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THE MYCENAEAN UNITS OF MEASURE

I. Introduction

Notwithstanding our detailed knowledge of many aspects of Mycenaean life and customs, through the interpretation of Linear B, our comprehension of the absolute values of the units of the system for measuring capacity[1] is still far from satisfactory. In the nineteenfifties[2], the main unit for dry capacity—which may be styled the Mycenaean medimnos[3]—was set, in a somewhat arbitrary fashion, at ca 120 litres; and that for liquid capacity—the Mycenaean metretes—at ca 36 litres. The argument went as follows: the first subdivision of both units—conventionally referred to as T and S respectively—had the same capacity, thought to correspond to the normal volume of the stirrup-jars of 12 to 14 litres; and the lower limit of that range was adopted for the sake of convenience. The information presented by the texts was none too helpful, as even the logical assumption that wheat rations must have been of the order of magnitude of one Attic khoinix per man per diem did not solve the issue, for none of the sub-units evidently qualified for such capacity.

However, insufficient importance was attached to the evidence of Gn, now Fr 1184; it seems that this tablet only came to light at a date (1954) when the conclusions setting the pattern for the first edition of Documents had been taken, and that the new evidence which it contained only led to the warning[4] that that particular text "may conceivably be taken to show that the normal value of the stirrup-jar in fact contains $1\frac{1}{2}$ ... in which case all the above figures must be reduced

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1 The Mycenaean talent had been established at a weight of ca 30 kilograms on the basis of archeological evidence (the gypsum octopus from Knossos and the copper ingots of Hagia Triada: 29 kilograms).

2 Cf. M. Ventris and J. Chadwick, Documents in Mycenaean Greek[1] 1956, 58—60. This standard work and its second edition by Chadwick (1973) will be referred to hereafter as Docs[1] & Docs[2].

3 As distinct from the Minoan unit, which I have called the (Minoan) medimnos, cf. the author, Kadmos 11, 1972, 11—21.

4 Docs[1] 60, cf. 217.

somewhat". Palmer[5] discussed the same text but did not take it into consideration when suggesting capacities of respectively sixty and eighteen litres for the medimnos and the metretes.

Lang[6], having measured all kind of vessels and established their frequency distribution, suggested capacities of repectively 48 and 14.4 litres. Chadwick[7] rejected Palmer's approach but accepted that of Lang and, as her values of 48 and 14.4 litres led to unacceptable figures for the rationing of personnel, proposed to double them.

I fail to see the importance of Lang's data for the solution of the issue, as it is by no means certain that we may equate statistical average with unit size; a certain volumetric range, like that of 12—14 litres for the stirrup-jars, allows for a correlation between some fraction or multiple of the unit size and a value lying whithin that range; but the very existence of a range demonstrates that the degree of accuracy in manufacture was rather low, and certainly too low to allow for hard-and-fast conclusions. In other words, the frequency-analysis does not present us with information additional to that contained in Fr 1184. A study of that particular text[8] leads to the conclusion that the metretes, comprising three primary sub-units, should have a capacity of twice the volume of the 'ideal' stirrup-jar and, consequently, should be sought within the range of 24 to 28 litres[9]. That range, then, is to be compared with the different suggestions of 36 litres (Docs[1]), 18 litres (Palmer), 14.4 litres (Lang) and 28.8 litres (Chadwick). Although the last value approaches the range, it is still outside it.

How can we come closer to the exact values? Perhaps on the basis of the more accurate values established for the Minoan system[10].

II. The units for the measurement of capacity

The Mycenaean system of measurement appears odd in its sub-division of the main units. The talent is divided into thirty parts, instead

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5 L. R. Palmer, The interpretation of Mycenaean Greek texts 1963, 12ff., 96ff., 269, 277.

6 M. Lang, AJA 68, 1964, 99—105.

7 Cf. Docs[2] 394.

8 "Kokalos repaid (Docs[2]: "has contributed") the following quantity of olive-oil to Eumenes: oil 18, from Ipsewas stirrup-jars 38".

9 When accepting Lang's approach, Chadwick inverted the argument of Docs[1] 60 in using the information of Fr 1184 to "calculate the average volume of a stirrup-jar in terms of Mycenaean measures"; cf. Docs[2] 481.

10 Cf. the author, Kadmos 11 op.cit.; 12, 1973, 28—59; 12, 1973, 134—148; 13, 1974, 95—116.

of into sixty minas as might be expected[11]; and the medimnos into ten T, each of six V, each in turn of four Z—which raises the question of why such a mixture of decimal and sexagesimal principles was ever adopted. The decimal principle is the more strange as the Minoans, with their system of fraction based upon the denominators 5 and 24, had no way of denoting one-tenth[12]. Further, the absence of a system of fractions in Linear B, and the reliance upon the more primitive system of multiples of sub-units for measurement, seem to indicate a less developed mathematical aptitude than in the case of Linear A.

That the talent was divided, not into sixty but into thirty parts only, may be because the Minoans—at least for the measurement of wheat—were using the heavy or double talent[13] of 120 minas. If that unit had been subdivided into sixty 'heavy minas'—although there is no evidence for this—the use of such a unit in the normal system of weight could have been responsible for the odd fraction of 1/30. However, the 'mina of wheat' attested at Hagia Triada argues against this possibility[14]. All in all, the question may be posed of whether the Mycenaean system of measurement by capacity resulted from some adaptation of the older Minoan system and, if so, for what reason.

The Minoan system must be considered first. The Minoan medimnos of 120 khoinikes (= 108 litres) and the metretes of a capacity of 36 khoinikes show the same ratio of 10:3 as the corresponding Mycenaean units, a promising correlation.

As to the use of the heavy talent for measuring the weight of wheat at Hagia Triada, I have shown[15] that the volume thereof corresponded with 100 khoinikes, a circumstance wich allowed for easy conversion from one system into the other. One hundred khoinikes equal 90 litres, and from Fr 1184 it follows that the Mycenaean medimnos had a

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11 The further sub-division of the talent is of no interest in this connection.

12 Cf. the author, Kadmos 10, 1971, 35—51. The Minoan system of notation had two ways of writing more complicated fractions; the juxtaposition of two signs, both of which belonged to a group with either the denominator 5 or 24, was read as a sum of the component parts; but a combination which included a fraction sign outside such a group—e.g. $\frac{1}{30}$ and $\frac{5}{24}$—stood for the product. It follows that the fraction $\frac{1}{10}$ could have been made by the juxtaposition of the signs for $\frac{1}{2}$ and $\frac{1}{5}$. However, no such combination has been attested, no doubt because the higher odd fractions with the denominator 'ten' could not be compounded in that fashion.

13 This permitted a concurrent use of both systems, as is evidenced in a number of texts: HT 15, 86, 120. HT 15 contains proof that the absolute value of the Minoan medimnos is 108 litres (120 khoinikes of 0.9 litres); cf. the author, Kadmos 12, op.cit.142.

14 Notation Lc11, cf. the author, Kadmos 12 op.cit. 140.

15 Kadmos 12 op.cit.141.

capacity within the range of 80 to 93 1/3 litres, (10/3 times that of 24 to 28 litres), a spread which nicely embraces the value of 90 litres. This, in its turn, suggests that the Mycenaean medimnos was the result of a deliberate reduction in size of the Minoan unit in order to ensure that such an amount of wheat had the weight of a heavy talent, or, in Mycenaean terms[16], of two talents. The reason for such an operation may have been the custom of using units of wheat for cadastral measurement.

Now turning to the symbols used, we may remark that the Mycenaean symbol for the unit V is the same as Lm 26[17], the Minoan sign for 1/30, and that the weight of such a volume of wheat is 1/30 of a talent. This surely is more than coincidence, especially considering that this is also the weight of the first subdivision of the Mycenaean talent. In addition, it may be observed that the Mycenaean cup-sign, Z, represented 1/240 medimnos, and that such a volume of wheat had a weight of 1/120 talent, corresponding to the secondary sub-unit of the Mycenaean system of weight.

Table I presents the correlations as established.

Table I
Conversion of units when measuring wheat[18]

ratio	volumetric units	units of weight	number of khoinikes
1	medimnos	2 talent	100
1/10	T	6 M	10
1/60	V	M	5/3
1/240	Z	N	5/12 (= 5/3 kotyla[19])

Using these values, the data on the rationing of personnel may be calculated in khoinikes and compared with those established for Hagia Triada. The text of MY Au 658.4, "*to-so* men 20 *si-to* wheat 4", has been taken[20] to record the payment for a month's period. The four medimnoi

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16 The existence of a heavy or double talent has not been attested in Linear B; the Minoan term for such a unit is *du*-65-*a*, perhaps a plural nominative, cf. the author, Kadmos 12 op.cit. 142.

17 Classification according to J. Raison & M. Pope, Index du linéaire A 1971, fig. 216; W. C. Brice, ILA 1961, classified as Lm'1.

18 For other cereals the conversion cannot have been much different, although not exact.

19 The Minoan khoinix equalled four kotyla, cf. the author, Kadmos 13 op.cit.

20 Cf. Docs[2] 420.

recorded equal 400 khoinikes and, accepting the Mycenaean month at thirty days, the ration is $\frac{1}{20} \times \frac{1}{30} \times 400 = \frac{2}{3}$ khoinikes per man per diem. The same ration follows for the men of KN Am 819, the 'boys' receiving $\frac{4}{5}$ of that amount[21]. Again, the women at Pylos[22] received $\frac{2}{3}$ of a khoinix, half in wheat and half in figs, as on HT 94[23], and the children half of that ration. At Hagia Triada rations were higher, as the normal amount was one khoinix per day, while others received less, in the same ratios of $\frac{4}{5}$ and $\frac{1}{12}$[24]. A difference of one-third between the issues at Hagia Triada and Pylos is considerable, but it may well have been that in the territory of Phaistos, the granary of Crete, rations were higher than elsewhere.

III. The measurement of land

Although the reason for the reduction in size of the Mycenaean medimnos remains a matter of speculation, its effect was to simplify the conversion of volume into weight. The smallest unit of land recorded at Pylos required one V unit of seed-corn, having a weight of one M, or, in Minoan units, two minas[25]. The Minoan volumetric measures were less simple, such an area requiring 5/3 khoinikes of wheat.

The leases recorded in the so-called 'first Pylos set' of land-tenure tablets[26], all held by humble folk, show the following multiples of the minimal plot: 3, 6, 9, 12, 16, 18, 24, 30, 54, and none larger. Apparently there was no correlation between the size of these leases and the social status of the tenants[27]. Leases of a size beyond 54 V are found in the other E-series and, with respect to size, these do not differ in essence from the 'private holdings'. However, it may be observed that the titles to land of 60 V upwards are different from those of the 'first set'; we

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21 Chadwick, Docs² 420, has stated that that text only allows for the conclusion that boys and men were treated on the same footing, a most unsatisfactory conclusion at that. However, I have demonstrated (Nestor 1976, 1031) that such a conclusion is by no means inevitable and have established the above-mentioned rations.

22 Cf. Docs² 157—62, 418; Palmer op.cit. 117.

23 Cf. the author, Kadmos 11 op.cit. The text from Hagia Triada even has the symbol 'wheat + *ḱʷe*' for 'wheat-equivalent', cf. the author, Kadmos 12 op.cit. 57 (4).

24 Cf. the author, Kadmos 12 op.cit. 26, Table XVII. Normally wine and/or oil was added. In one case, HT 88, only figs were mentioned.

25 If sown with wheat, the average harvest would have amounted to ten minas, a negligible quantity; it follows that such minuscule plots served as vegetable gardens.

26 Series En and Eo, cf. Docs² 240—50.

27 The smallest lease was held by *E*-65-*to* (En 74.9), the largest by *Tu-ri-ja-ti* (En 659.5), both 'servants of the god'.

find *ka-ma* holders with a feudal duty to perform, collectives[28], a priestess claiming that the holds the land as a 'private plot', and an individual named Kreteus, who may have been the field-commander's charioteer[29]. The plots of these series, leased to the same kind of humble folk as mentioned in the 'first set', measure 2, 6, 9, 12 and 14 V. The apparent upper size of 54 V in leases to these people raises the question of whether the size of 54 V held some legal significance in Pylian society[30].

The answer to this question may be found in the same 'first set', which commences[31] by mentioning that fourteen owners possess forty DA, the unit used in the Knossian cadaster. The total land of the series amounts to 2126 V, which gives us 53.15 V per DA[32]. Bennett[33] showed that the number of leaseholders is forty as well, but as it is clear that the DA is an amount of land of a defined size, it follows that the reference to forty DA in the heading of the text does not relate to the forty tenants

Table II
Conversion of sizes of leases in Minoan units.

Size in V	size in khoinikes	fraction of medimnos	size in V	size in combination of khoinikes and minas
54	90	3/4	16	25 + 2
30	50	5/12	14	25 − 2 = 1/6 (DA + talent)
24	40	1/3	13	20 + 2
18	30	1/4	2	2 × 2
15	25	5/24	1	2
12	20	1/6		
9	15	1/8		
6	10	1/12		
3	5	1/24		

[28] *Ki-ri-te-wi-ja* (Ep 704.4): 114 V, cf. Docs² 134; *E-qe-si-jo do-e-ro* (Ed 847): 82 V, cf. Docs² 451.

[29] Eq 59; *ra-wa-ke-si-jo-jo a-mo-te-wo* on Ea 809, cf. Docs² 259—60, 449—50; Palmer op.cit. 84, 220.

[30] The Knossian texts record the land-tenure in DA and PA units (vide infra).

[31] Cf. Docs² 241.

[32] The En series mention thirteen names of 'fief-holders' only, the missing one being mentioned on Eo 444.1. The abbreviation DA stands for damartes 'households', indicating an area of land adequate for the subsistence of a household; cf. Docs² 447; Yves Duhoux, Kadmos 13, 1974, 27—38.

[33] E. L. Bennett Jr., AJA 60, 1956, 103—33.

with their leases of different size. Moreover, there would be little sense in calling a plot with a possible harvest of ten minas of wheat a 'household'.

Why does a single DA require 54 V of wheat as seed-corn? This becomes comprehensible when we consider the amount of seed-corn required for each of the leases, as expressed in khoinikes. These data are presented in Table II, which also contains the sizes 13, 14 and 15 V as the lands of Warnataios, Aithiops and Ra-ku-ro[34], when expressed in DA units of 54 V amount to $2\frac{13}{54}$, $2\frac{14}{54}$ and $1\frac{15}{54}$ respectively. The plot sizes on the left-hand side of the table all correspond with quite plausible Minoan quantities of seed-corn, which suggest that the Minoans had a system which was copied in Pylos and expressed in the appropriate units. Indeed, we find in the records from Hagia Triada the symbol for wheat ligatured with fraction signs, which points to a cadastral use, for in order to record actual volumes of wheat—harvested or sold—no such convention was needed. A correlation between one DA and $\frac{3}{4}$ of a Minoan medimnos of seed-corn is encouraging, but does not prove the size of the DA We have to go to the Minoan ligatured wheat-signs to see whether the same limit applies there; see Table III. Obviously, we find that the same amounts of khoinikes correspond with the fractions of the

Table III
Ligatured wheat signs of Hagia Triada

Symbol[35]	meaning	amount expressed in khoinikes	minas	Mycenaean units
Lc11	wheat 1/144	5/6	1	Z 2
Lc2	„ 1/120	1	6/5	– – – – – – –
Lc4	„ 1/30	4	24/5	– – – – – – –
Lc8	„ 1/8	15	18	T 1 V 3
Lc74	„ 1/6	20	24	T 2
Lc7	„ 3/8	45	54	T 4 V 3
Lc106	„ 1/2	60	72	T 6
Lc6	„ 7/12	70	84	T 7
Lc72	„ DA	90?	108?	T 9 ?
Lc1	„ heavy talent	100	120	medimnos

[34] Respectively on En 609.3, En 74.11 and En 659.15.

[35] Classification of Raison & Pope op.cit. Lc72 and Lc106 correspond with L42 and Lc'7 of Brice's catalogue.

Minoan medimnos, but it is more significant that, from the list, we may remove Lc1, 'heavy talent of wheat', a symbol which had no fraction sign as an adjunct (cf. n. 16), and which was used to indicate amounts of wheat in a list of payment of labourers[36]. The same holds for Lc2 and perhaps[37] for Lc4, which amount cannot be expressed in the Mycenaean system. The highest amount, possibly used for cadastral recording, therefore, is that of Lc6, corresponding with T 7 or V 42, and, in addition thereto, we have the notation Lc1 'wheat + DA' in the simple text of HT 133: *a-du. te* wheat + DA 55. One may conclude that the evidence of Hagia Triada is in conformity with that of Pylos, and that we may set the DA at 54 V.

From the data of Table II it follows that the Pylian cadaster had two different minimal sizes, one corresponding with five khoinikes of seed-corn, the other with two minas (= one V), both inherited from the Minoans.

Why the juxtaposition of two cadastral systems, one volumetric, the other gravimetric? The former seems 'natural', but the latter needs explanation. The term *aroura* is attested by PY Eq 213; it has been taken to mean 'corn-lands'[38], but in essence it was a cadastral unit of Egyptian origin, corresponding to a surface of 27.56 ares[39]. The same term, with the typical Minoan *-u-*, occurs in *a-ru-ra-X* on HT 11a, where it indicates persons[40]. In view of the available space on the tablet, one is inclined to suppose that the first line had *a-ru-ra*-X-X and, in that perspective, one is reminded of the *ko-to-no-o-ko* of the Pylian cadaster[41]. Duhoux[42] has established the size of the DA as about 48 ares and, using this figure, the *aroura* should correspond with 51.67 khoinikes of seed-corn[43]; which statistic, when we recall that the figure of 48 ares is approximative only[44], is so close to fifty that we may take it that this indeed was the amount of seed-corn required for the *aroura*. Fifty khoinikes of wheat

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[36] Cf. the author, Kadmos 12 op.cit.142.

[37] The text of HT 22 does not allow detailed interpretation.

[38] Cf. Docs² 268, 534.

[39] H. Chantraine in Kl. Pauli 2, 559; A. Gardiner, Egyptian Grammar³ rev. 1969, 200, gives 27.35 ares.

[40] As evidenced by the 'labourers' ideogram L99 in the enumeration of the text.

[41] Cf. Docs² 557. Also *ko-to-ne-ta*, PY Ed 901. In *a-ru-ra*-X, X could well be '*ta*'.

[42] Op.cit. 37.

[43] 27.56 ÷ 48 × 90.

[44] Following the assumption about the amount of seed-corn used per hectare; where Duhoux made use of the figure of 175 litres per hectare, starting from the *aroura* at 50 khoinikes, his starting figure needs reduction to 170.6 litres per hectare.

have a weight of one talent, and it would be logical to subdivide the *aroura* with the aid of the system for weight, as neither the Minoans nor the Mycenaeans had a system like the Egyptian, of dividing the *aroura* into one hundred cubits[45]. It may be supposed that two distinct systems of land-measurement grew amalgamated because conversion, already easy in the Minoan system, became even easier in the Mycenaean: thus the sub-unit five khoinikes became three V, and two minas ($\frac{1}{60}$ of a heavy talent) one V. The figures of the left-hand column of Table II may be given as: DA 1, *aroura* 1, *aroura* $\frac{4}{5}$. *aroura* $\frac{3}{5}$, *aroura* $\frac{1}{2}$, *aroura* $\frac{2}{5}$, DA $\frac{1}{6}$, *aroura* $\frac{1}{5}$, and *aroura* $\frac{1}{10}$ respectively.

It will be recalled that, in the discussion of the possible size of the DA unit (above, p. 31), En 609 gave an average of 53.15 V per DA and not the 54 we have used instead. If the latter figure is correct, why did the scribe note 40 instead of $39\frac{1}{3}$ (for 39.370)? Perhaps because he wished to take the meaning of the abbreviation literally, in other words, to record how many 'households' had been in the hands of the named fief-holders and had thereby been withdrawn form their original social destination[46].

The Knossian land-tenure tablets record the sizes in DA + PA, and it has been taken that the latter is a fraction of the former. In the light of the values in Table II this seems odd, as the denominator of the fractions would have been eighteen[47]! The evidence from Knossos is too scanty to allow any definite conclusion, and we only know that three PA was less than one DA. Half an *aroura* would meet that condition, and four such half-units would be larger than one DA. This could be why no more than three PA have been found recorded in any single entry.

IV. Summary

It has been suggested that the Mycenaean system for the measurement of dry capacity resulted from an adaptation of the earlier Minoan system by reducing the capacity of the latter by one-sixth. As a consequence of such adaptation, and possibly as its main purpose, the Mycenaean unit, when used to measure wheat, would contain a weight of two talents. The available evidence points to a capacity of 90 litres for the 'medimnos' and of 27 litres for the 'metretes'.

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[45] In fact a misnomer, as the cubit was a measure of length.

[46] Rather remarkably, reduction of the size of each fief to the nearest whole number of DA yields a total of forty. I hesitate to believe that this was the scribe's intention.

[47] All values being multiples of three (= $\frac{1}{18}$ of 54).

The cadastral use of the units, if examined against the Minoan prototypes, suggests that the 'standard' DA corresponded with an amount of wheat of 54 V or 0.9 medimnos, and that, along with that cadastral unit, the *aroura* of 30 V or one talent of seed-corn was used as well.