MUSEUMS SHOULD CURATE BEYOND THE NATURAL: DOMESTIC BREEDS OFFER UNIQUE INSIGHT INTO EVOLUTIONARY PROCESSES & HUMAN CULTURE

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ABSTRACT

This short communication proposes that natural history museums should consider expanding their mission by intensively collecting and curating domesticated, hemerophilic, and genetically engineered animals, plants, and fungi to improve the study of evolutionary biology and anthropology, as well as mitigate against future climatic and economic challenges.

MAIN TEXT

Natural history museums, through their vast collections and long-term curation, are vital sources of data for many scientific disciplines across biology, geology, and anthropology (Gropp 2020). Unsurprisingly, these institutions focus on collecting naturally occurring biodiversity – across species, sexes, ontogeny, and genetic/geographic variants. This is, of course, extremely important in light of the current rate of anthropogenically driven extinction (De Vos *et al*. 2015). But is this strategy sufficient? Data from Bar-On *et al.* (2018) suggest that 62% of global mammalian biomass today is from domestic livestock, 34% from humans, and only 4% from wild mammals, while 71% of global avian biomass is from domestic poultry and only 29% from wild birds. We are currently in a period of radical alteration to the biosphere, and natural history museum collections should reflect these changes in biodiversity as a record for future generations of scientists. It is not simply the biomass of domestic species that is immense, their diversity is also impressive. The United Nations Food and Agriculture Organization estimates that there are more than 8,800 breeds of livestock across 38 species (FAO 2025), while Peru alone has over 4,000 varieties of natively domesticated potatoes (Devaux *et al.* 2020). Rubinstein & Schmitz (2024) summarized the challenge natural history museums must face:

> "*Additionally hidden from view in the halls of natural history museums were animals used for scientific study, such as the house mouse; those altered by humans, such as domesticated species; and Kulturfolger (hemerophile species), referring to life forms that thrive in human-made landscapes, such as crop weeds or pigeons—all considered within the sphere of human culture*

rather [than] belonging in the halls of natural history museums" (Rubinstein & Schmitz 2024, p. 107).

Domestication of animals might have begun as far back as 40 ka, according to some genetic analyses of the divergence of domestic dogs from wolves (Skoglund *et al*. 2015). Dogs were at least domesticated by 15 ka based on archaeological evidence, and ancient DNA from remains of domesticated animals or plants and their wild relatives has allowed for new insights into the history of domestication (Ramos-Madrigal *et al.* 2016; McHugo *et al*. 2019). Domesticated dogs therefore likely predate agriculture, and domesticated plants first appeared about 12 ka (Carey 2023). By now, breeds or lineages of organisms that could be considered domesticated include animals, plants, and fungi, such as the cultivated mushroom (*Agaricus bisporus*). Even some strains of microbes have been domesticated for industrial purposes, such as the fungi known as yeast (*Saccharomyces*) and mold (*Aspergillus*), as well as the bacteria *Lactococcus*, *Lactobacillus*, and *Oenococcus*, which are used in various fermentation processes (Steensels *et al*. 2019). Note that the expansion of natural history museums into the collection and curation of microscopic organisms, either wild or domestic, isolated or part of environmental microbiomes, is another worthwhile question that is beyond the scope of the discussion here.

Figure 1. Extinct versus living collections and the conservation of domestic breeds. *Left*: Whiskey, the only surviving specimen of the extinct turnspit dog breed. Housed at the Abergavenny Museum in Wales. Image from People's Collection Wales for non-commercial use only (© Abergavenny Museum 2025). *Right*: an unusually shaped, native potato variety from Peru's Parque de la Papa (photo by E.T. Saitta 2024).

Living collections, which include botanical gardens, arboreta, zoos, and aquariums, may not be enough. By analogy, the long-term prospects of species that are extinct in the wild and only held in captivity are clearly not desirable from a conservationist perspective. Just as wild species are going extinct, many domestic breeds have been lost. To give just one example, the English turnspit dog was used from the sixteenth to the nineteenth century to power roasting spits via a running wheel, and the breed went extinct by 1850 due to technological innovation rendering its role obsolete (Humphrey 2024). Only one taxidermized specimen, named Whiskey (Fig. 1), is known to survive and is housed at the Abergavenny Museum in Wales (Eveleigh 1990). Some efforts are indeed underway to conserve domesticated genetic diversity, such as Potato Park (Parque de la Papa) in Peru, which works to conserve domestic potato varieties of the indigenous Andeans (Argumedo 2008).

Many invocations to collect or display domestic species for museums date back to the early 1900s but were, sadly, often motivated by the eugenics movement at the time. Harvard University's Museum of Comparative Zoology began designing an exhibit dedicated to domesticated animals in 1905, and some of these specimens are still stored at the museum (Tonn 2019). In 1907, the Brooklyn Institute of Arts and Sciences (now Brooklyn Museum) announced the "nucleus" of a collection of domesticated animals through the donation of domestic fowl specimens (Brooklyn Museum 1907) and even solicited donations of domestic pigeons to expand this collection: "So far pigeons are wholly unrepresented in the Museum collections, and should any readers of the "News" who are pigeon fanciers be unfortunate enough to lose any fine birds we should be glad to receive them at the Museum" (Brooklyn Museum 1907, p. 62). In contrast, F.A. Lucas, Director at the American Museum of Natural History (1911–1923) defended his institution's avoidance of extensive domesticated collections by saying, "There is no collection of domesticated animals other than that illustrating variation under domestication, and, owing to lack of funds and space, no attempt can be made to bring together such a collection" (Lucas 1915, p. 370).

More recently, special exhibits have included domestic species, such as the Paris Museum national d'Histoire naturelle's 2024 exhibit 'Cats: Predators to Pets' at Chicago's Field Museum. Other exhibits have even been dedicated solely to domestic animals, such as University College London Grant Museum of Zoology's 2017 'Museum of Ordinary Animals' in London (Ashby 2017). The Grant Museum does have a skeleton collection of house mice inadvertently brought to various islands by humans (Ashby 2017), and the Tetrapods Collection of the Museum of Biological Diversity at Ohio State University keeps domestic specimens for educational and outreach purposes (Malinich 2016). These examples highlight how some modern scientists advocate for the utility of curating domestic or hemerophilic organisms. Still, this article proposes a much greater investment on the part of research collections into preserving data from species heavily altered by humans.

Domesticated species might generously be thought of as 'near-experiments' of sorts. Artificial selection is by necessity highly controlled through selective breeding, and the results can be compared to other domestic breeds or to wild ancestors and sister taxa. Iconically, the conceptual foundations of genetics were discovered through selective breeding experiments of domesticated pea plants by Mendel (1866). Whereas modern researchers might use gene editing to investigate a well-defined hypothesis (e.g., You 2020), selective breeding can still be a powerful evolutionary driver compared to natural selection, even over short timespans (e.g., a few generations [Jensen & Wright 2014]).

Domesticated organisms have unique, extreme, and diverse phenotypes and genotypes. Dogs are possibly the most phenotypically diverse species alive today due to artificial selection and high genetic diversity (Vilà *et al.* 1999). Ankole-Watusi cattle have enormous horns compared to wild bovids (Huber *et al*. 2008), while the largest domestic horses, draught horses (Perez *et al*. 1992) like the shire horse, can be roughly three times heavier than wild Przewalski's horses (Kuntz *et al*. 2006). Domesticated plants can have radically altered biochemistry from their wild counterparts – for example, wild almonds produce lethal amounts of the cyanogenic glycoside amygdalin, while domesticated almonds have been selected for a mutation that inhibits amygdalin biosynthesis to produce a sweet, edible variety (Sánchez-Pérez *et al*. 2019). If natural selection is worthy of study by evolutionary biologists, then artificial selection should likewise be worthy, even if in a purely academic capacity. Darwin himself drew heavily upon evidence from domestication when formulating his theory of evolution by natural selection (Darwin 1868).

Figure 2. Domestic birds artificially selected for shaggy, open feather vanes and hindlimbs bearing remex-like feathers are an interesting comparison to naturally selected, yet primitive feather morphologies and distributions in some non-avian dinosaurs. *Top left*: silkie chicken (Wikimedia Commons photo by user "Ohconfucius"; CC-BY-SA-4.0; released under the GNU Free Documentation License). *Top middle*: silky fantail pigeon (Wikimedia Commons photo by Graham Manning; CC BY-SA 3.0). *Bottom left*: Dutch booted bantam chicken (Adobe Stock photo by "cynoclub"; standard license). *Right*: paleoart by Rebecca Gelernter of the four-winged non-avian dinosaur *Anchiornis* with a simplified representation of its hypothesized contour feather morphology (see Saitta *et al*. 2018).

It is worth considering one particular example, in which the curation and study of domestic breeds might provide valuable insight into deep evolutionary history and functional morphology. Artificial selection has led to silky breeds of chicken and pigeon that bear a recessive mutation that leads to non-functional barbules and barbicels, open-vaned feathers (even in the flight feathers), and reduced flight and water-repellence functioning (Fig. 2), all while the genetics and development of this silky trait have been studied (Cole & Willard 1939; Miller 1956; Juhn & Bates 1960; Feng et al. 2014; van Grouw 2016). Such open-vaned, shaggy feathers resemble the primitive conditions in some paravian dinosaurs, such as *Anchiornis* (Saitta *et al*. 2018). Other breeds of domestic bird, such as the booted bantam chicken, have been bred to express feathers on their hindlimbs that resemble flight feathers (McGrew 1903), again similar to the primitive four-winged condition in paravian dinosaurs which can be hypothesized to have functioned in biplane-like gliding (Saitta *et al*. 2018). Furthermore, these 'booted' breeds might suggest that paravian hindlimb feathers should be reconstructed as erupting more mediolaterally than is sometimes depicted in paleoart, consistent with the articulation of remiges to the forelimb and with the range of motion between hindlimb elements. Therefore, these domestic breeds with unusual feathers provide an intriguing analogy to extinct feather morphologies and an opportunity to make 'evo-devo' inferences about these traits.

Historical records can readily provide independent evidence to evolutionary studies involving domestication, given the frequency with which domestic species have been included in historical accounts. While writings and art are clearly prone to subjectivity and error by their composer, this historical data is far better than nothing. As such, historical evidence can be used to complement data (e.g., molecular sequences) from living or recently extinct breeds/species in a manner analogous to the use of fossils to calibrate and improve molecular phylogenies (Donoghue *et al*. 1989). Rock art depictions of hunting dogs on leashes may date back at least 8,000 years, representing the first known depiction of dogs (Guagnin *et al.* 2018). More recent art, with advanced and more realistic techniques and pigments, can provide crucial anatomical and behavioral information about the early history of domestic breeds, such as the appearance of and specific roles played by dog breeds upon their introduction into a particular society (Fig. 3).

This independent historical evidence allows for inter-departmental study in museums across biology and anthropology. Domestic breeds are not just data for the study of artificial selection in evolutionary biology, they are the products of specific human cultures with direct anthropological relevance. Collections of domestic species are therefore synergistic with anthropological or archaeological collections and even historical art collections. For example, a study of goat domestication by Zeder & Hesse (2000) compared curated museum specimens of wild goats to archaeological collections of domesticated goat remains housed at the Field Museum and Smithsonian's National Museum of Natural History. The remains of domesticated organisms are themselves tightly associated with human society and culture, such as archaeological middens (e.g., Gautier 1984) or mummified animals (Ikram 2005), which may also represent unique taphonomic data in the manner of their preservation (Lynnerup 2007). If domesticated organisms from archaeological sites are worthy of curation, museums should look ahead and curate current domestic breeds as well.

Domesticated species, being human mutualistic symbionts, have had major cultural and economic impacts throughout history and into the present (Pierotti 2024). They provide food, services (e.g., service dogs [Winkle *et al*. 2012]), and medicine (e.g., medicinal plants [Ramawat & Arora 2021]) at industrial and society-wide scales. Domesticated animals can also have biotechnological utility, such as the production of antibodies for immunochemical purposes using goats, chickens, rats, guinea pigs, sheep, mice, hamsters, and rabbits (Hanly *et al*. 1995). Model organisms used for research also include domesticated species, such as laboratory rats (*Rattus norvegicus domestica*) (Modlinska & Pisula 2020).

Figure 3. Oil painting by English artist John Wootton entitled "A Grey Spotted Hound" from 1738. The painting depicts the dog's anatomy and posture. Furthermore, the dead bird in the corner indicates the breed's behavioral and symbiotic role in human economic and cultural practices – retrieving birds shot for sport hunting or consumption. According to the Yale Center for British Art, this dog is thought to be an early pointer, a breed introduced to England in the mid-1600s (https://collections.britishart.yale.edu/catalog/tms:1159). This image is in the Public Domain.

Artificial selection through both selective breeding and modern genetic engineering can be used to radically alter organisms (Cheng *et al*. 2022), and informed artificial selection will continue to be important in the future. In light of changing global environments due to anthropogenic activity (Prakash & Verma 2022), modifying economically and socially important organisms to better adapt to new conditions will be a vital mitigation strategy. Genetic engineering is already being utilized to create crops resistant to heat, salinity, and drought (Li *et al*. 2022). The recent sequencing of the domestic potato pan-genome has been celebrated as a major achievement in understanding this genetically diverse and vital crop, with implications for genomics-assisted breeding (Sun *et al*. 2025). Conserving genetic variation of existing breeds before they go extinct, along with morphological specimen curation in museums, will further assist these efforts.

Some efforts have even genetically modified animals to express traits reminiscent of extinct species. American biotechnology company Colossal Biosciences engineered wolves and mice to express specific genes similar to those of extinct dire "wolves" (*Aenocyon dirus*, an early-diverging lineage of Canini) and woolly mammoth (*Mammuthus primigenius*), respectively (Chen *et al*. 2025; Gedman *et al*. 2025). The only successfully cloned individual of an extinct subspecies was born in 2003; the individual was a Pyrenean ibex (*Capra pyrenaica pyrenaica*, which went extinct in 2000), but it died within minutes from a congenital defect (Folch *et al*. 2009). Using traditional selective breeding, Heck cattle (*Bos taurus*) have been modified to superficially resemble the extinct, wild aurochs (*Bos primigenius*) from which cattle were domesticated (Gordon *et al*. 2021; Sinding *et al*. 2021) – essentially a case of experimental convergent evolution through artificial selection. The utility and ethics behind the creation of these sorts of engineered organisms are highly debated (e.g., Sandler 2014). Once manipulated, whether through CRISPR gene editing or through selective breeding, should these specimens be curated – akin to keeping data records of an experiment for the purposes of reproducibility? This article argues that the answer is likely yes.

In conclusion, natural history museums should begin to dedicate sizeable research collections to diverse domesticated breeds. These can be curated as wet, skinned, and skeletonized specimens, alongside cryogenically stored genetic samples. The Center for PostNatural History in Pittsburgh (Pell & Allen 2015) is a small, atypical museum exhibiting organisms that result from selective breeding and genetic engineering, and it represents a domain that major natural history museums should seriously consider expanding into. Natural history museums are expanding their role into interdisciplinary basic and applied sciences capable of addressing topics such as disease, climate change, food security, and biomimetics (Bakker *et al*. 2020). It may even come to pass that future museums will have not only exhibits dedicated to domestic, hemerophilic, and genetically engineered species, but also entire wings of their backroom collections and curatorial positions dedicated to them as well.

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