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SOME PUZZLES ABOUT MINOAN WOOLGATHERING

Dr. J. T. Killen has recently offered what he suggests is "a plausible solution to a long-standing problem, the source of the wealth of Knossos in the Late Bronze Age"[1]. His approach is imaginative, and some of his results are attractive at first sight. But, on more detailed examination of all the relevant tablets as most recently edited[2], some of his assumptions and conclusions give rise to considerable doubt.

Killen is certainly right in rejecting the conclusion by Ventris and Chadwick[3] that the Series D tablets from Knossos are "a record of tribute imposed on his subjects by the overlord [of Crete]". Killen remarks: "Not, indeed, that it is with much regret that we abandon a view of the purpose of the D records which involves belief that the inhabitants of Mycenaean Crete were required to supply something approaching 100,000 animals to the palace every year." He notes that the latest modern figure, in 1956, for the sheep population of Crete was 529,910, and comments: "... it is extremely difficult to imagine that tribute of anything like 100,000 animals a year could have been extracted by the palace"[4].

Killen's paper was based on KT ed. 2 (1959), by Emmett L. Bennett, John Chadwick, and Michael Ventris, revised by Chadwick and Fred W. Householder. The third edition differs importantly in the classification of tablets relating supposedly to sheep in the D series. The original classification was made by Bennett before Ventris advanced his theory for the decipherment of Linear B texts, and was based on ideograms, recurrent groups of signs, format, and scribal hands. In the preface to KT ed. 3 Chadwick and Killen remark that "a future edition will have to make some drastic changes in classification". They think it desirable "that letter-classes should, as far as possible, coincide with sets of docu-

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[1] "The Wool Industry of Crete in the Late Bronze Age", The Annual of the British School at Athens, 59, 1964, 1—15

[2] John Chadwick and J. T. Killen, The Knossos Tablets, third edition, London, 1964, = KT ed. 3

[3] M. Ventris and J. Chadwick, Documents in Mycenaean Greek, Cambridge, 1956, = Docs., p. 197 ff.   [4] p. 5, and note 23

ments written at one time and filed together". This ideal is far from being realised, and we must keep in mind that we are not dealing, in the Dk or Dl groups of tablets with which Killen is mainly concerned, with the actual files of a group of administrators dealing with flocks. From KT ed. 2 to ed. 3 one notes that 14 tablets have been shifted out of the Dl group, and 28 others have been added to it.

Killen's thesis is that the D series tablets are records of flock management, containing an account of the animals themselves, and of their production, with the targets aimed at, in lambs and wool, and the extent of deficiencies, if any. He accepts the Ventris scheme of decipherment, and the evaluation of ideograms for RAM, EWE, and so forth. He believes that the ideogram RAM may be used for a true ram, i. e. an uncastrated adult male sheep, or for a wether, i. e. a castrated adult male sheep, or, in general, for any sheep of any age or sexual status. KT ed. 3 follows the 1961 Wingspread convention of writing OVIS^m for RAM, and OVIS^f for EWE, which seems cumbrous; and I prefer to follow Killen's article in using the English terms.

Killen accepts the evaluation of the WOOL UNIT, or LANA, as equal to approximately 3 kilograms, or roughly 6.4 pounds (lbs.); and the division of the wool unit into thirds, called LB in KT ed. 2, and M in KT ed. 3.

Killen notes the prefix *ki* before the RAM ideogram, and thinks that it denotes a "young animal of either sex". In plain English a *ki* RAM would be called a lamb. Killen accepts, too, the Ventris-Chadwick belief that the sign transcribed *o.* may be an abbreviation signifying 'deficit'.

Killen writes: "The Dk and Dl tablets record both sheep and wool, and there is invariably a fixed ratio between the number of sheep and the amount of wool listed. On the Dl texts, this ratio is normally ten sheep: one wool unit, on the Dk texts four sheep: one wool unit"[5]. Unfortunately, detailed study of the tablets does not bear out Killen's assertion that "there is invariably a fixed ratio between the number of sheep and the amount of wool listed". A variety of ratios is found, and there is a further question whether account should be taken of sheep and/or of wool to which is prefixed the sign transcribed *o.*, said to signify that they are in deficit.

Killen calculates in regard to the Dl texts on the basis of including ewes and lambs, whether actually present in the flock or

[5] op. cit. p. 4

in deficit, and so presumably absent, whether by being dead, or, if lambs, not yet born. Professor L. R. Palmer, however, argues that ". . . the immature lambs were unlikely to have contributed anything to the wool crop"[6]. He thinks that the 'Mycenaeans' had two crops of lambs, such as the two crops Columella mentions in connection with Roman husbandry; and suggests that the beginning of the Mycenaean calendar year fell between the two crops of lambs.

According to Columella the first mating of sheep took place in the third week of April. Allowing 21 weeks for gestation, the first crop of lambs would appear about September 9 to 16. Columella's second mating took place about July, which, from matings on July 15, would yield a second lamb crop from December 8. Thus, if Palmer is right, the Mycenaean year would begin between September 16 and December 8.

Palmer believes that the census recorded in the tablets took place in the spring before the flocks moved off to their summer grazing grounds[7]. If so, and if the date for moving were about May 15, then the September lambs would be aged about 8 months old, and the December lambs about 5 months. Would the ancient Cretans take a wool clip off such lambs, of which the older would be "last year's", and the younger "this year's", according to the theory of Palmer? Dr Konstantinos D. Ktistopoulos very kindly made some inquiries on my behalf from the Greek Ministry of Agriculture in Athens, concerning modern shepherding practices in Crete; and the information given may well be relevant to the issues raised by Killen and Palmer.

In modern Crete the lambing season runs from October to February; the shearing season is in April and May; lambs are first shorn at the age of 4 to 6 months. For Cretan sheep in general wool clips are from 0.5 to 1 kilogram (i. e. about 1.1 lbs. to 2.2 lbs.), according to the size of the animal. It may be, then, that Killen is right in thinking that wool would be clipped from actual lambs, at any rate the older ones.

Turning without more ado to details given on the Knossos tablets, we may consider first, in the Dk group with the RAM ideogram, the actual yields of wool from rams where no deficit of wool is noted by the sign o. (Table A).

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[6] L. R. Palmer, Mycenaeans and Minoans, ed. 2, London, 1965, p. 118
[7] op. cit. 117

Table A

Wool Yields of Rams where no deficit of Wool is noted

Dk Tablet Number	Total of Rams	Total of Wool Units	Average Wool Yield per Ram in lbs.
931 + 7293	100	28	1.792 lbs.
936	25	1 (or 2 or 3)	0.256 (or 0.512 or 0.768)
951	130	26	1.28
1613 + 5597	123	30.3 (?+)	1.579 (?+)
7295	100	16 (or 17 or 18)	1.024 (or 1.088 or 1.152)
7314	100	10 (?)	0.64 (?)

Thus a total of 578 RAMS, in six flocks, yield 111.3 wool units, making an average per ram of 1.229 lbs. of wool, or slightly more if the highest figures be allowed where there is some doubt about a digit. There is considerable variation within the six flock averages, from a low of 0.256 (? +) lbs., through 0.64 (?) 1.024, 1.28, and 1.579, to a high of 1.792 lbs.

In view of such figures, it is hard to accept Killen's contention that "there is invariably a fixed ratio between the number of sheep and the amount of wool listed". Of course, in an island so varied in terrain as Crete, one would not expect close uniformity in the quality and productivity of flocks. But two of the above figures seem much too low to be realistic as yields achieving the flockmaster's target with no deficit.

There are two further Dk RAMS tablets on which no deficit is noted, each requiring special discussion.

Dk 1064 runs thus:

A   X RAM 100   WOOL 7 LB 1
B *a-te-i-ja-ta/ku-ta-to*   WOOL 17 LB 2

X is supposed to be a check mark. The sign-groups are thought to represent the names of a shepherd and a place. What is curious is that there is no deficit mark, *o*. The two amounts of wool are stated positively. It is unlikely that a scribe with a clay tablet, to which addition must be made within a rather short period before it becomes too hard, would add a second sum later on receiving amended information about the wool yield. The total would be 25 units, making an average per ram of 1.6 lbs., which Killen thinks the invariable ratio for Dk tablets.

The other special case is Dk 5403 + 5562, in KT ed. 3:

A] RAM 98 WOOL 19 LB 2
B] RAM 2 [   ]   WOOL 4[

Killen assumes that the deficit sign *o.* must have preceded the ideogram on the lower line. If so, a flock notionally of 100 rams had a target notionally of 23.7 (?+) wool units, making an average of 1.515 lbs. Alternatively, one could assume two entries: 98 rams yielding an average of 1.29 lbs., and 2 rams yielding an average of 12.8 lbs. On Dp 2004 (formerly Dl M4) we find RAM WOOL 2[, which might be construed as one RAM yielding 12.8 lbs. of wool; but this is reckoned by Killen among totals, the supposed reference of the Dp group in KT ed. 3.

Let us go next to Dk and Dl tablets with RAM ideograms and deficit signs.

Table B

Wool Targets and Actual Yields from Rams
on Dk and Dl tablets where a deficit of wool units is noted by *o*[8]

Tablet Number	Total of Rams	Actual Wool Units	Wool Units in Deficit	Total Wool	Target average	Average realised
Dk 920						
+ 7294	60	8	7	15	1.6 lbs.	0.853 lbs.
+ 7330						
945	110	8	19	27	1.57	0.465
1065	100	11.3	13.7	25	1.6	0.725
1068	114	26	2	28	1.572	1.459
1070	100	7	18	25	1.6	0.448
1071	50	6	6.3	12.3	1.578	0.768
1072	100	13.3	11.7	25	1.6	0.85
1073	50	6.7	5.7	12.3	1.578	0.85
1074	100	19	6	25	1.6	1.216
1075	100	10	12 ? +	22 ? +	1.408 ? +	0.64 ?+
1076	200	31	16 ? +	47 ?+	1.504 ?+	0.992 ?+
1077						
+ 5292	100	5	10 ?+	15 ?+	0.96 ?+	0.32 ?+
5566	100	9	16	25	1.6	0.576
Dl 7249						
+ 7282	20	6.3	3.7	10	3.2	2.03
Totals:	1,304	166.7	147	313.7	1.539	0.818

On Table B we have, from 14 flocks, a total of 1304 RAMS, which were set a target (including deficits) of 313.7 (?+) wool units, making an average target per RAM of 1.539 lbs. If the 'deficits' be excluded, the actual yield from these 1304 rams is

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[8] For convenience one third is shown as .3 and two thirds as .7.

166.7 wool units, giving an average actual yield per ram of 0.818 lbs. The spread is from a low average of 0.32 (?+) lbs. to a high of 2.03 lbs. How plausible is this result in terms of a real situation dealt with by the bureaucrats of the Knossos Labyrinth? Note that on Table A, where no deficit for rams was noted, the average realised target was 1.229 lbs. of wool, a target only four fifths of that set for the rams in Table B. Though set a target a quarter higher than the rams in Table A, the rams in Table B produced an average wool yield only two thirds of that produced by the norm-achieving quadrupeds of Table A. It may be noted that the highest target, that for the rams on tablet Dl 7249 + 7282, is 3.2 lbs., which is double the average target for Table B rams.

Turning next to the EWES, let us examine them first in their maternal capacity as lamb-producers, and express the results in lambs (= *ki* RAMS) as a percentage of ewes. The figures are from the Dl tablets, excluding deficits with sign *o*.

Table C

Lambing Results
Actual lambs in proportion to actual ewes, excluding deficits

Dl number	total of Ewes	total of Lambs	Lambs as % of Ewes
463	55	5	9%
790	60	25	41.7
791	70	35	50
792	50	44	88
916	50	10	20
934	17	6	35.3
938	50	40	80
947	80	10	12.5
1060	50	10	20
7086	80	60	75
7116	50	20	40

A total of 612 ewes produce a total of 265 lambs, giving an average lamb-crop of 43.3 per cent.

The range of yields is this: 9%; 12.5; two flocks at 20; 35.3; 40; 41.7; 50; 75; 80; 88%. Of the eleven flocks, only three are well herded by modern standards. The average flock is somewhat over 55 ewes. In modern Crete the average flock of breeding ewes numbers 60, and shepherds regard a 60% lamb crop as satisfactory. Consider next the ancient Cretan targets set forth, as Killen thinks, on the Dl tablets.

Table D

Lambing Targets for Ewes (Dl tablets)

Number of Dl tablet	Ewes Actual	Ewes in Deficit	Total Ewes	Lambs Actual	Lambs in Deficit	Total Lambs	Target (Lambs per cent of Ewes)
463	55	35	90	5	45	50	55.55%
938	50		50	40	10	50	100
947	80		80	10	70	80	100
1060	50		50	10	15	25	50
414 + 6016	140	60	200		200	200	100
794 + 7069 + 7292	43	7	50		50	50	100
932 + 963 + 7291 + 7871	40		40		40	40	100
933 + 968	40	20	60		60	60	100
935 + 942	27	43	70		70	70	100
940	60		60		60	60	100
943	90		90		90	90	100
944	60	40	100		100	100	100
946	70		70		70	70	100
948 + 977	20	30	50		50	50	100
949 + 7145	40	20	60		60	60	100
950	50		50		50	50	100
952	40		40		40	40	100
Totals:	955	255	1210	65	1080	1145	94.63%

In Table D no account is taken of some tablets with the contro-versial WE ideogram, sign 75, which is also used of goats.

Comparing Tables C and D, it is anomalous that, in the eleven flocks for which there are actual numbers of lambs (Table C), the actual lamb crop averages 43.3 per cent. of the ewes, whereas, on the seventeen flocks for which 'deficits' are noted and the picture is otherwise complete enough for a computation (Table D), the Labyrinth administrators set an average target of 94.63%.

Moreover, what are we to make of the thirteen flocks where there is a total failure of the ewes to bear any lambs (Table D)? And what is the significance of tablet Dl 1060, where 50 ewes were set a target of only 25 lambs?

Killen concludes his article by discussing a puzzle on the tablet Dl 948 + 977, which may be evaluated thus:

A   *sa-qa-re-jo* EWE 20 WOOL 2 *o*. WOOL 8
B *pa-za-ti*   *ma-ri o*. EWE 30 *o. ki* RAM 50

He comments: "none of the fifty *ki*. RAMS evidently required from the fifty EWES listed have apparently materialized. It

might perhaps be tempting to think of these huge deficits as re-
flecting an emergency situation; and the tablets which we possess
are certainly those which record the transactions of the palace in
the months preceding its destruction."

It must have been disturbing to Minos on his woolsack to learn
from his bureaucrats about thirteen flocks of ewes that failed to
bear a single live lamb. Presumably the bureaucrats knew the date
of the relevant mating, and were not making their records before
21 weeks were up. It had occurred to me that an earthquake, or
an attack by dogs, or some such untoward event might have
scared the thirteen flocks, and caused losses. The question was
put to the Greek Ministry of Agriculture, what proportion of
unborn lambs might be lost through such an upset to pregnant
ewes. The answer was about 10 per cent. In Scotland a leading
authority informs me that a closely herded "heft" of ewes might
lose up to 30 per cent. of the unborn lambs if scared by dogs and
pressed together in a stampede; but with more openly herded
ewes in upland areas losses would be much smaller.

Indeed, the thirteen flocks of ewes with totally negative results
in achieving their lambing targets may incline some to believe
that Killen's whole picture is baseless.

In proceeding to consider the wool-yielding performance of
ancient Cretan ewes, we may look first at the targets on Dl tablets,
going, in the first place, on the assumption that any lambs (= *ki*
RAMS) listed were not expected to produce wool in their early
months while herded with their mothers.

Table E

Wool Targets for Ewes at Knossos
on Dl tablets, including deficits of ewes and of wool, but excluding lambs (if any)

Tablet number	Total of Ewes	Total of Wool Units.	Average per ewe in lbs.
Dl 463	90	16 (ed. 3)	1.138 lbs.
933 + 968	60	12	1.28
935 + 942	70	13 (?+)	1.189 (?+)
938	50	10	1.28
943	90	18	1.28
946	70	14	1.28
947	80	16	1.28
948 + 977	50	10 (?)	1.28 (?)
950	50	10	1.28
952	40	8	1.28
1060	50	8 (? +)	1.024 (?+)

Thus, on 11 Dl tablets, there are recorded, in round numbers, 700 ewes, which were set a total wool target of 135 wool units, making an average target per ewe of 1.263 lbs. The range is from a low of 1.024 (?+) lbs. to a high of 1.28 lbs., at which average we find 8 out of the 11 flocks concerned. Note, however, that on Dl 463 the total of 16 units is that given in the third edition of "The Knossos Tablets". In the second edition the total was 26 units, giving an average from 90 ewes of 1.849 lbs., which would be nearly 50% above the commonest average of 1.28 lbs. for the ewes on Dl tablets. Note further that, on Dk tablets of wool yields from rams where no deficit was noted for wool, the average target per ram was 1.229 lbs. of wool, which is below the commonest figure for ewes of 1.28 lbs. Compare Tables A and E.

Further, on tablet Dl 7132 + 7279, a parcel of 50 ewes and 50 rams are set a wool target totalling 10 wool units, making an average target for each animal of 0.64 lbs., which is half that of the average target most commonly found on the Dl tablets about ewes. The actual average yield from the 100 mixed ewes and rams comes to 0.384 lbs., which is oddly low, though not so low as the average yield of 25 rams on Dk 936, which was 0.256 (? +) lbs.

From the theoretical target of wool set by the Minoan bureaucrats for ewes, let us go on to look at the actual wool yields from ewes on the Dl tablets.

Table F

Actual Wool Yields from Ewes

Tablet number	Ewes total	Wool Units excluding deficits	Average Wool clip per ewe (lbs.)
Dl 414 + 6016	140	12	0.549 lbs.
463	55 (?)	5.3	0.62 (?)
794 + 7069 + 7292	43	3.3	0.496
933 + 968	40	3	0.48
935 + 942	27	2	0.474
938	50	7	0.896
943	90	11	0.782
944	60	5.7	0.604
946	70	7	0.64
947	80	11	0.88
948 + 977	20	2 (?)	0.64 (?)
949 + 7145	40	2	0.32
950	50	5	0.64
952	40	5	0.8
1060	50	7 (?)	0.896

Thus we have from 15 flocks a total of 855 ewes, yielding an actual total of 88.3 wool units, which makes an average yield per ewe of 0.664 lbs. The range of the averages per flock ascends from a low of 0.32 per ewe to a high of 0.896 lbs. The flock sizes range from 20 ewes to 140, with an average of 56.5625 ewes. It is probably coincidence that modern Cretans usually have 60 ewes to a breeding flock. In Dl 2021, the format of the tablet makes probable the supply of the EWES ideogram at the start of the top line: then we have 27 ewes yielding (?) 1 wool unit, an average per ewe of 0.236 lbs.

Next, it might be interesting to see the result if we assume that lambs were expected to give a wool crop while still classed as *ki* RAMS, and herded with ewes. And first we may consider the theoretical targets, counting in any deficits of ewes, lambs, or wool, recorded on the Dl tablets.

Table G

Wool Targets for Ewes and Lambs together,
including deficits of ewes and/or lambs and/or wool

Dl Tablet number	Ewes	Lambs	Total of Animals	Total of Wool Units	Average Target per animal
Dl 463	90	+ 50	= 140	16	0.886 lbs.
933 + 968	60	+ 60	= 120	12	0.64
935 + 942	70	+ 70	= 140	13	0.594
938	50	+ 50	= 100	10	0.64
943	90	+ 90	= 180	18	0.64
946	70	+ 70	= 140	14	0.64
947	80	+ 80	= 160	16	0.64
948 + 977	50	+ 50	= 100	10 (?)	0.64 (?)
950	50	+ 50	= 100	10	0.64
952	40	+ 40	= 80	8	0.64
1060	50	+ 25	= 75	8 (?)	0.683 (?)

Here, in 11 flocks, are recorded 700 ewes and 635 lambs, making a total of 1,335 animals, which are collectively set a target of 135 wool units, making an average target per animal of 0.6456 lbs. The range is from a low of 0.594 lbs. to a high of 0.886 (unless one accepts the figure of 26 wool units as the total on Dl 463, as in the second edition of KT: in which case the average target there would be 1.188 lbs.).

Let us now inspect the actual wool yields from actual ewes and lambs run in flocks together.

Table H
Actual Wool Yields from Ewes and Lambs Together
excluding deficits of ewes and/or lambs and/or wool units

Dl Tablet number	Ewes	Lambs	Total of Animals	Total of Wool Units	Average Yield per animal
463	55	5	60	5.3	0.571
938	50	40	90	7	0.496
947	80	10	90	11	0.782
1060	50	10	60	7 (?)	0.747 (?)

Thus, on four mixed ewe and lamb flocks, with 235 ewes and 65 lambs, a total of 300 animals, the total wool yield is 30.3 units, making an average per animal of 0.647 lbs.

The average of actual yield from four mixed flocks of ewes and lambs (Table H), at 0.647 lbs., is almost exactly the average theoretical target for eleven flocks of largely notional ewes and lambs (Tabel G), which was 0.6456 lbs. This triumph of State planning by the Labyrinth was achieved even though all four flocks in Table H missed their targets by substantial excess or deficiency, the smallest margin of error being 11.55 per cent.

For flocks of lambs alone yielding wool, we have apparently only three possibly relevant tablets. Dl 413 is broken, and the extent of the loss on it is doubtful, so that one can use it only with hesitation. But it lists 30 *ki*. RAMS (= lambs), followed by 2 (?+) wool units, and a deficit noted of 2 (?+) units. Thus we have a minimum target of 4 units, making an average target per lamb of 0.853 lbs. of wool. But the actual yield is 2 units, an average per lamb of 0.427 lbs. (This is taking the lowest figures for both yield and deficit. Taking the highest figures for each the yield and target and average would be doubled.)

On Dk 1066 we learn of *ki ne* RAMS. In Docs. (p. 197) it is noted that the adjuncts found with the RAM ideogram include both *ki* and *ne* separately, and *ki. ne* together; and it is suggested that *ne* might be *newos*, 'young'. If that is right, and if Killen is right in thinking that *ki*. RAM is a 'young animal of either sex', then perhaps it would be reasonable to think that a *ki. ne* RAM is a lamb somewhat younger than some other class of lambs.

On Dk 1066 we find 200 *ki. ne* RAMS yielding 19 wool units, with an average per lamb of 0.613 lbs. On Dk 1067 100 *ki. ne* RAMS yield 6.7 units, with an average of 0.427 lbs.

If we compute together the three tablets about lambs alone, Dl 413, Dk 1066, and Dk 1067, we find 330 lambs producing

actually 27.7 (?+) units, with an average actual yield of 0.5335 lbs. per lamb.

If now we take the 65 lambs on Table H, and allow each of them an average wool yield of that figure, 0.5335 lbs., then the average for the 235 ewes found with them in the four flocks would be, calculating for the ewes separately, 0.6785 lbs. But if we took tablet Dl 463 by itself, where the highest proportion of lambs is found, then, if the 40 lambs there are given an average yield of 0.5335 lbs. of wool, the 50 ewes with them could only average 0.468 lbs., which is less than their accompanying lambs.

A possible anomaly worth noting is on tablet Dk 7306, where KT ed. 3 reads: ? OVIS^m]4 LANA 9[. This would imply that 4 rams had produced 9 wool units, an average per ram of 14.4 lbs. of wool. If this were correct, Minos would appear to have had at least one pen of rams as well-fleeced as a champion long-wooled Blackface ram.

Another possible anomaly is on tablet Dl 1046 + 7281, where KT ed. 3, restoring the EWE ideogram, suggests that we have to do with 20 ewes and a deficit of 50 lambs. If this is a lambing target, on the pattern of the accompanying tablets classified with it, then it is an unusually optimistic one. But perhaps there is an error in the number 20. A larger figure before 20 may have been destroyed.

With very many of the tablets their defective state inhibits speculation. However, the supposed SHEEP tablets form over one fifth of the total Knossos archive, and, in view of the Killen theory that wool was a mainstay of the Minoan economy, in this collection of records, in particular, one might expect to find the suggested interpretation of the tablets gaining by cumulation, with all the tablets coming out in mutual support. Is that in fact what happens?