Cat Coat – Color, Pattern and Genetics

Sonja Prohaska

Computational EvoDevo
University of Leipzig

May 18, 2015
Cat Coat Color, Pattern and Genetics
How Hair Gets Color

- melanoblasts derive from neural crest
- dorso-ventral migration (back to belly)
- melanocytes move into epidermis
- at the basis of hair follicle
- differentiation of melanocytes
- produce Eumelanin
How Hair Gets Color – melanocytes

Melanine, the pigment, is produced by melanocytes and stored in melanosomes.
the $S$ “piebald-spotting” Locus

- dorso-ventral migration of myoblasts
- alleles: $S$, $s$
- incompletely dominant
- pigmentation is recessive
- $ss$ – completely pigmented
- $Ss$ – less than 50% white
- $SS$ – more than 50% white
- not necessarily all white

Dysfunction in dorso-ventral melanoblast migration, a dominant mutation, is the source of white spotts and patches.
Excursion into Genetics

- locus/gene
- allele
- diploidy
- homozygote – heterozygote
- dominant – recessive
- autosomes – sex chromosomes
Piebald-Spotted Phenotypes in Rats

“irish”  “berkshire”  “hooded”

Figure 24: Normal and hooded rat foetuses, showing the days on which melanoblasts reach the epidermis. It can be seen that there is a delay in migration of these cells in the hooded rat, and in the regions destined to become white they fail to reach the epidermis at all. (After WENDT-WAGENER, 1961.)

(Searle 1968)
the \textbf{W} “dominant white” Locus

- melanocyte migration to skin
- alleles: \textbf{W}, \textit{w}
- completely dominant
- pigmentation is recessive
- \textit{ww} – completely pigmented
- \textit{Ww} – white
- \textbf{WW} – white

Dysfunction in melanocyte migration to the skin is a dominant mutation and one source of completely white cats.
“dominant white” Phenotype and Eye Color

Hair, skin and eye color depend on the presence of Melanin.

- **Blue eyed white**: 50-80% deaf
- **Orange-eyed white**: (Yellow and hazel count as orange) 10-20% deaf
- **Odd-eyed white**: 30-40% deaf

**“blue-eyed”**

**“odd-eyed”**

**“orange-eyed”**

Dominant White cats with odd-eye color are usually deaf on the ear close the the blue eye.
How Hair Gets Color – Pigment Chemistry

Eumelanin

![Eumelanin molecule]

Pheomelanin

![Pheomelanin molecule]

Cat Coat – Color, Pattern and Genetics
the B “black” Locus

- eumelanin production
- alleles: B, b, b’
- B – black
- bb – brown, “chocolate”
- b’, b’ – light brown, “cinnamon”

Solid black cats might get a brownish tinge to their fur if the diet is deficient in tyrosine.
the **O** “orange” Locus

- pheomelanin production
- alleles: **O**, o
- **O** is located on the X chromosome
  - → sex-linked
- **males are XY**
  - XOY – orange (no “black”)
  - XoY – no orange (“black”)
- **females are XX**
  - one X is inactivated
  - X inactivation differs from cell to cell
    - XOXO – orange (no “black”)
    - XoXo – no orange (“black”)
    - XOXo – orange - black mixed
“Glückskatzen” und Co.

**Tortoiseshell**
- a XOXo female cat
- solid color, no spotting (ss)
- orange where Xo inactive
- black where XO is inactive

**Calico**
- an XOXo female cat
- piebald-spotted (SS or Ss)
- shows patches of orange
- and patches of black
- where she is not white
- “Glückskatze”
The \textbf{D} “dilution” Locus

- pigment density
- alleles: \textbf{D}, \textit{d}
- \textbf{D} – full density
- \textit{dd} – diluted
- dilution turns
  - black \rightarrow \textit{blue}
  - chocolate \rightarrow \textit{lilac}
  - cinnamon \rightarrow \textit{fawn}
  - orange \rightarrow \textit{cream}
Summary of Solid Colors

BLACK SERIES (EUMELANIN)
- BLACK
- CHOCOLATE
- CINNAMON

RED SERIES (PHAEOMELANIN)
- RED

DILUTE BLACK SERIES
- BLUE
- LILAC/LAVENDER
- FAWN (LIGHT LILAC)

DILUTE RED SERIES
- CREAM
The **C** “color” Locus

- codes the tyrosinase gene
- first step in melanin synthesis
- alleles: $C$, $c^b$, $c^s$, $c$
- temperature-sensitive variants
- $C$ is completely dominant
- $C > c^b = c^s > c$
- $C$ – full color
- $c^s c^s$ – Siamese/Pointed
- $c^b c^s$ – Tonkinese/Mink
- $c^b c^b$ – Burmese/Seal
- $cc$ – albino white

Complete dysfunction of tyrosinase on both alleles results in no pigment at all, i.e. an **albino** white cat (with pale blue or pinkish eyes).
The **A** “agouti” Locus

- transient inhibition of pigment production
- during hair growth
- causes bands of lighter color along the hair
- allele: **A**, **a**
  - **A** – agouti bands
  - **aa** – no agouti bands
- undercoat has color of bands
- banding pattern
  - smoked
  - shaded
  - tipped
  - tabby

Agouti hair banding is required to make patterns visible.
The I “inhibition” Locus

- Melanin inhibition
- seen in agouti banding of tabbies
- allele: I, i
- bands of lighter color
- I – white bands
- ii – yellow bands
- undercoat has color of bands

<table>
<thead>
<tr>
<th></th>
<th>tabby shaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>yellow</td>
<td>brown golden</td>
</tr>
<tr>
<td>white</td>
<td>grey silver</td>
</tr>
</tbody>
</table>
The **Ta** “tabby” and **Ti** “ticked” Locus

- alternate ticked and solid color hair
- causing formation of patterns
- alleles: $\text{Ta}^M$, $\text{ta}^b$
- $\text{Ta}^M$ – mackerel (getigert)
- $\text{ta}^b$, $\text{ta}^b$ – bloched (gestromt)
- alleles: $\text{Ti}^a$, $\text{Ti}^+$
- $\text{Ti}^a$ – Abyssinian (ticked allover)
- $\text{Ti}^a$, $\text{Ti}^+$ (stripes on face, legs and tail)
- $\text{Ti}^+$ – non-Abyssinian
- epistatic on tabby

These cats are back/brown (B), agouti (A), golden (ii) tabbies.
Unknown modifier of tabby

- locus: ?
- allele
  - mackerel → dots
  - bloched → spots
  - bloched → rosetted

cheetah (Gepard) and king cheetah