UMass Chan study shows canine behavior only slightly influenced by breed

Elinor Karlsson and colleagues examine genome-wide association mapping technologies against pet-owner surveys to understand canine personality traits

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April 28, 2022

A UMass Chan Medical School study of more than 2,000 purebred and mixed-breed dogs, published today in *Science*, suggests that behavioral traits in dogs are not specific for breed. That means, for example, a golden retriever is only slightly more likely to be friendly than another breed.

“Although ‘friendliness’ is the trait we commonly associate with golden retrievers, what we found is that the defining criteria of a golden retriever are its physical characteristics—the shape of its ears, the color and quality of its fur, its size—not whether it is friendly,” said senior author Elinor Karlsson, PhD, associate professor of molecular medicine at UMass Chan and director of the Vertebrate Genomics Group at the Broad Institute of the Massachusetts Institute of Technology and Harvard University. “While genetics plays a role in the personality of any individual dog, specific dog breed is not a good predictor of those traits.”

Kathleen Morrill and Elinor Karlsson, PhD

Canine behavioral disorders are often proposed as a natural model for human neuropsychiatric disorders. Compulsive disorders, for example, are often observed to manifest similarly in both humans and dogs. Thanks to the power of DNA sequencing technology and the close relationship between pet dogs and their owners who are able to describe in detail their dogs' behavioral traits, genome-wide association studies in dogs have the potential to identify unique genetic areas in the dog genome that could lead to new insights into similar genes in humans. Karlsson and colleagues show that large-scale genome-wide association studies in dogs can yield genetic loci associated with behavioral traits.

Genome-wide association studies are an approach used in genetics research to try to associate specific areas of variation in a genome that align with certain phenotypes. Taking whole genome sequences from hundreds of thousands of people with the same disease, for instance, allows researchers to pinpoint broad areas in the genome that may be predictive or causative for specific diseases.

The *Science* research, which included data from more than 18,000 owner-surveys of their dogs, along with the results of genome-wide association studies from canine DNA samples submitted by the dog owners, identified 11 locations along the canine genome that were strongly associated with behavior: surprisingly, none were specific for breed.

"A dog's personality and behavior are shaped by many genes as well as their life experiences. This makes them difficult traits to select for through breeding," Dr. Karlsson said. "For the most part, pure breeds are only subtly different from other dogs. A golden retriever is only marginally more likely to be more friendly than a mixed-breed or another purebred dog, such as a dachshund."

The story of how modern-day dog breeds emerged is a relatively short one in evolutionary terms, contrasted against the history of dog domestication from prehistoric wolves. Genetic research pegs the change from wolf to dog at about 10,000 to 15,000 years ago. Humans didn't begin intentionally breeding dogs until 2,000 years ago, when they were being selected for work roles such as hunting, guarding and herding. It wasn't until the 1800s that humans began selecting dogs consistently for the physical and aesthetic traits that today we commonly associate with modern "pure" breeds.

Yet modern dog breeds are often credited with characteristics and temperaments (bold, affectionate, friendly, trainable) that correlate to their ancestral function (herding, guarding or hunting). Likewise, the breed ancestry of dogs is assumed to be predictive of temperament and behavior. DNA tests are marketed as tools for dog owners to learn about a pet's individual personality. However, there are few genetic studies that attempt to map behavioral tendencies to ancestry or genetic, heritable factors.

By pairing genome-wide association mapping technologies with pet owner surveys obtained through Darwin's Ark, an open-source database of owner-reported canine traits and behaviors, Karlsson and first author Kathleen Morrill, a PhD student in the

Morningside Graduate School of Biomedical Sciences at UMass Chan, explored the complicated relationship between modern canine breeds and behavioral characteristics.

Karlsson, Morrill and colleagues sought to correlate areas of the canine genome with certain behavioral traits or characteristics. Pet owners who participate in Darwin's Ark provide scientists with DNA samples from their dogs, obtained from saliva. Researchers run whole genome sequencing on these samples to generate a robust genetic data set for investigation. For this study, owners filled out 12 surveys totaling 117 questions about their pet's behaviors and physical traits. Combined, this data provides the basis for scientists to evaluate the relationship between genetics and owner-reported behavior.

"Given a large enough sample size, genome-wide association studies are a really powerful tool for learning about genetics," said Morrill. "We only get that sample size by looking at all dogs—not just purebred dogs but mixed-breed dogs too. We compare all these DNA sequences computationally to identify areas of differences and commonalities that might be of interest."

Karlsson and Morrill collected more than 2,000 canine genome samples and 200,000 survey responses through Darwin's Ark. Because of powerful existing stereotypes about dog behavior and breeds, Karlsson and Morrill designed the study to account for possible owner bias, in part, by establishing standard definitions for reporting and rating canine behavioral traits such as biddability (a dog response to human direction), dog-human sociability (a dog's comfort with people, including strangers) and toy-directed motor patterns (a dog's interest and interaction with toys), among others. Physical and aesthetic trait standards were based on those published by the American Kennel Club.

Behavioral data were analyzed across owner-reported breeds and genetically detected breed ancestries. The results of these tests, which included data from 78 breeds, showed that while breed explained some minor variation in behavior, contributions from breed were relatively small (9 percent). For certain behavioral traits, such as toy-directed motor patterns, age was a better predictor of behavior: Younger dogs were more likely to score higher in this category. Physical traits like coat color were more than five times more likely to be predicted by breed than behavioral traits.

Additionally, investigators failed to find behaviors that were exclusive to any one breed. Even in Labrador retrievers, which had the lowest propensity for howling, 8 percent of owners reported their Labradors sometimes howl. Likewise, while 90 percent of greyhound owners reported that their dogs never bury their toys, three owners described greyhound dogs as frequent buriers.

The researchers also leveraged the genetic ancestry of highly mixed-breed dogs to test whether behavior is heritable in a breed-dependent manner. In some cases, heritable behavioral traits like biddability are somewhat more likely to correlate with breed, even if mixed a few generations back. In the case of purebred dogs, ancestry can make

behavioral predictions somewhat more accurate. For less heritable, less breed-differentiated, traits, such as how easily a dog is provoked by frightening or annoying stimuli, breed is almost useless as a predictor of behavior.

In all, Karlsson and Morrill identified 11 locations on the dog genome strongly associated with behavioral differences, none of which were specific for breed; and another 136 suggestively associated with behavior. The genetic differences between breeds such as golden retrievers, Chihuahuas, Labrador retrievers, German shepherd dogs and others primarily affected genes that control coat color, fur length and other physical traits—far more than breed differences affected behavioral genes.

“The majority of behaviors that we think of as characteristics of specific modern dog breeds have most likely come about from thousands of years of evolution from wolf to wild canine to domesticated dog, and finally to modern breeds,” said Karlsson. “These heritable traits predate our concept of modern dog breeds by thousands of years. Each breed inherited the genetic variation carried by those ancient dogs, but not always at exactly the same frequencies. Today, those differences show up as differences in personality and behavior seen in some, but not all, dogs from a breed.”

Link to the UMass Study:

https://www.science.org/doi/epdf/10.1126/science.abk0639