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Artikel: MODERN FUNDAMENTAL OPERATIONS IN AN EARLY ARABIC FORM: 'ANAB'S HEBREW COMMENTARY ON IBN LABBN'S KITB F USL HISB AL-HIND
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we say 5×5, or multiplied by something other than itself, and in the case of division." [28]

Terms of interest include *nelām*, " to record a symbol ". It is so " because in Arabic *alama* is equivalent to *rōshem*, a sign.

The Arabic *tanṣīf*, " duplation ", is called in Hebrew *dōmeh*. The fractional portion or remainder of the quotient in Judaeo-Arabic is *alqūshūr*, in Hebrew *yitrōn*. The integral part of the quotient is in Judaeo-Arabic *sīkhakh*. The square root is *jadr* in Judaeo-Arabic, *jadhr* in Arabic, and in Hebrew *shōresh*.

In determining the square and cube roots, every second or third numeral of the number is marked off. In the case of the square root, the first numeral on the right and all of its alternates are called in Hebrew *medaberet*, in Judaeo-Arabic *minṭakh*; the next one and its alternates are called *elemet* in Hebrew, in Judaeo-Arabic *asā*. *Yitrōn ha-yitrōn* is the remainder of the remainder.

7. Arabic text.

The Hebrew commentary was compared and checked with ibn Labbān's Arabic text after the former had been studied. It is planned to publish a completely collated version of these two manuscripts. The text was found in the Aya Sofya Library in Istanbul (number 4857).

NOTES AND REFERENCES

[1] M. L. is indebted to the National Science Foundation and the National Institutes of Health for research grants which aided in the preparation of this paper. He is also indebted to the American Philosophical Society for aid in investigating the Arabic MS.

[2] Aldo Mieli, " La Science Arabe " (Leiden, 1938), p. 108.

[3] J. Lelewel, " Géographie du Moyen Age " (Bruxelles, 1852-7), I, XLVIII, III;
A. Mieli, *op. cit.*, 21; P. Luckey, " Die Rechenkunst bei Gamsīd b. Mas'ūd al-Kašī " (Wiesbaden, 1951), p. 73;
H. Suter, Die math. u. astron. d. Araber in *Abh. z. Gesch. d. math. Wiss.*, 10, 83-84 (1910); Nachträge Vol. 14, 168; C. Schoy, *Isis V*, 395;
L. Ideler, " Hand. der math. und tech. Chronol. " (Berlin, 1825-6), I, p. 263; *Zeit. d. Deut. Morgen. Ges. XXIV*, 375.

[4] M. STEINSCHNEIDER, " Die Heb. Uebersetzungen d. Mittelalters " (Berlin, 1893), 352. *Cf.* also N. KRAUSE, Stambuler Handschriften islamischer Mathematiker. Quell. u. Studien zur Gesch. d. math. B3 (Berlin, 1936), pp. 472-3.

[5] Lexicon bibliographicum et encyclopaedicum a Mustapha ben Abdallah Katib Jele bi dicto et nomine Haji Khalfa celebrato compositum, ed. latine vertit et commentario indicibusque instruxit G. Flügel (Leipzig-London, 1835), V, 82, VII, 851.

[6] Haji Khalfa, *op. cit.*, V, 142.

[7] *Cf.* Steinschneider, *op. cit.*, p. 566.

[8] J. TROEPFKE, " Gesch. d. Elementar-Mathematik " (Berlin, 1930), I, p. 82; P. LUCKEY, *op. cit.*, p. 73.

[9] *Cf.* H. SUTER, *Bibliotheca Mathematica*, III/7; F. WOEPCKE, *Journal Asiatique I*, p. 492 (1863).

[10] C. BROCKELMANN, " Gesch. d. Arab. Lit." (Leiden, 1937/43), I, 222-3, suppl. I, 397-8.

[11] Aya Sofya 4857/7.

[12] Bodleian, Oppenheim 211; *Cf.* M. STEINSCHNEIDER, *Zeit. f. Math.*, XII, 33; *Zeit. Deut. Morg. Ges.*, XXIV, 332.

[13] *Cf.* M. STEINSCHNEIDER, Heb. Ueber., p. 124; J. C. WOLFIUS, Bibliotheca Hebraica (Hamburg, 1815-33); M. STEINSCHNEIDER, Hebraische Bibliographie (Berlin, 1858-64), XVI, p. 103.

[14] LUCKEY, *op. cit.*, p. 75.

[15] Luckey evidently never saw the Hebrew manuscript but accepted Steinschneider's very brief and inadequate description in *Abhandl. zur Geschichte der Mathematik*, *3*, 109 (1880). It is now certain that Shalōm ben Joseph 'Anābî knew both books of ibn Labbān contrary to Luckey's assumption.

[16] For al-Nasawī's (d. 1029/30) arithmetic, cf. F. WOEPCKE, Journal Asiatique, I, 489-500 (1863); *Vide* also Oskar SCHIRMER, " Studien zur Astronomer der Araber " (Erlangen, 1926), appendix by E. Wiedemann, pp. 46-8, 80-5; H. SUTER, *Bibliotheca Mathematica*, VII, 3rd series, pp. 113-9 (1906-7).

[17] Al-Nasawī changed the number to 57342.

[18] Ibn Labbān used an approximative method:

$$a^2 + r\,, \qquad a + \frac{r}{2a+1}\,.$$

To obtain a more exact answer zeroes were added in pairs to the original number and the answer was divided accordingly.

[19] Exactly the same method is carried out by al-Nasawī; *cf.* pp. 114-5 in H. SUTER, *Bibliotheca Mathematica*, VII, 3rd series (1906-7).

[20] *Cf. ibid.*, 115-7.

[21] *Cf.* H. SUTER, *op. cit.*, p. 116.

[22] $60496 = 3\,(a+b)^2+3\,(a+b)\,c+c^2$; $424 = 3\,(a+b)+c$
$4\times 60496 = 241984$; $242100 - 241984 = 116$
$241984 = 3\,(a+b)^2\,c+3\,(a+b)\,c^2+c^3$.

[23] The remainder should be 116 parts of (62209+428) or

$$\frac{r}{3(a+b+c)^2+3(a+b+c)+1}.$$

This error is also in al-Nasawī. Essentially, ibn Labbān's approximation is

$$\sqrt[3]{a^3+r} \sim a + \frac{r}{3a^2+3a+1}.$$

[24] This is called the middle line in the text; al-Nasawī had the same nomenclature. *Cf.* SUTER, *op. cit.*, p. 117.

[25] *Cf.* B. DATTA and A. N. SINGH, Hist. of Hindu Math. (Lahore, 1935); A. N. SINGH, *Archeion*, XVIII, pp. 43-62 (1936).

[26] SUTER, *op. cit.*, p. 118.

[27] S. GANDZ, "The Origin of the Term Root", *American Mathematical Monthly 33*, 161-5 (1926); *35*, 67-75 (1928).

[28] Introduction of MS.

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