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True Lakṣa-Scale Numeration System of the *Vālmīki-Rāmāyaṇa**

The decimal place-value system of numerals is India's remarkable scientific gift to the world. Using base ten and a fully developed concept of positional principle (along with zero), the Indian system is capable of representing large (integers) as well as small (decimal fractions) numbers and is used all over the civilized world. In India ten has been the base for counting since ancient Vedic times and several lists (both short and large) of decuple terms are avaialble for practical enumeration even upto 10^{96} (see *Gaṇita Bhāratī* Vol. 23, 2001, pp. 83-90).

For specifying large numbers, some non-decimal scales of numeration were also used. The *lakṣa-scale* numeration-system of the *Vālmikī-Rāmāyaṇa* (the *ādi-kāvya*) is one such scheme. Starting with *koṭi* ($=10^7$) or a crore, it extends to *mahauga* ($=10^{60}$). The Sanskrit text defining the system is simple and straight-forward. However, a few modern scholars have created a sort of confusion about the system by committing error of omission or interpretation. The purpose of the present note is to point out those errors and give the true form of the system by mentioning the text, its translation and a table in modern form for easy understanding.

The Gia Press edition of the *Vālmikī-Rāmāyaṇa* (Gorakhpur, 1960) describes the *lakṣa–scale* in twelve Sanskrit lines (see Vol. II, p. 1124) which can be transliterated as follows:

(L1) *Śataṃ śatasahasrāṇaṃ koṭimāhur-maniṣiṇaḥ.*
(L2) *Śataṃ koṭisahasrāṇaṃ śankur-ityabhidhīyate.*
(L3) *Śataṃ śaṅkusahasrāṇāṃ mahaśaṅkuriti smṛtaḥ.*
(L4) *Mahāśaṅkusahasrāṇāṃ śataṃ vṛndamihocyate.*
(L5) *Śataṃ vṛndasahasrāṇāṃ mahāvṛndamiti smṛtam.*
(L6) *Mahāvṛnda-sahasrāṇāṃ śataṃ padmamihocyate.*
(L7) *Śataṃ padma-sahasrāṇāṃ mahāpadmamiti smṛtam.*
(L8) *Mahāpadma-sahasrāṇāṃ śataṃ kharvamihocyate.*
(L9) *Śataṁ kharvasahsrāṇāṃ mahākharvamiti smṛtam.*

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(L10) *Mahākharva-sahasrāṇāṃ samudramabhidhīyate.*
(L11) *Śataṃ samudrasāhasramogha ityabhidhīyate.*
(L12) *Śatamogha-sahasrāṇāṃ mahaugha iti viśrutaḥ.*

These lines occur in verses of the 28th *sarga* in the *yuddha-kāṇḍa* of the work. They may literally translated as follows:

(L1) A hundred of hundred-thousand is said to be *koṭi* (crore) by the learned.
(L2) A hundred of thousand-*koṭi* is termed *śaṅku.*
(L3) A hundred of thousand-*śaṅku* is known as *mahāśaṅku.*
(L4) A hundred of thousand-*mahāśaṅku* is called *vṛnda.*
(L5) A hundred of thousand-*vṛnda* is known as *mahāvṛnda.*
(L6) A hundred of thousand-*mahāvṛnda* is called *padma.*
(L7) A hundred of thousand-*padma* is known as *mahāpadma.*
(L8) A hundred of thousand-*mahāpadma* is called *kharva.*
(L9) A hundred of thousand-*kharva* is known as *mahākharva.*
(L10) Thousand-*mahākharva* is termed *samudra.*
(L11) A hundred of thousand-*samudra* is termed *ogha.*
(L12) A hundred of thousand-*ogha* is heard to be *mahaugha.*

It should be noted that the text most frequently uses 'hundred-thousand' which is equal to a *lakṣa* (lac or *lākha* i.e. 10^5). For convenience the above numeration scheme may be presented in the form of following table:

Table of Indian Lakṣa Scale

100 *lac*	= 1 *koṭi*	= 10^7
1 *lac koṭi*	= 1 *śaṅku*	= 10^{12}
1 *lac śaṅku*	= 1 *mahāśaṅku*	= 10^{17}
1 *lac mahāśaṅku*	= 1 *vṛnda*	= 10^{22}
1 *lac vṛnda*	= 1 *mahāvṛnda*	= 10^{27}
1 *lac mahāvṛnda*	= 1 *padma*	= 10^{32}
1 *lac padma*	= 1 *mahāpadma*	= 10^{37}
1 *lac mahāpadma*	= 1 *kharva*	= 10^{42}
1 *lac kharva*	= 1 *mahākharva*	= 10^{47}
1000 *mahākharva*	= 1 *samudra*	= 10^{50}
1 *lac samudra*	= 1 *ogha*	= 10^{55}
1 *lac ogha*	= 1 *mahaugha* (= *mahā-ogha*)	= 10^{60}

The use of the scale factor 1000 in one place (instead of lac) may be noted. The use of the term *samudra* without corresponding *maha-samudra* was done perhaps to terminate the table at the sexagesimal power. The so-called Bombay version of the *Vālmīki-Rāmāyaṇa* has been recently published by the Rashtriya Sanskrit Sansthan, New Delhi (second edition, 2005). In this version the same above *lakṣa* scale is decribed in similar words in the six verses, 33 to 38 of the 28th *sarga* of the *yuddha-kāṇḍa* (see Vol. 5, p. 94). But there is one variant name. The term *śaṅku* is replaced by *śaṅkha* in this Bombay version. Mathematically this is a minor matter.

Mathematically serious is the confusion created about the above numeration system by the writings of some scholars. These may be pointed out as follows:

(i) C.N. Srinivasiengar in his *The History of Ancient Indian Mathematics* (Kolkata, 1967, p. 3) has quoted a Sanskrit text of only 11 lines omitting the important. L11 altogether. Thus his said enumeration ends with *mahaugha* = 10^{55} instead of 10^{60}. Due to this omission he had to also take the *ogha* of the 12th line to be the same as the *samudra* of the 10th line (Note that our 12th line is his last or 11th line).

(ii) S.A.S. Sarma in his "Vedic Numerical System including Śūnya" (see *The Concept of Śūnya*, New Delhi, 2003, pp. 30-31) has quoted the full above text of 12 lines. But in his translation he omits the L11 altogether thereby still getting the wrong value 10^{55} for the *mahaugha*! (He also coolly replaces *ogha* in 12^{th} line by *samudra* in his translation).

(iii) P.V. Arunachalam in his "Infinity in Mathematics" (*Ganita-Chandrika*, 3.2, 2002, p. 23) has mentioned some denominations from the *Vālmīki-Rāmāyaṇa* without quoting text source, or details. His values are:

Padman = 10^{37} (instead of 10^{32}); *Samudram* = 10^{52} (instead of 10^{50}); *Gugham* (*Ogham*) = 10^{57} (instead of 10^{55}); *Mahaugham* = 10^{62} (instead of 10^{60}).

Naturally readers will be confused and will wonder as to what the correct values are!

(iv) Venkatesha Murthy in his *Numbers and Numerals in Sanskrit Works* (Rashtriya Sanskrit Vidyapeetha, Tirupati, 2003) has committed error of

translation in this regard, although he has quoted the 12 Sanskrit lines (correctly) which are found in the Mumbai version (i.e. *śaṅkha* for *śaṅku* etc.) However, he wrongly translated L10 as (see p. 5 of his book)

"1 *Samudra* = $10^2 \times 10^3$ *Mahākhava*" (instead of 1 *samudra* = 1000 *mahākharva*).

This wrong translation also rendered his subsequent values of *ogha* and *mahaugha* to be both wrong (similar to what P.V. Arunachalam has mentioned).

(v) Vangeepuram V. Srinivasan in his recent *Chudamani Suthram* (Chennai, 2004) gives altogether a different interpretation. He states that *Vālmīki-Rāmāyaṇa's* relevant verses describe a centesimal number system (instead of the *lakṣa* scale). His list has *śaṅkha* (for *śaṅku*), *bindu* for *vṛnda*, and omits *samudra* altogether. Thus *mahaugha* comes to be 10^{27} (instead of 10^{60}) in his table (pp. 16-17).

Thus if the students or scholars of history of science read the above works, they will be confused. Writers on history of ancient Indian mathematical sciences should avoid creating such undesirable situation. They must study widely and should have a critical view. Creating confusion will go against the purpose of history of science and its popularity. Of course there may be variants in the original texts and sources consulted. But then, such variants should be mentioned clearly.

The *lakṣa* scale is not mentioned in the famous *History of Hindu Mathematics* by B. Datta and A.N. Singh (They placed the *Rāmāyaṇa* in about 1000 BC). But it is described correctly in V.D. Heroor's *The History of Mathematics and Mathematicians of India* (Bangalore, 2006) which is based mostly on the papers and findings of the present author.