Researchers use ancient DNA to map migration during the Roman Empire

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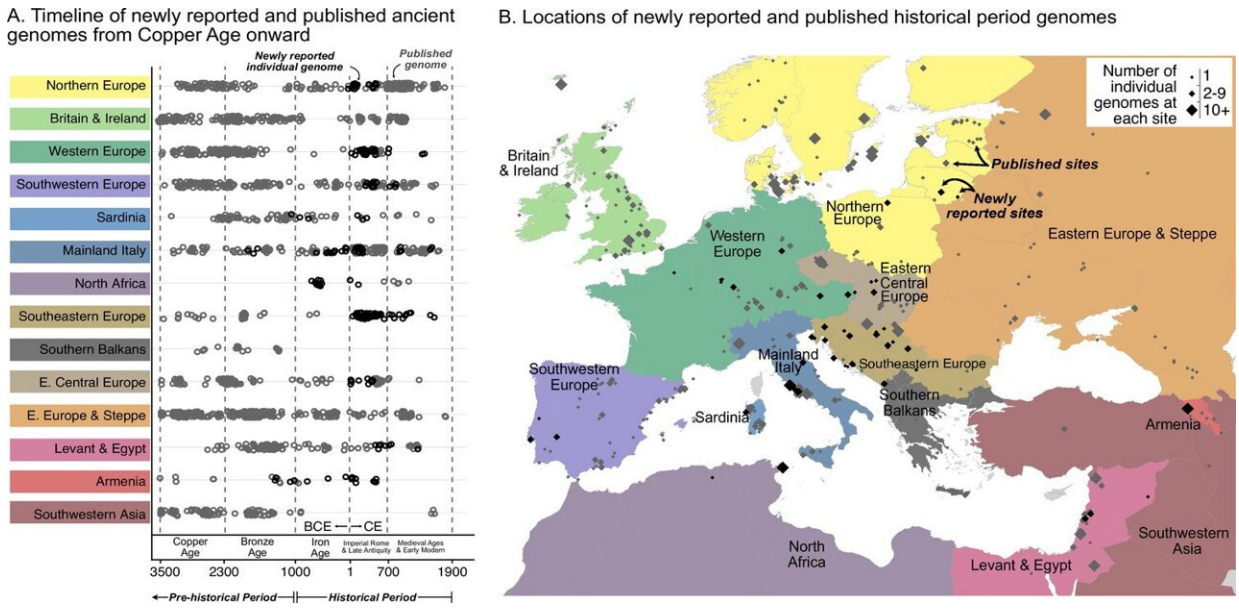

Timeline of new and published genomes. (A) 204 newly reported genomes (black circles) are shown alongside published genomes (gray circles), ordered by time and region (colored the same way as in B). (B) Sampling locations of newly reported (black) and published (gray) genomes are indicated by diamonds, sized according to the number of genomes at each location. Credit: *eLife* (2024). DOI: 10.7554/eLife.79714

Throughout the thousand-year reign of the Roman Empire, disparate populations began to connect in new ways—through trade routes, economic and political collaboration, and joint military endeavors. Now,

an international team led by Stanford Medicine researchers has used genetic material from ancient skeletons to assemble a detailed picture of travel and migration patterns during the empire's height.

Their study, published online Jan. 30 in *eLife*, analyzed the DNA of thousands of ancient humans, including 204 who had not been previously sequenced. It showed just how diverse many areas of the Roman Empire were: At least 8% of individuals included in the study did not originally come from the area of Europe, Africa or Asia in which they were buried.

"Until now, we had to rely on the historical and archaeological record to try to piece together how the population was interacting and changing during this time," said Jonathan Pritchard, Ph.D., a professor of genetics and biology and one of the paper's senior authors. "Now, we can add new details from a genetic perspective."

Expanding geography

Previously, Pritchard's group used ancient DNA to study the genetic diversity of people in and around Rome during a 12,000-year swath of history spanning the Stone Age to medieval times. They showed how the area rapidly grew more diverse around the time of the official founding of Rome, dated to 753 BCE.

The team wondered how much of that diversity was unique to Rome, the capital of the empire, and how diverse more remote areas might have been. In the study, they focused on a narrower window of time—from the conclusion of the Iron Age 3,000 years ago to today—but looked at a geographic area covering the entire Roman Empire.

They used existing DNA data from thousands of skeletons that had been collected from the empire as well as central Europe, Eastern Europe and

Central Asia, Britain and Northern Europe, and North Africa. They additionally sequenced 204 new genomes from 53 archaeological sites in 18 countries. Most were from individuals who died during the time periods known as imperial Rome and late antiquity, from the first to seventh centuries BCE.

"When we started this study, there weren't a lot of historical genomes from this period in time, so the new samples filled this gap," said Clemens Weiss, Ph.D., a former postdoctoral fellow in the Pritchard lab who co-led the work. He is now a research engineer at the Stanford Cancer Institute.

The first thing the team noticed was that, during the period in question, the less diverse areas tended to be those that were geographically isolated, such as the Armenian highlands, which are surrounded by mountains. Overall, however, most areas of the Roman empire had skeletons from a variety of genetic origins. Particularly diverse areas included Sardinia, the Balkans and parts of central and western Europe.

"For the most part, the observations complement what historians and archaeologists hypothesized," said Margaret Antonio, a graduate student in the Pritchard lab and co-first author of the paper. "For example, North African pottery was found throughout the Roman Empire. Now, we also find genetic evidence of people from North Africa residing in present-day Italy and Austria."

Mapping connections

To better understand which areas were connected to each other, the team undertook a large analysis of the people unearthed at every location whose genetic ancestry didn't match where they were found—suggesting that they or their recent ancestors had traveled or migrated.

They found that, among people not local to where they were found, there were common patterns of ancestry. People found in Britain and Ireland were most likely to be from northern or central Europe, for instance, and far less likely to come from southwestern Europe or North Africa. The analysis helped them explain how trade routes and military movements could have fueled the diversity.

"The expansion of the empire was a huge undertaking requiring thousands of troops with trade, labor, slavery and forced displacement," Weiss said. "As the empire expanded, it pulled in more and more people and increased mobility across entire continents."

The increase in mobility, the researchers concluded, meant that, for the first time, people were traveling across a continent within their lifetimes. While most analysis of ancient DNA reveals a diffusion of populations over many generations, the new results show that many people moved great distances during their lives.

A stable population

The new data led the researchers to a puzzling conundrum: If people had continued to move around at the rate seen during the studied period, the regional differences would have gradually begun to disappear. The genomes of people in Eastern Europe, for instance, would have become indistinguishable from those in western Europe and North Africa and vice versa. However, most of these populations—even today—remain genetically distinct.

That may be, in part, because individuals were not always reproducing in the locations where they died, and some may have traveled during their lifetimes but returned home before having children.

"All we can say for sure is where these people died," Weiss said. "If

someone died during a military deployment, it doesn't mean they had resettled permanently to the area where their body was found."

However, the team has another hypothesis: The mobility of people drastically declined when the Roman Empire collapsed. They don't have enough data from that period to know for sure, but they hope to carry out future studies that focus on medieval times, the Enlightenment and the Industrial Revolution to see how mobility patterns compare.

For now, the team is excited to get a glimpse into just how mobile people were during the Roman Empire.

"It shows that movement isn't new; people in the Roman Empire were really traveling in much the same way we do now," Antonio said. "They moved for trade and for work. Some people settled where they moved, and others did not."

More information: Margaret L Antonio et al, Stable population structure in Europe since the Iron Age, despite high mobility, *eLife* (2024). DOI: 10.7554/eLife.79714

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