Holy chickens: Did Medieval religious rules drive domestic chicken evolution?

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Chickens were domesticated from Asian jungle fowl around 6000 years ago. Since domestication they have acquired a number of traits that are valuable to humans, including those concerning appearance, reduced

aggression and faster egg-laying, although it is not known when and why these traits evolved.

Now, an international team of scientists has combined DNA data from archaeological chicken bones with statistical modeling to pinpoint when these traits started to increase in frequency in Europe.

"Ancient DNA allows us to observe how genes have changed in the past, but the problem has always been to get high enough time resolution to link genetic evolution to potential causes. But with enough data and a novel statistical framework, we now have timings that are precise enough to correlate them with ecological and cultural shifts." says Liisa Loog, the first author of the study.

To their surprise they found that this happened in High Middle Ages, around 1000 A.D. Intriguingly these strong selection pressures coincided with increasing urbanization and Christian edicts that enforced fasting and the exclusion of four legged animals from the menu. Could Medieval religious rules have increased the demand for poultry and thereby altered chicken evolution?

"With our new method we see that the time of selection coincides with an increase in the amount of chicken bones in the archaeological records across Northern Europe. Intriguingly, they also coincide with several socio-cultural changes, including a general increase in the popularity of Christian beliefs, new religious dietary rules and increase in urbanization (favoring traits that mean that animals could be kept in small spaces). We cannot say which one of these was most important but most likely a combination of all these factors affected selective pressures on European chickens and consequently their evolution." Says author Anders Eriksson.

Scientists have been attempting to link traits that distinguish

domesticated animals from their wild relatives to specific changes in their genomes. Recent studies of domestic chickens have pinpointed genetic variants in two genes: the thyroid-stimulating hormone receptor (TSHR) and the beta-carotene dioxygenase 2 (BCD02), both of which also show strong signals of selection. Having two copies of a form of the TSHR gene is thought to lead to a loss of seasonal reproduction in many domestic animals. In chickens, a variant of this gene has been shown to enable faster egg-laying, and result in reduced aggression and decreased fear of humans. BCD02 has an effect on skin pigmentation in birds, with one form associated with white or grey skin, and another associated with yellow skin in well-fed chickens.

In 2014, a group led by Greger Larson looked at these two genes in around 100 archaeological samples from Europe spanning the last 2,200 years. But due to a lack of the right statistical methods, they did not quantify the timing or strength of natural selection.

Now, a research team led by Liisa Loog, Anders Eriksson, Mark Thomas and Greger Larson analyzed ancient and modern chicken DNA using a statistical method they developed to pinpoint when selection starts and how strong it is. They found that selection on the TSHR gene began around 920 AD, which coincides with increased chicken consumption across the whole of Northern Europe, as seen in the archaeological record.

"Several independent archaeological studies have documented substantial increases in the frequency of chicken remains between the 9th and 12th centuries AD, as well as a shift towards the management of adult hens, presumably to increase egg production." said Mark Thomas, an author on the study. "Intriguingly, this is the period when selection on the TSHR variant most likely kicked off".

There are several socio-economic factors could have contributed to the

rise in popularity of poultry, including religious edicts that prohibited meat consumption during fasting. Importantly, chickens and eggs were not restricted by these edicts, which may have led to an increase in selective pressures on THSR, allowing chickens to be raised in closer confines as demand for their meat and eggs increased.

"This significant intensification of chicken and egg production has been linked to Christian fasting practices, originating with the Benedictine Monastic Order, which disallowed the consumption of meat from four-legged animals during fasting periods, but the restrictions did not extend to birds or eggs. These dietary rules were adopted across Europe and applied to all segments of society around 1000 AD." said author Anders Eriksson. "However, The increase in chicken production could also have been favored by urbanization, the introduction of the more efficient agricultural practices and a warmer climate."

For BCDO2, the gene which plays a role in leg color, they authors show that while the genetic patterns are compatible with some level of selection, the genetics of modern chickens is best explained as a consequence of Victorian breeding practices, which involved cross-breeding native European breeds with exotic Asian chickens.

The authors new statistical approach, which combines mathematical modeling with ancient DNA information, provides a tool for exploring the links between genetic evolution in domestic plants and animals and the parallel cultural changes in human populations, as they have each responded to alterations in natural and artificial selective pressures.

"We tend to think that there were wild animals, and then there were domestic animals. We tend to discount how selection pressures on domestic plants and animals varied through time in response to different preferences or ecological factors. This study demonstrates just how easy it is to drive a trait to a high frequency in an evolutionary blink of an

eye, and suggests that simply because a domestic trait is ubiquitous, it may not have been a target for selection at the very beginning of the domestication process", said author Greger Larson.

"The processes and driving mechanisms responsible for generating the patterns of genomic variation in humans and their co-dependent domestic plants and animals found today can be explored using this new tool" concluded first author Liisa Loog.

More information: Liisa Loog et al, Inferring allele frequency trajectories from ancient DNA indicates that selection on a chicken gene coincided with changes in medieval husbandry practices, *Molecular Biology and Evolution* (2017). DOI: 10.1093/molbev/msx142

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