Combining biomolecular, osteological analysis and historical research for the characterization of a post-medieval monastic community in northern Italy

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INTRODUCTION

In the past, religious women were often left out from historical-archaeological narratives, typically focussed on males. Today, interdisciplinary projects are beginning to integrate historical research and cutting-edge human remains analysis to understand female agency in premodern Europe monasticism[1].

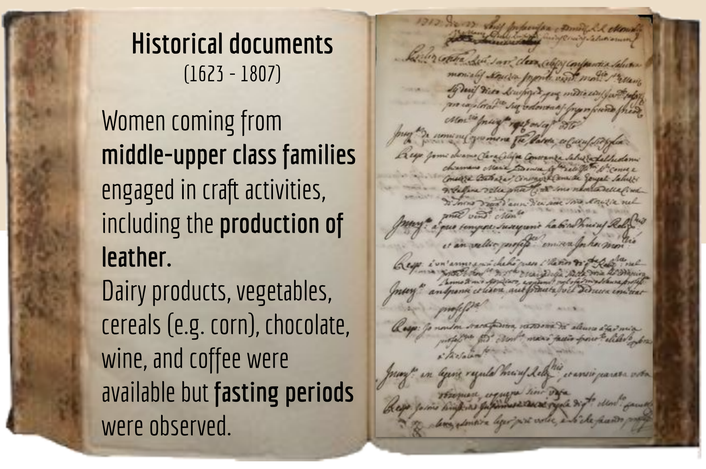
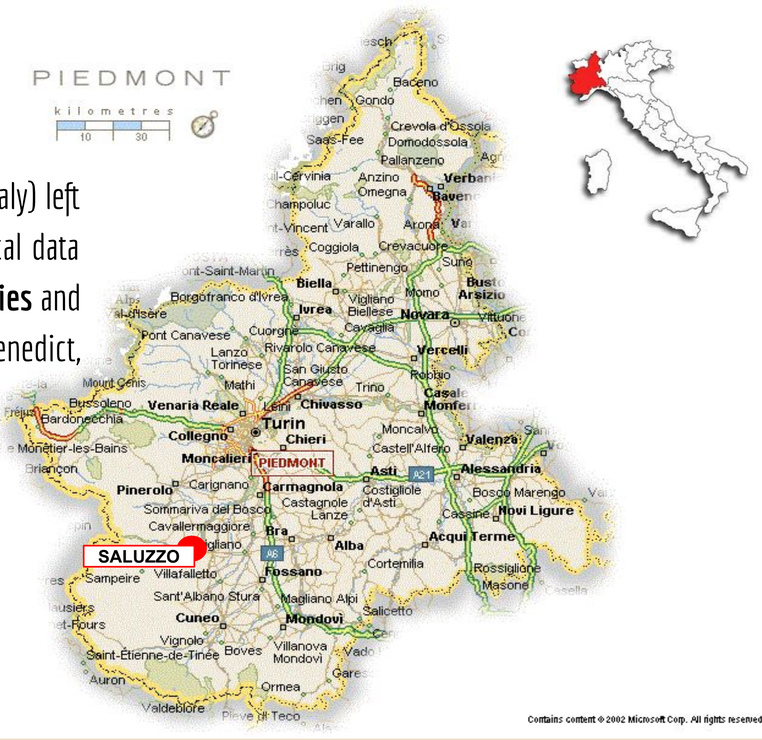


Fig. 1 - Historical data from S. Maria della Stella's archival documents

The female Cistercian **cloistered community of Santa Maria della Stella** (Saluzzo, Italy) left abundant written documentation (fig.1). We are combining this with bioarchaeological data collected from 48 burials from the 18th century, to produce individual **osteobiographies** and to reconstruct "hidden" aspects of the nuns' lifeways. According to the Rule of St Benedict, *ora et labora* (pray and work) should govern monastic life.



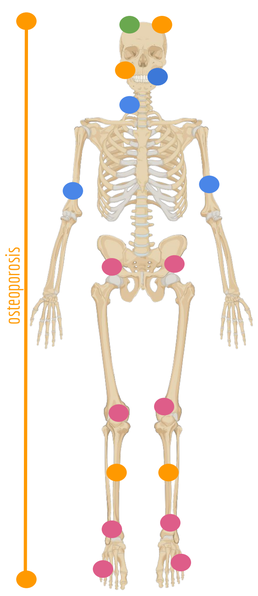
METHODS

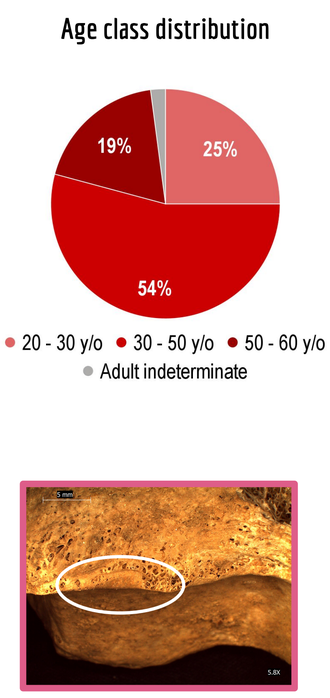
Osteological analyses were conducted on the 48 individuals in order to determine biological sex, age class, presence of pathologies or any activity-related markers Dental calculus was analysed in order to characterise micro-débris (12 samples - **micromorphology**[2] by polarized transmitted light microscopy) and to recover **ancient proteins** (7 samples, SP3 protocol, LC-MS/MS[3]) & ancient lipids (10 samples by TD/Py-GC-MS).

OSTEOLOGY

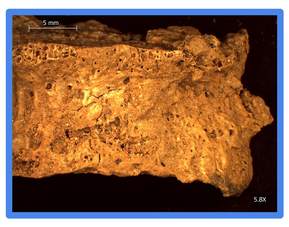
ORA ET LABORA: Markers

- **Religious activities**
  - Knee arthropathy
  - **Kneeling markers**[4-6] (tibia, metatarsal)
  - Enthesopathies (pelvis)
- **Other labour**
  - Articular degenerative disease cervical (vertebrae)
  - Enthesopathies (upper limbs)
  - Dental wear
- **Health**
  - Diffuse bone mass reduction: hypothetical **osteoporosis** in all age classes (skeletal metabolic disease)[7]
  - Diploe hyperplasia (skull)
  - Periosteal reaction (lower limbs)
  - Dental caries, intra-vitam loss of teeth, alveolar retraction
- **Taphonomic alteration** - contact with hair-veil pins



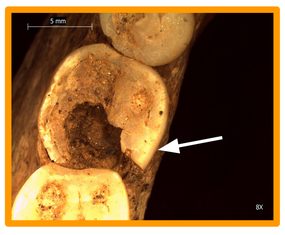


Tibia - Squatting facets



Cervical vertebrae arthrosis

Frontal bone- Green staining

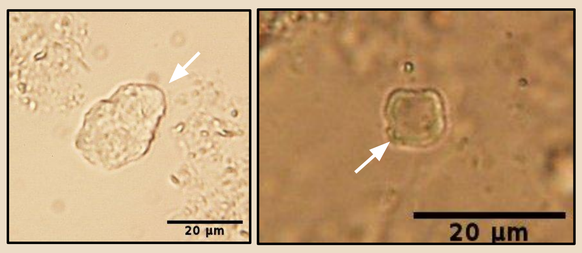


Dental caries

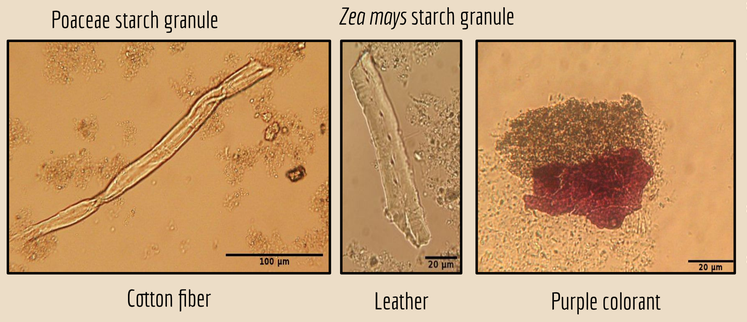
Grooving (dental wear)

Humerus- enthesopathies

DENTAL CALCULUS ANALYSIS



Poaceae starch granule — *Zea mays* starch granule



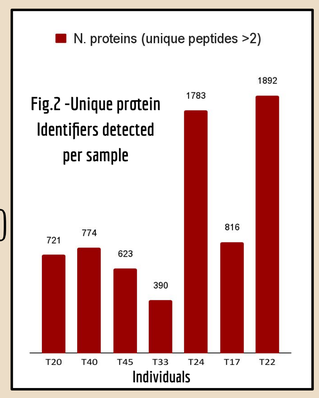
Cotton fiber — Leather — Purple colorant

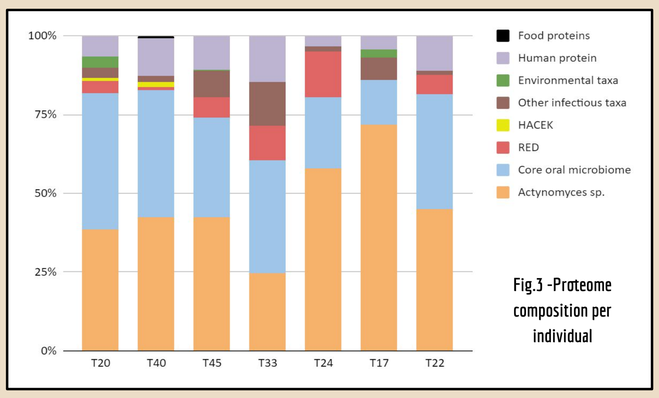
60 micro-débris morphotypes (animal, mineral, plant), were documented. These were compared to a reference collection and some could be identified as:

- Starch granules - **Poaceae** and **Fabaceae**
- Starch granules and phytoliths of corn, ***Zea mays*** (imported from the New World, typical in the area today)
- **Textile fibers** (e.g. cotton), **leather** (?)
- Natural purple colorant (?)

TD/PY-GC-MS biomarker analysis **did not detect evidence for chocolate**, namely theobromine, theophylline and caffeine, in the dental calculus, possibly due to low consumption of chocolate.

Ancient proteins (fig.2) were mainly assigned to **core oral microbiome taxa**, e.g. *Actynomyces sp.* (fig.3). **β-lactoglobulin** (Bovinae/*Ovis*) was found in only one sample (T40). Most individuals yielded evidence of **Red Complex bacteria** (periodontal disease), and two (T20 and T40) of taxa from the **HACEK group**, potentially related to infective endocarditis[8]. Many human proteins detected are linked to the **host defense** (e.g. myeloperoxidase), consistent with the poor health conditions of the monastic women. Interestingly, **zinc-α-2-glycoprotein** (T40) is a lipid and glucose-metabolism protein which is overexpressed in patients with cachexia[9] - we are investigating if this could be related to fasting.





DISCUSSION

DIET

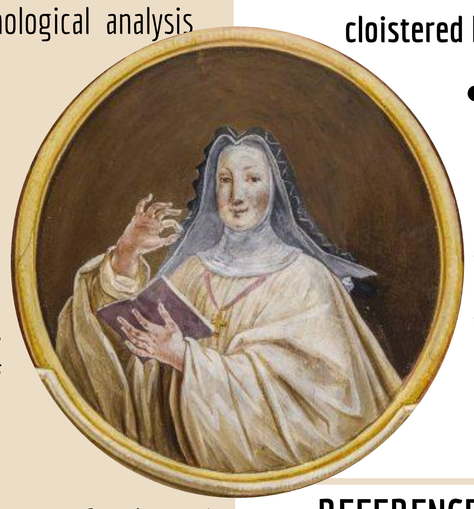
Morphological signs of **malnutrition** (fasting?) combined with the lack of dietary proteins in dental calculus may reflect a **poor diet**, even if the women had access to "exotic" and nutritious foods (e.g. chocolate, corn), as reported in historical texts. The micromorphological analysis of dental calculus also confirms the consumption of **cereals** and **legumes**.

LABOUR

Osteological markers reflect **spiritual** (kneeling) as well as **manual labour** (biomechanical disorders). Dental wear and micro-débris possibly related to leather and textiles suggest **craft activities**, as testified by the written documents. No significant differences between age groups were found, indicating that all were involved in religious-occupational activities, typical of Cistercian "equal labour" rules.

HEALTH

Dental calculus proteins related to the host immune response as well as the frequency of pathogenic bacteria support general **dysbiosis**, with diffuse **periodontal infections**, reflected by osteological data.



CONCLUSIONS

A comprehensive osteological assessment, combined with micromorphology and biomolecular techniques applied to dental calculus, has given us glimpses of the **social-economic role** of the monastery and of the **impact of cloistered life on women's health.**

- **Overall good congruence** between archival documents and bioarchaeological data **supports the application of osteology and biomolecular archaeology** to case studies where textual information is not available.
- Bioarchaeology revealed the presence of diseases not mentioned in the texts.
- Ongoing work: lipid analysis for detecting plant-based foodstuffs in dental calculus and aDNA analysis to reveal kinship in the monastery and to investigate the presence of genetic diseases detected osteologically.

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