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Cat Domestication & Breed Development

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ABSTRACT: The dynamics of cat domestication is like no other species. Cat "domestication" is associated with the development of societies, 10,000 – 12,000 years ago. One site of origin seems definitive, the Near East, however, as there were independent sites of agricultural development and various wildcat species inhabited those regions, multiple domestications seem likely for the cat. The most ancient archeological finds place cats within human societies at 5,000 ybp in China and 9,000 ybp in Cyprus. Controlled breedings were evident in Egypt ~2,500 – 3,000 ybp. Cat breeds were developed in the late 1800s. Cats from the Orient and Western Europe were clearly different and other fur and color varieties demarcated a few other "breeds". Today, although over 50 breeds are declared, far fewer are genetically unique. Presented is the evidence supporting cat domestication and breed development.
Keywords: *Felis silvestris catus*; mutations; phenotype

Introduction

The earliest archeological evidence for cat associations with humans has been dated to over 3,000 – 6,000 BC in Cyprus,[1-3] Egypt[4] and most recently, China.[5] Whether cats migrated to these different regions with trade and agriculture, or if regional wildcats were independently domesticated in different parts of the Old World remains an unresolved mystery. Since these early times, cats have continued their friendship with humans, having a symbiotic relationship – providing vermin control for humans, while gaining low energy expenditure for meals.[1,6-8] Hence, as soon as cats were somewhat tamed, they expanded and migrated around the world as man's constant but often inconspicuous companion. As trade and exploration opened new opportunities and resources for man, the cat too expanded its territory around the world.[9,10] However, like peoples that have formed ethnic groups and races, complete panmictic (random), worldwide breeding has not been possible for the cat, limited by natural boundaries, few founders and sporadic migrations. Thus, mutations and allele frequencies do differ between cat populations, forming races and breeds, as like races and ethnic groups of humans. Genetic studies of worldwide feral populations and breeds have shed light into the population structure of domestic cats,[11] providing important clues to their genetic identity and genetic health management.

Genetic Races of Domestic Cats

The domestic cat likely derived from one or more subspecies of wildcat (*Felis silvestris*).[12] At least one domestication event for the cat was very likely to have been the Near East,[13] however, independent domestications may be plausible due to the significant genetic distinction of cats in the Far East and the recent archeological find in China that associates cats with humans in an ancient agricultural site.[5] Different domestication events from many and perhaps different subspecies of wildcats implies high genetic diversity for the founding populations(s) of domestic cats, which should support health and the ability to adapt to different niches and physiological insults. Without archeological samples with sufficient DNA, only the present day populations of cats can be examined to evaluate genetic diversity and population differentiations. This genetic data can allow the potential extrapolation back to the number and different sites of cat domestication. However, regardless of the cat's ancient history, the extant, present day feline populations are the concern of owners, breeders and veterinarians.

World-wide cat populations have been genetically examined to define the differences that may be important for genetic-based health management.[11] Different genetic markers, such as mitochondrial DNA (mtDNA),[14] short tandom repeats (STR, a.k.a. microsatellites)[15] and single nucleotide polymorphisms (SNPs),[16] all have different "genetic clocks" and examine different time points in domestic cat history and evolution.[13,17] The combined analysis of these different markers then paints a picture of the present geographical demarcations and genetic distinction of cat populations. To date, several published studies have examined breeds but only one has extensively examined feral cat populations.[11] This previous study of feral cats has been expanded to include additional world-wide populations, refining the genetic races of feral cat populations. Figure 1 depicts groupings of cats based on genetic differentiation. The DNA variants used for population studies are not supposed to be under any type of selection, thus are usually random DNA variants that are not important to health or how the cat looks. However, one can infer that other genetic variants, such as those causing specific phenotypes, diseases or health concerns, would have similar frequencies in the genetically-like populations. Since the three different populations tested in Japan have similar allele frequencies and "cluster" as a common population, health concerns, such as the gangliosidosis, a rare genetic condition that has been documented in feral Japanese domestic shorthair cats,[18-20] should be more highly prioritized on a possible list of differentials for sick cats in the region. Cats from the UK have basically the same genetic composition as cats in the USA and Canada, due to their recent Old World to New World migrations in the past 500 years. Trade and colonization has broken the extensive, natural barrier of the

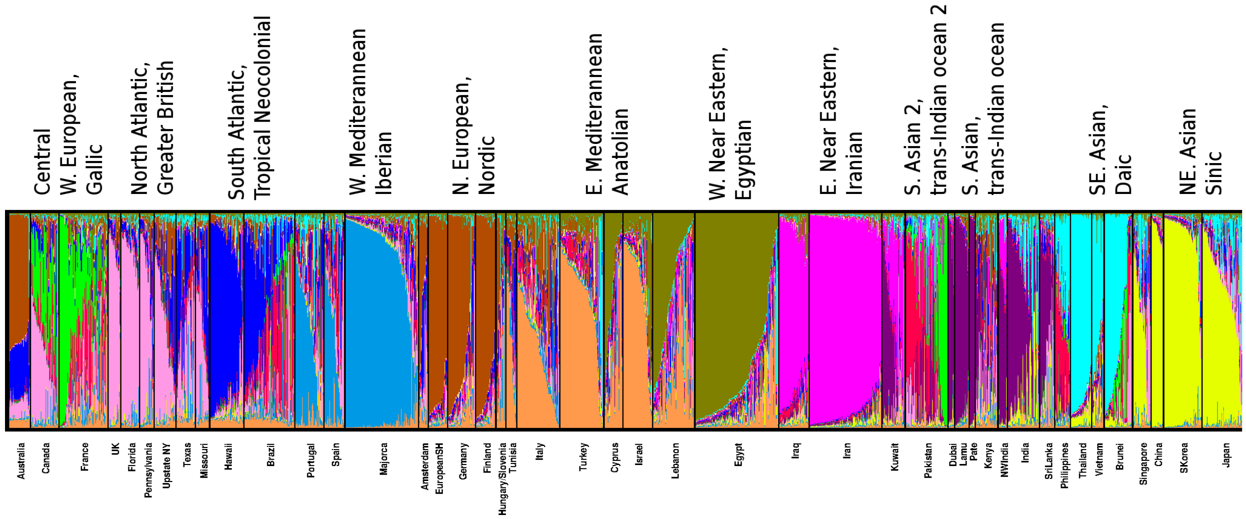

Figure 1. Genetic Structuring of World Cat Populations. The figure presents individual cats and their contributions from different genetic groupings. Each cat with similar genetic contributions are clustered in the figure, producing the groups. After the analysis, the groups are labeled with the country of origin of each cat and the group depicted with a color. For example, the cats from Majorca are genetically similar to cats from Spain and Portugal, but different from other world populations. The cats in these countries do show some mixture with cats from different regions, but are significantly similar. Twelve groupings are significantly distinct, suggesting twelve worldwide races of cats. (Figure courtesy of R. Khan, University of California, Davis)

Atlantic Ocean, thus cats in Australia, Kenya and the Americas show the marks of the past from various European invasions and colonizations. However, cats in close proximity can have different genetic origins, such as the Iberian peninsula and France. The Pyrenees mountain chain has apparently been an ecological barrier to cats, and like other species,[21] cats of Portugal and Spain appear to be genetically different from the remaining European continental cats. Overall, twelve different groupings, clusters or races of cats can be genetically defined from the various locations that have been sampled. Some island populations appear to have similar genetic signature to the mainland, such as Majorca and Iberia, while other island populations are more distinct, such as San Marcos, an island off the coast of California. Distinct island populations are likely unique when cat migrations are very limited or forbidden, such as the case of San Marcos, and the island is small and likely had limited founders to the population historically. Specific cats from several of the "races" have been extracted to develop our pedigreed fancy breeds.

Genetic Distinction of Cat Breeds

Breeds of cats act similar genetically to ethnic groups of humans. Previous studies have shown that cat breeds have been developed from Western European, the Mediterranean, the Arabian Sea and Southeast Asian populations.[11] Ongoing studies may suggest that breeds like the Norwegian Forest cat can now be refined to more specific populations, such as the Northern European / Nordic race of cats. Thus, cat breeds will share health concerns and genetic traits in common with their races of origin. The same types of genetic analyses that were used to compare feral, randomly bred populations of cats have also been used to compare different cat breeds. Table 1 presents a listing of popular cat breeds. Over three dozen breeds have been have been genetically examined with the same genetic markers as the cat races. Approximately 24 breeds appear to be genetically distinct, while the remaining breeds are derived from a specific breed family, such as the Persian, the Siamese or the Burmese families. These "parent" breeds have been bred to produce slightly different cat groups that are often declared a different breed, but are genetically different by perhaps only one genetic mutation. For example, the Persian family is composed of the Persian, Exotic, Selkirk Rex, Scottish Fold and British Shorthair breeds.[22] Exotics are different from Persians by having shorthair,[23] Selkirk Rex differ by having curly hair,[24] and Scottish Fold differ by having folded ears. Each difference is caused by a single gene mutation, which is not truly sufficient to affect the overall genetic constitution of the breed. Although the definition of cat breeds is arbitrary and of no major consequence, the health of the new and derived breeds can be significantly impacted by the individuals used to found and propagate the new breed. Selkirk Rex and Scottish Folds are new derivatives of Persians. Persians have historically been riddled with polycystic kidney disease (PKD).[25-33] Each derivative breed should be monitoring the same health and genetic issues as found in the parent breed, such as PKD in the Persian derived breeds. Any breeds produced from Burmese need to be leery of craniofacial defects,[34,35] feline oral facial pain,[36,37] hypokalemia[38] and diabetes.[39,40] Breeds associated with Abyssinians should be cognizant of progressive retinal atrophies and pyruvate kinase deficiency.[41-43] Additional reviews on cat mutations have been previously published.[44-46]

Table 1 Genetic Families of Domestic Cat Breeds

Breed / Family	Place founded	Derived Breed / grouping*
Abyssinian	Founder—India?	Somali
American Bobtail	Natural mutation	United States—random breds
American Curl	Natural mutation	United States—random breds
American Shorthair	Founder—United States	American Wirehair
American Wirehair	Natural mutation	American Shorthair
Australian Mist	Crossbreed hybrid	Burmese – Persian derived
Balinese	Variant	Siamese Family
Bengal	Species hybrid	Leopard cat × Egyptian Mau, Abyssinian
Birman	Founder—Southeast Asia	
Bombay	Variant	Burmese, Singapura, Tonkinese
British Shorthair	Founder—Europe	Scottish Fold
Burmese	Founder—Southeast Asia	Bombay, Singapura, Tonkinese
Burmilla	Crossbreed hybrid	Burmese, Persian
Chartreux	Founder—Europe	
Colorpoint Shorthair	Variant	Siamese Family
Cornish Rex	Natural mutation	United Kingdom—random breds
Devon Rex	Natural mutation	United Kingdom—random breds, Sphynx
Egyptian Mau	Founder—Mediterranean	
European	Founder—Europe	
Exotic	Variant	Persian
Havana Brown	Variant	Siamese Family
Japanese Bobtail	Founder	
Javanese	Variant	Siamese Family
Korat	Founder—Southeast Asia	
Kurilean Bobtail	Natural mutation	Eastern Russia, Kuril Islands
LaPerm	Natural mutation	United States—random breds
Maine Coon	Founder—United States	
Manx	Natural mutation	United Kingdom—random breds
Munchkin	Natural mutation	United States—random breds
Norwegian Forest Cat	Founder—Europe	
Ocicat	Crossbred hybrid	Siamese × Abyssinian
Oriental	Variant	Siamese Family
Persian	Founder—Europe	Exotic
Peterbald	Mutation	Russian—random breds, Don Sphynx
Pixie-bob	Crossbreed hybrid	Manx, Japanese Bobtail, United States—random breds
Ragdoll	Founder—United States	United States—random breds
Russian Blue	Founder—Europe	
Savannah	Species hybrid	Serval × domestic
Scottish Fold	Natural mutation	United Kingdom—random breds, British SH, Persian
Selkirk Rex	Natural mutation	United States—random breds , Persian
Siamese	Founder—Southeast Asia	Siamese Family
Siberian	Founder—Europe	Russian—random breds
Singapura	Variant	Bombay, Burmese, Tonkinese
Sokoke	Founder—Arabian Sea	African—random breds
Somali	Variant	Abyssinian
Sphynx	Natural mutation	Devon Rex
Tonkinese	Variant	Bombay, Burmese, Singapura
Turkish Angora	Founder—Mediterranean	
Turkish Van	Founder—Mediterranean	

*Modified from genetic studies based on 29 tetranucleotide short tandem repeat markers, 39 dinucleotide short tandem repeat markers, and unpublished data (LA Lyons)

Summary

Understanding the relationship of cats to the race of origin and their breed families can be predictive for health care issues. Genetic testing can provide definitive answers for many health concerns and can predict risk for certain diseases. Personalized medicine is improving human health care and is becoming available for the domestic cat. Technology and competition will reduce the costs of genetic testing in cats, making it feasible to perform large batteries of genetic tests and eventually whole genome sequencing. Veterinarians will have more predictive powers for health concerns and will be able to implement proper interventions. As the genetic data becomes more readily available, veterinarians will be providing larger roles in health care management of individual cats and their populations. Genetic counselling is becoming a norm in veterinary medicine, bringing together the tests of the individual into consideration with the genetic diversity and health of the entire breed population, As humans continue to live longer and higher quality lives, so too will our furry companion felines.

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