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Ancient Sheeppox Virus DNA Extracted from 1,000-Year-Old Medieval Manuscripts Reveals 3,700-Year Evolutionary History of Pastoral Pathogens

Emerging Pathogens & Public Health * Genomics * Paleovirology

For centuries, the illuminated parchment folios of medieval codices have been treasured as literary, theological, and artistic masterpieces. Now, an international paleogenomics team led by researchers at University College Dublin, the University of Cambridge, and the University of York has demonstrated that historical manuscripts also serve as unexpected molecular time capsules of ancient animal epidemics [1, 2] . In a study published in Science Advances , researchers successfully extracted and sequenced 21 ancient genomes of the sheeppox virus (SPPV) -- a destructive, highly contagious poxvirus that infects sheep and goats -- dating from the Bronze Age through the Early Modern era [1, 2] . Remarkably, several of the best-preserved viral genomes were recovered directly from sheepskin parchment leaves within famous British manuscripts, including the 1,000-year-old York Gospels and the 8th-century Corpus Glossary , pushing the documented evolutionary history of livestock poxviruses back more than 3,700 years [1, 3] .

Molecular Codicology: Parchment as a Biological Palimpsest

Before the widespread adoption of rag paper and printing presses in late medieval Europe, nearly all written administrative, legal, and liturgical texts were inscribed on parchment or vellum [3, 4] . Producing parchment required washing the flayed skins of sheep, cattle , or goats in lime baths (calcium hydroxide) to loosen wool and hair, scraping away the subcutaneous adipose tissue, and drying the dermis under intense mechanical tension on wooden stretching frames [3, 4] .

While this harsh alkaline preparation degraded much of the soft cellular tissue, it preserved the dense, fibrillar collagen matrix of the dermis [3] . When a medieval animal suffered from an acute systemic viral infection with cutaneous manifestations -- such as the characteristic necrotizing pocks and vesicular skin papules produced by sheeppox -- viral particles became physically trapped within the dermal extracellular matrix [1, 2] . Over a millennium later, non-invasive triboelectric eraser sampling (electrostatic extraction developed for peptide mass fingerprinting, or eZooMS) allows bioarchaeologists to lift trace DNA and collagen peptides from the surface of historical parchment without causing visible damage to ink or calfskin folios [1, 3] .

Paleovirological Telemetry & Evolutionary Timeline

By coupling codicological parchment extracts with ancient DNA recovered from archaeological sheep teeth and petrous bones across Eurasia, the authors assembled an uninterrupted chronosequence of capripoxvirus evolution [1, 2] .

| Specimen / Cohort | | Historical Provenance & Date | | Tissue / Matrix Type | | Genomic & Epidemiological Significance |

| Eurasian Steppe Pastoralists | | Bronze Age (~1,700 BCE) | | Archaeological ovine dental pulp | | Earliest direct physical proof of sheeppox circulating in early pastoral communities [1] . |

| Corpus Glossary | | Canterbury, England; ~800 CE | | Ovine parchment folio | | Confirms endemic livestock poxvirus circulation in Anglo-Saxon Britain [1, 2] . |

| York Gospels (York Minster MS 1) | | England; late 10th to early 11th century | | Illuminated sheepskin parchment | | Yielded high-coverage viral genome revealing remarkable nucleotide conservation [1, 3] . |

| Early Modern Legal Deeds | | Western Europe; 16th-18th centuries | | Archival sheepskin indentures | | Documents historical lineage transitions during agricultural intensification [1, 4] . |

| Modern Reference Strains | | Contemporary veterinary isolates | | Cultured viral isolates | | Serves as outgroup calibration for molecular clock and virulence gene decay [1, 5] . |

Genomic Stability of Capripoxviruses vs. Smallpox Evolution

Sheeppox virus belongs to the genus Capripoxvirus within the family Poxviridae , which also includes goatpox virus (GTPV) and lumpy skin disease virus (LSDV) in cattle [1, 5] . Unlike rapid-mutating RNA viruses such as influenza or coronaviruses, poxviruses are large, double-stranded DNA viruses (genomes spanning ~150 kilobase pairs) with high-fidelity proofreading DNA polymerases [1, 5] .

Molecular clock analyses conducted in the study indicate that the major pathogenic capripoxvirus lineages began diverging between 11,500 and 3,700 years ago, coinciding directly with the Neolithic agricultural revolution and the intensification of sheep and goat husbandry in the Fertile Crescent and Eurasian steppe [1, 2] . Intriguingly, comparative genomic alignment against modern virulent strains revealed that the core coding regions of SPPV have remained astonishingly stable over the last 3,500 years [1] .

This stability stands in stark contrast to human smallpox (Variola virus) [1, 5] . Recent paleovirological recoveries from Viking Age human skeletons revealed that ancient variola strains harbored a broad diversity of active genes that were systematically inactivated through pseudogenization over centuries of human host adaptation [5] . In sheeppox, by contrast, the essential gene repertoire responsible for host cell entry, immune evasion (chemokine-binding proteins and intracellular complement regulators), and host-range tropism was already fixed by the middle Bronze Age [1, 5] .

Historical Ecology: Wool Production and Transcontinental Trade

The temporal and geographic distribution of ancient sheeppox genomes closely tracks historical shifts in pastoral economies [1, 2] . During the European High Middle Ages, monastic estates and agrarian manors transformed sheep farming from localized subsistence meat production into continent-wide commercial wool production [1, 4] . Large flock densities, shared grazing pastures, and transhumant seasonal animal movements provided ideal ecological conditions for the continuous transmission of respiratory and cutaneous poxvirus infections [1, 2] .

Because parchment makers routinely bought raw hides from local butchers and agricultural skinners, skins exhibiting minor blemishes -- such as healed pox lesions or mild viral dermatitis -- were frequently scraped, bleached, and trimmed into secondary manuscript folios, inadvertently preserving the pathogen for future molecular analysis [1, 3] .

The Untapped Epidemiological Archive in Global Libraries

Beyond clarifying the evolutionary trajectory of an economically devastating agricultural pathogen, the recovery of viral genomes from the York Gospels and Corpus Glossary establishes parchment as a vast, non-destructive archive of historical epidemiology [1, 2, 3] . Millions of handwritten parchment rolls, monastic cartularies, legal deeds, and bound books reside in rare book vaults, national libraries, and diocesan archives worldwide [1, 3] .

Because these documents carry precise historical dates and geographical creation records (codicological metadata), they offer a spatial and temporal resolution rarely available from uncontextualized archaeological bones [1, 3, 4] . Applying high-throughput metagenomic sequencing to parchment opens up a transformative frontier in paleovirology -- enabling researchers to reconstruct the spread, virulence evolution, and host-pathogen dynamics of ancient zoonoses, livestock plagues, and human vector-borne diseases across millennia of human history [1, 2, 5] .

References & Primary Sources

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