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Measuring length in ancient Egypt

El mesurament de la longitud a l'antic Egipte

Units of length measurement were a key element of ancient Egyptian mathematics and are necessarily an integral part of its historiography. The first part of this article provides an overview of research on Egyptian length measurements from the earliest contributions by Isaac Newton to recent studies of the 21st century. The second part presents examples of how length measurements were used in ancient Egypt and their contexts up to the end of the New Kingdom.

Keywords: metrology, mathematics, cubit, length measurements, historiography of mathematics.

Les unitats de mesura de longitud van ser un element clau de les matemàtiques de l'antic Egipte i són necessàriament una part integral de la seva historiografia. La primera part d'aquest article ofereix una visió general de la investigació sobre les mesures de longitud egípcies, des de les primeres contribucions d'Isaac Newton fins als estudis recents del segle XXI. La segona part presenta exemples de com es feien servir les mesures de longitud a l'antic Egipte i els seus contextos fins al final del Regne Nou.

Paraules clau: metrologia, matemàtiques, cúbit, mesures de longitud, historiografia de les matemàtiques.

Introduction

Ancient Egyptian metrology, like all ancient metrology, is a complex subject. Its study is burdened by several methodological issues that have been recognized over time. Despite its importance to other fields of study, such as mathematics, administration, and trade to name the most obvious, the study of metrology has a reputation for being difficult and dull. Consequently, in depth-studies of individual areas of this field (e.g. measures of length, volume, area, or weight) are rare. A recent comprehensive study of capacity measures was presented by Tanja Pommerening (Pommerening 2005). A brief overview of ancient Egyptian weights and measures can be found in (Pommerening 2013).

Two questions regularly arise regarding Egyptian measures of length: First, how many units of measurement were used, and what were their specific lengths? Second, what do we know about the main Egyptian length unit, the cubit? How does evidence from various contexts, such as architectural and religious contexts, affect our knowledge of it? Both questions have prompted monographs and articles. Still, essential issues related to them have not yet been fully addressed, leading to unresolved arguments that will be detailed in the first part of this study. For a concise summary of our current knowledge of length units and the relevant issues, as well as their current state of discussion, see the appendix on the system of length measures by Tanja Pommerening (Pommerening 2005: 271–277). Obviously, this article-length study cannot answer the questions raised above. Instead, the focus of this contribution is on the various uses and contexts of ancient Egyptian length measurements. To accomplish this, the various attestations of length measures in different types of texts will be used, which may be supplemented (if available) by depictions and archaeological sources. For a sociological view of metrology, see the contribution by Hector Vera (Vera 2015). Additionally, while there will be occasional references to later material, this contribution focuses on material up to the end of the New Kingdom. For Demotic length measures, see the works by Vleeming, Yasuoka, and Ziegler (Vleeming 1985; Yasuoka 2016 [article in Japanese]; and Ziegler 2007).

A Brief and Sketchy Historiography of Egyptian Measurements of Lengths

*The cubit (*mḥ*)*

In 1865, Richard Lepsius (1810-1884) published his monograph on the Egyptian cubit and its subdivisions (Lepsius 1865). In this monograph, Lepsius states that the length of the Egyptian cubit was approximately 52.5 cm based on extant cubit rods (votive cubits). This measurement could be confirmed in some instances by measuring buildings that were assumed to have been planned using multiples of cubits (Lepsius 1865: 1–13; on the complexity involved in applying mathematical analysis to archaeological remains cf. Rossi 2004, on Lepsius' work on metrology cf. Reineke 1988). However, Lepsius was not the first scholar to tackle this issue. Since the early 17th century, the question of the unit of Egyptian length measurements and their actual dimensions has been discussed in literature, originating from measuring the pyramids at Giza.[1]

An early, unpublished contribution by Isaac Newton (1643-1727), which is now accessible thanks to the Newton Project, refers to measurements of the pyramids taken by John Greaves (1602-1652).[2] In 1737, ten years after Newton's death, the results of his work to establish the length of the Egyptian cubit ('ancient cubit of Memphis') were published, which determined the cubit to be 52.79 cm (see Sarton 1936: 6 to the accuracy of the result obtained from various wrong premises):

> From the Pyramids of Ægypt accurately measured by Mr. John Greaves, I collect the length of the antient Cubit of Memphis in this manner. The side of the first Pyramid was 693 English feet. It is very probable, that at first the measure of it was determined by some round number of Ægyptian Cubits. Ibn Abd Alhokm, quoted by Mr. Greaves, tells us, that the measure of each side was an 100 Royal Cubits of the ancient times. But it is probable, that the Ægyptians learn'd, from the Orgyiæ of the Greeks, their measure of four Cubits of Memphis, and gave it the name of the Royal Cubit. Thus the side of the Pyramid will be 400 simple Cubits, or four Arouræ; and the Cubit of Memphis will be equal to 1 732/1000 of the *English* Foot. (Newton 1737: 408-409)

In the 18th and early 19th centuries several European researchers took additional measurements of the remains of ancient Egyptian monumental buildings, particularly the pyramids at Giza. Their publications often speculate about the length of an Egyptian cubit, based on the assumption that monumental buildings were planned with integer values (in cubits) for their measurements, as Newton had also assumed. Two publications resulted from the French expedition under Napoleon: in 1809, Pierre-Simon Girard (1765-1836) published his estimate that the Egyptian cubit was 527 mm, based on his examination of the nilometer at Elephantine (Girard 1809: 7). Edmé François Jomard (1777-1862) contributed a section on the metrological systems to the publication of the expedition (Jomard 1809). In 1817, Jomard published another monograph on a similar topic (Jomard 1817). Based on his measurements of the Great Pyramid of Giza, Jomard estimated the Egyptian cubit to be 0.462 meters:

> En effet, la 500.e partie de 230,902 m est 0,462 m. Or la coudée Egyptienne usuelle, comme nous le verrons bientôt, a une longueur de 0,462 m; c'est cette mesure et le pied qui en est formé, qui ont présidé à la construction de toute la pyramide. (Jomard 1817: 24)

According to Jomard, this coincides with the statement of Herodotus (5th cent. BC) that the cubit is one-four hundredth of a stadium:

> Maintenant la valeur de la coudée est facile à déduire: Hérodote et tous les auteurs, sans exception, nous apprennent que la coudée Égyptienne étoit la 400.e partie du stade. Si l'on divise donc 184,722 m par 400, on a 0,462 m. (Jomard 1817: 26-27)

In addition to measuring buildings, Jomard measured statues and depictions of people in reliefs (Jomard 1817: 71ff.). In 1822, he was the first to describe a cubit rod found in Memphis by the Italian diplomat and antiquities looter Bernardino Drovetti (1776–1852) (Jomard 1822). Jomard measured it at 0.520 meters (Jomard 1822: 6; cf. Bökh 1838: 223: "Zuerst beschrieb sie Jomard, Étalon métrique trouvé a Memphis, jedoch mit einem später von ihm berichtigten Irrthum über ihre Länge.").

After visiting Egypt for the first time in 1835, English army officer Richard William Howard Vyse (1784-1853) began working at the site of the pyramids of Giza in 1836. He was joined by engineer John Shae Perring (1813-1869) in 1837 (for a summary of his works cf. Lehner 1997: 50-53). Vyse published the results of their work in three volumes entitled *Operations Carried on at the Pyramids of Gizeh in 1837* (Vyse 1840) Perring published another three volumes entitled *The Pyramids of Gizeh* from 1839 to 1842. The first volume of Vyse's publication includes detailed measurements of the pyramids and their parts in English units of measurement (feet and inches), e.g.: 'Their dimensions are as follows: — King's Chamber, thirty-four feet three inches, by seventeen feet one inch;' (Vyse 1837, Vol. 1: 206).

The second volume discusses claims by Herodotus about the Egyptian pyramids and directs readers to a 17th century work by Edward Bernard (1638-1697) about ancient weights and measures:

> 'Thus the Pyramids are of one hundred fathoms; and the one hundred fathoms make up a stade of six hundred feet - the fathom containing six feet and four cubits; the foot containing four palms, and the cubit six.' with note 5: 'The reader is referred to Bernard's work upon ancient weights and measures; where it will be seen that there were several sorts of cubits -the black, the royal, & c.' (Vyse 1837, Vol. 2: 184, appendix citing Herodotus; 'Bernard's work' mentioned in the quote refers to Edward Bernard, *De mensuris et ponderibus antiquis* (1688))

The Scottish astronomer Charles Piazzi Smyth (1819-1900) took further measurements of the Cheops pyramid, which resulted in three volumes titled *Of Life and Work at the Great Pyramid*, published in 1867. Smyth was interested not only in metrological issues but also in proving that prophecies and mystical information were hidden in the dimensions of the pyramid. Smyth's dedication from 1867 points to these aims:

> '... with discoveries in the Great Pyramid, both possessing crucial importance for that primeval monument's metrological theory, and bringing to clearer light things long since dimly alluded to in Holy Writ' (Smyth 1867: v)

The field of historical metrology gained prominence with August Böckh (1785-1867), a German classical philologist whose general work on ancient weights and measures included Egypt (Böckh 1838, Section XIII is entitled: 'Die Ägyptischen Längen- und Körpermaße. Arabische Ellen' (Egyptian Length- and Bodymeasures. Arabic Cubits)). In his contribution, Böckh provided an overview of the various measures, their origins, and how they became interconnected due to economic and political developments in the Mediterranean region. To determine the length of the Egyptian cubit, he used the six cubit rods available to him that were found in tombs (Böckh 1838: 223–227). Based on the examples he examined, he calculated their average length to be 524.587 mm (Böckh 1838: 227). These cubit rods include a distinction between a royal cubit of seven palms and a small cubit of six palms. Additionally, he used the markings at the nilometer in Elephantine to determine the length of the Egyptian (royal) cubit to be 527 mm (Böckh 1838: 228).

Friedrich Hultsch (1833-1906), a German classical philologist and early historian of mathematics, also contributed to historical metrology. His monograph, *Griechische und römische Metrologie* (Greek and Roman Metrology), first published in 1862, and again with a substantially expanded second edition in 1882, includes a section on Egyptian measures in its supplement (Hultsch 1862: 279–285; 1882: 349–380). Hultsch indicates the length of the Egyptian (royal) cubit as 525–527 mm, based on the results obtained by August Böckh (Hultsch 1862: 279; footnote 4 on that page). Additionally, he mentions a smaller cubit measuring 462–463 mm that was used in certain buildings:

> Dieselbe (i.e. the royal cubit) liegt als Maß vielen ägyptischen Bauwerken zu Grunde; andere dagegen sind nach einer kürzeren Elle von 462 bis 463 Millim., welche nur 24 Daktylen enthielt, erbaut worden. (Hultsch 1862: 279-280)

The first publication from the Egyptological perspective was the aforementioned monograph on the Egyptian cubit by Richard Lepsius (Lepsius 1865). Lepsius begins with a critical assessment of earlier researchers' assumptions that the dimensions of ancient Egyptian monumental buildings, especially pyramids, were intended to have integer cubit values:

> Nun braucht man aber nur eine Reihe anderer Pyramiden, deren Grundseiten nachgemessen werden konnten, zu vergleiche, um zu sehen, daß unmöglich alle dies verschiedenen Maße, wenn man auch der Ungenauigkeit der Nachmessungen viel Spielraum gewährt, auf bestimmte runde Zahlenverhältnisse zurückgeführt werden können. (Lepsius 1865: 3)

By examining measurements taken from rooms and sarcophagi, Lepsius (1865: 5-7) reaches similar conclusions. However, according to Lepsius, further evidence that is more straightforward to use in determining the length of the cubit can be found in preserved markings on buildings:

> In einem Grabe bei den Pyramiden von Gizeh, südlich von dem Grabe no. 95 waren die Wände noch leer, doch für Darstellungen schon vorbereitet. An der Hinterwand der Kammer gegen Westen war der schadhafte Fels mit schönbehauenen Blöcken mäßiger Größe ausgesetzt. Auf der glatten Felswand daneben und zum Theil auf der Mauer laufen zwei rothe horizontale Striche hin, welche von einer großen vertikalen Linie durchschnitten werden. Links von dieser lief parallel mit ihr eine andere, von der aber jetzt nur wenig mehr zu sehen ist. Diese 4 Linien bilden in der Mitte ein Quadrat, dessen Seiten ganz gleich sind und genau 0,52 m messen. Die horizontalen Striche wurden hier von oben nach unten gezählt, wie an ihren Beischriften 1. und 2. Elle zu erkennen ist. (…) Auf der linken südlichen Felswand finden sich wieder rothe Linien, die 0,52 m von einander entfernt sind. (Lepsius 1865: 11-12)

Based on this evidence, Lepsius argues that, despite the majority of measurements taken by Jomard, the cubit measuring approximately 52 cm was used in architecture from the 4th dynasty on (Lepsius 1865: 13). He also concludes that, as is indicated by the inscriptions on votive cubits, a second, smaller cubit, must originate either from a different time or its use must have been restricted to specific areas, making it unnecessary to indicate which cubit was used (Lepsius 1865: 13). The remainder of the monograph presents his study of the votive cubits.

The publication of Lepsius was followed by two publications on the pyramid of Cheops, which also included information on the Egyptian cubit. In 1880, William Matthew Flinders Petrie (1853-1942) published his monograph on the Great Pyramid, confirming the length of the Egyptian cubit to be 20.632 ± .004 inches (approximately 52,41 cm):

> Probably the base of the chamber was the part most carefully adjusted and set out; and hence the original value of the cubit used can be most accurately recovered from that part. The four sides there yield a mean value of 20.632 ± .004, and this is certainly the best determination of the cubit that we can hope for from the Great Pyramid. (Petrie 1883: 81)

In his discussion of measurements of the Great Pyramid, Ludwig Borchardt (1863-1938) stated that the Egyptian (royal) cubit was approximately 0.525 meters:

> So ergibt sich aus den Maßen der "verlassenen" Kammer in der großen Pyramide – 2 · (10 + 11) E – eine Ellenlänge von 0,52290 m, aus denen der Grabkammer – 2 · (10 + 20) E – eine solche von 0,52404 m. An der Pyramide des Königs Ne-user-re bei Abußir, an der eine halbe Seitenlänge scharf gemessen werden konnte – 75 E – ergab sich die Elle zu 0,52507 m. Diese Elle von rd. 0,525 m wurde, wie wir auf zahlreichen erhaltenen Maßstäben, allerdings aus späterer als der Pyramidenzeit, sehen, in 7 Handbreiten, also jede von rd. 0,075 m, geteilt, jede Handbreite wieder in 4 Finger, rd. 0,019 m. (Borchardt 1922: 9).

Bochardt, too, mentions the smaller cubit of ca. 0,450 m and the existence of further units (Borchardt 1922: 9).

While discussions about the length of the cubit continue (e.g. Pochan 1932), the next significant contribution to determining the length of the Egyptian cubit was made by Walter Friedrich Reineke (1936–2015), an Egyptologist who specialized in ancient Egyptian mathematics and metrology. Reineke studied the available sources for Egyptian cubits and other measurements in his works (Reineke 1963 and 2014; on Reineke cf. Popko 2021). He carried out a statistical analysis of the length of the cubit based on the method proposed by Simon R. Broadbent (Reineke 1990: 258 cites Broadbent 1955 as reference for the method used (which he sketches briefly in his article) and Rottländer 1979 for the possibility to use this method for metrological studies). The data he used originated from measurements of tombs from the first and second dynasties. The study confirmed the result of approximately 52.5 cm for the length of the (royal) cubit (Reineke 1990: 261).

However, as with capacity measures, studies of later buildings indicate that the length of the Egyptian cubit changed over time. For Graeco-Roman buildings, the length of the cubit has been established at approximately 53.2 cm (Pommerening 2005: 273, referencing Girndt 1996:

53–55; see also Cauville and Devauchelle (1984) for the length of the cubit at Edfu). Additionally, regional variations are possible and attested even in earlier times (Pommerening 2005: 273–274). Despite reaching a consensus, as indicated above, the discussion about the length of a cubit and how it can be determined continues, as illustrated by a recent dissertation and articles in journals (Hirsch 2013; Carlotti 1995a, 1995b; Waziry 2016, 2018, 2020).

Cubit rods

Since the first cubit rod was discovered, these items have been part of discussions about the length of the Egyptian cubit (cf. Jomard 1822; Girard 1824; Lepsius 1865: 14ff.; Wood 1887; Sarton 1936; Scott 1942; Scamuzzi 1961; Senigalliesi 1961; Gabra 1969; Schlott-Schwab 1981; Austin 1994; Monnet *et al*. 2016; Rosati 2017; St. John 2000; Zivie 1972, 1977a, 1977b and 1979). However, the various extant types of these cubit rods also merit their own analysis. In her dissertation, which focused on a larger unit of length measurement, the *jtrw* (cf. the following section), Adelheid Schlott Schwab also examined cubit rods. She proposed differentiating three groups of cubit rods based on the inscriptions found on them (Schlott-Schwab 1981: 53 and 58). The first group consists of cubit rods that were used as measuring devices (Schlott-Schwab 1981: 53, references for these are provided on pages 54–55). The cubit rods of the second group have the same shape and mostly show subdivisions of the cubit into smaller units. However, they were not meant to be used by craftsmen, as can be deduced from the texts written on them and their material, which is often stone. Further texts on these cubit rods include offering formulas, titles, and names of their owners, or titles and names of a king (Schlott-Schwab 1981: 53 and 55, with references in Schlott-Schwab 1981: 55-57). Schlott-Schwab (1981: 58) designates the cubit rods of the third group as votive cubits ('Votivellen'). They are always made of stone and inscribed with texts like those of the second group, but they do not include offering formulas (Schlott-Schwab 1981: 58). Additionally, they contain inscriptions about the dimensions of Egypt, the height of the Nile, and how to measure time, as well as other texts that provide numerical data about Egypt (Schlott-Schwab 1981: 58).

One example of a cubit rod from the first group, which was recently studied (Nishimoto 2017), is that of Kha, the overseer of works from Deir el-Medina in the mid-18th Dynasty. This cubit rod has a hinge and was found with its leather holster (fig. 1). The museum website indicates its length in the folded state as 26.3 cm, which equals 52.6 cm for the complete cubit when unfolded. More ac-

Figure 1. Folding cubit rod of Kha (Turin Museo Egizio Suppl. 8391, https://collezioni.museoegizio.it/en-GB/material/S_8391/)

curate values can be found in Naoko Nishimoto's study. Nishimoto indicates the length of the cubit rod as 52.76 cm and the lengths of the palms in its subdivisions as 75 mm, 76.8 mm, 75.8 mm, 72 mm (this is the palm that is divided by the hinge), 76 mm, 76.6 mm and 75.4 mm. On the first palm subdivisions into fingers are marked as 18.0 mm, 19.0 mm, 19.0 mm and 19.0 mm. Nishimoto explains the uneven spacing of the markings of the palms as a consequence of constructing the hinge (Nishimoto 2017: 452-454).

Another example is a wooden rod with markings from Lisht that shows seven subdivisions, as well as a marking for the rod's midpoint (fig. 2). This rod is 70.5 cm long.[3] It also does not have the 'usual form' of the ceremonial cubits and the folding cubit rod of Kha, but seems to be (as far as one can see from the photo) a round stick.

Subdivisions of the cubit

As one might imagine, discussions about the length of the cubit also included discussions about its subdivisions. These discussions can be found in the literature referenced above.

Ironically, the subdivisions of the (royal) cubit are detailed on those cubit rods which were not used for actual measuring purposes. According to these objects, the (royal) cubit was divided into 7 palms (*šzp*) each measuring approximately 7.5 cm. This can be seen on the cubit rod of Amenemope (fig. 3). The palm (*šzp*) was divided into 4 fingers (*ḏbʿ*) measuring approximately 1.875 cm. As seen in the photo of the cubit rod of Kha (fig. 1), markings are included for the fingers of the first palm, followed by markings for seven palms (without subdivisions into fingers).

In addition to palm and finger, the cubit rod of Amenemope (and other cubit rods of this type) has several other subdivisions: a small cubit (*mḥ šrj*) of 6 palms (equaling approximately 45 cm), a unit called *Remen* (*rmn*) of 5 palms (approximately 37.5 cm), a unit called *Djeser* (*ḏsr*) unit, a large span (*pḏ ꜥꜣ*) of 3.5 palms (approximately 22.5 cm), a small span (*pḏ šrj*) of 3 palms (approximately 26.25 cm), two hands of 2 palms (approximately 15 cm), a fist of 1.5 palms (approximately 11.25 cm), and a hand of five fingers (approximately 9.25 cm), as well a unit of 3 fingers (approximately 5.625 cm) and 2 fingers (approximately 3.75 cm) (all approximate values for individual units were taken from Pommerening 2005: 272).

The jtrw *('river-measure')*

The *jtrw* was a unit used to measure long distances (for a historiographical survey of this unit see Priskin 2004: 57-60). However, as Adelheid Schlott-Schwab pointed out, the *jtrw* is not a fixed unit of length. Rather, it designates the distance between two resting places for a team towing a boat on the Nile — that is, the distance that could be traveled by boat in one day (Schlott-Schwab 1981: 121–122). Thus, the commonly accepted value of 10.5 km for the *jtrw* is an average based on various individual values dependent on the type of terrain (Schlott-Schwab 1981: 121; cf. also Priskin 2004 who argues for a specific length of the *jtrw* at least in later times). Schlott-Schwab cites the assessment of Jomard of a similar Egyptian measure, the *malqât*, which was still in use at the beginning of the 19th century. According to Jomard, nothing is more variable than this measure, which depends on the season, the company that one travels in, the use (or not use) of animals, and the type of animal that was used ('Or, rien n'est plus variable que cette mesure, suivant la saison, selon que l'on marche isolément ou en caravane, selon enfin que la caravane est composée de chevaux, ou d'ânes, ou de chameaux plus ou moins chargés.' Schlott-Schwab 1981: 121; on variations of travelling speed – with numerical examples – see in detail Köpp-Junk 2015: 289-302).

The discussion about the length of this unit can be traced back to publications by Jomard and Hultsch (e.g. Hultsch 1882; for a discussion of earlier studies of the *jtrw* cf. Schlott-Schwab 1981: 118-120). In 1968, the *jtrw* was studied by Adelheid Schlott-Schwab in her dissertation (published in a second edition in 1981) and a subsequent publica-

Figure 2. Rod with subdivisions into halves and seven parts (MMA 15.3.1128, https://www.metmuseum.org/art/collection/search/557017)

Figure 3. Cubit rod of Amenemope (Turin Museo Egizio Cat. 6347, https://collezioni.museoegizio.it/en-GB/material/Cat_6347/)

tion of 1972 (Schlott-Schwab 1972 and 1981; the latter is the publication of the extended dissertation from 1968). According to these studies, the earliest attestation for the *jtrw* originates from the First Intermediate Period and attestations continue until the Roman period (Schlott-Schwab 1981: 102-107). Schlott-Schwab concluded that the 'length' of the *jtrw*, understood as an average, was 10,5 km until the Late Period (Schlott-Schwab 1981: 135). From the Late Period on, a larger average *jtrw* of 12,6 km seems to be attested (Beinlich 1987). Using Graeco-Roman evidence Gyula Priskin discusses the relation between *jtrw*, stade and *schoinos*, and has argued for the *jtrw* being equal to 50 stades (Priskin 2004: 63).

Further units

For measuring larger distances, the unit *ḫt* (*n nwḥ*) was used, which was equal to 100 *mḥ*. It is attested since the Middle Kingdom and may have been measured using a rope of the same length (WB III: 341). From the New Kingdom, there are depictions of measuring the area of a field using ropes (fig. 4). Scenes depicting the measurement of fields with ropes are found in the tombs of Deserkareseneb (TT38), Khaemhat (TT57), Menna (TT69), and Amenhotep-si-se (TT75), which are all located in Gurna. Statues of scribes involved in estate and field administration (e.g., Cairo CG42128) depict them holding coiled ropes (fig. 5). Some of the depicted ropes have a ram's head at their beginning, indicating that the measurement was carried out for or on behalf of an institution of the god Amun.

For the Old Kingdom, another unit was introduced in 1981 by Miroslav Verner (Verner 1981; cf. also Roik 1993: 63): the Egyptian foot (*ṯb.t*), which measures approximately 8.7 cm. Apparently, the unit is derived from the width, not the length, of a foot. However, the only attested reference of this unit thus far comes from the tomb of Ptahschepses.

Following several articles on another length measurement called *nbj*, Elke Roik published a monograph in 1993 entitled *Das Längenmaßsystem im Alten* Ägypten (The system of length-measurement in ancient Egypt) (Roik 1993; for a critical evaluation of this volume cf. the review Simon-Boidot 2000). However, rather than providing a survey of Egyptian length measurements, Roik aimed to argue for the devaluation of the Egyptian cubit, which was prompted by her discovery of a new unit of measurement: the *nbj*, which is approximately 65 cm long. Roik was not the only researcher to work on the *nbj*. Naguib Victor also tried to establish evidence connected to it (Victor 1991, cf. also Simon-Boidot 2000). As Simon-Boidot points out, the claims made by the various researchers about its length and usage are so different, that the 'Roik-*nbj*' and the 'Victor-*nbj*' require separate discussions (on the work of Victor see also Pommerening 2005: 275).

Despite the discussion initiated by Roik, the argument for the *nbj* has not resulted in a significant change in the assessment of Egyptian length measures. Therefore, Tanja Pommerening refers to the respective entry by Helck in the *Lexikon der Ägyptologie* for a summary of the *opinio communis* concerning length measures (Pommerening

Figure 4. Depiction of measuring ropes in assessing the size of a field (Wall painting scene from the tomb of Djeserkareseneb (TT38); Archivio Museo Egizio, Album 2_030, https://archiviofotografico.museoegizio.it/en/archive/theban-region/sheikh-abd-el-gurna/tt38-tomb-of-djeserkaraseneb/?)

Figure 5. Statue of Amenemhet called Surero, kneeling holding rope with ram's head (CG 42128, Legrain 1906: Plate LXXVII).

2005: 271). This is summarised by Pommerening as follows: 'Die Standardlehrmeinung, die von mir befürwortet und für diese Arbeit zugrundegelegt wird, spiegelt sich im Lexikon der Ägyptologie wider. Danach bildete die Elle (*mḥ*) von etwa 52,5 cm – die Maßzahl wird im Folgenden noch ausführlicher diskutiert – die Grundlage der ägyptischen Längenmaße, und zwar schon seit der Frühzeit.' ('The cubit (which is approximated at 52,5 cm) was the basis of Egyptian measures of length since the early dynastic period.') (Pommerening 2005: 271, cf. also Helck 1980: 1199-1200.)

Regardless some archeological sources and a few textual references pointing to the use of the *nbj* measure, the dominant measuring unit from both types of sources appears to be the cubit (*mḥ*) (Pommerening 2005: 271-272). While Roik challenged the evaluation of archeological evidence in support of the *nbj*, the philological evidence clearly favors the cubit (see the following section).

Despite the continuous interest in ancient Egyptian measures of lengths and the various sources available, no detailed study comparable to Tanja Pommerening's analysis of the volume measures has yet been completed. That this will not be a simple task can be seen from the historiography of length measurements so far, and most notably from the discussions of the *nbj* measure. Such a study is urgently needed due to the importance of length measurements for a large number of ancient Egyptian sources.

(Preliminary) Survey of Philological Attestations of the Cubit and Other Units

Evidence for Egyptian length measures can be found in archeological sources by measuring the dimensions of buildings and artifacts, assuming these were planned using units or subunits of a standardized measurement system (Pommerening 2005: 271). Evidence can also be found in philological sources that mention lengths of buildings, artifacts, or appearances. Regarding the latter, it seems reasonable that the number of attestations of individual units of measurement reflects their usage. To get an idea of how often individual measurements were used, the number of attestations for each term in the *Theasurus Lingua Aegyptia* (TLA) and the *Wörterbuch* (WB) can be used. The *Wörterbuch* used to be the academic point of reference for Egyptian words. However, it is now outdated and will eventually be replaced by the *Thesaurus Lingua Aegyptia*. Currently, however, some attestations found in the *Wörterbuch* have not yet been included in the TLA, which, in some cases, includes more attestations than the *Wörterbuch*. Therefore, both sources will be checked for each word.

*The Cubit (*mḥ*)*

The cubit (*mḥ*), according to *opinion communis* the most common unit of length in ancient Egypt, may – according to the *Wörterbuch* - be specified as a 'royal cubit' (*mḥ nsw.t*) or a 'small cubit' (*mḥ šrr*). The *Wörterbuch* lists the unqualified cubit (*mḥ*) as the usual occurrence (WB II: 120). The *Thesaurus Linguae Aegyptiae* does not include the specified attestations and has 300 attestations for the cubit (*mḥ*) from the Old Kingdom up to the Roman period.[4] The attestations given in the *Wörterbuch* for the royal cubit (*mḥ nsw.t*) are Pap. Leiden 350: 3,10 (Gardiner 1905: 27) and Lepsius (1865): plate 1b, 2a, and 3c. The translation of Pap. Leiden 350: 3,10 given by Gardiner is 'Sated (?) was the Royal Cubit, which measures blocks of stones.' The reference(s) from Lepsius lead to three cubit rods. Plate 1b refers to the cubit rod of Amenemope now in Turin (Cat. 6347), 2a to the cubit rod of Maya now in Paris (Louvre N 1538) and 3c to a cubit rod found by Anastasi sent to Italy in 1823, which was then lost (cf. Lepsius 1865: 14-16). All attestations for the 'small cubit' (*mḥ-šrr*) in the *Wörterbuch* are found on these cubit rods. The subdivisions of the cubit are also found on these rods. However, the latter also occur independently. Fingers (*ḏbʿ*) and palms (*šzp*) are attested as early as the Old Kingdom.

As one might expect, they are used either independently when the respective length is smaller than a cubit or in combination with the cubit, if the length of the object to be measured happens to be more than a specific integer cubit value.

*The 'river-measure' (*jtrw*)*

The 'river-measure' (*jtrw*) is listed in the *Wörterbuch* with the meaning 'ein größeres Wegemass' ('a larger measure of distance') (WB I: 147.2). Attestations given originate from four sources, including boundary stelae from Amarna (Davies 1908: plate 28, e.g. line 19), inscriptions from the temple of Ramses III at Medinet Habu and the Famine Stela (Barguet 1953). The *Thesaurus Linguae Aegyptiae* lists 31 attestations from the New Kingdom to the Roman period.[5] The study of Schlott-Schwab has a list of 60 attestations from the First Intermediate Period up to the Roman period (Schlott-Schwab 1981: 102-107).

The nbj

Although the *Wörterbuch* does not have an explicit entry for a unit of measurement *nbj*, it has an entry of *nbj* indicated as 'meaning unknown', which is among the references given for *nbj* in the *Thesaurus Linguae Aegyptiae* (WB II: 244). The latter has nine occurrences of *nbj*, all originating from the New Kingdom (cf. also Roik 1993: 42-46). However, several of these occurrences come from the same source (three attestations from Ostracon Senmut 73 and two attestations from Ostracon Senmut 62).[6] In the text of Ostracon Senmut 62, *nbj* is used alongside the cubit (*mḥ*). A further reference for *nbj* can be found on Ostracon Cairo CG 25501 (Hayes 1973: 21 note 87).

*The foot (*ṯb.t*)*

The only known attestation originates from the tomb of Ptahshepses (Verner 1981). It is neither included in the *Wörterbuch* nor in the *Thesaurus Linguae Aegyptiae*.

*The schoinos (*ẖt *(*n nwḥ*))*

The *Wörterbuch* lists *ẖt* and *ẖt n nwḥ* separately, possibly because the former is attested since the Middle Kingdom and the latter only in the New Kingdom and Graeco-Roman Period (WB III: 341.12 and WB II:223.12; cf also Peet 1923: 24: 'In the measurement of land the unit of length was the khet (ẖt) of 100 cubits, the full name of Which was ẖt nt nwḥ, or 'reel (?) of cord,' a measure which may well be compared with our chain'). The *Thesaurus Linguae-Aegyptiae* includes 17 references of *ẖt*[7] and one for *ẖt n nwḥ*[8]. The references for *ẖt* are from the *Book of the Dead*, from the boundary stelae of Amarna, from the magical Papyrus Leiden I 348 and from the magical Papyrus Budapest 51.1960. In addition to these references, there are also references of *ẖt* within the mathematical Papyrus Rhind. These come from problems 49-52, all of which are about the calculation of areas. The reference for *ẖt n nwḥ* can be found in the demotic Papyrus Rylands 9 (Vittmann 1998; a further German translation of the text is provided by Hoffmann and Quack 2007: 22-54). It is used to describe the dimension(s) of a court. In the slip archive further references of *ḫt n nwḥ* are attested (e.g. DZA 24.725.160, DZA 24.725.170, DZA 24.725.180, DZA 24.725.200, DZA 24.725.230).

Comparison of attestations of individual measures

Despite the vagaries that are inherent in ancient Egyptian sources, the number of attestations still provides an idea of the frequency of words. The cursory survey of textual attestations of the various measures confirms the *opinion communis* of the secondary literature that the cubit was the most common unit of length. The question concerning the usage of the unit of a foot (*ṯb.t*), which has so far only been recorded once, remains unclear.

In addition, studies of specific units of measurements, like that of the *nbj* by Roik and that of the *jtrw* by Schlott-Schwab, demonstrate that currently neither the *Wörterbuch* nor the *Thesaurus Linguae Aegyptiae* provide comprehensive lists of attestations. In the example of the *jtrw*, the study by Schlott-Schwab lists double the number of references in comparison with those of the *Thesaurus Lingua Aegyptiae*.

Selected Examples of Philological Sources Illustrating the Use of the Cubit in Ancient Egypt

As the previous section of this article indicated, there are a variety of philological sources available for studying Egyptian length measurements. This section presents selected examples of these sources, organized by cultural context. The order of discussion is not arbitrary, but rather reflects the frequency of attestations and consequently, the relevance of length measurements in this field. While the usage of the cubit is obvious in some contexts, such as in architecture to indicate building dimensions, it is less obvious in others. Analyzing these less obvious uses may provide better insight into Egyptian measurement concepts and their meanings.

The references in the following section offer only limited insight and do not claim to provide a comprehensive overview. At best, they demonstrate the breadth of source material that deserves an in-depth study.

The length measurement 'cubit' was also used to measure area. Since the two uses are not always distinguishable in writing, some of the following references may refer to areas.

Context of Architecture/Building

There is probably little doubt that the context of building is, apart from the administrative context, one of the areas in which the need for a unit to measure length arose. One of the earliest attestations comes from a sketch of a vaulted roof on an ostracon, where the indication of length is a vital information in the construction process (Gunn 1926; for a photo of the ostracon cf. Lightbody and Monnier 2017, fig. 4). The sketch shows a curve divided into intervals by five vertical lines that are supposedly equidistant. The height of the curve (from the ground?) is indicated by the respective lengths measured in cubits, palms and fingers is indicated (presumably for the highest point of each interval, i.e. at the left end). These lengths are 3 cubits, 3 palms, 2 fingers; 3 cubits, 2 palms, 3 fingers; 3 cubits; 2 cubits 3 palms; and 1 cubit, 3 palms and 1 finger. The horizontal distance between the lines is not indicated.

Further attestations of the cubit in architectural contexts come from the remains of buildings.[9] The slope of a building was conceptualized by the *sqd*, which indicated the horizontal displacement, usually measured in palms and fingers, for a vertical drop of one cubit (Rossi 2004:185).[10] Calculations of the *sqd* were included within the mathematical problems (e.g. Mathematical Papyrus Rhind, problems 57-60, see below). In the context of mastabas, markings used to determine the slope of walls have been found, e.g., at Mastaba 17 in Meidum (Rossi 2004: 188–192). Horizontal lines were spaced at a distance of one cubit, starting from an assumed baseline (fig. 6).

Texts detailing the size of buildings or other constructions, such as canals, often use the cubit and its subdivisions. [11] Similarly, the quality of building materials or elements could be indicated by dimensions in cubits (or parts thereof).[12] These kinds of descriptions often originate from autobiographies, i.e., texts found in tombs that describe the achievements of the tomb owner (see Stauder-Porchet *et al*. 2020, with references to earlier literature). They can also be found in the context of royal inscriptions.[13] Further attestations of this kind originate from letters.[14]

Additionally, in the contexts of architecture and the administration of labor, the work of a construction worker could be indicated by a specific number of cubits.[15] Lastly, the cubit is central to creating two-dimensional representations (see, for example: Iversen 1975; Robins 1982 and 1994; and Robins and Shute 1985).

Administrative Contexts

In administration, the cubit was also used as a basic unit of measurement for length in various contexts. It is attested on nilometers, which were used to measure the height of the inundation to determine the grain harvest dues. While the remaining nilometers are of Graeco-Roman origin,

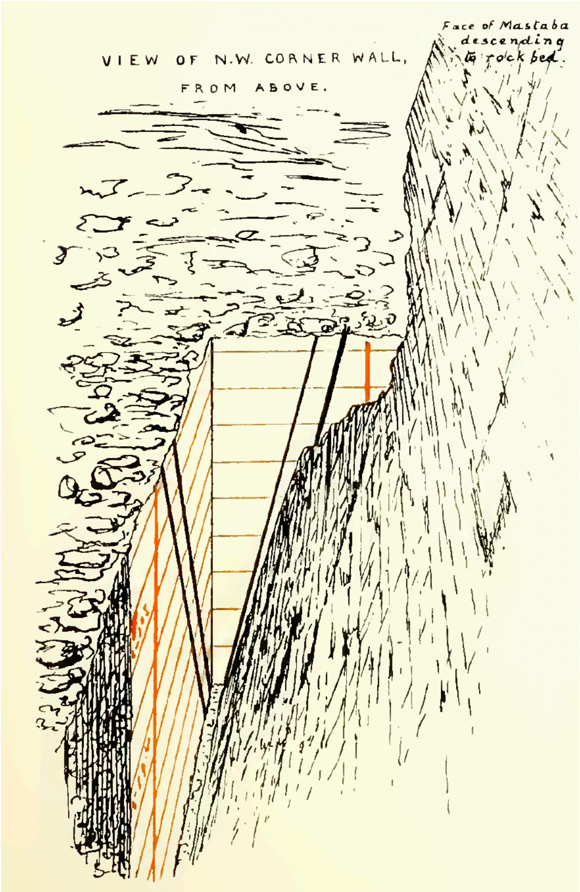

Figure 6. Mastaba 17 (Petrie 1892: plate VIII).

the practice of measuring the height of the inundation dates back to the First Dynasty (Seidlmayer 2022: 7; 2001; for an overview, see Borchardt 1906). Early records of inundation heights for successive years are found in the Royal Annals, the largest fragment of which is the Palermo Stone (Wilkinson 2000). Nilometers included a built-in scale for measuring the height of the Nile (for records of the height of the Nile see Seidlmayer 2001: 87-89). There are also later records of the height of the Nile, e.g. on the White Chapel of Sesostris I (cf. Seidlmayer 2001: 93-103) or on a stela from the 25/26th dynasty[16]. Information about the heights of the Nile is also included on votive cubits (cf. Schlott-Schwab 1981: 48).

The unit *mḥ* and its subdivisions are also used to quantify various goods, as for example in the description of a tribute from the Old Kingdom which is documented in the tomb of Sabni, a noble during the time of Pepi II. at the Qubbet el Hawa in Assuan: '(…) one three-cubit long elephant tusk to let it be known that I brought a seven-cubit (⌜5⌝ [+2]) long lion-skin (…)'[17]. In the tomb of Sechemkare (5th dynasty) at Giza, the harvest and processing of grain is depicted. There, the height of a large pile of grain is indicated as 46 cubits and 5 palms.[18] The accounts of the Abusir Papyri (5th dynasty) also include goods measured in cubits.[19] In the context of a ration list from the New Kingdom, *mḥ* is used to indicate the length of a piece of cloth.[20] Another indication of the size of a piece of cloth can be found in a letter from Deir el Medina.[21] In these last instances, *mḥ* may also be the area measure derived from the length measure (cf. the discussion of the question if *mḥ* refers to lengths or areas in the scenes discussed in Altenmüller 1987: 19-20). As expected, the cubit, the basic unit of measurement for length, is attested in various administrative sources.

Mathematical Contexts

The Egyptian hieratic mathematical texts are closely linked to administration and include significant sections that explain metrological units and their subdivisions (for a study of hieratic mathematical problems, see Imhausen 2003). Demotic mathematical papyri also include references to the cubit. However, since this contribution focuses on earlier material, these will not be discussed. Additionally, the hieratic mathematical texts include at least some problems related to architecture in which the cubit is also attested.

Within the hieratic mathematical papyri *mḥ* is attested 14 times in nine problems and three different papyri (Rhind Mathematical Papyrus: problem 43 (2), problem 46 (1), problem 56 (2), problem 57 (2), problem 58 (3), problem 59 (1), problem 60 (1); Moscow Mathematical Papyrus: problem 3 (1); Lahun Mathematical Fragments: UC32162-01-12 (1)). In the Rhind Mathematical Papyrus, *mḥ* appears in two problems that calculate the volume of granaries (problems 43 and 46) and in all of the problems related to pyramids (problems 56-60). However, the unit *mḥ* is not found in problems that calculate areas. In these problems, the larger length measure, *ẖt*, is used instead. In all instances where *mḥ* can be found, it is used in the context of indicating numerical dimensions of the objects that are the topic of the problem. In the text of the problems of the Rhind Mathematical Papyrus, the cubit is explicitly stated as being subdivided into 7 palms: 'Concerning 1 cubit, it is 7 palms'. This introduces the subunit palm in the context of a problem about the slope (*sqd*) of a pyramid (Rhind Mathematical Papyrus, problem 56, cf. Imhausen 2016: 113).

Unfortunately, the occurrence of *mḥ* from the Mathematical Papyrus Moscow comes from one of the first three badly damaged problems. Problem 3 of the Mathematical Papyrus Moscow is the calculation of the mast of a ship. The length of the mast is indicated as 30 cubits – what was supposed to be calculated is not extant. Only the end of the first instruction remains, indicating the calculation of 1/3 of 30 cubits (cf. Imhausen 2003: 309).

In the mathematical Fragment UC32162 from Lahun, *mḥ* is used in the final line of a problem about area calculations. The problem states that an area of 40 by 3 cubits should be divided into 10 smaller areas, each with a width that is 3/4 of its length. The beginning of the problem is lost, therefore *mḥ* is found only once within the text of this fragment in the statement of the result.

Contexts of Trade

Apart from evidence of measuring goods for administrative purposes, there are also depictions in the context of tombs showing the exchange of goods (see Livingstone-Thomas 2011, with references to earlier literature). These scenes are accompanied by descriptions that may indicate the conversation between buyer and seller. The Egyptian cubit is attested at least once in these descriptions, in the tomb of Nianchchnum and Chnumhotep (5th Dynasty), where it accompanies the trade of cloth.[22]

Literary Contexts

Several literary works include indications of size using the Egyptian cubit. These explicit measurements may serve to emphasize impressive dimensions, as in the *Story of the Shipwrecked Sailor*. The text is extant in Papyrus Leningrad 1115 dating to the Middle Kingdom (Lichtheim 1975: 211; English translations can be found in Lichtheim 1975: 212-215 or Parkinson 1997: 89-101). The frame of the story describes the return of an official from an unsuccessful expedition by boat. His attendant attempts to cheer him up by telling him the story of a previous boat expedition on which he was shipwrecked on an island. He found the island to be plentiful in resources, and with the help of a snake-god who ruled the island, he turned disaster into success. Length measurements are indicated eight times within the papyrus. The attendant's ship is described by its length (120 cubits), width (40 cubits), and the number of sailors (120).[23] The height of the fatal wave that led to the shipwreck is indicated as 8 cubits tall.[24] The snake-god is described as 30 cubits long with a beard of more than 2 cubits.[25] When the shipwrecked sailor tells the snake-god how he came to be on his island, the dimensions of the ship and the wave are repeated.[26] It is interesting to compare this description with that of the return of the sailor towards the end of his tale. There, the resources that the shipwrecked sailor gets to take home with him are listed without specifying any measuring units at all: 'Then he gave me a load of myrrh, *ḥknw*-oil, laudanum, *ẖsyt*-spice, *tišpss*-spice, perfume, eye-paint, giraffe's tails, great lumps of incense, elephant's tusks, greyhounds, long-tailed monkeys, baboons, and all kinds of precious things.' (Lichtheim 1975: 214). Thus the grandeur of the gift of the snake god is left to the readers imagination.

In the tales of Papyrus Westcar, the cubit is used to indicate the size of a (magic) crocodile and the changing height of a body of water (also involving magic manipulations).[27]

The description of the profession of a carpenter in the *Teaching of Khety* also includes specific measurements indicated in cubits:

> Vile is the carpenter, working at a ceiling;
> it is the roof of a chamber,
> a chamber of ten by six cubits.
> (Translation: Parkinson 1997: 277)[28]

In the *Teaching of Khety*, which compares a variety of professions to that of a scribe, the section about the carpenter cited above is the only one that includes specific numerical/metrological data. Much more frequent are references to metrology in the *Teaching of Amenemope*, which (unsurprisingly) comes from a respective 'background'. Its alleged 'author', Amenemope, is identified at the beginning of the teaching as:

> (…) the overseer of fields, experienced in his office,
> The offspring of a scribe of Egypt,
> The overseer of grains who controls the measure,
> Who sets the harvest-dues for his lord,
> Who registers the islands of new land,
> In the great name of his majesty,
> who records the markers on the borders of fields,
> Who acts for the king in his listing of taxes,
> Who makes the land-register of Egypt (…)
> (Lichtheim 1976: 148-149)

Based on this introduction, one might imagine that metrology and the cubit were central components of Amenemope's work. However, while several passages of the text refer to the proper use of measurements, there is no specific mention of lengths measured in cubits.

As the examples from literary contexts indicate, scribes often used references to specific lengths in cubits, which could serve various purposes. For example, large numerical values could indicate largeness, as in the *Story of the Shipwrecked Sailor*. Alternatively, they could simply indicate an average size, as in the *Teaching of Khety*.

Contexts of Religion and Magic

As the object class of votive cubits introduced above indicates, length measurements were used within a religious context as well. Information on votive cubits not only exist in the form of extant objects, but also on sketches on papyrus, presumably used in their creation (cf. Rosati 2017).

The numerical assessment and control of resources in administrative contexts gave rise to an aura of justice associated with the processes of measuring (this also holds for other measuring devices, cf. for example the scale used in the judgement of the dead). Obviously, this requires that the measuring process is carried out without cheating (e.g. by tampering with the measuring devices), and may point to why the cubit became named first the royal and then the gods cubit (*mḥ nṯr*), thereby invoking the power of the king to ensure its validity. The fact that tampering with measuring processes was an issue can be inferred from the number of persons send to carry out such tasks, cf. e.g. Papyrus Harageh 3 (Smither 1941). In addition, the *Teaching of Amenemope* details various measuring units and the forbidden ways of tampering with them (cf. Imhausen 2016: 158-161).

In addition to votive cubits, references to measuring units can also be found in various religious texts. For example, the cubit is attested in religious contexts as early as the *Pyramid Texts* (e.g., the texts found in the Pyramid of Pepi I), such as in the indication of the length of the ship in which the deceased king supposedly traveled, which is said to be 770 cubits.[29]

The Amduat contains various attestations of specific lengths expressed in cubits. In the Amduat of the tomb of Thutmosis III, it is attested in the text of the twelfth hour (during which the sungod is reborn) to indicate the length of the spine of a god as 1300 divine cubits.[30] The lengths of sandbanks that have to be overcome during the journey though the netherworld are detailed as 450 and 443 cubits, another one is indicated by lengths and width both of 440 cubits.[31]

In the *Book of the Dead*, the cubit is used to indicate the size of various beings (e.g. a '*qfdnw* ape' as 3 cubits and 2 fingers, that of a falcon as 4 cubits or even 1000 cubits).[32] Several references specify the height of grain in the netherworld.[33] The sizes of those that harvest the grain are also mentioned in cubits.[34] The size of an eye which is passed by the god Re is detailed as 7 cubits, its iris as 3 ½ cubits.[35] The *Book of the Dead* also contains references to the careful handling of measuring lengths in the context of the negative confession (i.e. the dead details various transgressions that he did not commit in his lifetime).[36]

Other than the attestations found in descriptions of magic actions in literary texts mentioned above, the cubit is also used in magic texts, e.g. in combination with a very large number to express (magic) power.[37]

Royal Inscriptions

Further attestations for indications of sizes using cubits can be found in the context of royal inscriptions. Some of these refer to the sizes of buildings or related objects.[38] Other than detailing building or construction work, the cubit is also found in the description of a royal bird hunt by Amenemhet II (12th dynasty), to indicate the size of the nets that were used (a translation of the inscription can be found in Dantong 1999). One of the nets is said to have had a width of 12 cubits.[39]

In the Great Sphinx Stela of Amenhotep II. at Giza, indications of sizes in cubits are found twice: the size of the rudder of the boat the king was travelling in is said to be 20 cubits:

> Strong of arms, untiring when he took the oar, he rowed at the stern of his falcon-boat as the strokeoar for two hundred men. Pausing after they had rowed half a mile, they were weak, limp in body, and breathless, while his majesty was strong under his oar of twenty cubits in length. He stopped and landed his falcon-boat only after he had done three miles of rowing without interrupting his stroke. (Lichtheim 1976: 41; *jtrw* has been translated as 'miles')[40]

The use of concrete numerical data in this passage highlights the king's achievement of surpassing his 200 men. The second instance of the cubit in this text is found in the next paragraph, which details the king's ability to shoot a bow and arrow by describing targets placed in the garden.

Conclusion

As the historiography of Egyptian length measures and examples of their usage in various kinds of ancient Egyptian texts indicates, a detailed, critical analysis of Egyptian length measures using archaeological and philological sources is an urgent need in Egyptology. As the final part of this contribution suggests, those who undertake this challenging task will be rewarded with the opportunity to work with a vast array of Egyptian sources from various time periods and contexts. This will give them a comprehensive understanding of not only the metrological aspects of ancient Egyptian civilization, but also its overall workings and concepts.

First insights into the various contexts, in which units of lengths can be found, were presented in this contribution. While some contexts were expected, such as the use of length measures in construction and administration, others, such as references in literary texts and texts describing the netherworld, were surprising, at least in terms of their frequency.

Similar observations can probably be made for other units of measurement. As has been argued elsewhere, ancient Egyptian mathematics was developed to control resources (Imhausen 2023). The king or scribes working for the king exercised this control. The royal right to control resources came with the obligation to handle them according to an ancient Egyptian ideal of justice, i.e., according to the Maat. Metrological units provided the basis for this proper handling of resources and were thus inextricably linked to royal power and obligation. As control over resources evolved, so did the profession of the scribe—someone literate and numerate. Mathematics then became associated with justice because fixed numerical values were believed to protect e.g. against arbitrary greed. In this process, metrological units are a key element. Metrology supposedly provided the guarantee for a correct handling of resources, at least locally. The resulting connection between metrology and justice led to the use of the former in other contexts, such as religion and literature.

As the texts indicate, tampering with metrological units was a known problem in ancient Egypt. The first provisions to counter fraud included sending teams of scribes to measure the size of a field. Additionally, moral literature included specific ethical guidelines regarding metrology, most notably in the teachings of Amenemope.

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Notes

1. I chose to not include the work by John Greaves (1602-1652) 'Pyramidographia: or, a Description of the pyramids in Egypt' London 1646, which discusses the sizes of Egyptian pyramids (he determined) in comparison with those that have been recorded by ancient writers.

2. https://www.newtonproject.ox.ac.uk/view/texts/normalized/THEM00276 (accessed 4/09/2024).

3. https://www.metmuseum.org/art/collection/search/557017; Accessed April 2nd 2025. The Metropolitan Museum has another measuring rod (22.1.678) which is described as being 37 cm long. Unfortunately, there is no image available online. Cf. https://www.metmuseum.org/art/collection/search/568564; Accessed 02/04/2025.

4. https://aaew.bbaw.de/tla/: Lemma-Nummer 73330. Accessed 13/05/25. (When accessed in February 2025 there were only 286 references – presumably all numbers cited in this contribution will be outdated soon. It is at this point unclear, if the overall impression gained from them, remains unchanged.)

5. https://aaew.bbaw.de/tla/: Lemma-Nummer 33360. Accessed 17/02/25.

6. https://thesaurus-linguae-aegyptiae.de/lemma/82600.

7. https://thesaurus-linguae-aegyptiae.de/lemma/121210. Accessed 28/02/25.

8. https://thesaurus-linguae-aegyptiae.de/lemma/d4613. Accessed 28/02/25.

9.E.g. https://thesaurus-linguae-aegyptiae.de/text/HXDICYWOZNE7XLS2NTABPYXIBY/sentences, in: TLA (accessed: 25/06/2025)

10. For the description of slanted lines in two-dimensional depictions cf. also Robins and Shute 1985.

11. Examples can be found from the Old Kingdom on: https://thesaurus-linguae-aegyptiae. de/text/XMSY7B4ABVEZ7FC4ZI4GU2QZHM/sentences, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd 6O0Q7W6pE6ipoAJORJmvso, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd2uGolJ2CkwaugZxEeegy QU, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdz9tIi6XDU8pi2wjTQwTN6c, https://thesaurus-linguae-aegyptiae.de/sentence/ICQCFHDvLqScO0lpn6jWtaapU2I; all in: TLA (accessed 06/24/2025).

12.https://thesaurus-linguae-aegyptiae.de/sentence/ICQCFHDvLqScO0lpn6jWtaapU2I; https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd0Q6HWXwN0nvn7EctUqBA3E; https://thesaurus-linguae-aegyptiae.de/ sentence/IBUBd90ZYy9A40htp6DW0vmsYTU; https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd0RXyi HaTkykvXnLG qiMxGI, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd0Q6HWXwN0nvn7EctUqBA3E, all in: TLA (accessed 26/06/2025).

13. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdz9tIi6XDU8pi2wjTQwTN6c, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdxDL9LTUMkNkgQHEgHpHtJQ, both in: TLA (accessed 26/06/2025).

14. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd0RXyiHaTkykvXnLGqiMxGI, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdW226C7D6UiQnoxRwUWjUOI, https://thesaurus-linguae-aegyptiae.de/ sentence/IBUBdQgfEpAYOkvjoe56JZ9YMik; all in: TLA (accessed 26/06/2025).

15. https://thesaurus-linguae-aegyptiae.de/text/CLVJOT2XUJFILCEHGMP5YOV3TY/sentences, https://thesaurus-linguae-aegyptiae.de/sentence/ICQCUQuPoc7D1kQWrOa7uXX1HVw; https://thesaurus-linguae-aegyptiae.de/ sentence/ICQCU0pu37wygEGYln6UrrpemRA, https://thesaurus-linguae-aegyptiae.de/sentence/ICQCUQuPoc 7D1kQWrOa7uXX1HVw; all in: TLA (accessed 06/04/2025).

16. https://thesaurus-linguae-aegyptiae.de/sentence/IBcDJwCBQKmTdk1ZjOgYfoloatI, in: TLA (accessed 06/24/2025).

17. https://thesaurus-linguae-aegyptiae.de/sentence/ICMCcup29Q8HV0R9hwYVeWQJU2E, in: TLA (accessed 24/06/2025). Another example for the use of *mḥ* in a tribute indicating the sizes of an animal skin is found in an inscription by Hatshepsut of the New Kingdom, cf. https://thesaurus-linguae-aegyptiae.de/sentence/ICMCNisGhjpnUkMmg1ugy6tf2Go, in: TLA (accessed 24/06/2025). In this example two dimensions of the skin are indicated as 6 cubits and 4 cubits.

18. https://thesaurus-linguae-aegyptiae.de/text/ZE5THHH7EFDLNMNVJJHEFJLFCM/sentences, in: TLA (accessed 25/06/2025). Cf. Hassan 1943: 110.

19. https://thesaurus-linguae-aegyptiae.de/text/XCEGHYZMLZAKLO6HG4TLKNL3U4/sentences, in: TLA (accessed 25/06/2025).

20. https://thesaurus-linguae-aegyptiae.de/text/ZHBZYMHULBDS3P474FKTAN3MBY/sentences, likewise: https://thesaurus-linguae-aegyptiae.de/text/ZHBZYMHULBDS3P474FKTAN3MBY/sentences; both in: TLA (accessed 06/04/2025).

21. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd7tsmdTu9EyOmlcXafXAhEc, in: TLA (accessed 06/04/2025).

22. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdWY1OWv6ykTNpKtj2EKSeeo, in: TLA (accessed 25/06/2025).

23. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd9716bXMU0bmniGQMMmXGIY, in: TLA (accessed 25/06/2025).

24. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdzyylhFcEUAjlQzJJpzRBlc, in: TLA (accessed 26/06/2025).

25. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdznZrglRukKGrfaBXdGvxro, in: *Thesaurus Linguae Aegyptiae*; https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdzOeFkZodkiMkSW8vpGW3RY, in: TLA (accessed 26/06/2025).

26. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd8atTLmFYEK1nXhD2ATuWD4, in: *Thesaurus Linguae Aegyptiae*; https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdzGmAdjbn0qcttR4F8SkrKc, in: TLA (accessed 26/06/2025).

27. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdyIRrYWduk57vYiP203kvdM, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd39NETuO1UNKs0qcA4hQ4eo, https://thesaurus-linguae-aegyptiae.de/ sentence/IBUBd4QDbazQkUUInEWEVba4NsM, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd5ssd27v10S0quTns4q8dCc, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd2nPuNOXLEEKg5TeSiCYiBA, all in: TLA (accessed 26/06/2025).

28. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd1jc2If5UULNgy WUThHeQQw, in: TLA (accessed 26/06/2025).

29. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd2mogen9w0QHlzRQ9n38iVo, in: TLA (accessed 25/06/2025).

30. https://thesaurus-linguae-aegyptiae.de/text/6BWILK2RZJCRPGPZUNUSJCT6LU, in: TLA (accessed 26/06/2025).

31. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdzwepo4SDUKzgnlo9gyQrrw, https://thesaurus-linguae-aegyptiae.de/sentence/MSG5P32T5ZETHBQLIIWPEOKRPQ, https://thesaurus-linguae-aegyptiae.de/ text/CQHXH4JVD5H3LMENHIDO5OR3VM/sentences; all in: TLA (accessed 26/06/2025).

32. https://thesaurus-linguae-aegyptiae.de/text/5GPTF4PVHJASXFVEWJJNDIA7SQ/sentences, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdWhUpldJ8E9SmobamxWHmvI, https://thesaurus-linguae-aegyptiae.de/ sentence/IBUBd7QOWYyVI0BCpCUWuYofHho, all in: TLA (accessed 26/06/2025).

33. Various indications measured in cubits of grain sizes (as well as other items) can be found in the Papyrus of Nu (BM EA 10477), cf. Lapp 1997, e.g. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd4bcfI4jT0BTg25jXQwOi0w, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdyvIAeqWKkrWvMoUJGlKnWE, both in: TLA (accessed: 26/06/2025). Further attestations for the cubit to detail the size of grain can be found in Papyrus Maiherperi (pCairo CG 24095), eg. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBdWZWt3bNg0cyvEBDWHI4w4Y, in: TLA (accessed: 27/06/2025) or Papyrus Juja (pCairo CG 51189), e.g. https://thesaurus-linguae-aegyptiae.de/sentence/ IBUBdwdKujfR50jcgUVyn5tYQD4, in: TLA (accessed 27/06/2025).

34. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd8vg1UwVtEGvj0odOHuJG9E, in: TLA (accessed 27/06/2025).

35. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd9WFQueErEX6sNgUc90s0EQ, https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd0oDOPZx40XNqLODQ8hmOz4, both in: TLA (accessed 27/06/2025).

36. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd2jQscWqVEdTq9DUPx1mVSI, in: TLA (accessed 27/06/2025).

37. https://thesaurus-linguae-aegyptiae.de/text/274VCIEE7NCYPJSPST3H3JKNFY/sentences, https://thesaurus-linguae-aegyptiae.de/sentence/IBcDOOa1CBNdsUvzgljV2wBizkA, both in: TLA (accessed 27/06/2025).

38. https://thesaurus-linguae-aegyptiae.de/sentence/IBkAU5xGsJ59iUd2qpPD5LTFi8k, in: TLA (accessed 27/06/2025).

39. https://thesaurus-linguae-aegyptiae.de/sentence/IBUBd3LFYV0soUw8saDAlTzyPWk, in: TLA (accessed 26/06/2025).

40. https://thesaurus-linguae-aegyptiae.de/sentence/IBkAiFPpAbxdtEh1kh3Kbb0Wsnc, in: TLA (accessed 27/6/2025).

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