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NUMERICAL FRACTIONS IN THE MINOAN LINEAR SCRIPT A

III. THE MEASUREMENT OF LIQUIDS

I. Introduction

In the preceding report in this series[1] the system used for the measurement of dry commodities was investigated. It emerged that wheat was measured by a medimnos of one hundred and twenty khoinikes. A similar system has been suggested by the analysis of the hieroglyphic text from Mallia[2], H 20. The two systems, which were probably used simultaneously[3], differed with respect to the intermediate sub-units.

The Mallia text mentioned two liquid commodities, wine and olive oil, and it was assumed that both were measured with the same unit. Construing this text, like those from Hagia Triada which have "*sara*$_2$" in the heading (HT 89 and HT 100), as being a record of the payment in kind of labourers, it became evident that the unit for liquid measure was of considerably smaller capacity than that for dry measure, perhaps one-fifth thereof. Otherwise the value of the liquid compounds in the pay package would be out of proportion to the dry compounds[4]. The liquid metretes appeared to be sub-divided into eight sub-units, khowes, and each of those in its turn into sixty small units of exactly the same capacity as the classical kyathos.

In the study of the Mallia text attention was paid to the allocation of wine, and it was shown that, if the aggregates of wine were measured by the use of the dry system, acceptable results emerged.

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[1] Kadmos 11, 1972, 1—21

[2] cf. the author, B. I. C. S. 18, 1971, 16—25.

[3] This text dates from MM IIIb; the Mallia text in Linear A, III 12 (cf. W. C. Brice, Inscriptions in the Minoan Linear Script of Class A, Oxford, 1961), which shows the Hagia Triada system for dry measure, is undated but likely to be of that same period.

[4] In the Mallia text wheat, figs, barley and olives are mentioned.

The daily rations appeared as two-, three-, four- or five-tenths of a khoinix, which necessitated a unit smaller than the khoinix to accommodate these amounts. When measured in the kyathos as inferred above, the daily rations of wine would correspond to twenty-fold of those numbers.

It seems, therefore, that the recording of wine on the Mallia tablets was executed in medimnoi, but that the system for liquid measure was used in measuring daily amounts for labourers.

The object of the present report is to explore the system used at Hagia Triada for the measurement of liquid commodities. In particular, the distribution of olive oil will be investigated, as this commodity was — in view of its high value — an important constituent of the complete pay package. In the study of the Mallia text its value has been taken as four times that of wheat due to its caloric content. A somewhat lower value might be assumed when the Minoan economy was geared to the export of oil and wine and the import of cereals.

In the preceding report it was possible to check the data on the allocation of dry commodities to a certain class of labour, as they occur on two different texts. Such paired texts, or 'duplets', as they may be called, when sufficiently complete for analysis, provide a sound basis for investigation. In dealing with the system for liquid capacities, therefore, we may usefully begin by looking for similar comparable texts.

II. The duplet HT 114 and HT 121

Fortunately such a comparable duplet exists. The texts may be simplified as follows.

HT 114		HT 121	
kiweta$_2$, *sara*$_2$		*kiweta*$_2$	
wheat	10	oil + *di* + *k*^{w}*e*	10
oil	7	*sara*$_2$	
figs	1	wheat	5
wine	1	oil	4
L'2	3	figs	2
sa		wine	3
wine	8	L'2	3

During analysis of the distribution of dry commodities, it appeared that the heading, "*sara*$_2$", could be construed to mean "distributed" or "so much to pay". On HT 114 the entry at the end of the list, "*sa*, wine 8", might indicate that "*sara*$_2$" comprises two words; a final entry "so much wine" would make sense. This point will be reverted to below.

The amounts of wheat and figs should be distributable to the number of labourers to be paid. In some other texts these numbers are recorded, but not in these two cases[5]. The amounts of wheat and figs are recorded in medimnoi, but in order to facilitate calculation they will be converted into khoinikes, one khoinix being the normal basic payment per diem.

This involves reduction of the listed amounts by a factor 120.

Possibility I:

HT 114	2a ($^1/_2$ of wheat, $^1/_2$ of figs)	= 1 wheat, 1 figs
	9b (1 of wheat)	= 9 wheat
		10 wheat, 1 figs
HT 121	4a ($^1/_2$ of wheat, $^1/_2$ of figs)	= 2 wheat, 2 figs
	3b (1 of wheat)	= 3 wheat
		5 wheat, 2 figs

Possibility II:

HT 114	3a ($^2/_3$ of wheat, $^1/_3$ of figs)	= 2 wheat, 1 figs
	8b (1 of wheat)	= 8 wheat
		10 wheat, 1 figs
HT 121	6a ($^2/_3$ of wheat, $^1/_3$ of figs)	= 4 wheat, 2 figs
	1b (1 of wheat)	= 1 wheat
		5 wheat, 2 figs

To account for the listed quantities it is necessary to accept that the records deal with two types of personnel (which may be referred to as a and b) receiving wheat and figs in different proportions[6].

[5] Data on amounts and numbers of people indicate the period for which labour was hired (normally ten days or a multiple thereof). In the present case only the product of days and persons follows. This, however, has no consequence for the investigation of the per diem allowances.

[6] This follows from the consideration that the aggregates of wheat and figs in the two texts compare in the ratio 11 to 7, which is not applicable to any of the other entries or combinations thereof.

It then appears that there are two possible interpretations of these accounts; and both interpretations allow for identical treatment in each text of the two categories of labour[7].

It will be appreciated that the numbers given to the categories a) and b) may be replaced by their multiples, thereby reducing the number of pay-days accordingly[8].

Now it becomes possible to calculate the allocations of the other commodities on the basis of the two possibilities.

Possibility I:

HT 121 (i) 4a + 3b = 3 wine + 4 oil + 3 L′2
HT 114 (ii) 2a + 9b = 1 wine + 7 oil + 3 L′2

doubling (ii) we get

(iii) 4a + 18b = 2 wine + 14 oil + 6 L′2

subtracting (i) from (iii) yields

(iv) 15b = − 1 wine + 10 oil + 3 L′2

dividing this last equation by 15 leads to the conclusion

(v) b = $-\,{}^{1}/_{15}$ wine + $^{2}/_{3}$ oil + $^{1}/_{5}$ L′2

Possibility II:

HT 121 6a + 1b = similar to I
HT 114 3a + 8b = similar to I

ergo, by similar calculation, b received as under I

A negative payment is impossible; consequently we must return to the final entry on HT 114 which has been discussed above. The "so much wine, 8" should be included in the calculation; it seems to have resulted from the inadequacy of the wine listed higher up in the record. The total amount of wine on HT 114 should then be 9. Recalculation on the lines set out above gives the following results.

Possibility I: b received 1 wine, $^{2}/_{3}$ oil, $^{1}/_{5}$ L′2
a received no wine, $^{1}/_{2}$ oil, $^{3}/_{5}$ L′2

[7] This assumption is justified by the similarity of the two texts; otherwise no comparison would be possible. The assumption will be considered to be proved if it leads to acceptable distributions. In the absence of any indication on the categories of labour, normal pay (1 khoinix of cereals + figs) may be assumed.

[8] The listed amounts would allow for a 10 days' payment for twelve times the number of people indicated, etc.

Possibility II: b received 1 wine, $^{2}/_{3}$ oil, $^{1}/_{5}$ L'2
a received $^{1}/_{3}$ wine, $^{5}/_{9}$ oil, $^{14}/_{30}$ L'2

N. B. In the above calculations all amounts are expressed in the applicable units (the khoinix for wheat, figs and wine, a unit as yet undetermined for the other two commodities).

The first possibility is to be preferred, as the fractions are by far simpler than those emerging from the other: moreover, it has been found that wine was allocated in one-tenth or one-twentieth (the kyathos) parts of a khoinix, and the amount of wine in possibility II (one-third) does not fit into such a system. Consequently, only the first possibility will be retained for further consideration. According to that system, category a) receives the same amounts as category L 126 on HT 94, as far as the allocations of cereals and figs are concerned[9].

The reference to "oil + *di* + *k*^{w}*e*, 10" on HT 121, preceding the distribution list, will receive attention below (see Appendix 4).

III. The system for liquid capacity

As has already been said, the value of olive oil needs consideration and necessitates a unit for liquid measure considerably smaller than the medimnos. That system should be able to accommodate the amounts per diem found for the two categories of labour on HT 114 and HT 121. In the succeeding calculations the medimnoi listed have been transformed into khoinikes by reducing the amounts recorded by a factor 120. Similarly, accepting the full unit for liquid measure to be the metretes and applying the same factor 120, category a) received $^{1}/_{240}$ metretes per diem, category b) $^{1}/_{180}$ of such a unit.

Now we may consider the size of the metretes on that basis; this is done in the following table, which lists the data relevant to various possible capacities of the metretes.

From Table I it will be seen that preference is to be given to alternative 4; the capacity of the lowest sub-unit, the kyathos, corresponds with that of the classical unit[10]; the capacity ratio of the main liquid to the main dry unit corresponds with the ratio in the Linear B system; and, as in the case of the medimnos, the metretes is twice the size of the corresponding Mycenaean unit[11].

[9] It is possible that the damaged parts of HT 94 contain a reference to wine.

[10] 45 millilitres; cf. H. Chantraine, Kleine Pauly, Lex. d. Ant., 3, 382

[11] Cf. L. R. Palmer, Interpretation of Mycenaean Greek Texts, Oxford 1963, 12ff.

Table I

Data relevant to the system for liquid measure

Alternatives	1	2	3	4	
Size of metretes	18	24	30	36	khoinikes
p. d. ration a	$^{3}/_{40}$	$^{1}/_{10}$	$^{1}/_{8}$	$^{3}/_{20}$	khoinix
p. d. ration b	$^{1}/_{10}$	$^{2}/_{15}$	$^{1}/_{6}$	$^{1}/_{5}$	khoinix
capacity of lowest sub-unit	$^{1}/_{40}$	$^{1}/_{30}$	$^{1}/_{24}$	$^{1}/_{20}$	khoinix
number thereof in metretes	720	720	720	720	
metretes-medimnos capacity relation	$^{3}/_{20}$	$^{1}/_{5}$	$^{1}/_{4}$	$^{3}/_{10}$	
do. in Mycenaean system				$^{3}/_{10}$	

If the classical pattern were applied, the sub-division of the main liquid unit would be somewhat as follows:

1 metretes = 12 khowes
1 khoos = 15 (or 12, or 10) kotylai
1 kotyla = 4 (or 5, or 6) kyathoi

The system deduced from the hieroglyphic text from Mallia compares thus:

1 metretes = 8 khowes
1 khoos = 60 kyathoi

If the khoos and the kyathos of the one system corresponded with those of the other, the Mallia metretes would be two-thirds of the Hagia Triada unit. The existence of the khoos follows from the Mallia text. It will be necessary to consider the fractions recorded in all texts to settle the matter of the size of the sub-units intermediate between the metretes and kyathos in the Linear A system. This investigation will be reported below (see Section V). However, there are some other texts which allow a check of the conclusions derived from HT 114 and HT 121; these texts will be analysed in the next Section.

Meanwhile, two remarks should be made. First, as has already been said in the Introduction, the amounts of wine recorded on HT 89 and HT 100 do not fit into the system for liquid capacity, for the daily allowances would be too small to be expressed in kyathoi. Consequently, it remains a matter of conjecture whether

the wine recorded on the Mallia tablet H 20 was expressed in the unit for dry or in that for liquid capacity. If it were in dry measure, the daily allowance would equal $1^1/_4$ khoinikes, which seems unduly large; on the other hand, the Hagia Triada system has an allowance of one khoinix on HT 114 and HT 121, to which the same remark may apply.

Second, the same texts show that the daily allowances of the commodity represented by L'2 were $^1/_{200}$ and $^1/_{600}$ respectively of a full unit. Such fractions would not fit into the system for liquid measure if the amounts were recorded in that system. It seems, therefore, that the same dual system was applied as in the case of wine; the recording took place in medimnoi, the daily allowances being measured in kyathoi.

Such a dual system permitted a more extended range of subdivision than either of the basic systems; whereas the system for dry measure allowed $^1/_{120}$ as the lowest fraction and the system for liquid measure $^1/_{720}$, the dual system would span a factor 2400. The daily allowances of L'2, measured in this way, would comprise 12 and 4 kyathoi respectively.

IV. Checking the system for liquid capacity

HT 100 (cf. Part II 10—12) contains a detailed account of the numbers of various categories of labour and of the aggregate of the commodities comprising the pay package, 'millet,' figs, wine and

Table II

Per diem payment of labour according to HT 100

Category of labour	Millet and figs in khoinikes	Ratio between millet and figs	Wine in khoinikes
4 Lc'5	$^4/_5$	1:1	$^2/_{10}$
2 *ki*	$^4/_5$	1:1	$^2/_{10}$
5 L 66	$^4/_5$	1:1	$^2/_{10}$
58 Lc 55	1	3:2	$^3/_{10}$
12 *sadi*	1	9:1	$^3/_{10}$
16 L 125	1	only millet	$^5/_{10}$

three types of olive oil. From HT 116 it follows that such special qualities of olive oil can be added and that the total is expressed by the unligatured oil symbol[12], L 89.

[12] On HT 114 and HT 121 the genus symbol for olive oil has also been used.

The specific categories of HT 100 were paid as indicated in Table II (cf. Part II 18, Table III).

The categories have been presented in order of status rising according to payment.

The olive oil is recorded in metretes as follows: oil + *ro* $2^{7}/_{12}$; oil + *mi* 3; and oil + *ha*[13] $^{3}/_{4}$ — which, if the aggregate amounts represented a ten days' allowance, would have expressed the following numbers of kyathoi available per diem: 186, 216 and 54, total 456.

The allocation to individuals appears to have been as presented in Table III.

Table III

Per diem allocations of olive oil in kyathoi according to HT 100 (statistics in parentheses indicate aggregates)

Recipients	oil + *ro*	oil + *mi*	oil + *ha*	total
Lc'5, *ki*, L 66 (11)	—	—	2 (22)	2 (22)
Lc 55 (58)	3 (174)	2 (116)	—	5 (290)
sadi (12)	1 (12)	3 (36)	—	4 (48)
L 125 (16)	—	4 (64)	2 (32)	6 (96)
Total issues	(186)	(216)	(54)	(456)

From this table three conclusions follow. First, the possibility of distributing the three types of olive oil in kyathoi to the various categories supports the correctness of the deductions in the preceding section.

Second, it is remarkable that rising status is reflected mainly in the second type of oil, rather than in the total. This would seem to indicate a difference in price between the various types of oil.

HT 90

heading		heading	
sara$_2$		wheat	1
wheat	20	figs	1
figs	10	oil + *mi*	1
oil + *di*	3	barley	1

[13] L 61 is transliterated by *ha* as being a possible cognate of Linear B *25.

Thirdly, a per diem allocation of olive oil[14] amounting to six kyathoi also emerges from the *sara*$_2$-list of HT 125.

HT 90 also lists oil in a *sara*$_2$-list. At first sight the record presents some problems, and it therefore needs discussion in detail.

The number of recipients is not indicated; in this respect the text resembles those of HT 114 and HT 121. However, it has another list besides that headed by *sara*$_2$. Such additional information should, as has been seen in HT 114, correlate in some way with the *sara*$_2$-list. In this particular case, however, the concept of 'deficit' or 'left-over' cannot apply, as follows from a study of the numerals. The right-hand list does fit if it served as a record of the bonuses, paid to the supervisors, who were found[15] on HT 88 and HT 94. Such individuals were assigned to the hired labour and received a fixed bonus in addition to the pay of the others. The bonus has been found to comprise one-third of a khoinix of cereals and/or figs per diem; in this particular case oil has also been added.

Table IV

Per diem allocation according to HT 90

	Category c	Supervisors to c	Category d	Supervisors to d
numbers of individuals	12	4	68	1
wheat in khoinikes	$^2/_3$	$^2/_3$	$^2/_3$	—
figs in khoinikes	$^1/_3$	$^2/_3$	$^1/_3$	—
barley in khoinikes	—	—	—	$^8/_3$
oil + *di* in kyathoi	4	—	—	—
oil + *mi* in kyathoi	—	4	—	—

It may be mentioned that barley is never found on any *sara*$_2$-list; payment to labour was made in wheat, 'millet' and figs. The rarity of barley in the records and the lower amounts listed as compared

[14] The ligature, if any, has been eroded.

[15] cf. Part II 12–16

with wheat, taken together with the evidence that it was not eaten by hired labour but accepted by those belonging to the palace administration, may hint at the existence of distinct cultures[16].

As barley is assessed at half the worth of the same amount of wheat[17], it presents another complication. The total amount of cereals and figs recorded on the second list is then two and a half, which indicates that we may do best to increase the number of recipients at the cost of the number of work days covered by the total payment. To cut a long argument short, accepting that the second list contains the payments due to the supervisors, the entire tablet would list payments for forty-five days for eighty labourers and five supervisors[18]. The payment system which emerges is presented in Table IV.

Of some interest is the difference in degree of supervision of the better and less well paid labour. The former received the same amount of olive oil as the *sadi* category of HT 100 (cf. Table III), but then it should not be overlooked that the species of oil is different.

HT 27 is a record of the same type as HT 89, starting with an enumeration of labour groups followed by a list recording amounts of cereals ('millet'), figs and wine. Face b) has some detailed information about wine and wheat, and the first question is how this second part tallies with the first. I have been hesitating for a long time on the analysis of this document because of the damage it has sustained. However, the consistent data emerging from the surviving part of the text may provide sufficient information to compensate for the loss.

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[16] In the Mallia text barley was, among other commodities, included in a normal payment record.

[17] cf. L. R. Palmer, op. cit. 14, 96ff.

[18] Mr. R. M. Pinkerton of the Department of Humanity of the University of Edinburgh, who most kindly checked the calculations and arguments on which the conclusions of this paper rest, rightly pointed out to me that other solutions of the data contained in the texts are possible; e. g. these may represent payment for a period of fifteen days to 240 labourers and 15 supervisors. — Such solutions I have not retained, however, as these would necessitate the conclusion that the bonus paid to supervisors included an allocation of oil in addition to that expressed in cereals/figs. — This would be at variance with the bonuses found in HT 88 and HT 94. Moreover, there would have been a difference between the bonuses paid to the supervisors for the two kinds of labour with which the present text deals. The present solution is the only one in which the supervisors get the same pay as their group of labourers and a fixed bonus in addition.

The recorded amount of wheat-equivalent (millet + figs) corresponds to 2630 khoinikes. The number of recipients is limited to the following possibilities: 325, 327, 329; and the twenty may be thirty or forty; with the other numerals there is less room for conjecture. The order of magnitude of these numbers indicates a record of payment for a period of ten days for groups of people the majority of whom belong to the so-called underpaid categories, receiving only four-fifths of a khoinix of wheat-equivalent per diem.

HT27

face a		face b	
heading		heading	wine + *wa*
(1) L 99	40 [+]	*sa*	7
(2) [A]	50	[	]
(3) L 35	51	[heading]	wheat
(4) entry	[x]	*sa*	1
(5) entry	43	*re*	24
(6) entry	21		wine + *ne*
(7) entry	[y]	[	]
(8) entry	[z]	*re*	[ ]
(9) entry	5	heading	wine + *wa*
(10) L 99	42	*sa*	2
kuro	325 [+]	*re*	60
millet	$9^{11}/_{12}$	[heading]	wheat
figs	12	*sa*	4
wine	7	*re*	[ ] 20

However, it turned out that none of the possible numbers allowed for a reasonable sub-division of the commodities listed. This seemed to be the end of the matter, and a rather unsatisfactory end as well, apparently in contradiction with the systematic data hitherto discovered. The solution, however, was given by the incomplete information of face b), on the assumption that it contained instructions on how to deal with various categories of labour. Obviously, the symbol for wheat was used in that case as a genus denominator for the millet and figs recorded on face a), and this is the reason why the term 'wheat-equivalent' has been introduced above. Below (see Appendix 4) more attention will be paid to such a possible convention.

On the basis of the identification of "*sa*" as "so much" the information contained in the text of face b) is of the following nature:

"heading, commodity, so much, numbers, *re*, numbers"

This suggests that "*re*" indicates the number of allowances of the commodity in question corresponding with the amount thereof listed after "so much". If so, and taking cognizance of the circumstance that the record is for a ten days' payment, the following indications emerge:

Wine, 60 portions of $^4/_{10}$ of a khoinix per diem, gives 240 khoinikes = 2 medimnoi as listed

Wheat equivalent, 24 of $^1/_2$, gives 120 khoinikes (1 medimnos)

Wheat equivalent, 60 of $^4/_5$, gives 480 khoinikes (4 medimnoi)

(N. B. As far as the last item is concerned, one could also read 120 of $^2/_5$, which, however, makes no sense.)[19]

The headings, as far as preserved, are of interest as well; before the entries "wine + *wa*" one finds "*mida*", and "*pase*" respectively. In the train of thought followed, these should describe certain categories of labour. Now these words are not found on face a), and they may therefore represent denominations of a more general nature than the entries on face a). If so, it should be possible to re-group the ten categories listed on face a) on the principle of equality of treatment.

First, however, it is necessary to investigate in what manner the commodities listed may be allocated to the recipients. Here for the first time we meet a phenomenon already known from other areas, including the Linear B records referring to boys and girls, namely that a certain category receives only one-half of a normal per diem allowance of wheat-equivalent. Then there would have been four main categories, as listed in Table Va, of which some comprised various sub-sections, distinguished by the amount of figs in the wheat-equivalent and the different allocations of other commodities.

Two of these categories have come forward from the data presented by face b), one of twenty-four, the other of sixty individuals. This facilitates the solution of the problem presented by face a).

[19] Both wine and wheat should be allocated to the same number (= 60); $^2/_5$ of wheat-equivalent in itself seems odd as well.

Table Va

Main classes of recipients of payment on HT 27

"mida"	lowest (children)	$^1/_2$ wheat-equivalent per diem
"pase"	intermediate	$^4/_5$
	normal	1
	supervisors	bonus of $^1/_3$

Indeed the uncertain total number of recipients leaves little room for manoeuvre, and it will be found that only the following solution is valid:

Table Vb

Rations of the five categories of personnel on HT 27

	number of recipients	khoinikes of wheat-equivalent p.d.		khoinikes of wine p.d.	
(a)	24	$^1/_2$	(= 12)	$^2/_{10}$	(= 4·8)
(b)	240	$^4/_5$	(= 192)	$^2/_{10}$	(= 48)
(c)	60	$^4/_5$	(= 48)	$^4/_{10}$	(= 24)
(d)	5	1	(= 5)	$^6/_{10}$	(= 3)
(e)	6	1	(= 6)	$^7/_{10}$	(= 4·2)
total	335		263		84

It will be seen that the group of 5 is found as item (9) on face a). The group of 6, the only other group receiving normal pay, could be placed in one of the empty places, but probably it is more realistic to accept that each of the rather large groups with sub-normal payment counted one foreman receiving normal pay. If so, there should be six of these groups. This is indeed possible, as indicated in Table VI, in which the ten numbered references correspond with the ten numbered items in the transcription of face a).

The following comment may be given. It appears that there is more than one 'underpaid' category receiving different allocations of wine; the c) category, probably called *"pase"*, obtains double the amount of the other, b), which received only two-tenths of a khoinix per diem, as in the case of the 'underpaid' sub-groups listed in Table III (Lc'5, L 66, *ki*).

The 'underpaid' category b) receiving the single amount of wine comprised inter alia the sub-groups indicated by the ideograms L 35 and L 99. In the record HT 94 these sub-groups received normal pay in the ratio cereals: figs = 3:1 (Part II 18, Table III). It will

Table VI

Possible grouping of labour categories on HT 27

reference number	number of recipients	sub-group denominator
(1)	40^{+a}	L 99
(3)	51	L 35
(4)	43^{-a}	by name
(5)	43	by name
(6)	21	by name
(10)	42	L 99
group b — total	240	
group e	6	foremen to each of preceding sub-groups (if so, (4) should be 49^{-a})
(2)	50	?
(7)	10	by name
group c — total	60	
(8) group a	24	by name
(9) group d	5	by name
Total, groups a—e	335	

therefore be of interest to compare the pay of the same categories according to the different sources. For this purpose it is necessary to find the cereals-figs ratio of HT 27. This is given in Table VII (see also Appendix 6).

Table VII

Ratio cereals-figs for various categories of labour on HT 27

	category	total issue (Table Vb)	division between cereals and figs	implied ratio	wine
(a)	(*mida*)	12	6/ 6	1:1	$^{2}/_{10}$
(b)	(L 35, L 99 etc.)	192	96/96	1:1	$^{2}/_{10}$
(c)	(*pase*)	48	12/36	1:3	$^{4}/_{10}$
(d)	(*saradi*)	5	2/ 3	2:3	$^{6}/_{10}$
(e)	(foremen)	6	3/ 3	1:1	$^{7}/_{10}$

From the above it will be apparent that, by comparison with the treatment of L 35 and L 99 on HT 94, not only is the total amount of cereals and figs per diem reduced by one-fifth of a khoinix, but also the ratio between those two commodities is changed. Such different treatment of identical people would seem to point to different conditions of employment, perhaps according as they were working or not; though in other cases the same categories have proved to receive identical treatment on separate records (L 66 and Lc 125 on Part II Table III). Another explanation can be ruled out by calculation, namely that the group had been compensated by a double issue of wine. Such an assumption would mean that the value of wine corresponded to the difference in value between millet (or wheat) and figs, which makes no sense.

Unless more data come to light, we shall have to live with this oddity.

This review of the *sara*$_2$ texts mentioning liquid commodities may be concluded by analysing HT 28, a record in almost perfect condition as far as the text is concerned, but of a most intricate nature. However, two fresh clues have made it possible to break this complex puzzle; the first involves the variety of oils in somewhat

HT 28

face a				
anejaka	*uminane*			
sara$_2$	wheat 20,	oil + *di* 5,	figs 2,	wine 4
pura$_2$			figs 6	
ja L 48				wine 6
widina		oil + *di* 3		wine 4*, L 44[?]
face b				
anejaka				
ja L 48	wheat + *k*^{w}*e* 5,	oil + *ro* 2		
		oil + *ki* $^1/_4$		
		oil + *mi* 1		
		oil + *di* $^1/_{30}$		
sara$_2$		oil + *di* 1,	figs 2,	wine 3
Lc 55				wine 6
arudara	wheat 5, barley 2,	oil + *di* 3		
notanu		oil + *di* 10		

* the last digit has been eroded.

odd amounts on face b); the second, the addition of barley at the end of the same face. The first clue narrowed the choice of the number of pay-days to two possibilities, of which only one (twelve days) fitted some of the other data.

The second clue is of the same kind as that already mentioned in the analysis of HT 90 (p. 36); barley was not allocated to the hired labour but to those belonging to the palace administration whom we styled 'supervisors'.

Table VIII gives the allocations per diem, expressed in khoinikes for the commodities wheat, barley, figs and wine, and in kyathoi for olive oil.

Table VIII

Per diem allocations following from HT 28
(all in khoinikes, but for olive oil in kyathoi)

(1)	wheat 200,	oil + *di* 300,	figs 20,	wine 40
(2)			figs 60	
(3)				wine 60
(4)		oil + *di* 180		wine 40, L 44 (?)
(5)	wheat + *kʷe* 50,	oil + *ro* 120		
(6)		oil + *ki* 15		
(7)		oil + *mi* 60		
(8)		oil + *di* 2		
(9)		oil + *di* 60,	figs 20,	wine 30
(10)				wine 60
(11)	wheat 50, barley 20,	oil + *di* 180		
(12)		oil + *di* 600		

A start should be made by considering sections (5) to (8), with respect to which two circumstances should be taken into account. First, that sector is preceded by a word, "*ja* L 48", which also precedes (3). The amount of wine mentioned after (3) may therefore be intended to be joined (partly) to the sector under consideration. Second, the enumeration of commodities starts with "wheat + *kʷe*" instead of "wheat"; in connection with this I read therefore "wheat-equivalent". Such an entry does not indicate in what way the wheat-equivalent should be made up from its constituents, and would therefore be insufficient, unless, as seems to be the case, the various entries are interconnected and the necessary information follows from such further entries. The observation that only (2) and (9) mention figs, but no wheat, can be similarly explained; admittedly

HT 88 records a distribution of figs only, but in no case has it been found that, if wheat or 'millet' is mentioned next to figs, any labourer-recipient was paid in the latter commodity only. These considerations lead to the assumption that the entry (1) is the main 'reservoir', not only for paying those groups of personnel included under the entry *uminane*, but also for providing a balance for transfer to groups involved later in the account.

This has led to the following break-down of the record. Entry (1) lists 20 of figs. Together with the same amount of wheat, this would suffice for 50 people of the 'underpáid' category[20] who receive two-fifths of both per diem. We have seen (Tables II and III, above) that such people receive also two-tenths of a khoinix of wine and 2 kyathoi of oil per diem; in this case therefore 10 of wine and 100 of oil would be needed. The balance then is 180 of wheat, 200 of oil and 30 of wine. The next item adds 60 of figs, which for distribution purposes would require to be combined with a certain amount of wheat. However, as the 'reservoir' had also to be used for the entries of face b), starting from (5), those must be taken into account before considering what further groups are covered on face a).

Passing on then to face b), it must straightway be observed that the first group of entries differs from the first on face a).. In fact, judged from the headings, the system is as follows.

face a	*anejaka*				
		uminane			
			sara$_2$		commodities
			pura$_2$		commodities
		ja L 48			commodities
				widina	commodities
face b	*anejaka*				
		ja L 48			commodities
			sara$_2$		commodities
	Lc 55				commodities
		arudara			commodities
	notanu				commodities

According to this there are three groups, identified by the words "*uminane*", "*ja* L 48", and "*arudara*". Both face a) and face b) end with a final consideration, viz. "*widina*" and "*notanu*". "*Pura*$_2$" is a form like "*sara*$_2$", both comprising two 'words'. If the second

[20] It seems to be a convention to deal first with that category.

means "so much to pay", then the first should logically be understood as "additionally to pay". That "*pu*" is a separate 'word', follows also from HT 14, where it precedes the ideogram for wine[21].

The consequence of the system could be that part of the amount of wine mentioned after "*ja* L 48" on face a) is to be reserved for the "*anejaka*" of "*ja* L 48" on face b), which is about to be analysed, starting from (11). As has already been remarked, the allowance of barley points to the possibility that we are confronted with the pay of 'supervisors' receiving a bonus of one-third of a khoinix of wheat, or double that amount of barley, per diem. The amounts mentioned lead to the following simple solution (see also Appendix 5).

arudara: 30 (Lc 55) of 1 wheat + 4 oil + (bonus) of $^1/_3$ wheat
15 of $^2/_3$ wheat + $^2/_3$ barley + 4 oil + (bonus) of $^2/_3$ barley

total:	wheat	30 + 10 + 10 =	50
	barley	10 + 10 =	20
	oil	120 + 60 =	180

Obviously, the group was also entitled to an allowance of wine, for wine is apparently listed for the other groups. The preceding entry (10) reads "Lc 55, wine 60", which is far too much for forty-five individuals. Moreover, Lc 55 represents a specific kind of labour which is also found on HT 100, whereas the group of (11) consists of two distinct categories. The solution seems to be that (10), "60 wine for the Lc 55 people", refers at the same time backwards and forwards as an aid to the calculations made by the scribe; at that particular moment he recalls the information just quoted as a check of where he stands with the distribution. We do not know as yet the preceding number of the Lc 55 people, but have to keep them in mind.

The first part of face b), entries (5)—(9), first lists 50 wheat-equivalents which should have been carried forward from entries (1) and (2) of face a), and follows with a *sara*$_2$-list with, inter alia, additional figs. The "*arudara*" part has barley for the first time, and should be considered as a separate sub-account. This would indicate that the distribution given on face a), in addition to the twenty khoinikes of wheat and the same amount of figs for the fifty 'underpaid' people, involves 180 wheat (= 200 — 20 just quoted) + 60 figs — 50 wheat-equivalents = 190 wheat-equivalents.

[21] In that text the reading could be "additional to wine", since that heading is followed by an enumeration of commodities not comprising wine.

Now face b) starts with an enumeration of various amounts of oil, which seems to indicate that all oil mentioned on face a) had already been accounted for. The amount left after deduction of the one hundred kyathoi for the underpaid is 380 of such units, exactly the double of the wheat-equivalents just mentioned. So the following distribution is indicated: 190 individuals each with 1 khoinix of wheat-equivalent and two kyathoi of olive oil. The amount of olive oil is too low when considering (11) (also Tables III and IV), which points to the significance of (12) as an account of the aggregate deficit or saving[22]; to this further reference will be made later. The detailed composition of the group of 190 can only be deduced if we can find the composition of the wheat-equivalents as distributed on face b).

The allocation recorded for "*ja* L 48" on face b) leads to the solution given in Table IX, the only one which has proved to make sense of the complete text.

Table IX

Allocation for "ja L 48" of HT 28b

number of individuals in each group	wheat in khoinikes per diem	figs in khoinikes per diem	oil + *ro*	oil + *mi*	oil + *ki* in kyathoi per diem	oil + *di*
entries 40	$^4/_5$	$^1/_5$	3 + 1			
(5)—(8) 4	$^3/_5$	$^2/_5$		4		
5	$^3/_5$	$^2/_5$			3	
1	$^3/_5$	$^2/_5$		4		2
sub-total*	38	12	120	60	15	2
entry (9) 20	$^4/_5$	$^1/_5$				3
sub-total	16	4				60
grand total	54	16				60**
balance from face a)	54	—4				0

* It will be appreciated that 38 of wheat and 12 of figs make up the 50 wheat-equivalents of entry (5).

** oil + *di* from three lines above not included as the account of entries (5)—(8) is self-contained but for wheat and figs.

[22] A similar entry has been found on HT 94.

This would disclose that the 190 individuals on face a) receive 126 khoinikes of wheat (= 180−54), 64 khoinikes of figs (60 + 4), which together make up the 190 wheat-equivalents already mentioned, and 380 kyathoi of olive oil (380−0), leading to the pattern of distribution presented in Table X in which the rations of wine have not as yet been included (see Appendix 7).

Table X

Allocation for "uminane" of HT 28

		number of individuals in each group	wheat in khoinikes per diem	figs in khoinikes per diem	olive oil in kyathoi per diem
		50	$^2/_5$	$^2/_5$	2
		30 (= Lc 55)	1		2
		160	$^3/_5$	$^2/_5$	2
	sub-total		146	84	480
to face b)	−Table IX		54	−4	—
	grand total		200	80	480
entry (1)	*sara*$_2$		200	20	300
entry (2)				60	
entry (4)	*widina*				180
	total		200	80	480

We may now proceed to consider the amount of oil + *di* "saved" according to entry (12) which lists 600 kyathoi. It may be taken that the normal ration is 4 kyathoi per diem (cf. Tables III and IV, above). Then the saving corresponding to the data contained in Table X comes to $30 \times 2 + 160 \times 2 = 380$, leaving 220 of the 600. In Table IX the group of 20 of entry (9) received 60 instead of 80, therefore 20 short. The remaining 200 should be found in the entries (5) – (8) and this section has replaced 195 kyathoi of oil + *di* by other brands of olive oil. In addition a group of five has received 15 instead of 20, which adds another 5 to the 195, making the total of 200 we were looking for.

Presently it will be necessary to allocate the listed amounts of wine. We have assumed already (p. 43) that the sixty khoinikes listed after "*ja* L 48" in entry (3) were carried over to face b). There another allowance of thirty khoinikes is made after *sara*$_2$ in entry (9). We have also seen (p. 45) that entry (10), "Lc 55, wine 60"

may refer to the total available for that category of labour. This category appears to consist of two groups, each of thirty individuals, whose basic ration comprised only wheat; the first group was covered by the entry *"uminane"* of face a) (Table X), the second by *"arudara"* on face b) (see the analysis on p. 45). It stands to reason that these sixty Lc 55 individuals obtained one khoinix per diem. This would account for sixty khoinikes, and the text may therefore be analysed as follows:

Line (1) lists inter alia 40 of wine, 10 of which were distributed to the fifty people of the 'underpaid category', while the balance, of 30 khoinikes, was given to the thirty Lc 55 people.

Line (3) lists 60 of wine under the reference *"ja* L 48", which are to be distributed according to face b).

Line (4) has an additional item of 40 of wine distributed to the 160 people who (cf. Table X) receive three-fifths of a khoinix of wheat and two-fifths of a khoinix of figs.

Face b) should be considered with the mental reservation of the carry-over of 60 of wine from face a).

Line (9) lists again 30 of wine, making a total to be distributed of 90 khoinikes.

Line (10) is then a reminder that the Lc 55 people are to be given 60 khoinikes, i. e. 30 on face a) (see line (1) above) and 30 to the *arudara* denomination in the next line. Therefore the others whose allowances are recorded on face b) should receive 60 khoinikes.

In the above it has also been assumed that the 160 people referred to in Table X receive forty khoinikes of wine, which makes for a daily allowance of one quarter of a khoinix, an amount not found in any record previously analysed. In every case the amounts allocated per person and per diem were always expressible in tenths of a khoinix. However, in the present case the pertinent entry, (4), has another item following, for which Brice reads L 44. This item resembles the Linear B ideogram *134, for which Palmer[23] proposed to read linseed oil, notwithstanding the observation made by Bennett[24] that in the HT records that symbol either precedes

[23] Op. cit. 9, 274

[24] E. L. Bennett Jr., Trans. Amer. Philos. Soc. 48, 1958, 101

or follows the wine ideogram. It seems evident that in the present case the odd amount of wine points to a shortage which was made good by the additional distribution of the commodity represented by L 44. This may point to its identity as vinegar, a common substitute beverage in antiquity.

Obviously, as in other cases, the allocation of wine increases with rising status, as indicated by the amount of wheat in the pay-package. Thus on face a) we have found three categories receiving respectively 0.2, 0.25 plus an amount of vinegar, and 1 khoinix per diem.

On face b) the distribution is recorded (cf. Table IX) to 40 + 20 individuals who receive $^4/_5$ of a khoinix of wheat and $^1/_5$ of figs per diem, and who thus belong to a category intermediate between the last two of face a). In addition, there are 10 people of the same category as the 160 individuals of face a), but no vinegar is recorded here. Presently we will assume that the pay of this category included 0.3 or 0.4 of a khoinix of wine per diem.

Finally face b) deals with the wine for the *arudara* (supervisor) category. Thirty thereof, belonging to the Lc 48 type, receive, as on face a), one khoinix per diem. The other fifteen should of necessity fall into two groups similar to the two, of respectively sixty and ten people, which they are supposed to supervise. If we take nine individuals in one and six in the other group and allocate 0.8 of a khoinix to those of the first and 0.3 to those of the second group, the total comes to the sixty khoinikes available for distribution, as follows:

60 + 9 at 0.8 makes 55.2 khoinikes
10 + 6 at 0.3 makes 4.8 khoinikes
aggregate = 60 khoinikes

However, it is somewhat unsatisfactory that a group of ten labourers should be supervised by another six; in addition there is the question of the group of sixty labourers, which is dealt with in two separate parts of the text. The fact that one part thereof, forty people, receive the normal amount of oil, viz. four kyathoi per diem, and the other group of twenty receive one less, may be the reason for the separate grouping, but such different treatment could well be reflected in the allocation of wine too. On that assumption, and maintaining the equal treatment of the group of ten with the equivalent group of 160 of face a), a more satisfactory solution is presented in Table XI. It will be seen that the special

category, consisting of one single man only (cf. Table IX), which received in addition to the normal allocation of four kyathoi of oil per diem an extra of two of those units of the quality "oil + *di*", which was to be saved, as followed from line (12), finds itself without wine in Table XI. The corresponding supervisor receives the normal allocation of both oil and wine.

Table XI

HT 28

Distribution to the "ja L 48" group and supervisors

number of individuals in a group	wheat in khoinikes per diem	figs in khoinikes per diem	barley in khoinikes per diem	olive oil in kyathoi per diem	wine in khoinikes per diem	total wine
40	$^4/_5$	$^1/_5$		4	0.8	32
8*	$^2/_3$		$^4/_3$	4	0.8	6.4
20	$^4/_5$	$^1/_5$		3	0.7	14
4*	$^2/_3$		$^4/_3$	4	0.7	2.8
1	$^3/_5$	$^2/_5$		6	nil	—
1*	$^2/_3$		$^4/_3$	4	0.4	0.4
4	$^3/_5$	$^2/_5$		4	0.4	1.6
1*	$^2/_3$		$^4/_3$	4	0.4	0.4
5	$^3/_5$	$^2/_5$		3	0.4	2
1*	$^2/_3$		$^4/_3$	4	0.4	0.4
Aggregate						60

* Supervisors to preceding category

If the solution here presented is indeed a correct reconstruction, some interesting points arise. Apparently it was possible to swop wine for oil in the ratio of two kyathoi of oil against eight kyathoi of wine, in other words oil was four times as expensive as wine. As in HT 116, all kinds of oil, including the variety indicated as "oil + *di*", could be added, the various sorts not being distinguished by price. On HT 28 the supervisors received the *di* variety of oil exclusively, though they did not according to the account of HT 90; perhaps they were given the choice. It is also of some interest that three-eighths of the amount of wine due to the group of 160 people of face a) were replaced by vinegar. Since it can hardly

be assumed that this was due to individual preference, distinction by group, for example owing to work in hot circumstances, could be the explanation.

Also of interest is the distribution of the supervisors; on face b) one such supervisor is allocated to each group comprising five or less labourers. Turning to face a), as indicated in Table XII, it will be noted that here are thirty supervisors of equal pay for a total of 240 people, or one for each group of eight. Apparently such was a mixed group, and that might be the reason why the pay of the supervisors, apart from their bonus of $^1/_3$ khoinix of wheat, was equal to that of the best-paid labourers in the group. This is a phenomenon we have not met before.

Table XII

HT 28

Distribution to the "uminane" group and supervisors

number of individuals in a group	wheat in khoinikes per diem	figs	olive oil in kyathoi per diem	wine in khoinikes per diem	vinegar
30	1		2	1	
30 (supervisors)	$^4/_3$		4	1	
160	$^3/_5$	$^2/_5$	2	0.25	[ ]
50	$^2/_5$	$^2/_5$	2	0.2	

V. The subdivision of the metretes

Now the argument of Section III may be pursued, since the existence and size of the main unit and of the lowest sub-unit have been substantiated by their appropriate functioning when applied to the texts. The existence and capacity of sub-units, intermediate between the metretes and the kyathos, can only be deduced by reference to numerical fractions in the texts dealing with olive oil. The indications are far less complete than in the case of dry measure, where the convention of ligaturing commodity ideograms with numerical fraction symbols is so helpful[25].

The evidence is given in Table XIII.

[25] cf. previous report

Item	Entry	Personnel (inferred)	Wheat	Barley	Oil *to*	Oil *ki*	Oil *mi*	Oil *di*	Figs	Wine	Vinegar	Significance of Entry
	anejaka											General heading
	uminane											Category 1
1	*sara*$_2$	*50* (Underpd.) *30* (Lc 55) *160*	*20* *30* *96* (54) } 200					*100* *60* *320* } 300 +	*20* *64* } 20	*10* *30** *40* = } 40		'So much to pay'
2	*pura*$_2$								60 +			'Additionally to pay'
3	*ja* L 48									(60)		Category 2 *(item carried forward)*
4	*widina*							(180)		(40)	(?)	Extra due to *'uminane sara*$_2$ *160'* category
	anejaka											General heading—repeated
5-8	*ja* L 48	*50* { *40* *4* *5* *1*	*32* # *2 2/5* # *3* # *3/5* # } 50#		120	15	*40* *16* *4* } 60	2	*8* # *1 3/5* # *2* # *2/5* #	*32* *1·6* *2*		Category 2 (50# = 'wheat equivalent' referring to # items)
9	*sara*$_2$	*20*	*16*					60	*4* (4) } 20	*14*	30⊕	'So much to pay'
10	Lc 55										[60*]	[Reminder on Lc 55 wine payments*]
11	*arudara*	*30* (Lc 55) *15*	*40* *10* } 50	20				*120* *60* } 180		*30** *10·4*		Category 3
12	*notanu*							600				'Saving'

N. B. a) ⊕ 30 Wine (Item 9) + 60 carried forward = 90 for distribution to categories 2 and 3.
b) Items ringed ◯ are referred elsewhere ⌒▲ for allocation.
c) Only the statistics in **heavy type** are directly deduced from the record on the tablet. All others are inferred, and drawn in *italics*.

Figure 1 summarises in tabular form the conclusions reached about the structure of the account recorded on HT 28.

Table XIII

Olive oil recorded in fractions of the main unit

text	fraction	text	fraction
HT 8	$^1/_4$	HT 91	$^1/_{12}$
HT 23	$^7/_{12}$	HT 100	$^7/_{12}$, $^3/_4$
HT 28	$^1/_4$, $^1/_{30}$	HT 125	$^1/_5$
HT 30	$^1/_5$, $^2/_5$	HT 139	$^1/_4$
HT 32	$^{11}/_{24}$	IV 9	$^1/_6$, $^1/_2$, $^1/_5$
HT 35	$^1/_{12}$	IV 14	$^{60}/_{120}$
HT 50	$^1/_2$		

The last text listed, IV 14, proves the existence of a sub-unit with a capacity of $^1/_{120}$ of the metretes, and comprising six kyathoi. In accordance with the nomenclature used in this series, that unit must be identified as the kotyla. Assuming, for the sake of argument, that the khoos also existed, as at Mallia, all the fractions can easily be expressed in khowes and kotylai, as demonstrated in Table XIV.

Table XIV

Amounts of olive oil expressed in sub-units

fractions of metretes from Table XIII	number of khowes		number of kotylai
$^1/_4$	3		
$^1/_2$	6		
$^3/_4$	9		
$^1/_5$	2	+	4
$^2/_5$	4	+	8
$^1/_{12}$	1		
$^1/_6$	2		
$^7/_{24}$	7		
$^{11}/_{24}$	5	+	5
$^1/_{30}$			4

The fractions which cannot be solely expressed in whole numbers of khowes occur, with one exception only[26], on *sara*$_2$ texts which,

[26] The Tylissos tablet IV 9

by their very nature, require such broken figures, due to the number of labourers involved and their per diem allowances. Hence the existence of a khoos, although not proved, becomes highly likely.

Table XV shows the resulting system in comparison with other systems.

Table XV

Systems for the measurement of liquids

Classical	Metretes	= 12 khowes	= 144 kotylai	864 kyathoi
Linear B	Half metretes	= 3 double knowes	= 18 khoinikes	73 kotylai
Linear A	Metretes	= 12 khowes	= 120 kotylai	720 kyathoi
Hieroglyphic	Metretes	= 8 khowes	=	480 kyathoi

As the capacity of the kyathoi in the various systems is identical, the classical kotyle is also equal to the Linear A kotyla; but the unit has not been established for the hieroglyphic system. The khoinix of Linear B is an anomaly as it belongs to the system for dry measure; the upper two units in the Linear B system are also somewhat out of line, considering the parallelism of the three other systems. A comparison of capacities is shown in Table XVI.

Table XVI

Capacities of units for liquid measure

Capacity in khoinikes	Hierogl. system	Linear A system	Linear B system	Classical system	Multiples
$^1/_{20}$	kyathos	kyathos		kyathos	1
$^1/_4$			kotyla		5
$^3/_{10}$	?	kotyla		kotyle	6
1			khoinix		20
3	khoos	khoos?			60
3.6				khoos	72
6			double-khoos		120
18			half-metretes		360
24	metretes				480
36		metretes			720
43.2				metretes	864

Within the as yet unidentified commodity ideograms a variety of other liquids, like the vinegar which may have been represented by L 44, might be hidden. As further examples, judging from their positions in the various types of enumeration, the following might be taken into consideration: Lc 13, Lc 50 (both connected with the 'vinegar' ideogram), Lc'1, Lc 48, and Lc'2 (varieties of the same commodity, in the last case mixed with olive oil). It cannot be proved that these are liquid commodities; but, assuming that they were, the fractions recorded are of the same calibre as those presented in Table XIII; in other words, the volumetric amounts recorded for these products would, again with the exception of those amounts recorded in *sara*$_2$-lists[27], fit into the system for liquid measures as now established.

VI. Summary

Analysis of a number of *sara*$_2$-lists has demonstrated the use in Linear A of a system for the measurement of liquid commodities based on a main unit which relates in capacity to that used for dry measure in a ratio of three to ten. This metretes comprised 120 kotylai, just as the medimnos comprised 120 khoinikes. The kotyla was subdivided into 6 kyathoi, the capacity of which, like that of the kotyla, was equal to its classical equivalent.

Although the evidence is not conclusive, it appears likely that the metretes was initially subdivided into 12 khowes.

This system was primarily used for the measurement of olive oil, and perhaps for other similar liquids. Wine, however, was recorded in the larger unit of the dry system, although in the distribution of wine to labourers use was made of the kyathos.

The daily allowances for labour appear to have comprised from 4 to 20 kyathoi of wine and 2 to 4 (or exceptionally 6) such units of olive oil, in addition to the per diem payment in cereals and figs. In one case the wine was partly replaced by the commodity L 44, probably vinegar.

Table XVII presents the data on the payment of labour; supervisors received, in addition to the same pay as the category to which they were assigned, a bonus of one-third of cereals and/or figs, sometimes in the form of barley which, being of half value, was issued in double quantity.

[27] HT 30 and HT 32 show amounts which, when expressed in khowes, would require the notations 2.4, 4.8 and 2.5.

Table XVII

Summary of per diem payment of labourers

Category	cereals	figs	wine	olive oil	L'2	L44	Evidence
	in khoinikes		in kyathoi				
mida	1/4	1/4	4				HT 27[4]
pase[1]	1/5	3/5	8				HT 27[4]
L 35, L 99[2]	2/5	2/5	4				HT 27[4]
Lc'5, L 66, ki, (—)[3]	2/5	2/5	4	2			HT 28, HT 100
saradi	2/5	3/5	12				HT 27[4]
(—)	1/2	1/2	—	3	12		HT 114, HT 121
(—)	1/2	1/2	14				HT 27[4]
(—)	2/3	1/3		—			HT 90[5]
(—)	2/3	1/3		4			HT 90[5]
(—)	3/5	2/5	5	2 (4)*		?	HT 28
(—)	3/5	2/5	8	3 (4)*			HT 28
(—)	3/5	2/5	8	4			HT 28
Lc 55	3/5	2/5	6	5			HT 100
(—)	3/5	2/5	—	6			HT 28
(—)	4/5	1/5	14	3 (4)*			HT 28
(—)	4/5	1/5	16	4			HT 28
sadi	9/10	1/10	6	4			HT 100
L 125	1	—	10	6			HT 100
(—)	1	—	20	2 (4)*			HT 28
(—)	1	—	20	4	4		HT 114, HT 121

Legenda: [1] comprising *kidaro*
[2] also *nomisara*
[3] (—): undisclosed
[4] no oil listed
[5] no wine listed
* entitled to figures in brackets, on the evidence of the text

Although different levels of payment are clearly attested, it is quite possible that contractual freedom is responsible for some of the more detailed variations in the pay package.

VII. Appendices

1. In Section II it has been found that two categories of labour received per diem one-fifth and three-fifths respectively of a unit of the commodity L'2. These fractions demonstrate that this

commodity was measured by the khoinix ($^1/_5$ and $^3/_5$ kotyla make no sense), and that the allowances, like those of wine, were calculated in kyathoi per diem, in this case four and twelve respectively.

2. A study of the payment on Table XVII may provide enlightenment on the price structure of the commodities listed. However, additional evidence with regard to relationships of price will be necessary if this issue is to be solved. The lack of such evidence is also the reason why some *sara*$_2$-lists have not been analysed (e. g. HT 30), as they involve too many commodities which may or may not replace others.
3. One of the labour categories is identified by *pase*; it comprises at least two sub-categories of which one can be identified as *kidaro*. Remarkably enough, the word *pase* also occurs next to a *sara*$_2$-list on HT 18, and the *pase*-list mentions barley which (cf. Summary) would indicate the bonuses payable to the supervisors. This, however, makes no sense with respect to the amount of oil listed. The only solution seems to be to accept that the *pase* category did not belong to the category of hired labour, but to the palace staff receiving, like the supervisors, barley instead of wheat. *Paseja* followed by the labour ideogram, L 99, occurs on HT 93, and also on the roundels Cr IV 15 and 16. As the relation between the two words is still obscure and HT 93 is far too complex to be solved by the method used in this report, HT 18 also cannot be fully understood.
4. Reference has been made to the notion of 'wheat-equivalent' used in calculations of the aggregate of wheat and figs (see HT 27 above). HT 18 has "wheat + *k*^{w}*e* 20" and, on the accompanying *sara*$_2$-list, "wheat 10, figs 10". Similarly, HT 28 uses "wheat + *k*^{w}*e*", which also refers to such an equivalent. The symbol Lc 3 is also found on HT 36, HT 99 (a damaged *sara*$_2$-list) and on HT 101 in a position comparable to that on HT 18. In the last case the reference "wheat + *k*^{w}*e* 40" is substantiated by "wheat 40" on the *sara*$_2$-list. "Oil + *di* + *k*^{w}*e*" (Lc 28) occurs, preceding the *sara*$_2$-list, on HT 121, and that list mentions the additional commodity L'2. The 'millet' ideogram, L 71, is also ligatured with *k*^{w}*e*, Lc'6, on Cr IV 4. All this may suggest that *k*^{w}*e* (L 91) is an abbreviation for the idea of equivalency[28]. It remains to be

[28] J. T. Hooker, Non-Greek Elements in the Linear B Tablets, Indog. Forsch., 73, 1968, 67—86, on the function of *-que*

seen whether the use of the symbol as a ligature in Lc 58, Lc 60 and Lc 67 refers to the same idea.

5. Solutions other than that given in the text for the distribution of the commodities listed in line (11) after *arudara* on HT 28 are mathematically possible and have been tried. However, none fitted the other data, and in particular the datum about the amount of wine due to the Lc 55 category indicated in line (10). The most ambitious was an attempt to correlate in a fixed ratio the number of supervisors remunerated in line (11) with the various groups of personnel found. The following data may illustrate that such attempts lead to unsatisfactory results.

supervisors	supervised	wheat	barley	=	wheat	barley
5	for 50	$^{2}/_{5}$	$^{4}/_{5}$	=	$^{10}/_{5}$	$^{20}/_{5}$
17	for 170	$^{3}/_{5}$	$^{4}/_{5}$		$^{51}/_{5}$	$^{68}/_{5}$
6	for 60	$^{4}/_{5}$	$^{2}/_{5}$		$^{24}/_{5}$	$^{12}/_{5}$
(Lc 55) 3	for 30	$^{5}/_{5}$			$^{15}/_{5}$	
31					20	20
31 bonuses at $^{1}/_{3}$ wheat					$10^{1}/_{3}$	
available					50	20
residue					$19^{2}/_{3}$	
(Lc 55) 2	for 17	1			17	
		$1^{1}/_{3}$			$2^{2}/_{3}$	

The total number of Lc 55 people and supervisors assigned to that category would then be 30 + 3 + 17 + 2 = 52. They have to divide sixty khoinikes of wine among themselves, an improbable situation. A similar situation occurs if the number of the Lc 55 category is set at 13 instead of 17; in that case a total of 51 recipients should receive the 60 khoinikes. Only if we set the number of supervisors at 8, and that of those being supervised at 9, would each recipient receive the round number of 24 kyathoi. However, and this holds for the two previous cases as well, the relation between the two categories is too odd to be acceptable.

6. The calculation of the cereals-figs ratio of HT 27 (cf. Table VII) is to be based on a single equation with five unknown factors, therefore not solvable mathematically. However, the trial and error method is facilitated if one reduces the number of people receiving less than a khoinix per diem to the lesser numbers corresponding with full payment, so that the following emerges:

$$12a + 192b + 48c + 5d + 6e = 119,$$

in which the letters indicate the amount of millet expressed in khoinikes (figs would then come to 1—a, etcetera).

All numerals can be divided by a factor of 3, with the exception of 5d and the sum of 119. If one sets d at $^2/_5$, the other categories receive an aggregate of 117, also divisible by the same factor. The equation is then reduced to

$$4a + 64b + 16c + 2e = 39,$$

number of people 86.

If $a=b=c=e=^1/_2$ the aggregate would be 43, which differs from the actual sum by 4, pointing to $c=^1/_4$ and $a=b=e=^1/_2$.

7. The problem involved in the calculation of the groups of individuals of face a) of HT 28 (cf. Table X) is the allocation of 126 khoinikes of wheat and 64 of figs to two groups together numbering 190 people.

One of those groups is later, in entry (9), referred to with regard to the amount of wine which that category (Lc 55) should receive, and this may be significant for their relatively high status. Payment exclusively in wheat, as in the case of the first *arudara* group of 30 individuals, may be appropriate.

Then two other solutions of the equation are feasible

a) 110 people à 1 wheat
   80 people à $^1/_5$ wheat + $^4/_5$ figs

b) 94 people à 1 wheat
   96 people à $^1/_3$ wheat + $^2/_3$ figs

None of these possibilities have been retained, as they imply that people at full pay would receive a lesser allocation of wheat than the group of 50 individuals, which constitutes an 'underpaid category'.

Errata

In Part II of this series (Kadmos 11, 1972): p. 11, third entry of HT 89: for Lc'58 read Lc 58. p. 16, penultimate line: for "two days' pay" read "eight days' pay". p. 18, l. 12: for Lc 126 read L 126, ll. 19, 24: for Lc 125 read L 125, l. 28: for HT 89 read HT 88.

In Figure 1 (p. 52), at the head of the first oil column, for *to* read *ro*.