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Mathematical Literature in the Regional Languages of India*

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Ever since the great Henry Thomas Colebrooke (1765–1837) translated the *Līlāvatī* into English[2] at the beginning of the nineteenth century, the concern of the historians of Indian mathematics has been the exploration of primary sources in Sanskrit. This emphasis on the Sanskrit texts is unexceptionable because Sanskrit has been the chief medium of intellectual discourse in India and the major vehicle of pan-Indian dissemination of ideas.

However, there have also been other parallel streams of intellectual communication in India: the Middle Indo-Aryan variants called the Prakrits, the succeeding New Indo-Aryan languages, the Dravidian languages of the South, and Persian. All these languages possess rich and varied literature, which may contain works on mathematics as well.

The extent and the nature of the exchanges between the pan-Indian Sanskrit on the one hand, and these regional languages on the other, have yet to be properly mapped. We may, however, postulate certain hypotheses on the nature of the exchanges. It is certain that these exchanges were never one-sided, i.e., from the "Great Tradition" of Sanskrit to the "Little Traditions" of regional languages. The two traditions were mutually complementary. While mathematical ideas and processes were systematized in Sanskrit manuals, the

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[2] Henry Thomas Colebrooke (tr), *Algebra, with Arithmetic and Mensuration, from the Sanscrit of Brehmegupta and Bháscara*, London 1817, First Indian Reprint: *Classics of Indian Mathematics: Algebra with Arithmetic and Mensuration, From the Sanskrit of Brahmagupta and Bhāskara*, with a foreword by S. R. Sarma, Sharda Publishing House, Delhi (2005).

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broader dissemination of these ideas took place in the regional languages. Conversely, Sanskrit has also absorbed much from the local traditions. Anthropologists recognize today that the so-called "Little Traditions" played a significant role in shaping the "Great Tradition."[3]

As mentioned earlier, the process of give-and-take is yet to be mapped, and this is especially true of mathematical literature. Without exploring the literature in regional languages, a full picture will not emerge on how mathematical ideas were developed and systematized in Sanskrit manuals and how they were disseminated and popularized in the regional languages.

The mathematical literature in Sanskrit has been surveyed and studied to a large extent.[4] But no attempts have been made so far to even survey the mathematical literature available in the regional languages. There have been one or two exercises to compile bibliographies of source materials in the regional languages, but none have come to fruition.[5] In the late 1950s, K. R. Rajagopalan published brief surveys of mathematical literature in the four states of South India.[6] This includes works composed in Tamil,

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[3] On this, see, *inter alia*, Swami Agehananda Bharati, *Great Tradition and Little Traditions: Indological Investigations in Cultural Anthropology*, Chowkhamba Sanskrit Studies, Vol. XCVI, Chowkhamba Sanskrit Series Office, Varanasi (1978).

[4] To mention the most prominent works: Bibhutibhusan Datta and Avadhesh Narayan Singh, *History of Hindu Mathematics: A Source Book*, 2 parts, 1935, 1938; single volume edition: Asia Publishing House, Bombay etc., 1962; A. K. Bag, *Mathematics in Ancient and Medieval India*, Chaukhamba Orientalia, Varanasi-Delhi, 1979; T. A. Saraswati Amma, *Geometry in Ancient and Medieval India*, Motilal Banarsidass, Delhi-Varanasi-Patna, 1979; David Pingree, *Census of the Exact Sciences in Sanskrit*, Series A, Volumes 1–5, American Philosophical Society, Philadelphia, 1970–1994 (in progress); also the large number of papers by R. C. Gupta listed in: Takao Hayashi, A Bibliography (1958–1995) of Radha Charan Gupta, Historian of Indian Mathematics, *Historia Scentiarum*, 6.1 (1996) 43–53.

[5] K. V. Sarma, *A Bibliography of Kerala and Kerala-based Astronomy and Astrology*, Vishveshvaranand Institute, Hoshiarpur, 1972, though primarily devoted to works in Sanskrit, contains several works on mathematics composed in Malayalam as well. The Government Oriental manuscripts Library, Madras, brought out a Malayalam work on Mathematics, *Kaṇakkusāram*, ed. D. Achyutha Menon, Madras, 1950. But, as far as I know, no study of this work has appeared to date.

[6] K. R. Rajagopalan, Mathematics in Karnataka, *Bhavan's Journal*, 5.6 (October 1958) 52–56; Mathematics in Tamil Nadu, ibid. 5.20 (May 1959) 39, 42–44; Mathematics in Andhra, ibid. 6.8 (November 1959) 47–49; Mathematics in Kerala, ibid. 6.10 (December 1959) 61–64. See also R. C. Gupta, Some Telugu Authors and Works on Ancient Indian Mathematics, *Souvenir of the 44th Conference of the Indian Mathematical Society*, Hyderabad, pp. 25–28 (1978).

Malayalam, Kannada, and Telugu. In a recent article, K. K. Bishoi mentions the names of several scholars who composed mathematical works in Oriya.[7] One wishes to know more about them.

Popularization of mathematics or any other science in India is not necessarily coterminous with vernacularization. Within the Sanskrit tradition itself there were attempts to compile popular handbooks of mathematics. In the eighth century, Śrīdhara abridged his own voluminous *Pāṭīgaṇita* and prepared the *Triśatikā* in 300 verses. In his admirable analysis of *The Bakhshālī Manuscript*, Takao Hayashi has shown that it was not an independent manual but a compilation made from diverse sources for practical application.[8] Hayashi also brought to light two other compilations of popular nature, namely the anonymous *Pañcaviṃśatikā*[9] and the *Caturacintāmaṇi* of Giridharabhaṭṭa.[10]

But these attempts at popularization received sharper focus in Prakrit and other regional languages. The mathematical works composed in these languages, though largely modeled on Sanskrit manuals, contain much information of contemporary relevance. The Śrīmāla Jainas in the West, the Kāyasthas in the North, the Karaṇams and other village accountants in the South, and the merchants in all parts of India were the numerate professionals who used mathematics in their daily transactions. The experience these classes of people gained in the application of arithmetical computations in their professions may be available from the sources in regional languages. To put it differently, while the theoreticians of mathematics wrote in Sanskrit, the practitioners of mathematics wrote in the regional languages. It is in the writings of these professionals that we come across shortcuts in computational

[7] K. K. Bishoi, Palm-Leaf Manuscripts in Orissa, in: A. Pandurangan and P. Maruthanayagam (ed), *Palm-Leaf and Other Manuscripts in Indian Languages*, Institute of Asian Studies, Madras, 1996 pp. 46–56; esp. pp. 52–53: "Orissa. . . has a rich heritage of mathematical treatises. Proficiency in mathematics is exemplified in the manuscripts. The authors of Orissan Mathematical manuscripts are Anirdha, Artta Dasa, Krushna Padhiari, Ucchavananda, Kunjabana Pattnayaka Krupasindhu, Gangadhara, Nimai Charana, Radha Charana, Brajabhusana, Vamadeva, Shiva Mohanty, Sarangadhara, Hari Nayaka and Srinatha of the Ganita Sāstras. The *Līlāvatī Sūtra* is very popular in Orissa. The manuscript is available in all parts of the state. It provides scope for all age groups to study mathematics through works of addition, subtraction, multiplication, division, mensuration, trigonometry, algebra, etc."

[8] Takao Hayashi, *The Bakhshālī Manuscript: An Ancient Indian Mathematical Treatise*, Groningen Oriental Studies, Vol. XI, Egbert Forsten, Groningen, 1995.

[9] Takao Hayashi, *The Pañcaviṃśatikā* in its Two Recensions: A Study in the Reformation of a Medieval Sanskrit Mathematical Textbook, *Indian Journal of History of Science*, 26, 393–448 (1991).

[10] Takao Hayashi, The *Caturacintāmaṇi* of Giridharabhaṭṭa: A Sixteenth Century Sanskrit Mathematical Treatise, *SCIAMVS: Sources and Commentaries in Exact Sciences*, 1, 133–209 (2000).

processes, verifying results, e.g., by casting off nines, conversion of one set of monetary units into another, and so on.

For example, a Telugu manuscript of uncertain date contains an elaborate classification of the variations of the Rule of Three, and also a simpler method of solving the problems of the Rule of Five, etc. Thus, in the case of the Rule of Five, the product of the last three terms is divided by the product of the first two terms; or in the case of the Rule of Seven, the product of the last four terms is divided by the product of the first three terms. This, in effect, is what Bhāskara I seemed to suggest before Brahmagupta proposed the arrangement of all the terms in two vertical columns. The Telugu solution is the ultimate stage of a mechanical solution.[11]

Furthermore, the Sanskrit texts on arithmetic employ in their sums the so-called *Māgadhamāna*, i.e., units of measurement, weight, and coinage, which are said to have been prevalent in Magadha in ancient times (probably when Āryabhaṭa was writing at Kusumapura) and not the contemporary units. Thus the Sanskrit texts – be it the *Āryabhaṭīya* composed in the fifth century in Kusumapura or the *Gaṇitalatā* by Vallabha Gaṇaka of Jayanagara of the mid-nineteenth century[12] – are neutral in relation to space and time. Not so the texts in the regional languages. Even when they are directly translated from Sanskrit, these texts employ in their sums the contemporary metrological units. This is of great value not only to metrology, but also for the economic history of the region. I shall illustrate these features through the example of an Apabhraṃśa text composed by a Śrīmāla Jaina, called Pherū.

In the first quarter of the fourteenth century, Ṭhakkura Pherū,[13] a learned Jaina employed as the assay-master at the court of the Khalji sultans of Delhi, wrote six scientific texts of a popular nature in Apabhraṃśa.[14] One of the six works composed by him is on arithmetic and geometry. It is variously called *Gaṇitasārapāṭīkaumudī*, *Gaṇitasārakaumudī*, or just *Gaṇitasāra*.[15] This

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[11] Sreeramula Rajeswara Sarma, Rule of Three and Its Variations In India: Yvonne Dold-Samplonius et al. (eds.), From *China to Paris: 2000 Years Transmission of Mathematical Ideas*, Steiner Verlag, Stuttgart, pp. 133–156, especially 149 (2002).

[12] This is perhaps the last work on mathematics to be composed in Sanskrit in the traditional style, and is yet to be published. The Department of Sanskrit, Aligarh Muslim University, possesses three manuscripts of this work.

[13] On his life and works, see Sreeramula Rajeswara Sarma, *Ṭhakkura Pherū's Rayaṇaparikkhā*, Viveka Publications, Aligarh, 1984, Introduction.

[14] These six scientific works (and a seventh of a religious nature) were edited and published by the Jaina savant Jinavijaya Muni under the title *Ṭhakkura-Pherū-viracita-Ratnaparīkṣādi-sapta-granthasaṃgraha*, Rajasthan Oriental Research Institute, Jodhpur, 1961.

[15] *Gaṇitasārakaumudī: The Moonlight of the Essence of Mathematics by Ṭhakkura Pherū*, edited with Introduction, Translation and Mathematical Commentary by SaKHYa (Sreeramula Rajeswara Sarma, Takanaori Kusuba, Takao Hayashi and Michio Yano), Manohar, New Delhi (2009).

work is largely based on Śrīdhara's *Pāṭīgaṇita*; several verses are phonetically converted from Śrīdhara's Sanskrit.

But there is a considerable amount of input by Pherū himself, which is related to contemporary society. The units of measurement and the illustrative examples given by Pherū reflect their wide applications in different professions of that period, such as that of traders, carpenters and masons. The section on solid geometry contains rules for calculating the volumes of bridges (*pulabaṃdha*), niches (*tāka*), staircases (*sopāna*), domes (*goṃmaṭa*), square and circular towers with a spiral stairway in the middle (*pāyaseva*), and so on. Some of these are new architectural features that were being introduced by the sultans in the fourteenth century. Consider the following definition: "The *munārayās* are like circular towers with a spiral stairway in the middle, as far as the inside is concerned. But outside there is this difference. The outer wall consists of half triangles and half circles." The meaning of the cryptic last sentence is this: the horizontal cross-section of the outer circumference consists of alternate triangles and semicircles. It should be remembered that about one hundred years prior to this, Qutbuddin Aibak built the Qutb Minar in Delhi. The lower storey of the Qutb Minar has alternately circular and angular columns, the second storey has circular columns, and the third has angular columns. I believe that Pherū is referring here to such a tower with fluted columns.

Pherū also touches upon various aspects of contemporary life that are quantifiable, from the average yield of different crops per *bīghā* to the quantity of ghee that can be extracted from cow's milk and buffalo's milk. He is perhaps the first mathematician to devise rules for converting the dates of the Vikrama era into those of the Hijrī era and vice versa.[16] Finally, he teaches us how to construct magic squares for even (*sama*), odd (*viṣama*), and oddly even (*sama-viṣama*) orders. This is the first systematic treatment of magic squares in India; and it precedes the most elaborate discussion by Nārāyaṇa in his *Gaṇitakaumudī* by about 40 years.[17]

[16] Cf. S. R. Sarma, Conversion of Vikrama-Saṃvat to Hijrī in: B. V. Subbarayappa and K. V. Sarma (eds.), *Indian Astronomy: A Source-Book*, Bombay, pp. 59–60 (1985); idem, Islamic Calendar and Indian Eras in: G. Kuppuram and K. Kumudamani (eds.), *History of Science and Technology in India*, Delhi, Vol. 2, pp. 433–441 (1990).

[17] On Nārāyaṇa's treatment of magic squares, see Schuyler Cammann, Islamic and Indian Magic Squares, *History of Religions*, 8.3–4, 181–209, 271–299 (1969); Parmanand Singh, Total Number of Perfect Magic Squares: Nārāyaṇa's Rule, *The Mathematics Education*, 16.2 (June 1982) 32–37; idem, Nārāyaṇa's Treatment of Magic Squares, *Indian Journal of History of Science*, 21.2, 123–130 (1986); idem, The Gaṇitakaumudī of Nārāyaṇa Paṇḍita, Chapter XIV, English Translation with Notes, *Gaṇita-Bhāratī*, 24, 35–98 (2002); Takanori Kusuba, Combinatorics and Magic Squares in India: A Study of Nārāyaṇa Paṇḍita's Gaṇitakaumudī, Chapters 13–14, PhD Thesis, Brown University 1993.

About the mathematical activity of Kāyasthas in North India, information is available only from Assam, where they were known as Kāiths who kept the land records. They developed a professional variety of arithmetic called *Kāithelī Aṃka*, which was in verse form. A certain Daṇḍirām Datta meticulously collected these *Kāithelī* sums and puzzles, and published them in a book entitled *Kautuk Āru Kāithelī Aṃka.*[18] In the sixteenth century, the *Līlāvatī* of Bhāskara II was brought to Assam from Bengal by Durgāracan Barkāith, and several translations were made into Assamese by different mathematicians.[19]

But the earliest of such translations from Sanskrit into a regional language is the *Pāvulūrigaṇitamu* in Telugu.[20] That under the caliphate of al-Mansūr at Baghdad Sanskrit astronomical-cum-mathematical texts were translated or adapted into Arabic is well known, but not so well known is the fact that Mahāvīra's *Gaṇitasārasaṃgraha* was translated into Telugu by Pāvulūri Mallana in the eleventh century. Indeed it is the second extant work in the Telugu language. Yet, only a small fragment of this text was published.[21]

From the small fragment published so far, we can see that Mallana was a superb translator. The lucidity with which he rendered the terse Sanskrit of Mahāvīra is worth emulating by every modern translator of scientific texts. His way of handling mathematical rules or examples containing large numbers – some examples have as many as 36 digits – is unrivaled even in Sanskrit. He abridged the material of the Sanskrit original at certain places and expanded at others. Thus, while the Sanskrit *Gaṇitasārasaṃgraha* contains five methods of squaring and seven of cubing, the Telugu version has only one each and avoids all algebraic methods. Mallana also employs units of measure that were prevalent in the Andhra region of his time. Another innovation or addition in the Telugu version pertains to mathematics proper. There are 45 additional examples under multiplication and 21 under division, which are not found in Sanskrit. All these examples have one common feature: to produce numbers containing a symmetric arrangement of digits. The Sanskrit original has only a few, and Mahāvīra calls them "necklace numbers" (*kaṇṭhikā*) because the

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18 Dilip Kumar Sarma, Kautuk Āru Kāithelī Aṃka: A Study, *Summaries of Papers*, All-India Oriental Conference, 40th Session, Chennai, 2000. p. 505 (TS & FA-32).

19 Dilip Kumar Sarma, A Peep into the Study of Development of Mathematics in Assam from Ancient to Modern Times, *Summaries of Papers*, All-India Oriental Conference, 39th Session, Vadodara, 1998, pp. 437–438 (TS & FA-11). See also Ganganand Singh Jha, Asam kī gaṇitīya den, *Pūrvānchal Praharī*, Guahati, 3 May 2000, p. 5; cited in : Hiteshwar Singh, Dr. G. S. Jha: A Broad-Based Historian of Mathematics, *Gaṇita Bhāratī*, 25, 150–153 (2003).

20 Sreeramula Rajeswara Sarma, The Pāvulūrigaṇitamu: the First Telugu Work on Mathematics, *Studien zur Indologie und Iranistik*, Hamburg, 13–14, pp. 163–176 (1987).

21 *Sārasaṃgrahagaṇitamu, Pāvulūri Mallana (Mallikārjuna) praṇītamu,* ed, Veṭūri Prabhākara Śastri, Part 1, Tirupati, 1952. This edition contains only a small part of the text, corresponding to Sanskrit *Gaṇtasārasaṃgraha* 1.1–3.53.

symmetric arrangement of digits is like the symmetric arrangement of beads in a necklace. The Telugu version abounds in necklace numbers of diverse patterns. For example, necklaces made up of just unities:

$$\begin{aligned}37 \times 3 &= 111,\\ 101 \times 11 &= 1111,\\ 271 \times 41 &= 11111,\\ 37 \times 3003003 &= 111111111,\\ 37 \times 3003003003003 &= 111111111111111,\end{aligned}$$

and finally,

$$1\ 763\ 668\ 430\ 335\ 097\ 001\ 763\ 668\ 430\ 335\ 097 \times 63 = \\ 111\ 111\ 111\ 111\ 111\ 111\ 111\ 111\ 111\ 111\ 111\ 111\ .$$

Or necklaces containing unities intermingled with pearl-like zeros:

$$\begin{aligned}14287143 \times 7 &= 100010001,\\ 157158573 \times 7 &= 1100110011,\\ 142857143 \times 7 &= 1000000001,\\ 777000777 \times 13 &= 10101010101.\end{aligned}$$

And here is the largest pearl necklace:

$$20\ 408\ 163\ 265\ 306\ 122\ 449 \times 49 = 10\ 000\ 000\ 000\ 000\ 000\ 000\ 01.$$

Mallana introduces a new pattern and calls it a "moon-like" number because here the digits increase from 1 to n and then decrease to 1 just as the phases of the moon gradually increase up to the full moon and then decrease in an *amānta* lunar month, e.g., $111111 \times 111111 = 12345654321$.

There are also reverse "moon numbers" in which the digits first decrease from n to 1 and then increase up to n, like the phases of the moon in a *pūrṇimānta* lunar month, e.g., $146053847 \times 448 = 65432123456$.

I should also add that often several sets of factors are given for one product.

It is indeed likely that problems such as these which produce startling results attracted the attention, not just of serious mathematicians who invented more problems like these, but also of laymen who posed these problems as puzzles or riddles under the village tree. Thus we come to the realm of recreational mathematics.[22] A large corpus of such mathematical riddles exists as oral literature, now styled ethno-mathematics.[23] This oral literature has not

[22] David Singmaster, South Bank University, London, is compiling the *Sources in Recreational Mathematics: An Annotated Bibliography*. The seventh preliminary edition was released in January 2002.

[23] Cf. D. K. Sinha, Ethno-mathematics: A Philosophical and Historical Critique, in: D. P. Chattopadhyaya and Ravinder Kumar, *Mathematics, Astronomy and*

yet been recorded in a systematic manner. It consists of mnemonic tables of multiplication and the like and also recreational mathematics.

In the seventeenth century, European travelers were much impressed by the Indian merchant's ability to perform mental calculations with great speed. Thus, the French jeweller Jean-Baptiste Tavernier wrote in 1665 that the Indian merchants learned arithmetic "perfectly, using for it neither pen nor counters, but the memory alone, so that in a moment they will do a sum, however difficult it might be."[24] The secret lies naturally in the number of multiplication and other tables the merchant had committed to memory in childhood. Hemādri, the chancellor of the exchequer (*mahākaraṇādhipa*) under the last Yādavas of Devagiri in the second half of the thirteenth century, was described as the outstanding computer (*gaṇakāgraṇi*). D. D. Kosambi writes that a few tables for quick assessment survive in Hemādri's name.[25] Writing in the first quarter of the nineteenth century, John Taylor records that "in the Mahratta schools, this table [of multiplication] consists in multiplying ten numbers as far as 30, and in Gujarati schools, in multiplying ten numbers as far as one hundred."[26] At the beginning of the twentieth century, the *Gazetteer of the Bombay Presidency* reports that merchant boys memorized no fewer than 20 types of tables: multiplication tables of whole numbers and of fractions, tables of squares, tables of interest, and so on.[27]

In Bengal, Śubhaṅkara is a household name as a repository of mathematical or computational expertise,[28] but nobody seems to have collected the

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Biology in Indian Tradition: Some Conceptual Preliminaries, PHISPC Monograph Series on History of Philosophy, Science and Culture in India, No. 3, Project of History of Indian Science, Philosophy and Culture, New Delhi, pp. 94–119 (1995).

[24] Jean-Baptiste Tavernier, *Travels in India,* tr. V. Ball, second edition, edited by William Crooke, London, Vol. 2, p. 144 (1925).

[25] Damodar Dharmanand Kosambi, Social and Economic Aspects of the *Bhagavad-Gītā*, in: idem, *Myth and Reality: Studies in the Formation of Indian Culture*, Popular Prakashan, Bombay, 1962, pp. 12–41, especially 32. I have not been able to find any information on these surviving tables.

[26] John Taylor, *Līlāwatī: or a Treatise on Arithmetic and Geometry by Bhascara Acharya*, translated from the Original Sanskrit by John Taylor, M. D. of the Hon'ble East India Company's Bombay Medical Establishment, Bombay, 1816, p. 145. The quotation is from a highly interesting "Short Account of the Present Mode of Teaching Arithmetic in Hindu Schools" (pp. 143–161) which he appended to his introduction.

[27] *Gazetteer of the Bombay Presidency*, Volume IX, Part 1: Gujarat, Population, Hindus, Bombay, 1901; reprinted as *Hindu Castes and Tribes of Gujarat*, compiled by Bhimbhai Kriparam, ed. James M. Campbell, Gurgaon, 1988, Vol. 1, p. 80.

[28] The Rev. Lál Behári Day, *Govinda Sámanta or the History of a Bengal Ráiyat*, London, 1874; new edition under the title *Bengal Peasant Life*, London, 1878; reprint: Macmillan and Co., Limited, London, 1920, p. 75: "He (the village school master) was the first mathematician of the village. He had not only Subhankara,

texts or sayings attributed to him.[29] Surely children must have memorized multiplication tables throughout the ages in India, but we do not know how these were formulated or under what name they were known. In a Telugu commentary on the *Pāvulūrigaṇitamu*, I came across fragments of tables of multiplication, of squares and square roots, and of cubes and cube roots. These tables are in Prakrit and must have been in use in the Andhra region at some time.[30]

But what is so special about these tables in the regional languages, when the results can be obtained from any pocket calculator today? These mnemonic tables are couched not in the modern form of the regional languages, but in earlier forms of languages. Thus in Uttar Pradesh, elderly people tell me that they had memorized several multiplication tables of whole numbers and fractions in Vrajbhāsā or in Avadhī. Therefore the importance of the tables is more cultural than mathematical. These tables tell us about the milieu in which they were formulated; the variety and the extent of the tables tell us about the nature of mathematical education. Therefore these tables are important and deserve to be recorded.

I mentioned earlier that much of the recreational mathematics is oral and unrecorded. Allow me to present one case in which I luckily found a written record as well as an oral version. In one of my visits to my native Andhra Pradesh, a friend of my father gave me several copybooks in which his own

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the Indian Cocker, at his finger tips, but was acquainted with the elements of Víjaganita or Algebra."

See also W. Adam, *State of Education in Bengal*, 1835–1838 (Extracts reprinted in: Dharampal, *The Beautiful Tree: Indigenous Indian Education in the Eighteenth Century,* Biblio Impex Private Limited, New Delhi 1983, pp. 269–270): "The only other written composition used in these schools, and that only in the way of oral dictation by the master, consists of a few of the rhyming arithmetical rules of *Subhankar*, a writer whose name is as familiar in Bengal as that of Cocker in England, without anyone knowing who or what he was or when he lived. It may be inferred that he lived, or, if not a real personage, that the rhymes bearing that name were composed, before the establishment of the British rule in this country, and during the existence of the Muslim power, for they are full of Hindustani or Persian terms, and contain references to Muslim usages without the remotest allusion to English practices or modes of calculation."

Edward Cocker (1631–1675) was an English pedagogue whose posthumous publications *Arithmetick, Being a Plain and Easy Method* (1678) and *Algebraical Arithmetic or Equations* (1684) were so popular that "according to Cocker" has become a proverbial expression to mean "very reliable." An analogous expression in German "nach Adam Riese" perpetuates the memory of Adam Riese (1492–1559), who wrote the earliest mathematical primers in German.

[29] D. K. Sinha, Ethnomathematics: A Philosophical and Historical Critique, op. cit., discusses on pp. 99–102 some old Bengali rhymes, which may be of Śubhaṅkara.

[30] Sreeramula Rajeswara Sarma, Some Medieval Arithmetical Tables, *Indian Journal of History of Science*, 32, 191–198 (1997).

father had collected various items of mathematical interest.[31] Here I found a Telugu version of the so-called Josephus problem.[32] The solution to this problem consists in arranging in a circle two groups of an equal number of persons or objects in such a manner that each nth person or object belongs to the same group. Though named after the Jewish historian, Flavius Josephus (37–100 C.E.), this problem was not known in Europe before the tenth century. There the problem runs as follows:

Fifteen Jews and fifteen Christians were traveling in a boat when the boat developed a leak. So the Christian captain arranged all the thirty persons in a circle and kicked out each ninth person and thus got rid of all the Jews.

Japan is the only other place where this problem was known, and there it became popular some time after the twelfth century. In the Japanese version, a man had 15 sons by his first wife. After her death, he married another woman who already had 15 sons of her own. The second wife arranged all the 30 sons and stepsons in a circle, explaining that she would count and take out each tenth one from the circle and that the last one in the circle would inherit the father's property. After she had thus eliminated 14 stepsons one after the other, the 15th stepson realized the trick and insisted that the counting should begin from him. She agreed to do so, but the consequence was that all her 15 sons were eliminated. The last one to remain in the circle and thus to inherit the patrimony was the 15th stepson, who cleverly saw through the stepmother's game.[33]

The Telugu version that I discovered runs as follows. Fifteen Brahmins and 15 thieves had to spend a dark night in an isolated temple of Durgā. The goddess appeared in person at midnight and wanted to devour exactly 15 persons, since she was hungry. The thieves naturally suggested that she should consume the 15 plump Brahmins. But the clever Brahmins proposed that all the 30 would stand in a circle and that Durgā should eat each ninth person. The proposal was accepted by Durgā and the thieves. So the Brahmins arranged themselves and the thieves in a circle, telling each one where to stand. Durgā then counted out each ninth person and devoured him. When the 15 were eaten, she was satiated and disappeared, and only Brahmins remained in

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[31] My father's friend and his father were hereditary Karaṇams who maintained the village records. The copybooks are datable to the 1930s, but the material collected therein is much older.

[32] On the Josephus problem, see David Eugene Smith, *History of Mathematics*, New York, Vol. II, pp. 541–544 (1925).

[33] Osamu Takenouchi et al. (eds. and trs.), *Jinko-ki*, Wasan Institute, Tokyo 2000, pp. 139–140. "Wasan" is the indigenous mathematics developed in Japan during the Edo Period (1603–1867). The *Jinko-ki*, which was published in 1627, is one of the earliest texts of this genre. The present edition contains an English translation, together with the facsimile reproduction of the original Japanese illustrated woodblock edition of 1627.

the circle. The problem is, how did the Brahmins arrange themselves and the thieves in the circle? The answer is composed in a Telugu verse of a classical meter.

The copybooks contained another variant of the problem, namely, to arrange 30 Brahmins and 30 thieves in a circle in such a way that each 12th person would be a thief. The solution to this also is given in a classical meter. Since I was pleased with this discovery, a farmer in my village posed the same problem to me. His solution is the same, but it is couched in free verse.[34]

Two versions of the solution to the same riddle in the same geographic area does indeed demonstrate the wide popularity of mathematical riddles in Andhra Pradesh. Whether this is an offshoot of the popularity of mathematical literature, or whether riddles – mathematical or otherwise – are transmitted in a different process independent of literature, is a question I am not competent to answer. But a collection of such mathematical riddles would certainly enrich the history of our mathematics.

There is yet another area in which regional languages provide valuable source material, viz. the dissemination of modern mathematics in the nineteenth century through mathematical textbooks in regional languages. As far as I know, Dhruv Raina and S. Irfan Habib are the only scholars who have studied this aspect, in connection with the Urdu textbooks and other popular writings on mathematics by Master Ramchandra (b. 1821).[35]

I conclude this presentation with a plea that organized efforts be made to save this mathematical heritage in the regional languages, both of the recorded and of the oral varieties.

A final poser: Watching TV on a visit to Tamil Nadu, I discovered that zero is called *pūjyam* in Tamil, "worthy of worship." I would worship any person who can explain why zero has such an exalted name in the Tamil language.[36]

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[34] Sreeramula Rajeswara Sarma, Mathematical Literature in Telugu: An Overview, *Sri Venkateswara University Oriental Journal*, 28, 7790 (1985).

[35] S. Irfan Habib and Dhruv Raina, The Introduction of Scientific Rationality into India: A Study of Master Ramchandra, Urdu Journalist, Mathematician and Educationist, *Annals of Science*, 46.6 (November 1989), pp. 597–610; Dhruv Raina and S. Irfan Habib, Ramchandra's Treatise through the "Haze of the Golden Sunset": An Aborted Pedagogy, *Social Studies of Science*, 20.3 (1990), pp. 455–472; Dhruv Raina, Mathematical Foundations of a Cultural Project: Ramchandra's Treatise through the "Unsentimentalized Light of Mathematics," *Historia Mathematica*, 19, pp. 371–384 (1992).

[36] In the discussion following my lecture, I learned that zero is called *pūjyam* in Malayalam and Marathi also. It would be interesting to know when this designation came into vogue and in what context. I also learned a Tamil proverb, which declares, "Inside the *pūjyam* (zero), there exists a *rājyam* (kingdom)."

"Mathematical Literature in the Regional Languages": Addenda

Sheldon Pollock, "The Language of Science in Early modern India" in: Karin Preisendanz (ed), *Expanding and Merging Horizons: Contributions to South Asian and Cross-Cultural Studies in Commemoration of Wilhelm Halbfass,* Vienna 2007, pp. 203-220. An excellent study of the attitudes of various scholars towards writing in regional languages.

To the works listed in footnote 4, add: Kim Plofker, *Mathematics in India,* Princeton 2009.

Marathi

Śrīpati of Rohiṇīkhaṇḍa was perhaps one of the earliest scientists to wrote both in Sanskrit and in his local language. Author of several influential works in Sanskrit on all branches of *Jyotiḥśāstra,* viz. *Dhīkoṭida-karaṇa* (1039), *Dhruvamānasa* (1056), *Siddhāntaśekhara, Gaṇitatilaka, Jyotiṣaratnamālā* and *Jātakapaddhati,* Śrīpati wrote a commentary on his *Jyotiṣaratnamālā* in Marathi (ed. M. G. Panse, Poona 1957). (On his writings, see the *Dictionary of Scientific Biography,* s.v.).

Bengali

The Asiatic Society of Kolkata has published *Śubhaṅkarī: An indigenous Tradition of Elementary Mathematical Instruction* by Santanu Chacraverti in 2007. The book is full of ill-digested post-modernist jargon, but very little on the legendary Śubhaṅkara or on the mathematical content of the verses attributed to him. However, I gather from this book that the verses attributed to Śubhaṅkara have been collected and published in the following works:

Panchanan Ghosh, *Śubhaṅkarī:Indigenous Bengali Arithmetic including a Complete System of Mental Arithmetic,* 7th edition, Calcutta 1893.

Madhusudan Deb, *Śubhaṅkarī:Indigenous Bengali Arithmetic including a Complete System of Mental Arithmetic,* Sarbamangala Library, Calcutta 1936 [Is it a reprint of the above?].

Hemendranath Palit (ed), Ashok Kumar Palit (re-edited), *Śubhaṅkarī: Rarh Banger Gaṇit Padābalī,* Bardhaman University, Bardhaman 2001.

Tamil

I understand that the multiplication tables (*encuvati*) which are memorized and recited by children contain a verse at the end of each table which tells the sum of all products. This is an unusual feature and is worth investigation.

The following texts are available in print.

Thirumalai Sree Saila Sarma (ed), *Astana Kolakalam,* Madras Givernment Oriental Series No. III, Government Oriental Manuscripts Library, Madras 1951.

K. Satyabama Kamesvaran (ed), *Kanakkatikaram – Tokuppu Nul,* Tanjore Sarasvati Mahal Publications series No. 388, Tanjore 1998.

P. Subramaniam & K. Satyabama (ed), *Kanita Nul: A Treatise on Mathematics,* (with English translation), Part 1, Publication No. 68, Institute of Asian studies, Chennai 1999.