

## LOST SHEEP? ON THE LINEAR B EVIDENCE FOR BREEDING FLOCKS AT MYCENAEAN KNOSSOS AND PYLOS <sup>1</sup>

In the surviving corpus of Linear B inscriptions, records relating to sheep form the largest single component, while the production of wool and manufacture of woolen textiles are by far the best documented areas of palatial farming and craft activity. The great majority of the sheep records were concerned with the administration of flocks which in some sense belonged to the palaces and provided the raw material for palatial textile workers (Killen 1963; 1964; 1984; in press). In contrast with many comparable archives in the bronze age Near East <sup>2</sup>, the Linear B sheep records are overwhelmingly concerned with highly specialised wool flocks dominated by wethers (castrated adult males). Wethers produce more and finer wool than breeding rams or ewes, but are of course incapable of reproduction. This paper reviews the Linear B evidence for breeding flocks: did the mycenaean palaces control enough ewes to ensure the renewal of their wool flocks, or were large numbers of wethers acquired through taxation or exchange from flocks not under direct palatial control?

### *The Linear B evidence from Knossos* <sup>3</sup>

The total number of sheep controlled by the Knossos administration has been estimated at ca. 100,000 (Killen 1964, p. 5 n. 23; Olivier 1967, p. 89). Of these, ca. 60-65,000 belonged to a main group of wool flocks, which were widely distributed across central Crete (Killen 1977) but were centrally recorded by scribal hand 117 in the document series Da-Dg (Olivier 1967, p. 80; 1988, p.

<sup>1</sup> I am indebted to John Killen for advice and critical comment during the preparation of this paper.

<sup>2</sup> See forthcoming issue of *Bulletin on Sumerian Agriculture* devoted to sheep and goats.

<sup>3</sup> Readings of individual texts after Killen and Olivier 1989.

264). Ca. 69 % of these wool sheep were solely owned or directly controlled by the palace, while ca. 31 % were in some way owned or controlled through important intermediaries, conventionally known as 'collectors' (Olivier 1967, pp. 79-80; Bennet in press). The wool from some of the Da-Dg flocks (those assigned to the toponym *ku-ta-to* or to the closely associated 'collector' name *da-mi-ni-jo*) is recorded by hand 119 in the Dk(2) set (Killen 1964; Olivier 1967, pp. 88-9). The use of wool from the Da-Dg flocks is almost certainly documented by records of wool, weaving personnel, textile production and finished textiles in which Da-Dg toponyms of 'collectors' recur (Killen 1964, p. 15; 1974; 1984, p. 50, p. 54 n. 15; 1988). The Da-Dg 'collectors' were evidently involved in the entire sequence of running wool flocks and producing woolen textiles (Bennet in press), and there are some indications that the relative output in woolen cloth of 'collector' and 'non-collector' workshops approximated to the 31:69 balance already noted between 'collector' and 'non-collector' sheep (Killen 1976, p. 121).

Overall the Da-Dg wool flocks comprised ca. 87 % wethers and ca. 13 % adult females (after Olivier 1988, p. 264, excluding sheep recorded as missing [*o*], young [*pe*] or old [*pa*] and those of uncertain status). Assessment of the distribution of the adult females between 'collector' and 'non-collector' flocks is difficult because of the fragmentary nature of much of the material, but at least 24 % of these adult females belonged to 'collector' flocks (TABLE 1). This figure is lower than the estimated 31 % of all wool sheep belonging to 'collectors', but the 'non-collector' category will include some fragmentary records with the 'collector' name broken off. In the case of Knossos, therefore, females probably made up a similar proportion of 'collector' and 'non-collector' sheep.

TABLE 1. *The distribution of female sheep among 'collector' and 'non-collector' flocks listed in the Da-Dg series*

	female sheep	
	no.	%
certain 'collector' flocks	1525	24 %
certain + possible 'non-collector' flocks	4727	76 %
	6252	

It has been argued, both by analogy with medieval records from England and on the basis of some circumstantial evidence in the Knossos archives, that Mycenaean wool sheep will have been replaced at about 5-6 years of age (Killen 1963, p. 87), that is at a rate of ca. 17-20 % per year. On this basis, the Da-Dg flocks alone will have required something like 10-13,000 replacement wool sheep each year. If these replacement sheep approximated to the male:female ratio recorded for the Da-Dg wool flocks overall (87:13 or 6.7:1), then ca. 9-11,000 new male sheep will have been needed each year. Assuming a normal sex ratio at birth of ca. 1:1 and an optimistic lambing rate of 100 %, therefore, replacement of the Da-Dg wool sheep will have required ca. 18-22,000 breeding ewes. This figure may well be a considerable underestimate: the average lambing rate is unlikely to have been as high as 100 %; a significant number of lambs are likely to have died before transfer to the wool flocks; and a significant number of wool sheep may have died or been culled before 5-6 years of age.

The Knossos archives contain nine series of records detailing significant numbers of female sheep, each of which must be considered as possible evidence for the breeding ewes needed to restock the Da-Dg wool flocks.

(1) **Da-Dg** The main wool flocks included over 6000 female sheep, perhaps 8000-8500 if the sex ratio in preserved documents is representative. There is no indication, however, in the form of associated lambs or lambing targets, that any of these females were being used for breeding. Conversely, it is clear from concordances between the Da-Dg flock records and the Dk(2) shearing records that the latter do not distinguish between male and female sheep and that flocks including female sheep were set exactly the same wool target (1 unit of wool: 4 sheep) as those consisting exclusively of wethers<sup>4</sup>. This contrasts with the reduced wool target for breeding ewes in the Dl(1) and Dl records (see below).

It is puzzling that the Da-Dg flock records do distinguish between male and female sheep, but young, old and missing sheep are also distinguished without any apparent effect on Dk(2) shearing targets. Perhaps these different categories of wool sheep were distinguished, therefore, not because of their immediate productive capacity, but because of their relevance to decisions on the culling

<sup>4</sup> E.g. Dk(2) 1076 and Df 1121.

and transfer of stock at the annual census and reformation of flocks (cf. Killen in press). In that case, the female sheep in the Da-Dg flocks may have been distinguished because of their potential *future* use as breeding stock, or alternatively to facilitate their replacement with the preferred wethers if the opportunity arose.

(2) **Dk(1)** The Dk shearing records include both the Dk(2) set by hand 119, which can be securely related to the Da-Dg wool flocks (above), and a more enigmatic set Dk(1) by hand 120. The Dk(1) texts cannot be related to known wool flocks, but share four out of five unambiguous toponyms and a single 'collector' name with the Da-Dg series<sup>5</sup>. One of these texts lists 80 female sheep<sup>6</sup>, but the Dk(1) set as a whole records at least 835 male sheep. There is little doubt, therefore, that the Dk(1) shearing records refer only to wool flocks and not to breeding ewes.

(3) **DI(1)** The DI series apparently lists flocks of breeding ewes (totalling at least 1939 ewes), for which production targets have been set in lambs and wool (Killen and Olivier 1989, pp. 109-18; Killen 1964, pp. 11-12). Most of these records (53 out of 76) and most of the ewes which they list (1503 out of 1939) belong to the coherent set DI(1) written by scribal hand 118. For these ewes, a lambing target of one lamb per ewe (Killen 1964, p. 12) is indicated by 18 records<sup>7</sup> in which the number of ewes and lambs is completely preserved<sup>8</sup>. One further complete record<sup>9</sup>, which lists 20 ewes and 30 missing wethers/rams against a target of 50 lambs, may fit the same pattern if accurate information on gender was not considered critical for *missing* sheep. The identification of the DI(1) set as the records of flocks of breeding ewes, together with their lambs and lambing targets, seems very secure. The wool target for these flocks (Killen 1964, pp. 11-12) is only 1 unit of wool: 5 ewes

<sup>5</sup> The shared toponyms are *da-ra-ko*, *da-22-to*, *ra-su-to*, and *su-ri-mo*. A fifth toponym, *si-ja-du-we*, shared with the DI(1) breeding flock records, occurs on Dk(1) 969 which is only assigned very tentatively to hand 120. The 'collector' name is *ko-ma-we-to*.

<sup>6</sup> Dk(1) 7117; it cannot be demonstrated that these females were treated like wethers rather than breeding ewes, because the size of the wool target is not preserved.

<sup>7</sup> DI(1) 412, 414, 794, 930, 932-35, 938, 940, 943-44, 946-47, 949-50, 952, 7132.

<sup>8</sup> Some DI(1) texts also list *we* sheep (?yearlings), perhaps in the proportions 2 ewes: 2 lambs: 1 yearling (Killen 1964, p. 11 n. 57); on DI(1) 934, *we* sheep seem to be included in the lamb total (36 ewes: 30 lambs + 6 yearlings).

<sup>9</sup> DI(1) 948.

(+ 5 lambs), as against 1 unit of wool: 4 wethers/ewes in the shearing records for the main Da-Dg wool flocks. A reduced wool target for ewes is widely attested in other contexts (e.g. Killen 1964, p. 5 n. 30, p. 11 n. 58) and reflects the severe stress of reproduction upon breeding females (cf. Spedding 1970, p. 197; MAFF 1956, p. 49). These contrasting wool targets thus provide confirmatory evidence both that the Dl(1) females were breeding ewes and that the Da-Dg ewes were not.

Eight of the fourteen attested Dl(1) toponyms (Killen and Olivier 1989, pp. 109-18), representing 58 % of the 31 toponym occurrences, recur in the Da-Dg series (Olivier 1988, pp. 239-50)<sup>10</sup>. This suggests a connection between Dl(1) and the Da-Dg series, and the absence of the remaining 23 Da-Dg toponyms from Dl(1) could simply reflect poor preservation of these breeding flock records. On the other hand, six of the fourteen Dl(1) toponyms are not attested in the extensive Da-Dg series (over 400 toponym occurrences). Moreover, at least 900 (60 %) of the Dl(1) ewes are recorded as belonging to three 'collectors' or to the goddess Potnia<sup>11</sup>; none of these four is attested among the 138 references to the 15 'collectors' of the Da-Dg series (cf. Olivier 1988, pp. 252-5). Likewise none of the Da-Dg 'collectors' recurs in Dl(1). Finally, the Dl(1) documents also monitor the wool production of these breeding flocks, whereas separate flock composition (Da-Dg) and shearing records (Dk(2)) were kept for the main wool flocks by different scribes (117 and 119 respectively)<sup>12</sup>.

Although the Dl(1) records do list breeding ewes and their lambs, therefore, they seem administratively isolated from the main block of records detailing palatial wool production and textile manufacture. Even with a 100 % lambing rate, the surviving number of ewes in Dl(1) could only have produced ca. 7-8 % of the minimum number of male lambs needed to replenish the Da-

<sup>10</sup> Dl(1) toponyms which recur in Da-Dg are *da-wo*, *e-ko-so*, *e-ra*, *ku-ta-to*, *ra-ja*, *ra-su-to*, *su-ri-mo*, \*56-*ko-we-e*; those which do not recur in Da-Dg are *da-ta-ra-mo*, *ka-ru-no*, *ma-ri*, *ma-so-mo*, *qa-nwa-so*, *si-ja-du-we*.

<sup>11</sup> The 'collector' names (or adjectives) are *e-se-re-e-jo*, *ra-wo-qo-no-jo*, *sa-qa-re-jo*; *po-ti-ni-ja-we-jo* is apparently used in the same way as a 'collector' name (Bennet in press); on the derivation and meaning of this word, see Killen 1983, pp. 73-4.

<sup>12</sup> Wool belonging to Potnia is also recorded, on Dp 997 (again in hand 118) and Dp 7742 (hand indeterminate), in the distinctive form of new and ?last year's fleeces (*po-ka*).

Dg wool flocks, and anyway their lambs may have been directed elsewhere. For example, the single text D 1650, tentatively assigned to the Dl(1) hand 118 and bearing both a Dl(1) 'collector' name (*ra-wo-qo-no-jo*) and Dl(1) toponym (*da-wo*), lists 68 male sheep. These might represent a wool flock stocked by the Dl(1) ewes. Equally, the lambs of the 300 ewes attributed to Potnia might have been destined as offerings to that divinity<sup>13</sup>.

(4) **Dl** Of the remaining 23 Dl records, four are by scribal hand 215, two by hand 218, and 17 are unattributed. These fragmentary and disparate records list at least 436 ewes, variously associated with lambs and/or wool, and almost certainly represent further breeding flocks. A single record, for which the number of ewes and lambs is completely preserved<sup>14</sup>, indicates a lambing target of only one lamb per two ewes. The same record also suggests a reduced wool target equal to or lower than that documented for the Dl(1) set<sup>15</sup>. Ewes are associated on Dl records with the toponyms *ri-jo-no*, *su-ki-ri-ta*, *u-ta-no* and perhaps *qa-ra*, all of which to recur in the Da-Dg series. Thus some at least of the Dl records of breeding flocks may have been administratively related to the main Da-Dg wool flocks, but the preserved number of ewes (436) could have produced only ca. 2 % of the required number of young males, assuming a 100 % lambing rate, and as little as ca. 1 %, assuming a 50 % lambing rate.'

(5) **Do** This set, written by scribal hand 106, lists flocks of ewes and lambs at *se-to-i-ja*. These are again evidently breeding flocks, but in this case there is no reference to wool production. Five well preserved records indicate a variable lambing target of 80 %, 50 % or 40 %<sup>16</sup>.

<sup>13</sup> Cf. Killen 1985, p. 295 n. 89.

<sup>14</sup> Dl 1060 by hand 215.

<sup>15</sup> The preserved text records 50 ewes + 25 lambs: 7 units of wool; the wool target may be incomplete but cannot exceed  $10 \frac{1}{3}$  units (1060.A  $8 \frac{2}{3}$  units + 1060.B  $1 \frac{2}{3}$  units) and so may match the Dl(1) target of 1 unit of wool: 5 ewes. Similarly on Dl 2021, 50 ewes are associated with a preserved wool target of 3 units, but again a maximum of  $10 \frac{1}{3}$  units (2021.A  $3 \frac{2}{3}$  units + 2021.B  $6 \frac{2}{3}$  units) is possible. I am grateful to John Killen for advice on the reading and interpretation of these two texts.

<sup>16</sup> 100 ewes: 80 lambs in Do 927 and 929; 100 ewes: 50 lambs in Do 7079 and 7087; 100 ewes: 40 lambs in Do 5010. In some cases, the lambs are distinguished as *za* (? this year's) and *pe* (? last year's) (cf. Killen 1963, pp. 81-3); these terms perhaps refer to late and early lambs respectively, rather than to the progeny of successive breeding seasons.

The Do set represents breeding flocks which might have contributed to the renewal of the Da-Dg wool flocks. The number of ewes recorded in surviving Do texts, however, is only 1500, potentially accounting for ca. 3 % (with a 40 % lambing rate) or 5-7 % (with an 80 % lambing rate) of the male lambs needed to restock the Da-Dg wool flocks. The location of *se-to-i-ja* is uncertain and so the ovine carrying capacity of the area is unknown, but the numbers of wool sheep at individual Da-Dg toponyms seem to have ranged between ca. 150 and 4500 (Olivier 1988, p. 266). Only the massive (and probably temporary) assembly of 11,900 young sheep at *a-mi-ni-si-ja* (see below) exceeds these limits. In other words, the Do set may be a relatively complete record of a fairly small group of breeding ewes which did not greatly exceed the surviving total of 1500 ewes.

It is also questionable whether the male offspring of the Do breeding ewes were available for restocking the Da-Dg wool flocks. *Se-to-i-ja* is probably a second-order centre within the territory of Knossos (Bennet 1985, p. 242; Killen 1977, p. 42) and also occurs (twice) in the Da-Dg series, but the only 'collector' name in the Do texts (*ka-to-ro*) does not recur in the Da-Dg series<sup>17</sup>. The name *ka-to-ro* does appear, however, on two texts<sup>18</sup> by the Do scribal hand 106, each listing a flock of male sheep at *se-to-i-ja*, and also on a probable cloth record L(4) 489<sup>19</sup>. In other words, the *se-to-i-ja* breeding flocks may well have supported wool flocks and textile workshops quite separate from the Da-Dg flocks and associated textile records.

(6) **Dq(2)** Seven texts by hand 216 list 238 ewes, variously associated with male, old, missing or indeterminate sheep. Two fragmentary texts in this set<sup>20</sup> may list flocks consisting solely of wethers/rams, and there are no references to young sheep. These flocks are all located at *ti-ri-to* and the Dq(2) texts seem to represent a local variant of the main Da-Dg flock census records, with which they were in fact mixed (Olivier 1972, p. 27). These female sheep seem, like their counterparts in the Da-Dg series, to have been run as wool sheep rather than as breeding ewes.

<sup>17</sup> The 'collector' name associated with the two Da-Dg wool flocks from *se-to-i-ja* is *a-te-jo* (Olivier 1988, p. 252).

<sup>18</sup> Dq(4) 438 and 686.

<sup>19</sup> Perhaps also on the fragmentary L(4) 480 by the same hand.

<sup>20</sup> Dq(2) 1377 and 5595.

(7) Ce Text Ce 50 lists four shepherds with a total of 134 male and 126 female sheep on the obverse face, and the same shepherds with 190 male and 427 female sheep on the reverse face. Although two of the 'shepherd' names recur in the Da-Dg series<sup>21</sup>, the scribe of Ce 50 (hand 124) was also responsible for a text (Ce 144) dealing with livestock at *a-pa-ta-wa* in western Crete. The possible role of western Crete in restocking the Da-Dg flocks is considered below. Whatever its administrative significance, however, this single text can do little to resolve the shortage of breeding females for the Knossian wool flocks.

(8) Co This small set (6-8 texts) by hand 107 lists 479 male and 2370 female sheep, together with goats, pigs and cattle of both sexes, at a group of west Cretan toponyms (Godart 1971)<sup>22</sup>. The stock are described as *a-ko-ra-ja* or *a-ko-ra-jo*, which might denote 'ownership' by 'collectors'<sup>23</sup>. Scribal hand 107 also wrote text C(1) 5753, which apparently records the transfer of 13 cattle to *Knossos*, but the Co set seems unambiguously to refer to stock *at* places in western Crete. Co female sheep are far more numerous than their male counterparts and so may well have been breeding ewes (Godart 1971). Assuming an even sex ratio at birth, this imbalance between males and females also implies that several hundred male sheep had been culled or despatched elsewhere —conceivably to central Crete (Godart 1971).

It might be argued that the sheep listed on the surviving Co texts are just the rump of a much larger population, but this is unlikely. The format of the texts (toponym + *a-ko-ra-ja/jo*, without 'herder' names), the mixture of livestock species and sexes listed, and the size of some individual ewe records (650 ewes on Co 906, 750 on Co 907, 600 on Co 7056) make clear that the Co texts do not represent individual flocks. Rather they represent local totals (perhaps of 'collector' livestock)<sup>24</sup> for major west Cretan sub-centres such as *ku-do-ni-ja* and *a-pa-ta-wa*. Indeed, the Co texts may represent a complete set, because their distinctive dimensions

<sup>21</sup> *a-nu-ko* and *a-qi-ru* recur in Da-Dg, *qa-ra<sub>2</sub>-wo* and *ru-ro* do not, cf. Olivier 1988, pp. 221-33.

<sup>22</sup> On the location of these toponyms in W. Crete, see also MacArthur 1981.

<sup>23</sup> Killen 1976; also Bennet in press.

<sup>24</sup> 'Collectors' may have controlled most palatial interests in western Crete, to judge from surviving livestock (Co) and cloth (Lc(2)) records and also from the apparent use of the term *wa-na-ka-te-ro* to denote 'non-collector' —Bennet in press.



would make any further fragmentary examples readily recognisable (Godard 1971, p. 419).

With a lambing rate of 100 %, the 2370 Co females could have produced 1185 male lambs per year. Of these, between 80 and 96 would have been needed as replacements for the 479 Co male sheep, if these were culled on a 5-6 year cycle. Thus ca. 1100 male lambs could in theory have been available each year for transfer to central Crete, making up ca. 10-12 % of the annual Da-Dg requirement for replacement male stock. On the other hand, there were west Cretan 'collector' workshops producing woolen cloth, which are recorded in the Lc(2) set by hands 113 and 115 (Killen 1988). These workshops are tenuously linked to the Co sheep by the 'collector' name *i-se-we-ri-jo*, which appears on a personnel text (B 798) written by the Co scribe (hand 107) and also on Lc(2) 7377<sup>25</sup>. It is just as likely, therefore, that any surplus Co male sheep were transferred to west Cretan wool flocks.

(9) C(4) Three texts by hand 111 list both male and female sheep, together with goats or pigs. In C(4) 911 and 912, single-sex flocks of between 40 and 270 sheep or goats are listed against a series of persons, who are variously qualified as the *do-er-o*, *po-ku-ta*, *wo-we-u* or *da-nu-wo* of a second personal name. The reverse of C(4) 912 also gives a total (*to-so*) of 900 male sheep. The third text C(4) 917, which also carries the term *po-ku-ta* and shares with C(4) 912 the personal name *re-ko-no*, gives livestock totals including 1700 male and 1200 female sheep, perhaps with 170 female goats and 500 pigs. This set, the administrative significance of which is far from clear, is dominated by male sheep (TABLE 2).

TABLE 2. *The balance of male and female sheep in the Knossos C(4) series*

	male sheep		female sheep	
	no.	%	no.	%
C(4) 911*	480	59	340	41
C(4) 912**	990	85	170	15
C(4) 917	1700	59	1200	41
Total	3170	65	1710	35

\* Accepting the probable reading of OVIS<sup>f</sup> 100 in l. 12.

\*\* Including the probable OVIS<sup>f</sup> 70 but excluding the total of OVIS<sup>m</sup> 900 on the reverse.

<sup>25</sup> Killen 1976. Lc(2) 7377 is broken and the name is truncated to ]*we-ri-jo-jo*, but this reading is strengthened by association with the western toponym *ku-do-ni-ja*.

If all the C(4) female sheep were breeding ewes and attained the optimistic 100 % lambing target of the Dl(1) series, they should have produced 855 male lambs per year. If all the C(4) male sheep were wethers replaced on a 5-6 year cycle, ca. 528-634 replacement male lambs would have been needed each year.

Theoretically, therefore, the C(4) flocks could have produced a small surplus of male lambs for restocking the Da-Dg flocks, and geographically the C(4) set has modest circumstantial links to central Crete. Seven of the 19 intelligible 'herder' names recur in Da-Dg<sup>26</sup>; four 'herder' names recur in the As records by hands 101, 103 and 105, which are in turn widely involved in the management of personnel at toponyms in central Crete<sup>27</sup>; and the second personal name or ethnic adjective qualifying *wo-we-u* on C(4) 911 is derived from the Da-Dg toponym *su-ki-ri-ta*. On the other hand, there is no evidence that the C(4) female sheep were breeding ewes, little likelihood that they would have attained a 100 % lambing rate, and no evidence that C(4) male lambs were transferred to the Da-Dg flocks.

In addition to these nine series of records referring to female sheep, there are a few texts which list young sheep. The text Dn 1319 lists at least 11,900 young sheep at *a-mi-ni-si-ja*. This toponym does not recur in the Da-Dg series, but the text is written by hand 117 (the author of that series) and may record an annual assembly of young sheep to be drafted into the main wool flocks (Olivier 1967, pp. 81-2). The Dh(1) set of tablets comprises three records by hand 117 (the Da-Dg scribe), while the Dh(2) set contains two by hand 120 (one perhaps including a reference to wool) and one of indeterminate hand. Together these list at least 345 young sheep (lambs and yearlings) at four toponyms<sup>28</sup>, all of which recur in the Da-Dg series. While Dn 1319 and the Dh(1) set at least may well be related to the restocking of the main Da-Dg wool flocks, however, they shed no light on the source of these young sheep.

Altogether, the Knossos archives list ca. 16-17,000 female sheep, but more than half of these (in Da-Dg, Dk(1) and Dq(2)) were apparently run as wool sheep rather than breeding ewes (TABLE 3).

<sup>26</sup> From C(4) 911: *a-ra-ko* in Db 1236. From C(4) 912: *a-\*56-no* in Dv 5232; *ka-sa-ro* in Dv 1450; *qa-sa-ko* in Dd 1283; *wa-du-na-ro* in Db 1242 and Dc 1118.

<sup>27</sup> From C(4) 911; *a-ra-ko* in As(1) 607 (hand 103); *ta-so* in As(1) 608 (hand 103). From C(4) 912: *a-\*56-no* in As 1520 (hand 105); *pu-wo* in As(2) 1516 (hand 101).

<sup>28</sup> *e-ko-so*, *ti-ri-to*, *tu-ri-so*, and *u-ta-no*.

TABLE 3. *The evidence for (potential) breeding ewes at Knossos*

texts	female sheep	breeding ewes?	lambing target	male lambs/yr no.	male lambs/yr %*	location	link + Da-Dg
Da-Dg	?8000 -8500	No	—	—	—	C Crete	—
Dk(1)	80	No	—	—	—	C Crete	?Yes
Dl(1)	1503	Yes	100 %	752	7-8 %	C Crete	?No
Dl	436	Yes	?50 %	109	1 %	C Crete	?Yes
Do	1500	Yes	40-80 %	300-600	3-7 %	?C Crete	?No
Dq(2)	238	No	—	—	—	C Crete	Yes
Ce**	427	?	—	0-214	0-2 %	?W Crete	?No
Co	2370	?Yes	—	0-1185	0-13 %	W Crete	No
C(4)	1710	?No	—	0-855	0-10 %	?C Crete	?Yes
	?16,000 -17,000	3439 (-7946)	—	1161 (-3715)	11 % (-41 %)	—	—

\* as % of annual Da-Dg requirement for 9-11,000 replacement males.

\*\* taking the larger figure for female sheep on the reverse of Ce 50, not the smaller figure on the obverse.

A further 4500 female sheep (in Ce, Co and C(4)) might have included breeding ewes, but probably did not contribute to the restocking of the Da-Dg wool flocks. Known breeding ewes (in Dl(1), Dl and Do) amount to fewer than 3500, and will have been incapable of producing more than ca. 11 % of the minimum number of young males needed to restock the Da-Dg wool flocks. The Dl series, which alone records breeding ewes apparently linked to the Da-Dg wool flocks, accounts for only 1 % of the required young males.

That surviving records of breeding ewes are strikingly scarce has long been recognised (Killen 1964, p. 13 n. 63b). One suggested explanation for this dearth is that the palace was destroyed too early in the year for lambing records to have been made, but it is arguable that records should have existed of lambing targets or at least of the size and composition of the breeding flocks.

Another possible explanation is that the proportion of surviving records is much smaller for breeding flocks than for wool flocks. On the other hand, the large Dl(1) group of 1503 known breeding ewes appears to have been administratively isolated from the main Da-Dg wool flocks and may well have supplied lambs and wool to a different (and presumably smaller-scale) set of wool flocks and

textile workshops. The second group (Do), restricted to *se-to-i-ja*, may not have exceeded greatly the surviving total of 1500 ewes and may have supplied male lambs to local wool flocks, distinct from the main Da-Dg flocks. Likewise the Co list of 2370 possible breeding ewes in western Crete may be fairly complete and may be unconnected with the Da-Dg flocks and related workshops of central Crete. In other words, the Dl(1), Do and Co sets may be relatively complete records of groups of breeding ewes which made little or no contribution to restocking the Da-Dg wool flocks.

The most plausible recorded source or replacement sheep for the Da-Dg flocks is the small Dl group of 436 ewes. These records are very fragmentary and could perhaps represent the rump of a large corpus listing 20,000 breeding females, but this demands that the Dl records were much more poorly preserved than both the corresponding Da-Dg records of wool flock composition and the apparently separate Dl(1), Do and Co records of (possible) breeding flocks.

*The Linear B evidence from Pylos*<sup>29</sup>

The Cn sheep records from Pylos are much fewer and much less detailed than those from Knossos. Taking together all documents dealing with sheep<sup>30</sup>, TABLE 4 presents the *minimum* numbers of the different categories of sheep listed at Pylos.

Of ca. 10,000 listed sheep, males (presumably wethers) make up 65 % and so, although shearing records are not preserved, it may reasonably be inferred that the Cn series is also principally concerned with wool production (Godart 1977, pp. 39-40; Killen in press). Other categories of sheep listed, in descending order of abundance, are females, old males (OVIS<sup>m</sup> *pa-ra-jo*)<sup>31</sup> and young males (OVIS<sup>m</sup> *wo-ne-we*)<sup>32</sup>. In addition, three texts carry the heading *we-re-ke*, perhaps indicating 'herds' or 'enclosures' (Palmer 1963, p. 168; Ventris and Chadwick 1973, p. 433), while on Cn

<sup>29</sup> Readings of individual texts after Bennett and Olivier 1973.

<sup>30</sup> Excluding Cn 4 and 595, which record small numbers of missing sheep of a particular category (OVIS + TA).

<sup>31</sup> The Knossos records indicate that OVIS<sup>m</sup> may sometimes refer to sheep of both sexes; at Pylos, there is some circumstantial evidence that these old sheep were indeed male (below).

<sup>32</sup> Cf. Palmer 1963, p. 464. Again it is possible that young sheep of both sexes are referred to.

TABLE 4. *The composition of sheep flocks in the Pylos Cn records*

	male	female	old male	young male	indet. sheep
Cn 40	530	210	370	75	—
Cn 45	—	245	—	—	—
Cn 131*	2127	135	—	—	—
Cn 155	204	—	—	—	—
Cn 201	—	—	—	—	160
Cn 202*	256	—	—	—	—
Cn 254	260	—	180	—	100
Cn 285	466	—	—	—	—
Cn 314	162	—	—	—	—
Cn 328*	450	190	—	—	—
Cn 436	—	150	—	—	100
Cn 437	50	—	—	—	—
Cn 491	60	50	—	—	—
Cn 600	492	350	—	—	—
Cn 655**	694	307	564	—	94
Cn 702	100	40	—	—	—
Cn 719	538	90	296	100	—
Cn 1075	—	15	—	—	—
Cn 1197	2	—	—	—	3
Cn 1286	—	—	—	—	3
Total	6391	1782	1410	175	460
	65 %	18 %	14 %	2 %	—
<i>we-re-ke</i>	2833	325	—	—	—
total excl.	3558	1457	1410	175	460
<i>we-re-ke</i>	54 %	22 %	21 %	3 %	—

\* texts including the term *we-re-ke*.

\*\* Including at least 350 male and 94 indeterminate sheep qualified as *a-ko-ra*.

655 some male and some indeterminate sheep are qualified as *a-ko-ra*. As has been suggested for *a-ko-ra-ja/jo* in the Knossos Co set, *a-ko-ra* may help to identify the preceding personal name as being that of a 'collector' (Killen 1976), but the term only occurs with *some* of the 'collector' names on Cn 655 and so may indicate something more specific than 'collector flock'.

On Cn 40, 254, 655 and 719, whole flocks are listed as old (and presumably needing replacement) and the process of collecting up these elderly sheep and of drafting younger replacements into the wool flocks seems to be documented rather more clearly at Pylos than at Knossos. First, the totals of old male sheep listed in the Cn texts for the areas of *ma-ro* (714 head) and *pi- \*82* (516 head) are

identical with the numbers of unqualified male sheep listed against each of these two areas (Godart 1977, pp. 36-7)<sup>33</sup>. This raises the possibility that the same sheep have been listed twice on these documents, once as unqualified males making up wool flocks (average size 77 head) and then as old sheep grouped in rather larger flocks (average size 112 head) destined for slaughter (Killen in press).

Secondly, twelve of the 32 shepherds listed on Cn 655 and Cn 719 recur on a further text (Cn 131), associated with different flocks (Lang 1966). It has been persuasively argued that Cn 655/719 and Cn 131 may be records from different years (Killen in press), with individual shepherds evidently taking on different numbers of stock and even switching between shepherding and goat-herding from one year to the next. Cn 131 is headed *we-re-ke* ('herds' or 'enclosures') and, in common with the other two texts carrying this heading (Cn 202 and 328), lists no *old* sheep. It seems likely that Cn 131 refers to an assembly (area) for the annual re-formation of flocks and distribution of replacement sheep (Godart 1977, p. 37; Killen in press).

In the Pylos sheep records, no lambing targets are documented and the two flocks of young sheep listed on Cn 40 and Cn 719 are not associated with adult females. In sharp contrast to the Knossos Da-Dg series, however, the minority of ewes listed in the surviving Cn records is not scattered through flocks numerically dominated by wethers, but is segregated into single-sex flocks. Moreover, these ewe flocks are substantially and significantly smaller than the wether flocks (TABLE 5).

TABLE 5. *The size of male, female and old male flocks at Pylos*

	range	mean*	st. dev.	no. of flocks**
male***	30-200	93.8	36.53	56
female	10-100	56.9	22.68	28
old male	60-230	116.1	55.52	11

\* T-tests show female flocks are very significantly smaller than male ( $p \leq .0005$ ) and old male flocks ( $p \leq .0005$ ); male flocks are significantly smaller than old male flocks ( $.025 < p < .05$ ).

\*\* Based only on completely preserved flock sizes (i.e. excluding several flocks included in TABLE 4).

\*\*\* Including OVIS<sup>m</sup> *a-ko-ra* and *we-re-ke*, but not OVIS<sup>m</sup> *wo-ne-we*.

<sup>33</sup> Excluding flocks of males qualified as *pa-ra-jo*, *wo-ne-we*, *we-re-ke* or *a-ko-ra*, but including flocks of males merely qualified by a 'collector' name. *Inter alia*, this implies that *a-ko-ra* does indeed mean something more than association with a 'collector' and perhaps also that OVIS<sup>m</sup> *pa-ra-jo* refers only to old *males*.

There is no obvious reason why female sheep kept for wool (in the manner of the Knossos Da-Dg ewes) should be run in smaller flocks than wethers kept for the same purpose. On the other hand, breeding ewes need better pasture than wethers and also need more attention from the shepherd at lambing time (e.g. Campbell 1964, pp. 19-20; also Lang 1966, p. 253), and for either reason might be run in smaller flocks. Alternatively, the Cn ewes flocks might conceivably represent young or reserve females, run as wool flocks but kept on high quality pasture in preparation for drafting into the breeding flocks.

These two suggestions can be further explored by considering in more detail the relative numbers of ewes and wethers in the Cn flocks. This exercise is complicated by the fragmentary and diverse nature of the Cn series, which plainly includes several different categories of record, probably spans more than one year, and perhaps lists some wool sheep both before and after selection for culling *in addition to* recording their replacements. As a result, some types of sheep may only be dealt with in one category of record, while others may in effect be listed twice or even thrice. Nonetheless, *in surviving records*, ewes make up somewhere between 17 % (assuming all *pa-ra-jo*, *wo-ne-we*, *a-ko-ra*, *we-re-ke* and indeterminate sheep were male and did not duplicate any of the unqualified males listed) and 37 % (considering only female and unqualified male sheep).

Following Killen's argument for the Knossos Da-Dg flocks, Cn wethers may be assumed to have been replaced at something like 5-6 years of age or at a rate of ca. 17-20 % per annum. Adopting the 100 % lambing target of the Knossos Dl(1) series and again assuming an even sex ratio among new born lambs, ca. 34-40 breeding ewes would have been needed for every 100 wethers in the wool flocks<sup>34</sup>. On this basis, breeding ewes should have made up ca. 25-29 % of the adult sheep population, compared with the estimated range of 17-37 % ewes in surviving Cn records. This is sufficiently close to suggest that the Cn ewes records represent flocks of actual rather than future (young or replacement) breeding ewes.

<sup>34</sup> The 'male sheep' in the wool flocks could have been a mixture of wethers and non-breeding ewes, as in the Knossos Dk(2) set. Fewer breeding ewes would have been needed at Pylos, if both ewe and wether lambs were drafted as replacement stock into the wool flocks.

If the surviving Cn records are broadly representative of the relative numbers of wethers and ewes, therefore, the administration at Pylos may have controlled enough breeding females to produce a large proportion, at least, of the annual requirement for replacement wool sheep. These breeding ewes are very unevenly distributed (TABLE 6), however, both between the hither and further provinces (Godart 1977, p. 38) and between 'collector' and 'non-collector' flocks (Bennet in press).

TABLE 6. *The distribution of male and female sheep among different types of flock at Pylos\**

		'non-collector' flocks		'collector' flocks	
		male	female	male	female
hither province	no.	3453	325	1608	537
	%	91	9	75	25
further province	no.	330	150	322	435
	%	69	31	43	57
total	no.	4258		2902	
	%	59		41	

\* Excluding OVIS<sup>m</sup> *pa-ra-jo* and *wo-ne-we* (but not *a-ko-ra* or *we-re-ke* sheep). Bennet (in press, TABLE 3) arrives at a broadly similar breakdown, based on a slightly different selection of texts and types of sheep.

While 'non-collector' sheep in the hither province consist almost exclusively of wethers, ewes make up an increasingly large proportion in the further province and in 'collector' flocks; ewes are in the majority in 'collector' flocks in the further province. Further possible evidence for regional specialisation in sheep breeding is provided by two records (Cn 4 and 595) listing missing 'steading' sheep (OVIS + TA), which have been interpreted as breeding rams (Lang 1966, p. 254). These records deal with *a-si-ja-ti-ja* and *e-ra-te-re-wa-o*, both in the further province, and the breeding rams listed as missing on these two records (92 and 33 respectively) would have been able to service a very large number of breeding ewes<sup>35</sup>.

<sup>35</sup> E.g. recently the ratio of breeding rams to ewes averaged 1:25 among the Sarakatsani of Epirus (Campbell 1964, p. 24), and ranged between 1:10 and 1:70 with a norm of 1:30 in the southern Argolid (Koster 1977, p. 262). A relatively modest ratio of 1:14 would have been required for 125 rams to have serviced the 1782 ewes listed in the Cn records for both the further and hither provinces.



Overall, the breakdown in the Pylos Cn records between 'non-collector' and 'collector' sheep (ca. 59:41) is not very different from that in the Knossos Da-Dg series (69:31), while the greater involvement of Pylos 'collectors' in the further province may be paralleled at Knossos by administrative arrangements in western Crete<sup>36</sup>. The suggestion that Pylos may have been (largely) self-sufficient in replacement wool sheep, however, implies that substantial numbers of young males were transferred from 'collector' breeding flocks (particularly those in the further province) to 'non-collector' wool flocks concentrated in the hither province<sup>37</sup>. This contrasts strongly with the apparent relationship between 'collector' and 'non-collector' flocks at Knossos.

### *Conclusion*

Although Knossos and Pylos both ran wool flocks on a large scale, some differences are apparent between the two palaces in the organisation of sheep husbandry. At Pylos, flocks of elderly wool sheep were evidently culled wholesale and replaced with new stock, whereas the Knossos wool flocks contained small numbers of young and old sheep, implying that culling and restocking of individual flocks took place piecemeal. At Pylos, wool flocks were ostensibly restocked exclusively with wethers, whereas at Knossos these flocks were dominated by wethers but also contained a small minority of female sheep. At Pylos, breeding flocks were heavily concentrated in the further province, whereas at Knossos such regional specialisation was less marked and perhaps non-existent. The Pylos 'collectors' specialised in breeding sheep, perhaps transferring many of their male lambs to 'non-collector' wool flocks, whereas most of their Knossos counterparts seem to have been involved in the entire process of sheep husbandry and textile production.

In each case, these differences between the two palaces could be explained away as the result of partial and unrepresentative preser-

<sup>36</sup> And possibly also at *se-to-i-ja* —Bennet in press.

<sup>37</sup> The *a-ko-ra* sheep might represent replacement stock transferred from breeding flocks in the further province to wool flocks in the hither province (Godart 1977, pp. 37-8 [the arithmetic of the argument is unclear to this reader]); they are always associated with a 'collector' name, however, and so apparently do not represent stock transferred from 'collector' to 'non-collector' flocks.

vation of texts or of inconsistent and ambiguous scribal conventions. Similar differences are apparent in the organisation of palatial textile production, however, with Pylos displaying far greater centralisation and regional specialisation than Knossos (Killen 1984)<sup>38</sup>. Likewise the evidence from the two palaces for breeding flocks differs in both quality and quantity. At Pylos, breeding ewes are not explicitly recorded as such, but are nonetheless identifiable in large enough numbers to suggest that they may have been capable of restocking the palatial wool flocks. At Knossos, breeding ewes are explicitly identified as such, but in numbers far too small to have sustained the known wool flocks. Indeed, in keeping with the relatively decentralised nature of the Knossian textile industry, the three largest groups of known or possible breeding ewes may all have been linked to minor wool flocks quite separate from the main central Cretan group of 60-65,000 wool sheep.

It is beyond dispute that the Linear B records of the Mycenaean palaces have suffered greatly from the accidents of partial and variable preservation and retrieval. It is also clear, however, that the surviving archives contain some striking *lacunae* which are unlikely to be the result solely of partial preservation, but instead reflect the very patchy nature of central control over economic activity within the territory of each palace. A range of commodities (such as pulses) and activities (such as potting, the acquisition of exotic raw materials, and the disposal of finished craft goods) is more or less unknown in the texts, revealing much about the relationship of the palaces both with their subjects and with other polities (Halstead 1992a; 1992b). Caution must be exercised, therefore, in dismissing all gaps in the Linear B evidence as the result of partial preservation. In the present case, critical examination of surviving records of female sheep at Knossos has emphasised the scarcity of breeding ewes and has arguably made explanation simply in terms of poor preservation less plausible.

It seems likely that the palace of Knossos raised only a fraction of its numerous wool sheep and that large numbers of wethers were acquired from outside the 'palatial sector' of the economy. Moreover, the fact that the procurement of these wethers is not

<sup>38</sup> The same contrast may also be apparent in the structure of scribal administration at Knossos and Pylos —Olivier 1984.

recorded in the archives suggests that they were acquired not by taxation (which tended to be regular and documented) but by exchange (cf. Halstead 1992b). These sheep may have been part of a complex series of transactions in which grain, livestock, agricultural and craft labour, and finished craft goods flowed between the palace and the non-palatial sector, providing a source of emergency staple foods for the populace at large and a supply of basic resources and dependent labour for the palace (Halstead in press).

One final consideration may add some support to this interpretation. The foregoing attempt to estimate the reproductive capacity of breeding ewes at Knossos has for the most part adopted a lambing target of 100 %. For present purposes, given the conclusion that this reproductive capacity was inadequate, the adoption of this optimistic target is appropriately cautious. It is unlikely that such a high lambing rate was normally attained<sup>39</sup>, however, suggesting that the herders of individual D1(1) breeding flocks, at least, will have had to make up missing lambs from other sources (cf. Killen in press). The 40-48 % lambing targets indicated for the D1 and D0 breeding flocks are more feasible, but may often have been unattainable because of the large number of missing ewes. Thus the high lambing targets (and large numbers of missing ewes and lambs) of the extant breeding records imply that palatial ewe flocks too were partly sustained by stock transferred from «non-palatial» flocks.

To cover such shortages, it is possible that the Knossos breeding flocks retained any surplus female lambs, but in that case the scarcity of recorded breeding ewes is even more striking. Alternatively, the palace could have run 'reserve' females as wool sheep, and the minority of females in the Da-Dg wool flocks may have been distinguished as such because of their potential as replacements for sterile or lost ewes within the breeding flocks. The 8000-8500 Da-Dg females represent a very large reserve, however, in comparison to *known* palatial breeding ewes (cf. TABLE 3). Moreover, the distribution of females through the wool flocks does nothing to strengthen their identification as replacement breeding stock. They are dispersed through 50 % of the Da-Dg wool flocks (FIGURE 1), whereas concentration in just a few flocks would have facilitated

<sup>39</sup> For extensive herding, an average lambing rate of 80 % or less is more realistic, cf. Payne 1973; Dahl and Hjort 1976; Koster 1977, p. 262; Redding 1981.

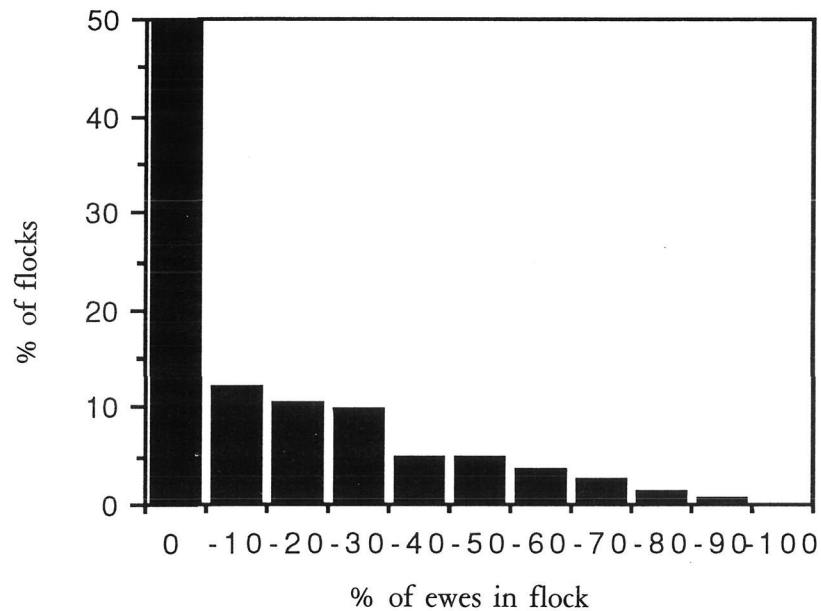


FIGURE 1. *The distribution of female sheep in individual wool flocks in the Da-Dg records at Knossos*

Based on 434 Da-Dg (+ Dv) flock records, excluding texts where the number of male or female sheep is clearly lost; missing, old and yearling sheep (OVIS<sup>m</sup> *pa*, *pe* and *o*) are omitted from the flock totals. Because the figure for male sheep precedes that for female sheep (if any) in these texts, a few broken texts will wrongly have been treated as complete and the percentage of flocks containing no females will have been inflated slightly.

bureaucratic control of their eventual drafting as breeding ewes and would have made it possible for them to be run on higher quality pasture. Equally, they make up between 0 % and 87 % of individual wool flocks, whereas a more regular distribution would have ensured that replacement ewes were available throughout central Crete. Finally, although most flock totals were round numbers (i.e. multiples of 10 or 100), these were frequently made up of odd numbers of ewes and wethers (e.g. Killen 1964, p. 2), suggesting that the sexual composition of individual flocks was of secondary bureaucratic importance to their overall size.

On the other hand, if sheep breeding largely took place outside palatial control, most of the females in the Da-Dg flocks may have been transferred (along with a much large number of spare male sheep) from non-palatial breeding flocks. In this case, they would presumably represent discarded sterile ewes and any ewe lambs not needed in non-palatial flocks either for breeding or for reserve purposes. Until very recently, shepherds in Greece and neighbouring

countries tended to retain most or even all female lambs to compensate for inevitable sterility and premature mortality among breeding ewes and, where possible, to build up flock size as a defence against occasional disastrous losses. Ewe lambs were more likely to be disposed of (or adult ewes culled) after a run of good lambing seasons or when a failed grain harvest or impending wedding made it necessary to exchange livestock in order to acquire other resources (cf. Dahl and Hjort 1976; Campbell 1964, p. 22; Koster 1977; Payne 1973; Redding 1981; Halstead 1990). In Late Bronze Age Crete, the owners of non-palatial flocks will have faced similar losses among their breeding ewes and may likewise have responded by retaining most of their ewe lambs. If so, the proportion of female sheep disposed of by non-palatial flocks would usually have been very low, but might occasionally have been high for individual flocks or localities. The recorded contribution of females to individual Da-Dg flocks is usually low but occasionally high (FIGURE 1), and so is consistent with the replenishment of these palatial wool flocks principally from non-palatial breeding flocks.

For the staple grain crops which fed their numerous dependents (servants, craft workers etc.), the Mycenaean palace apparently relied on two sources of supply: the harvest from palace-run, arable estates and surplus grain acquired (probably by exchange) from the non-palatial sector (Halstead 1992a; 1992b). This examination of the textual evidence for breeding flocks suggests that Knossos, at least, likewise used both the progeny of its own breeding flocks and surplus lambs acquired from the non-palatial sector to restock palatial wool flocks. In each case, the palace specialised in extensive husbandry (plough-based cereal agriculture, running wether flocks for wool) involving a low input of human labour and modest risk of failure (cf. Halstead 1992a); the more labour-intensive and risky enterprises of growing pulses and breeding sheep were largely left to the non-palatial sector. By contrast, if Pylos was indeed (largely) self-sufficient in the breeding of wool sheep, this represents a significant intensification of palatial input. Such a shift is consistent with other indications of more extensive and centralised bureaucratic control at Pylos than at Knossos (e.g. Killen 1984).

## BIBLIOGRAPHY

- J. Bennet, 1985. «The structure of the Linear B administration at Knossos», *American Journal of Archaeology* 89, pp. 231-49.
- J. Bennet, in press. «'Collectors' or 'owners'? An examination of their possible functions within the palatial economy of LMIII Crete», in J.-P. Olivier (ed.), *Mykenäika: actes du 9e colloque internationale sur les textes mycéniens et égéens* (BCH supplementary volume) [Paris 1992, pp. 65-101].
- E. L. Bennett and J.-P. Olivier, 1973. *The Pylos tablets transcribed, I: texts and notes* (*Incunabula Graeca* 51). Rome, Edizioni dell'Ateneo.
- J. K. Campbell, 1964. *Honour, family and patronage*. Oxford: University Press.
- G. Dahl and A. Hjort, 1976. *Having herds: pastoral herd growth and household economy*. Stockholm: University of Stockholm.
- L. Godart, 1971. «Les tablettes de la série Co de Cnossos», *Minos* 12, pp. 418-24.
- L. Godart, 1977. «Les ressources des palais mycéniens de Cnossos et Pylos», *Les Études Classiques* 45, pp. 31-42.
- P. Halstead, 1990. «Waste not, want not: traditional responses to crop failure in Greece», *Rural History* 1, pp. 147-64.
- P. Halstead, 1992a. «Agriculture in the Bronze Age Aegean: towards a model of palatial economy», in B. Wells (ed.), *Agriculture in ancient Greece*. Stockholm: Swedish Institute at Athens, pp. 105-16.
- P. Halstead, 1992b. «The Mycenaean palatial economy: making the most of the gaps in the evidence», *Proceedings of Cambridge Philological Society* 38, pp. 57-86.
- P. Halstead, in press. «Banking on livestock: indirect storage in Greek agriculture», *Bulletin on Sumerian Agriculture* 7.
- J. T. Killen, 1963. «Some adjuncts to the SHEEP ideogram on Knossos tablets», *Eranos* 61, pp. 69-93.
- J. T. Killen, 1964. «The wool industry of Crete in the late bronze age», *Annual of the British School at Athens* 59, pp. 1-15.
- J. T. Killen, 1974. «A problem in the Knossos Lc(1) (cloth) tablets», *Hermathena* 118, pp. 82-90.
- J. T. Killen, 1976. «Linear B *a-ko-ra-ja/-jo*», in A. Morpurgo Davies and W. Meid (eds.), *Studies in Greek, Italic and Indo-European linguistics offered to L. R. Palmer*. Innsbruck, pp. 117-25.
- J. T. Killen, 1977. «The Knossos texts and the geography of Mycenaean Crete», in J. L. Bintliff (ed.), *Mycenaean geography*. Cambridge: British Association for Mycenaean Studies, pp. 40-7.
- J. T. Killen, 1983. «Mycenaean possessive adjectives in *e-jo*», *Transactions of the Philological Society*, pp. 66-99.
- J. T. Killen, 1984. «The textile industries at Pylos and Knossos», in T. G. Palaima and C. W. Shelmerdine (eds.), *Pylos Comes Alive*. New York: Fordham University, pp. 49-63.
- J. T. Killen, 1985. «The Linear B tablets and the Mycenaean economy», in A. Morpurgo Davies and Y. Duhoux (eds.), *Linear B: a 1984 Survey*. Louvain: University Press, pp. 241-305.

- J. T. Killen, 1988. «Epigraphy and interpretation in Knossos WOMAN and CLOTH records», in J.-P. Olivier and T. G. Palaima (eds.), *Texts, tablets and scribes* (Minos supplementary volume 10). Salamanca: University Press, pp. 167-83.
- J. T. Killen, in press. «Records of sheep and goats at Mycenaean Knossos and Pylos», *Bulletin on Sumerian Agriculture* 7.
- J. T. Killen and J.-P. Olivier 1989. *The Knossos Tablets*<sup>5</sup> (Minos supplementary volume 11). Salamanca: University Press.
- H. A. Koster, 1977. *The ecology of pastoralism in relation to changing patterns of land use in the northeast Peloponnese*. Ph. D. dissertation, University of Pennsylvania.
- M. Lang, 1966. «Cn flocks», in J. Chadwick and L. R. Palmer (eds.), *Proceedings of the Cambridge colloquium on Mycenaean studies*. Cambridge: University Press, pp. 250-59.
- J. K. MacArthur, 1981. «The textual evidence for location of place-names in the Knossos tablets», *Minos* 17, pp. 147-210.
- MAFF, 1956. *Sheep breeding and management (Ministry of Agriculture, Fisheries and Food Bulletin 166)*. London: HMSO.
- J.-P. Olivier, 1967. «La série Dn de Cnossos», *SMEA* 2, pp. 71-93.
- J.-P. Olivier, 1972. «La série Dn de Cnossos reconsidérée», *Minos* 13, pp. 22-28.
- J.-P. Olivier, 1984. «Administrations at Knossos and Pylos: what differences», in T. G. Palaima and C. W. Shelmerdine (eds.), *Pylos Comes Alive*. New York: Fordham University, pp. 11-18.
- J.-P. Olivier, 1988. «KN: Da-Dg», in J.-P. Olivier and T. G. Palaima (eds.), *Texts, tablets and scribes* (Minos supplementary volume 10). Salamanca: University Press, pp. 219-67.
- L. R. Palmer, 1963. *The interpretation of Mycenaean Greek texts*. Oxford: University Press.
- S. Payne, 1973. «Kill-off patterns in sheep and goats», *Anatolian Studies* 23, pp. 281-303.
- R. W. Redding, 1981. *Decision making in subsistence herding of sheep and goats in the Middle East*. Ph. D. thesis, University of Michigan.
- C. R. W. Spedding, 1970. *Sheep production and grazing management*<sup>2</sup>. London: Baillière, Tindall and Cassell.
- M. Ventris and J. Chadwick, 1973. *Documents in Mycenaean Greek*<sup>2</sup>. Cambridge: University Press.