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A Heavy Artaba and Its Ninety-six Loaves

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An ostrakon in the British Library[1] preserves a brief metrological text of the Roman period with a striking weight for the artaba and some surprising consequences. I present first the text and translation, then give a brief exploration of the implications.

BL Ostr. 43893 (1907-1-12-503). 12.5 x 9 cm.
Thebes?, middle of the second century AD[2]

1 ″ ἡάρτάβη του σιτου οφειλει εχ[ειν]
2 λι(τρας) ρκδ, οι στατηρες B9ο[5,]
3 ωστε οαρτος λαμβανει .[   ]
4 [σ]τατηρ(αs) λα.όταν όπτη[θῇ,]
5 [?γι]νεται στατηρ(ων) κζ.

"The artaba of wheat ought to contain 124 litrai, which are 2,976 staters, so that the loaf of bread takes 31 staters. When it is baked, it weighs 27 staters."

2 The restoration of line 2 is certain, as the fact that the litra weighed 96 drachmas = 24 staters is well attested (see, e.g., *P.Oxy.* XLIX 3455.21-23), and in any case the litra:stater ratio is unlikely to have been anything other than an integer.
3 Perhaps εκ[αστοs], but that seems long for the lacuna in other lines.

The basic arithmetic at stake is not difficult. Using a figure of 322.8 g for the Roman pound,[3] it is a simple matter to divide that number by 24 to calculate the stater at 13.45 g and consequently the drachma at 3.3625 g. The artaba of wheat (.3228 kg x 124) amounts to 40.03 kg. It can be seen that if the loaf of bread requires 31 staters of wheat, that will amount to about 417 g. After baking, however, the loaf will weigh only 363 g, and simple division (2,976/31) shows that there will be 96 loaves to the artaba.

This arithmetic is very straightforward, but it plunges us immediately into several controversies, most immediately that over the size of the Egyptian artaba, bearing new evidence very much at odds with most of what has been thought. Much of this discussion has relied on Pliny, *NH* 18.66, who gives the weights for wheat from a variety of sources, in each case measured by the modius (evidently the modius Italicus of 8.62 liters, equalling 16 sextarii/ξεσται of about .54 liters each, although this is not explicitly said by Pliny). These fall within a narrow range, varying only fractionally. Alexandrian wheat is said to weigh 20

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[1] Which I thank for permission to publish the ostrakon and the photograph of it here.

[2] The style of writing is very similar to that of *O.Leid.* 104 (*O.Leid.* II, Plate 27; AD 148/9), and other parallels (*O.Leid.* 116, 130, 227; *O.Cair.GPW* 73, 83), although less exact, are all of the 130s to 150s.

[3] R. P. Duncan-Jones, *Economy of the Roman Empire*[2] (Cambridge 1982) 369-70; *Money and Government in the Roman Empire* (Cambridge 1994) 214, showing 322.8 g from the Pompeian evidence. This figure is preferable to the 327.45 g commonly found in the literature, even if one must suppose that for practical purposes the digit to the right of the decimal point represents specious precision. For that matter, even the last digit to the left of the decimal point may not mean very much in day-to-day measurement.

5/6 librae (= litrai, thus 2000 dr. or 500 staters) per modius Italicus.[4] Modern students of the question have agreed that Pliny's figures are acceptably close to those attested in modern times for the weight of wheat. Now it can be seen at a glance that the 124 litrai figure of our ostrakon is almost exactly six times Pliny's modius weight (6 x 20 5/6 = 125), suggesting perhaps that an alternative weight per modius of 20 2/3 was also in use. In either case, it seems likely that the writer here is using an artaba equivalent to 6 modii Italici. Each modius would thus yield 16 loaves (96 loaves/artaba, divided by 6 modii/artaba), each containing one sextarius of wheat.

This size of artaba is rather at odds with what is generally supposed and what is elsewhere attested. Modern authorities have agreed that there was not a single artaba standard in use, either in real life or in the metrological writings. Dominic Rathbone has shown that in *P.Oxy.* XLIX 3455 the writer is evidently using an artaba equal to 1.5 modii Italici, which he describes as "an artaba of rather unusual size, but . . . not inherently implausible" (*ZPE* 53 [1983] 265-75 at 267). Rathbone cites in addition the normal assumption that the artaba equalled 3 3/4 modii Italici, and figures from Dioskoros of Aphrodito indicating that he used sources with equivalences of 4.5 and 5 modii Italici, the latter amounting to 100 mnai or 104 1/6 litrai.[5] Of these, however, that of 1.5 modii Italici is aberrant (unique to this papyrus, even if it be granted that the restorations on which it rests are correct), and that of 5 modii based only on reconstruction of what one of Dioskoros's sources had. It is the other two, of 3.75 and 4.5 modii Italici, which are generally taken to be the standard.[6]

Our artaba of 124 litrai and 6 modii Italici will have been equated to 96 sextarii. The ratio of 1.29 litrai/sextarius is close to the 1.30 litrai/sextarius implied by Rathbone's correction of Dioskoros (1 29/64, to be precise), but the size of artaba is nowhere else attested in Egyptian sources.[7] The unit of measurement that equated to 6 Italic modii is in fact the Attic medimnos. Hesychios and the Suda (both s.v. αρταβη), giving identical texts, define the artaba as a Persian measure equal to the Attic medimnos, but this is certainly not the artaba in use in the papyri of the Ptolemaic and Roman periods. Knowledge of, or belief in,

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[4]What Pliny actually says is that wheat from Gaul and the Chersonnesus weighed 20 librae per modius, that from Sardinia an additional half-libra, and that from Alexandria a further third. It is possible that totalling these to precisely 20 5/6 is taking Pliny too literally, as all of his discussion here deals in standard fractions like a quarter, a third, and a half.

[5]The metrological table from Aphrodito (*P.Lond.* V 1718) actually gives a weight of 100 litrai for the artaba of 80 sextarii (5 modii), or 1.25 litrai per sextarius. Rathbone argues persuasively that Dioskoros's source meant mnai, not litrai.

[6]Anyone familiar with the controversies over Egyptian measurement of grain will want to ask how many choinikes we are dealing with here. It will be evident that our choices are to suppose that the same choinix was in use as in other artabas, e.g., 48 choinikes of 3/32 modius or .808 liters each in the 4.5 modius artaba, in which case there would be 64 of them to the artaba; or, alternatively, to imagine that there were still 48 choinikes, but each of them was instead proportionately larger, being 1/8 modius and 1.08 liters. As the fixed or variable nature of the choinix is itself a matter of controversy, and this ostrakon offers no help in resolving it, the choice is perhaps best left unresolved. There is, of course, the tantalizing equation in *P.Oxy.* XVI 1920.16 of the choinix of bread with 2 litrai. Dividing 124 by 2 gives us 62, which would suggest the correctness of a 64-choinix hypothesis for the medimnos-sized artaba here.

[7]Duncan-Jones, *ERE*[2] 372, cites Epiphanius (J. E. Dean, *Epiphanius' Treatise on Weights and Measures: The Syriac Version* [SAOC 11, Chicago 1935] 62d) for a 96-sextarius /artaba, but in fact Epiphanius speaks only of a 72-sextarius artaba; confusion may have arisen because Epiphanius says that the metretes is the liquid equivalent of the artaba, and he mentions a variant metretes of 96 sextarii. But no artaba of this size is mentioned. As 72 sextarii represents the 4.5 modii Italici size of the artaba, it is no evidence for the 6-modius artaba at stake in the ostrakon.

such an artaba, however, clearly survived into the Roman period and seems to be reflected in our ostrakon as well as in the late lexicographers.

As far as I can see, the information concerning the size of the loaf of bread—1/96 of an artaba—has no parallel. But the calculated weight figure for the loaf of 363 g after baking reminds one of the computation by L. Saffirio of the weight of the *kyllestis* loaf (made of spelt[8]) in the New Kingdom; three loaf sizes were deduced from the documentation, of 3, 3.5, and 4 deben. The last of these would weigh 364 g, virtually exactly the same as our loaf.[9] We learn from another source that one *khar* of wheat yielded 60 of these loaves.[10]

The final information is that the loaf, when baked, weighs only 27 staters instead of the 31 with which it started; that is, that it reduces to .871 of its initial weight. This datum is also problematic. The amount of bread produced by milling and baking a quantity of wheat is determined essentially by two factors, the extraction rate (i.e., how much is left when the undesired parts are discarded after milling) and the water absorption capacity of the particular wheat. Detailed discussions of these questions can be found most usefully in L. A. Moritz, *Grain Mills and Flour in Classical Antiquity* (Oxford 1958) 184-209 and L. Foxhall and H. A. Forbes, "Σιτομετρεια," *Chiron* 12 (1982) 41-90, esp. 75-90 (appendix by L. Foxhall). Pliny (*NH* 18.67) informs us that Alexandrian wheat was 'weak,' i.e., relatively low in absorption, and that it produced about 20 litrai of bread per modius, or about 96 percent of its wheat weight. Because the bread made from whole-meal flour with a high extraction rate normally weighs some 30-40 percent more than the flour, Pliny's figure would suggest that the extraction rate for Egyptian wheat was relatively low (Moritz 202).

Our ostrakon indicates bread yield only 87 percent of the weight of the wheat used. From Moritz's Table XI (p. 197), it can be seen that even at the low end of absorption, an extraction rate of 70 percent will produce bread of 90 percent of the weight of wheat. That would mean that our ostrakon must be assuming an extraction rate of only 67 percent. By comparison, Foxhall's experimentation with hand-grinding modern wheat with ancient implements gave her an extraction rate of 94.6 percent. Is it conceivable, one wonders, that we are dealing with a phenomenon analogous to that which Saffirio deduced for pharaonic texts dealing with bread made from spelt, in which volumes given for grain appear to represent not the bare grains but rather grains with the glumes still adhering to them, i.e., not yet ready for grinding. He cites evidence for a yield of about 66 percent going from "vestito" grain to flour.[11] The difference in grains and the absence of any indication of such a fact here may make one

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[8]See references in *WB* I, s.v.

[9]See L. Saffirio, "Razioni e salari in natura nell'antico Egitto," *Aegyptus* 57 (1977) 31-32.

[10]If the same ratio was in effect for the quantity of wheat used to final loaf weight, the *khar* would then be 60/96 of our medimnos, or precisely equal to the 3.75 modius artaba.

[11]*Aegyptus* 57 (1977) 31-32. It is worth remarking that on 32, in line 2 of the second paragraph, Saffirio refers to the *khar* of "clothed" spelt as being 32.47 litres; that is a mistake for 32.47 kilograms. When turned into flour at a ratio of .657 (calculated by dividing 27.75 by 42.25, see the figures given on p. 31), this would yield 21.33 kg of flour, or 355.6 g per loaf (at 60 to the *khar*). If the finished loaves were only 364 g, the amount of moisture added would have to be very small indeed. But it is probably a mistake to push these calculations for too much precision.

cautious. But, although neither term appears here, this text may also open up a set of questions about the precise meanings of ρυπαρος and καθαρος in referring to grain.[12]

A couple of side observations may be interesting. First, one notices that the total weight of the baked bread produced can be calculated as 108 litrai (124 litrai x .871). This happens to be the figure given for the weight of the medimnus in some manuscripts of the Suda (s.v. μεδιμνος):

μεδιμνον ουν μοδιων 5 ωs ειναι μετρον ξεστων οβ, ητοι λιτρων ρη.[13]This would, of course, if both statements were true, suppose that the weight of the sextarius was 1.5 litrai, a figure at odds with the approximate figure of 1.3 litrai derived above. It is also worth observing that the loaves when baked should weigh 1 1/8 litrai (108 litrai divided by 96 loaves). It would not be possible to distribute a nominal daily ration of 3 or 4 pounds of bread, such as is commonly found in the later empire,[14] in such units.

It remains difficult to see what the purpose of this ostrakon was. Even if one can find a way of reconciling the yield from wheat to bread with our other evidence, perhaps along the lines suggested above, the size of the artaba seems to have no connection with everyday experience in Roman Egypt. It seems rather a sort of metrological exercise, perhaps of a historical character. How it came to be written on an ostrakon in a good scribal hand is not clear.[15]
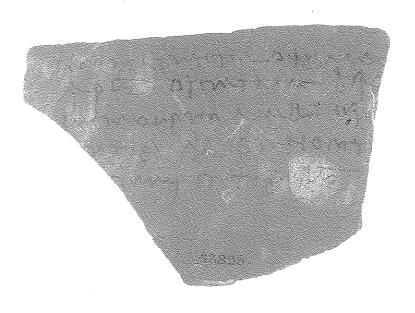
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[12]It is also possible that οπτη[θη] here refers to a second baking, i.e., that one is producing hard biscuit. But this is not explicitly indicated.
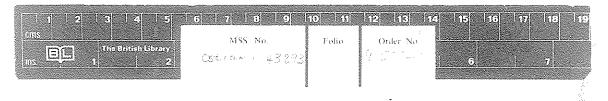
[13]What precedes this sentence derives from Harpocration, but this sentence is not found in Harpocration.

[14]See J. Gascou, "Le table budgétaire d'Antaeopolis (P.Freer 08.45 c-d)," *Hommes et richesses dans l'Empire byzantin* I (Paris 1989) 279-313 at 290.

[15]I am indebted to Dominic Rathbone and Klaas Worp for discussion of this text, but they are not to be held responsible for the interpretation of it I give in this paper.

Plate 1