Ageing and Sexing Animal Bones from Archaeological Sites

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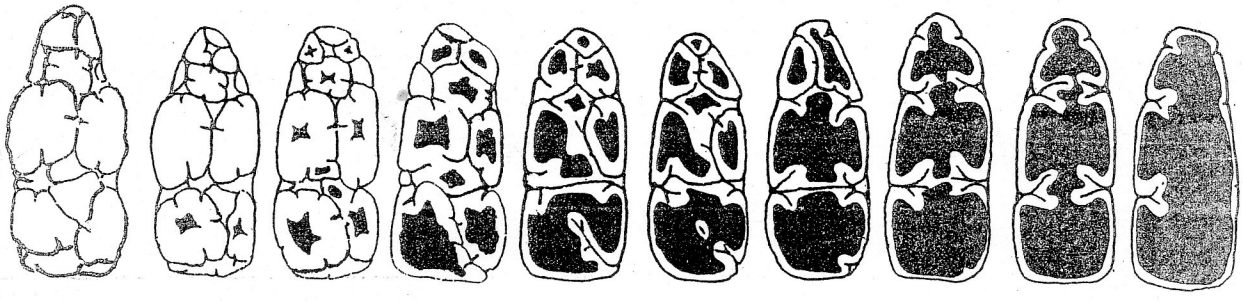
Bob Wilson, Caroline Grigson and Sebastian Payne



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Annie Grant

28 Beckwith Road,
London. SE24 9LG

THE USE OF TOOTH WEAR AS A GUIDE TO THE AGE OF DOMESTIC UNGULATES

A method for recording the eruption and wear of the mandibular teeth of cattle, sheep/goats and pigs was published by the author in 1975. Since then, that method has been applied to a large number of mandibles from a variety of British sites of periods from the Bronze Age to the eighteenth century. This paper summarizes the original paper and discusses the application of the method outlined there to a larger and more varied sample.

When a tooth erupts, its upper surface is completely covered in enamel. As the tooth comes into wear, the enamel of the occlusal or biting surface is gradually worn away, revealing the darker coloured dentine below. The shape of the enamel and dentine on the occlusal surface forms distinct patterns. At first, 'islands' of internal enamel are left within the dentine, but as wear proceeds, these islands gradually disappear so that the occlusal surface of the tooth is formed entirely of dentine, with only a border of enamel around the edge. Finally, the tooth may wear right down until only the roots are left in the jaw. Figures 1 - 3 show stages of wear observed by the author on the last four teeth of the mandibular row of cattle, sheep/goats and pigs respectively. These stages are termed tooth wear stages or T.W.S. and are shown from the earliest stages of wear, when only the enamel surface is worn and no dentine is exposed (T.W.S. a), to the latest stages seen, when in some instances only the roots remain in the jaw. Since M_1 and M_2 are structurally very similar, the wear stages are the same for both these teeth.

Two further points should be noted. Firstly, in some pig mandibles and especially in sheep/goat mandibles, overcrowding of the jaw, often appearing to follow the eruption of P_4 may lead to wear of the mesial and distal surfaces of the teeth. This may be visible on the occlusal surface, but should be ignored for the purpose of identifying a tooth wear stage. Secondly, it is important to note that the intervals that occur between the T.W.S. illustrated do not represent equal intervals of time. Some stages last for a relatively short period, while others last much longer. For example, T.W.S. g in all three lower molars of sheep is a very long lasting stage - the pattern of enamel and dentine on the occlusal surface of the teeth remains more or less unchanged while a significant amount of the tooth is worn away, The early stages of wear in most teeth tend, however, to be relatively short lived.

It has been found that almost every worn tooth observed can readily be assigned to one of the T.W.S. illustrated. Occasionally there are problems. Since the wear on a tooth is a continuous process, some teeth may exhibit wear patterns that lie between two T.W.S. illustrated. In these instances, the teeth can be assigned to which ever T.W.S. most closely resembles the observed wear pattern, with the wear on the anterior pillar generally considered as more diagnostic than the wear on the other pillar/pillars.

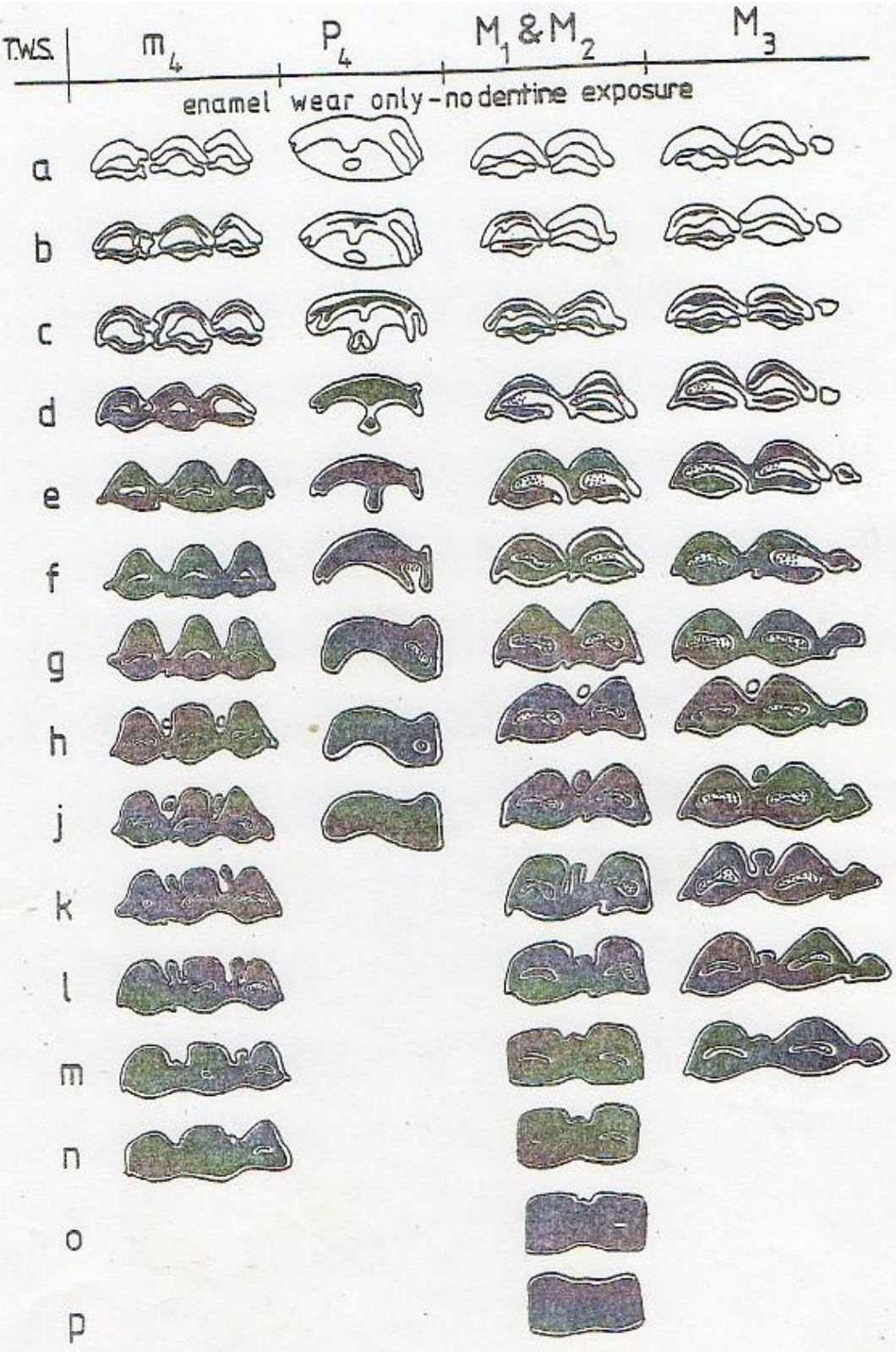


Figure 1 Tooth wear stages of cattle teeth

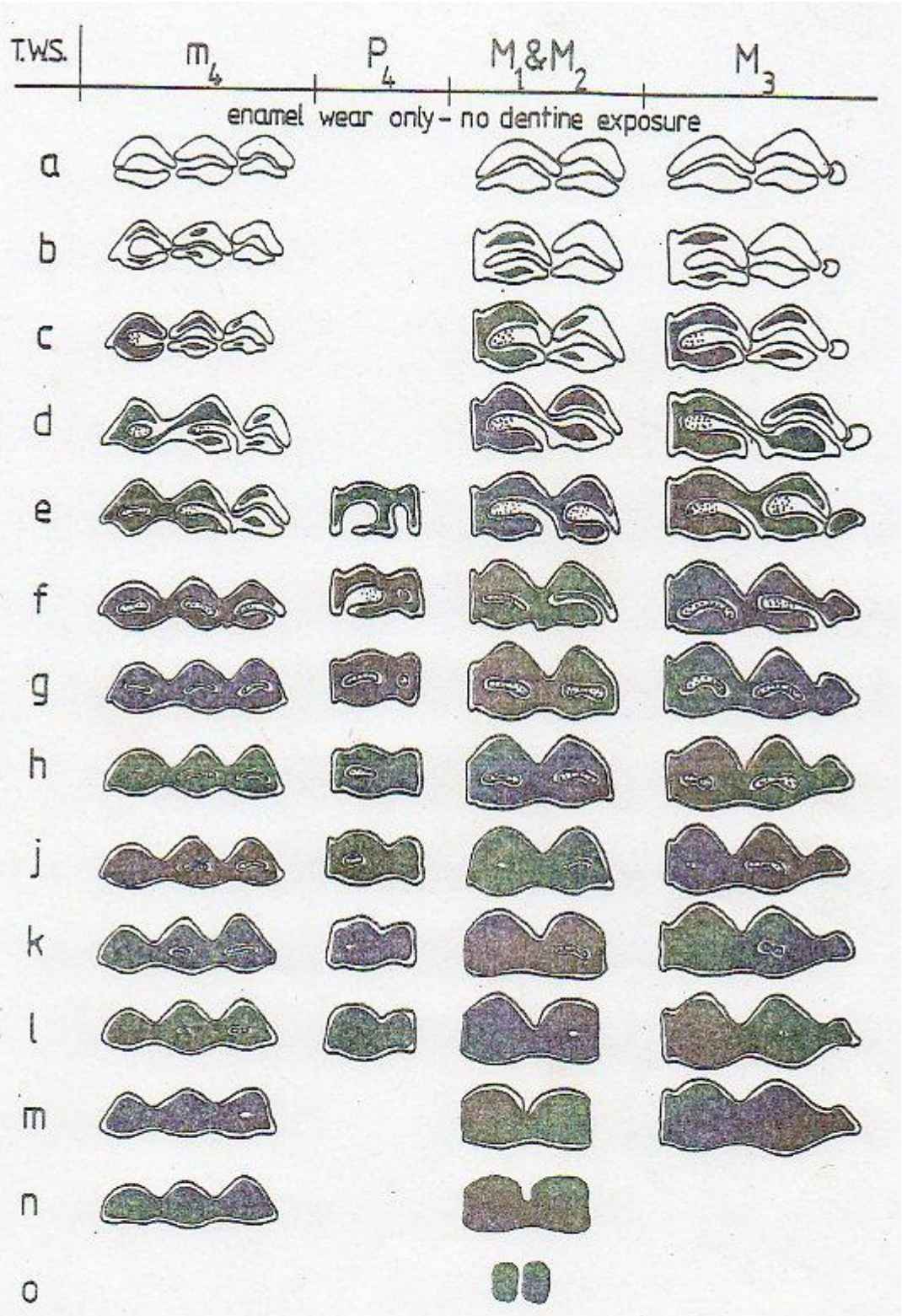
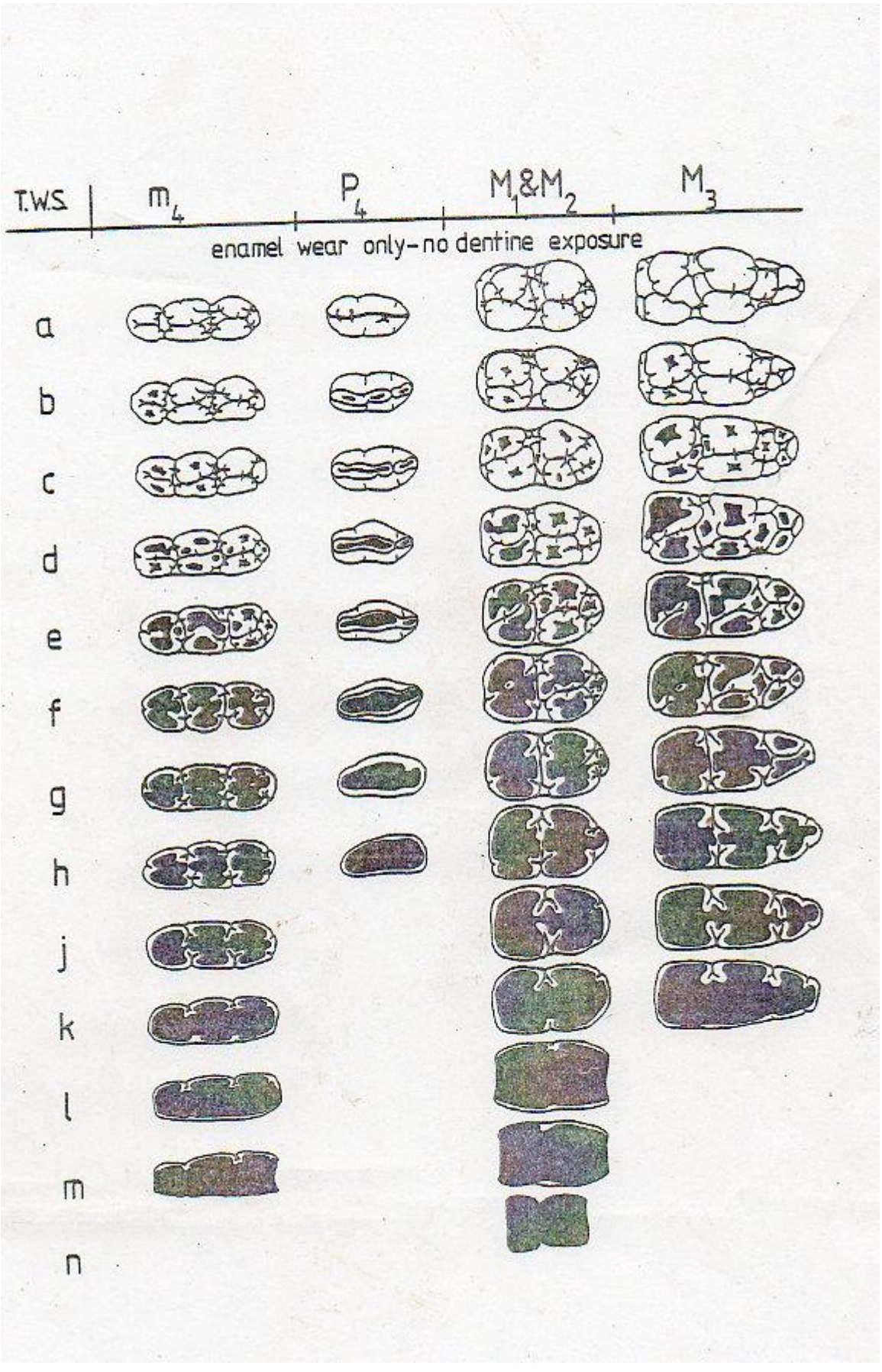


Figure 2 Tooth wear stages of sheep/goat teeth


T.W.S.
m4
P4
M1&M2
M3
enamel wear only – no dentine exposure
a
b
c
d
e
f
g
h
j
k
l
m
n

The wear on a tooth is normally heaviest on the anterior pillar since this erupts first and consequently comes into wear sooner than the other pillar or pillars. Occasionally teeth that have more severe wear on the posterior than on the anterior pillar have been observed. This may be due to some anomaly in the upper jaw, such as the loss of a tooth. In such cases, the assignation of a T.W.S. is more difficult. The writer has found it best to assign to such a tooth a T.W.S. that shows approximately the same amount of wear as the anomalous tooth. The anomaly may be separately noted. Uneven wear is found fairly frequently on heavily worn teeth, but this does not usually affect the pattern of wear exhibited.

The eruption and wear of P_4 in sheep/goats is frequently difficult to record accurately as in many instances observed by the writer, this tooth becomes impacted against M_1. This seems to affect not only the angle of the tooth and therefore the pattern of wear, but also the rate of eruption. For this reason, early stages of wear of P_4 are not illustrated.

Finally, occasional problems are encountered in assigning precise wear stages to cattle molars, as the height and therefore the wear of the accessory pillar may vary from tooth to tooth. However, any inaccuracy is unlikely to be of more than one or two T.W.S.

By reference to the tooth wear charts, it has been possible to record accurately and quickly the state of wear of the deciduous fourth molar, the permanent fourth premolar and the three permanent molars of cattle, sheep/goat and pig mandibles from a wide variety of archaeological material. For teeth that are erupting, but not yet in wear, the notation proposed by Ewbank, Phillipson, Whitehouse and Higgs (1964) is used, although with this method only the eruption of the anterior pillar of the teeth is recorded. The symbols used are:-

C - perforation in crypt visible
V - tooth visible in crypt but below head of bone
E - tooth erupting through bone
  - tooth half erupted
U - tooth almost at full height but unworn

The next stage would be T.W.S. a as shown in the relevant tooth wear chart.

The writer records each mandible across a form with vertical columns ruled for each individual tooth. Although the T.W.S. of m_2 and m_3 or P_2 and P_3 are not given, their presence and state of eruption may be recorded, together with details of any anomalies such as caries, impacted teeth, rotated teeth, supernumary teeth or oral pathology. Ante- and post-mortem tooth loss is also noted. Deciduous teeth are distinguished from permanent teeth by the use of a bracket around the relevant T.W.S.

The method as outlined so far, merely gives a way of recording the state of eruption and wear of mandibular teeth. With the data in this form, analysis and interpretation are tedious and, where a large number of mandibles have been recorded, very time consuming. Thus, once the tooth wear and eruption of a group of mandibles has been recorded, a numerical value is assigned to each mandible, representing the total amount of wear on each of the molar teeth in the tooth row. This is known as the mandible wear stage or M.W.S. and may represent the T.W.S. of a single permanent molar, when for example only M_1 has erupted, or a combination of two or three T.W.S. The eruption and wear stages of the individual teeth are given a numerical value as shown in Table 1.

Table 1

Eruption/T.W.S.	Numerical equivalent
C	1
V	2
E	3
½	4
U	5
a	6
b	7
c	8
d	9
e	10
f	11
g	12
h	13
j	14
l	15
k	16
m	17
n	18
o	19
p	20

The M.W.S. is obtained by totalling the numerical values of all the permanent molar teeth in the jaw. P_4 and m_4 are not included in the M.W.S. For example, a mandible with P_4 at ½, M_1 at g , M_2 at e and M_3 at b (g e b) will have a M.W.S. of 29. In general, the higher the M.W.S., the older the animal will have been at death. Once the M.W.S. has been calculated for each mandible, it becomes easy to order the mandibles in probable relative age.

However, with archaeological material, a major difficulty is encountered at this point. In order to assign a M.W.S. to a mandible, it is necessary to have a T.W.S. or an eruption stage for each molar tooth in the tooth row, but many mandibles recovered during excavation are broken, or have post-mortem tooth loss. However, these mandibles may be given a M.W.S. if the eruption stage or the T.W.S. of the missing tooth or teeth can be predicted. The prediction of the T.W.S. of any missing tooth in a mandible is made by reference to complete molar rows in which the wear stages of the teeth are the same as those that are present in the incomplete mandibles. In Table 2, 3 and 4 are given complete lists of each combination of T.W.S. observed by the writer for cattle, sheep/goat and pigs, arranged according to their M.W.S. The provenance of the mandibles examined is given in the notes to the tables. If we look at these M.W.S., calculated from complete mandibles, it is clear that in many instances a single M.W.S. can represent more than one set of three individual T.W.S. For example, three sheep mandibles with M_1, M_2 and M_3 respectively at T.W.S. h, g and f, j, g and e and g, g and g would each have a M.W.S. value of 36. In order to distinguish between the different combinations of T.W.S. that form each M.W.S., the vertical columns in the tables are ordered so that for each M.W.S., the mandibles on the left side are those where the wear is comparatively heavier on M_3 and lighter on M_1, while on the right

side are those where the tooth wear is heavier on M_1 and lighter on M_3. Each vertical column shows, as far as was practical, a possible sequence of wear, although in many instances the wear on a mandible could proceed to the next stage in an adjacent column. For example, the wear on a sheep/goat mandible at M.W.S. 24, with the three molar teeth at T.W.S. g, e and V could have proceeded, given the evidence shown in Table 3, to M.W.S. 25 with the three molar teeth at T.W.S. g, e and E or g, f and V.

The tables also give the observed T.W.S. for m_4 and P_4 for each M.W.S. It is unfortunate that although a fairly large number of mandibles were available to the writer, there are gaps in the sequences of wear, especially in the cattle M.W.S sequence. These gaps in the cattle M.W.S. sequence occur especially in the stages representing young and juvenile animals and are thought to reflect, at least in part, the cattle management practices of the sites studied. Fortunately the cattle age structure at the Iron Age and Roman site at Odell, Bedfordshire, recently analysed by the writer (Grant, in press), was rather different to that seen at other sites studied and allowed several gaps to be filled. It is hoped that even more gaps will be filled as more sites are studied.

The tables just described can be used for two purposes. Firstly they can be used to find the M.W.S. for complete molar rows. Secondly, they can be used to predict the wear stage on missing teeth. In some instances, a missing tooth's T.W.S. can be predicted with a fair degree of confidence. If, for example, a sheep/goat mandible had only M_2 and M_3 present and these teeth were at T.W.S. e and V respectively, then the missing M_1 would almost certainly have been at T.W.S. g, with a small chance that it might have been at T.W.S. h. The M.W.S. of this mandible could thus be fairly confidently predicted as 24.

In many cases, mandibles with only one missing molar tooth can be assigned M.W.S. within narrow limits, but in some cases the range of possible M.W.S. is unacceptably large. A sheep/goat mandible with only M_1 present at T.W.S. g could indicate a M.W.S. of anything from 15 to 36. If P_4 or m_4 were present, the range could be narrowed down, but the M.W.S. range might still be too wide to allow that particular mandible to be included in any detailed analysis of the age structure of a group of sheep/goat mandibles.

The range of likely M.W.S. of a damaged jaw may also be narrowed down if the frequency of occurrence of particular combinations of T.W.S. is taken into account. Tables 2 - 4 not only include the numbers of complete mandibles seen for each M.W.S., but also the number of examples of each particular combination of T.W.S. that have been seen by the writer up to the time of writing. Some combinations of T.W.S. have been found to be very common while others are much rarer. By and large the most common combinations are to be found in the central columns of the tables (columns ii - iv for cattle and sheep/goat and columns iii - vi for pigs). If only the more commonly occurring T.W.S. combinations are used for estimating missing values, a more precise estimate of the probable M.W.S. of a damaged mandible may be possible. For example, a sheep/goat mandible with M_1 at T.W.S h, M_2 at g and M_3 missing (h g -) could, according to Table 3, have had a M.W.S. of 32, 33, 34, 35, 36 or 37 (i.e. h g b, h g c, h g d, h g e, h g f or h g g). However, we can see that mandibles at h g b and h g c are relatively rare, while those at h g d - h g g are much more common. The M.W.S. of this mandible could then be estimated as 34 - 37.

Table 2 Cattle: mandible wear stages

M.W.S.	(m_4) P_4	i	ii	iii	iv	v	N
1	(½)			C			
2	(½,U)			V			
3	(½,U,b)			E			
4	(e,f)			½ 2			2
5				½ C 1			1
6							
7							
8	(j)			b C 1			1
9				b V 1			1
10	(g)		b E 1	c V 1			2
11			c E 1				1
12	(d,h)		d E 1	e V 2			3
13	(h,j)		d ½ 1	e E 2			3
14	(j)			e ½ 4	f E 2		6
15							
16		c a V 1					1
17			d b C 1				1
18				f U V 1			1
19				f b C 1			1
20				g b C 3			3
21	(h)		g b V 1	g c C 4	h b C 1		6
22							
23	(k)		g c E 1	g d V 1			2
24	(h,m)			g d E 4			4
25	(j)			g d ½ 1		g f V 2	3
26	(k)		g d U 1	g e ½ 2		g f E 1	4
27	(g)		g e U 1	g f ½ 1	h e ½ 1	g g E 1	4
28				h f ½ 2			2

Notes for Tables 2 to 4

M.W.S. = Mandible wear stage

N = number of complete examples seen of each M.W.S., with the number of each individual combination of T.W.S. given separately.

The cattle, sheep/goat and pig mandibles whose M.W.S. are given in the following tables were found with other animal bones material during excavations at the following locations:

Fishbourne, Sussex (Grant 1971b)
Bedford (Grant 1970; 1974; 1979b)
Lyveden, Northamptonshire (Grant 1971a; 1975c)
Portchester Castle, Hampshire (Grant 1975a; 1975b; 1978a; in press)

Table 2 Cattle, cont.

29	(j)			h f U 2	j f ½ 1		3
30			g f b 1	h f a 1			2
31	E		g g b 1				1
32	U		g g c 1	h g b 1	j f b 1		3
33			h g c 1	j g b 2	j f c 1		4
34	d		h g d 1	j g c 2	k f c 1	k g b 2	6
35	(o), ½		j g d 1	k g c 1			2
36	a		j h d 1	k g d 7			8
37		h g g 2					2
38	E,U,b,c		j g g 3	k g f 7	k j d 2		12
39	½,b,c,d,e	j j f 1	k g g 4	k h f 2	k j e 2		9
40	c		k h g 1	k j f 5			6
41	c,e,f,g,h	j j h 1		k j g 20	l h g 1	l j f 1	23
42	c,d,e,f			k k g 13	l j g 1	l k f 1	15
43	e,f,g			l k g 19			19
44	d		k k j 10	l k h 1	l l g 3		14
45	f,g,h			l k j 21	m l g 3		24
46	f,g	l l j 1	l k k 13	m k j 1	n l g 1		16
47	g,h	l l k 2	m k k 5	m l j 2			9
48	g k			m l k 8	n m h 1		9
49			m l l 5	n l k 2		p m g 1	8
50	g,h,j		m m l 1	n l l 2	n m k 1	o l k 1	5
51	h		m m m 3			o l l 3	6
52	h			n m m 1	o m l 1		2
53	h			o m m 1			1
54	h			o n m 1			1

Notes, cont.

Dorchester-on-Thames, Oxfordshire (Grant 1978b)
Bath, Avon (Grant 1979a)
Burgh Castle, Norfolk (Grant in press)
Ashville, Oxfordshire (Wilson 1978)
Danebury, Hampshire (Grant in preparation)

Table 3 Sheep/goat: mandible wear stages

M.W.S.	(m_4) P_4	i	ii	iii	iv	v	vi	N
1	(E, ½, a)			C				
2	(E, ½, U, a, b, c, d)			V				
3	(c, d, e)			E				
4	(c, d, e, f)			E C 14	½ 5			19
5	(c, d, e, f, g)		E V 3	½ C 51	U 5			59
6	(c, d, e, f, g)		½ V 3	U C 19				22
7	(f)		U V 3	a C 6				9
8	(f, g)		a V 1	b C 53				54
9	(f, g, h)		b V 16	c C 32				48
10	(f, g, h)		b E 1	c V 32	d C 14			47
11	(f, g, h, j)		c E 2	d V 31	e C 3			36
12	(f, g, h, j)		d E 8	e V 23				31
13	(g, h)			e E 7	f V 1			8
14	(g, h, j)			e E C 1	f E 7	g V 1		9
15	(g, h, l)			f E C 1	f ½ 1	g E 2		4
16	(g, h, k)		e U C 1	f ½ C 2		g ½ 2		5
17	(g, h, j)	d b C 1	e a C 1	f U C 4	g ½ C 2			8
18	(h, j)		e b C 2	f a C 1	g U C 1			4
19	(g, h, j, k)		e c C 1	f b C 18	g a C 2		f c 1	22
20	(h, j)		e ctV 1	f c C 7	g b C 12			20
21	(g, h, j, k, m)	e b ½ 1	f c V 3	f d C 2	g c C 31	g b V 1	h b C 1	39
22	(g, h, j, k)	f c E 3	g c V 12	g d C 11				26
23	(h, j, l, m)E	f d E 3	g c E 2	g d V 8	g e C 3		h d C 1	17
24	(h, k, l, m)½	f d ½ 1	g c ½ 1	g d E 16	g e V 13	g f C 2	h d V 2	35
25	(j, k, l)V, ½		g d ½ 1	g e E 16	g f V 6		h e V 1	24

Table 3 Sheep/goat, cont.

26	(l)E,a,b							g	e	½	10	g	f	E	3			h	e	E	1	14
27	(j,m)E,½,b							g	e	U	4	g	f	½	4	g	g	E	1			9
28	(n)½,d,f			g	d	b	3	g	e	a	3	g	g	½	1	h	g	E	1			8
29	g,f			g	d	c	1	g	e	b	25									h	f	U	1	27
30	½,d,e,f,g			g	e	c	9	g	f	b	32					h	e	b	1				42
31	U,a,e,f,g,h			g	f	c	23	g	g	b	25									h	f	b	2	50
32	½,U,e,f,g,h			g	f	d	5	g	g	c	54	h	g	b	7	h	e	d	1	h	f	c	5	72
33	e,f,g			g	f	e	1	g	g	d	33	h	g	c	9	h	f	d	1					44
34	e,f,g,h							g	g	e	59	h	g	d	16	h	f	e	2	j	g	c	3	80
35	f,g,h			g	g	f	18	h	g	e	30													48
36	g,h			g	g	g	12	h	g	f	21	j	g	e	16									49
37	f,g,h,j			h	g	g	19	j	g	f	24	k	g	e	2									45
38	g,h,j,k			j	g	g	40	j	h	f	1	k	g	f	8	l	g	e	1					50
39	g,h,j,m							j	h	g	4	k	g	g	50									54
40	g,h,j,m			k	h	g	11	l	g	g	27													38
41	j,k,l			k	j	g	3	l	h	g	2	m	g	g	20	m	h	f	1					26
42	h,j,k,l			l	j	g	5	m	h	g	28													33
43	h,j,k,l							m	j	g	26													26
44	l			m	j	h	2	m	k	g	11													13
45	k,l	l	l	h	1			m	k	h	5	m	l	g	2	n	k	g	1					9
46	k,l							m	l	h	2	m	m	g	1									3
47	l			m	k	k	1	m	l	j	2	m	m	h	2	n	l	h	1					6
48								m	l	k	2	m	m	j	2									4
49												n	m	j	1									1
50												n	m	k	1									1
51								m	m	m	1													1
52								o	m	m	2													2

Table 4 Pig: mandible wear stages

MWS	(m_4) P_4	i	ii	iii	iv	v	vi	vii	viii	ix	N
1	(E,½,U,a,b)				C						
2	(U,a,b,c,e)				V						
3	(b,c,d)				E						
4	(b,c)			E C 3	½ 5						8
5	(b)			E V 1	½ C 2	U 1					4
6	(b,c,f,k)				U C 5						5
7	(b,c,d,e)				a C 10						10
8	(b,c,f,k)			a V 10	b C 7						17
9	(e,f,h,j)				b V 11	c C 2					13
10	(g,j,k)			b V C 4	b E 3	c V 3	d C 1				11
11	(c,d)				b E C 3	c V C 2		e C 1			6
12	(f)		b E V 1	b U C 1	c E C 3		d E 1				6
13	(k)				c ½ C 1	d E C 1	e E 1	f V 1			4
14	(k)				c U C 1	e E C 1	f E 1				3
15	(g,E)				c a C 2	e ½ C 2					4
16	U				c a V 3	e U C 1					3
17	(k,l)½		c a E 1	c b V 1	d a V 3	e a C 1					6
18	U,b			d b V 5	e a V 5	e b C 5					15
19	U,b,c			d b E 3	e b V 4	e c C 1					8
20	b		d b ½ 2	d c E 1	e b E 2	f b V 6	g a V 1				12
21	b		d b U 1	e c E 1		g b V 4					6
22	b,c	d c U 1	e b U 1	f b ½ 1	g b E 2	g c V 4	h b V 1				10
23	b	d c a 1	e c U 2	f c ½ 1	g b ½ 1	g c E 2	h b E 2				9
24	b,c	d c b 1	f c U 1		g b U 1	g c ½ 4	h c E 3	g d E 1	h d V 1		12
25	b		f c a 1		g c U 3	h c ½ 1	h b U 1	h d E 1	j b ½ 1	j c E 1	9

Table 4 Pig, cont.

26	b,d				g	c	a	2	g	e	½	1	h	c	U	1			h	b	a	3	h	d	½	1	13
27	b,c	f	d	b	2	g	c	b	1	g	d	a	4	h	c	a	2	j	c	U	5					16
28	b,c,d					g	d	b	5	h	d	a	1	j	c	a	2	k	c	U	4					14
29	c,d					g	e	b	3	h	e	a	1	j	c	b	1					j	d	a	1	7
30	b,c,e					g	f	b	1					j	d	b	3	j	e	a	7	k	d	a	1	14
31	c,d					h	f	b	1	j	e	b	5	k	d	b	2	j	f	a	1	k	e	a	2	13
32	d,f													k	e	b	2	k	f	a	2	l	e	a	1	6
33	d,e					h	f	d	1	j	g	b	1	k	f	b	6					l	e	b	2	11
34	e									j	g	c	1	k	g	b	3					m	e	b	1	6
35	e,f					l	f	c	1					l	g	b	3					m	f	b	3	9
36	e	j	h	d	1					k	h	c	1	l	g	c	2	m	g	b	1	m	f	c	2	7
37	e,f					l	h	c	1					m	g	c	1	m	h	b	2					5
38	e,f									l	h	d	1	m	g	d	1	m	h	c	2					6
39	f																					n	g	d	1	2
40	d,g													m	j	d	3	n	h	d	1					5
41						m	h	f	1					n	j	d	1									2
42	f,g									m	k	e	2	n	k	d	2	o	j	d	1					5
43										m	l	e	2	n	l	d	1									3
44																										
45																										
46																										
47	h									n	m	g	1													1

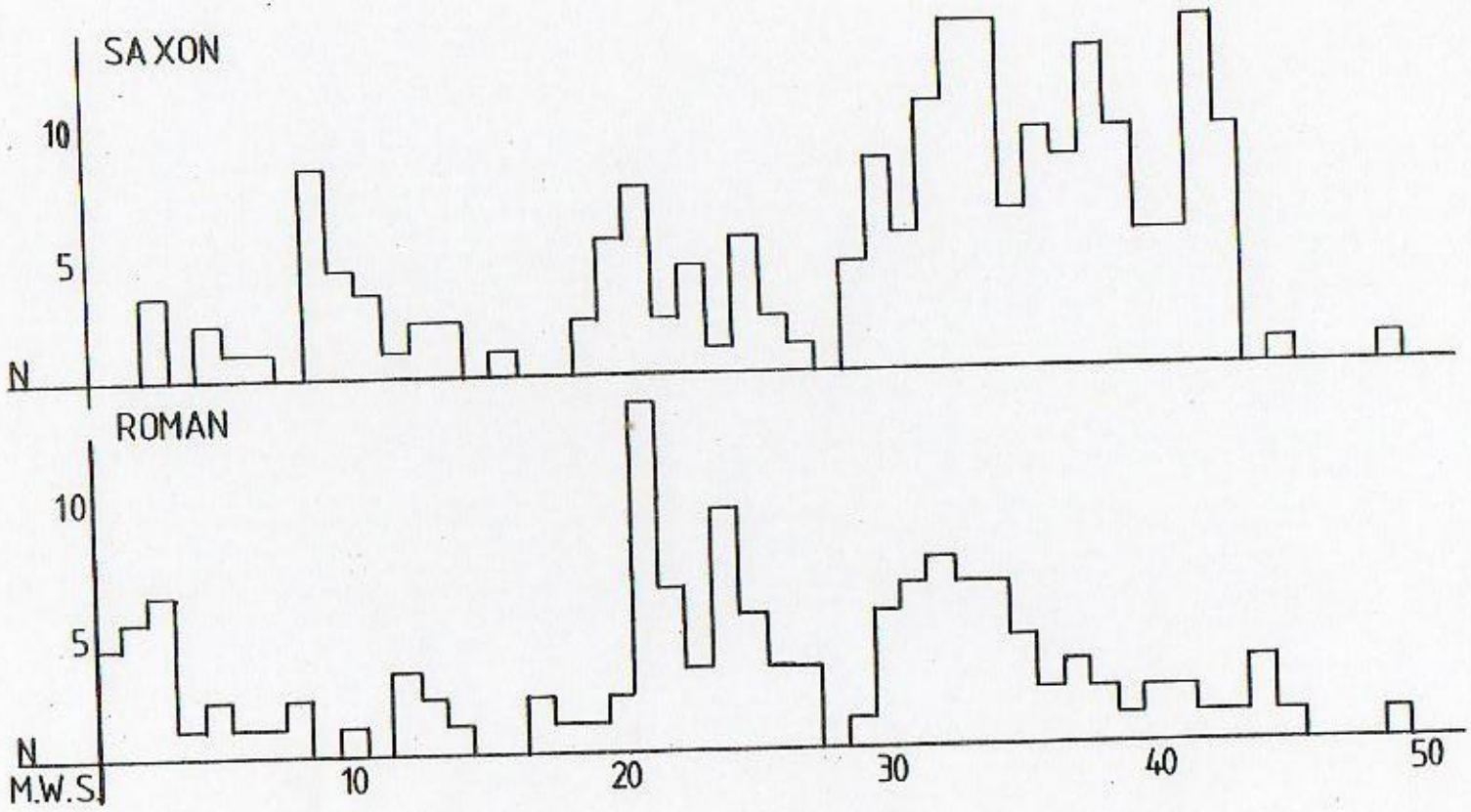


Figure 4 Sheep/goat mandible wear stages from Portchester Castle, Hampshire

The tables clearly show the variability in the possible combinations of T.W.S. for any given M.W.S. It can be seen that the greatest variation is to be found in the mandibles of pigs where, for any single M.W.S., there may be as many as eight different combinations of T.W.S. This may well reflect differences in the feeding habits of pigs and sheep/goats and cattle and makes the estimation of missing T.W.S. much more difficult for pigs than for the other species.

In practice, it is generally only for sheep/goat mandibles and for cattle mandibles at M.W.S. between 38 and 48 where enough examples of complete molar rows have been seen for the narrowing down of likely M.W.S. for incomplete molar rows to be carried out with real confidence. It is hoped that as more mandibles are examined, the estimation of missing T.W.S. may become easier, at least for sheep/goats and cattle. It may well be that for pigs there will always be problems. The evidence available so far suggests that the larger the sample size, the greater the variation seen in the combinations of T.W.S. for pig mandibles. However, it is anticipated that most samples of mandibles will generally conform to the pattern described here.

Since the tables have been arranged so that for each M.W.S. the mandibles where wear is relatively further advanced on M_1 are on the right hand side and those where wear is more advanced on M_3 are on the left side, it is possible to use the tables to see if there is, in any group of mandibles, a particular trend visible in the mandible wear. If, in a population of animals, the eruption of M_3 was comparatively early, one would expect that the observed M.W.S. of the mandibles from these animals would mostly be found in the left hand columns of the tables. If however, the eruption of M_3 were delayed, the M.W.S. would be expected to be found in the right hand columns of the tables. However it is understood that early or late eruption of the teeth are not the only factors that can influence the relationship of the wear of one tooth in the molar row to that of another (Grant 1978c). Estimation of missing T.W.S. could take into account any evidence of early or late eruption and of particularly severe tooth wear.

As it stands, this method can only be used to give an indication of the relative ages of animals and although it can be stated with a high degree of probability that a mandible with a M.W.S. of 20 was from an animal that was younger at death than one with a M.W.S. of 30, it was not necessarily younger than one with a M.W.S. of 21. The limitations and problems of ageing animals by tooth wear have been discussed in detail elsewhere (Grant 1978c) and will not be reiterated here. The assignment of absolute ages to mandibles is a difficult problem which has not yet been satisfactorily solved. Some idea of absolute age may be given by reference to the M.W.S. where any tooth eruption is occurring. However, there is considerable difference of opinion about the timing of tooth eruption in ancient animal populations. Silver (1969) gives fairly late dates for tooth eruption in unimproved breeds, but Payne (1973) in his article on sheep/goat tooth wear suggests rather earlier tooth eruption for the Medieval and Hellenistic/late Roman sheep/goat mandibles from Turkey, used in his study. It is hoped that more work on sites yielding larger samples of mandibles in combination with other classes of evidence may yield further clues to elucidate this problem.

As a brief example of the application of this tooth wear ageing method to an archaeological sample, Figure 4 shows histograms

constructed from the M.W.S. calculated from sheep/goat mandibles recovered from excavations of the Roman and Saxon layers at Portchester Castle in Hampshire (Grant 1975a; 1975b). For the Roman period, mandibles recovered from all periods of Roman occupation are included and thus date from the period 290 A.D. to the end of the Roman occupation. The Saxon period mandibles are those dated to the 'middle-late' period and are from the eighth to the tenth centuries A.D.

Of the 130 Roman sheep/goat mandibles included in the histograms, 96 had complete molar rows. A further 24 were from damaged jaws where the M.W.S. was estimated to within two or three M.W.S. and ten were originally estimated to within four to five M.W.S. by taking account of the relative frequency of occurrence of possible combinations of T.W.S. These 130 mandibles represented 86% of the total number of mandibles found in the Roman levels with at least one molar present in the jaw. The other 14% were mandibles where the M.W.S. could only be estimated to within four or more M.W.S. Although they are not included in the present analysis of the age structure, they could be included in a more general analysis.

In the Saxon sample, of the 188 mandibles included, 148 had complete molar rows, 29 were estimated to within two or three M.W.S. and 11 were estimated to within four to five M.W.S. but the likely range was narrowed down to two to three M.W.S. They together form 81% of the mandibles found with at least one molar tooth in the jaw. Where a M.W.S. was estimated to within two stages, the lower value was used for the histogram, and where the estimate was to within three M.W.S., the middle value was used.

The construction of histograms from the M.W.S. allows a visual picture to be obtained of the age structure of these groups of sheep/goat mandibles,. The calculation of the M.W.S. also allows the distributions of M.W.S. to be compared statistically. Figure 4 suggests differences in the age structure of the sheep/goats from the two periods of occupation at Portchester, and statistical testing (Kolmogorov - Smirnov test, $p > 0.05$) shows that the distribution of M.W.S. from the Roman and Saxon occupation differs significantly. The difference between the two M.W.S. distributions suggest that in the Saxon period, a larger proportion of the sheep/goats were kept until they were relatively mature (M.W.S. 30+), while in the Roman period more very young animals were killed or died. The increase in the proportion of more mature animals in the Saxon period may indicate an increase in the importance of wool to the economy and it may also reflect better feeding conditions in the later period.

In the Saxon period, the combinations of T.W.S. seen on complete mandibles were very consistent and were almost invariably found in the central columns of Table 3. In the Roman material there was a slightly higher proportion of mandibles with combinations of T.W.S. shown in the left and right hand columns (i, v and vi) of the table. Although the evidence is not very strong, this may be an indication of differences in feeding conditions, animal management or food supply in the Roman period. This site has already been discussed in detail elsewhere (Grant 1975a; 1975b), but it is hoped that this brief discussion will serve as an illustration of the application of this method of tooth wear recording and analysis.

The writer would be grateful to receive details from anyone who uses this method to record and interpret the tooth wear of domestic ungulates from any area or period.

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