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Battles Between Wolf Packs

How Nature and Nurture Influence Aggression

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Ed. note: Wolves in the photos are not the packs described in the story.

Even though they were well beyond the border of their own pack's territory, seven wolves from the Druid Peak pack seemed at ease as they travelled along a sage-covered hillside in northern Yellowstone National Park. And then, through my spotting scope, I saw the Agate Creek pack of 10 suddenly charging toward them. The Agates were shoulder-to-shoulder and quickly advancing on the smaller pack. Their tails and hackles were raised, and they moved like a line of professional rugby players rushing to a major scrum.

A few seconds later, the Druid group saw the Agates crest the ridge only 40 meters (44 yards) away. With a quick glance among pack mates, they closed ranks so their bodies were touching and charged back at the larger pack, their own tails waving high.

The fight lasted for less than 10 minutes, with wolves chasing back and forth in pairs or small groups. To the sounds of howling in every direction, the packs eventually separated and regrouped over the next few hours. The Agates were displaced from the fight's original location; they gathered about two kilometers (1.2 miles) to the south. Both packs were missing one or two wolves—those chased far in the opposite direction, perhaps injured or even killed.

Battles between wolf packs are fairly common, especially in the fall and winter when it's important to secure territory with plenty of vulnerable prey in order to survive the winter and raise pups in the spring. Approximately half of all adult wolves' lives end during a fight—that's nearly 10 percent of the adult population each year. Because these aggressive encounters have such a major impact on wolf survival and on a pack's likelihood of success, the Yellowstone Wolf Project studies the encounters at several scales: the individual, the pack and the population.

Witnessing a daytime clash in the open, like the one between the Agate pack and the Druid wolves, is somewhat rare, so Project members rely on surveys by experienced, long-term field biologists and technicians who spend thousands of hours in the field each year. The result is a slow and steady collection of behavioral data. Now, nearly 26 years after wolves were reintroduced to Yellowstone, having recorded the first pack-versus-pack fight in October 1995, Yellowstone Wolf Project researchers have amassed a database of 398 inter-pack conflicts.

Thanks to these observations, we now know some wolves are more likely to fight than others; male wolves are more aggressive and more likely to fight with opponents than females, and their aggression increases with age. Wolves with gray coats are more aggressive than black wolves, likely because the darker coat-color gene mutation seems to interact with hormones that influence behavior. Wolves that live in large packs are more willing to fight, knowing they have strength in numbers—for good reason, too. Large packs usually defeat smaller packs, unless those small packs have a disproportionate number of large, adult males or an old, experienced wolf guiding the rest of the pack.

But all these results were found through direct observation, and the fight between the Druids and Agates didn't fit all the predictions, in that the trespassing Druids had fewer wolves, and they still won. Each pack had one old wolf, but the Druids had six adult males and the Agates only had two. Did that make all the difference? Or were the Druids helped by some other force?

Some mysteries remained....

It was time to combine our observations with a new method by examining the tiniest parts of the wolf—their strands of DNA.

Every winter during wolf captures in Yellowstone, we attach or replace 12 to18 radio collars and take a series of measurements and samples, including blood. After storing that blood in a freezer set to -80 degrees Celsius (-112F), we send small vials to scientists at Princeton University and the University of California, Los Angeles, both of which specialize in canine

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genetics research. Very few wildlife research programs benefit from knowing the genetic makeup of all the founding members of the population, which makes Yellowstone wolves a rare and interesting population for testing the utility of cutting-edge genetic research.

Drawing blood from captured wolves isn't new in wolf research. It has been done for decades to test for disease exposure, measure levels of inbreeding and determine a wolf's origin at the population or pack level—sometimes even to identify a wolf's parents, siblings and offspring. Recent advances have enabled scientists like Dr. Bridgett vonHoldt at Princeton University, lead author of a recent article in *Molecular Ecology* (see citation below)—to progress from using eight to 40 DNA fragments, to employing the entire *Canis lupus* genome.

Variations in specific sections of DNA can affect the function and expression of certain genes. Understanding these small differences can be invaluable when considering heritability and variation in behavior because some genes can be turned on and off throughout an animal's life. In this study we wanted to discover if, and to what degree, aggressive inter-pack behavior was heritable. Heritability measures how much of the wolves' variation in aggression could be explained by their genetics.

Of the two packs fighting that warm October day in 2008—the Agate Creek pack and a subgroup of the Druid Peak pack—five of the wolves were radio-collared. As our Yellowstone Wolf Project team watched that fight, we knew their blood samples were already being processed by Dr. vonHoldt's team. Additionally, most of the non-collared wolves were recognizable, and eight more of them would be collared and have their blood drawn and analyzed over the next few years. We could now combine our recorded data on fights between known wolves with their

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genetic information to figure out how those unique strands of DNA might influence each wolf's behavior.

We used data from 121 conflicts observed from 1995 through 2010 and assigned each wolf a score from 1 to 10, depending on its behavior. The least aggressive behavior (running away) was given a score of one and the most aggressive (leading an attack and killing another wolf), a 10. The middle values captured intermediate behavior such as approaching an enemy within 50 meters (55 yards) and then running away (2), chasing an enemy from the last third of the pack (5), or chasing an enemy from the first third of the pack (7), etc.

What drives individual wolf behavior during pack battles?

What makes one wolf turn and run away at the first sight of a stranger while another charges into a fight outnumbered? What makes one wolf lead a chase while another lopes along behind? What makes one wolf consistently score above a 7 and another score only 1s, 2s and 3s?

The two simplest answers recall the old scientific question of "nature versus nurture," or genetics versus environment. But thanks to epigenetics—the study of how genes are turned on or off by external things like environment or experience—we know that the answers are complicated. Nature and nurture interact, each influencing the other.

Aggression between packs has probably defined gray wolves for hundreds of thousands of years. But aggression is a trait that must be balanced—too much, and a wolf takes unnecessary risks, increasing the chance of injury or death; too little, and a wolf likely finds its pack pushed around by other packs, losing territory and resources. Changes in wolf density, prey density and wolf-to-prey ratios can change the level of competition between packs and cause the "appropriate" amount of aggression to increase or decrease on the aggression scale at different times and locations. Areas with high prey density usually have low wolf competition and aggression—but an increase in wolf density might promote aggression in response to greater competition.

Previous research found patterns in aggression, and even though sex, age, coat color, breeding status and relative pack size had been accounted for, there was always some additional, unmeasured variable that influenced behavior during conflicts. Was this unknown factor based on genetics? Did the Druids win that day because of the way their genes influenced their behavior? We used the Yellowstone wolf pedigree—a family tree beginning with the founding wolves in 1995 and continuing through seven successive generations—and also certain DNA data from the sampled wolves to find out.

Since we were able to account for so many of the *nurture* factors (environment and experience), we were left to work with estimates of the *nature* (genetic) factors. First, we looked at each wolf's pedigree, confirming relatedness between parents and offspring through field observations and matching portions of their DNA, and found the aggression heritability estimate to be 14 percent. The behavior of wolves observed in fights is driven by many things—age, sex, etc.—but we now know that genetics explains a percentage of it, too. It's rather like an average person taking part in a home-run derby. Success will depend partly on the person's size, age, strength, baseball experience and ability to perform under pressure, of course—but performance is also influenced by inherent, genetic hand-eye coordination. (Thanks, mom and dad!) All those influences add up to 100 percent.

Certain parts of a wolf's DNA can change throughout its life as a gene gets turned on or off by some experience or environmental influence. We looked at those DNA parts, too, and we found that 37 percent of a wolf's aggression is inherited. Since this estimate measures the influence of genetics AND some environmental factors, it is considered the maximum estimate of inheritance.

To understand, consider this: Did your parents start teaching you to hit a baseball before you could walk? As a kid, did you shake an apple tree and try to catch the falling fruit? Those early experiences may have influenced genes related to some of your muscles or your optic nerve and helped you do better in a home-run derby years later. You would be benefitting from your genetics *and* your early experience *and* hours of practice as you sent those baseballs sailing over the fence.

In addition to the heritability estimates, our analysis also found that wolves in larger packs and wolves that had produced pups scored higher in aggression. This important link between breeding success and aggression indicates that the most beneficial amount of aggression for wolves in Yellowstone is a bit closer to the "more aggressive" end.

Though this study analyzed hundreds of wolves, thousands of DNA segments, and aggression scores using high-powered statistical modeling, the results are specific to those years in Yellowstone. Wolves living in other places and times, with different prey availability, territory overlap, disruption by humans and other, unknown factors, may operate at a slightly different, carefully-balanced spot on the aggression scale.

Wolves are intelligent and behaviorally flexible animals with personalities that vary along all kinds of spectrums including boldness, shyness, gregariousness, curiosity and aggression. Where each wolf falls on those spectrums may depend on its demographics, experience, current situation, genes—and probably some still-mysterious factors, too. As technology advances, we will continue to combine behavioral observations with new research methods to explore these questions just as we used DNA—the building blocks of a wolf—to answer questions about those battles to protect the pack, its territory and its resources—the building blocks of a wolf's life. ■

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