A Pig for all Seasons? Approaches to the Assessment of Second Farrowing in Archaeological Pig Populations

ANTON ERVYNCK[1*] & KEITH DOBNEY[2]

(1) Institute for the Archaeological Heritage of the Flemish Community,
Doornveld Asse Industrie 3 n° 11 box 30, B-1731 Zellik, Belgium
E-mail: lentacker.ervynck2@yucom.be
(2) Department of Archaeology, University of Durham, South Road, Durham DH1 3 LE, UK
E-mail: k.m.dobney@durham.ac.uk

*Correspondence to: Institute for the Archaeological Heritage of the Flemish Community, Doornveld Asse Industrie 3
n° 11 box 30, B-1731 Zellik, Belgium
Tel.: + 32 2 4818038 (work); fax: + 32 2 4818056; e-mail: lentacker.ervynck2@yucom.be
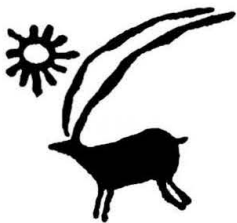
ABSTRACT: An attempt is made to re-evaluate the evidence for second farrowing in archaeological pig populations, beginning with a critical evaluation of a previous review which, based on selected historical sources, implied that second farrowing could have been common in the past. Consequently, several ways of addressing this problem using the bone material itself are introduced and tested on nine archaeological pig assemblages of varying date. Firstly, detailed recording and analysis of tooth eruption and attrition has shown that double farrowing was probably absent at all the sites studied, although the small dataset from Sugny could be the exception. Secondly, reconstruction of the chronology of dental enamel defects for each site is compared with a newly proposed theoretical model which (we propose) can be used to identify second farrowing. Once again, none of the sites studied showed the clear presence of a second litter of pigs. Finally, data are presented from a special deposit at the Roman site of Tienen, Belgium, where clear evidence for the presence of two age groups of pigs born in the same year has been recovered. In conclusion, factors are discussed that could possibly bias the recognition of second farrowing by the methodology described.

KEY WORDS: *SUS SCROFA*, DOMESTIC PIG, REPRODUCTION RATE, HUSBANDRY REGIMES, SEASONALITY

RESUMEN: Se aborda aquí una revaluación de la evidencia indicadora de segundas camadas en poblaciones arqueológicas de cerdos comenzando por una valoración crítica de un trabajo, basado en fuentes documentales, donde se apuntaba la posibilidad de que tales segundas camadas podrían ser un fenómeno común en el pasado. Por ello, una serie de métodos para evidenciar dicho fenómeno son comentados y puestos en práctica en nueve muestras arqueológicas de porcino. Los registros pormenorizados de emergencia y desgaste dentario demuestran la ausencia de esta práctica en todos los yacimientos. Si bien la pequeña muestra de Sugny podría ser una excepción. Posteriormente, una reconstrucción de la cronología de defectos dentarios del esmalte en estas poblaciones es contrastada con el modelo teórico que, según proponemos, podría emplearse como detector de segundas camadas. De nuevo, ninguna de las muestras evidencia indicios de segundas camadas. Por último, se presentan los datos de un peculiar depósito procedente del yacimiento romano de Tienen (Bélgica) en donde existen pruebas claras de la presencia de dos cohortes de cerdos nacidos en el mismo año. Para concluir, se discuten aquellas causas que podrían sesgar la detección de tales segundas camadas en función de las limitaciones de las metodologías consideradas.

PALABRAS CLAVE: *SUS SCROFA*, CERDO, CICLO REPRODUCTOR, TÉCNICAS PECUARIAS, ESTACIONALIDAD

SECOND FARROWING: AN INTRODUCTION

It has been a common practice within zooarchaeology to attempt to establish the season in which an animal was killed by estimating the age at death (see, *e.g.*, Davis, 1987: 75-90). In the case of animal populations that have a single, fixed breeding season, which covers a limited period of time, a detailed estimation of the age at death can indeed permit an assessment of when within the year an animal died. This method has been applied on archaeological pig populations (*e.g.*, Clason, 1967 for an early example), until Lauwerier (1983) criticised it by pointing out that pigs can have multiple litters per year. In fact, this possibility had already been considered in some other studies (*e.g.*, Boessneck & Driesch, 1979) but Lauwerier (1983) provided circumstantial evidence which showed that an additional litter in the same year (traditionally called a second 'farrowing') could be expected in archaeological domestic pig populations. The author used different lines of evidence to support this statement, *i.e.*, biological information on recent wild boar and domestic pigs, and some selected historical sources on pig breeding in Roman, late medieval and post-medieval times.

While Lauwerier's (*Op. cit.*) arguments highlighted the possibility that second farrowing was present in ancient domestic pig populations, they do not prove that the phenomenon was present in all archaeological pig herds (and it was indeed not the intention of the author to do this). It could be argued that the Roman treatises on agriculture written by Varro, Columella and Plinius, and used by Lauwerier as evidence for the possibility of second farrowing, represent a scheme for animal husbandry that is perhaps more applicable to southern Europe. The late medieval and early post-medieval evidence used by Lauwerier (1983: 485-486) are limited to (English) husbandry books, with the exception of one source: the late 13th to early 14th century accounts of an English late medieval demesne farm. The question thus remains whether a second litter in pigs was perhaps only a theoretical option in the husbandry books, that was in reality rarely or never taken, because it was not possible or because farmers preferred other options. On the other hand, pig breeding could have been quite different on large estates compared to the more numerous smaller farms. A general problem is that Lauwerier's sources reveal nothing about prehistoric pig breeding or about the situation between the end of the Roman empire and the late Middle Ages. Remarkably enough, in a recently published account of early Irish farming, based on law texts from the 7th and 8th century AD (Kelly, 1997), no mention is made of second farrowing, although the pig's reproductive cycle is described at length and in detail!

It is unfortunate that the possibility of multiple farrowing in domestic pigs undermines any estimation of the season of death. As a result of this uncertainty, what is even more problematic for archaeozoological analysis is that archaeological populations in which only single farrowings have occurred, are also excluded from interpretation. Since no method has been developed within zooarchaeology to firmly establish from the material itself whether a second farrowing cohort was present within a population, and since it remains always questionable whether general historical information is valid for a specific site studied, the problem seems unresolvable. However, the present paper proposes three different ways that could provide an assessment of second farrowing in archaeological pig populations or even in individuals. The approaches are: 1) through the detailed recording of age at death patterns within a population; 2) through the recording of linear enamel hypoplasia as a phenomenon in individuals or a pattern in populations; and 3) through the combination of archaeological contextual information and the age characteristics of the animal remains. The development of these approaches not only seems worthwhile because of the problems in seasonality estimations discussed above, but also because the occurrence of second farrowing is in itself an interesting phenomenon to study, since it can reveal important information about past environmental conditions or changes in animal husbandry.

MATERIAL STUDIED

In this paper, data obtained from domestic pig remains excavated at nine different sites will be used. They date from the late Neolithic to the 15th century AD and are located in different geographical regions within Belgium and the United Kingdom. A short introduction to the sites is provided as a basis for further discussion.

The late Neolithic henge-enclosure of Durrington Walls (UK) is located in Wiltshire, on Salisbury Plain, not far from Stonehenge. During the

excavation campaigns of 1966-67 (Wainwright & Longworth, 1971), an important sample of domestic pig remains was recovered, which approximately dates from 2800 to 2400 BC (Albarella s.d.: recalibrated from ^{14}C dates from Wainwright & Longworth, 1971). Overall, the animal remains have been interpreted as representing ceremonial food deposits, although an admixture of domestic refuse cannot be excluded (Albarella s.d.). A review of the available archaeological mollusc studies, compiled within the framework of the Stonehenge Environs Project (Richards, 1990), indicates a phase of woodland regeneration in the area, during late Neolithic times (Allen *et al.*, 1990).

At Tienen (Belgium), the remains of a Roman vicus were excavated, dating from the middle of the 1st to the end of the 3rd century AD. The site is characterised by a significant number of so-called 'special' deposits, including a 3rd century pit, containing a large number of ritual parafernalia, found in connection with the remains of a building that served as a Mithraeum (a temple for Mithras). On the basis of the structural characteristics of the pit and of the stratigraphy of its fill, the deposit represents a single event of very short duration (Vanderhoeven *et al.*, 2001). The animal remains within the deposit, which are still under study, include thousands of chicken bones, representing perhaps 100 individuals, the (partial) skeletons of at least 9 lambs and 5 young pigs, and remains from a number of other edible species (Ervynck, unpubl. data).

The early medieval site of Wellin (Belgium) represents the center of a large Carolingian domain (Evrard, 1993, 1997). The settlement is located in the southern part of Belgium, in the transition zone between the geographical areas of the Famenne and the Ardenne. During excavation, a large context containing consumption refuse, dating from the 8th century AD, was found, with a clear dominance of pig remains amongst the large mammal bones (Wattiez, 1984). General historical knowledge of the land use, occupation patterns and evolution of the forests in Belgium (Verhulst, 1990), together with the actual ecological characteristics of the area, strongly indicates that woodland was amply present in the area, during Carolingian times.

The Anglo-Saxon settlement of Flixborough (north Lincolnshire, UK), dating from the early 7th to the early 11th centuries AD, is located eight kilometers to the south of the Humber estuary (Loveluck, 1998). The analysis of the animal remains has proven that pig was a common meat supplier throughout the occupation of the site. Most probably, the animals were kept in herds in the woodland that was present on sandy soils in the vicinity of the site (Dobney *et al.*, unpubl. data). Large samples of pig remains were obtained from several subphases of the site, i.e. '2-3a' (late 7th to mid 8th century AD), '3b' (mid 8th to early 9th century), '4-5b' (early 9th to early 10th century), '6' (early to late 10th century) and '6iii' (late 10th to early 11th century) (Loveluck, unpubl. data).

The castle of Ename (Belgium) was erected during the 10th century AD and demolished during the 11th century (Callebaut, 1991). The site was located in the valley of the river Schelde, in the geographical area of Flanders. The excavated animal remains demonstrated that pig herding was extremely important for the meat supply of the castle (Van der Plaetsen, 1991). The site was situated near the 'Bos t'Ename', a forest that around 1000 AD was already severely degraded, mainly by its use as pasture.

The castle of Sugny (Belgium) was erected towards the end of the 10th century AD and remained occupied until the end of the 11th century (Matthys, 1991). Sugny is located in the Ardennes, southern Belgium, in an area that is still wooded today. Historical data suggest that the castle was founded in an unexploited region as a coloniser site, aiming for the deforestation and agricultural exploitation of the area (Matthys, 1991: 260). This evidence and the general historical knowledge on the evolution of the forests in Belgium (Verhulst, 1990) makes sure that the site of Sugny was located in a wooded area. The animal remains recovered from the site included an important portion of pig remains (Ervynck, 1992).

The medieval fortified site at Vilvoorde (Belgium) yielded a collection of animal remains dating from the 11th to the 12th century (Borremans, 1979). Pig remains dominate the assemblage (Gautier s.d.). From the historical context (Verhulst, 1990), it can be inferred that the forest around the site will not have been severely degraded although in the area some deforestation must certainly already have taken place.

Excavations in the castle of Londerzeel (Belgium) recovered an archaeozoological collection, dating from the 13th to the 14th century AD, and once again characterised by a dominance of pig remains (Ervynck, 1994). The ecological history

of the area (Verhulst, 1990) indicates that, during late medieval times, virtually no real forest was to be found in the vicinity of the castle. Therefore, it is posssible that some husbandry regime in semi-confinement was applied to the pigs.

The former fishermen's village of Raversijde is located west of Oostende, along the Belgian coast. Rescue excavations have mainly uncovered struc-tural remains and refuse deposits dating from the 15th century AD (Pieters, 1997). Preliminary results of the archaeozoological analysis show that pig was not a very common meat supplier to the site (Bollen, 1998), but due to the large volume of excavated bone, a significant sample of pig remains was available for study. The relatively low frequency of pigs within the Raversijde material must be linked to the environment around the site, i.e. coastal dunes and wet grasslands on clayey soil without forest cover. In fact, it is thought that the pigs at the site were kept in semi-confinement and were nourished with human consumption refuse and the leftovers collected after cleaning fishing nets or after sorting the catch. In Flanders, this practice was still common in traditional fisher-men's households until the middle of the 20th cen-tury. The hypothesis that the Raversijde pigs were fed marine products is corroborated by stable iso-tope analysis of the bones (Ervynck et al., unpubl. data).

DETAILED RECORDING OF AGE AT DEATH: GRANT'S MOLAR WEAR STAGES

A detailed, rapid and cheap method to estimate the age at death in collections of pig remains can be achieved by recording the eruption and wear of the mandibular teeth, following the method of Grant (1982). By comparison with a figurative scheme, the eruption stage and wear of each indi-vidual permanent molar in the mandible is coded. These codes (in the case of pigs: 19 different ones for M_1 and M_2, and 16 for M_3) are subsequently given a numerical which are then added together for the complete molar row. This sum (MWS: mandibular wear stage) is an evaluation of the wear of the molar dentition in the lower jaw. Since tooth eruption and wear gradually develop through time, the wear stages also represent age classes, although there is no straightforward way to calcu-late one from another, for each MWS. Despite the uncertainties about real ages, Grant's method is

powerful, particularly because of its detailed observation. When considering pigs, it enables one to recognize 52 separate MWS (from 0 to 51), which is a considerable number compared to the limited descriptive set of wear stages used by other authors (e.g., 7 in Becker, 1980; 6 in O'Connor, 1989).

It has been theoretically argued (Ervynck, 1997) that, when seasonal killing was exercised upon a pig population, the distributions of the MWS-values should show discrete peaks, repre-senting the ages the animals attained during the killing season. In the case of a single seasonal killing period, the distance between the peaks should represent the time span of one year. Follo-wing this logic, it has been possible to document the historically known practice of almost exclusive winter slaughtering on the pig remains from four medieval Belgian sites, i.e. Wellin, Sugny, Vilvo-orde and Londerzeel (Ervynck, 1997; figs 3-6). Of course, the theoretical concept applied is based on the assumption that the populations had only one litter per year. In the case of a second farrowing and a single killing season, the distributions should show double the number of peaks, that must then be at distances that roughly represent half a year (Ervynck 1997, fig. 1 versus fig. 2). In fact, the MWS distribution for the site of Sugny (Figure 1) did show a less clear pattern, which could be inter-preted as showing twice the number of peaks than is the case for the distributions from the other medieval Belgian sites. However, the sample size was low for Sugny (n=49) and a definitive conclu-sion was not proposed (Ervynck, 1997: 75-76).

Following the study of the four medieval Bel-gian sites, MWS distributions were made for two more collections, i.e. the sites of prehistoric Durrington Walls, and medieval Ename. They have been published within the context of a study on linear enamel hypoplasia on pigs' teeth (Ervynck & Dobney, 1999, fig. 3) (see further). In this paper, six more MWS distributions are introduced, deri-ving from the vertebrate assemblages from five phases of Saxon Flixborough (Figure 2) and from the late medieval settlement at Raversijde (Figure 3). None of these additional data, however, show a pattern that could be compared to that of Sugny. Thus far, Sugny remains the only site for which the detailed recording of age at death possibly provi-des an indication of the presence of second farro-wing. However, given the low sample size, little real significance can be attributed to this conclu-sion.
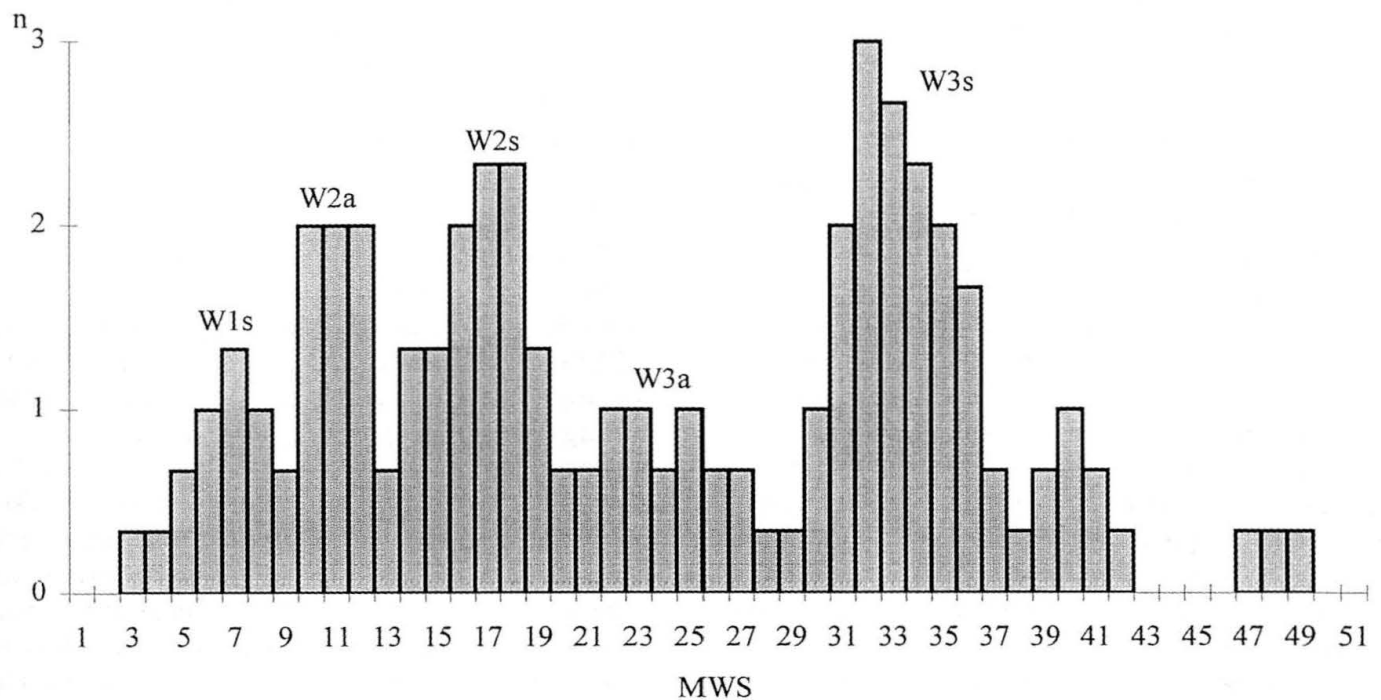
FIGURE 1

Frequency distribution (calculated as running means, n=19) of the age at death of the pig population from Sugny, evaluated by the Mandible Wear Stages (Grant, 1982) (after Ervynck, 1997). 'Wxs' indicates the animals, born in spring, killed just before their xth winter; 'Wxa' indicates the animals, born in autumn, killed just before their xth winter.

Of course, it remains possible that, in some populations with second farrowing, the numerical importance of the second litter was so low compared to the first, that a peak associated with the killing of animals born as part of a second farrowing remains obscure within the distribution. It must not be forgotten that the MWS-distributions are influenced by considerable 'noise' associated with variations in the timing of birth and slaughtering, and differences in tooth eruption and wear, due to food abundance, genetic variation or climatic conditions (Ervynck, 1997). Nevertheless, for the sites studies (except perhaps Sugny) the conclusion could be that, even when second farrowing occurred within these populations, it was of little real significance.

LINEAR ENAMEL HYPOPLASIA

Linear enamel hypoplasia (LEH) is a deficiency in enamel thickness occurring during tooth crown formation, typically visible on a tooth's surface as one or more grooves or lines, and related to deve-

lopmental stress. A methodology for recording LEH on archaeological pig molars from the lower jaw has recently been published (Dobney & Ervynck, 1998). It was subsequently proven that LEH was not a rare or randomly occurring event. In fact, for five different archaeological assemblages (Durrington Walls, Wellin, Ename, Sugny and Londerzeel), it was shown that it was possible to construct a chronology of physiological stress events, explaining why, generally, LEH is always present at the same heights on the molar crowns. In this study, it was proposed that birth and weaning are the direct causal agents of two discrete peaks in the height distribution of LEH on the first permanent molar (M_1), whilst a period of under-nutrition encountered during the first winter of the animals' life is thought to be the main causal factor for the occurrence of the single distinct LEH peak noted on the M_2. A broad peak on the M_3 is similarly interpreted. This chronology could be consistently applied to all five archaeological collections studied (Dobney & Ervynck, 2000). The conclusion has been corroborated by the analysis of two more assemblages: Flixborough and Raversijde (Dobney et al., in prep.). It has
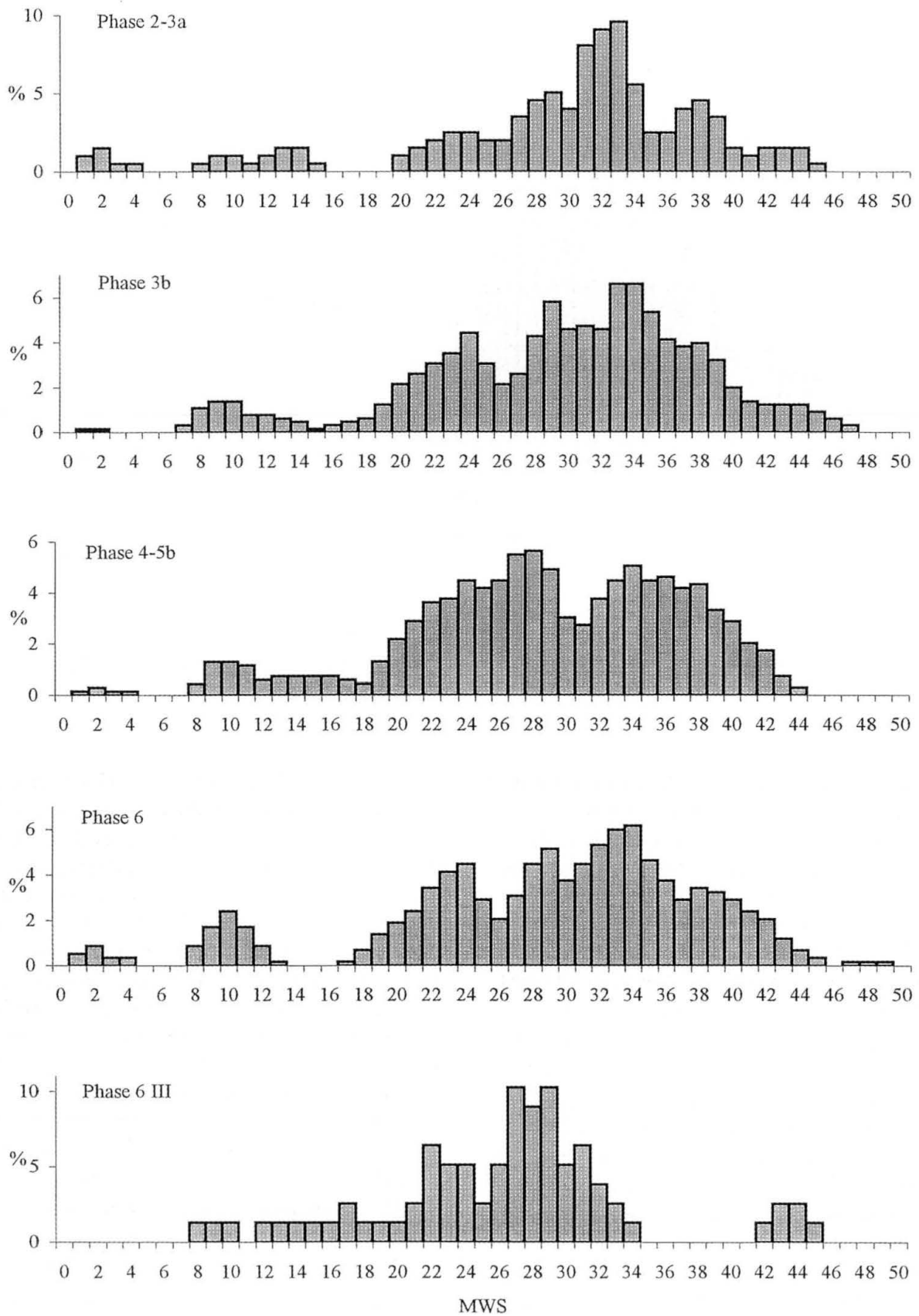
FIGURE 2

Frequency distribution (calculated as running means, n=66, 218, 231, 195, 26) of the age at death of the pig population from five phases of Flixborough, evaluated by the Mandible Wear Stages (Grant, 1982) (phase codes, see text).
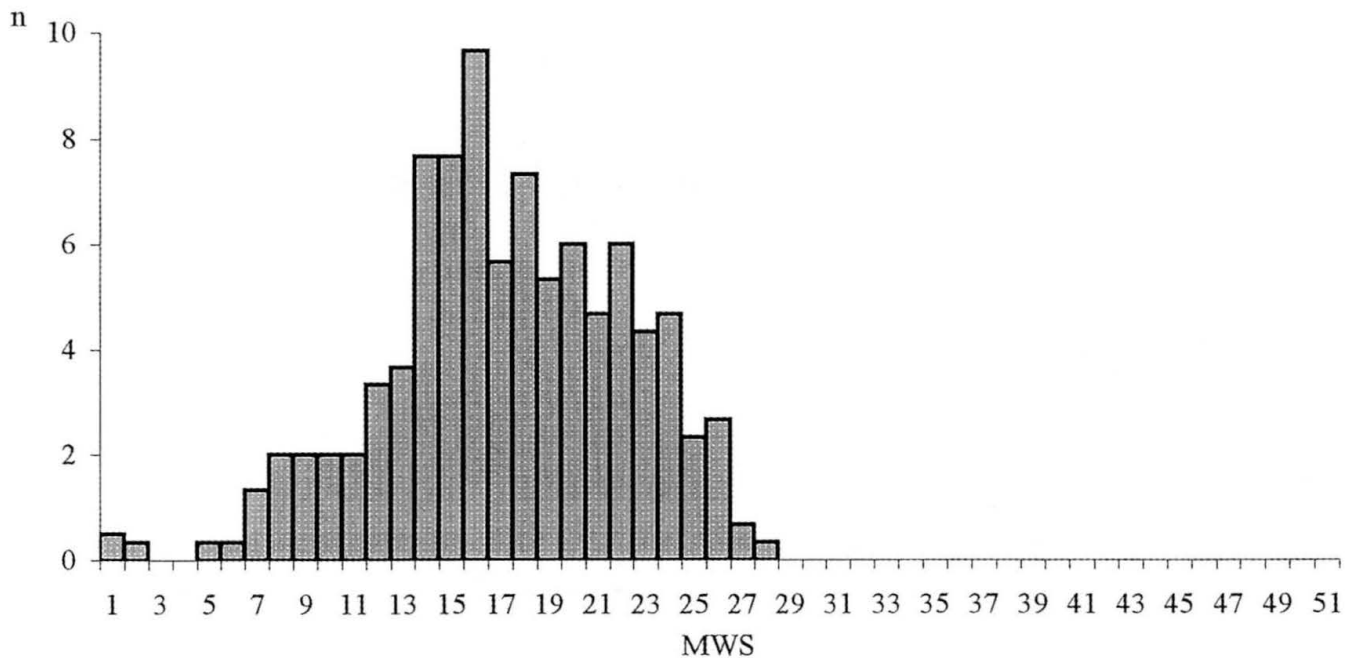
FIGURE 3

Frequency distribution (calculated as running means, n=93) of the age at death of the pig population from Raversijde, evaluated by the Mandible Wear Stages (Grant, 1982).

further been demonstrated that taking into account the form in which LEH appears (i.e. discriminating between what we term "lines" and "depressions"), provides an even clearer image and points towards the depressions as the real indicators of stress caused by undernutrition in winter, on the M_2 and M_3. On the M_1, the effect of stress related to birth and weaning manifests itself both by lines and depressions (Dobney et al., in prep.).

The underlying assumption which allows the connection between single peaks in the LEH height distribution on the M_2 and the M_3, and the period of winter, to be made, was that the analysis deals with populations characterised by a single, spring birth season. This is summarised theoretically in Figure 4, where, in the case of animals born in spring, the LEH height distribution on the M_1 shows two peaks, caused by birth and weaning, whilst the distributions on the M_2 and M_3 each show a single peak, corresponding with the survival of the first and second winter, respectively. This single peak occurs towards the end of the tooth's development and is thus located on the lower half of the crown (tooth crowns develop

from top to bottom). However, in an animal born in Autumn, and thus belonging to a second farrowing, the winter peaks in the LEH distributions of the M_2 and M_3 must develop earlier in the process of crown formation and will thus be located on the upper half of the molar (Figure 5). The distribution for the M_1 will show the same pattern of two peaks, as was the case in the animals born in spring (since birth and weaning are not influenced by the seasonal weather cycle). It is possible that the youngest peak on the distribution for the first molar, representing a cluster of LEH events on the lower part of the tooth, is more pronounced than in the distribution for the M_1 of the first farrowing because in the former case the arrival of the first winter coincides with the process of weaning (Figure 5). This combination should, without doubt, cause extra stress to the juvenile pigs.

Within a pig herd, it is highly unlikely that an autumn farrowing would have occurred without a farrowing in spring. Therefore, when archaeological populations are studied and not individuals, it should be born in mind that the LEH distributions potentially would always show a combination of
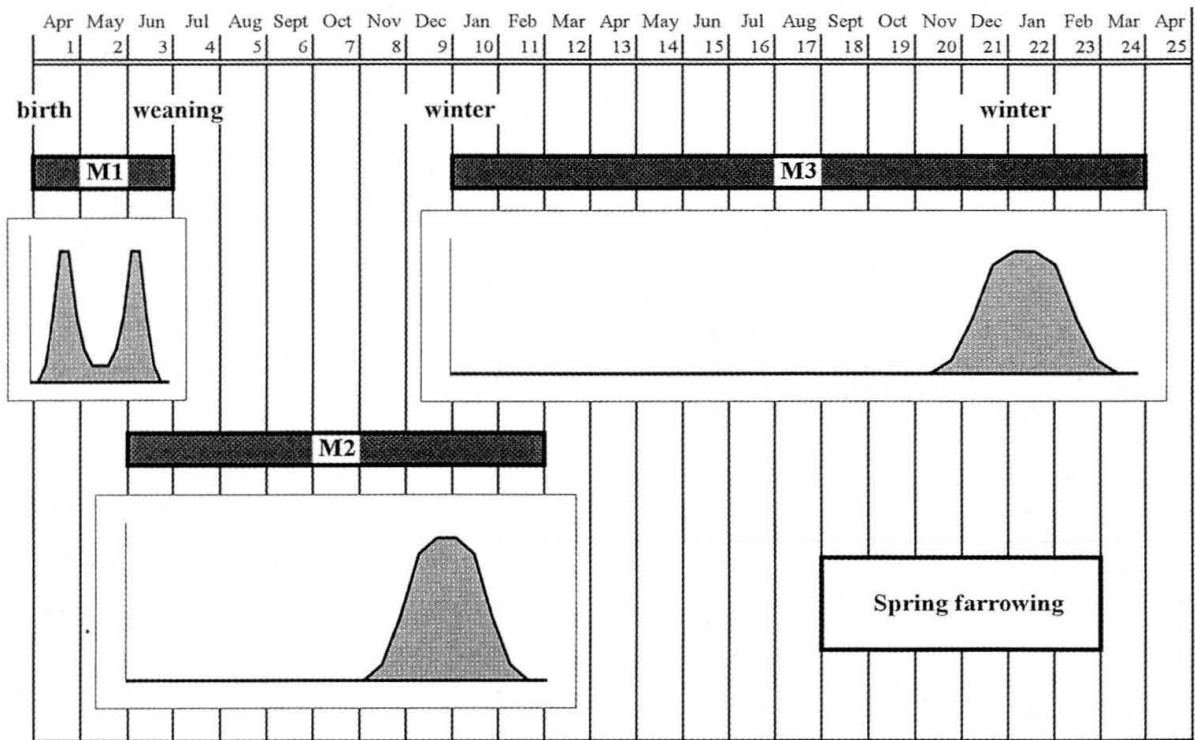
FIGURE 4

Theoretical representation of the occurrence of LEH on the permanent molars compared with major events in the life cycle of the primitive domestic pig, in the case of animals from a first, spring farrowing (solid bar: tooth germ formation, graphs: theoretical LEH height frequency distribution).
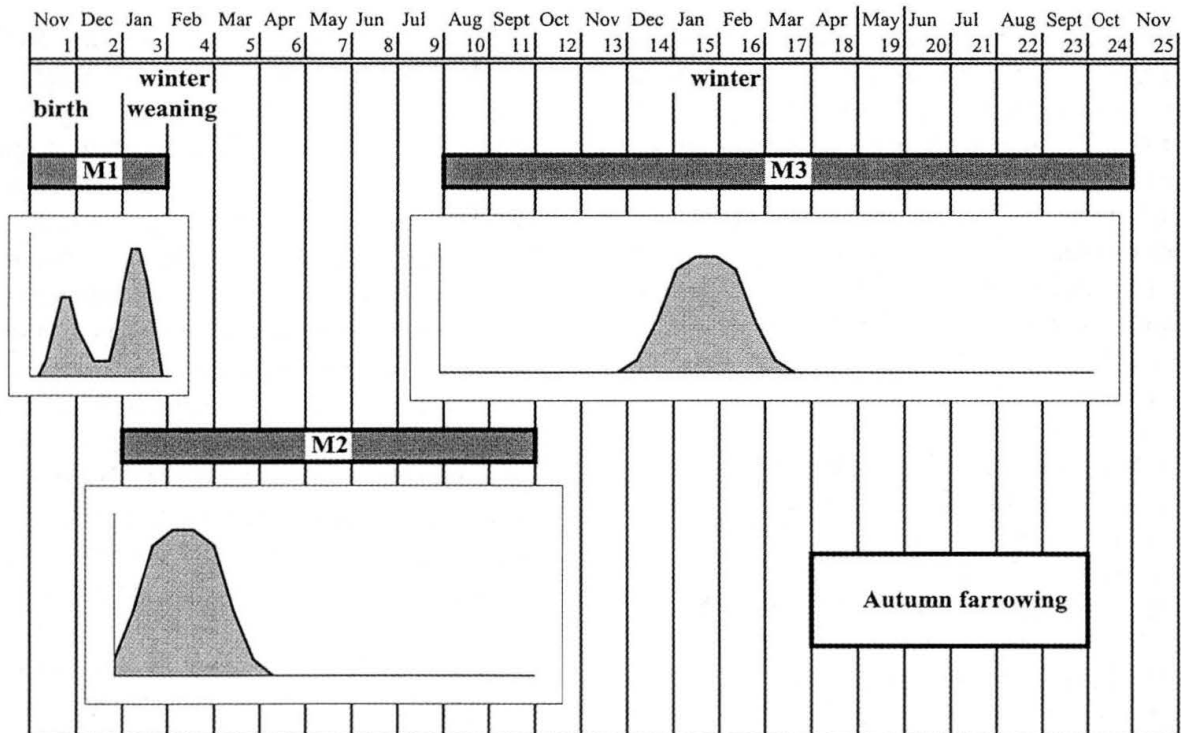

FIGURE 5

Theoretical representation of the occurrence of LEH on the permanent molars compared with major events in the life cycle of the primitive domestic pig, in the case of animals from a second, autumn farrowing (solid bar: tooth germ formation, graphs: theoretical LEH height frequency distribution).
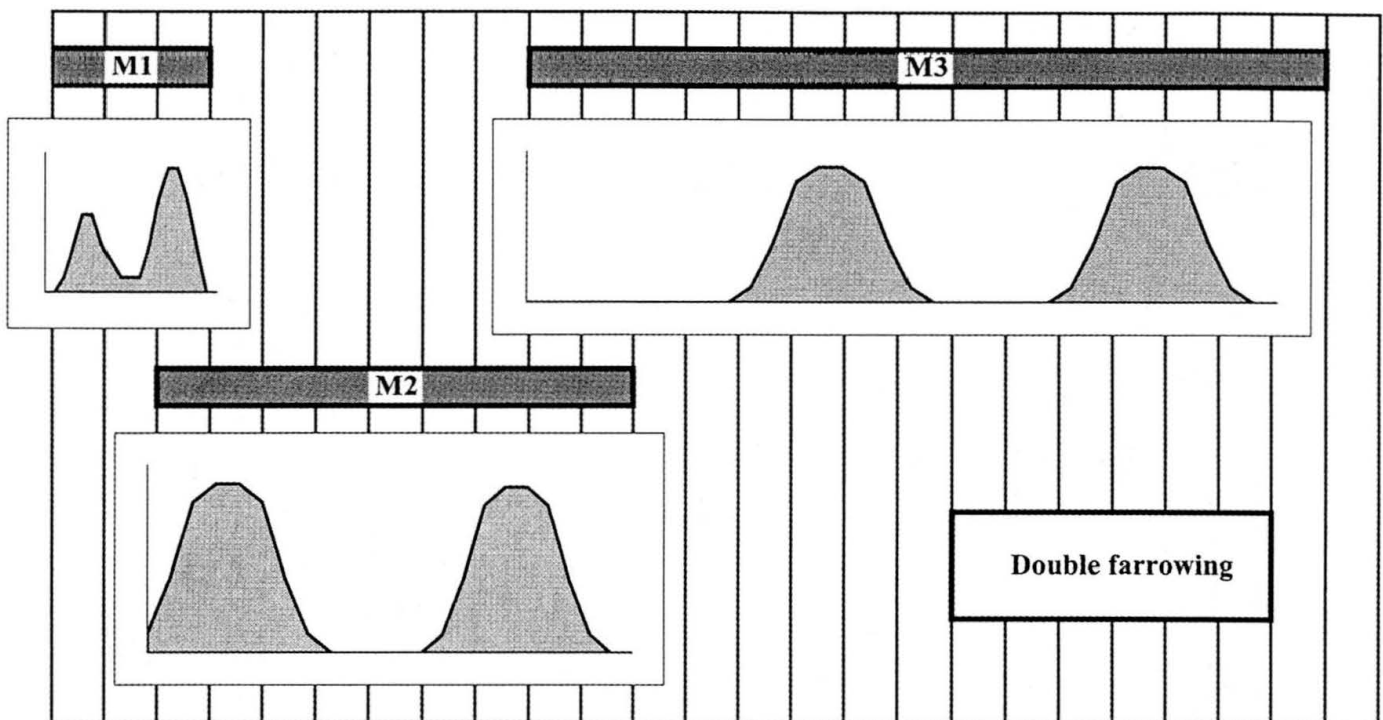
FIGURE 6

Theoretical representation of the form LEH height distributions for the permanent molars will take when animals from a first, spring farrowing and animals from a second, autumn farrowing are both equally present within a domestic pig population (solid bar: tooth germ formation, graphs: theoretical LEH height frequency distribution).

the patterns for the individual farrowings (Figure 6). The LEH distributions on the M_2 and the M_3 will thus show a double peak, just as will be the case for the M_1. From the models (Figures 4 to 6), it is clear that, through the observation of the number of LEH peaks, second farrowing will only be visible on the second and third molar, and not on the first. It could be that the LEH cluster on the lower half of the crown of the M_1 is more pronounced (Figure 6) due to the coinciding of winter and weaning stresses in the second litter. However, little much importance should be attributed to the height of the peaks in this model. It could, for example, also be proposed theoretically that, in the case of the distributions of the M_2 and the M_3, the relative importance of the peak corresponding with LEH on the lower half of the tooth, versus the one reflecting LEH on the upper half, might enable an estimation of the numerical importance of the first farrowing versus the second. Biasing factors undermine this approach, *i.e.*, different susceptibility to LEH between the different litters (because the animals have different ages when they go through winter), and different kill-off patterns between the litters (see further).

When LEH height distributions are analysed for Durrington Walls, Wellin, Ename, Sugny, Londerzeel (Dobney & Ervynck, 2000, fig. 6), Flixborough and Raversijde (Dobney *et al.*, in prep., figs 1 & 2), it becomes evident that no clear pattern, similar to the one theoretically proposed in Figure 6, emerges, while the similarity to the pattern of Figure 4 is evident. A possible exception can be found in the distribution for the posterior cusp of the M_2 of Raversijde (Dobney *et al.*, in prep., fig. 2) and will be discussed further. The data for the third molar always show most 'noise' although a consistent second peak is not observable. Generally, the figures seem to indicate that second farrowing was absent or numerically not important in the pig populations of the seven sites studied to date. When the data from Sugny are separately presented (Figure 7) (taking into account the small sample size), it is evident that the possible second farrowing hypothesis, previously made on the basis of the molar wear stages, is not corroborated by the LEH distribution graphs.

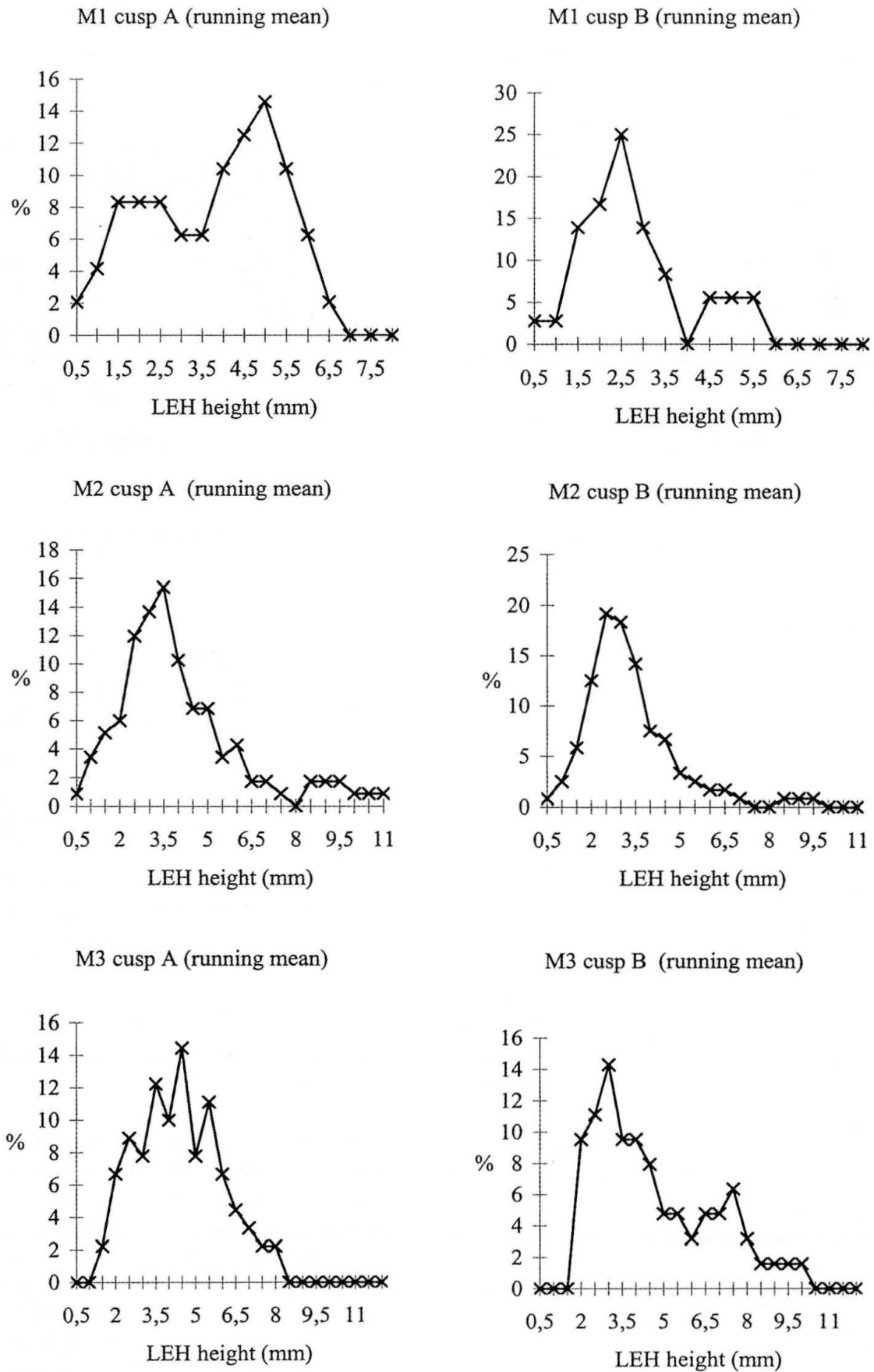The LEH height distributions discussed so far were calculated without a distinction being made

FIGURE 7

Frequency distribution of LEH heights (running means, lines and depressions combined) for Sugny, per individual tooth and cusp (after Dobney & Ervynck, 2000).
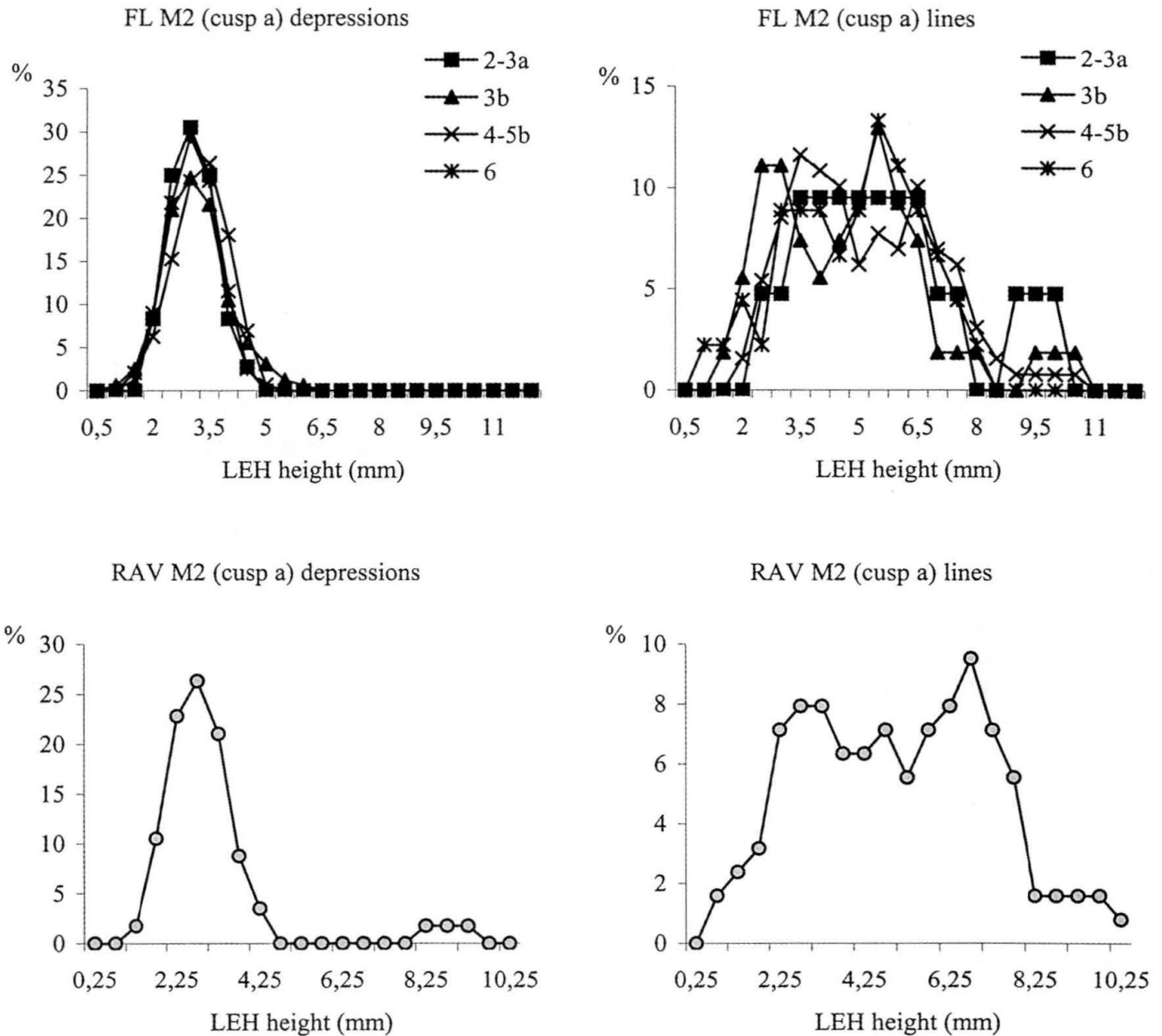
FIGURE 8
Frequency distribution of LEH heights (running means, lines and depressions combined, depressions separately, and lines separately) for Flixborough and Raversijde, for the anterior cusp of the second molar (after Dobney et al., in prep.).

between the forms of LEH, i.e. lines and depressions. However, it has been demonstrated that, on the M_2 and the M_3, the effect of winter is best visible by looking only at the depressions (Dobney et al., in prep.). However, taking into account the form of LEH has thus far only been undertaken during the analysis of Flixborough and Raversijde. Nevertheless, the data from these sites (Dobney et al., in prep., figs 3 to 5, partly repeated here in Figure 8) amply show that the distribution of the depressions on the M_2 and the M_3 is characterised by only one peak, and that any suggestion of a

cluster of LEH in the upper part of the crowns of those teeth is caused by the random distribution of lines. Within this context, it must be repeated that depressions indeed can occur on the upper part of the molars (and that, in the sites studied, their absence there is not caused by morphological characteristics of the teeth), a point that is proven by the data from the M_1 at Raversijde (Dobney et al., in prep.). The absence of LEH depressions on the upper part of the crowns of the M_2 and the M_3 is thus meaningful. On this basis, the suggestion of a second peak in the distribution for the posterior
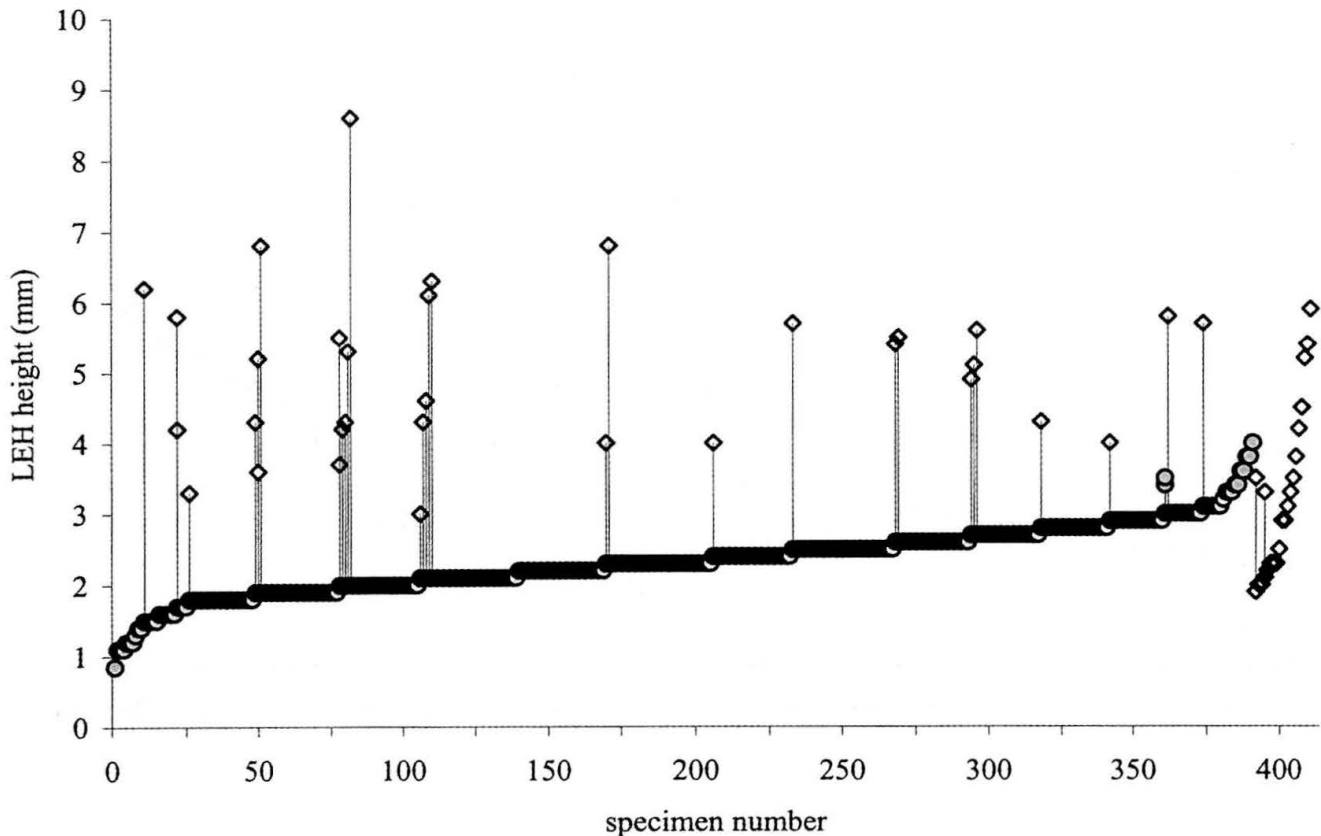
FIGURE 9

LEH heights on the anterior cusp of the second molar, per individual specimen, for all phases of Flixborough combined (circles: LEH depressions, diamonds: LEH lines, n=411)

cusp of the M_2 of Raversijde (Figure 8) can be ruled out as being related to winter, and must thus not be seen as an indication of second farrowing in that population.

The previous discussion is placed even more firmly in perspective when the occurrence of LEH is analysed per individual, instead of per population. When the heights of the LEH lines and depressions are plotted per specimen (Figures 9 & 10), it is clear that an important part of the lines on the upper part of the anterior cusp of the second molar occur in specimens that also have a depression on the lower part of the tooth (in the case of Flixborough, Figure 9), or that also have additional lines on the lower part (in the case of Raversijde, Figure 10). In neither case, can the lines on the upper part of the tooth be used as evidence that an individual belonged to a second farrowing. Similar results obtained for the posterior cusp of the M_2 and for the M_3 are not represented here.

The overall conclusion from the analysis of LEH must be that, apparently, in the seven popula-

tions studied so far, second farrowing was of minor importance or absent altogether.

SPECIAL ARCHAEOLOGICAL CONTEXTS: THE MITHRAEUM AT TIENEN (BELGIUM)

On the basis of the observations made above, the impression could grow that second farrowing in archaeological pig populations is a myth. The contents of the Roman ritual pit at Tienen, howe-ver, show that the phenomenon indeed existed in archaeological pig populations. Amongst the ani-mal remains from the pit, nine mandibles were present from sheep or goat that must have been slaughtered around the age of three months (all age estimations follow Habermehl, 1975). Given the traditional birth season of sheep and goat, in or around March (Williams, 1977), as a rough esti-mation, the ritual deposit must have been made in or around the month of June (Figure 11). The man-
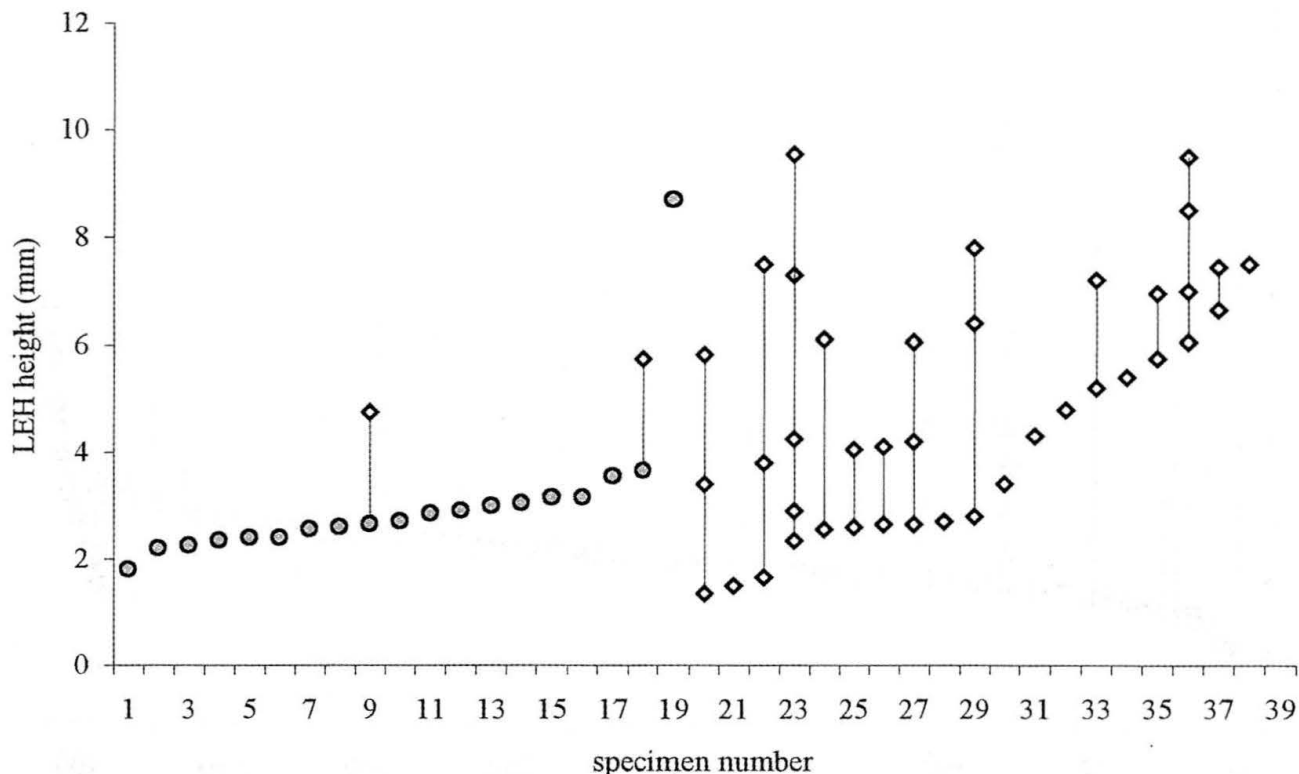
FIGURE 10

LEH heights on the anterior cusp of the second molar, per individual specimen, for Raversijde (circles: LEH depressions, diamonds: LEH lines, n= 38)

dibles of three pigs, traditionally assumed to be born in April (Williams, 1977), fit well within this estimation because the eruption and wear stage data of the teeth show they were slaughtered at an age somewhat older than 2 months. This again points to June, or possibly July, as the month during which the pit was filled (Figure 11). However, the mandibles of two additional pig specimens showed ages that do not fit this pattern, i.e. an age of approximately 8 months, and an age of slightly more than 8 months. The assumption that these animals were born in spring would imply that they

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.		N
Pig																	
1st farrowing	-	-	-	-	-	-	B	1	2	3	4	5	6	7	8		3
2nd farrowing	B	1	2	3	4	5	6	7	8	9	10	11	12	13	14		2
Sheep																	
1st lambing	-	-	-	-	-	B	1	2	3	4	5	6	7	8	9		9

FIGURE 11

Scheme showing how pigs of circa 3 and circa 8 months, and lambs of circa 3 months could have occurred at the same time, i.e., in the period from June to July, on the Roman site of Tienen (represented are the ages in months the animals reach per calendar month, B: birth, N: number of specimens).

were killed in December, but when autumn is taken as the season of birth, the period of June to July again is the best estimate for the moment of deposition (Figure 11). A realistic conclusion could be that the pit was filled on or around the longest day of the year, which could have been a major celebration event within the cult of Mithras, since this religion was strongly organised around astronomical principles (Ulansey, 1989).

This reconstruction of events implies that at least part of the domestic pig population living in or around the 3rd century *vicus* of Tienen had a second farrowing season. The small sample size of course provides no information about the relative importance of the second litter. Since the animals were chosen to be offered (most probably after consumption), it could be that the larger animals born the previous autumn were perhaps preferred over the smaller ones more recently born in spring.

DISCUSSION

The combination of a special archaeological context and detailed age at death information on the animals represented in the fill, has so far proven to be the only secure way to establish the presence of second farrowing in an archaeological pig population. However, the question remains whether it is a coincidence that a second litter is apparent in the only Roman site studied. It is of course possible that second farrowing occurred in numerous Roman pig herds, even in northwestern Europe, but not in medieval ones. However, the answer could be far more complex. It is, *e.g.*, possible that second farrowing occurred in some populations but that it is not represented in the collections studied, because animals from the second litter were killed and eaten as suckling pigs. It must not be forgotten that for a second litter the arrival of winter coincides with the period of weaning, a combination that compromises the survival of the animals. Therefore, for many pig breeders it was perhaps an economical option to utilize individuals from the second farrowing at a young age. In this case, the second litter would be represented by a peak of young wear stages in the MWS-distribution (as is the case for Wellin: Ervynck, 1997, fig. 5). On the LEH chronology graphs, it would be impossible to discriminate the suckling pigs of the second litter from the others because only the first molar would be available for analysis (see earlier).

Further complicating factors could be that the bones of suckling pigs do not preserve as well as those from the older animals, that the young bones end up at different places within a site (*e.g.*, non-buried table leftovers versus buried slaughtering waste), or that the sucklings pigs from the second litter were sold to be eaten elsewhere (considering the high price that was paid for them). The latter option is perhaps less feasible in the case of the medieval high status sites of which the material was studied, but it cannot be ruled out.

If it were true that in all medieval pig populations studied second farrowing was of little or no importance, this would imply that the shift in husbandry regime, from herding in the woods to rearing in semi-confinement (as hypothesised for Londerzeel), had no immediate effect on reproduction rate. Similarly, the condition of the woodlands appears to have played no significant role in this aspect of the domestic pig's biology. Furthermore, the peculiarities of the diet of the pigs at Raversijde, and their supposed semi-confinement, seem also not to have coincided with changes in the seasonality of reproduction. These tentative conclusions are remarkable since it has been demonstrated that the medieval populations studied showed marked differences in the frequency of LEH, and thus in their general health and feeding conditions. Of course, if the animals from a second farrowing were absent from the adult populations, for the reasons outlined above, conclusions about husbandry and environmental conditions remain problematic.

CONCLUSION

Data from the sites presented here have yielded no evidence for the existence of second farrowing within their pig populations, with the exception of Roman Tienen. As a result, the following alternative hypotheses can be put forward:

1) That the methodology proposed is not reliable. This statement is difficult to prove on the basis of sample populations that had no second farrowing. Doubt will remain until an archaeological pig population is analysed, which categorically shows the presence of animals from a second farrowing. Most convincing of all will, of course, be a large sample from a population recovered

from a 'special' archaeological context, comparable to the Mithras pit from Tienen.

2) That the methodology is reliable. This implies that second farrowing was absent or of little importance in all the medieval populations studied. However, it is possible that these particular populations included individuals from a second farrowing, but in which all animals from the second litter were culled as juveniles, before they could be identified by the methods outlined here. Hence, it is possible that second farrowing could, instead of being of minor importance or even absent in the whole populations studied, be of minor importance or even absent in the *adult* populations studied. In fact, it could even have been of major importance, although this could not have been detected with the methodology proposed.

Overall, it has not been conclusively proven that the methodology presented here can categorically establish second farrowing. However, the approaches that have been outlined could well prove to be useful when, *e.g.*, Roman pig herds or populations of wild boar are studied (i.e. populations that enjoyed ample food supplies and that, therefore, may have produced more than a single litter per year). Analysis of such populations should therefore be the next step in the search for second farrowing in archaeological pigs.

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