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KAṬAPAYĀDI NOTATION ON A SANSKRIT ASTROLABE

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The *Kaṭapayādi* system of numerical notation has been discussed quite often. Yet the knowledge about its antiquity and the geographical extent of its spread remains rather hazy. Still less is known about its use in north India. In these circumstances, the discovery of a Sanskrit astrolabe produced in north India on which the degrees of altitude are marked in the *Kaṭapayādi* notation is a significant datum for the history of this system. Even otherwise, this astrolabe occupies an important position in the history of Indian astronomical instruments. This paper provides a full technical description of the astrolabe, now preserved in the Sarasvati Bhavan Library of Sampurnanand Sanskrit University, Varanasi, and explains the use of the *Kaṭapayādi* notation on this astrolabe.

Keywords: Alidade, Almucantars, Geographical gazetteer, *Kaṭapayādi* system, *Kursī*, Mater, Mughal astrolabes, Rete, Sanskrit astrolabes, Shadow squares, Sine graph, Star pointers, Vaṃśāvalīnagara.

1.1 The *Kaṭapayādi* system is an ancient method of alphabetical notation where each consonant of the Sanskrit alphabet is given a numerical value.[1] The system is described in an anonymous line thus: *kādi nava, ṭādi nava, pādi pañca, yady aṣṭau,* "the nine [consonants] starting with *ka*, the nine starting with *ṭa*, the five starting with *pa* and the eight from *ya* [successively denote the numbers 1 to 9]." But the line does not say how the zero is to be represented.The *Sadratnamālā*, composed by Śaṅkara Varman in 1819 AD, gives a more comprehensive definition: "*na, ña* and the vowels are zero. The letters (of the consonant groups) commencing with *ka, ṭa, pa* and *ya* are digits. In conjunct letters the last consonant is to be taken as the digit. A consonant not attached to a vowel is to be ignored."[2] This may be graphically shown in the following table:

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1	2	3	4	5	6	7	8	9	0
ka	*kha*	*ga*	*gha*	*ṅa*	*ca*	*cha*	*ja*	*jha*	*ña*
ṭa	*ṭha*	*ḍa*	*ḍha*	*ṇa*	*ta*	*tha*	*da*	*dha*	*na*
pa	*pha*	*ba*	*bha*	*ma*					
ya	*ra*	*la*	*va*	*śa*	*ṣa*	*sa*	*ha*		

Though neither of the definitions expressly states, the numerals represented in this system are read from the right to the left.[3] This is a neat and elegant method of expressing long numbers, more so because the chronograms, apart from the numerical value they represent, are otherwise also meaningful. An oft quoted example is of Narayaṇa Bhaṭṭa, a great Sanskrit poet of Kerala, closing his devotional poem *Nārayaṇīyam* with the expression *āyurārogyasaukhyam*. On the one hand, it is a prayer for longevity (*āyur*), health (*ārogya*) and happiness (*saukhyam*); on the other it is a chronogram expressing the date of composition, viz., 17,12,211 civil days from the beginning of the Kali era.[4]

1.2 What is the anitquity of this system and the geographical extent of its use? Perhaps the earliest occurrence of this notation is in the *Candra-Vākyas* of Vararuci who is said to have lived in the fourth century AD.[5] In his commentary on the *Āryabhaṭīya*, Sūryadeva Yajvan persuasively argues that Āryabhaṭa must have known the *Kaṭapayādi* system,[6] thereby implying that the system was already prevalent in the fifth century AD. However, the first positive and datable occurrence is its use by Haridatta in his *Grahacāranibandhana*, composed in 683 AD.

1.3 Regarding the geographical extent of its use, Kunjunni Raja observes: "The *Kaṭapayādi* system is well known only in South India and is most popular in Kerala. [...] It is geneally believed to be one of the major contributions of Kerala to Indian mathematics."[7] That it was employed in Kerala very widely, not only in works on astronomy and mathematics, but also in non-scientific works, not only in Sanskrit writings but in Malayalam as well, is now quite well established.[8] Indeed, in order to facilitate its use in Malayalam texts, the Dravidian consonant ഺ was also incorporated into the system with a numerical value of nine.[9] Even in non-scientific works, the authors preferred to give the date of compostion in terms of *ahargaṇa* in the *Kaṭapayādi* system. Since the number expressing the *ahargaṇa* is rather large, *Kaṭapayādi* notation is more convenient than the word-numerals; the added advantage being that the chronogram can be so formed as to yield some significant or charming meaning besides the numerical data. While the use of

this system of notation in Kerala has been well documented, very little information is available about other parts of south India; still less about the use of the system north of the Vindhyas.

1.4 In thses circumstances, the discovery of a Sanskrit astrolabe[10] produced in north India on which the degrees of altitude are marked in the *Kaṭapayādi* notation is a significant datum in the history of this system. Even otherwise, this is an important specimen for the history of Indian astronomical instruments. While the majority of extant Sankrit astrolabes contain a single plate calibrated for the use at a single terrestrial latitude, the present astrolabe is one of the few that contain multiple plates or tympans and it shows great affinity to the Mughal astrolabes of the sixteenth and seventeenth centuries. Therefore, this astrolabe deserves an independent treatment. In the following pages, a full technical description of the instrument will be given first and then the use of the *Kaṭapayādi* notation on it will be explained.

2.0 In connection with my project on "A Descriptive Catalogue of Indian Astronomical and Time-Measuring Instruments,"[11] I have studied the instruments preserved in the Sarasvati Bhavan Library of the Sampurnanand Sanskrit University, Varanasi. This library has one of the richest collections of Sanskrit manuscripts. It also possesses three astrolabes:

i. Indo-Persian astrolabe with four plates, produced in the eleventh regnal year of Jahāngīr in 1616 AD.[12]

ii. Sanskrit astrolabe with five plates, anonymous, not dated but attributable to the seventeenth century—the subject of the present paper.

iii. Sanskirt astrolabe with a single plate, anonymous and undated (but probaly manufactured in the eighteenth century).[13]

There are also some interesting European instruments, such as a Gunter's Quadrant and a "synchronom" pendulum clock designed to measure not only hours and minutes but also *ghaṭīs* and *palas.*

2.1 The present astrolabe is made of brass. One of the sighting vents attached to the alidade is broken and lost. Plate no. 2 has a crack running across two-thirds of the width parallel to the diameter. Otherwise, the astrolabe is in a good state of preservation. It is medium sized with a diameter of 202 mm and a thickness of 9 mm (Fig.1). The circular body or mater is surmounted by a triangular suspension piece known as *kursī* or "throne". The *kursī* is high, rising above the mater by 47 mm. It is lobed and scalloped, and culminates in a trifoliate top. To this top is attached the suspension mechanism consisting of a shackle and a ring. The trifoliate design is repeated in the terminals of the shackle as

On the front side of the *kursī* is engraved the name *Paṃ. Rāmayatna Ojhā* in Devanāgarī script. This engraving is somewhat broader in comparison to the other engraved forms of writing on the astrolabe. It is probably a later addition, indicating the name of a subsequent owner of this astrolabe and not necessarily of the one who got it originally manufactured for his use.[15] Leaving this aside, there are yet three distinct styles of engraving of letters and numerals, to be found respectively in (i) the geographical gazetteer, (ii) altitudes written in the *Kaṭapayadī* notation on the plates, and (iii) the rest. The first two styles are somewhat akin to one another with a common characteristic form of the letter *ra*.

The limb of the mater contains a double band of scales. The inner band is graduated for each degree, while groups of 5° are marked on the outer band; these are labelled in Devanāgarī numerals as 5, 10, 15.....90, separately for each quarter, starting from the east or west point and proceeding to the south or north point.

2.2 Within the mater, the inner surface is divided into six annular rings. The first three are divided into 48 cells, while the three inner rings are divided into 24 cells each. The 48 cells of the outer circle are filled respectively with the names, longitudes and latitudes of 47 towns of the Indian subcontinent, Afghanistan and Iran; the 48th cell contains the argument. The longitudes are measured from the Fortunate Isles (Arabic : *al-Jazā'ir al-Khālidāt*), roughly 35° west of Greenwich. Data for further 24 towns could have been filled in the 24 cells in the inner circle also, but these are left blank.

The information about the 47 towns, or the so-called geographical gazetter, is not obtained by the astrolabe maker through his own measurements. It is often derived from earlier astrolabes or from the Islamic astronomical tables known as *Zījs*. Therefore, such gazetteers can indicate the path of transmission of this geographical knowledge. In the present case, it is very clear that the coordinates are derived from the Mughal astrolabes of the sixteenth and seventeenth centuries. In their catalogue of the astrolabes at the Smithsonian, Sharon Gibbs and George Saliba give a consolidated list of place names and their geographical parameters.[16] A comparison of the gazetteer of our Sanskrit astrolabe with this consolidated list shows a great degree of correspondence.

The following table reproduces the gazetteer, reading from the top and proceeding in the clockwise direction. Those marked with an asterisk have coordinates identical with those in the consolidated list of Gibbs-Saliba. If the consolidated list has a different value, it is noted in parenthesis. It will be noticed that most of the deviations occur in the case of longitudes and that several of these are just scribal errors. The place names marked with a plus sign do not occur in the Gibbs-Saliba list. These are verified from other sources.[17]

S. No.		Place Name *nagaranāma*	Longitude *vistāra*	Latitude *aksāmśa*	Identification
1		Vagdāda	80;30 (80:00)	33;25	Baghdad
2	*	Sīrāja	88	29;36	Shiraz
3	*	Valaka	101	36;41	Balkh
4		Hareu	94;13 (94;20)	34;30	Herat
5	*	Hosama	85;10	37	Hausam/ Khuzem
6	+	Katamī	85	36;55	Kutom
7		Kamdhāra	106;40 (107;40)	33	Qandahar
8		Mulatāna	106;35 (107;35)	29;40	Multan
9		Thaho	102;7	25;10	?
10		Huramuja	95;25 (92;00)	25	Hurmuz
11	*	Vadakasāna	104;24	37;10	Badaksan
12		Kāsagara	106; 3 (106;30)	44 (45)	Kashghar
13		Samarakamda	99;15 (99;16)	39.37	Samarqand
14	*	Vukhāro	97;30	39;50	Bukhara
15		Bhorura	108;40	31;10	?
16		Parasanūra	115;55 (85;55)	31;4	Peshawar
17		Ayodhyā	118;6 (108;6)	37;22 (27;22)	Ayodhya
18	+	Mānikapūra	118;10	26;49	Manikpur
19	*	Jaunapura	119;6	26;36	Janupur
20	*	Gopāmāū	116;33	26;45	Gopamau
21	*	Daulatāvādu	111	20;30	Daulatabad
22		Śamarakotu	105	25	?
23		Kāvila	104;40	34;30 (34;26)	Kabul
24		Sevāta	117;10	32;50	?
25		Ujjayinī	102 (110;5)	22;30	Ujjain
26	*	Vijayapura	105;3	17;20	Bijapur
27		Bhī (?) harāica	109;4 (111;05)	22;20 (21;20)	Broach
28	+	Caṃpānairi	108;45	22;30	Champaner
29	*	Ahamadābāda	108;40	23;15	Ahmedabad
30	+	Karo	117;6	26;35	Korah
31		Saṃbhara	115 (115;20)	28;6 (28;18)	Sambhal
32	*	Vadāū	114;59	27;32	Badaun
33		Āgarā	114	37;13 (27;13)	Agra
34	*	Thanesvara	112;33	3[0];10	Thanesar
35	*	Pānīpathā	113;20	28;52	Panipat
36	*	Kola	114;19	28;4	Aligarh
37		Syālakoṭa	109;4 (109;00)	33	Siyalkot
38	+	Varana	114	28;48	Baran

are labelled as 5, 10, 15....90, starting from the east and west points and proceeding to the top. The edge of the two lower quadrants contains the cotangent scales as projected from the shadow squares. The upper left quadrant has engraved on it 60 parallel horizontal lines, each fifth being highlighted by a dotted line, and thus forms the sine graph. From the centre are drawn 18 radian lines for each 5°.

In the upper right quadrant are drawn 17 equidistant and concentric quarter circles. The space between two successive circles repressents 10° of the zodiac. These spaces are labelled along the vertical and horizontal radii with the serial number and the first letter of the name of the zodiac sign in the following manner. On the vertical radius, starting from the top: 9 *Dha[nuṣ]*, 8 *Vṛ [ścika]*, 7 *Tu[lā]*, 6 *Ka[nyā]*, 5 *Siṃ [ha]*, 4 *Ka [rka]*; then on the horizontal radius, starting from the centre: 3 *Mi[thuna]*, 2 *Vṛ[ṣabha]*, 1 *Me[ṣa]*, 12 *Mī[na]*, 11 *Kuṃ[bha]*, 10 *Ma[kara]*.

Upon these arcs is projected the curve of the meridian altitude of the sun through the year; below the curve is written *Lāhaura* 32, indicating that the solar meridian altitudes pertain to the city of Lahore situated roughly at 32° N. In the Mughal astrolabes by Muḥammad Muqīm (fl. 1609-1659), Ḍiyā' al-Dīn Muḥammad (fl. 1645-1680) and others, one finds similar curves for 27° and 32°; i.e. for the two imperial cities of Agra and Lahore.[18]

The lower half is occupied by a double shadow square; on the left for the gnomon of 12 digits and on the right for the gnomon of 7 digits. There are, however, no labels on these squares. Within the shadow squares are two semi-circular bands; the outer one is divided into 12 parts in which the names of the 12 zodiac signs are written. The inner band contains the 28 names of the lunar mansions. Thus these two bands display the mutual correrspondence between the 12 signs and 28 lunar mansions. This is also a characteristic feature of the Mughal astrolabes.

At the centre of the back is pivoted an ornate alidade (*vedhapaṭṭī*). It is 197 mm long and has a bevelled edge. Arçs corresponding to those in the upper right quadrant are engraved over half the length of the alidade. One of the two sighting vents attached to the alidade is broken. The alidade together with the plates and the rete are attached to the mater by means of a large broad-headed pin passing through the central hole. A bird-shaped nut is screwed to the end of the pin so that the alidade and the plates are held tightly in position.[19]

2.4 In the recessed space on the front side of the mater are a series of plates for various latitudes and on the top of them the star map called rete (Arabic *ankabūt*; Sanskrit *bhapatra*) with a diameter of 181 mm (see Fig. 1). This is a circular open work plate,

from which large portions have been cut off, leaving out the outer periphery constituted by the Tropic of Capricon, the ecliptic circle and parts of the equatorial circle. These are held together by an east-west bar with two counter changes and a vertical bar with a single counter change.

The ecliptic circle is divided into 12 signs of the zodiac and labelled with the respective names in Sanskrit. Each sign is further subdivided into five parts of 6° each and labelled as 1, 2, 3, 4, 5. There are 19 star pointers, shaped like tiger's claws or stepped up tiger's claws. These arise from the circles and the horizontal and vertical bars. All but one of these are named. There is a small knob at the north point, with which the rete can be rotated around the centre.

The Mughal astrolabes contain highly ornate retes with floral traceries joining various star pointers. In comparison, the rete of the present astrolabe is rather simple and austere. But so is the rete in the very first extant Indo-Persian astrolabe, made by Allahdad in 1567 AD,[20] and the similarity between these two retes in respect of design and in respect of the fewer number of star pointers is quite striking.

Given below are the names of the stars marked in the rete of our astrolabe and their identification. The first seven are outside the ecliptic and the rest are within.

S. No.	Name of Star in Sanskrit	Identification
1	Samudrapakṣī	ι Ceti
2	Rohiṇī	α Tauri
3	Dakṣiṇapāda	κ Orionis
4	Ārdrā-(?)	α Canis Maioris
5	Lubdhakabandhu	α Canis Minoris
6	Maghā	α Leonis
7	Citrā	α Virginis
8	Aśvinī	γ Arietis
9	Pretasara	β Persei
10	Skanda	α Aurigae
11	Āryamā	β Leonis
12	Svātī	β Boötis
13	Viśakhā Mātṛmaṇḍala	α Coronae Borealis
14	Dhanakoṭi (read: Dhanuḥkoṭi)	α Opiuchi
15	Abhijit	α Lyrae
16	Sravana	α Aquilae
17	Kukkutapakṣa	α Cygni
18	Pū[rva] bhā[drapadā]	β Pegasi

2.4 Nested within the hollow space of the mater are five circular plates or tympans (Arabic: *ṣafīḥa;* Sanskrit: *akṣapatra*) with projections engraved on both sides. One plate, slightly thicker than the others, carries the projections of the ecliptic co-ordinates on the obverse and multiple horizons on the reverse. Other four plates serve eight different latitudes. The degrees of these latitudes (*akṣāṃśāḥ*) are engraved at the centre of the plate concerned. In three cases, the name of an important town situated on that latitude is also mentioned.[21]

1a	*akṣāṃśāḥ*	18	
1b	*akṣāṃśāḥ*	21	
2a	*akṣāṃśāḥ*	24	
2b	*akṣāṃśāḥ*	27	
3a	*akṣāṃśāḥ*	28	*Vaṃśāvalīnagare*
3b	*akṣāṃśāḥ*	25;39	(read 28;39) Yoginīpure (= Delhi)
4a	*akṣāṃśāḥ*	30	
4b	*akṣāṃśāḥ*	32	Lāhaura
5a	ecliptic coordinates		
5b	multiple horizons		

Of the first four plates, 1 a, b; 2 a, b, 3 b; 4 a, b are sexpartite, that is to say, on these plates equal altitude circles or almucantars (from the Arabic *al-muqanṭara;* Sanskrit *unnatāṃśa-rekhā*) are drawn for each 6° (see Fig. 3). Plate 3a, however, is tripartite. Here equal altitude circles are drawn for each 3° (see Fig. 4) . But in all the plates, azimuth lines are drawn for each 10°, that too only below the horizon. On the right hand side below the horizon is written *para* or *paścima* (west) and on the left *pūrva* (east). On all the plates, lines are drawn for seasonal or unequal hours, and these are numbered from 1 to 12, starting at the western horizon and proceeding towards the eastern.

3.1 *Kaṭapayādi* Notation on the Astrolabe. It has been mentioned that on all the plates, with the exception of 3a, equal altitude circles are drawn for each 6°. Interestingly, these lines are numbered not in Devanāgarī numerals but in the *Kaṭapayādi* notation. Thus here we have alphabetic notation for multiples of 6, from 6 to 90. Likewise plate 3a provides the *Kaṭapayādi* notation for multiples of 3 from 3 to 90. As in Mughal astrolabes, these arguments are marked on both the eastern and the western sides of the altitude circles, in such a manner that the numbers form an interesting pattern like a double arch. A consolidated list of the two sets of notations is given below. The few variants are shown in parenthesis.

3	*ga*	6	*ti*
9	*dhā*	12	*ropa (raya)*
15	*meke (mayā)*	18	*daya*

tripartite, thereby allowing finer measurements of altitude at this place. Can it then be that the maker is from this Vaṃśāvalīnagara? However, in spite of painstaking search, it has not been possible to locate any mention to this place situated, roughly on 28° N, either in Gujarat, or in Rājasthan, or in western Uttar Pradesh. It is possible that the place is now known under a Middle Indic form of the name that is phonetically far removed from Vaṃśāvalīnagara.

3.4 Be that as it may, this astrolabe demonstrates that the *Kaṭapayādi* system of representing numerals was not just confined to South India; it was known well enough in north India to be employed in an astrolabe. A fresh search in epigraphic records may yield further examples.

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NOTES AND REFERENCES

1. The important literature on the *Kaṭapayādi* system in the following arranged in chronological order. Whish, C.M., "On the Alphabetical Notation of the Hindus," *Transactions of the Literary Society of Madras,* 1827, 1, 54-62; Ojha Gaurishankar Hirachand, *Bhāraṭīya Prācīna Limpimālā. The Palaeography of India,* [Delhi 1894; revised and enlarged second edition 1918]; reprint: Delhi 1971, p. 123; Fleet, J. F., "The Katapayadi System of Expressing Numbers," *Journal of the Royal Asiatic Society,* 1911, pp. 788-794; Datta, Bibhutibhusan & Singh, Avadhesh Narayan, *History of Hindu Mathematics : A Source-Book,* [1935-38], second edition, Bombay 1962, part I, pp. 69-72; Raja, K. Kunjunni, "Astronomy and Mathematics in Kerala (an Account of Literature)," *Adyar Libarary Bulletin, 1963, 27, 118-167;* Sarma. K.V.,*A History of the Kerala School of Hindu Astronomy (In Perspective),* Hoshiarpur 1972,

pp. 6-8; idem, "Word and Alphabetic Numerical Systems in India," to appear in the Proceedings of the Seminar on the Concept of Śūnya, Indian National Science Academy and Indira Gandhi National Centre for the Arts, New Delhi 1997.

2. Cf. Sarma, K.V. "Word and Alphabetic Numerical System" (see n.1).

3. Following an anonymous dictum *aṅkānāṃ vāmato gatiḥ*, "the numerical digits in a chronogram proceed towards the left." This is true also for the word notation, commonly known as *Bhūtasaṃkhyā* system. However, nobody has so far tried to investigate how this "right to left" sequence of numerals in an otherwise "left to right" writting came into being.

4. Cf. Sarma, K.V., "Word and Alphabetic Numerical Systems."

5. Ibid. However, according to Pingree, David, *Jyotiḥśāstra: Astral and Mathematical Literature*, Wiesbaden 1981, p. 47, "the earliest attested epoch of the lunar *vākyas* is 1184."

6. Cf. Sarma, K.V. (ed), *Āryabhaṭīya of Āryabhaṭa, with the Commentary of Sūryadeva Yajvan*, New Delhi 1976, p. 10.

7. Raja, Op. Cit., p. 122.

8. Cf. Sarma, K.V. "Word and Alphabetic Numerical Systems in India."

9. Cf. Sarma, K.V., *A History of the Kerala School of Hindu Astronomy*, pp. 6-8.

10. On Sanskrit astrolabes in general, see Sarma, Sreeramula Rajeswara, "Yantrarāja: The Astrolabe in Sanskrit," *Indian Journal of History of Science, 1999*, **34**, 145-158.

11. On this project, see Sarma, Sreeramula Rajeswara, "Indian Astronomical and Time-Measuring Instruments: A Catalogue in Preparation," *Indian Journal of History of Science*, 1994, **29**, pp. 507-528.

12. It was described, together with a photograph, in Dube, Padmakara, "A Seventeenth Century Astrolabe" in: Gopinath Kaviraj (ed), *The Princes of Wales Sarasvati Bhavan Series*, vol. II, Benares 1923, pp. 129-136. Another photograph appeared in Bhaṭṭācārya, Vibhūtibhūṣaṇa (ed), *Yantrarāja-Vicāra Viṃśādhyāyī*, Varanasi 1979.

13. See ibid, for a photograph.

14. For example, an astrolabe made by Mullā 'Īsa ibn Allāhdād (fl. 1601-1604 AD), now in a private collection in UK. It is illustrated in Wynter, Harriet & Anthony Turner, *Scientific Instruments*, London 1975, pp. 16-18. Astrolabe no (i) of the present colloction also has a solid *kursī*.

15. Upādhyāya, Baladeva, *Kāśī kī Pāṇḍitya Paramparā*, second edition, Varanasi 1994, pp. 307, 907, 909, mentions a Rāmayatna Ojha, who was the first Head of the Department of Jyotiṣa in Banaras Hindu University. He died in 1938. But he is too recent to have been the owner of this astrolabe.

16. Gibbs, Sharon & Saliba, George, *Planispheric Astrolabes from the National Museum of American History*, City of Washington 1984, pp. 192-200.

17. Kennedy, E. S. & M. H., *Geographical Coordinates of Locations from Islamic Sources*, Frankfurt 1987; Habib, Irfan, *An Atlas of the Mughal Empire*, second edition, Delhi 1986.

18. See, for example, Fig.2, showing the back of an astrolabe produced by Muḥammed Muqīm in the year 1031 AH (1621 AD), in Sarma, Sreeramula Rajeswara, "The Lahore Family of Astrolabists and their Ouvrage," *Studies in History of Medicine and Sicience*, 1994, 13, pp. 205-224.

19. This is not the traditional practice in astrolabes. Usually the other end of the pin has a hole, into which a horse-shaped wedge is inserted.

20. It is with the Salar Jung Museum, Hyderabad; cf. Sarma, Sreeramula Rajeswara, *Astronomical instruments in the Salar Jung Museum*, Hyderabad 1996, esp. pp. 7-10, Plates 1-3, 8, 11.

21. Together with the latitude, it is customary also to mention the maximum duration of the sunlight hours (*paramadina*) and sometimes also the length of equinoctial shadow (*chāyā*), but these are not mentioned here.

22. On *Abjad* notation, especially on the astrolabes, see Khareghat, M.P., *Astrolabes*, M.P. Khareghat Memorial Volume II, edited by Dinshaw D. Kapadia, Bombay 1950, pp. viii-xiii. In the last century, Ghulām Qādir of Kapurthala started using the Arabic numerals, i.e., the numerals connected with the Arabic /Persian (and Urdu) script in his astrolabes. One astrolabe made in 1861 is in the National Museum, New Delhi. For an illustration, see Gupta, S. P. (ed), *Masterpieces from the National Museum Collection*, New Delhi 1985, p. 179, item no. 272. The National Museum has a few other astronomical instruments with similar numerals. Though instruments are not signed, they may be attriubted to Ghulām Qādir for this and other stylistic reasons.

23. The gazetteer mentions Dillī and not Yoginīpura and assigns to Lāhaura a more accurate latitude of 31;50°.

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