Man's new best friend? A forgotten Russian experiment in fox domestication

- By Jason G. Goldman on September 6, 2010

Dmitri K. Belyaev, a Russian scientist, may be the man most responsible for our understanding of the process by which wolves were domesticated into our canine companions. Dogs began making for themselves a social niche within human culture as early as 12,000 years ago in the Middle East. But Belyaev didn't study dogs or wolves; his research focused instead on foxes. What might foxes be able to tell us about the domestication of dogs? Domesticated animals of widely different species seem to share some common traits: changes in body size, in fur coloration, in the timing of the reproductive cycle. Their hair or fur becomes wavy or curly; they have floppy ears and shortened or curly tails. Even Darwin noted, in *On the Origin of Species,* that "not a single domestic animal can be named which has not, in some country, drooping ears." Drooping ears is a feature that does not ever occur in the wild, except for in elephants. And domesticated animals possess characteristic changes in behavior compared with their wild brethren, such as a willingness or even an eagerness to hang out with humans.

Belyaev and other Soviet-era biologists looked around at domesticated dogs, a species they knew had descended from wolves, and were puzzled. They could not figure out what mechanism could account for the differences in anatomy, physiology, and behavior that they saw in dogs, but they knew that they could find the answers in the principles ofMendelian inheritance. At that time in Stalinist Russia, however, Lysenkoism was state doctrine, and biologists were unable to carry out the research necessary to investigate these questions.

In the late 1920s and early 1930s, Trophim Lysenko, an agronomist with a peasant upbringing, claimed to have invented a new farming technique that could triple or even quadruple crop yields. Lysenko's illegitimate science held that the acquired characteristics of a plant could be inherited by its offspring. Despite the fact that his technique, called vernalization, was neither new nor effective, Lysenko quickly rose through the hierarchy of the Communist Party in the Soviet Union. The Communist officials thought that if the peasants could be motivated to cultivate grains, no matter the reason, this was a positive change from the earlier days when peasants eagerly destroyed crops to keep them from the Soviet government. For this reason, while biologists were investigating the genetics of the fruit fly *Drosophila melanogaster*, Lysenko's appeal to party officials was his ability to involve peasants in an "agricultural revolution." From his position of power, Lysenko was able to pit classical geneticists against the Communist Party.

Lysenkoism was of course directly in contrast to Mendelian genetics, which declared that acquired characteristics could not be genetically passed down to offspring; the unit of inheritance was the gene, and not experience. But the slow work of academic science and genetics couldn't provide the Communists with the same sort of political gain and therefore simply couldn't compete with Lysenko's non-science. Genetics was branded a "fascist science," perhaps because of the way that Nazi Germany attempted to leverage genetics and eugenics in their attempt to build a master race. In the mid to late 1930s, many geneticists were executed or sent to labor camps. In 1948, genetics was officially declared a pseudoscience, resulting in the firing of all geneticists from their jobs.

It was in this political environment that Belyaev lost his job at the Department of Fur Animal Breeding at the Central Research Laboratoryin Moscow, because of his commitment to classical genetics. Belyaev continued to discreetly study genetics, however, by overtly studying animal physiology throughout the 1950s. In 1959, after Nikta Khrushchev rose to power and began to reverse the Communist scientific policies, Belyaev became of the

director of the Institute of Cytology and Genetics of the Russian Academy of Sciences, in Novosibirsk, Russia, a post he retained until his death in 1985. Belyaev hypothesized that the anatomical and physiological changes seen in domesticated animals could have been the result of selection on the basis of behavioral traits. More specifically, he believed that tameness was the critical factor. How amenable was an animal to interacting with humans?

Belyaev wondered if selecting for tameness and against aggression would result in hormonal and neurochemical changes, since behavior ultimately emerged from biology. Those hormonal and chemical changes could then be implicated in anatomy and physiology. It could be that the the anatomical differences in domesticated dogs were related to the genetic changes underlying the behavioral temperament for which they selected (tameness and low aggression). He believed that he could investigate these questions about domestication by attempting to domesticate wild foxes. Belyaev and his colleagues took wild silver foxes (a variant of the red fox) and bred them, with a strong selection criteria for inherent tameness.

Starting at one month of age, and continuing every month throughout infancy, the foxes were tested for their reactions to an experimenter. The experimenter would attempt to pet and handle the fox while offering it food. In addition, the experimenters noted whether the foxes preferred to hang out with other foxes, or with humans.

Then, upon reaching sexual maturity (seven to eight months), they had their final test and assigned an overall tameness score. They rated each fox's tendency to approach an experimenter standing at the front of its home pen, as well as each fox's tendency to bite the experimenters when they tried to touch it. Only those foxes that were least fearful and least aggressive were chosen for breeding. In each successive generation, less than 20 percent of individuals were allowed to breed. Belyaev then began breeding a line of foxes with the opposite behavioral traits, to be fearful and aggressive, using a similar method. To ensure that tameness resulted from genetic selection and not simply from experience with humans, the foxes were not trained and were only allowed short "time dosage" contact with their caretakers and experimenters.

The result of this breeding program conducted over more than 40 generations of silver foxes was a group of friendly, domesticated foxes. These domesticated foxes, which were bred on the basis of a single selection criteria, displayed behavioral, physiological, and anatomical characteristics that were not found in the wild population, or were found in wild foxes but with much lower

frequency. One of the reasons that these findings were so compelling was that the criterion used to determine whether an individual fox would be allowed to breed was simply how they reacted upon the approach of a human. Would they back away, hissing and snarling, and try to bite the experimenter? Or would they approach the human and attempt to interact?

The domesticated foxes were more eager to hang out with humans, whimpered to attract attention, and sniffed and licked their caretakers. They wagged their tails when they were happy or excited. (Does that sound at all like your pet dog?) Further, their fear response to new people or objects was reduced, and they were more eager to explore new situations. Many of the domesticated foxes had floppy ears, short or curly tails, extended reproductive seasons, changes in fur coloration, and changes in the shape of their skulls, jaws, and teeth. They also lost their "musky fox smell."

The first physiological change detected was in the hypothalamic-pituitary-adrenal axis. This system is responsible for the control of adrenaline, which is a hormone that is produced in response to stress, and controls fear-related responses. The domesticated foxes had significantly lower adrenaline levels than their undomesticated cousins. The researchers hypothesized if the foxes were not afraid of humans, they would produce less adrenaline around them. This explains the foxes' tameness, but it doesn't account for their changed fur coloration patterns. The scientists initially theorized that adrenaline might share a biochemical pathway with melanin, which controls pigment production in fur. Further research has since supported this initial hypothesis. And so it was that selecting for a single behavioral characteristic— allowing only the tamest, least fearful individuals to breed—resulted in changes not only in behavior, but also in anatomical and physiological changes that were not directly manipulated.

More than 50 years have passed since Belyaev began his silver fox breeding program, and research with these foxes continues to uncover thegenetic changes that occur with consequences for physiology, anatomy,behavior, and cognition, as a result of the process of domestication, though on a smaller scale. 1n 1996, the breeding population contained 700 individuals, but by 1999, it was down to 100. Because of the realities of the Russian economy and the shortage of funding for science, in order to maintain the research, some foxes had to be sold for fur, and some are now being sold as pets. Of course, domestic foxes aren’t domestic dogs. But by being raised in households as pets, with similar upbringing as dogs, these foxes could provide us with a sort of natural experiment by which we can even better understand the ancient relationship between man and man’s best friend.

Want to see videos of the different responses of the domesticated and aggressive foxes upon the approach of a human experimenter? Check them out here.

ABOUT THE AUTHOR

Jason G. Goldman is in his fourth year as a doctoral student in developmental psychology at the University of Southern California. His research focuses on the evolution and architecture of the mind and how different early experiences might affect innate knowledge systems. To investigate these issues, he conducts studies in three populations: human adults, nonhuman adult animals, and nonhuman infant animals. Studies of each population allow unique questions to be asked about the evolution and development of cognition. He is also psychology and neuroscience editor atResearchBlogging.org and is the editor of the 2010 edition of Open Lab, the yearly anthology of the best science writing on the web. He writes theThoughtful Animal blog.

Image of Belyaev and his foxes; source unknown but probably from the Belyaev lab.
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