

Application of Molecular Phylogenetics – The Domesticated Dog

Molecular phylogenetics can be used to address a number of evolutionary questions. One example involves the domesticated dog. This species shows incredible phenotypic diversity, but has a relatively short evolutionary history.

Questions:

1. What is the phylogenetic relationship of domesticated dogs to other dog-like wild species?
2. When were dogs first domesticated?
3. Was there a single domestication event? Or were dogs domesticated independently in different human populations?
4. What is the phylogenetic relationship among current dog breeds?

Fossil evidence:

- Dog-like jaws and other bones have been found in central Europe (Germany) dating to 14,000 years ago.
- Dog-like skeletons have been found buried with human remains in Israel dating to 12,000 years ago.

Molecular Studies:

Large-scale studies of intron/exon sequences of many species indicate that dogs are most closely related to wolves, as would be expected from morphology. So question 1 from above was relatively easy to answer. The other questions required more extensive analysis:

A) Comparison of mitochondrial DNA sequences (maternally inherited)

Approach:

Mitochondrial DNA sequences from 654 worldwide dog breeds, 38 wolves from Europe and Asia, and 2 Coyotes were analyzed using a hybrid ML and Neighbor-Joining strategy (too many sequences for full ML analysis).

Results:

- Dogs are closest to wolves.
- There are at least 5 major dog clades, suggesting a minimum of 5 different domestication events from wolves.
- 95% of dogs fall into 3 clades (A, B, C).
- 71% of dogs fall into 1 clade (A).
- The most diverse clade appears to be of East Asian origin, suggesting that it is the oldest group.
- Domestication began \approx 15,000 years ago (but could be as high as 40,000 years ago).

B) Origin of American dogs

Were dogs domesticated independently in America? Or were domesticated dogs brought from Europe?

The first humans reached North America by crossing the Bering Strait (Asia -> Alaska) 10,000 to 15,000 years ago. Europeans arrived in 1492 (Columbus).

Approach:

Mitochondrial DNA from pre-Columbian dog bones (“ancient DNA”) and modern dogs and wolves was compared. In total 37 dog bones from Mexico and South America, 11 dog bones from Alaska, 140 modern dog breeds (worldwide), and 259 wolves from America, Europe, and Asia were investigated.

Results:

- Ancient dog DNA matched current Eurasian dog DNA.
- Ancient American dogs were closer to Eurasian wolves than to American wolves.
- Thus, American dog were derived from previously-domesticated Eurasian dogs. They were not domesticated independently in America.

C) Genetic structure of purebred dogs

Approach:

Mitochondrial DNA evolves relatively slowly, so it is not good for determining relationships among dog breeds. Microsatellite DNA (short tandemly-repeated sequences) evolves faster and is much more variable within species. Unlike mitochondrial DNA, microsatellites are inherited from both parents. In total, 96 microsatellite loci were typed (repeat length determined) in 85 purebred dog breeds.

Results:

- There are four major dog clades.
- Most modern dogs were in one clade.
- Asian breeds were in the oldest clades, supporting the Asian origin of domesticated dogs.

Other dog studies

Since the first molecular phylogenetic studies of dog origins were published, there has been continuous work in this field. There have been conflicting results and interpretations of the data. While the Pre-Columbian origin of American dogs has been supported by other studies, the geographic origin of domestic dogs in East Asia has been called into questions. An analysis of the Y chromosome supported an East Asian origin, while studies of nuclear DNA suggested that middle Eastern wolves made a substantial genetic contribution to modern dog breeds. A study of ancient mitochondrial DNA from wolf-like and dog-like bones suggested that domestic dogs are most closely related to European wolves. See references below for more information.

What about domestic cats?

Similar studies have been done using mitochondrial DNA from domesticated cats and wild cat species. They indicate that domestic cats have a Near Eastern origin and are most closely related to the Near Eastern wild cat (*Felis silvestris* subspecies *lybica*). Domestication probably began \approx 9,000 years ago with the advent of agriculture.

References and additional reading:

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