# Establishing and maintaining a novel domestic cat breed through genomics and pedigree analysis


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## BACKGROUND INFORMATION

- Breeding cats for a desired phenotype carries the risk of inadvertent inbreeding depression
- Closely monitoring pedigrees and genotypes of cats can guide breeding practices to:
  - Maintain and refine desired breed attributes
  - Minimize or prevent adverse health conditions
- Population Management or Species Survival Plans (PMPs/SSPs) are used to manage captive populations in zoos. Similar genetic analyses can be used to develop Breed Management Plans (BMPs)
- A cat colony in Qatar is being used to establish a new breed of cat, the Katari

## RESEARCH QUESTION

- How can genetic data be used to understand and maintain a cat colony and establish a new breed of cat?

## OBJECTIVES

- Parentage verify the colony
- Determine known variants of phenotypic traits like coat color, pattern, length, etc.
- Determine genetic diversity of founders
- Determine presence of known disease variants
- Develop recommendations for further breeding pairs to:
  - Refine the desired Katari phenotype
  - Eliminate or minimize undesired allele variants
  - Reduce inbreeding coefficients
- Recommend general husbandry and wellness protocols to maintain a healthy colony

## MATERIALS AND METHODS

- Constructed colony pedigree using Pedigree-Draw (PedDraw)
- Mitotyped founders and key cats:
  - DNA isolation from buccal swabs
  - Mitochondrial control region (mtDNA CR) PCR
  - Sanger sequencing of mtDNA CR
  - Determined mitotype of mtDNA CR DNA using Sequencher software
- Genotyped cats for disease and trait variants
- Conducted parentage analyses using whole genome sequencing (WGS), microsatellite (STR), and single nucleotide polymorphism (SNP) data
- Genotyped cats for parentage & ancestry verification (~121-138 SNPs)

## Example nuclear family

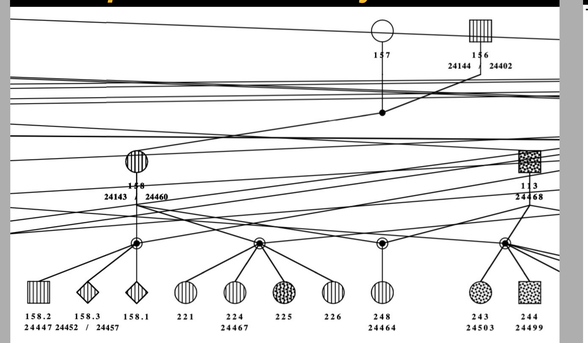


**Figure 4.** Nuclear family within the pedigree that increases population diversity but carries an undesired phenotype

## Genotype summary

**Table 2. Current Katari phenotypic genotypes**

| Phenotype | | M | F | U | Total |
|---|---|---|---|---|---|
| Agouti (ASIP) | AA | 3 | 1 | 2 | 6 |
| | Aa | 5 | 5 | 0 | 10 |
| | aa | 5 | 8 | 0 | 13 |
| Brown (TYRP1) | BB | 39 | 38 | 13 | 90 |
| | Bb | 0 | 0 | 0 | 0 |
| | bb | 0 | 0 | 0 | 0 |
| Colorpoint (TYR) | CC | 3 | 0 | 0 | 3 |
| | CCs | 4 | 5 | 0 | 9 |
| | CsCs | 0 | 1 | 0 | 1 |
| Dilution (MLPH) | DD | 15 | 14 | 3 | 32 |
| | Dd | 24 | 28 | 0 | 52 |
| | dd | 9 | 8 | 3 | 20 |
| Inhibitor | (I-) | 0 | 0 | 0 | 0 |
| | ii | 9 | 4 | 4 | 17 |
| Longhair (FGF5) | LL | 42 | 42 | 14 | 98 |
| | Ll | 7 | 12 | 0 | 19 |
| | ll | 2 | 2 | 0 | 4 |
| Ticked (DKK4) | TiTi | 7 | 3 | 0 | 10 |
| | Titi | 22 | 12 | 0 | 34 |
| | titi | 29 | 27 | 4 | 60 |
| Tabby (LVRN) | TmTm | 15 | 13 | 2 | 30 |
| | TsTs | 11 | 10 | 0 | 21 |
| | TmTs | 2 | 2 | 4 | 8 |
| | TbTb | 0 | 1 | 0 | 1 |

## RESULTS

- 171 cats currently included in pedigree (Fig. 1)
  - 16 founders (8 male, 8 female)
- 9 different mitotypes; 5 maternal origins (Table 1)
  - A novel mitochondrial subtype (A10) was discovered in three cats
- Representative phenotypes illustrated in Figure 2
- Current phenotypic genotypes summarized in Table 2
  - Novel variants may explain unknown phenotypic variance (Fig. 3)
- All putative disease variants were likely benign polymorphisms
- The Katari breed should resemble cats in early stages of domestication, with colors conducive to desert survival
  - Phenotypic traits of extant domesticated cats (long hair, orange color, etc.) should be minimized
  - Maintaining genetic diversity may require retention of some undesirable traits until further generations (Fig. 4)
- Population modeling will help determine breeding pairs, colony size, and founder importation
- The pedigree currently has minimal inbreeding; the colony is only in its second and third generations

## Katari cat mitotypes

**Table 1. Mitotypes of founders, selected offspring**

| Ref.* | Mitotypes | | | | | | | | | | Founders | | | | | | | | | | | | Missing founders | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | Inferred via offspring | | | | | |
| | SRS | A | A10** | B | C | D | G | H | I | L | 101 24147 | 102 24146 24490 | 103 24145 24443 | 105 24150 24458 | 106 24151 | 108 24148 24451 | 126 24149 24436 | 156 24144 24402 | 177 24153 24475 | 262 24463 | 155 24404 | 150 24141 24142 24479 | 157 24143 24460 | 186 24446 | 222 24438 | 137 | 152 | 154 | 158 | 229 | 251 |
| 2 | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | T | | | | | | | | C | | | | | | | | | | | | | | | | | | | | |
| 11 | A | | | B | G | G | | | | | | G | | G G | B | | G G | | | G | | G G | | | | | | |
| 12 | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | T | | | | | T | | | | | | | | | | T | | | | | | | T T | | | | | | |
| 46 | C | | | | | | | T | T | | T T | T T | T T | T T | | | | | | | T | | | | | | | | |
| 64 | C | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 86 | T | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 144 | C | | | | | | | T | | | | | | | | T | | | | | | | | | | | | | |
| 148 | A | | | | | | G | | | | | | G G | | G | | | | | | | | | | | | | | |
| 149 | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 160 | T | | | | | | | A | | A | | A | | A A | | | | | | | | | | | | | | | |
| 172 | A | | | | G | | | G | | G G G | | | | | | | | | | | G | | G G | | | | | | |
| 173 | T | C | C | | | | | C | C | | | | C C | | G | C | | C | C C C | C | | C C | | | C | C | | | | |
| 175 | C | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 178 | T | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 184 | G | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 203 | A | | | | | | G | | | | | | | | G | | | | | | | | | | | | | | |
| 256 | C | | | | | T | | T | | T T T T | | | | | | T | | | | | T | | T T | | | | | | |
| 259 | T | | A | | | | | | T | | | | | | | T | | | | | | A A | | | A | A | | | |
| 260 | T | | | B | A A A | | | A | | A | | | | A A | B | A A A | | | | | A | | A A A A A | | | | | | |
| 326 | T | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 327 | T | C | C | | | | | C | C | | | | C C | | G | C | | C | C C C | C | | C C | | | C | C | | | | |
| 328 | T | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 356 | T | | | B | C C | G | | | | C | | | | C C | B | | C C | | | C | | | G G G | | | | | | |
| 357 | C | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 358 | T | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 365 | G | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 366 | T | | | | C | C | | | | C | C | | | C C | | | C C | | | | | | | | | | | | |
| 370 | G | A | A | | | | A | A | | A A | | | | | A | A | | A | A A A A | A | | A A | | | A | A | | | |

*Reference sequence from R.A. Grahn et al.[1]
**Mitotype A10 is a previously undocumented mitochondrial subtype

## Mystery Katari phenotypes

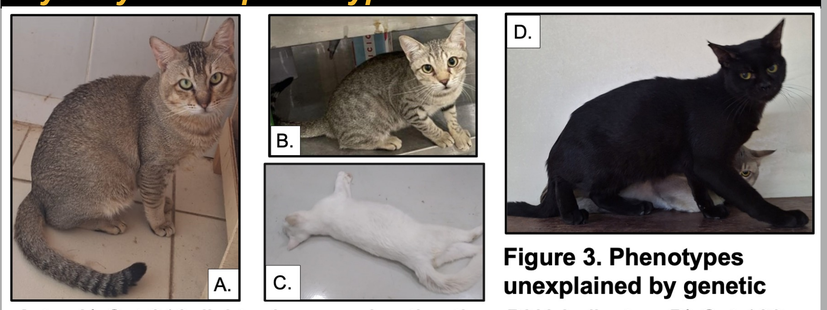


**Figure 3. Phenotypes unexplained by genetic data.** A) Cat 213; lighter brown coloration than DNA indicates. B) Cat 108; appears dilute, yet genotype indicates dense coloration. C) Cat 150; coloration implies *SS* (high white) genotype, yet no kittens descended from that cat has *Ss* (bicolor) fur. D) Cat 218; looks like it should be homozygous recessive for ASIP *(aa),* yet inherited at least one (A-) from a parent.

## Katari cat phenotype


**Figure 2. Current Katari phenotype overview.** A) ideal Katari phenotype, cat 101. Agouti, black, full color, dense, shorthaired, ticked.* B) alternate Katari phenotype under consideration, Cat 111. Blue, not black. C-E) undesired Katari phenotypes. C) Cat 126; mackerel tabby, not ticked. D) Cat 157; longhaired, not shorthaired. E) Cat 116; solid, not agouti.
*Information on causative variants for coat phenotype gathered from OMIA[2]

## FUTURE DIRECTIONS

- Population management software will be used to recommend breeding practices that minimize inbreeding and maximize genetic diversity
- Communication and collaboration will continue with the Katari colony to:
  - Sample and sequence more cats to complete population genomic data
  - Improve healthcare and husbandry practices

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- Genotyping – Veterinary Genetics Laboratory, UC Davis



- 1 – R.A. Grahn et al., “Feline non-repetitive mitochondrial DNA control region database for forensic evidence”, *Forensic Science International: Genetics* 5 (2011) 33-42
- 2 – Online Mendelian Inheritance in Animals (OMIA), *Felis catus* (9685) database, https://omia.org/results/?gb_species_id=9685&search_type=advanced


## Katari colony pedigree

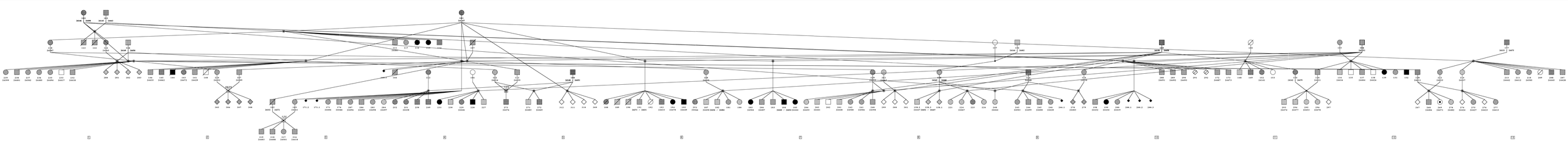

**Figure 1.** Katari cat colony pedigree as of 8/5/24. 171 cats are currently included on the extended pedigree. 18 founders are present. 162 kittens were born across 39 matings in 35 different mating pairs; approx. 4 kittens born per litter on average. 62 female kittens (~38.3%), 68 male kittens (~42%), and 32 kittens of unknown sex (~19.8%) were born; 7 were stillborn, indicating approx. 4.32% loss.