pca

european journal of
postclassicalarchaeologies

volume 12/2022

SAP Società Archeologica s.r.l.

Mantova 2022

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"Post-Classical Archaeologies" is indexed in Scopus. It was approved on 2015-05-13 according to ERIH PLUS criteria for inclusion and indexed in Carhus+2018. Classified A by ANVUR (Agenzia Nazionale di Valutazione del sistema Universitario e della Ricerca).

DESIGN:
Paolo Vedovetto

PUBLISHER:
SAP Società Archeologica s.r.l.
Strada Fienili 39/a, 46020 Quingentole, Mantua, Italy
www.saplibri.it

Authorised by Mantua court no. 4/2011 of April 8, 2011

ISSN 2039-7895

pca
european journal of
postclassicalarchaeologies

volume 12/2022

CONTENTS **PAGES**

Antonio Fornaciari*, Alessio Amaro**, Letizia Cavallini*,
Francesco Coschino*, Valentina Giuffra*

The cemetery of San Pietro di Pozzeveri, Lucca. Bioarchaeology and funerary archaeology of a medieval monastic churchyard (11th-13th centuries)

1. Archaeology of monastic churchyards in Italy

The archaeology of monasteries has had a fair development in Italy, especially in relation to the settlement of important early medieval monasteries (Gelichi, Librenti, Cianciosi 2018). In the last twenty-five years various projects have been dedicated to the excavation of monastic complexes dating back to the central and late medieval centuries. The topic is closely linked to the study of the dynamics of rural populations. Indeed, the wave of monastic foundations between the end of the 10th and the first quarter of the 12th century was connected to the initiatives of the lay families, with the establishment of private monasteries. These buildings, which acted as organizational centers of goods favoring the territorial roots of the nobility, in large part reflected the parallel phenomenon of encastlement (Ceccarelli Lemut 2003).

Monastery archaeology explores the structures (architecture archaeology), the function of the spaces, the environmental impact on the landscape, the characterization of the material culture and, although less systematically, the funerary contexts related to the monasteries (Gelichi 2009). In this regard, we believe the monastic sites have a lot to offer in terms of historical reconstruction, since they constitute privileged settings for the study of buried individuals (both ecclesiastical and lay) who had relations with the monastic institution for different reasons. The monastery, as a privileged centre of aggregation of the burials, often in contrast with other religious institutions, becomes a remarkable test for churchyard archaeology, of which the English context is a fertile example (Gilchrist, Sloane 2005).

In the last twenty-five years, medieval archaeology in Tuscany has undertaken various studies in the field of monastic sites, often requiring several excava-

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tion campaigns (Cambi, Dallai 2000; Della Negra 2005; Gelichi, Alberti 2005; Arslan *et al.* 2006; Giannichedda, Lanza, Ratti 2011; Dadà 2012; Baldassarri 2014; Bianchi, Gelichi 2016; Fornaciari *et al.* 2016).

Many of these excavations have involved, alongside traditional themes, the study of samples of skeletal individuals and have benefited from collaboration of composite teams of researchers, including anthropologists working on the field.

In this paper we present the first data resulting from the bioarcheological study of a sample of 40 buried individuals belonging to the 11th-13th centuries phases of the cemetery of Badia Pozzeveri (Lucca).

The individuals studied can be related to two distinct cemetery periods, one preceding the foundation of the monastery in the early 12th century, and the other corresponding to the 12th-13th centuries when the Camaldolese Abbey of San Pietro di Pozzeveri was most active (Seghieri 1978).

2. Historical background of the site

The archaeological site of San Pietro di Pozzeveri is close to the village of Badia Pozzeveri, located about 10 km southeast of the city of Lucca, in the municipality of Altopascio (Tuscany, Italy) (fig. 1). It is situated near the basin, now entirely dried up, of the medieval Lake of Sesto (or Lake of Bientina), which was the largest lake in Tuscany, with a perimeter of 50 km, until the 19th century (Ribolini *et al.* 2017).

The first mention of the site of Pozzeveri dates back to the year 952, when Uberto, Marquis of Tuscia, granted Teudimondo Fraolmi, member of an important family from Lucca, *quinque casis set rebus illis massariciis in loco et finibus ubi dicitur Pozeuli* (five farmhouses with their equipment in the place and in the boundaries known as Pozzeveri) (Seghieri 1978, p. 7).

This document attests the existence of a village located near the northern shore of Lake Sesto and the Via Francigena. The area, through waterways and the Romea route, was well connected to the Arno valley and to the main urban centers of northern Tuscany. In 1039 the site was mentioned again as a village that included two ecclesiastical buildings: the church of Santo Stefano *que esse videtur in Burgo de Puctieuli* (located in the village of Pozzeveri), and the church of San Pietro *prope suprascripto burgo de Puctieuli* (near the above-mentioned village of Pozzeveri) (Seghieri 1978, pp. 9-10). After the year 1044 the village of Pozzeveri and the church of Santo Stefano were no longer named in documents, while the church of San Pietro, starting from 1056, became the site of a community of priests. It can be hypothesized that the village underwent a process of depopulation and that the religious center constituted by the church of San Pietro survived, and was institutionally transformed into a different ecclesiastical entity (Seghieri 1978, pp. 13-16). The new rectory, created by following the dictates of

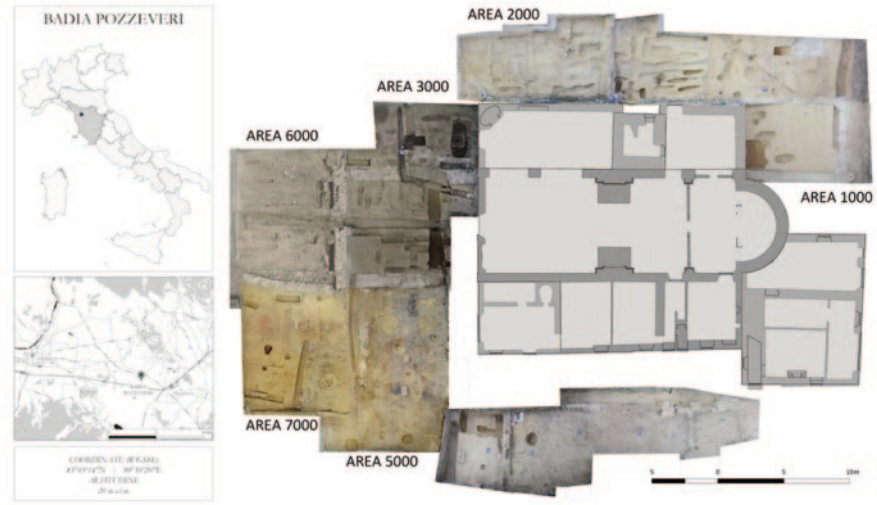


Fig. 1. Geographical location of the Badia Pozzeveri village and the excavation areas of the archaeological site.

the reform of the Catholic Church, which in those years was particularly powerful thanks to the role of the bishops of Lucca (in 1061 the bishop of Lucca Anselmo was elected Pope as Alexander II), was the fourth to be established in the diocese of Lucca in an extra-urban area after the rectory of Santa Maria a Monte (1025), the rectory of San Pantaleone on *Mons Heremitae* (1044), and the rectory of San Genesio (Fonseca 1991).

Already in the year 1086, however, the documents mentioned *ecclesia et monasterium beati sancti Petri apostoli qui est consctructus in loco ubi dicitur Potieule* (the church and monastery of the blessed apostle Peter, which was built in the place known as Pozzeveri); the conversion of the rectory into a monastery was sanctioned in the privilege of Pope Urban II of February 1, 1095, by which the right of burial was also established.

The lords of Porcari (*Porcaresi*), an important aristocratic family with considerable interests in the region of Lucca, invested in the creation and endowment of the monastery, which assumed the characteristics of a sort of proprietary monastery (*eigenkloster*) for their lineage (Seghieri 1985, pp. 45-49).

Starting from 1103 an abbot, and no longer a rector or a prior, was appointed at the head of the monastery. This change of title probably coincided with the arrival of the Camaldolese monks in Pozzeveri. The abbey, richly endowed by the Porcaresi nobles, who in 1138 had already obtained from Pope Innocent II the privilege of having their own sepulcher in the monastery, enormously expanded its real estate assets during the 12th and 13th centuries (Seghieri 1978, pp. 17-24).

According to the *Libellus extimi lucane diocesis* of 1260, the Abbey of Pozzeveri was estimated at 2,800 lire and ranked among the richest religious institutions in the diocese of Lucca (Guidi 1932, pp. 241-275).

In the 14th century the abbey area was at the center of the Tuscany war events that led to the damage of the territory and to the progressive deterioration of the institution. In September 1325 the abbey was occupied, together with its surrounding land, by the Florentine army camps; on September 22 the military operations of the battle of Altopascio, between Lucca and Florence, took place precisely in the area of Badia Pozzeveri. The abbey was later abandoned by the community of monks. Agostino, the last abbot, acting as a sort of commendatory abbot until the definitive suppression of the abbey by Pope Gregory XII (8 July 1408), ruled the Camaldolese monastery from 1388 to 1408 (Seghieri 1978, pp. 47-64). Throughout the modern and contemporary periods, the church of San Pietro became the parish church, with its annexed cemetery, of the scattered settlement of Pozzeveri, bordered to the north by the Via Francigena and to the south by the marshes of the Sesto Lake.

3. Excavation of the medieval phases

In 2011 the archaeological excavation of the site was started by the University of Pisa (Division of Palaeopathology) in an attempt to reconstruct the evolution of the monastery and to obtain a large set of osteological samples for bioarcheological studies of the medieval and modern Tuscany population (Fornaciari *et al.* 2016).

After a preliminary survey with ground penetrating radar (GPR), which provided important guidelines for the excavation (Ribolini *et al.* 2017), seven large areas covering a total surface of about 800 sq m were opened during the 2011-2019 archaeological campaigns around the church of San Pietro (fig. 1), the only building of the medieval monastic complex that still partially exists.

Two different periods defined the funerary use of the churchyard of San Pietro: the former, linked to the pre-abbey church (11th century), site of a rectory from 1056 (fig. 2); the latter, relative to the Camaldolese monastery, which developed from the beginning of the 12th century throughout the 13th century (fig. 3).

The 11th century church was identified in the area located to the west of the modern church. Here it was possible to identify the robber pit (1,3 m wide and 70-80 cm deep) of the façade of a church building (ca 9 m wide) identifiable with the *Ecclesia Sancti Petri* attested since 1039.

Belonging to the same period of the pre-abbey is the lower portion of the bell tower, as well as traces of buildings identified in the excavation areas to the west of the church, probably part of the residential structures of the Rectory of Pozzeveri.

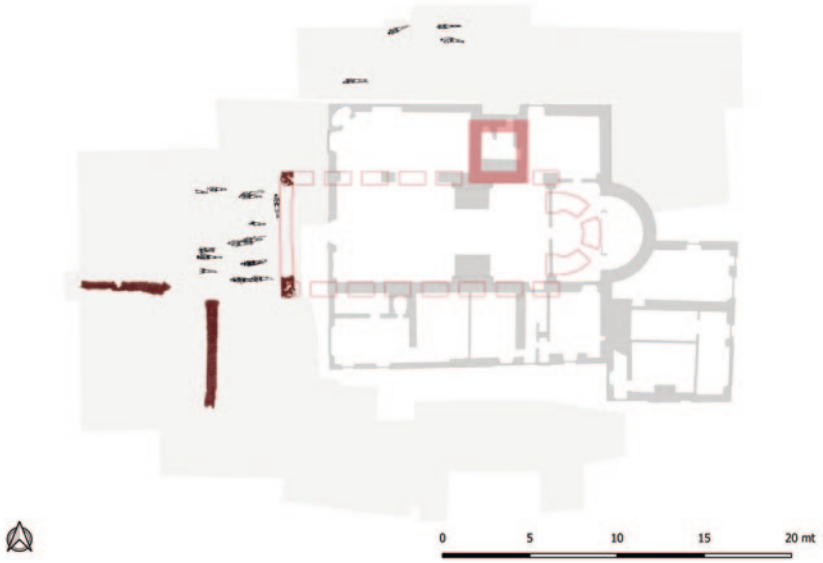


Fig. 2. San Pietro di Pozzeveri. Map with 11th century structures and burials.

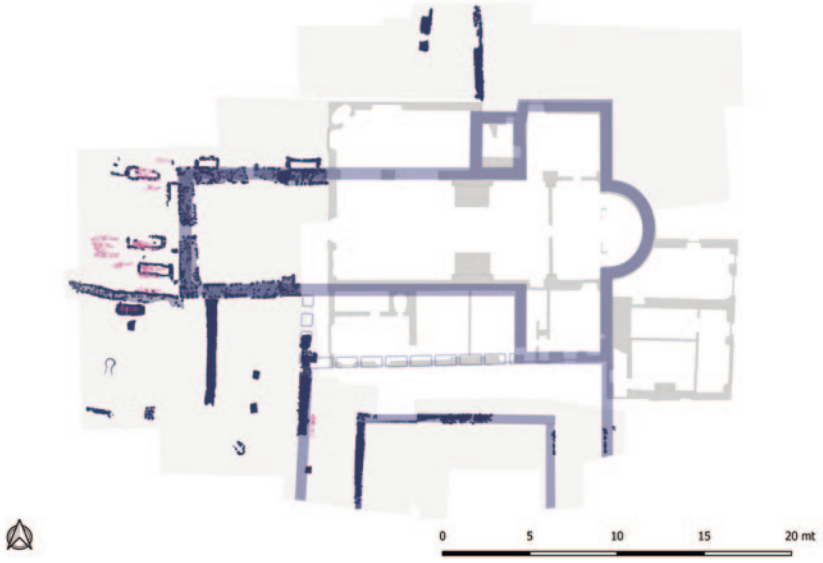


Fig. 3. San Pietro di Pozzeveri. Map with 12th-13th centuries structures and burials.

During the 11th century the funeral spaces were located to the west, north and north-east of the church. These burials, in a simple ground trench, or in a trench with some stones arranged around the cut (complex trench), or around the skull to delimit a sort of cephalic alveolus, are generally oriented west-east.

During the 12th century the site of Pozzeveri underwent profound transformations: originally a rectory, it became the site of a monastery.

In the early 12th century, the 11th-century church was partially demolished and despoiled for the building of the new Camaldolese abbey church of the same width. The church expanded towards the east and was equipped with transepts that protruded 5 m from the body of the nave (extending over 7 m to the west) and defined a cross plan of 34×19 m.

The building probably used as a canonical house in the 11th century was almost completely dismantled. A wall delimited the churchyard to the south, closing the new monastic buildings that surrounded the cloister. This consisted of a quadrangular 14-m courtyard on the side, surrounded by a portico with a 3.5 m wide deambulatory.

The cemetery area for lay people is structured as follows: burials in a simple trench invade the churchyard and the space north of the abbey, while four large lithic coffin burials are leaning against the church, two on the sides of the door entrance (with north-south orientation), and two close to the northern side, with west-east orientation. These lithic burials contained many individuals. Four other lithic coffin burials with west-east orientation, each containing a single skeletal individual, are positioned in the churchyard, a few meters from the façade of the church.

Burials in a simple trench inside the monastery have been identified in the deambulatory of the cloister, probably destined exclusively to the Camaldolese monks.

After the suppression of the abbey in 1408, the monastery structures fell into disrepair. The progressive collapse of the roofs was accompanied by the first processes of robbery of the walls, which intensified between the 15th and 16th centuries. Around the second half of the sixteenth century the front portion of the church was in an advanced state of collapse. A new façade was built ten meters to the east of the front of the medieval church, in the form we can still appreciate nowadays.

4. Osteological samples

This study includes 40 skeletal individuals (11-13th centuries AD) from the medieval site of Badia Pozzeveri (Italy): 22 dating back to the 11th century, and 18 to 12-13th centuries (fig. 4). The excavation of the medieval cemetery revealed the presence of three different burial typologies. The most common typology was a simple ground trench with an elliptical or rectangular shape (fig. 5). The sec-

Individual	Sex	Age-at-death	Heigth (cm)	Phase	Burial typology
USK3588	F	45-55	157(F)	11th century	Simple trench
USK3641	F	25-35		11th century	Simple trench
USK3653	F	25-35	157,9 (H,R,F,T)	11th century	Simple trench
USK3590	IND	30+	151,1 (R,U,T)	11th century	Simple trench
USK3743	F	40-55	165,7 (H,R,U)	11th century	Simple trench
USK3781	F	35-45		11th century	Complex trench
USK3786	F	25-35	147,3 (R)	11th century	Complex trench
USK3829	F	30+		11th century	Simple trench
USK3855	F	25-35	172,1 (H,R,F,T)	11th century	Simple trench
USK2730	M	35-40		11th century	Simple trench
USK2754	M	30-35	167,5 (H,F)	11th century	Simple trench
USK2757	M	30+		11th century	Simple trench
USK2776	M	45-55	173,4 (H,U,F,T)	11th century	Simple trench
USK3564	M	30-40	167,3 (R)	11th century	Simple trench
USK3640	M	18-22		11th century	Simple trench
USK3730	M	30-40	170,4 (U)	11th century	Simple trench
USK3746	M	30-40	174,4 (H,F,T,Fi)	11th century	Complex trench
USK3793	M	40-45	174,5 (U)	11th century	Simple trench
USK3857	M	25-35		11th century	Simple trench
USK3863	M	40-50	171 (F)	11th century	Simple trench
USK3874	M	35-49		11th century	Simple trench
USK3894	M	25-45		11th century	Simple trench
USK4821	M	35-50	170,8 (U)	12th-13th centuries	Simple trench
USK6015	M	18-25	160 (H,R,U,F,T)	12th-13th centuries	Simple trench
USK6053	M	35-40		12th-13th centuries	Simple trench
USK6054	M	35-50	170,4 (R,U,T)	12th-13th centuries	Complex trench
USK6071	M	20-25	164,3 (F,T)	12th-13th centuries	Simple trench
USK6072	M	35-50		12th-13th centuries	Simple trench
USK6073	M	25-30	165,1 (F)	12th-13th centuries	Lithic coffin
USK6082	M(?)	16-24	170,2 (F)	12th-13th centuries	Simple trench
USK6130	M	25-30		12th-13th centuries	Simple trench
USK6154	M(?)	11-14		12th-13th centuries	Complex trench
USK6165	M	25-30	164 (H,R,U,F,T)	12th-13th centuries	Complex trench
USK6175	M	30-45	167 (U)	12th-13th centuries	Complex trench
USK6182	M	30-40	164 (H,R,U,T)	12th-13th centuries	Lithic coffin
USK6065	F	35-55		12th-13th centuries	Simple trench
USK6158	F	25-35	159,7 (H,F)	12th-13th centuries	Simple trench
USK6201	F	40+		12th-13th centuries	Simple trench
USK6023	IND	18+		12th-13th centuries	Simple trench
USK6197	IND	30+		12th-13th centuries	Lithic coffin

Fig. 4. Skeletal sample (USK) from the medieval site of Badia Pozzeveri. The table shows for each individual: Sex, Age-at-the death, Height (estimated by O= humerus; R= Radius; U= Ulna; F= Femur; T= Tibia; Fi= Fibula), Phase, Burial typology.

Fig. 5. Burial in a simple ground trench (USK 3743), 11th century.

ond typology, referred to as complex burial, was also a ground trench with positioned stones around part of the perimeter, often designed to form a housing for the head of the dead (cephalic alveolus) (fig. 6). A third type of grave, recorded from the 12th century, is that of the lithic coffins. These structures were made of rough-hewn stones organized around the perimeter, where they formed the walls of the burial itself (fig. 7). Some lithic coffins contained different individuals, suggesting a family use of the burial. The presence of more than one individual within a single burial was recorded only for lithic coffins. No pattern has been recognized in terms of spatial disposition.

All individuals were buried supine, and the burials were oriented west-east, with the exception of two. The west-eastern orientation of the burial is a common trait during the Middle Ages, with the face looking to the east, towards Jerusalem (O'Sullivan 2013). The two exceptions, USK3743 and USK4821, had a south-north orientation. The former was that of a female who lived in the 11th century, because it is aligned with the façade of the church. The latter, instead, was buried under the western corridor of the cloister, where other traces of burials probably belonging to monks were discovered.

A detailed recording of the position of the upper and lower limbs was performed for each individual. The upper limbs of most of the males and females were outstretched (F = 50%, M = 65.4%), whereas smaller percentages were straight to the body (F = 20%, M = 19.2%), or in asymmetric position (F = 30%, M = 15.4%). The lower limbs of most males and females were flexed and parallel (F = 90%, M = 96.1%), while those of only a few individuals were flexed (F = 10%, M = 3.85%). These patterns were recorded for both sexes and for both phases.

The taphonomic examination of the burials shows that the decomposition process took place in an empty space (F = 81.8%, M = 80.8%), and in only a few

Fig. 6. Burial in a complex ground trench with the cephalic alveolus (USK 6154), 12th-13th centuries.

Fig. 7. Burial in a lithic coffin (USK 6073), 12th-13th centuries.

cases in a full space (F = 18.2%, M = 19.2%). Some wooden elements in the ground trench burials probably created a void around the decomposing body, so as to prevent direct contact between the sediment and the body. These elements surrounding the corpse, the coffins, or the planks created significant space for the bones to migrate beyond their original anatomical position. We may also hypothesize that these individuals were buried after having been wrapped in cloth shrouds. As for the structural elements like the wooden coffins, the shroud may have created an empty space, preventing the body from getting into contact with the sediment, and allowing the bones to partially move from their anatomical position. A cloth shroud in a wooden coffin would eventually decompose and leave no archaeological evidence (Duday, Guillon 2006; Duday 2009). No grave goods were recovered.

4.1. Bioarchaeology methods

The biological profile of each individual was established at the laboratory of the Division of Paleopathology (Pisa, Italy). Sex estimation was conducted on cranial and pelvic features (Ferembach *et al.* 1980; Buikstra, Ubelaker 1994; Nikita 2017). Age at death was estimated by following various methods that focussed on morphological features of the pubic symphysis and of auricular surface, dental wear, and cranial suture closure (Brothwell 1981; Lovejoy 1985; Meindl, Lovejoy 1985; Lovejoy *et al.* 1985; Brooks, Suchey 1990; Nikita 2017). When possible, stature was calculated by measuring complete long bones (Trotter, Gleser 1952, 1958, 1977).

Periodontal disease was recorded following the indications outlined by Brothwell (1981) and Nikita (2017). Caries were evaluated on the basis of the macroscopic appearance of carious lesions using a bright light, and the lesions were scored only in the presence of a cavitation in the teeth. Any abscesses were described according to their location and appearance. The evaluation of each lesion was conducted following the guidelines suggested by Minozzi and Canci (2015). The distribution of *intra vitam* tooth loss was described by tooth/alveolus frequency. Only those individuals with at least 14 teeth/alveoli were included in this analysis. Linear enamel hypoplasia (LEH) was recorded for each tooth (on the anterior and posterior dentition) by means of a magnification lens and a digital calliper (0.01 mm precision) in order to measure the location of LEH from the cement-enamel junction (CEJ). For this analysis, teeth characterized by severe attrition (i.e., more than one third of the crown missing) and those covered by dental calculus were excluded. The age of occurrence was calculated using the regression equations suggested by Goodman and Rose (1990). If two or more teeth presenting LEH were in the same 3-month-age range, on the basis of their distance from CEJ, they were considered to be the same event. For this contribution, LEH was described according to two degrees: slight hypoplasia (observable by the naked eye) and moderate hypoplasia (observable by the naked eye and felt with a fingernail). LEH was recorded for both males and females; the number of individuals, as well as total number of lines, numbers and percentages of teeth affected, were recorded. LEH was then distributed by age class depending on the age of occurrence. These data were also compared between the males and females from phases one and two. Dental calculus was evaluated following Brothwell (1981).

Periosteal reaction was assessed according to its severity by following the method of Stothers and Metress (1975). *Cribra cranii* and *cribra orbitalia* were analyzed using the scale of Stuart-Macadam (1982, 1992) which assesses the severity of porotic lesions. When present, trauma and fractures were described macroscopically (Buikstra 2019).

4.2. Results

4.2.1. Demographic distribution

The 40 burials studied were occupied by a single individual. Twenty-six males and eleven females were identified (M : F = 2.36). Owing to their poor state of preservation, some individuals (n=3) were classified as indeterminate (IND).

The age-at-death of the skeletal individuals revealed that almost half of the sample had died between 30 and 39 years (M = 44%, F = 45.5%). The subadults (n = 2) recovered at the site had died between 10 and 19 years (based on their dental development). Additionally, the age-at-death distribution for each sex revealed that most of the males had died between 20 and 39 years (72%), and most of the females had died between 30 and 49 years (82%) (fig. 4).

4.2.2. Stature

Stature was estimated for the individuals with long bones in a good state of preservation (6 females and 20 males) (fig. 4). The mean value was 168.7 cm for males and 158.0 cm for females. The height of the males (n = 7) from phase one (11th century AD) was 172.1 cm and that of the males from phase two (n = 9) (12th-13th centuries AD) was 166.2 cm, with a difference of ~5 cm between the two phases, which resulted within the limits of statistical significance (p: 0.078). Females, instead, had an average stature of 157 cm for the first phase (n=5), and 159.7 cm for the second phase (n=1). The female values should also be taken with caution considering the limited data available for this portion of the population.

4.2.3. Periosteal reaction

Periosteal reaction is commonly referred to as a non-specific indicator of stress that might be related to a trauma, infections, or metabolic diseases (Larsen 2015; Roberts 2019). Most of the individuals (F = 81.82%, M = 69.23%) show signs of periosteal reaction, mainly located in the lower limbs (tibia). This condition was diffused in both sexes (F = 66.67% diffused, 33.33% localized; M = 77.78% diffused, 22.22% localized), and of mild intensity (M = 79.73% mild, 20.27% severe; F = 67.74% mild, 32.26% severe).

4.2.4. Cribra orbitalia *and* cribra cranii

Porotic lesions on the cranial vault and on the orbital roof are commonly identified in archaeological remains (Grauer 2019). Traditionally, *cribra cranii* and *cribra orbitalia* are considered to be associated with iron deficiency anemia, but

	Females	Males	Total
Observed individuals	11	26	40
Cavities	20	73	93
Observed teeth	173	454	627
teeth with 1 cavity (%)	11.56%	16.08%	13.82%
Individuals with cavities	6	18	24
individuals with cavities (%)	54.54%	69.23%	61.86%

Fig. 8. Distribution of carious teeth by sex.

new research is highlighting that other biological conditions may cause porotic lesions (Walker *et al.* 2009; Brickley 2018).

Cribra cranii was recorded in 46% of the 37 observable individuals (42% of males and 54.5% of females), whereas *cribra orbitalia* was detected in 39% of the 23 observable individuals (31% of males and 57% of females). The majority of the lesions are mild (degree 1).

4.2.5. Oral health

Periodontal disease

Periodontal disease, caused by the accumulation of dental plaque and bacteria, which favour the inflammation of the gums, is probably the most common oral disease (Hillson 2005). Its mildest form (gingivitis) affects between 50 and 90% of the population (Armitage 2000). In this sample, 71.39% of the observed alveolar sockets in the females were affected by periodontal disease (42.7%: grade 2; 29.24%: grade 3). In contrast, 58.31% of the observed male alveolar sockets were affected by periodontal disease (31.66%: grade 2; 26.65%: grade 3).

Caries

The development of caries is a multi-factorial process, mainly characterized by the presence of bacteria and by fermentation of carbohydrates (Hillson 2005; Kinaston *et al.* 2019).

The analysis of caries revealed that 13.82% of the observable teeth (627) were affected by cavities. As shown in figure 8, the cavity rate is slightly higher in males (16.08%) than the females (11.56%), although the number of observable teeth is considerably higher in males. Most of the teeth are affected by one cavity, only a small percentage is affected by more than one (0.66%). In the whole assemblage, 60% of the individuals are affected by cavities (F = 54.54%, M = 69.23%).

	Females	Males	Total
Observable individuals	9	20	29
% affected individuals	44.44	55	47.22
Number observable teeth	173	454	627
Total number of LEH lines	26	136	162
Affected teeth	16	61	77
Unaffected teeth	157	393	550
% affected teeth	9.25	13.44	11.35
Affected individuals	4	11	15

Fig. 9. Distribution of linear enamel hypoplasia (LHE).

Abscess and intra vitam tooth loss

An abscess is usually referred to as the result of an infection, and it can be recognised by the formation of a cavity bone (Hillson 2005; Kinaston *et al.* 2019). In this population, only 6 abscesses have been detected (F = 1, M = 5). *Intra vitam* tooth loss, recognised by the closure of the alveolar socket, can be due to numerous factors (destructive caries, severe wear, abscesses, etc.). At Badia Pozzeveri *intra vitam* tooth loss was detected, and 66.67% of the female sample was affected, in contrast to 60% of the males, with a tooth/alveolus frequency of 9.3% and 10.6% respectively.

Linear Enamel hypoplasia (LEH)

LEH is caused by interruption of the mineralization process involved in tooth development (Kinaston *et al.* 2019). The aetiology of enamel hypoplasia is still debated, but genetic as well as environmental factors seem to be involved (Brook 1998).

Our analysis of LEH revealed that 55% of males and 44.5% of females were affected by LEH (fig. 9). Specifically, 8 episodes were identified for females (7 slight degree, 1 moderate degree) and 38 episodes for males (36 slight degree, 2 moderate). Most of the events occurred between 3 and 3.9 years (fig. 10). Grouping of the samples on the basis of biological sex revealed that the males experienced most of their stressful events between 2 and 3.9 years. Conversely, females experienced most of these events between 4 and 4.9 years (fig. 11). Further analyses based on the comparison between individuals from phase one and phase two revealed that LEH occurred mostly between 2 and 3.9 years in the former, while it occurred between 2 and 4.9 years, with a peak between 4 and 4.9 years in the latter (fig. 12).

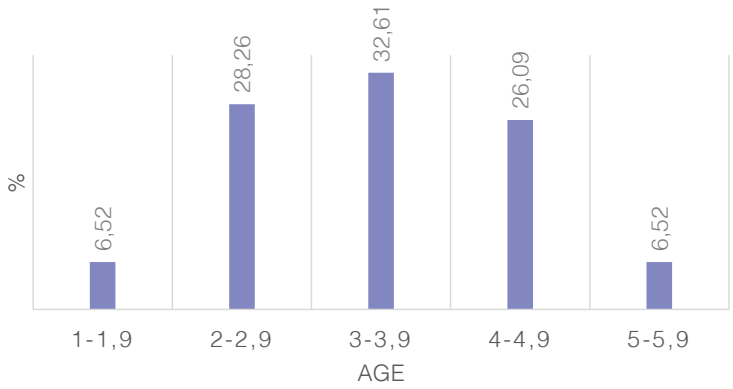


Fig. 10. Chronological distribution (%) of linear enamel hypoplasia (LHE).

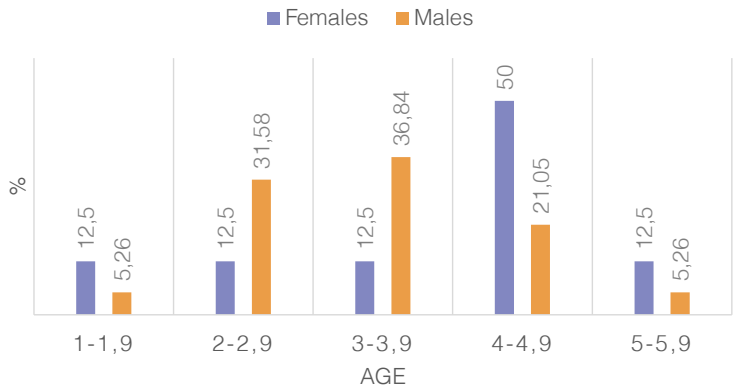


Fig. 11. Chronological distribution (%) of linear enamel hypoplasia (LHE) in males and females.

Dental calculus

Dental calculus is the mineralisation of dental plaque and its presence is due to poor oral hygiene and to an alkaline environment (Hillson 2005; Kinaston *et al.* 2019). Dental calculus is generally found in the teeth that are close to the ducts of salivary glands. At Badia Pozzeveri 88.89% of the females, and 85% of the males were affected by dental calculus. Most of the population affected by dental calculus presented only a slight grade (F = 61.28%, M = 71.43%).

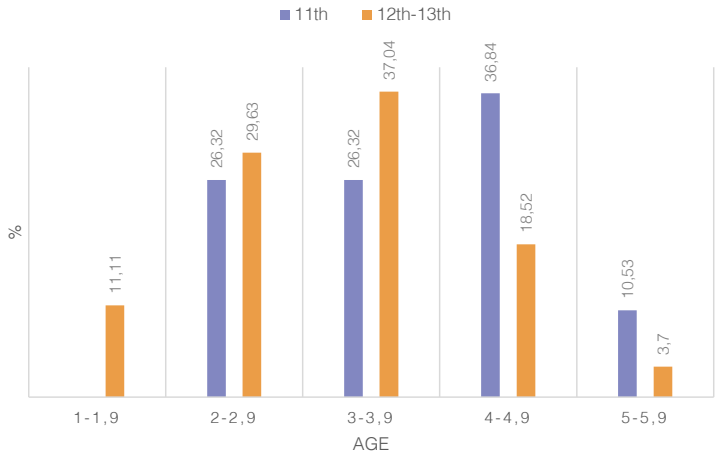


Fig. 12. Chronological distribution (%) of linear enamel hypoplasia (LHE) in different phases.

Individual	Sex	Upper limbs fractures	Lower limbs fractures	Ribs fractures	Weapon lesions
USK3746	M		Right tibia		Frontal bone
USK3863	M	Right ulna	Left tibia		
USK6015	M		Right tibia		
USK6054	M				Right parietal
USK6065	F			Left ribs (4)	
USK6182	M				Frontal bone

Fig. 13. Traumatic lesions and their localization.

4.2.6. Traumatic lesions

In the skeletal assemblage presented in this study, six individuals suffered from traumatic injuries. Only three *ante mortem* lesions caused by weapons have been identified, with evidence of remodelling at the location of the injury. Additionally, a total of 5 completely healed fractures was recorded, three in males and two in a female individual (fig. 13).

USK 3746, a male with an estimated age-at-death between 30 and 40 years, and an estimated stature of 176.7 cm, suffered from a traumatic lesion located on the frontal bone. The oval shape lesion (3.93x1.28 cm) is located between the left orbital ridge and the coronal suture. The lesion, completely healed, shows a lateromedial oblique orientation with a large U-section and a central area marked by some irregular bone spicules (fig. 14). The shape, location and orientation of the lesion suggest that the sharp force trauma was inflicted by a right-handed assailant facing the victim. A sword may be reasonable candidates for the

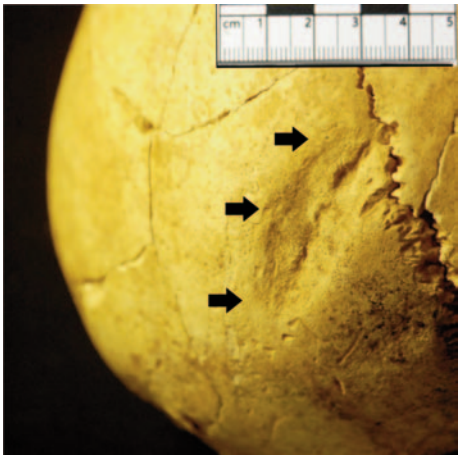


Fig. 14. Sharp force lesion on the frontal bone of USK 3746 (11th century).

weapon that caused the injury. The same individual also shows the healing outcomes of a fracture on the distal portion of the right tibia.

USK 6054 is an adult male with an age-at-death estimated between 35 and 50 years, and a stature of about 174.1 cm. A V-shaped lesion produced by a sharp force trauma can be observed on the right parietal bone of this individual (fig. 15). Although the preservation of the lesion is incomplete, its diameter can be calculated between 0.93 cm and 1.54 cm. Considering the shape and location of the injury, we estimate that the stab wound was caused by a right-handed frontal aggressor. Even in this case the lesion, probably determined by a sword, was fully healed.

USK 6182 is an adult male (30-40 age-at-death), with a stature of about 164 cm. The left side of the frontal bone displays a rounded lesion with a diameter of 1.5 cm (fig. 16). The injury is likely to have been inflicted by a blunt weapon that was unable to break through the skull. The internal cranial vault shows no signs of remodeling, demonstrating that the blow did not have a sufficient penetrating force. The lesion appears completely healed with signs of long survival.

Fracture-healing outcomes were recorded on the tibia of three males: on the right tibia of USK 3746 (the male, 30-40 years old, also shows a sharp force trauma completely healed on the frontal bone); on the left tibia of USK 3863, a male 40-50 years old, and on the right tibia of USK 6015, a male 18-25 years old. Individual USK 3863 also shows a fracture on the right ulna.

Two of the fractures located in the lower limbs (USK 3863 and USK 6015), on the tibial distal third, are characterized by a *callus* in the anterior surface (<50% of the shaft affected). The fracture observed in the lower limbs (on the tibial distal third) of USK 3746 is characterized by a *callus* formation surrounding all tibial surfaces (>50% of the shaft affected). Considering the outer ap-

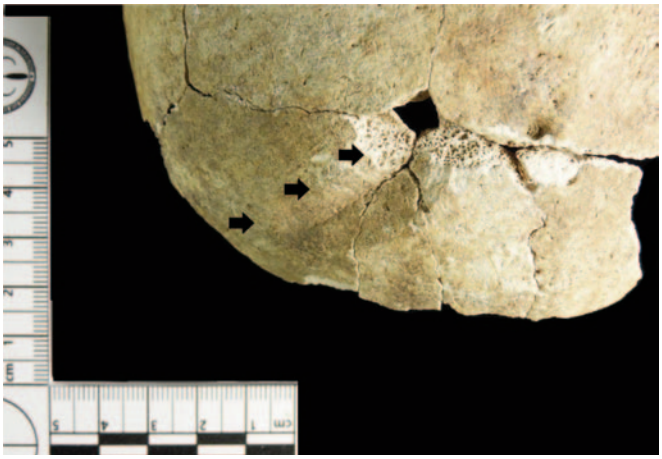
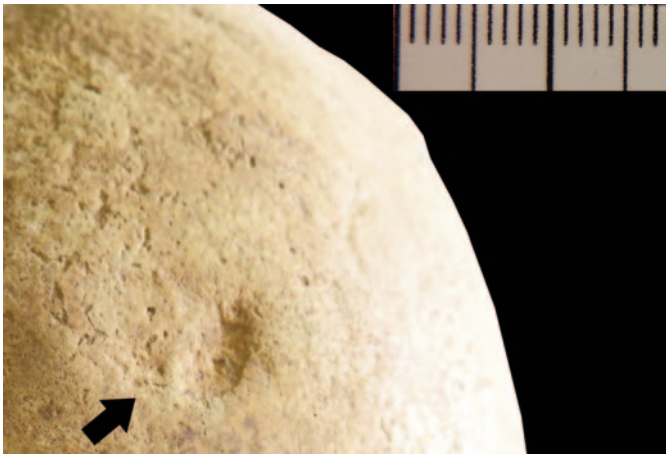


Fig. 15. Sharp force lesion on the right parietal bone of USK 6054 (12th-13th centuries).



aFig. 16. Blunt force lesion on the frontal bone of USK 6182 (12th-13th centuries).

pearance of the *callus*, this lesion might be classified as an oblique or spiral fracture (Lovell 1997). The only fracture recorded in the upper limbs is located on the distal third of an ulna (USK 3863). The outer appearance of this lesion is characterized by the presence of a *callus* formation all around the area and by the neoformation of a bony protuberance. From a macroscopic observation it is possible to recognise the oblique line of the fracture. For this reason, we may hypothesise that the fracture was not well treated (e.g., there was no immobilization of the forearm).

Finally, on the left ribs of the female individual USK 6065 there is the presence of a fracture involving at least four ribs, with ossification of the intercostal ligaments.

5. Conclusion

The study of the skeletal sample of Badia Pozzeveri provides valuable information on the cemetery belonging to the church of San Pietro in two distinct phases, correlated to an important institutional change. In the 11th century the building became the site of a rectory, but starting from the early 12th century it evolved towards a monastery. In the most ancient phase, the burials had simpler and less differentiated structures, but in the second phase there were also sepulchral structures with lithic coffins, which denoted greater economic effort. The distribution of the burials, in both the first and second phase, presented no particular hierarchical-spatial differentiation, since the corpses were distributed in the area of the churchyard homogeneously, with the exception of some individuals of the 11th century placed northeast of the church.

The sample is imbalanced in terms of gender, in favor of a greater male presence (26 males versus 11 females; M : F = 2.36). The data from Badia seem to reflect the well-known problem of under-representation of females in the medieval cemeteries (Barbiera, Dalla Zuanna 2009).

The age-at-death of the skeletal individuals reveals that most of the males had died between 20 and 39 years (72%), whereas most of the females had died between 30 and 49 years (82%).

From the point of view of stature, there is a significant difference between the skeletal individuals of the first phase and those of the second.

In our example, although the numbers are small and therefore probably not representative of the entire population, we note a decrease which resulted within the limits of statistical significance (p: 0.078) in the average male height of about 5-6 cm between the 11th (mean value = 172.1 cm) and the 12th-13th century phases (mean value = 166.2 cm). The average height of 11th-century male individuals is considerable compared to the average established for the Middle Ages in the central Italian area (equal to 166.9 cm) (Giannecchini, Moggi Cecchi 2008). Stature is the result of different genetic-environmental factors and principally a childhood indicator of health (Vercellotti *et al.* 2014). Socioeconomic and environmental aspects are fundamental to determine the final phenotypic expression of stature (Steckel 1995; Koepke, Baten 2005; Giannecchini, Moggi Cecchi 2008). This difference, to be considered cautiously given the small size of the sample, could indicate a general worsening of the local living conditions during the late medieval phase.

As concerns the non-specific indicators of stress, no statistically significant differences were detected between the two phases of burials. Periosteal reaction is very diffused (about 3/4 of the individuals with 25% of severe degree) mainly in the lower limbs and in both sexes, showing that the rural environment was exposed to infections resulting especially from agricultural and farming activities. However, such a high percentage might suggest the presence of

crowded living environments that favoured the inter-human spread of germs (Roberts 2019; Larsen 2015, pp. 86-96). Comparable data come from the skeletal sample of the monastery of Santa Maria di Montescudaio (Pisa), a rural female Benedictine monastery, where cases of periosteal reaction reach a similar percentage between the 11th and 14th centuries (D'Andretta *et al.* 2014). Instead, from the study of the skeletal sample of the monastery of San Michele alla Verruca (Pisa) we have surprisingly very few cases of periosteal reaction (Bertoldi, Giacomello 2005, p. 266). This could be partly justified by the characteristics of this skeletal sample, attributed to monks (buried in the cloister of the monastery) and to eminent laymen (buried in lithic tombs abut to the façade of the monastic church), less exposed to infections resulting from physical activities and few working traumas.

Cribra cranii and *Cribra orbitalia* were recorded in about 40% of the observable individuals with a slightly higher percentage incidence in females. This is in agreement with other studies in which a prevalence of females was observed (Riccomi 2021, p. 115). Menstruation, pregnancy, childbirth and lactation may induce low levels of iron and consequent iron deficiency anemia in women (Grauer, Buikstra 2019).

About half of the individuals analyzed are affected by mild LEH, with no statistically significant differences between males and females. However, this incidence does not appear high if compared with other late antique and medieval Tuscan cemeteries like San Genesio / Vico Wallari (PI) and Pieve di Pava (SI), with 86.9% of individuals affected by hypoplastic defects (Riccomi 2021, pp. 73-78), or with the monastic site of Santa Maria di Montescudaio (PI), where 60-70% of individuals are affected (D'Andretta *et al.* 2014).

In Badia Pozzeveri, most of the events occurred between 3 and 3.9 years. Grouping of the samples on the basis of biological sex revealed that the males experienced most of their stressful events between 2 and 3.9 years. Conversely, females experienced most of these events later, between 4 and 4.9 years. Further analyses based on the comparison between individuals from phase one and those from phase two revealed that LEH in the former occurred mostly between 2 and 3.9 years. Instead, LEH in the latter occurred between 2 and 4.9 years, with a peak between 4 and 4.9 years. This data suggests also differences between the first and second phase in terms of childhood stress.

The incidence of hypoplasia is generally included in the range between 2 and 4-5 years, the period of childhood most exposed to infectious diseases in conjunction with the weaning and post-weaning periods (Goodman, Armelagos 1989). Finally, half of the infant population was subject to different types of stress events during the first years of life, but this value is not excessive if compared to the findings resulting from the analysis of other Tuscan sites of the same period.

Periodontal disease is observed in 60-70% of individuals, with a slightly higher incidence in females. 13.82% of the 627 observable teeth was affected by

caries. In the whole assemblage, 60% of the individuals were affected by cavities (F = 54.54%, M = 69.23%), but only a small percentage of teeth was affected by more than one cavity (0.66%). In this sample, only 6 abscesses have been detected (F = 1, M = 5), but about 60% of individuals shows *intra vitam* tooth loss with a tooth/alveolus frequency of 10% about. At Badia Pozzeveri over 85% of individuals were affected by dental calculus, mostly in slight form.

The picture of dental pathologies that emerges is similar to what was found in the skeletal sample of Santa Maria of Montescudaio (10-12% of teeth affected by caries in the 12th-14th century and about 60% of individuals with *intra vitam* tooth loss) (D'Andretta *et al.* 2014). Studies on the incidence of caries in the Middle Ages show important variables related to the food habits (carbohydrates consumption), socioeconomic contexts, poor oral hygiene and genetics (Carayon *et al.* 2016), as indeed occurs nowadays in the contemporary world (Kassebaum *et al.* 2015). The general trend, however, shows a decisive increase in caries between the Middle Ages and the modern period, due to the introduction of sucrose and other fermentable carbohydrates in the diet (Müller, Hussein 2017). In our sample, the incidence of caries seems to be within the range found in populations with a good consumption of carbohydrates in the Middle Ages (Bertilsson *et al.* 2022).

The traumatic lesions are not numerous: in 6 individuals, of which 5 males and only 1 female, we identified two injuries deriving from a sharp force trauma, probably a sword, one for a blunt trauma and five fractures. In some cases, traumatic lesions seem to be significant, in particular those related to episodes of interpersonal violence, probably of a war nature. In any case, the injured individuals received care and assistance until the wounds were healed.

The bioarchaeological study of the osteological sample of Badia Pozzeveri shows that the area of the churchyard, of the pre-abbey and then of the abbey, was used by a group of lay people (males and females) belonging to a social group that followed a healthy diet (tall stature; modest incidence of enamel hypoplasia; diet with good supply of carbohydrates)[1], and was subject to non-specific infections of the periosteum in the lower limbs, probably in relation to agricultural and farming activities.

In conclusion, the entire space of the churchyard was probably considered as a sort of "privileged area" in the system of the abbey cemetery, reserved to distinguished lay people of the local rural society.

[1] This hypothesis is supported by the results of paleonutritional investigations, based on the stable isotopes of Carbon and Nitrogen, currently in progress.

Abstract

In this paper we present the preliminary data resulting from the bioarcheological study of a sample of 40 individuals belonging to the medieval cemetery of Badia Pozzeveri (Lucca, Tuscany). The individuals studied can be related to two distinct cemetery periods, the former preceding the foundation of the monastery (11th century), the latter coinciding with the time after the construction of the Camaldolese Abbey of San Pietro di Pozzeveri (12th-13th centuries). This study has allowed us to define the population buried in the churchyard of Pozzeveri between the 11th and 13th centuries as a group of distinguished lay people of the local rural society.
Keywords: Tuscany, Badia Pozzeveri, Late Middle Ages, monastic churchyard, bioarchaeology.

Questo articolo presenta i dati preliminari risultanti dallo studio bioarcheologico di un campione di 40 individui appartenenti al cimitero medievale di Badia Pozzeveri (Lucca, Toscana). Gli individuiu studiati sono relativi a due distinte fase cimiteriali, la prima precedente la fondazione del monastero (XI secolo), la seconda coincidente con il momento successivo alla fondazione dell'abbazia Camaldolese di San Pietro di Pozzeveri (XII-XIII secolo). Lo studio ha permesso di definire la popolazione sepolta nel cimitero di Pozzeveri tra XI e XIII secolo come un gruppo di laici benestanti appartenenti alla società rurale locale.
Parole chiave: *Toscana, Badia Pozzeveri, basso medioevo, cimitero monastico, bioarcheologia.*

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