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Synopsis

In antiquity Egypt was par excellence a wheat producing and wheat exporting country although that is no longer the case today. This is reflected in the innumerable surviving tax documents, farm accounts and leases that are reckoned in wheat. Many hundreds of these documents have been published; many more no doubt await publication. Anyone concerned to utilise this evidence for economic or financial history (which is where its value generally lies) must at some stage ask what was the size of the units in which grain was reckoned.

This paper is an attempt to elucidate the many different units of reckoning in

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BEVERIDGE 1930 = W. H. BEVERIDGE, Wheat measures in the Winchester Rolls, Economic History 2, 1930, 19–44.

CAM = R. P. DUNCAN-JONES, The choenix, the artaba and the modius, ZPE 21, 1976, 43–52.

DEAN = J. E. DEAN (ed. and trans.), Epiphanius' treatise on weights and measures: the Syriac version, 1935 (Or. Inst. Univ. Chic., Stud. Anc. Or. Civ. 11).

MSR = F. HULTSCH (ed.), Metrologicorum scriptorum reliquiae, 1864–6.

SEGRÈ 1918 = A. SEGRÈ. Att. Acc. Sci. Torino 54, 1918–9, 343–365; 391–409.

SEGRÈ 1920 = A. SEGRÈ, Aegyptus 1, 1920, 159–188; 317–344.

SEGRÈ 1928 = A. SEGRÈ, Metrologia e circolazione monetaria, 1928.

SEGRÈ 1931 = A. SEGRÈ, SIFC 9, 1931, 111–115.

SEGRÈ 1950 = A. SEGRÈ, Maia 3, 1950, 66–74.

SHELTON = J. C. SHELTON, Artabs and choenices, ZPE 24, 1977, 55–67.

SMC = R. P. DUNCAN-JONES, The size of the modius castrensis, ZPE 21, 1976, 53–62.

the Greco-Roman period.[1] Since Egypt is virtually our only source of documentary evidence for agrarian history in classical times, the relevance of the study is not necessarily limited to the history of Egypt alone.

The findings are listed on pp. 367–373 below. In the first section of the list (nos. 1–82) individual examples of particular sizes of artaba are collected from papyri and metrological writers. In the second section (nos. 83–108 and sections IV–V below) an attempt is made to translate the ratios in metrological papyri into specific sizes of artaba. A table of the different sizes of artaba in ascending order is given in Appendix I. Appendix II contains an index of names.

I. Introduction

The vital importance that using the right grain measures for taxation was felt to have can be seen in the following passages. The first is Ptolemaic, the second Byzantine, and the third is from the start of the Arab period.

A. «And since it sometimes happens that the sitologi and antigrapheis use larger measures than the correct bronze measures appointed in each nome ... in estimating dues to the State, and in consequence the cultivators are made to pay (more than the proper number of choenices), they [the King and Queen] have decreed that the strategi and the overseers of the revenues and the basilico-grammateis shall test the measures in the most thorough manner possible ..., and the measures must not exceed (the government measure) by more than the two ... allowed for errors. Those who disobey this decree are punishable by death.» (P. Tebt. I. 5, 85–92 = Sel. Pap. II 210 = C. Ord. Ptol. 53, 118 B. C.; restored and translated by Grenfell and Hunt).

B. «Collect on behalf of the inhabitants of Neophytos the wheat of the fifteenth and first indictions ... And make sure you collect it by *cancellus* measure ...» (P. Sorb. I. 60, letter from tax-official to his subordinate, first half of the c5 A. D.; from French translation by. H. Cadell).

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[1] This survey concentrates on the different artaba measures; component units are not considered fully (for the metron and mation, see no. 59 note). A number of careful discussions of capacity measure by Grenfell and Hunt are still worth consulting, though they have sometimes been overtaken by the appearance of fresh evidence (see. e.g. P. Teb. I p. 233; P. Hibeh I p. 229; P. Oxy. XVI pp. 143–4). But the main group of existing interpretations comes from Segrè, whose final conclusions are summarised in Segrè 1950, 74. His findings are often unsatisfactory (cf. nn. 19, 25 and 28 below; see also CAM 47–49 and SMC 56 n. 7). A brief preliminary discussion of this evidence by the present writer appeared in Chiron 6, 1976, Appendix I, 257–60; such of its conclusions as remain useful have been incorporated here. The traditional equivalence between Egyptian measure and Italic measure that were utilised there however appear irreconcileable with the co-ordinates of P. Lond. V. 1718 and other sources: see discussions in CAM.

C. «I ordered them that they should not measure with the *dīmūs* [*demosion*] measure, so I cut that off from the people of the land. Order the *qabbāls* that they measure with the *qanqal* [*cancellus*]. Do you then set up a fair *qanqal* by which you can test what the *qabbāls* take from the villagers. If you find any of the *qabbāls* acting unjustly to the people of the land in respect of the measure, or going in any way beyond the amount that you have imposed for him, then give him 100 lashes and shave his beard and his head, as well as fining him 30 dinars, over and above the fine of the excess that he took, above what you ordered him to take. Know that if I find any of the *qabbāls* have treated the people of the land unjustly in respect of the measure, or has taken from them more than that I have ordered him to do, then there will reach you from me that which will narrow for you your land.» [i. e. «I will take some of your land away»?]. (P. Schott Reinhardt I. 3, 41–62, letter from the Arab governor of Egypt to the ruler of Atfih [Aphroditopolis], August A. D. 710; translated by M. C. LYONS).

These examples clearly show the problems of measurement that existed in one major grain-producing area of the Roman Empire. The position can be documented in detail in Egypt. But silence elsewhere is no indication that diversity of measure did not exist outside Egypt. Examples of local variation in the small island of Cyprus are given by Epiphanius.[2] Florentine trading manuals show a great deal of variation in measure from town to town in the Mediterranean of the c14 and c15. Wherever there is anything approaching full evidence for capacity measures, ancient or mediaeval, we seem to find variation of units. In England this was still true as recently as the c19.[3]

Local particularism of this kind is clearly not in the interest of the ruling power. Concern with collecting taxes efficiently meant seeing that measures produced the required amount in aggregate. But diversity in measure created loopholes by which tax-officials could drain off the revenue-potential of the taxpayers by collecting in a large measure and rendering account in a smaller. We have seen the Ptolemies attempting to standardise measure in 118 B. C. (p. 348); the Roman Emperors attempted it throughout their domain in AD 386.[4] And the artaba found in Roman times in former Persian domains as far apart as Asia and Egypt originated as an official measure in the Persian Empire.[5] Units employed by the government in

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[2] DEAN 59 c p. 41. Epiphanius gives 3 different levels for the medimnos, one for Cyprus in general, one for Salamis/Constantia, and one for Paphos.

[3] See e.g. F. D. PEGOLOTTI, La pratica della mercatura (written c. 1340) (ed. A. EVANS), Cbamridge/Mass., 1936. The Commissions on Weights and Measures still found a wide diversity of local bushels in use in England in 1820 (W. H. BEVERIDGE, Journ. Econ. and Bus. Hist. 1, 1928–9, 503–533, at 516). See also BEVERIDGE, Prices and Wages in England, 1939, xxvii.

[4] C. Th. 12. 6. 21. For the King of England engaged in the same pursuit in the c14, see n. 6 below.

[5] Asia: K. M. T. ATKINSON, Historia 21, 1972, 45–7, col. 1, 15–16. Egypt: Herodotus

Greco-Roman Egypt are seen in the present study. But there was never full standardisation. Private corn accounts might still be reckoned in a mixture of as many as five different artabas (P. Mil. Vogl. IV 214; cf. 212, 249). Individual measures might also exist in two versions; the differential between them was not always the same. A vessel might be filled either to the brim, with the contents smoothed off to give a flat surface, or beyond it, with a heap sticking up above the brim. This practice continued in mediaeval and Renaissance Europe. In England a partial attempt to suppress heaped measure was made in the c14.[6] The size of the heap depended on the geometry of individual vessels and might vary (by design) between as much as 1/7 and 1/11 of the flat capacity (see section VII). It was common to make the measuring vessel a truncated cone, so as to narrow the brim and thus limit the size of the heap (n. 6 and n. 33).

II. Pharaonic elements in the artaba evidence

The central documents are a papyrus and a wooden tablet of the sixth century A. D. which both state that an artaba has 48 choenices, and the choenix $1^{1}/_{2}$ xestai. In other metrological sources the artaba of 48 choenices is called a medimnos (nos. 66–67 below). These and other co-ordinates in the main documents show the choenix in use in Egypt as a measure of about 0.808 litres. 10 2/3 choenices equalled 1 Italic modius.[7]

1, 192 and below passim. Herodotus gives the size of the artaba as 51 Attic choenices. This equals 68 choenices of the size used in Egypt (CAM 44 n. 6). But there seems to be no trace of such a measure in Greco-Roman evidence from Egypt. This is surprising when elements of older metrology from the Pharaonic period are still found in the Roman period. But the Persian measure may have been assimilated in the course of time to local measures already used in Egypt, though the Persian word ‹artaba› remained in use.

[6] See e.g. Pegolotti (n. 3 above) 167 for c14 Florence. An emended English statute of 1351 states that «all the measures, that is to say, bushels, half bushels, peck, gallon, pottle and quart, shall be *according to the King's standard*; ... and *every measure of corn shall be stricken without heap*, saving the rents and ferms of lords, which shall be measured by such measures as they were wont in times past. And the purveyors of the King ... shall make their purveyances by the same measure ...» (25 Edw. 3, 5, c. 10). The Bishop of Winchester and others were prosecuted in 1357 for failing to use the King's standard (Beveridge 1930, 34). Eloquent words about heaped measure and its abuses come from Walter of Henley writing in the c13. «In heaping there is fraud ... If the bushel be wide, you will find that 4 heaped will make the fifth ... And if it is not so wide 5 (will make) the sixth. And if it is less wide, of 6 the seventh. And if it is less wide, of 7 the eighth. And again if it is less wide, of 8 the ninth ... Now some of these reeves come and only render account of the 8 for 7, whether the bushel be wide or narrow. And if the bushel be wide, there is great deceit.» (Quoted in Beveridge 1930, 27). Cf. D. Oschinsky, Walter of Henley, 1971, 325.

[7] P. Lond. V. 1718; B. Boyaval, Une tablette métrologique, ZPE 15, 1974, 173–8. For discussion, see CAM passim.

In order to see why a 48 choenix measure should have been considered the main artaba, we must go back to Pharaonic evidence.

Egyptian sources yield the following equivalences:[8]

1 large khar = 200 hin = 2/3 of a cubed cubit
1 lesser khar = A = 160 hin = 1 medimnos
1 oipe = 40 hin
1 heq̂at = 10 hin

A bilingual copy of the Rosetta inscription found at Naucratis indicates that 1 artaba (Greek text) = 8 heq̂at (Egyptian text). The artaba was therefore 4/15 of a cubed cubit. The royal cubit is known to have been about .525/.526 metres, from surviving measures.[9] If the value .526 is adopted, the Rosetta artaba contains 38.808 litres, within 1/1250 of the 48 choenix artaba whose size is 38.78 litres (P. Lond. V 1718). According to the Pharaonic schema, the artaba thus equals 80 hin = 8 heq̂at = 2 oipe = $^1/_2$ medimnos = 48 choenices). The equation is corroborated by metrological texts which make the Ptolemaic artaba equal to half a medimnos or $4^1/_2$ modii Italici (nos. 63–4). That again gives 1 artaba as 38.78 litres.[10]

Thus the 48 choenix artaba is a direct descendant from Pharaonic practice. In P. Oxy I. 9 verso (p. 77) it is called medimnos, the term that earlier denoted the A or double artaba. A further survival from Pharaonic metrology was the measure known in classical times as the hin. Writers in the c4 AD refer to a sacred hin of 9 xestai and a great hin of 18.[11] These two units are 10 and 20-fold multiples of

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[8] See the classic discussion by F. L. GRIFFITH, Proc. Soc. Bibl. Arch. 14, 1892, 403–450. The most important single source is the Rhind mathematical papyrus of the XVIth Dynasty.

[9] See F. HULTSCH, Metrologie[2] 355 (.525 metres); F. PETRIE, Weights and Measures, 1934, 3–4, citing 1 st Dynasty examples which average 20.7 inches = .526 metres. If the classic artaba equalled 8 heq̂at or 80 hin, as in the Naucratis text, this makes it less easy to accept GARDINER's suggestion that the Egyptian hin might have been the same as the Graeco-Roman choenix. There seems to be no evidence for an 80-choenix artaba (A. H. GARDINER, The Wilbour Papyrus, 1948, II, 65). Quite apart from this, the Egyptian hin contained about half a litre (LUCAS and ROWE, n. 33 below), while the choenix in the Roman period was about 4/5 of a litre (above at n. 7).

[10] For slightly different computations which make the lesser khar 76.88 litres and the oipe 19.22 litres see W. REINECKE, Der Zusammenhang der altägyptischen Hohl- und Längenmaße, Mitt. Inst. Orientforsch. 9, 1963, 145–163. Cf. J. J. JANSSEN, Commodity Prices from the Ramessid period, 1975, 108–9. Pharaonic evidence which makes the mation 1/12 of an artaba (H. BRUGSCH, Die Aegyptologie, 1891, 380–1) again seems to point to the 48 choenix measure; for the mation as 4 choenices, see note on no. 59 below. Metric equivalences are set here for an Italic modius of 8.6185 litres. Those of HULTSCH are somewhat larger, generally answering to an Italic modius of 8.75 litres (see CAM Appendix).

[11] Epiphanius, DEAN p. 56; Eusebius, MSR I. 277. 13–14.

the Pharaonic hin (9 xestai = 6 Egyptian choenices = 10 hin). Evidently they are the heq̂at and double heq̂at under a transferred name.

The main co-ordinates implied by the Pharaonic system are:

Projections			*Examples*
1 oipe =	4 heq̂at =	24 Egyptian choenices	–
	5 heq̂at =	30 " "	nos. 11–13
	6 heq̂at =	36 " "	nos. 16–17
	7 heq̂at =	42 " "	nos. 56–58
2 oipe =	8 heq̂at =	48 " "	nos. 61–74
	9 heq̂at =	54 " "	–
	10 heq̂at =	60 " "	no. 81

All but two of these levels are found in the Greco-Roman evidence (references are shown in col. II). But none equalled an exact number of Italic modii, nor an exact number of the larger modius xystos. Consequently there was still scope for additional units that tallied precisely with Roman measure.

III. Italic and other elements

The main junction-points with Italic measure are as follows:[12]

Projections	*Examples*
3 Italic modii = 32 choenices	(cf. no. 14)
4 Italic modii = 42 2/3 "	(cf. nos. 101; 108)
5 Italic modii = 53 1/3 "	nos. 76–8
6 Italic modii = 64 "	no. 82

The two higher levels are both attested in the evidence for artabas, and there are approximations to the other two.[13]

The modius xystos was apparently also used to generate artaba units. The main equivalences that can be predicted are:

Projections	*Examples*
2 modii xystoi = 29 1/3 choenices	(cf. nos. 2–10)
3 modii xystoi = 44 "	nos. 59–60; 104
4 modii xystoi = 58 2/3 "	no. 80

The 29 choenix artaba (nos. 2–10) may be older than the modius xystos, in which case the virtual equivalence between it and 2 modii xystoi (29 1/3 choenices) is fortuitous.

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[12] For the equivalence, see CAM 50.

[13] CAM 45.

In summary the projected values that correspond to the respective matrices of Pharaonic measure, Italic measure and the modius xystos are as follows (values independently attested are asterisked):

24	choenices = 1 oipe = 4 heqat	*44	choenices = 3 modii xystoi
29 1/3	choenices = 2 modii xystoi	*48	choenices = 2 oipe = 8 heq̂at
*30	choenices = 5 heq̂at	*53 1/3	choenices = 5 Italic modii
32	choenices = 3 Italic modii	54	choenices = 9 heqat
*36	choenices = 6 heq̂at	*58 2/3	choenices = 4 modii xystoi
*42	choenices = 7 heq̂at	*60	choenices = 10 heq̂at
42 2/3	choenices = 4 Italic modii	*64	choenices = 6 Italic modii

IV. The interpretation of ratios

Before looking at the papyri that give synopses of different artabas, two facts should be noted.

1. The papyri which give synopses never explicitly state that a given artaba contains so many choenices.[14] But we know from the copious evidence tabulated below (nos. 1–82) that artabas were often reckoned in choenices nevertheless, especially in the Ptolemaic period (see notes on nos. 19 and 25–33).

2. In the papyri where artabas *are* explicitly defined in choenices or in a unit which must be understood as choenices (see nos. 1 ff.), they usually form whole numbers of choenices. Since the reckonings in papyri are sometimes inefficient, calculations that almost approximate to whole numbers of choenices are probably most often attempts to reach those whole numbers.[15] But the existence of heaped measure, with its uneven increments of 1/11, 1/9 and 1/7, also inevitably led to some totals containing fractions (section VII). It may have been difficulty in defining these quantities in the fractions in common use that led to reluctance to reckon different artabas in choenices. It has been argued that the choenix is in fact without quantitative meaning of its own. Shelton has pointed out that virtually all papyri that contain internal workings in choenices assume 40 to the artaba.[16] It is possible, as Shelton in effect suggests, that some represent a purely nominal choenix, one that equalled a constant 1/40 of any given artaba. But we do not know the relative frequency of the different measures in use. The 40-choenix measure, which is ex-

[14] This was pointed out by Shelton 56–7. Shelton's general thesis (that all artabas had 40 choenices, whatever their absolute size) has not been followed here. See notes on nos. 19; 25–33 (p. 368 below).

[15] Papyri whose internal calculations contain obvious discrepancies include the following: P. Oxy. XVI. 2025; XVII. 2140; XVIII. 2195; P. Lond. II 265 (see p. 258); P. Hib. I. 74, p. 228, 1. 2 n; P. Flor. III. 87; P. Lips. 97, p. 250; P. Teb. I. 74.

[16] Shelton 56 ff. See n. 14 above.

plicitly defined as such in a Ptolemaic papyrus (no. 19), may even have been as common as its occurrence in these workings suggests. The great majority of artaba calculations do not employ choenices, and are therefore not necessarily part of this pattern. Almost all the ratios point either to artabas defined as whole numbers of choenices or as whole numbers plus fractions that suggest a heaped version of a smaller artaba having a whole number of choenices.

V. Artaba sizes implied by ratios

A. Cancellus measure

The term cancellus may be of Persian origin.[17] Late documents provide valuable clues to its size. Cancellus measure is found as early as AD 44.[18]

The ratio between cancellus and large cancellus is given as about 10:13 in P. Oxy. XVI 1906 (c6 AD). The actual ratios are 1:1.300387 and 1:1.2994277. The 10:13 ratio between an un-named artaba and ‹cancellus› measure in P. Aberd. 34 (c7 AD) argues that ‹large cancellus› could be referred to as ‹cancellus› *tout court*. Three late documents give ‹cancellus› 40 choenices (P. Oxy. XVI 1907, 1910, 2037). If these statements are meaningful, the 10:13 ratio would then make ‹large cancellus› 52 choenices or thereabouts.[19] This equivalence is apparently confirmed by the evidence for official purchases of grain in the late Empire. Here 10 (normal) artabas cost 1 solidus in 2 cases.[20] Another purchase shows that 1 solidus alternatively bought 9 1/6 cancellus artabas.[21] The fixed compensation price is likely to have been related to a standard tax-measure. If the standard was the 48 choenix artaba used for tax-collection in Diocletianic papyri,[22] 1 solidus bought 480 choenices of wheat. Cancellus would then have 480 ÷ 9 1/6 = 52 4/11 choenices. This is very close to the 52 choenix value implied by the 10:13 ratio between cancellus and large cancellus (within 0.7 %); it implies that ‹cancellus› here means ‹large cancellus›.

If it contained 52 4/11 choenices, large cancellus was exactly 1/11 larger than the 48 choenix artaba. It is therefore quite likely to be a heaped version of the 48

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[17] C. H. Becker, P. Schott Reinhardt, 1906, p. 32.

[18] P. Oxy. XII. 1447.

[19] For virtually the same inference, see P. Oxy. XVI 1906 p. 135 and Segrè 1928, 504. For problems of interpreting the 40 choenix artaba, see n. 14 and note on nos. 25–33 below. Segrè 1950, 74 gives large cancellus as 51 17/18 choenices; but the source cited (P. Lips. 97) does not in fact refer to this measure.

[20] P. Oxy. XVI 1909, 1920.

[21] P. Oxy. XVI 1907. These prices are cited by A. H. M. Jones, Later Roman Empire III, 115 n. 87, but without noticing the different artabas in question. Another grain price shown there, from SEG VIII 355, is restored and has no independent value (reproduced from Johnson-West, Byzantine Egypt 177).

[22] P. Cair. Isid. 11 with SMC 56–7; P. Princ. Roll. See SMC 56–7.

choenix measure, attested as a flat measure (see section VII below). The equivalence recurs in P. Oxy. XVI 2037, 27 where an artaba 1.3082275 larger than cancellus measure must have 52 1/3 choenices (correct to .009 %). This is a better approximation than the 13:10 ratio in P. Aberd. 34, and comes within .06 % of the 52 4/11 value implied by the grain purchase document.

If this interpretation of ‹small› and large cancellus is correct, other measures can be deduced. The metron artaba was 15 % larger than cancellus.[23] This appears to make the metron artaba 46 choenices. The value does not agree with the version of the metron artaba in P. Lips. 97 (see section V B below). But it is not the only case where the same name is used of different measures (see section VI below). The 46 choenix artaba recurs under a different name in P. Lond. II. 265 where it is called Philippus (no. 93).

Another artaba was 20 % larger than cancellus (P. Iand. 63). Related to ‹small› cancellus, this can be clearly identified as the 48 choenix artaba, the half medimnos of Pharaonic usage, a known tax-measure (see nos. 61–74, and p. 351 above).

Finally, another Oxyrhynchus papyrus gives an artaba that is 1/3 greater than cancellus (P. Oxy. XVI 1917, 98). Related to ‹small› cancellus, this has 53 1/3 choenices. It exactly corresponds to one of the main predicted values, 5 Italic modii (see section III above). The 5 modius artaba is elsewhere directly attested by 2 metrological writers and implied by a late mathematical papyrus (nos. 76–78).

The cancellus documents thus yield the following conspectus (the numbering of new items follows on from that of the first part of the list on pp. 367–372 below):

Cancellus and related measures

Nos.			
22–24.	40 ([small] *cancellus*)	Oxyrhynchus	P. Oxy. XVI 1907; 1910; 2037
83–86.	46 (*metron*)	Oxyrhynchus	P. Oxy. XVI 1910, 13–14; 2024, 20; XVIII 2195, ll.98–101; XIX 2243a, 65, 59n. Cf. XVI 2025
87.	48	Arsinoite	P. Iand. 63
88.	52 4/11 (*large cancellus*)	Oxyrhynchus	P. Oxy. XVI 1907 with 1909, 1920. Cf. XVI 1906; P. Aberd. 34 [52 choenices]; P. Oxy. 2037 [52 1/3 choenices]
89.	53 1/3	Oxyrhynchus	P. Oxy. XVI 1917

[23] P. Oxy. XVI 1910, 13–14; 2024, 20; XVIII 2195, 98–101; XIX 2243 a, 65, 59 n. Cf. XVI 2025.

B. P. Lond. II. 265 (p. 257)

The papyrus that is richest in information about different artabas is P. Lond. II. 265, perhaps from Hermopolis (P. Tebt. I, p. 232). Like all available documents of its kind, it deals in abstract ratios or conversions, not in numbers of choenices. It has been the subject of a number of interpretations.[24] Plausible and straightforward results emerge if we take the artaba called *anelotikos* as the 40 choenix measure of that name (nos. 20–21). *Anelotikos* is otherwise mainly known from Ptolemaic usage; the London papyrus belongs to the first century AD. Three of the other values emerge as whole numbers of choenices, or very close approximations thereto. The conspectus reads:

	Choenices	
Anelotikos	40	(from equivalence in nos. 20–21 below)
Chalcos	42	(25/32 of dromos [= 168/125 of anelotikos])
Hermos	43.008	(4/5 of dromos)
Gallus	43.4717	(300/371 of dromos)
Philippus	46.08	(6/7 of dromos)
Dromos	53 19/25	(168/125 of anelotikos)

Hermos is given elsewhere in the papyrus (l. 57) as 1 1/25 of chalcos. This implies 43.68 choenices. As the identical value is implied for hexachoenic measure in P. Mil. Vogl. I. 28 (no. 98), it is perhaps more plausible than the 43 choenix version, otherwise unattested.[25]

Ignoring minute excess amounts that almost certainly result from calculating error, we can read:

P. Lond. II. 265

Nos.	*Schedule*			*Other Examples*
20–21.	Anelotikos	40	choenices	
90.	Chalcos	42	”	nos. 56–8
91.	Gallus	43 25/53	”	–
92.	Hermos	43 2/3 (?43)	”	no. 98
93.	Philippus	46	”	nos. 83–86
94.	Dromos	53 19/25	”	(cf. nos. 76–78; 89)

[24] Cf. CAM 50 nn. 28–9. For SEGRÈ's interpretation, see n. 25 below.

[25] Cf. E. M. BRUINS, P. J. SIJPESTEIN and K. A. WORP, Janus 61, 1974, 297–312, at 309 and 311. The present schedule corresponds to that put forward in an addendum by SEGRÈ 1928, 501–2, with the difference that Philippus measure is 46 choenices here; SEGRÈ's 46 1/5 was based on faulty arithmetic. Later however S. preferred another interpretation of this papyrus. Taking the size given to dromos measure as the index, in S. 1918, 35 and 1920, 324 it is 51 1/5; in 1928, 35, 51 1/3; in 1928, 501–2; 53 19/25; in 1931, 115 and 1950, 74, dromos is 49 7/25.

C. P. Mil. Vogl. I. 28

This Tebtunis papyrus of AD 162/3 is another rich source of information. It provides the following data (shown for convenience in decimal form):

Tetrachoenic = Hero x 1.063596
Colobus = tetrachoenic ÷ 1.0240963
Hero = colobus x 1.0250984
Hippotrophon = tetrachoenic x 0.9521276
Hexachoenic = colobus x 1.12
Dromos = colobus x 1.2083333

Following Foraboschi in identifying tetrachoenic as the 40 choenix unit mentioned in the papyrus[26] the following values ensue. Metron tetrachoenicon evidently denotes the 40 choenix artaba in the Heroninos archive (no. 58 and n.).

Hippotrophon	38.085104	(38 + 0.22 %)
Colobus	39.058826	(39 + 0.15 %)
Tetrachoenic	40	
Hero	40.07373	(40 + 0.18 %)
Hexachoenic	43.745885	
Dromos	47.196068	

The figures become less untidy if we assume that the colobus value is a faulty attempt to render 39 choenices. This means that:

Hero	= 39.978837
Hexachoenic	= 43.68
Dromos	= 47.124987

The Hero measure is now within .06 % of 40, hexachoenic is within .08 % of 43 2/3 and dromos is within .00003 % of 47 1/8. The suggested conspectus thus reads:

P. Mil. Vogl. I. 28

Nos.	*Schedule*			*Other Examples*
95.	Hippotrophon	38	choenices	–
96.	Colobus	39	”	–
97.	Tetrachoenic	= Hero = 40	”	nos. 19–55; 100
98.	Hexachoenic	= 43 2/3	”	no. 92
99.	Dromos	= 47 1/8	”	–

26 D. Foraboschi, CE 41, 1966, 180–4.

D. P. Lips. 97

A third document giving important ratios is P. Lips. 97, a c4 papyrus from Hermonthis.[27] The key to the equivalences seems to be the statement that 3 modii = 11/12 of an artaba (23.12; cf. 31.5–32.3). 1 artaba thus equals 3 3/11 modii. This is the relation between the 48 choenix artaba and the modius xystos of 22 xestai/sextarii.[28] Since the present modius explicitly contained more than 19 xestai (n. 27) the modius xystos, not the modius Italicus, must be in question. The artaba concerned is denoted as *metron modion*. The reason might be the fact that the measure represents exactly 3 modii cumulati or modii castrenses.

The remaining measures are:

Thesauric	= modion x 48/55	= 41.890905
Phoric	= thesauric x 65/48	= 56 8/11
Demosion	= thesauric x 18/19	= 39.68612

It is difficult to credit that all these ratios are precise. The author of the papyrus was bad at arithmetic and his equivalences between the modius and the modion artaba almost all vary.[29] However, the value for phoric measure appears possible, since it represents 1 1/11 of a round figure measure of 52 choenices, and may be a heaped version of that measure (whose existence is posited by some of the cancellus ratios, see p. 354). The values for thesauric and demosion are less easy to accept. It seems quite likely that demosion should be the familiar 40 choenix measure. In that case thesauric if the ratio is correctly denoted will be 42 2/9 (see also no. 108, section V G below). This is 1 1/9 of 38 choenices, and thus possibly a heaped version of that measure. The inference raises phoric measure in turn, to 57.17592. This is within .06 % of 57 1/7, a possible heaped version of a 50 choenix measure, based on a heap of 1/7. But from this evidence alone it is difficult to determine which interpretation of phoric measure is preferable.

P. Lips. 97

Nos.	*Schedule*			*Other examples*
100.	Demosion	40	choenices	nos. 19–55; 97
101.	Thesauric	42 2/9	"	no. 108
102.	Modion	48	"	nos. 61–74; 87
103.	Phoric	57 1/7 or 56 8/11	"	–

[27] MITTEIS misunderstood the underlying metrology. The statement «8 modii 19 xestai» should have been enough to show that the modius here contained more than 19 xestai. M. nevertheless assumed the Italic modius of 16 xestai, and interpreted the statement as though it meant 9 Italic modii and 3 xestai (p. 285, IX, 21).

[28] See SMC 56–7. SEGRÈ 1928, 503 writing before P. Cair. Isid. was known, took as his starting point the modius cumulatus, thereby reaching an equivalence for *modion* of 51 17/18 choenices. He also mistook the ratios, making demosion greater than thesauric (as in SEGRÈ 1950, 74).

[29] See P. Lips. p. 250 (some of MITTEIS' equivalences are slightly faulty).

E. P. Flor. III. 387

A Trajanic papyrus from Hermopolis Magna, P. Flor. III. 387, gives further ratios. The papyrus has it that 24 1/8 deximos = 25 1/4 dochikos (l. 18), a ratio of 1:1.0466321. But in l. 78 $12^1/_2$ deximos = 15 dochikos, a ratio of 5:6. However, the second ratio is almost repeated in the third ratio in the papyrus, though that apparently concerns a different relationship. In ll. 34–5, 195 2/3 dochikos = 164 me(galon), a ratio of 1:1.1930893. If we take dochikos as 42 2/9 choenices (no. 108, section V G), the first and third ratios imply the following values:

Deximos	44.19
Megalos	50.37

Neither projection is entirely convincing. But if dochikos is taken as a round 42 choenices in this case, the figures become less irregular.

P. Flor. III. 387

Nos.	*Schedule*		*Other examples*
104.	Deximos	44 (actually 43.9585) choenices	See also nos. 59–60; 106
105.	Megalos	50 (actually 50.1097) "	(cf. no. 75)

The second ratio above (5:6) is probably a crude approximation to the third (1:1.1930893). If megalos means heaped deximos the heap would equal on the third ratio (50/44 – 1) = 3/22. This is slightly less than the heap of 1/7 (or 3/21) indicated elsewhere (see section VII, p. 364). But the present evidence is equivocal.

F. P. Lond. I. 125

This fourth century papyrus gives the following ratios:

Un-named: thesauric = 25:24
Phoric: thesauric = 9:7

If we take thesauric as 42 2/9 choenices from P. Lips. 97 (see p. 358 above), the un-named artaba equals 43.98, and phoric 54 2/7 choenices. Both values appear plausible, much more so than those which result if phoric in P. Lips. 97 (V D above) is taken as the starting point. We may infer:

P. Lond. I. 125

Nos.	*Schedule*			*Other examples*
106.	(Un-named)	44	(43.98) choenices	nos. 59–60; 104
107.	Phoric	54 2/7	"	–

On this interpretation the un-named artaba ist the same as the deximos measure in P. Flor. III. 387 (no. 104) and as the hendekametron artaba (no. 59).

The value for phoric is lower than either of those projected in P. Lips. 97 (56 8/11 or 57 1/7, no. 103). 54 2/7 nevertheless looks like a heaped version of a smaller measure. Of the known heap fractions, only 1/7 produces anything like a recognisable flat version, the implied value being 47½ choenices. This is ½ choenix below the familiar tax-measure of 48 choenices (nos. 61 ff.). It is 3/8 of a choenix more than the dromos measure of 47 1/8 implied in P. Mil. Vogl. I. 28 (see V C).

G. Dochikos and anelotikos

Several specific values of these measures occur in Ptolemaic evidence:

dochikos	32 2/3 choenices		no. 14
	36	"	no. 17
anelotikos	36 2/3	"	no. 18
	40	"	no. 21

The two values of anelotikos stand in the ratio 9:10 and presumably represent flat and heaped measure (see section VII). The same may be true of the two values of dochikos; they stand in the ratio 49:54, which is between the known ratios of flat to heaped measure, 9:10 and 11:12.

Ratios of dochikos to anelotikos in other Ptolemaic evidence surprisingly make dochikos the larger:

	dochikos	*anelotikos*	*ratio*
P. Hib. I. 74; a	2368 3/4	2500	1:1.0554089
sub-total gives	1600	[16]84	1:1.0525
P. Teb. III. 1045, 18–19	163½	172	1:1.0519877
P. Lond. VII 1940 with P. Col. Zen. 8	3017 (apodochikos)	3190	1:1.0573417
(P. Lond. VII p. 25, n. 11)	826 3/4	872½	1:1.0553371

In the Hibeh papyrus the sub-total ratio presumably deviates from the grand total through some error. Excluding it, the other ratios read in ascending order:

1:1.052 1:1.055 1:1.055 1:1.057

The value that occurs twice, 1:1.055, is also the ratio of thesauric to demosion in P. Lips. 97, where demosion appears to be 40 and thesauric thus 42 2/9 choenices. This suggests that in the present cases anelotikos is the 40 choenix version (no. 21); the dochikos measure would thus be identical with thesauric measure of 42 2/9 choenices. (The alternative here of taking anelotikos as 36 2/3 yields the uncertain projection of 38.7037 choenices for dochikos.)

The full conspectus then reads:

	dochikos	32 2/3	
		36	
no. 108		42 2/9	P. Hib. I. 74; P. Teb. III. 1045; P. Lond. VII 1940; P. Col. Zen. 8. See also no. 101
	anelotikos	36 2/3	
		40	

In P. Flor. III. 387 of the c2 AD dochikos appears to equal 42 choenices (see V E above). This is an approximation to the highest value suggested by the Ptolemaic evidence (42 2/9).

A papyrus from Antinoopolis shows that there was still more than one dochikos standard in the c6; it specifies *mikron metron dochikon* (P. Strasb. I. 40, 45, AD 569). This must presumably indicate one of the two lower levels shown above. If so, it is useful in demonstrating the continued existence of artabas below 40 choenices in the Byzantine period. (Cf. also P. Cair. Masp. II 67138 fol. III recto, where the artaba would have 36 choenices if the 3 modii that it contained are Italic.)

VI. The names of artabas

Nomenclature alone is not a stable guide to the identity of an artaba. But where an existing name is revealed, this should reduce the range of possibilities.[30] Chalcos could mean 29 choenices or 42 (nos. 2, 90), dochikos 32 2/3, 36, or 42 2/9 (nos. 14, 17, 108), anelotikos 36 2/3 or 40 (nos. 18, 20–21), while dromos might mean 33 1/6, 42, 47 1/8 or 53 19/25 (nos. 15, 56, 99, 94). (See Name Index in Appendix II.)

Cancellus apparently meant 40 and great cancellus 52 4/11 choenices (see V A). But the larger measure might be referred to as cancellus without qualification (see p. 354). When the Arab governor insisted on cancellus in preference to demosion measure, he is presumably referring to large cancellus (p. 349), since on our evidence small cancellus appears to have been identical with demosion (nos. 22–4; 100). The only value for demosion that is specifically attested is 40 choenices, which is of course much less than large cancellus. But the name demosion could potentially be applied to other measures in public use; there is little evidence that the system was ever fully standardised. Demosion in the Arabic document may actually refer to the common modion artaba of 48 choenices, which is also Epiphanius's ‹holy› artaba (no. 73). (For possible association of demosion and the 48 choenix artaba, see below.)

The artaba most frequently specified in the Roman period is probably the *metron demosion xyston* used for tax payments in the Principate (see n. 34). In P. Lips.97

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[30] For similar problems of nomenclature in English grain measures of the c13 and 14, see BEVERIDGE 1930, 19.

demosion appears to be equated with the 40 choenix measure, the commonest artaba of those whose size is known (unless this is misleading).[31] The 40 choenix measure itself may sometimes have been heaped, since it forms 1 1/9 of 36 choenices and 1 1/11 of 36 2/3, both of which are independently known (nos. 16–18). The *metron demosion xyston* measure might then be one of the flat artabas corresponding to the heaped 40 choenix measure, probably 36 choenices, which occurs as the measure of payment in Ptolemaic tax-documents, where it is called dochikos (no. 17).

However it is probably better to associate *metron demosion xyston* with the 48 choenix measure, since that is attested for tax payment in synagoristic texts of the mid c2 AD, as well as in Late Empire texts. The 48 choenix tax artaba is specifically a flat measure in P. Princ. Roll of 310–324 AD, where it is called *metron modion xyston*. The 36 choenix measure is not attested as such in the Roman evidence. A newly published document attests a measure called *metron demosion xyston cancellon* in the Arsinoite nome in A. D. 96. It is used for measuring barley from an imperial estate intended for soldiers and quarrymen. This is presumably the flat version of large cancellus posited above, 48 choenices, where the heaped version had 52 4/11 (see V A).[32]

VII. *Flat measure and heaped measure*

Heaping grain above the brim, as an alternative to levelling it at the brim, is common in agrarian societies, and it is found for instance in England and in Italy in the c14.[33] In the papyri flat measure is widely attested by specific references.[34]

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[31] See note on nos. 25–33.

[32] P. Mich. Inv. 6767 published by H. C. Youtie, ZPE, 28, 1978, 251–4. For the 48 choenix artaba used in tax-payments, see nos. 68–9 and n. 22 above.

[33] See n. 6. For a photograph of modern Egyptian grain vessels of ancient type, see Schuman (n. 34 below) 283. For ancient Egyptian vessels, see A. Lucas and A. Rowe, Ann. Serv. Ant. Égypte 40, 1940, 69–100, plates X–XII. The truncated cone profile is seen here and in the Ostian vessel in the mosaic in Schuman p. 282. It is also found in the modius Claytonensis and in the official modius Mediceus from Rome of c. 244/9 (ILS 8627; photographs in Arch. Ael. 3. 13, 1916, 89–90). Comparison of the two Egyptian vessels clearly shows that the larger, being nearer to a cylinder than the smaller, would allow a significantly higher ratio of heaped to flat measure. It thus illustrates the variation in the size of the heap that we also find in the ancient evidence (see section VII above). For mediaeval parallels, see n. 6 above. Grain measures from Pompeii and Herculaneum are both cylindrical; their heap would be larger still, and necessarily larger than that of any vessel of the truncated cone type (Arch. Ael. 3. 13, 1916, 91).

[34] There are many references in tax-payments of the Principate to *metron demosion xyston* and *metron demosion xyston epaiton* (Wörterbuch III, 363. 1; Supp. I, 429). The explanation of *epaiton* offered by V. B. Schuman does not seem convincing, and the expression remains mysterious (CE 50, 1975, 278–284).

Heaped measure is rarely referred to as such, but its existence can sometimes be inferred.

The main explicit references to heaped measure are in P. Lond. V. 1718 and in the Louvre document (no. 62 below). Both sources show a ‹heap› or *koumoulon* that added 1/9 to flat measure. In these documents the flat *modius xystos* has 21 3/5 xestai, and the heaped *modius koumoulatos* has 24. Elsewhere the modius xystos commonly has 22 xestai; that would reduce the heap to 1/11 if the modius koumoulatos remained at 24 xestai.[35] Elevenths are so common in this evidence that they suggest that a koumoulon of this size existed in Egyptian usage.

This duality probably explains part of the wide range of artabas found in the papyri. A number of artabas deduced here can be interpreted in this way:

11:12 ratios	*9:10 ratios*
36 2/3:40	36:40
42 2/9:46	38:42 2/9
48:524/11	48:53 1/3

A further case is suggested by the figure of 56 8/11 for the phoric artaba (no. 103). Since that is 1/11 greater than 52 choenices, it could argue that there was a flat measure of that amount.

The interpretation of this evidence is uncertain. At first sight some of the ratios appear mutually contradictory. For example, if 42 2/9 was the flat version of a 46 choenix artaba, it would seem unlikely that it could also be the heaped version of one of 38 choenices. But P. Lond. V 1718 and the Louvre document may imply that the same measure could exist in either heaped or flat form when they state that the 48 choenix artaba contained either 3 heaped modii or 3 4/11 flat modii. That suggests flexibility in the physical format by which target values were achieved. In flat form, an artaba that equalled 48 choenices including the heap of 1/9 indicated in P. Lond. V 1718 would equal 43 1/5 choenices. This is within .7 % of the ‹Gallus› artaba of 43.47 choenices in P. Lond. II. 265 (no. 91). But the resemblance is not close enough to serve as corroboration.

In each of the pairs standing in a known ratio the smaller artaba will presumably be flat measure, and the larger heaped. For what the argument is worth, 40 choenices would seem on this basis to be heaped, since it is an orthodox projection of two smaller known artabas (36 and 36 2/3). 48 choenices on the other hand would seem to be flat, since it is the smaller partner (with 52 4/11 and 53 1/3).

A further variant is implied by a long papyrus which describes tax payments in 310/324 in the Herakleides division of the Arsinoite nome. Here the artaba is the *metron modion xyston,* specifically a flat measure (see P. Princ. Roll p. 18 II. 4–5 n.). In P. Lips. 97 the *metron modion* evidently has 48 choenices. But the payments in the present papyrus are made *sun dekatais*. That would suggest on the face of it a

[35] SMC 55.

koumoulon of 1/10. The total would thus be 52 4/5 choenices. The total is close to large cancellus of 52 4/11, but it is not attested in itself. Neither is the heap of 1/10. Thus it is probably more satisfactory to consider the ‹tenths› as tenths of the total measure, making them 1/9 of the flat artaba. This would make a total of 53 1/3 choenices. This artaba, already implicit in P. Oxy. XVI 1917 (no. 89), is exactly 5 Italic modii, and it directly corresponds to the 5 modius artaba attested in two late metrological sources (nos. 76–7). If the interpretation is correct, P. Princ. Roll is thus useful as a case where the government is seen to make exactions in units that were readily translated into Roman units.

Two sizes of the heap, 1/9 and 1/11 have now been considered. Confusing though it is, there appears to have been a third heap, representing 1/7 of flat measure. There is no doubt that a heap this size was physically possible. We know that in c14 Florence, the heaped staia colme was 1/7 larger than the flat staia rase.[36] An increment of 1/7 is also found in an English estate account of 1264.[37] The existence of this unit in Egypt is suggested by two pieces of evidence. The *dromos* artaba of 33 1/6 choenices attested at Euhemeria in AD 26 appears to be the only case where an artaba is explicitly defined in a fractional number of choenices (no. 15). It is likely to be a heaped projection of a smaller unit defined as a whole number. The only good approximation to a known measure that emerges is obtained when the heap is taken as 1/7. In that case the smooth version is the 29 choenix artaba familiar from Ptolemaic documents (nos. 2–10). In strict arithmetic the heaped version should read 33 1/7, but the fraction of 1/7 is abnormal in Egyptian practice. The error is negligible, 1/1392.

The second case again involves *dromos* measure, thereby suggesting a specific link between *dromos* and a heap of 1/7. In that case, *dromos* presumably denoted a measuring vessel with a relatively wide brim, which would enlarge the size of the heap. The dromos measure of 53.76 choenices in P. Lond. II. 265 (no. 94) is irregular in itself, and does not exactly correspond to any obvious Pharaonic or Roman matrix. But it is very close to being 1 1/7 of the dromos measure of 47 1/8 choenices implied in P. Mil. Vogl. I. 28 (no. 99). 53.76 is in fact 1 1/7 of 47 1/25 choenices. The difference between that and 47 1/8 is .18 %, a small variant.

These conclusions can be summarised as follows.

Dromos ratios of 7:8

(small) dromos	= 29 choenices	flat	(inferred; cf. nos. 2–10)
	33 1/7–1/6	heaped	no. 15
(large) dromos	= 47 1/25–1/8	flat	no. 99
	53 19/25	heaped	no. 94

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[36] Pegolotti (n. 6 above) 167.

[37] Beveridge 1930, 25 n. Other c13–14 evidence shows heaps of 1/9, 1/8, 1/7, 1/6, 1/5 and 1/4 (Beveridge 1930, 26). See also Oschinsky (n. 6 above) 425 cc. 14–15, a mediaeval treatise on husbandry where 5 quarters stricken equal 4 heaped.

A further instance of dromos measure is the 42 choenix artaba found at Tebtunis in 118 BC (no. 56). If this is heaped, the flat measure on a ratio of 8:7 would be 36 3/4 which is not directly attested (unless by O. Bodl. 339; see no. 18 note). But if 42 choenices is flat, the heaped artaba 1/7 larger is the classic 48 choenix measure. This may be more plausible, though it would create a heaped 48 choenix measure to set beside the flat versions deduced above (p. 363).

To some extent the present inferences of heaped measure remain fluid. The fact that the arithmetic fits is not always enough to tell us that measure B was indeed a heaped version of measure A. Simple coincidence cannot always be ruled out when interpreting the ratios. Further testing of the conclusions presented in this section is very desirable, if suitable documents can be found.

VIII. Conclusion: implications of the evidence

The range of grain measures in use was extremely diverse. Documenting the range of variation has an obvious usefulness for the interpretation of new papyri, and for more systematic analysis of those already published. The survey gives us some idea of the artabas that are likely to have been most frequent, though it is important to recall that the 40 choenix measure was sometimes only a unit of account (cf. note on nos. 25–33 below).

Table of frequency

Size	*Number of examples*
40	38
48	16
29	9
46	5
53 1/3	4
44	4
30	4
42	3
43 2/3	2
42 2/9	2
36	2
all others	1 each

The fact that the same name could be used for different grain measures (see Appendix II) suggests that there were pockets of completely isolated local practice, and an absence of national norms that were universally recognised. If this was the situation it was not very different from that still obtaining in England as late as 1820 (n. 3). Nevertheless grain taxation in Egypt was so highly organised that equivalences for different measures were presumably known in tax-bureaux. Tables of ratios like those in P. Lond. II. 265 may suggest some official consciousness of the problem.

Awareness of diversity in measures can help the agrarian historian in interpreting evidence.[38] A curious change in the rations of some slaves about 248 BC is noted in a recent work on grain payments in the Zeno papyri. The earlier level is known only as 1 1/2 artabas per man per month. The later level of 1 1/2 choenices per day (first attested in Feb./March 248, P. Lond. VII 2003) also equals 1 1/8 artabas per month; the author assumes that the artaba was constant at 40 choenices in these accounts.[39]

A 25 % cut in rations appears very strange in itself. But it is doubtful whether this reduction in fact took place. The earlier rations are known only from statements made in artabas.[40] The later are known both in artabas and in choenices, showing that there was undoubtedly a ration of 1 1/2 choenices per day = 1 1/8 artabas per month. This denotes the 40 choenix artaba.[41] But the earlier and later co-ordinates do not necessarily conflict. To reconcile them we need only assume that the earlier rations were reckoned in the artaba of 30 choenices (since 30 x 1 1/2 = 40 x 1 1/8 = 45). The 30 and 40 choenix artabas appear side by side in a flour account in the Zeno papyri (nos. 10A and 19); the 30 choenix measure is also specified in the Revenue Laws of Ptolemy Philadelphus (no. 11). It involves less strain on our credulity to suppose that rations were constant and that the fluctuation arose from the different artaba standards recorded in these papyri, than to conclude that household rations were cut by one-quarter for no apparent reason.

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38 For an excellent illustration of what is possible in this direction, see BEVERIDGE 1928–9 (n. 3 above). He is able to show from price records that in 1670 the authorities at Exeter covertly adopted the official grain measuring standard that they should have been using for many years previously.

39 T. REEKMANS, La sitométrie dans les archives de Zénon, 1966 (Pap. Brux. 3), 18–19.

40 Only 3 recipients of the ration of 2 choenices that R. is deducing here are explicitly known: P. Cair. Zen. IV 59676, where 2 out of 14 receive 2 choenices, the rest 1 1/2; and PSI VII 861, where one man receives 2 choenices. The three do not include any of the slaves known to have received 1 1/2 choenices per day (REEKMANS 29).

41 REEKMANS 11, 20.

List of Artabas

Items whose numbers are italicized are the subject of notes on pp. 367–372 below.

No.	*Size of artaba in Egyptian choenices*	*Provenance*	*Date*	*Reference*
1	26(?)	Thebes	Ptolemaic	W. O. II 706 with I p. 743
2	29 (*chalcos*)	(Heracleopolite?)	261 BC	P. Hib. I. 85
3	29 (sesame)		251 BC	P. Lond. VII 1991, 104
4	29 (poppy)		c. 250 BC	P. Cair. Zen. IV 59717, 12
5	29	Diospolis or Apollonopolis Magna	163 BC	SB VI 9367
6	29		239/8 BC	PSI IV 398 with SEGRÈ 1918, 359
7	29	Thebaid	132 BC	P. Grenf. I. 18
8	29		early 2 BC	O. Bodl. 339
9	*kws* of 29	Thebes	127 BC	K. SETHE and J. PARTSCH, Demotische Urkunden, 1921, no. 10, p. 207
10	*kws* of 29	Upper Egypt	Ptolemaic	O. Stras. 774
10 A	30		259 BC	P. Cair. Zen. I. 59004, 14–16
11	30		259 BC	P. Rev. 39. 2
12	30 (sesame?)		c. 250 BC	P. Cair. Zen. IV. 59717, 9
13	(30)		(c. 250 BC)	Zeno papyri; see p. 366 above.
14	32 2/3 (dochikos)		c 2–1 BC	O. Bodl. 255 with SEGRÈ 1931, 111
15	33 1/6 (*dromos*)	Euhemeria	A. D. 26	P. Ryl. II. 166

1. The reading of the second digit is uncertain (W. O. I. p. 743 n). As Dr THOMAS suggests by letter, this may in fact be another case of the common 29 choenix artaba (see nos. 2–10).

9. For 4 further demotic examples of ‹the *kws* of 29› see SETHE–PARTSCH, op. cit. 222.

11. This artaba of 30 choenices is explicitly laid down for use in measuring sesame in the revenue laws of Ptolemy Philadelphus. The measure is also found in the Zeno papyri (nos. 10 A, 12–13). A *metron triakontachoenicon* occurs in another Zeno papyrus, PSI IV 358. 6 and 19 (SHELTON 60 n. 12).

15. Explicit statement of the size of an artaba (we must understand the unit as choenices) giving a total that includes a fraction is most unusual. Though the reading is less than certain, the figures are spelt out in words, and the explanation for this irregular total is apparently supported by other evidence for dromos measure (see p. 364). This may be a heaped measure that incorporates a heap of 1/7, since 7/8 of 33 1/6 is almost exactly 29, the familiar Ptolemaic artaba (nos. 2–10) (in fact 29 1/48). The text is close in date to

No.	*Size of artaba in Egyptian choenices*	*Provenance*	*Date*	*Reference*
16	36	Hermopolite	Ptolemaic	P. Rein. 9 bis
17	36 (*dochikos*)	Tebtunis	Ptolemaic	P. Teb. I p. 227–8 with IV, p. 9
18	36 (2/3?) (*anelotikos*)		early c 2 BC	O. Bodl. 339 with SEGRÈ 1931, 112
19	40 (flour)		259 BC	P. Cair. Zen. I. 59004, 14–16
20	40 (*an*[*elotikos*])		169 BC	P. Lond. VII 2190 = SB VI 9600
21	40 (*anel*[*otikos*])		250 BC	P. Cair. Zen. II 59292, 282–8
22–24	40 (*cancellus*)	Oxyrhynchus		P. Oxy. XVI 1907; 1910; 2037
25–33	40 (9 further examples)		Ptolemaic	see note

the Ptolemaic period (AD 26). If the flat measure was 29 choenices, a heap of 1/7 would strictly lead to 33 1/7. But the error implicit in 33 1/6 is only .07 %. The artaba in question was *epaiton*; for this mysterious expression see n. 34 above.

17. This 36 choenix artaba on the *dochikos* standard inferred from the Tebtunis papyri by two generations of editors seems to be sound, though now doubted by one editor on general grounds (see SHELTON 62 n. 15). The *trichoenicon* was levied as 1/12 of an artaba per aroura in P. Teb. I 93–4 and IV 1105–7 (SHELTON 60, cf. P. Teb. I. p. 413).

18. 21 *anelotikos* = 26 7/12 artabas of 29 choenices. That makes *anelotikos* 36.710317 choenices. This may well be an approximation to 36 2/3 choenices. If so, there is an error of .12 %, though SEGRÈ writes as though the implied figure were exact.

19. This artaba, used here for measuring flour, is explicitly described as having 40 choenices (ἀναμετρούμενον τῆι τεσσερακονταχοινίκωι ἀρ[τάβηι]). If the total of 40 choenices had to be defined, it follows that its existence could not be assumed. It also follows here, as with all the other artabas openly defined in choenices (nos. 5–12; 15; 61–62), that the choenix was meaningful as a quantitative measure in its own right, and not an elastic term signifying 1/40 of any artaba. These considerations alone make it impossible to conclude with SHELTON that «the word choenix, whenever it appears in our documents, invariably means one-fortieth of an artab» (SHELTON 66.) See also note on nos. 25–33.

22–24. For *cancellus* measure, see section V A.

25–33. A number of Ptolemaic papyri contain internal reckonings based on a 40-choenix artaba (see below). The 40-choenix artaba is found as a variable unit of account in a few conversions between one artaba and another in papyri of the Empire (see discussion in SHELTON 58–9). In such cases the choenix is apparently an elastic term meaning 1/40 of an artaba. But this makes it vital to note that the 48, 40, 33 1/6, 30, 29 and 26 choenix measures are all mentioned explicitly in other papyri. In all these cases the choenix is clearly meaningful as a quantifying device (nos. 61–62, 19, 15, 1–12). There are likewise artabas whose internal workings show levels of 36, 42 and 48 choenices (nos. 16–17, 58, 68–69). There were also direct translations of the choenix into weight, as 2 litrai (P. Oxy. XVI 1920, 16) or 2 1/12 litrai (P. Lond. V 1718).

Three Ptolemaic cases of the 40-choenix artaba are listed above (nos. 19–21). Ptolemaic

No.	*Size of artaba in Egyptian choenices*	*Provenance*	*Date*	*Reference*
34–55	40 (22 further examples)		Imperial & Byzantine	see note
56	42 (*dromos*)	Kerkeosiris	118/7 BC	P. Tebt. I. 61, p. 233; IV, p. 9
57	(42)	Kerkeosiris and Tebtunis	AD 149	P. Tebt. II. 394
58	(42)	Theadelphia	AD 252/3	SB VI 9409 (3), 32–3; L. Varcl, LF 81, 1958, (Eunomia Supp.) p. 76
59	(44) (*metron hendekametron*)	Arsinoite	AD 234	P. Fay. 90 with P. Oxy. XIV p. 62

examples of internal workings in 40 choenices include: UPZ I. 54; 91; 93 (with pp. 277, 408–9); P. Hib. I. 119; P. Petr. II. 25 with WO I. 741–2; P. Lond. VII 1994; P. Cair. Zen. I 59004; II 59292 (cf. P. Lond. VII 1940, 11 n); IV 59707.

34–55. For the significance of the 40-choenix artaba see also note on 25–33. Further examples in papyri of Roman date include: P. Erl. 101; P. Oxy. I 9 verso (p. 77); IV 740; VII 1044; VIII 1145; X 1286; XVI 1913; 1920; 2024; 2046; XXII 2350; XXXI 2591; XXXVIII 2868; XLIV 3169; 3170; P. Princ. III 136 verso 6–7; 10; P. Ryl. II 199; 207; P. Iand. 63 with P. Oxy. XVI 1910 introd.; P. Mert. II 74; P. Mil. Vogl. I 28; SB VI 9409 (3) (LF 81, 1958, Eunomia supp. 22 & 76).

56. P. Tebt. I. 61 b, 385–390 gives the *dromos* measure of Suchus as 7/6 of *dochikos. Dochikos* in this archive means 36 choenices (see no. 17 and note). The *dromos* measure in question is thus 42 choenices. Grenfell and Hunt also deduced a 42-choenix artaba at Hermopolis. But this was part of a generally unconvincing interpretation of P. Lond. II. 265, where a Hermos measure is listed (for the implications of this document see section V above). They further deduced a 42-choenix artaba from the equation 8 2/3 artabas = 8 $^{1}/_{2}$ artabas 7 choenices in P. Oxy. IV 740. As Shelton points out (57 n. 8), this is inconclusive, since if the true value had been 6 2/3 choenices, indicating a 40-choenix artaba, it would still almost certainly have been rounded up to 7. Subdivision of the choenix is not usual (but see no. 15).

57. If we assume a constant compensation price for synagoristic wheat purchases by the government during the second century, 7 drachmae per artaba paid here as against the 8 drachmae per 48-choenix artaba paid in other cases implies that we are dealing with a 42-choenix artaba. That measure it attested at Kerkeosiris, one of the places concerned here, in the c2 BC (no. 56 and note; fuller discussion of this evidence in Chiron 6, 1976, 258). For an alternative view, conjecturing a 1 drachma fall in official prices c. 147/8 AD because of good harvests, see Shelton 67. There is no direct evidence for modulation of official prices by as little as 1 drachma. The other official prices that we know in the period before Diocletian are all in multiples of 8: 8 drachmae (13 examples) 16 (1), 24 (1), 40 (1). See Chiron 6, 1976, 254 with P. Oxy. XLII 3048 (24 drachmae).

58. 75 artabas 3 choenices by *metron tetrachoenicon* equal 71 $^{1}/_{2}$ artabas. As Varcl points out, these figures tally if *tetrachoenicon* has 40 choenices and the other artaba 42. For another account where *tetrachoenicon* corresponds to 40 choenices, see section V C.

59. The *metron* is defined as 4 choenices in the metrological text in P. Oxy. I. 9 verso

No.	Size of artaba in Egyptian choenices	Provenance	Date	Reference
60	44?	Theadelphia	AD 252/3	SB VI 9409 (3), 108
61	48	Aphroditopolis	c 6 AD	P. Lond. V. 1718; CAM 43–46
62	48		c 6 AD	B. Boyaval, ZPE 15, 1974, 173–8
63	4 1/2 Italic modii (= 48) (1/2 *Ptolemaikos medimnos*)			MSR I. 258. 17–20 with Lagarde, Symmicta, 1877, I. 170. 2
64	4 1/2 Italic modii (= 48) (1/2 *Ptolemaikos medimnos*)			MSR II. 145. 22–25
65	(4 1/2 Italic modii) (= 48)			MSR I. 204. 18–20
66	48 (*medimnos*)	Oxyrhynchus		P. Oxy. I. 9 verso (p. 77) with CAM 44 n. 6; cf. no. 71
67	48 (*medimnos*)			MSR I. 206. 8–10 with CAM 44 n. 6; cf. no. 70
68	48	Oxyrhynchus	AD 100	P. Oxy. XLI 2960
69	48	Oxyrhynchus	AD 154	P. Oxy. XLI 2967

(also as 1/10 of an artaba, here and in P. Cair. Isid. 57). In P. Lond. II. 428 mation= metron; and P. Lond. V 1718 shows two double matia, one of which has 8 choenices. Consequently it may well be plausible to see a *hendekametron* artaba as having 44 choenices. There are possible difficulties about interpreting *metron* as 4 choenices in all contexts (one of the *matia* implied by P. Lond. V 1718 has 4 4/5 choenices). The not infrequent expression *metron dekaton* might mean ‹by the 40-choenix artaba› (cf. Chiron 6, 1976, 258–9 where it is interpreted differently). But it is more doubtful whether e.g. *metron tetarton* can mean ‹by the 16-choenix artaba›, when no artaba as small as that appears in explicit evidence (cf. P. Oxy. XIV p. 62).

60. Here 1 artaba makes 44 pairs of loaves. In another part of the account, which uses the 40 choenix artaba as its main unit of reckoning (see no. 58 n.), 1 artaba makes 40 pairs of loaves, SB VI 9409 (7) 22. Hence there may be a 44 choenix artaba here. For this artaba see also nos. 59, 104 and 106.

64. This is a Latin translation of the text in no. 63.

65. The *pēchus chōrei* has 13 1/2 Italic modii or 3 artabas. The artaba thus defined contains 4 1/2 Italic modii. Cf. Hultsch, Metrologie², 626 n. 1.

68. See note on 69.

69. As noted by the editor, the arithmetic of the choenix and artaba totals indicates 48 choenices to the artaba here (P. Oxy. XLI 2967, 12n; the same is true in 2960 = no. 68). Shelton adopts a more involved explanation which assigns the artaba 40 choenices, assuming that the totals contain rounded off fractions and are not exact (57–8). But the evidence for a 48-choenix artaba in the Roman period is direct (nos. 61–62 etc.) and its implied appearance here is not anomalous.

No.	*Size of artaba in Egyptian choenices*	*Provenance*	*Date*	*Reference*
70	48	Arsinoite		P. Iand. 63 with P. Oxy. XVI 1910 introd.
71	3 1/3 modii (xystoi) (= 48 choen.)			Carmen de ponderibus, MSR II. 98. 88–90; see CAM 47–49
72	3 1/3 modii (xystoi) (= 48 choen.)			Jerome, ad Dan. 11. 5; see CAM 47–49
73	72 xestai (= 48 choen.) (*to metron to hagion*)		c 4 AD	Epiphanius (see CAM p. 44 n.)
74	72 sextarii (= 48 choen.)		c 6 AD	Isidore, MSR II. 120. 18
75	4 16/21 (Italic) modii (= 50.8 choen.)	Oxyrhynchus	c 5 AD	P. Oxy. XVI 2004
76	5 (Italic) modii (= 53 1/3 choen.)		c 4 AD	MSR I. 224. 13
77	5 (Italic) modii (= 53 1/3 choen.)		c 4 AD	Oribasius, MSR I. 245. 28
78	8/27 cubit[3] (= 53 1/3 choen.)	Akhmim	c 4–5 AD	P. Akhmim, problem 2

75. The papyrus equates 42 artabas with 200 modii. If the modii were *xystoi* modii of 21. 6/22 xestai (SMC 55), the artaba would have 68.57–69.84 choenices. These values are implausibly high. Assuming that the modii were therefore Italic, the implied size is 50 4/5 choenices. This inexact total is possibly a heaped version of a smaller artaba. But the only sub-value that looks in any way plausible is still inexact. If the artaba contains a heap of 1/7, the smooth version would have 44 9/20 choenices. This is close to the 44 choenix measure implied in nos. 59–60, 104 and 106.

78. Problem no. 2 in the Akhmim mathematical papyrus states that a granary of 800 cubits capacity can hold 2,700 ạ granted that 3 3/8 ạ go to the cubed cubit; ạ is clearly artaba (cf. W. O. I. 752). If the cubit is the royal cubit of .525–.526 metres traditional in Egypt, the artaba contains 5 Italic modii. (For the royal cubit, see n. 9 above; observations from actual Egyptian measures seem preferable to the formula of Didymus which gives the royal cubit 1 4/5 Roman feet or .532 metres, MSR I. 180. 9–10, 17–18). A cubit of .525 metres holds 144.7031 litres; one of .526 metres holds 145.5315. 3 3/8 x 5 Italian modii of 8.6185 litres (CAM Appendix) equals 145.4372 litres (within .07% of the .526 metre projection). The 5 modius artaba is twice attested in c4 sources (nos. 76–77); the Akhmim papyrus belongs to the c4 or c5 (Hultsch below; published by J. Baillet, Le papyrus mathématique du Akhmim, 1892, Mém. publ. par membres de la Miss. arch. franç. au Caire IX. 1.)

Hultsch's explanation of the text is more involved. His starting point is the assumption

No.	*Size of artaba in Egyptian choenices*	*Provenance*	*Date*	*Reference*
79	84 xestai (= 56 choen.)		c 4 AD	Epiphanius, DEAN 62 d
80	88 xestai (= 58 2/3 choen.)		c 4 AD	Epiphanius, DEAN 62 d
81	15 matia (= 60 choen.)		c. AD 350	P. Lond. II. 428 (SEGRÈ 1928, 505)
82	96 xestai (= 64 choen.)		c 4 AD	Epiphanius, DEAN 62 d

that the artaba concerned was the 3 1/3 Italic modius measure (whose existence even elsewhere may be doubted, cf. SHELTON 65, improving on CAM 49–50). J. HULTSCH, Archiv 2, 1903, 272 ff.

81. For the *mation*, see note on no. 59. The 4-choenix measure seems to have been the *mation* in common use. If we assume it here, it leads to a 60-choenix artaba, or 10 heq̂at in classical Pharaonic measure (see p. 352).

Conspectus of artabas discussed in section V

(A list of all examples in size order is given in Appendix I below.)

No.	*Size*	*Provenance*	*Discussion*	*Reference*
83–86	46 (metron)	Oxyrhynchus	V A	P. Oxy. XVI. 1910; 2024; XVIII. 2195; XIX. 2243 a. Cf. XVI 2025
87	48	Arsinoite	V A	P. Iand. 63
88	52 4/11 (large cancellus)	Oxyrhynchus	V A	P. Oxy. XVI 1907 with 1909
89	53 1/3	Oxyrhynchus	V A	P. Oxy. XVI 1917
90	42 (chalcos)	Hermopolis?	V B	P. Lond. II. 265
91	43 25/53 (Gallus)	Hermopolis?	V B	„
92	43 2/3 (43?) (Hermos)	Hermopolis?	V B	„
93	46 (Philippus)	Hermopolis?	V B	„
94	53 19/25 (dromos)	Hermopolis?	V B	„
95	38 (hippotrophos)	Tebtunis	V C	P. Mil. Vogl. I 28
96	39 (colobos)	Tebtunis	V C	„

No.	*Size*	*Provenance*	*Discussion*	*Reference*
97	40 (tetra-choenic/Hero)	Tebtunis	V C	P. Mil. Vogl. I 28
98	43 2/3 (hexa-choenic)	Tebtunis	V C	"
99	47 1/25–1/8 (dromos)	Tebtunis	V C	"
100	40 (demosion)	Hermonthis	V D	P. Lips. 97
101	42 2/9 (thesauric)	Hermonthis	V D	"
102	48 (modion)	Hermonthis	V D	"
103	56 8/11 or 1/7 (phoric)	Hermonthis	V D	"
104	44 (deximos)	Hermopolis Magna	V E	P. Flor. III. 387
105	50 (megalos)	Hermopolis Magna	V E	"
106	44	–	V F	P. Lond. II 125
107	54 2/7 (phoric)	–	V F	"
108	42 2/9 (dochikos)		V G	P. Hib. I. 74; P. Teb. III 1045; P. Lond. VII 1940; P. Col. Zen. 8

Appendix I: Conspectus of artaba sizes

Size in choenices	*Name(s)*	*Reference no.*
26	–	1
29	chalcos	2–10
30	–	10 A–13
32 2/3	dochikos	14
33 1/6	dromos	15
36	dochikos	16–17
36 2/3	anelotikos	18
38	hippotrophos	95
39	colobos	96
40	anelotikos cancellus demosion Hero tetrachoenic	19–55; 97; 100
42	chalcos dromos	56–8; 90
42 2/9	thesauric (?dochikos)	101 108
43 25/53	Gallus	91

Size in choenices	*Name(s)*	*Reference no.*
43 2/3 (?43)	Hermos	92 (p. 356)
43 2/3	hexachoenic	98
44	deximos hendekametron	59–60; 104; 106
46	metron Philippus	83–86; 93
47 1/25–1/8	dromos	99 (p. 357)
48	hagios medimnos modion	61–74; 87; 102
50	megalos (deximos?)	105
50 4/5	–	75
52 4/11	large cancellus	88
53 1/3	–	76–78; 89
53 19/25	dromos	94
54 2/7	phoric	107
56	–	79
56 8/11–57 1/7	phoric	103 (p. 358)
58 2/3	–	80
60	–	81
64	–	82

Appendix II: Name-Index of identifiable artabas

Name	*Size*	*Reference no.*
anelotikos	36 2/3	18
anelotikos	40	20–21
cancellus	40	22–24
cancellus, large	52 4/11	88
chalcos	29	2
chalcos	42	90
colobos	39	96
demosion	40	100
demosion xyston	48	pp. 361–362
deximos (v. megalos)	44	104
dochikos	32 2/3	14
dochikos	36	17
dochikos	42 2/9	108
dromos	33 1/6	15
dromos	42	56
dromos	43 25/53	99
dromos	47 1/8	94
Gallus	53 19/25	91
hagion	48	73
hendekametron	44	59

Name	*Size*	*Reference no.*
Hermos	43 2/3	92
Hero	40	97
hexachoenic	43 2/3	98
hippotrophon	38	95
medimnos	48	66–7
megalos (deximos)	50	105
metron	46	83–6
modion	48	102
Philippus	46	93
phoric	54 2/7	107
phoric	56 8/11 or 57 1/7	103
tetrachoenic	40	97
thesauric	42 2/9	101