The genetic effects of expansive admixture and reductive selection on modern domestic pigs

Greger Larson
Make your own Nature Cover
The value of quantifying diversity

- Practical benefits

"...linking rate of allele loss with inbreeding coefficient."
The value of quantifying diversity

- Practical benefits

Genome-wide assessment of worldwide chicken SNP genetic diversity indicates significant absence of rare alleles in commercial breeds


“...linking rate of allele loss with inbreeding coefficient.”
Curiosity

The value of quantifying diversity

Troy et al. 2001
Curiosity

The value of quantifying diversity

Troy et al 2001
The value of diversity

- The underlying assumption of these inferences is
- 1) a linear progression from origin to present,
- 2) modern wild animals look like ancient ones
The underlying assumption of these inferences is:

1) a linear progression from origin to present,
2) modern wild animals look like ancient ones
Direct assessment of past diversity
Direct assessment of past diversity
Direct assessment of past diversity

- Cave Bears
- Pacific Chickens
- Bottle Gourds
Chicken Diversity in 3 loci
1) Modern Chicken mtDNA Phylogeography

Liu et al. 2006
Modern Chicken Phylogeography

- Genetic cline
Modern Chicken Phylogeography

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- Genetic cline
Modern Chicken Phylogeography

• Genetic cline
2) Ubiquitous Yellow Legs
2) Ubiquitous Yellow Legs

- Wild ancestors
2) Ubiquitous Yellow Legs
2) Ubiquitous Yellow Legs

mtDNA  nuDNA (not Chr. 24)  BCDO2 locus

yellow white  yellow white  white
3) A domestication gene

- **TSHR ubiquity**

- **Domestication gene:** Of 271 birds, 36 breeds, 264 birds had domestic variant of TSHR gene

- **18 of 51 Red Junglefowl had domestic allele**

Rubin et al 2010
3) A domestication gene

- TSHR ubiquity

- Domestication gene: Of 271 birds, 36 breeds, 264 birds had domestic variant of TSHR gene

- 18 of 51 Red Junglefowl had domestic allele

- “TSHR may be a domestication locus...a locus where all individuals carry a mutant allele.”

Rubin et al 2010
Seeing the past with aDNA

- Sample locations

- ~60 samples
- 200BC - 1200AD
Modern Chicken Phylogeography

- Modern
  - Fancy: N=113
  - Commercial: N=273

Map showing geographical distribution:
- E
- BE
- BDE
- ABCD
- EFG

Color codes:
- E
- D
- C
- B
- A

Diagram categories:
- Fancy
- Commercial
Modern Chicken Phylogeography

- Modern
  - N=113 Fancy
  - N=34 Ancient

- Ancient
Ubiquitous Yellow Legs

- Yellow not always so popular

- Majority homozygous for Red Junglefowl grey skin
Ubiquitous Yellow Legs

- Yellow not always so popular

- Majority homozygous for Red Junglefowl grey skin

- Only 1 bird was (homozygous) Yellow skin in ~100BC
• Modern

TSHR Domestication Gene

N=271

0.98

0.02

Domestic
Modern

Ancient

Minority are homozygous for domestic allele
It’s all change through time

- mtDNA - diversity --> diversity
- Relatively recent import of East Asian breeds
It’s all change through time

- mtDNA - diversity --> diversity
  - Relatively recent import of East Asian breeds

- Yellow skin - diversity --> diversity
  - Heavy recent selection for introgressed allele
It’s all change through time

- **mtDNA** - diversity --> diversity
  - Relatively recent import of East Asian breeds

- **Yellow skin** - diversity --> diversity
  - Heavy recent selection for introgressed allele

- **TSHR** - diversity --> diversity
  - Selective sweep was POST domestication
Not quite linear
Not quite linear
Not quite linear
Not quite linear
Not quite linear
Not quite linear

Wild
1

2 3 4 5
Commercial Breeds
Limited wild distribution
Bigger range, bigger problems
Pig Tails

• The initial process (archaeological record)

Larson et al 2005
Western Eurasia

1. Ulucak Höyük
2. Malkayasi
3. Menteşe Höyük
4. Bademliği
5. Sogukkaya-Duzen Tepe
6. Gordion
7. Çamlıbel Taşlışı
8. Şirkeli Höyük
9. Lidar Höyük
10. Hassek Höyük
11. Çayönü
12. Leilan
13. Armenia
14. Tchair Perde-Aruchlo
15. Kohneh Tepesi-Haftavan
16. Iran (others)

Years:
- Neolithic 7,000-6,000 BC
- Chalcolithic 6,000-3,100 BC
- Early Bronze Age 3,100-2,000 BC
- Middle Bronze Age 2,000-1,600 BC
- Late Bronze Age 1,600-1,200 BC
- Iron Age 1,200-600 BC
- Hellenistic-Roman 500 BC-5th cent AD
- Medieval 5th cent AD-15th cent AD

Y1, Y2, Arm1T, Arm2T, European

Ottoni et al 2013
Western Eurasia

[Diagram showing archaeological sites and their associated time periods, such as Neolithic 7,000-6,000 BC, Chalcolithic 6,000-3,100 BC, and so on. The diagram also includes maps and pie charts indicating the distribution of different archaeological findings.]

Ottoni et al 2013
Western Eurasia

11,000 BC - 5,500 BC

Larson et al 2007
Eastern Eurasia

- The initial process (archaeological record)
Eastern Eurasia

○ The initial process (archaeological record)
Eastern Eurasia

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Eastern Eurasia

- The initial process (archaeological record)
Old World Amalgamation

- The incorporation and amalgamation
Nuclear signatures as well

mtDNA

60k SNPs
Nuclear signatures as well

mtDNA

60k SNPs

Maternally Near Eastern Nuclear clusters w Italian
Never stops

- Victorian improved breeds
Never stops

- Victorian improved breeds
Never stops

- Victorian improvements

Groenen et al 2012
Never stops

• Victorian improvements

~35% Asian fraction in European breeds

Groenen et al 2012
So what

- Traditional model

Wild

Domestic
“We found that managed honey bees actually have higher levels of genetic diversity compared with their progenitors in East and West Europe, providing an unusual example whereby human management increases genetic diversity by promoting admixture.”
So what

- Bees

Wild

Domestic
• Bees

So what

Wild

Domestic
So what

- Embrace the complex narrative
So what

- Embrace the complex narrative
- Step 1) Reduction during domestication
So what

- Embrace the complex narrative
- Step 1) Reduction during domestication
- Steps 2-x) Tension between:
So what

• Embrace the complex narrative

• Step 1) Reduction during domestication

• Steps 2-x) Tension between:

  • a) repeated bottlenecks (selection, migration)
So what

- Embrace the complex narrative

- Step 1) Reduction during domestication

- Steps 2-x) Tension between:
  - a) repeated bottlenecks (selection, migration)
  - b) repeated admixture = increase variability
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- Step 3) Commercial production bottlenecks
So what

- Embrace the complex narrative
- Step 1) Reduction during domestication
- Steps 2-x) Tension between:
  - a) repeated bottlenecks (selection, migration)
  - b) repeated admixture = increase variability
- Step 3) Commercial production bottlenecks
- Identify reservoirs / quantify variability
Makers of the modern world