī ro ṣā cin mū ṣaṇ yaḥ sū mā dhā ṇaḥ /
re mṛ ghā svā po jaḥ kṛ ṣyo ha jye ṣṭhā ity ṛkṣā liṅgaiḥ //.
Both recensions note the *designatum* of Śatabhiṣak incorrectly. The proper (*ṣak*) is given in Dvivedin 1908 in his edition of *Jyotiṣavedāṅga*, however it (incorrectly) marks Āśleṣā with *ṣāś* and Maghā with *ghāḥ* (*jau drā gaḥ khe śve hī ro ṣāś cin mū ṣak ṇyaḥ sū mā dhā ṇaḥ / re mṛ (mre) ghāḥ svā po jaḥ kṛ ṣyo ha jye ṣṭhā ity ṛkṣā liṅgaiḥ //*). For the proper list of *designata* see Dixit 1969: 72.

[23] For the list of *nakṣatra*s with their *designata* see Dixit 1969: 72 and Sarma 1985: 56. For the comparison of Indian *nakṣatra*s and European constellations see Basham 1954: 492.

*prapadyete śraviṣṭhādau s**ūryācandramasāv** udak /*
*sārpārdhe dakṣiṇ**ārkas** tu māghaśrāvaṇayoḥ sadā //*

When **the Sun** and **the Moon**, accompanied with Vāsava, rise together in **the sky**, [then] with this begin a ***yuga***, [the lunar month of] Māgha, [the solar month of] Tapas, **the bright** [fortnight], and the northern **pathway** [of the Sun]. **The Sun** and **the Moon** move northwards [when situated] at the beginning of Śraviṣṭhā [and] southwards [when situated] in the middle of Āśleṣā. [In the case of] **the Sun**, [this happens] always in Māgha and Śrāvaṇa, [respectively].

The Sun and the Moon were recognised as the only moving celestial bodies in the Vedic period and were believed to occupy a part of the sky called *svar*. *Svar* was also considered the abode of the gods, and therefore both deities, the Moon and the Sun, could walk within this space in their personified forms.[24]

The aforementioned stanzas also explain the arrangement of the *nakṣatra*s, the Sun and the Moon in the sky at the time when the periodic five-year cycle (*yuga*) begins (*ṚJV* 5 and *YJV* 6) and on the solstices when the Sun changes the direction of its movement in the sky (*ṚJV* 6 and *YJV* 7). Between two successive solstices, the Sun advances along one of the two pathways (*ayana*s), the northern and the southern parts of its ecliptic.[25] The time needed for the Sun to cover one path equals half a year and may be called *ayana* as well.[26]

2.2. Time Reckoning

Observation of the repetitive phenomena in the sky enabled the Vedic astronomers to divide the time and arrange such divisions (b) in definite order for the sake of the religious observances and regulation of daily activities.[27] Such a system of time reckoning was based on a five-year cycle (*yuga*) in which all phenomena in the sky visible with the unaided eye are repeated. The further division of the *yuga* is explained in the *ṚJV* 1 (*YJV* 1) and *ṚJV* 32 (*YJV* 5):

*pañca**saṃvatsara**mayaṃ **yugā**dhyakṣaṃ prajāpatim /*
***dinartvayanam** āsāṅgaṃ praṇamya śirasā śuciḥ // […]*
*māghaś**ukla**pravṛttasya pauṣa**kṛṣna**samāpinaḥ /*
***yugasya** pañca**varṣasya** kālajñānaṃ pracakṣate //*

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[24] MACDONELL 1893: 371, MONIER-WILLIAMS 1899: 1281, WILSON 1832: 962.

[25] These were called *dakṣiṇāyana* and *uttarāyana*, respectively. See SEN 1971: 63, cf. DIXIT 1969: 23.

[26] BENFEY 1866: 46, CAPPELLER 1891: 39, MACDONELL 1893: 50, MONIER-WILLIAMS 1899: 84, WILSON 1832: 64.

[27] See MALINOWSKI 1927: 203.

> Having bent before Prajāpati, the lord of a five-**year** ***yuga*** comprised of **days**, **seasons**, and **half-years**, [I] Śuci […]. [Scholars] declare the knowledge about the [division of] time within a five-**year** ***yuga*** commencing with the **bright** [fortnight] of [the lunar month of] Māgha and concluding with the **dark** [fortnight] of [the lunar month of] Pauṣa.

A *yuga* is comprised of five years (*saṃvatsara*, *varṣa*), seasons (*ṛtu*), half-years (*ayana*), and days (*dina*). A year is divided into lunar months and a lunar month into two fortnights: bright (*śukla*) and dark (*kṛṣṇa*).[28] However, this is quite a general statement, without more specific details on how many days count in a month or months in a year. *YJV* 28 amplifies the information on the division of a year marked by the journey of the Sun along its ecliptic:

> *triśyaty* ***ahnām*** *saṣaṭṣaṣṭair* ***abdaḥ*** *ṣaṭ ca****rtavo'yane*** */*
> ***māsā*** *dvādaśa* ***sūryāḥ*** *syuḥ etat pañcaguṇaṃ* ***yugam*** *//*
>
> A [solar] **year** [comprises of] three hundred and sixty-six **days** and six **seasons**, two **half-years**, [and/or] twelve **solar months**. This repeated five times [makes] a ***yuga***.

Unlike the aforementioned stanzas, the *YJV* 28 lists time units that only depend on the movement of the Sun in the sky.[29] Thus, the full ecliptic cycle of the Sun, the solar year (*abda*), is divided into two half-years (*ayana*), six seasons (*ṛtu*), and twelve solar months (*sūrya māsa*). Accordingly, two solar months correspond to one season. A solar year (*abda*) comprises also of 366 civil days (*ahan*),[30] which gives 61 days per season or 30.5 days per solar month (*sūrya māsa*).

Sidereal days amount to sidereal months and other lunar time divisions as given in the *ṚJV* 19:[31]

> […] ***staryān māsān*** *ṣaḍ abhyastān vidyāc* ***cāndramasān ṛtūn*** *//*
> […] multiply the **starry** (=sidereal) **months** by six, the result will be **lunar** (=synodic) **seasons**.

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[28] The fortnights reflect the progress of the lunar phases. The Moon waxes during the *śukla* fortnight and wanes during the *kṛṣṇa* fortnight. See Freed and Freed 1964: 68.

[29] *ṚJV* 1 (*YJV* 1) were rather general while *ṚJV* 32 (*YJV* 5) mention the names of lunar months and their division into *śukla* and *kṛṣṇa* fortnights.

[30] See Sen 1971: 78.

[31] There is *svārkṣān* instead of *staryān* in Dvivedin's edition of *Jyotiṣavedāṅga*: […] *svārkṣān māsān ṣaḍ abhyastān vidyāc cāndramasān ṛtūn* // ['multiply own stellar (=sidereal) months by six, the result will be lunar (=synodic) seasons']. See Dvivedin 1908: 65.

The adjective 'starry' (*starya* << *stṛ* 'a star') highlights the Moon's relation to stars, i.e. its position against their background, thus starry month (*starya māsa*) is another name for a sidereal month. For the lunar seasons (*cāndramasa ṛtu*), they are not identical to solar seasons.[32] Their number is six times as much as the number of sidereal months in a *yuga*, which is 402. However, they were not as applicable as the Sun's seasons, marked by its movement along the ecliptic.[33]

This movement along one of the pathways (*ayana*s) lasted six months, which were further divided into three solar seasons, six solar months, and then civil days (*dina*, *ahan*). One more term for a day is referred to in the *YJV* 39 (*ṚJV* 18):[34]

> *sasaptakaṃ* ***bha****yuk* ***somaḥ sūryo dyūni*** *trayodaśa /*
> *navamāni ca pañc****āhnaḥ*** *[…] //*
>
> **The Moon** [1: during a *yuga* or 2: within a day] is connected with (=resides in) **lunar mansions** for seven more times [than 1: sixty or 2: the length of the civil day], **the Sun** [stays in a lunar mansion] for 13 and 5/9ths of a **day** […]

The second and third *pāda* of this stanza determine the number of days (*ahan*, *dyūni* → *div*) that elapse while the Sun measures off one *nakṣatra* (*bha*) during its journey along the ecliptic. However, the very first *pāda* can be understood twofold.

Firstly, as an explanation of the number of coincidences of the Moon with *nakṣatra*s (*bha*) within a *yuga*. Such coincidences determine sidereal months[35] and their number equals 67, while the number of noticeable synodic months[36] is 60.[37] Hence the difference in the number of sidereal and synodic months equals

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[32] *Ṛtu,* however associated with a season, is considered rather a unit of distance than time. As SARMA 1985: 38 explains it is 'the period of the Sun or Moon moving through 4 ½ segments' of the stellar frame, i.e. *nakṣatra*s. Cf. *ṚJV* 9 (*YJV* 10): […] *ardhapañcamabhas tv ṛtuḥ* // ['[…] one season equals four and a half parts of *nakṣatra*s'].

[33] See SARMA 1985: 38.

[34] This stanza is shared with *ṚJV* 18 however there is a possible misspelling in the third *pāda* of the *ṚJV* 18 ('bhā' → *navabhāni* instead of 'mā' → *navamāni*). Thus, the stanza of the *YJV* is considered correct because it adds up to the total number of days (*navama* means 'ninth'). However, *bhāni* might be deceptive as it refers to an asterism (*bha* means 'star, planet, asterism, lunar asterism or mansion').

[35] A sidereal month is 'the time needed for the Moon to return to the same place against the background of the stars' (BRITANNICA 2011, 'month') that is to come across all lunar mansions. It is divided further into thirty sidereal days (SEN 1971: 73).

[36] A synodic month equals the time of a 'complete cycle of phases of the Moon' (BRITANNICA 2011, 'month'). Cf. RIDPATH 1997: 466.

[37] However, there are 62 synodic months in a *yuga*, two of which were added to the noticeable

seven (**7** = $67^{\text{sidereal months}} - 60^{\text{synodic months}}$). A *yuga* is comprised of both lunar time units however the sidereal ones were less significant for the calculations of the Vedic calendar and the performance of the ritual.

Secondly, it may be understood as the relationship between solar and lunar time units. According to *jyotiṣa,* a civil day is comprised of smaller time units, *inter alia*, 603 *kalā*s.[38] Considering the length of the civil day and the compliance between the Moon's occupation of *nakṣatra* and the length of a sidereal day, it can be assumed that this stanza explains the difference between a civil day (solar reckoning) and a sidereal day (lunar reckoning). In such a case, the latter is seven units (*kalā*s) longer than the former, which makes a sidereal day of 610 *kalā*s (**7** = $610^{\text{sidereal day}} - 603^{\text{civil day}}$). *YJV* 39 (*ṚJV* 18) proves the dual nature of ancient Indian time reckoning as it combines both lunar- and solar-based time units.

Another lunar-based time unit was synodic days (*tithi*s), derived from the lunation, i.e. the time elapsing between successive phases of the moon. There were thirty *tithi*s in a synodic month and fifteen in each fortnight. They were named after the ordinals.[39] According to Sen 1971: 73, synodic days were calendrical tools of 'not much astronomical significance except as an artificial division of the lunation.' However, they were useful for the sake of rituals[40] as well as for establishing the days of the important moon phases or equinoxes, as given in *ṚJV* 31:

> ***viṣuvaṃ*** *tad guṇaṃ dvābhyāṃ rūpahīnaṃ tu ṣaḍguṇam /*
> *yal labdhaṃ tāni* ***parvāṇi*** *tathārdhaṃ sā* ***tithir*** *bhavet //*
>
> Double the **equinox** (=the equinoctial ordinal) and subtract one. Multiply [this] by six. [The number of] **full and new moons** [that have passed] are obtained. Half of this [number] gives the **lunar day** [at the end of which the equinox occurs].

This stanza gives a mathematical formula for determination of the ordinal of the sidereal day (*tithi*) on which the equinox (*viṣuvat*) occurs. By means

number of 60 months. Such an emendation was necessary to align two calendars, based on solar and lunar observations. See Sen 1971: 78 and Narahari Achar 1997: 21.

38 The relationship between diurnal time units is given in the *jyotiṣavedāṅga*: '10 and 1/20ths *kalā*s are equal to *muhūrta* that comprises [also] of two *nāḍika*s, [and] thirty times this [=*muhūrta*] makes a day which is equal to 603 *kalā*s' [*ṚJV* 16 (*YJV* 38): *kalā daśa saviṃśā syāt dve muhūrtasya nāḍike / dyutriṃśat tat kalānāṃ tu ṣaṭchatī tryadhikaṃ bhavet //*]. For the division of a civil day see also Sen 1971: 78. Cf. Thibaut 1877: 419.

39 See Ashfaque 1977: 153, Basham 1954: 494, and Sen 1971: 73. Cf. Narahari Achar 1997: 21.

40 See Monkiewicz 2021: 137–155.

of the ordinal of the equinox, the number of new and full moons (*parvan*) is obtained. A similar stanza can be found in the *YJV*. Much as its meaning is similar to that of the *ṚJV* 31, the *YJV* 23 differs slightly in wording (especially in the third and fourth *pāda*):

> ***viṣuvantaṃ*** *dvir abhyastaṃ rūponaṃ ṣaḍguṇīkṛtam /*
> ***pakṣā*** *yad ardha* ***pakṣāṇāṃ tithiḥ*** *sa* ***viṣuvān*** *smṛtaḥ //*
>
> Double the **equinox** (the equinoctial ordinal) and subtract one. Multiply [this] by six. [The number of] **fortnights** [that have passed are obtained]. A half [of the number of] **fortnights** [gives] the lunar day termed an **equinox**.

The first verse conveys exactly the same meaning. The second explains the method to obtain the sidereal day (*tithi*) of the equinox (*viṣuvat*) as well, but by means of fortnights (*pakṣa*). The similarity of the two stanzas (*ṚJV* 31 and *YJV* 23) comes from the use of convergent time units. In a synodic month, there are two *parvan*s, a new moon and a full moon. The time that elapses between them is fifteen days, which corresponds to a fortnight (*pakṣa*). Thus, the method of calculating equinoctial *tithi* in both stanzas is the same; the difference is due to consideration of particular synodic days (*ṚJV* 31) or synodic half-months (*YJV* 23).

However, if one wishes to omit the calculations, it is possible to refer to the *ṚJV* 33, which gives the exact *tithi*s on which successive equinoxes occur as the *yuga* progresses:

> *tṛtīyāṃ navamīṃ caiva* ***paurṇamāsīm*** *athāsite /*
> *ṣaṣṭhīṃ ca* ***viṣuvān*** *prokto dvādaśīṃ ca samaṃ bhavet //*
>
> The **equinox** is proclaimed to occur on the third and ninth lunar days, and on the **day of the full moon** [of the bright fortnight, then] on the sixth and twelfth lunar days [of the dark fortnight]. [This] happens twice [in a *yuga*].

The equinox (*viṣuvat*) occurs on a particular *tithi*s, most of which are named after their ordinals. The *tithi* of the full moon bears a special name (*paurṇamāsī*), which emphasises that it is the day of the month associated with the full moon.[41]

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[41] The name *paurṇamāsī* is a compound of *paurṇa* (<< *pūrṇa* 'filled with, full of') and *māsī* (a day of the month << *māsa* 'a month' or *mās* 'a month, the moon'). Cf. MONIER-WILLIAMS 1899: 814, 642; WILSON 1832: 549, 660; MACDONELL 1893: 167, 227; CAPPELLER 1891: 324, 409 and BENFEY 1866: 705.

Aside from establishing the *tithi* of the equinox and observing the recurring phenomena in the sky, Vedic astronomers were aware of the regular change in the length of the civil day. This progress was of vital importance due to the daily life cycle and activities undertaken during the daytime, such as tillage or household chores. The problem of the length of daytime is recorded in the *ṚJV* 7 (*YJV* 8):

> ***gharmavṛddhir*** *apāṃ prasthaḥ* ***kṣapāhrāsa*** *udag gatau /*
> *dakṣiṇe tau viparyāsaḥ ṣaṇ* ***muhūrty ayanena*** *tu //*
>
> Increase of the heat (=**daytime**) equals [a measure of] one *prastha* of water, [which is also a measure of] **the decrease of the nighttime**. Both [take place] when [the Sun is on its] northern path [and] when [moving] towards the south [the duration of a day changes] contrarily. The lapse [of the increase] is six ***muhūrta*s** within [each] **pathway of the Sun** (=half-year).

It had long been noticed that the length of the daytime (*gharma*), understood as the time between sunrise and sunset, draws in and out between solstices, that is within half a year (*ayana*). And the length of the nighttime (*kṣapā*) changes at the same rate. Therefore, the increase (*vṛddhi*) of the time is equal to its decrease (*hrāsa*) and amounts to six *muhūrta*s (one *muhūrta* equals 48 minutes).[42] This lapse was measured by means of the water in *prastha*s, a unit of quantity or capacity.[43] The flow of time was not only admeasured but also calculated. The formula for estimation of the length of any day in a year is given by *ṚJV* 22 (*YJV* 40):[44]

> *yad* ***uttarasyāyanato*** *gataṃ syāc cheṣaṃ tu yad* ***dakṣiṇato'yanasya*** */*
> *tad ekaṣaṣṭyā dviguṇaṃ vibhaktaṃ sadvādaśaṃ syād* ***divasapramāṇam*** *//*
>
> What has passed after the **northern pathway of the Sun** [or] is left in the **southern pathway of the Sun**, divided by sixty-one, then doubled [and] increased by twelve produces the **length of a day**.

The formula is as follows: the time that has passed after the day on which the Sun completed its journey along the northern pathway (*uttarāyaṇa*), the summer solstice, must be multiplied, divided and increased accordingly to get the length of the daytime (*divasapramāṇa*). Similarly, if the Sun covered the southern path (*dakṣiṇāyana*), the time that has elapsed after the winter solstice should be applied.

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[42] Kak 1998: 32.

[43] See Monier-Williams 1899: 699, Wilson 1832: 583, Macdonell 1893: 183, Cappeller 1891: 348 and Benfey 1866: 610.

[44] *ṚJV* 22 is identical to *YJV* 40 with one exception. *YJV* has *tathā* instead of *yad* in the second *pāda*.

3. Calendrical Terminology

The stanzas discussed in the previous part of the article introduce the basic ideas and terms of early Vedic astronomy termed *jyotiṣa* (*ṚJV* 35; *ṚJV* 3, 36 [*YJV* 2, 3]), or more precisely *gaṇita* (*YJV* 4). The names and concepts presented there can be distinguished due to various factors, considering their relationship with time or space, or with a particular celestial body.

The article proposes four groups of calendrical terminology that include vocabulary relating to: (a) sky topography and phenomena visible in the sky, (b–c) time units, and (d) quality (adjectives). The vocabulary is grouped in tables. In each table, there are words belonging to the particular group (a–b), their Sanskrit names, and references to the stanza in which they occur.

3.1. Celestial Phenomena and the Sky Topography

Among the vocabulary describing the topography of the sky, there are those words that refer to its static or moving elements. This first group is comprised of words for stars (2. row in **Table 1**), parts of the ecliptic (3.–5.), pathways of the Sun (9.), and the sky itself (1.). The second group includes different names for the Sun (6.–8.) and the Moon (10.–11.) as well as the phenomena resulting from noticeable changes in the lunar phases (12.–13.).

Table 1. Calendrical terminology due to the sky topography and celestial phenomena

No	Element of the sky	Term	Occurrence in the treatises
1.	the sky	*svar*	*ṚJV* 5 (*YJV* 6)
2.	a star	*stṛ*	*ṚJV* 30 (*YJV* 43)
3.	1/27th of the ecliptic	*nakṣatra*	*ṚJV* 28 (*YJV* 35)
4.		*ṛkṣā*	*ṚJV* 14 (*YJV* 18)
5.		*bha*	*ṚJV* 9 (*YJV* 10), *ṚJV* 18 (*YJV* 36)
6.	the Sun	*sūryā*	*ṚJV* 18 (*YJV* 36), *ṚJV* 30 (*YJV* 43)
7.		*sūrya*	*ṚJV* 6 (*YJV* 7)
8.		*arka*	*ṚJV* 5–6 (*YJV* 6–7)
9.	the pathway of the Sun (the half of the ecliptic)	*ayana*	*ṚJV* 5 (*YJV* 6), *ṚJV* 22 (*YJV* 40)

No	Element of the sky	Term	Occurrence in the treatises
10.	the Moon	*soma*	*ṚJV* 5 (*YJV* 6), *ṚJV* 18 (*YJV* 36), *ṚJV* 30 (*YJV* 43)
11.		*candramas*	*ṚJV* 6 (*YJV* 7)
12.	moon phase (full moon or new moon)	*parvan*	*ṚJV* 31 (*YJV* 23)
13.	full moon	*paurṇamāsī*	*ṚJV* 33

Altogether, there are six terms for the (static) sky elements, i.e. topography (1.–5., 9.), two for celestial phenomena (12.–13.), and five for moving elements of the Vedic sky: three for the Sun (6.–8.) and two for the Moon (10.–11.). Hence these elements are solar (6.–9.; four terms in total), lunar (10.–13.; four terms), or stellar (1.–5.; five terms).

3.2. Calendrical Time Reckoning

The first group of time units proposed in the article is comprised of those that allowed time reckoning and arranging it in a calendrical system applied to organise the life of societies in accordance with their customs or everyday practice.[45]

The Vedic calendar was based on a five-year cycle called *yuga* (1. row in **Table 2**), and the *yuga* comprised of five years (2.–4.). A year was divided into two half-years (5.) or seasons (6.).[46] The year consisted also of months (7.), their number varied depending on whether the solar, sidereal or synodic months were considered. Each month was divided into days (11.–16.) or in the case of synodic measures also into fortnights (8.–10.).

Table 2. Calendrical terminology due to the calendrical time reckoning

No	Time unit	Term	Occurrence in the treatises
1.	a five-year cycle	*yuga*	*ṚJV* 1 (*YJV* 1), *ṚJV* 5–6 (*YJV* 6–7), *ṚJV* 32 (*YJV* 5), *YJV* 28

[45] See Malinowski 1927: 203.

[46] It should be remembered that a distinction was made between lunar and solar seasons, and the latter were generally used.

No	Time unit	Term	Occurrence in the treatises
2.	a year	*saṃvatsara*	*ṚJV* 1 (*YJV* 1)
3.		*varṣa*	*ṚJV* 32 (*YJV* 5)
4.		*abda*	*YJV* 28
5.	a half-year	*ayana*	*ṚJV* 1 (*YJV* 1), *ṚJV* 7 (*YJV* 8), *YJV* 28
6.	a season	*ṛtu*	*ṚJV* 1 (*YJV* 1), *ṚJV* 9 (*YJV* 10), *ṚJV* 19, *YJV* 28
7.	a month	*māsa*	*ṚJV* 19, *YJV* 28
8.	a fortnight	*pakṣa*	*YJV* 23
9.	a bright fortnight	*śukla*	*ṚJV* 5 (*YJV* 6), *ṚJV* 32 (*YJV* 5)
10.	a dark fortnight	*kṛṣna*	*ṚJV* 32 (*YJV* 5)
11.	a day	*ahan*	*ṚJV* 18 (*YJV* 36), *YJV* 28
12.		*dina*	*ṚJV* 1 (*YJV* 1)
13.		*div*	*ṚJV* 18 (*YJV* 36)
14.		*divasa*	*ṚJV* 22 (*YJV* 40)
15.		*tithi*	*ṚJV* 31 (*YJV* 23)
16.	the equinox	*viṣuvat*	*ṚJV* 31 (*YJV* 23), *ṚJV* 33

These time divisions are solar- (2.–5., 11.–14., 16; nine terms in total) or lunar-based (8.–10., 15.; four terms) but some of them combine both counts (1., 6.–7.), hence confirming the dual character of Vedic time reckoning.

3.3. Diurnal Time Units

The second group of time units comprises of variable measures (rows 1.–3. in **Table 3**) and diurnal time divisions (6.–8.). These units (six terms in total) divided the day into smaller parts and made it possible to determine important moments during the day, e.g. sunrise or sunset.[47]

[47] The rule to determine the beginning and end of the daytime, as well as its length, is given in stanzas *ṚJV* 7, 22 (*YJV* 8, 40).

Table 3. Calendrical terminology due to the diurnal time units

No	Time unit	Term	Occurrence in the treatises
1.	daytime	*gharma*	*ṚJV* 7 (*YJV* 8)
2.		*divasapramāṇa*	
3.	nighttime	*kṣapā*	
4.	increase	*vṛddhi*	
5.	decrease	*hrāsa*	
6.	*muhūrta*		*ṚJV* 7 (*YJV* 8), *ṚJV* 16 (*YJV* 38)
7.	*nāḍika*		*ṚJV* 16 (*YJV* 38)
8.	*kalā*		

In addition to diurnal units, this group also includes terms denoting the increase (4.) and decrease (5.) of the time.

3.4. Quality of the Calendrical Elements

The last group includes adjectives that occur in the discussed stanzas and determine the quality of the elements of the Vedic calendar, especially these of a dual nature such as months (rows 1.–2. in **Table 4**; two terms in total) and seasons (4.). One adjective referring to sidereal reckoning (3.) might refer both to days and months, as proven in Part 2.2 of this article.

Table 4. Calendrical terminology due to the adjectives

No	Adjective	Term	Occurrence in the treatises
1.	solar	*sūrya*	*YJV* 28
2.	sidereal (related to the moon, residing in the moon)	*starya*	*ṚJV* 19
3.		*bhayuj*	*ṚJV* 18 (*YJV* 36)
4.	lunar	*cāndramasa*	*ṚJV* 19

No	Adjective	Term	Occurrence in the treatises
5.	southern	*dakṣiṇa*	*ṚJV* 22 (*YJV* 40)
6.	northern	*uttara*	*ṚJV* 22 (*YJV* 40)

Some adjectives discussed in the previous paragraph refer to units of time (1.–4.), i.e. they characterise time elements of the calendar. There are also adjectives in the treatises describing the spatial elements. These distinguish the pathways of the Sun (5.–6.).

4. Conclusions

The stanzas discussed in this article are excerpts of the *Jyotiṣavedāṅga* treatise, namely of its *Ṛk*- and *Yajurveda* recensions. Both texts give a lecture on the measurement of time and its division based on a cycle of *yuga*s, lunisolar (solar, synodic, and sidereal) units such as months and days, the *nakṣatra* system, and sky observations. Some basic mathematical operations are also applied in order to calculate the flow of time (*ṚJV* 22, *YJV* 40), the number of lunar units (*ṚJV* 19 and *ṚJV* 18, *YJV* 36) or the relationship between the solar and lunar time reckoning (*ṚJV* 18, *YJV* 36). References to tradition are given as well (*ṚJV* 28, *YJV* 35). Thus, the work has threefold nature and served for the purpose of astronomical considerations, observance of religious practices, and time reckoning.

The old Indian time reckoning was based on the astronomical concepts discussed in Section 2.1 of this article, such as the movement of the Sun along its pathways, the movement of the Moon and its phases, the division of the sky, and the *nakṣatra* system. The Sanskrit names for these astronomical ideas presented here form a basic astronomical vocabulary of *jyotiṣa*.

The notion of the passing of time resulted in arranging it into measurable units that depended on the aforementioned astronomical phenomena. Thus, the calendar comprised of solar- and lunar-based divisions was established. Based on these lunisolar units, some mathematical calculations within *jyotiṣa* were made. Sanskrit names of these time units were summarised in Section 3.2–4 of this article.

Some of the Sanskrit terms found in the *Jyotiṣavedāṅga* denote topographical names (*svar*, *stṛ*, *ṛkṣā*, *bha*, *sūrya*, *arka*, *soma*, *candramas*), observable celestial phenomena (*parvan*, *paurṇamāsī*, *viṣuvat*), and astronomical concepts

(*nakṣatra*, *tithi*, *ayana*) that have been developed in later astronomical works. Others (such as *muhūrta*, *nāḍika*, *kalā*, *saṃvatsara*, *varṣa*, *abda*, *māsa*, *pakṣa*, *ahan*, *dina*, *div*, and *divasa*) define a system of measurement within a narrow field of application (calendrical time reckoning). There are also terms specifying the relations between concepts and phenomena and classifying them, e.g. the group of adjectives summarised in Table 4 and highlighting the origin (*sūrya*, *starya*, *bhayuj*, *candramāsa*) or position/direction (*dakṣiṇa*, *uttara*). Together, they form a group of specialised words referring to the field of astronomical observations and calendrical calculations. This meets the definition of terminology formulated as 'the set of technical words or expressions used in a particular subject' (*OLDAE*, 'terminology'). Hence my closing conclusion is that both Vedic astronomical and calendar naming systems together form a common terminology that can be considered a primary *jyotiṣa* lexicon.

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Institute of Mediterranean and Oriental Cultures
Polish Academy of Sciences

ACTA ASIATICA VARSOVIENSIA

No. 34

Warsaw 2021

PL ISSN 0860-6102
eISSN 2449-8653
ISBN 978-83-7452-091-1

Contents