

An arithmetical shadow-scheme for time-reckoning

nišān ī sāyag ī nēmrōz ud uzērin

There is a short text in Pārsīg about the length of the shadow at midday and in the afternoon during a year.

Translation¹

I write the indications of the noon shadow

May it be fortunate!

When the sun enters into Cancer, [the shadow] is half of a man's foot²; at the fifteenth degree of Cancer it is 1 foot.

When the sun enters into Leo, it is 1 ½ feet; at the fifteenth of Leo, it is 2 feet.

When the sun enters into Virgo, it is 2 ½ feet; at the fifteenth of Virgo, it is 3 ½ feet.

When the sun enters into Libra, it is 4 ½ feet; at the fifteenth of Libra, it is 5 ½ feet.

When the sun enters into Scorpio, it is 6 ½ feet; at the fifteenth of Scorpio, it is 7 ½ feet.

When the sun enters into Sagittarius, it is 8 ½ feet; at the fifteenth of Sagittarius, it is 9 ½ feet.

When the sun enters into Capricornus, it is 10 feet; at the fifteenth of Capricornus, it is 9 ½ feet.

When the sun enters into Aquarius, it is 8 ½ feet; at the fifteenth of Aquarius, it is 7 ½ feet.

¹ . Editions and translations:

E. W. West, *Pahlavi Texts*, Part I, Oxford, 1880, 397-400.

Chr. Bartholomae, *Die Zendhandschriften der K. Hof- und Staatsbibliothek in München*, München, 1915, 59-61.

F. M. P. Kotwal, *The Supplementary Texts to the Šāyest nē-šāyest*, København, 1969, 86-9 (tr.), 44-45 (text).

² . West reads thus: panzag ī pāy ī mard. “Mulla Firoz in his *Āvīzeh Dīn*, p. 279 seq., takes 5 khaduk pai (panz ēk pāy) as implying that the shadow is under the sole of the foot, or the sun overhead ; but neither this reading, nor the more literal ‘one-fifth of a foot,’ can be reconciled with the other measures ; though if we take 5 as standing for panjak, ‘the five toes or sole,’ we might translate as follows: ‘When the sun is at Cancer, the shadow is the sole of one foot of the man.’ ” D. N. Mackenzie notices that “from the series of measurements given one would at first sight expect some high fraction of one foot here, certainly not panj-ēk ‘one-fifth’”, but he emends it thus: “*ii iii ’ywk = dō sē-yak ‘two-thirds’”. “A Zoroastrian Master of Ceremonies”, *W. B. Henning Memorial Volume*, 1970, 268.

When the sun enters into Pisces, it is 6 ½ feet; at the fifteenth of Pisces, it is 5 ½ feet.

When the sun enters into Aries, it is 4 ½ feet; at the fifteenth of Aries, it is 3 ½ feet.

When the sun enters into Taurus it is 2 ½ feet; at the fifteenth of Taurus, it is two feet.

When the sun enters into Gemini, it is 1 ½ feet; at the fifteenth of Gemini, it is 1 foot.

May the noon shadow [written here] have good issue!

I write the indications of the afternoon [shadow]

May it be well and fortunate (with happy issue) by the help of the Yazata!

When the day is on the increase, and the sun comes unto the head (/ beginning) of Cancer, and one's shadow becomes six feet and two parts, he makes the Uzērin gāh.

Every 30 days, it (the shadow) always increases by one foot and one-third; therefore, about every 10 days, the reckoning is always half a foot.

When the sun is at the head (/ beginning) of Leo, the shadow is seven feet and a half.

In this order, every sign of the zodiac is treated alike, and the months alike, until the sun comes unto the head of Capricornus, and [then] the shadow becomes fourteen feet and two parts.

In Capricornus it decreases again by one foot and one-third; and from there where it turns back, because of the decrease of the night and increase of the day, it always decreases one foot and one-third each one of the months; and so, every ten days, the reckoning is always half a foot, until it comes back to six feet and two parts. Every sign of the zodiac alike, and the months alike.

Commentary

First, it is necessary to provide definitions for the terms used in the text:

The daytime is divided into five parts (Pers. *gāh*). This text regulates the times of two *gāh*, *nēmrōz* and *uzērin*³:

nēmrōz or *rabiḥvin* (*gāh*) from Av. *rapiθβina*- ‘the *gāh* pertaining to the lunch’ (from *rapiθβā*-). It commences shortly after midday when an augmentation in the shadow's length is discerned.

uzērin from Av. *uzayeirina*- ‘the *gāh* pertaining to a declining day, late afternoon’ (from *uzayara*- ‘afternoon’).

pāy ‘foot’⁴ from Av. *pāda*-. One foot is equal to 16 finger-breadths (FO 27.i).⁵

bahr ‘part’ (of a foot). It is equal to one-twelfth of a foot.

The noon and afternoon shadows are symmetrically arranged so that seven (or, thirteen) values determine them for the whole year. The shadow table is for each half of zodiacal signs (or, halves of the zodiac) between summer and winter solstices. The extreme values for the noon shadows are $S_{n4} = \frac{1}{2}$, $S_{n10} = 10$. Thus, the equinoctial noon shadows will be $S_{n1} = S_{n7} = 4\frac{1}{4}$ (in the text, we have: $4\frac{1}{2}$). The geographical latitude φ used by the author was apparently 28° north –some locality such as Khonj in Persis–, and the base for the gnomon length was $7\frac{1}{2}$ feet.⁶ If we assume $\varepsilon = 24^\circ$ (often assumed by Indians and Persians), then the noon shadow lengths at the summer solstice and winter solstice will be respectively:

$$7.5 \times \text{tg } 4 \approx \frac{1}{2} \text{ (more precisely, 0.52445),}$$

$$7.5 \times \text{tg } 52 \approx 10 \text{ (more precisely, 9.59956).}$$

The text starts the year with the sign of Cancer. This confirms the word of Bērōnī that the Persians adopted the time of the summer solstice as the beginning of the year.⁷

The basic pattern is as follows:

Signs ↓	Hāvani	Rapiθβina	Uzayeirina	
♋ 0	6 1/6	1/2	6 1/6	
15	6 5/6	1	6 5/6	15
♌ 0	7 1/2	1 1/2	7 1/2	♍ 0↑
15	8 1/6	2	8 1/6	15
♍ 0	8 5/6	2 1/2	8 5/6	♎ 0↑

³ . In Arabic (astronomical) texts the corresponding terms are: *عصر* and *ظهر*.

⁴ . Its corresponding Arabic term is *قدم*.

⁵ . West has taken a *pāy* as 14 finger-breadths.

⁶ . According to West, “calculating the latitude from each of the thirteen different lengths of shadow, the mean result is $32^\circ 1'$ north latitude, which is precisely the position assigned to Yazd ...”.

⁷ . الآثار الباقية . 9.15.

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13 . D, F 8

14 . K

15 . K

16 . D, F 8 سرس ا ا لہ۔ ا

17 . K, SP, ا ا ا D, F 8

18 . M

19 . M, F 8

20 . ا ا SP

21 . SP

x^varšēd ped karzang do ēk ī pāy ī mard ; pānzdahum ī karzang ēk pāy.

x^varšēd ped šagr ēk pāy ud nēm ; pānzdahum ī šagr do pāy.

x^varšēd ped hōšag do pāy ud nēm; pānzdahum ī hōšag sē pāy ud nēm.

x^varšēd ped tarāzōg cahār pāy ud nēm; pānzdahum ī tarāzōg panz pāy ud nēm.

x^varšēd ped gazdum šaš pāy ud nēm; pānzdahum ī gazdum haft (K : šaš) pāy ud nēm.

x^varšēd ped nēmasp ašt pāy ud nēm; pānzdahum ī nēmasp nō pāy ud nēm.

x^varšēd ped vahīg dah pāy; pānzdahum ī hōšag nō pāy ud nēm.

x^varšēd ped dol haft (*ašt) pāy ud nēm; pānzdahum ī dol haft pāy ud nēm.

x^varšēd ped mähīg šaš pāy ud nēm; pānzdahum ī mähīg panz pāy ud nēm.

x^varšēd ped varrag cahār pāy ud nēm; pānzdahum ī varrag sē pāy ud nēm.

x^varšēd ped gāv do pāy ud nēm; pānzdahum ī hōšag do pāy.

x^varšēd ped dopehikar ē pāy ud nēm; pānzdahum ī dopehikar ē pāy.

sāyag ī nēmrōz *nibišt. xūbfrazām²⁸ bavād !

nišān ī sāyag ī uzērin nibēsam

xūb ud farrox (xūbfrazām) bavād ped yazdān ayyārīh !

ka rōz ped abzōn baved x^varšēd ped sar ī karzang āyed ud sāyag šaš pāy ud do bahr baved, uzērin gāh gīred.

harv sīh rōz-ē pāy-ē ud sē-ēk ī pāy hamē abzāyed. nūn ceōn harv dah rōz nēm pāy ušmār hamē baved ; x^varšēd ped sar ī šagr sāyag haft (ašt) pāy ud nēm.

²⁸ . Cf. Y 28 Z 0 hujahišn humurvāg xūbfrazām.

ped ēn pedisār harv axtar-ē hamgōnag, ud mähīgān
hamgōnag ; dā x^varšēd x^vped sar ī vahīg āyed, sāyag cahārdah
pāy ud do bahr baved.

andar vahīg se-ēk ī pāy abāz kāhed. az ānōh abāz varded ceōn
kāhišn ī šab ud abzāyišn ī rōz. harv mähīgān-ē pāy-ē sē-ēk-ē
hamē kāhed, ceōn harv dah rōz nēm pāy ušmār hamē baved dā
abāz ō šaš pāy ud do bahr āyed. harv axtar-ē hamgōnag ud
mähīgān hamgōnag.

Raham Asha

Vahrām rōz ī Urdvahišt mäh, sāl 1395 pas az Yazdegird

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