The Plague Cemetery of Alghero, Sardinia (1582-1583)

The bioarchaeological study

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Cover: Aerial view of trenches 2, 3 and 4 of the Alghero cemetery

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Preface

This volume, authored by Valentina Giuffra, presents the detailed bioarchaeological analysis of a large post-medieval population from Alghero (Sardinia) dating to the end of the 16th century.

The study focuses on a sample from an important plague cemetery, where emergency excavations were carried out by a research team of medieval archaeologists and anthropologists under my direction between 2008 and 2009.

To better contextualize the research, the initial pages of the volume briefly illustrate the archaeological background and various cemetery phases identified within the stratigraphic sequence of the site, topics that formed the subject of a book I edited in 2010, immediately after the end of the excavations. Building on this previous research, Valentina Giuffra explores the bioarchaeological aspects of this important archaeological discovery in an original way, also referring to numerous papers published in scientific journals between 2010 and 2020 for the synthesis and interpretation of data.

A fundamental element to take into account for bioarchaeological considerations on the population of Alghero is represented by the migratory flows and repopulation events that characterized this port city in the medieval and post-medieval periods, and particularly during the 16th century, that is the time when the plague cemetery was in use. The city of Alghero was born from the initiative of Ligurian (Genoese in particular) and Sardinian noble groups in the 13th century. In the mid-14th century, the Catalan-Aragonese conquest of Alghero led to its repopulation by Iberian pobladors, radically changing the soul of this city, where a dialect variant of the Catalan language is still spoken today in place of Sardinian.

The plague cemetery (1582-1583), whose bioarchaeological study is at the heart of this volume, reflects a specific phase of use (the most important, in fact) of the vast and multi-layered cemetery of San Michele in Alghero. The excavation of the cemetery of San Michele allowed to document numerous phases of cemetery use, from the 13th century to the 17th century; however, this research focuses specifically on the bioarchaeology of individuals from the plague phase, certainly the most intriguing and informative of the whole stratigraphic sequence.

The plague cemetery of Alghero is unique in Europe due to peculiarities in the organization and management of the burial area during the plague epidemic that decimated the inhabitants of the city. Burial workers (fossadors) dug numerous long and narrow trenches, inside which the bodies of the deceased were carefully deposited in collective burials.

The archaeological excavation of these burials has revealed a picture of high mortality, with the simultaneous death of large numbers of individuals and, in several cases, with multiple deaths occurring within the same family unit. Despite the health emergency and the consequent rush in burial operations, care was taken to maintain connections within family units at the time of interment. Indeed, family members were buried close to one another, with the children protectively placed between the legs of their parents and adult relatives. To carry out this delicate and risky operation, the fossadors are believed to have been paid well by the surviving families. Knowledge of these particular circumstances has allowed an extremely precise archaeological and bioarchaeological study of the buried individuals, with the possibility of recognizing familial groups.

Accordingly, in consideration of the chronological span covered by the different cemetery phases (13th-17th centuries), the high number of buried individuals, the fair state of preservation of the skeletal remains, and the limited impact of post-depositional processes, the cemetery of San Michele in Alghero can be considered as an extraordinary biological archive of the site, the place that, more than any other, bears the material traces of the troubled ethnic history of the city and its inhabitants, including Sardinian, Genoese, and Catalan people.

The phase of the plague cemetery of Alghero studied by Valentina Giuffra captures quite a faithful snapshot of society and its social composition (relations between the sexes and between various age groups and the infant population) at a precise time, circumscribed to the few months of the epidemic.

An anthropological sample obtained from a catastrophic cemetery in use during an epidemic provides more reliable information than samples originating from attritional cemeteries and reflecting ordinary mortality profiles, in which stratigraphy can offer only limited insights into the precise

chronological relationships between different burials within each phase. Nevertheless, the possible and perhaps non-negligible impact of a certain selectivity of death toward the most fragile individuals should also not be underestimated in cemeteries linked to catastrophic events.

A broad objective of the book is the characterization of the health status of the Alghero population at the end of the 16th century based on analytical data collected on a large number of individuals. In a truly extensive catalogue, which occupies a substantial part of the volume, anthropological records are presented for each trench and for each individual, with indication of the results of anthropological assessments and paleopathological observations.

The Author provides a detailed picture of the pathologies she identified in the analysis of the skeletal remains from the plague cemetery. Among the various pathologies illustrated and discussed by the Author are those affecting the spine (DISH), which are not necessarily to be associated with ergonomic causes and occupation, but can also be ascribed to metabolic disorders (obesity, diabetes).

Furthermore, evidence of mild periosteal reaction can be seen as indicative of living and working conditions without an excessively heavy workload, while traces of *cribra* (cranial and orbital) can be related to forms of malaria that are more frequent in males than in females and can be interpreted in terms of a greater involvement of the former in occupational activities performed in extra-urban and, possibly, swampy areas. As pointed out by the Author, a high prevalence of dental pathologies is suggestive of overall poor oral hygiene, but can also be linked to the quality of nutrition.

Lastly, there are very particular paleopathological cases, such as that of a child of about four years of age who was subjected to mercury treatment, probably to cure congenital syphilis, which had been passed on to him by his mother.

The Author interprets this set of paleopathological data as reflective of a physically active population, not engaged in excessively strenuous work and living in a fairly healthy environment.

The case of the cemetery of San Michele in Alghero is particularly significant from a contextual perspective, also at a European level, as it is very rare to find burial sites with a high number of individuals that can reflect the health status of a population over an extremely short period of time. Indeed, most large cemeteries are characterized by multiple phases, which are often less stratigraphically distinguishable and can therefore encompass and conflate different burials spanning many decades or even centuries, weakening the chronological reliability of anthropological records and hindering the interpretation of the biological history of specific populations from given sites.

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Chapter 1

Introduction

1 Introduction

Society has always understood the importance of historical memory enclosed in archives and monuments. However, the construction of historical memory can be assisted not only by written texts and material culture, but also by information that can be inferred from the biological history of a society. Therefore, the research in this field benefits greatly from the study of ancient cemeteries, which can preserve crucial data on lifestyle, disease, work activities, economic and environmental conditions of past populations.

In our case, the San Michele cemetery of Alghero in Sardinia (Italy), used for 350 years, from the 13th to the beginning of 17th century, can be considered as a source of biological information about the population which lived in that period in Alghero; this community was composed of several different ethnicities, including Sardinian, Genovese and Catalan people. San Michele's cemetery was rediscovered in 2008 by a team led by Prof. Marco Milanese of the University of Sassari during the urban redevelopment of the Jesuit complex in Alghero; this site represents by size and burial rite a unique find in the Mediterranean basin and one of the most important Italian medieval and post-medieval cemeteries documented so far, as it contains about 600 individuals. In fact, the cemetery is large in terms of total sample size, thus representing a wider section of the population than other sites, and the preservation of the remains is advantageous, as the skeletons are articulated. Initially, the archaeological investigation, in the form of an emergency excavation, was concentrated in the most ancient internal rooms of the structure of the former Jesuit Convent, where a portion of the medieval cemetery was found. Subsequently, the central part of the garden of the complex was investigated. The total excavated area was about 1000 square meters.

The area corresponding to the courtyard of the Jesuit college revealed a particular burial typology, consisting in 16 long and narrow trenches, rarely documented in the Mediterranean region. Archaeological elements, based on the analysis of the pottery and objects associated with the skeletal remains, allowed to date the trenches back to the second half of the 16th century (Milanese 2010). For this period the written sources document a plague episode that ravaged the town of Alghero in 1582-1583.

During this work, 181 individuals exhumed from the plague cemetery, recovered from 15 trenches, have been studied from the anthropological and paleopathological point of view, providing insight into the health conditions and lifestyle of the population of the late 16th century Alghero. The aim of this book is in fact to examine all the individuals recovered from the trenches of Alghero referable to the plague outbreak, in order to reconstruct as much as possible the health status and the life conditions of this population. For this purpose, the burial modalities adopted in this site will be analysed, the biological profile of the inhabitants of Alghero will be determined, and all the dental and bone pathologies observable on the skeletal remains will be evaluated.

1.1 The Plague: historical and biological aspects

Plague is an infectious disease caused by the bacterium *Yersinia pestis*, a Gram-negative bacterium, belonging to the family *Enterobacteriaceae*. Most mammals can be infected by *Y. pestis*, but rodents are the most common hosts. Many species of fleas are likely to be vectors of plague, but the most effective vector is *Xenopsylla cheopis*, the oriental rat flea. In particular, the plague passes from the rat to the flea through the blood; at this point the cells multiply within the intestine of the flea and can be transmitted to a healthy animal through the bite. When the disease begins to spread, rat mortality becomes so great that fleas are forced to find new hosts, including humans (Raoult *et al.* 2013; Yang 2017).

Plague is divided into three main types, bubonic, septicemic and pneumonic, depending on which part of the body is involved. Bubonic plague is the most common variety of the disease. It is named after the swollen lymph nodes (buboes) that typically develop in the first week after the infection; other symptoms of bubonic plague are fever and chills, headache, fatigue, muscle aches. Septicemic plague occurs when plague bacteria multiply in the bloodstream; other symptoms beside those typical of the bubonic form are abdominal pain, diarrhea and vomiting, bleeding from the mouth, nose or rectum, and gangrene of the extremities. The least common form of plague is the pneumonic one, which can be transmitted from human to human via cough droplets; it is the most dangerous form of plague and symptoms include cough with bloody mucus, difficult breathing, high fever, headache, nausea and vomiting, weakness and chest pain. In the bubonic form

the mortality rate is of 40-70% of cases, if left untreated; the septicemic and pulmonary forms are lethal in 100% of cases in absence of antibiotic therapy (Raoult *et al.* 2013; Stenseth *et al.* 2008).

Plague has evolved quite rapidly and has decimated the European population for centuries. The first pandemic clearly attested by molecular studies is the so-called Justinian plague (541-767 AD) that, coming from Asia, soon spread to all the Mediterranean cities (Wagner *et al.* 2014). Then the great pandemic, known as the 'Black Death', began around 1346 around the coasts of the Caspian Sea and, through successive waves, ravaged Europe for more than four centuries at regular intervals of about half a century (Spyrou *et al.* 2019). Finally, a third pandemic occurred in 1894 in Hong Kong quickly reaching all the world, particularly in areas previously excluded from the bacillus attack, such as North and South America, South Africa and Madagascar, while Europe managed to keep the event under control (Bramanti *et al.* 2019). It was during the third pandemic (1894) that the aetiologic agent of the disease, *Yersinia pestis,* was firstly isolated by Alexander Yersin in Hong Kong.

During the 19th and 20th centuries progress in medicine and scientific discoveries made it possible to stem the number of catastrophic episodes linked to *Yersinia pestis*. In particular, in addition to the work done by the physician Yersin, we must remember that of the French physiologist Emile Roux, who understood the role of mice and fleas in the spread of the disease. Finally, with the arrival of antibiotics and the improvement of socio-economic conditions and hygiene, mortality has been greatly reduced, although the disease cannot be considered to be completely eradicated. In fact, since 2001, 14 major outbreaks have been reported to the World Health Organization (WHO), mainly from Africa and Asia (Butler 2014; Yang 2017).

Plague, like other epidemic diseases, leaves no pathognomonic signs on the skeletal remains, because its evolution is very rapid and frequently mortal, in the absence of an adequate antibiotic therapy. Therefore, the development of new techniques to identify biological traces of the bacillus (proteins, ancient ADN) in the skeletal remains of plague victims is particularly important, and in the last years several molecular studies have been focused on the evidence of past plague occurrences (i.e. Andreades Valtuena *et al.* 2017; Bos *et al.* 2011; Feldman *et al.* 2016; Rasmussen *et al.* 2015; Scheuenemann *et al.* 2011; Seifert *et al.* 2016; Spyrou *et al.* 2016; Wagner *et al.* 2014).

It is out of doubt that the trenches brought to light in Alghero should be referred to an epidemic outbreak. The presence of ceramic fragments and other objects associated to the burials and surely referable to the second half of the 16th century permits to associate the trenches to the plague outbreak of 1582-1583 reported by historical sources. However, the confirmation of the *Yersinia pestis* infection as the etiological agent of the epidemic should be obtained through molecular analyses. Up until now, bone samples taken from four individuals exhumed from four distinct trenches were tested through palaeoimmunological techniques. The analysis was carried out using the Rapid Plague Diagnosis Test (RDT), an immunochromatographic test developed and validated by the Pasteur Institutes of Madagascar and Paris. This test recognizes Y. pestis specific immunogenic F1 capsular glycoprotein (Bianucci *et al.* 2007). The Yersinia pestis F1 antigen was identified in all four tested samples with concentrations between 2.5 ng / ml and 0.625 ng / ml. However, to be considered valid, the results of the palaeoimmunological analysis should have be confirmed by molecular analysis. Two different laboratories worked on samples from the trenches of Alghero but, unfortunately, no positive results have been obtained so far, as for the poor state of preservation of aADN. It cannot be ruled out that in the future the refinement of the molecular techniques could offer positive results of the presence of plague in the skeletons from the trenches of Alghero, which at the moment remains the most likely option.

1.2 The history of Alghero from the origins to the plague of 1582-83

Alghero is a city of medieval foundation, born under the influence of the powerful Genoese family of the Doria and then impacted by an intense process of Catalan colonization, and therefore characterized by a distinct set of traits to the rest of Sardinia. The historical sources attest in fact that the original Sardinian-Ligurian population was integrated with the Catalan settlers since the half of the 14th century, when the city was under the control of the Spanish Aragonese crown. Other episodes of resettlements are recorded, also conducted attracting people from other regions of Sardinia (Budruni 2010). Therefore, unlike other sites of Sardinia, which were characterized by a stationary population of prevalently local origin, Alghero represents a distinct situation, characterized by a mixed composition of its population.

The history of the origins of the town is not entirely known; in fact, documentary sources are unclear in this respect. According to the bishop of Bosa, Giovanni Francesco Fara, a historian, geographer and Sardinian humanist of the 16th century, the city was founded between 1102 and 1112, when the area was yielded to the Genovese family of the Doria, in origin D'oria, a Genovese family emerged around 941. However, the date of foundation of Alghero has been questioned in light of the earliest written record of a human settlement attested about 150 years later, and has been proposed to

be dated back to the second half of the 13th century. In particular, Bertino relies on a document dated February 26, 1281: an act of the notary Leonardo Negrino where the name Alegerium appears for the first time. Instead, the first reference to the city dates back to 1288 in a diplomatic document, a peace treaty between Pisa and Genoa, which provided compensation to the Genovese for the damage done by an incursion onto Alghero by a Pisa and Arboretum navy (Bertino 1989; Bertino 1994; Brown 1994).

The Doria founded the first historical settlement in that area of the Giudicato di Torres and, at the same time, around 1270 built the fortress of Castelgenovese, located in the present Castelsardo. It is not known if formerly there was a settlement defending that part of the northwest coast from Saracen raids (Casula 1998).

Regardless of debates about the precise dating of the city's origins, it is clear that the city of Alghero entered, from 1260 onwards, into the wide network of Sardinian settlements with which the powerful family of Doria implemented a project of centralization of the local population (Milanese 2013). Under the control of the Genovese family, the city of Alghero underwent a vast development, as its port became one of the most important of the island and for two centuries it remained under the influence of the maritime republic of Genoa (Meloni 1994). The life of the community was based on commercial activities exploiting the port that was constantly connected with Genoa and Marseille.

In the meantime, the Republic of Pisa raised as maritime nation reaching the supremacy in the Thyrrenian Sea. Alghero was destroyed and conquered by the Pisans in 1283, but the Doria regained the possession of the city of Alghero in 1284 with the battle of Meloria, which resulted in the defeat of Pisan power (Budruni 1981; Ferretto 1903). This naval battle between the Republic of Genoa and the Republic of Pisa took place off the coast of Porto Pisano.

Following the plague that struck in Europe in 1347, which also hit the Sardinian city, some of the Doria descendants gave their rights to Peter IV of Aragon, who at that time was intent on creating the Kingdom of Sardinia. Other descendants of the family, however, granted the rights to the Republic of Genoa (1353), and this inevitably created a clash between the Catalan-Aragonese and the Judicate of Arborea, an independent local kingdom which occupied the central-western portion of the island (Casula 1998), and which in this occasion was assisted by the Genovese. Thus, on August 27, 1353, Peter IV organized a naval expedition, commanded by General Bernardo of Cabrera, and defeated enemy forces near Porto Conte, not far from Alghero. With the Catalan control over the city a large part of the inhabitants was deported to the Balearic Islands and to the Iberian Peninsula, whereas a group of colonists, the pobladors, was sent to Alghero to oppose the local population. The city grew and became an important commercial center of the island, until in 1412 the last Judge of Arborea, William III of Narbonne (1370-1424), tried, without success, to conquer the city.

Subsequently, with the Decree of Alhambra of 1492, the Jewish community was expelled from the city and, three years later (1495), King Ferdinand the Catholic (1452-1516) granted citizenship to the non-Catalan inhabitants of Alghero, thus promoting the arrival of Sardinians, Ligurians, Corsicans and Provencals that changed the ethnic structure of the city. From the political and economic point of view, the crown of Aragon granted Alghero a series of advantages and privileges, and on August 28, 1501 the rulers Ferdinand II of Aragon and Isabella I of Castile, with a decree issued in Granada, conferred the title of Royal City to Alghero (Budruni 1989). Furthermore, only two years later (1503), a pontifical edit of Pope Julius II named the city a bishop's office with the name Diocesis de l'Alguer y Unions (Sechi Copello 1984). At this point Alghero became a center of great importance in Sardinia both from an economic and cultural point of view.

In November 1582, at the hight of the city's power, a violent plague epidemic broke out, stopping its development and making it difficult to recover. The estimation of deaths from this epidemic wave appears to have been disastrous: the sources report about 6,000 deaths, and 150 survivors for the city of Alghero (Manconi 1994). Even if the number reported by the sources could not be considered reliable, it provides an idea about the catastrophic impact of the plague on the demographic structure of the city and therefore on its economy. It was possible to circumscribe the epidemic outbreak and preserve Sassari and its district, thanks to the intervention of the Neapolitan court doctor Quinto Tiberio Angelerio, hired by the municipality of Alghero (Bianucci *et al.* 2013), who recognized that the outbreak reached epidemic levels and declared the state of the epidemic of the city imposing on citizens the prohibition of leave the area (Manconi 1994). During epidemic waves, such as that of the plague of 1582, in Sardinia, as well as in Spain, special boards with extraordinary powers of political and administrative government were established; these institutions were headed by the Protomedical Bureau, which imparted the prophylactic and therapeutic directives.

Angelerio worked at the services of the Alghero City Council for four years, from 1581 to 1584. The Neapolitan physician has left important writings (Angelerio 1598) on the treatment of the infected and prophylactic measures to be implemented during plague outbreaks.

He resumed the model proposed by another relevant a physician of 16th century epidemiology, the Sicilian Gian Filippo Ingrassia (1576). His purpose was to preserve public health, in addition to treat the individual ill persons, thus implementing a healthcare protocol based on models that had already been tested in the rest of Italy. This standard represented the start of a new strategy for epidemiological defense that was then widely applied during the 17th century in the Kingdom of Sardinia. According to this protocol, the city was divided into areas within which specialized personnel enforced prohibitions against citizens meeting, the isolation of suspected cases and the rapid identification of new cases. This series of measures were accompanied by others aimed at assisting the aforementioned guards, but also the poor and the sick, and by special arrangements made for the maintenance of the city's hygiene, including the invention of the dry heat sterilization process, which gave Angelerio a prominent role among the active plague physicians between Italy and Spain. In addition, the medical staff also had the power to perform forced treatments (Bianucci *et al.* 2013; Manconi 1994).

It is not possible to determine the mortality rate of the Alghero outbreak of 1582-83, as death registers were kept only from 1677 onward. Toda y Güell (1888) claims that plague caused 6,000 death and only 150 people survived. According to other authors, it is unlikely that Alghero counted 6,000 inhabitants at the end of the 16th century; probably the mortality rate (97.6%) was inflated by local authorities in order to obtain a tax reduction (Budruni 1986; Serri 1980). The only reliable documents of that time which permit a partial or rudimentary reconstruction of the population's demographic structure are represented by the baptismal registers (Nughes 1980; 1994). These sources indicate that 1582 was demographically quite a normal year, with 158 children baptized, a number close to the annual average of baptisms (154 baptisms) for the previous five years (1577-1581). As for 1583, when plague reached the city, the number of baptism decreased to 62 or by around 60%, whereas in 1584 there was a strong increase in the number of baptisms (173 baptisms), as expected after the end of epidemic; this was likely due to the great upsurge in marriages among young adults who suddenly had easy access to good work and housing.

However, after the end of the epidemic, it was necessary to repopulate the city, partly with Sardinian and partly with Ligurian inhabitants (Budruni 1986; Manconi 1994); this action led to the gradual reduction of the Catalan population within the city, although the Catalan minority continued to hold power. Thus, Alghero was able to overcome this period of crisis, even if the city did not reach the same level of economic and social development of the previous periods.

1.3 The site of Lo Quarter

The San Michele cemetery is located in the area of the city, which in the 19th century was called 'Lo Quarter', that is the 'barracks', as the spaces of the former College of Jesuits were re-used with other destinations. This area is located on a low relief, inside the walls, in the southeast area of the city, between Largo San Francesco and via Carlo Alberto (Figure 1).

This area was occupied in the medieval period by the complex of the Church of San Michele and by the associated cemetery; the date of the construction of the church is unknown, but the first reference to a place of worship in the area is reported in a Catalan document of 1364, which mentions the tower of St. Michael, named after the church nearby. Over time the area was subject to several functional and architectural changes. In particular, from 1589 to 1773 the site was used by the Jesuits for the establishment of a college. They arrived in the city in 1585 and were granted by the Bishop the use of the medieval church of San Michele and its cemetery. In 1661 San Michele was replaced with the present church and in 1625 the cemetery was moved in a neighboring area. This event marked the end of the use of the cemetery for burials. In 1773 the Jesuits abandoned the city and, therefore, the College was closed.

In the 19th century, from 1822, the Barracks of the Carabinieri Royal Corps of Sardinia, which gave the name of the Quarter to the area, were established here (Milanese 2010). Currently, part of the structure is used as a Civic Library.

1.4 The cemetery (end of 13th-beginning of 17th centuries)

The San Michele cemetery occupies an area of about 1000-1300 square meters. It remained in use from about 1280 to 1590-1620, from the establishment of the church to the arrival of the Jesuits. Five well-distinguished chronological phases have been identified within the site, some of which are attributable to the medieval period and others to the post-medieval era. Archaeological excavations were carried by the team of Prof. Marco Milanese of the University of Sassari between 2008 and 2009.

1.4.1 Phase 1. End of 13th-first half of 14th century

With regard to the medieval phases, the archaeological investigations carried out in a group of ajoining rooms of the Jesuit's college (areas 1000, 3000 and 4000) (Figure 2) have brought to light the graves of about 120 individuals exhibiting retained anatomical connection; they were dated back to the late 13th – early 14th century on the base of archeological elements, such as pottery and objects

Figure 1. Satellite photo of the site of Lo Quarter and, in detail, of the Church of San Michele (from Google Earth)

associated with the skeletal remains. These are single burials, west-east oriented, sometimes marked by the presence of tomb markers, which are preserved in the rocky bench. The presence of some wooden coffins and grave goods of modest value could suggest that they were individuals of medium social class within Alghero society of that time. The alignment of these burials with each other clearly indicates a topographic planning of the burial space (Milanese 2010). The period to which this phase is related is marked by the presence of Sardinian-Ligurian population, under the dominion of the Doria.

1.4.2 Phase 2 and 3. Half of 14th-beginning of 16th centuries

This phase is distinguished from phase 1 by a rise in the ground level, probably due to lack of cemetery space, which resulted of intentional building up of the ground to create new burial plots. The burials attributable to the second phase of use of the cemetery are located in the area 2000 and have a south-west/north-east orientation. The burials of the third phase, scarcely represented, are oriented north-south. Many of them are intercut by the burials of later periods (Milanese 2010).

It is hypothesized that most of the burials of phases 2 and 3 precede the edict of August 27, 1495, in which Ferdinand the Catholic granted citizenship to all the inhabitants of the city, then attracting groups of different origins, including Corsicans, Provencals and Italians. For this reason it is possible that the cemetery of these phases was mainly associated with the Catalan pobladors. At the moment no other cemeterial areas of the same periods are known in Alghero.

1.4.3 Phase 4. The plague cemetery of 1582-83

Sixteen trench burials belong to this phase, located within the area 2000 (the courtyard of the Jesuit's college of San Michele) (Figure 3), and their excavation was delimited by the West wall of the graveyard. The orientation of these burials is different from that of previous phases, as the skulls are oriented northwest.

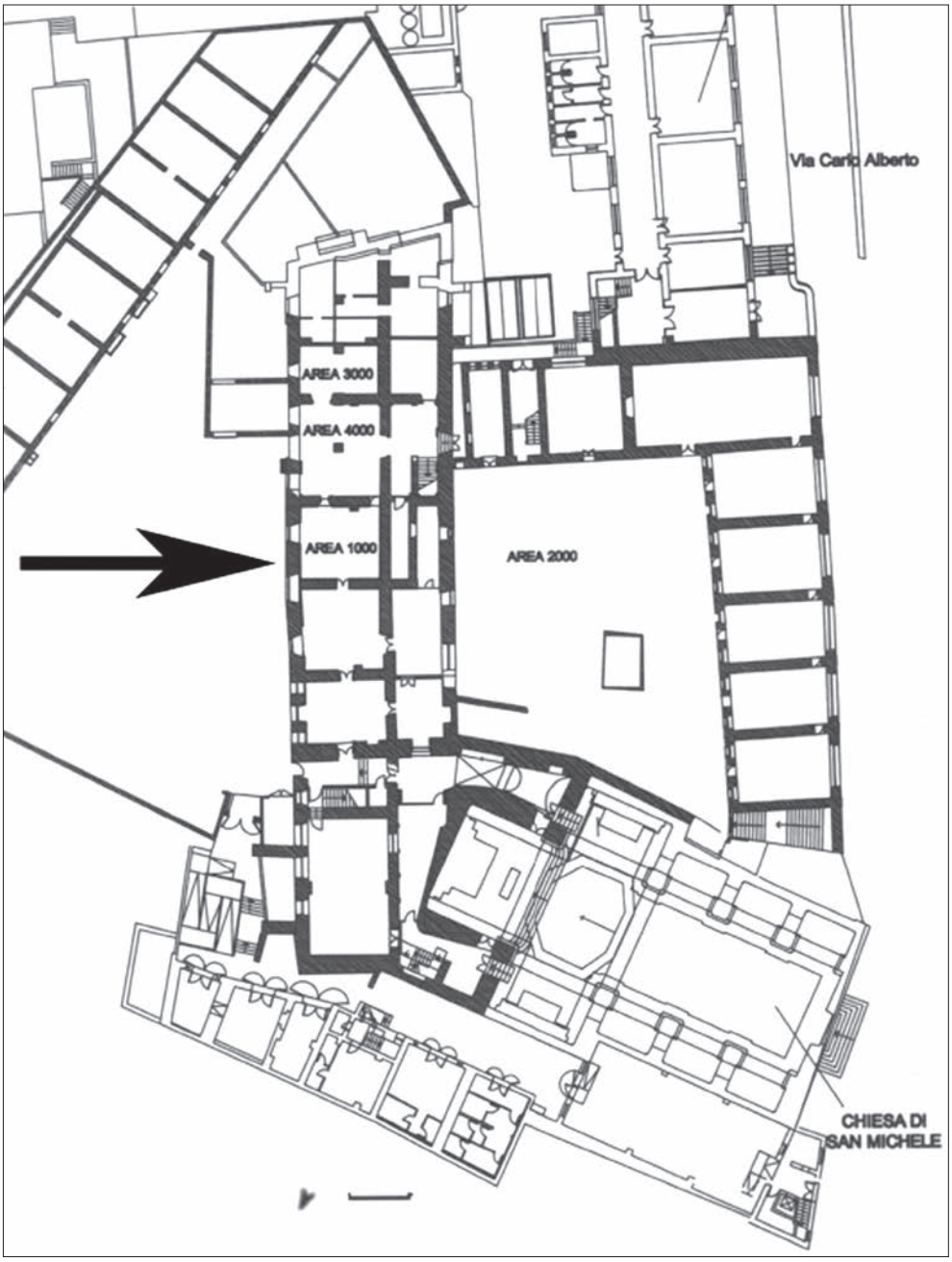

Figure 2. The excavation area of San Michele (from Milanese 2010, p. 35)

The trenches show that they were created with a precise planning, since they do not intercept each other; the deceased were interred in two rows, with the head placed on the pelvis of the previously inhumed person. The burial structure is a proof of their contemporaneity and of the catastrophic course of the epidemic event that, within a few days, killed a large number of people. Nevertheless, the requirement for rapid burials of a high number of persons did not prevent to maintain a regular order and the individuality of the deceased. The dating of this phase of burial was indicated by pottery in the grave fills. For example, in trenches 8 and 10, Catalan majolica lustre ware and Ligurian majolica ware were discovered, which date to the second half of the 16th century (Milanese 2010).

The city of Alghero, as well as the whole island, was affected by several waves of plague epidemics beginning in the 14th century. The historian Giovanni Francesco Fara, in his De rebus sardois (1835), informs us of an epidemic of 'Black Plague' in 1347-48, which first touched Cagliari and then extended to the entire region. A second wave, which seems to have been the most violent of the medieval period, ravaged the island in 1376, then in 1398 and 1403. In 1424 the city of Alghero suffered an epidemic that caused such a demographic decline that a repopulation of the city with a hundred new settlers was needed (Fara 1835). In 1477 the plague reappeared and from Alghero soon spread to Spain through commercial routes that favored the displacement of fleas-bearing rats affected by the

Figure 3. The courtyard of the Jesuit's college of San Michele (area 2000) in which the trenches were found (photo courtesy of Prof. Marco Milanese©, University of Sassari)

disease. For this reason, outbreak cities were usually cities along the coast. Plague epidemics returned cyclically throughout the 16th century: in 1522, in 1528-29 until the outbreak of 1582-83, documented by the tombs of the San Michele cemetery, as confirmed by archaeological dating.

This last plague attack started in 1580 in the city of Sassari and reached Alghero, which is far about 35 km, two years later (Biraben 1975). The city of Sassari was heavily affected by the catastrophic event, with a human loss evaluated around twenty thousand people (Loddo Canepa 1974). The epidemic wave appears to have been disastrous also for Alghero, as previously mentioned. This massive demographic loss for the two cities could be solved by the government through repopulation with inhabitants of the cities of the Catalan coast and of the Genoese Riviera or of Sardinian villages from the internal areas of the island. This event strongly undermined the economy of the northern region of Sardinia. Thus, the Alghero government requested the intervention of the Viceroy, who, in order to stimulate the economic recovery of the city, devoted to it a part of the Parliament's budget. However, this intervention was not sufficient to restore the economic situation and therefore the repopulation plan, formulated by the government, was accompanied by a system of public reforms necessary to restore the economic activity of the city.

1.4.4 Phase 5. Late 16th-beginning of 17th centuries

This phase of the cemetery is represented by a series of single, double or multiple burials, belonging to the last period of use of the cemetery. The dating is based on the presence of Ligurian majolica found in grave 233. It is possible that a group of tombs located in the 1000 and 4000 areas can be attributed to the period when the Jesuit College was already under construction and could reflect an occasional, emergency, use of the cemetery (Milanese 2010).

1.5 The collective burials of Alghero: the trenches

The 'trenches' are burials characterized by long and narrow pits, each containing multiple inhumations. The use of large, collective burial trenches is usually related to catastrophic events, such as epidemics which result in high mortality in a short period of time. Multiple interment in trenches is not a normative form of burial for Italy and Sardinia in the medieval period and, therefore, its use in Alghero suggests that an extraordinary event occurred, in this case an epidemic disease, which required an unusual burial modality. In fact, use of trenches indicates that there was not time or manpower available to dig individual graves quickly enough for the large number of dead. These specific features make the trenches a form of organization of cemetery space rarely found in the ancient world, not only in Sardinia and Italy, but throughout the Mediterranean area. The only exception is represented by similar burials excavated in southern France, although more recent than those of Alghero (17th-18th centuries BC) (Signoli *et al.* 1995; Tzortzis and Signoli 2009).

Specifically, in Alghero sixteen trenches were excavated in area 2000 (Figure 4), with a width of about 60 centimeters and a variable length ranging from a minimum of 2 to a maximum of 11 meters, while the average depth is around 50 centimeters. The trenches were dug in parallel rows and are mainly oriented on

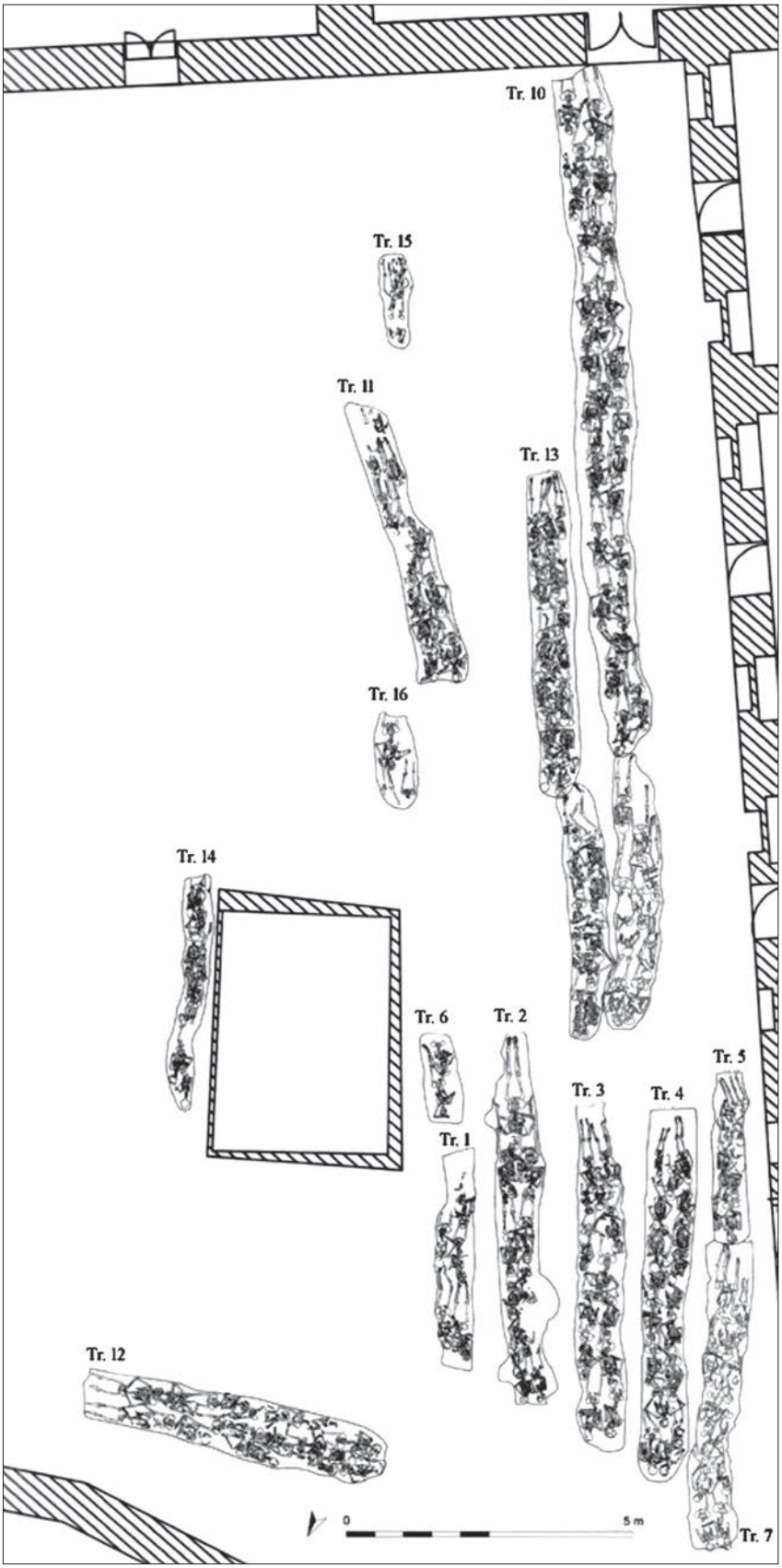

Figure 4. Map of the area 2000 with the trenches (modified from Milanese 2010, p. 39)

a northwest-southeast axis. They contain a total of 183 individuals, with the number of individuals per trench ranging from a minimum of 2 to a maximum of 30.

Two sectors were identified in area 2000, sector 2100 and sector 2500 (Figure 5).

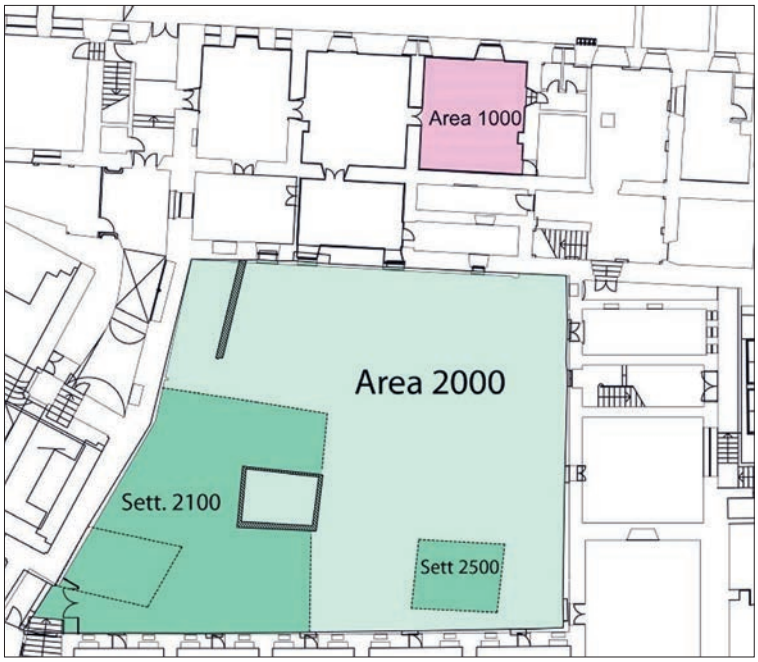

Figure 5. Detailed map of area 2000 (modified from Milanese 2010, p. 195)

1.5.1 Sector 2100

In the sector 2100, which is part of area 2000, 11 trenches (trench 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 14) have been identified and can be grouped based on their peculiar elongated shape (Figure 6). These are long and narrow pits, placed parallel to the NW-SE axis and each containing 2 to 30 skeletons, for a total of 116 individuals.

The bodies were deposited at the same time and according to a well-defined pattern, which was repeated systematically in each trench: the skull of all individuals was lying on the pelvis of the individual previously interred and are disposed in two parallel rows. Based on this arrangement, it was possible to reconstruct quite accurately the deposition dynamics and the chronological relationships between the various statigraphic units (SU). This care in the deposition was observed also in other multiple burials related to epidemic events, as in the examples of 17th century France. The trenches can be dug rapidly, as required by the large number of victims to be

Figure 6. A view of the excavation of area 2000 with trenches 2, 3 and 4 (from the top down) (photo courtesy of Prof. Marco Milanese©, University of Sassari)

managed. This necessity, coupled with the fear of contagion, usually leads to a haphazard deposition of the bodies (Tzortzis and Signoli 2009). In this case, however, we are faced with very accurate burials aimed at maintaining a certain individuality of the deceased, despite the collective character of these pits. In some cases, there is also the need to recreate close relationships, probably of kinship, between some individuals; this can be supposed when an adult has their arms around the body of another individual and infants are positioned between their legs, indicating perhaps a family group. The bodies have been deposited in a filled space, but in some cases shrouds have created some secondary empty spaces that caused the disconnection of some anatomical districts, which therefore resulted in a loose connection. In other cases, this effect was caused by the decomposition of adjacent bodies. The trenches are also well separated and do not intersect each other, which suggests that they were excavated at the same moment. Particularly the trenches 1-7, made in a very narrow space, had probably been dug at the same time.

Trench 1
Trench 1 is located northwest of the central cistern, is a little longer than 3.6 m. and contains 5 individuals, oriented with the skull at north-west and the feet at south-east.

Trench 2
Located northwest of the trench 1, it is 6.50 m. long and contains 12 individuals with orientation northwest -southeast. This is the longest trench of the area.

Trench 3
Located northwest of the trench 2, it is a little longer than 6 m. and 1 m. wide, and contains 13 individuals with the orientation northwest – southeast.

Trench 4
Located northwest of the trench 3, it is 6.40 m long and 1.80 m wide, and contains 18 individuals with the same orientation of the other trenches (Figure 7).

Trench 5
Located southwest of trench 4 and south of trench 7, it is a little longer than 3 m., and contains 10 individuals oriented northwest – southeast.

Trench 6
Located south of trench 1, close to the cistern, it is a little longer than 2 m. and contains only 2 individuals. This trench is anomalous in comparison to the others and can be considered also as a double burial.

Trench 7
Close to the external wall, it is cut by trench 5; 5.50 m long, it contains 13 individuals.

Trench 8
Trench 8 is located south of the previous trenches, and west of trench 9; it is 4.9 m. long and contains 9 individuals.

Trench 9
Located east of trench 8 and south of trench 3, it is 4.5 m. long and contains 10 individuals (Figure 8).

Trench 12
Positioned in the northeast area of the sector 2100, this is the only trench with a different orientation: southwest-northeast instead of northwest-southeast. It is 5.5 m. long and 1 m. large and contains 17 individuals. The trench is cut by the foundation of a wall, and therefore it is not possible to establish its originary length (Figure 9).

Trench 14
Located east of the cistern, it is 4 m. long and contains 7 individuals.

1.5.2 Sector 2500

This enlargement of sector 2500 is located between the walls which delimit the courtyard of the Jesuit College respectively to the west and to the south. In this sector 5 of the 16 total trenches were excavated (trench 10, 11, 13, 15, 16), arranged according to the north-south axis, containing a total of 67 individuals and a fetus.

Trench 10
Located east of trench 13 and south of trench 8, it is 11.50 m. long and 0.80 m. large; this is the longest trench of the cemetery and contains 30 individuals.

Trench 11
Located east of trench 13, it is 5 m. long and contains 14 individuals. The final part of the trench is cut by a pit and therefore it is not possible to determine its original length.

Trench 13
Located east of trench 10 and south of trench 9, it is 5.5 m. long and 0.70 m. large, and contains 16 individuals and a fetus (Figure 10).

Trench 15
It is a multiple burial containing 3 individuals. The trench is cut by a pit excavated in more recent times and the skeletal remains were largely missing and poorly preserved. For this reason, the 3 individuals were not included in this study.

Trench 16
Located east to trench 13 and north to trench 11, it is 2 m. long and contains 4 individuals.

Figure 7. Trench 4 (photo courtesy of Prof. Marco Milanese©, University of Sassari)

Figure 8. Trench 9 (photo courtesy of Prof. Marco Milanese©, University of Sassari)

1.6 Aims of the study

The present study is aimed at examining the individuals exhumed from the trenches of Alghero (Sardinia) attributed to the plague outbreak of 1582-83 from an anthropological and paleopathological point of view. Given the rarity of human remains from epidemic contexts and buried in trenches, the skeletal sample from Alghero represents valuable material that offers a bioarchaeological picture of a post-medieval population which faced a plague epidemic. In particular, no other Italian plague cemeteries have been examined through a detailed bioarchaeological analysis, representing a model and a comparison for future researches.

The objective of this study is to examine a series of parameters, starting from the demographic profile of the sample, constituted by 181 individuals from

Figure 9. Trench 12 (from Milanese, 2010, p. 125)

Figure 10. Trench 13 (photo courtesy of Prof. Marco Milanese©, University of Sassari)

15 trenches, and the taphonomic analysis, and then analyzing stature, dental pathologies, stress indicators, degenerative joint disease, entheseal changes and other pathologies. The study is intended to illuminate a cross section of the Sardinian society during the 16th century in a coastal city through a holistic view, which interweaves the documentary evidence for plague, funerary responses and population health status at the time. The main objective is therefore to examine a population which lived during a period of plague, revealing its lifestyle, activity pattern and illnesses and providing a significant contribution to bioarchaeology, paleopathology, and archaeology of the Italian territory.

Comparisons with other samples from plague cemeteries of the same period from other countries will be performed, by analyzing the available parameters. In particular, the most suitable plague cemetery samples to be compared with Alghero are those of Les Fedons (France) and Dendermonde (Belgium), both dated the 16th century, composed of 133 and 99 individuals respectively (Kacki 2016).