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Genetics and Health

The importance of environmental resilience and adaptation for small-holder poultry production

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Background and goals

- Small-holder backyard poultry farming is an important economic activity in Africa
  - Contributes major share of meat and egg production (e.g. ~97% in Ethiopia)
  - Major source of income and nutrition for the smallholders farmers.
- Backyard farming relies predominantly on locally adapted indigenous chickens.
- But production is relatively low compared to commercially improved birds.
- Finding genetic basis of tropical adaptation would allow to combine adaptability and performance of improved dual-purpose breeds.

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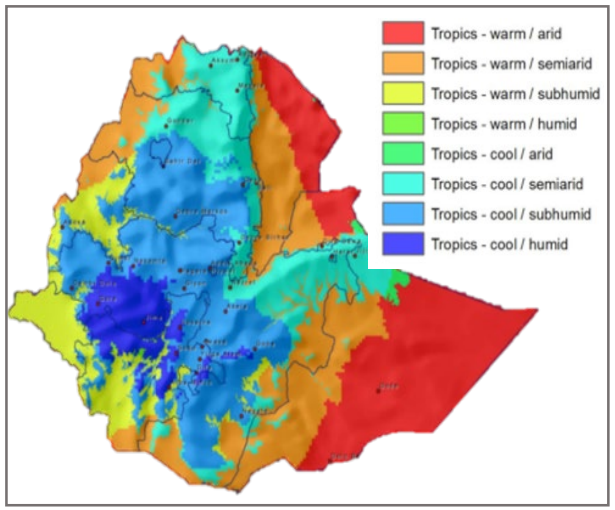
Dissecting environmental adaptation

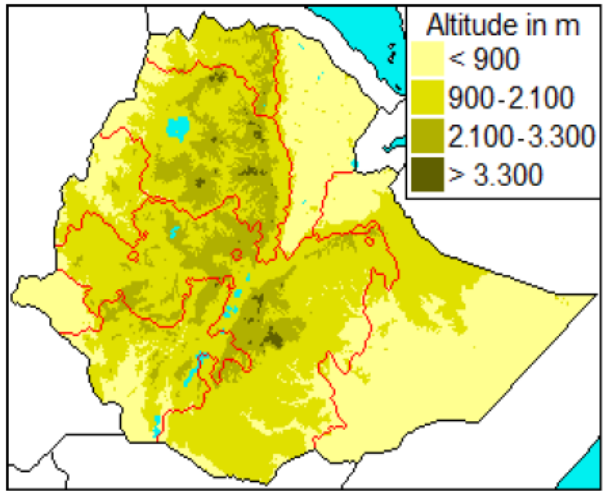
- **What are the key environmental drivers of adaptation?**

→ Ecological Niche Modelling

Climatic zones



Altitude



- **What are the genetic bases of adaptation?**

→ Genomic analyses based on whole genome sequence data

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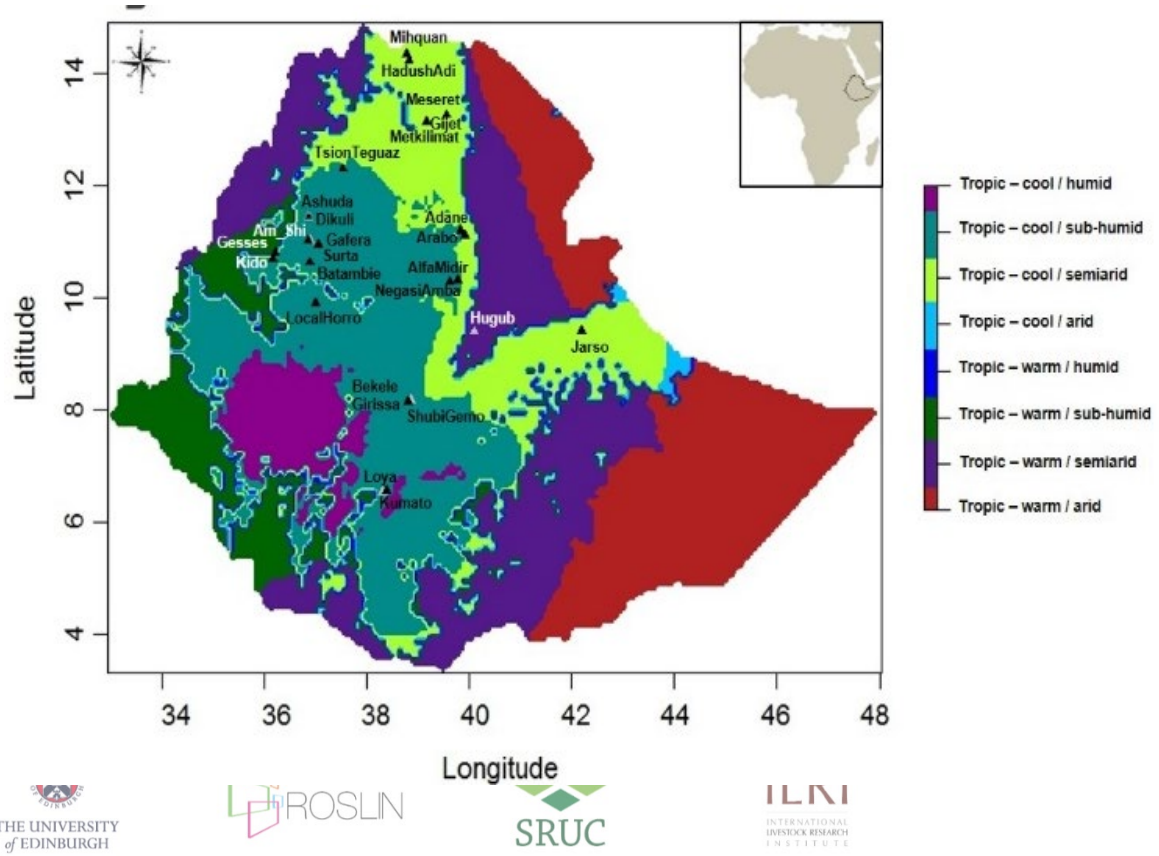
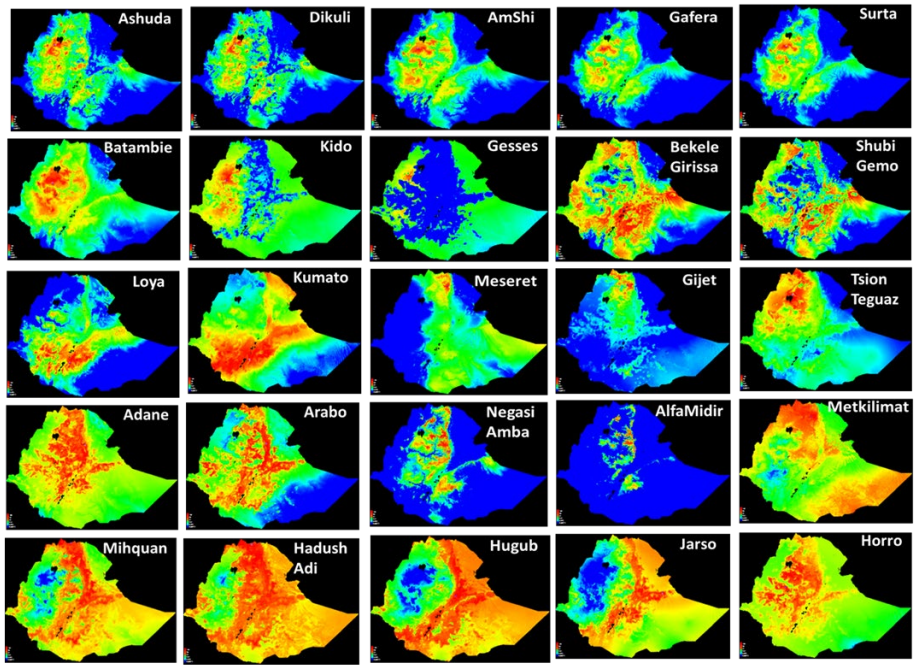
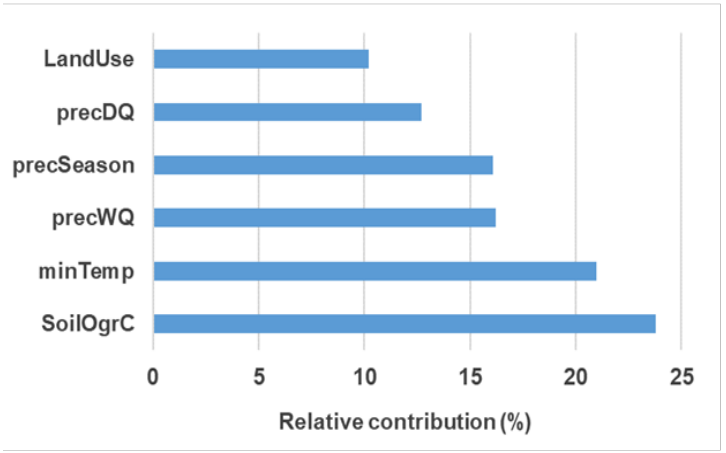
Ecological Niche Modelling (ENM): Ethiopia

Data for ENM:

- 25 chicken populations (250 samples)
- 32 agro-climatic variables (collected from public databases)







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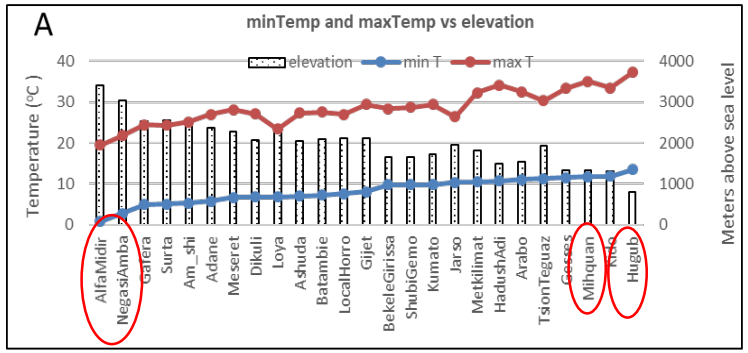
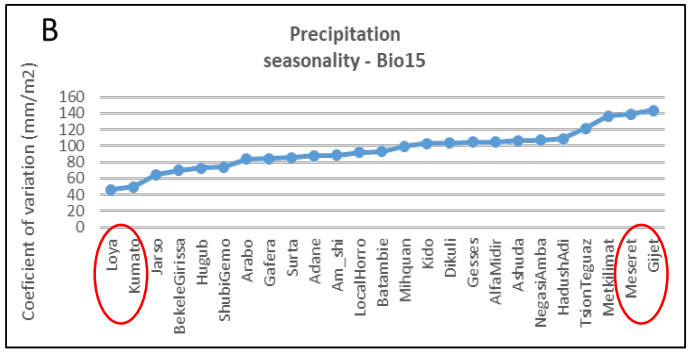
Genomic analysis

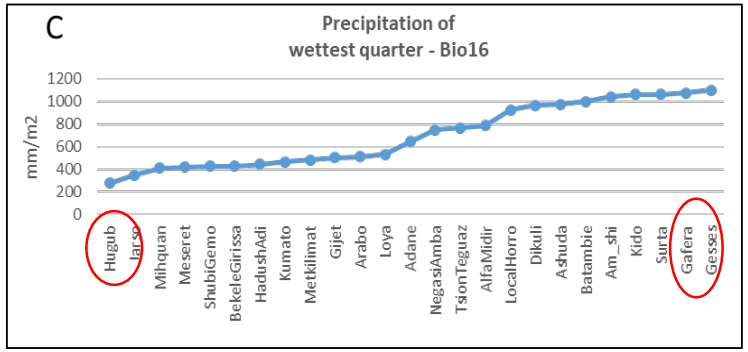
Selection signature analyses on extreme populations

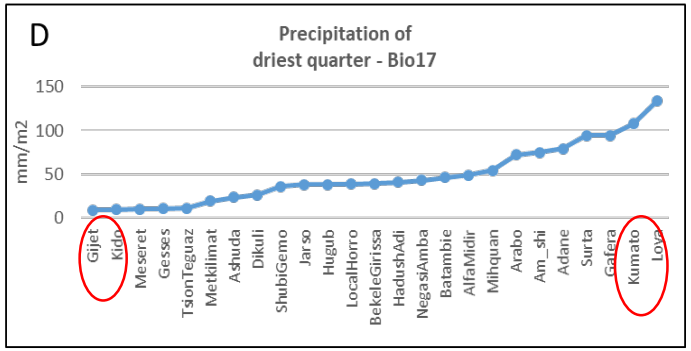
(Fst and XPEHH)

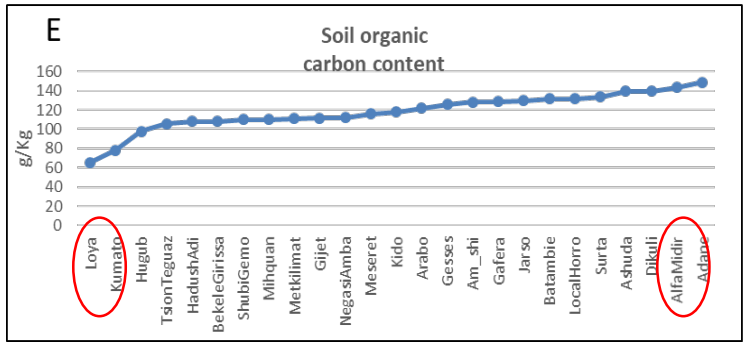
Genotype-environment association across environmental gradient (Redundancy Analysis)

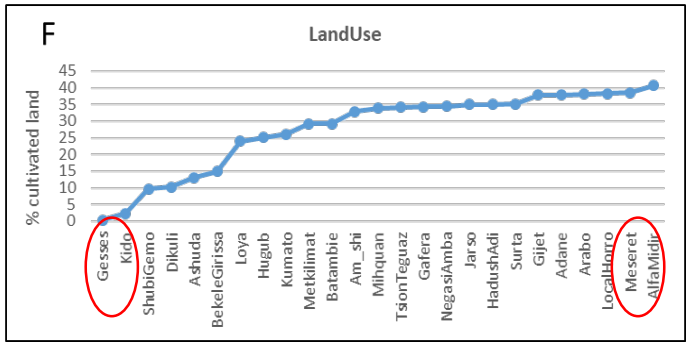












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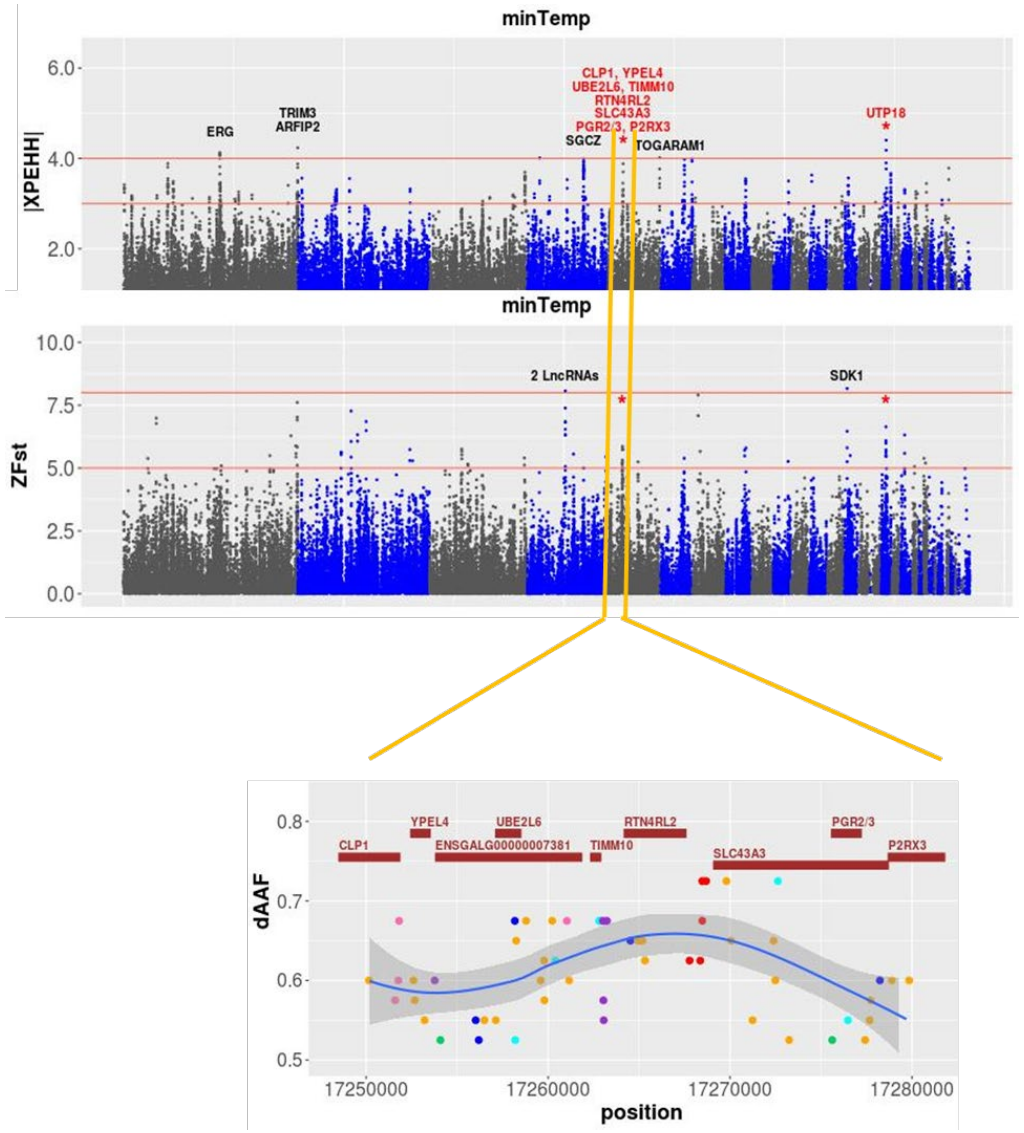
Important findings: extreme population comparison

- Strong adaptive candidate genes detected for high altitude stress, drought, and scavenging conditions but few for heat stress.
- Many candidate genes detected but only a few with possible large effects - supporting oligogenic control of adaptation.
- Strongest candidates often appeared in clusters – possibly being modulated concurrently by one or few regulatory elements.

High altitude/Low temperature adaptation



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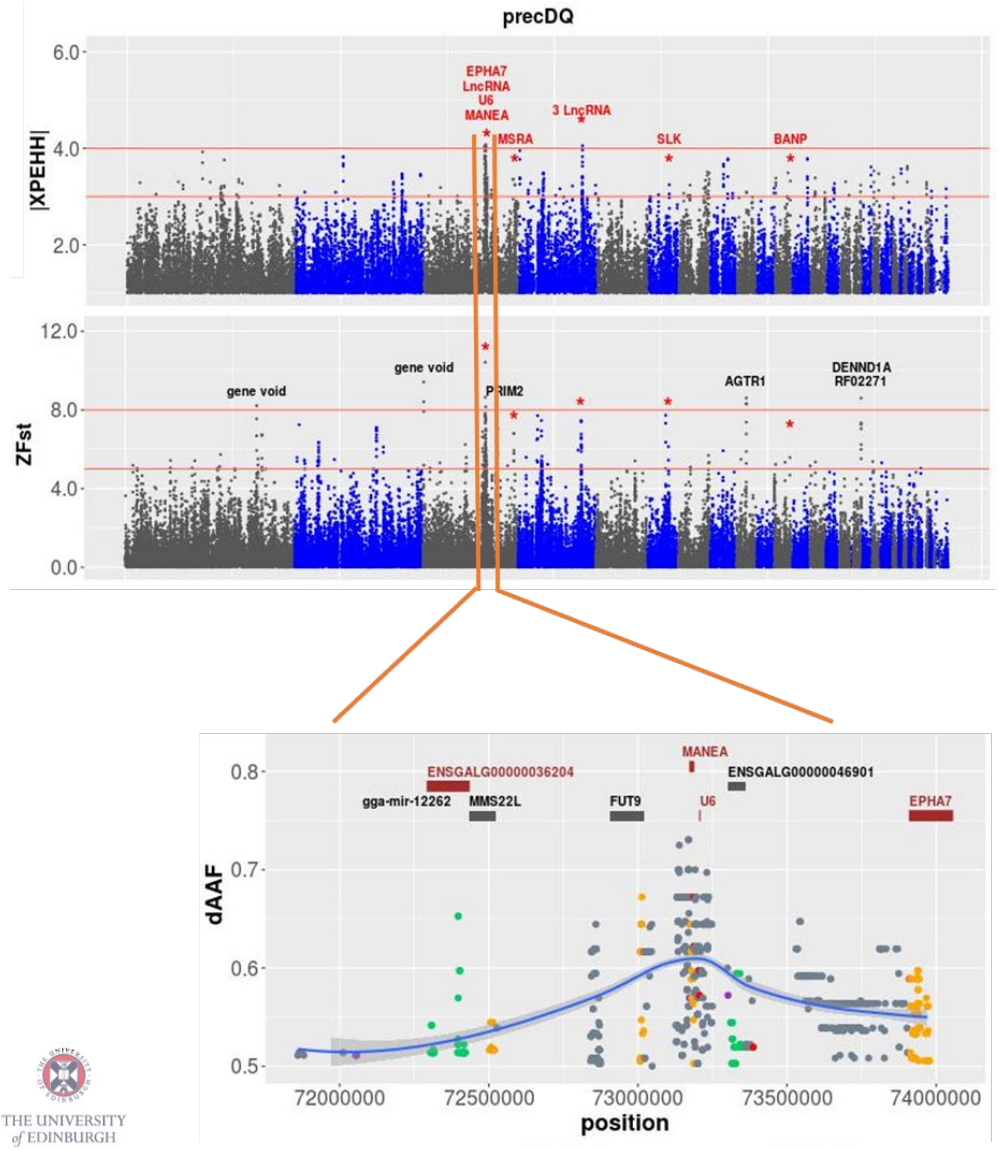
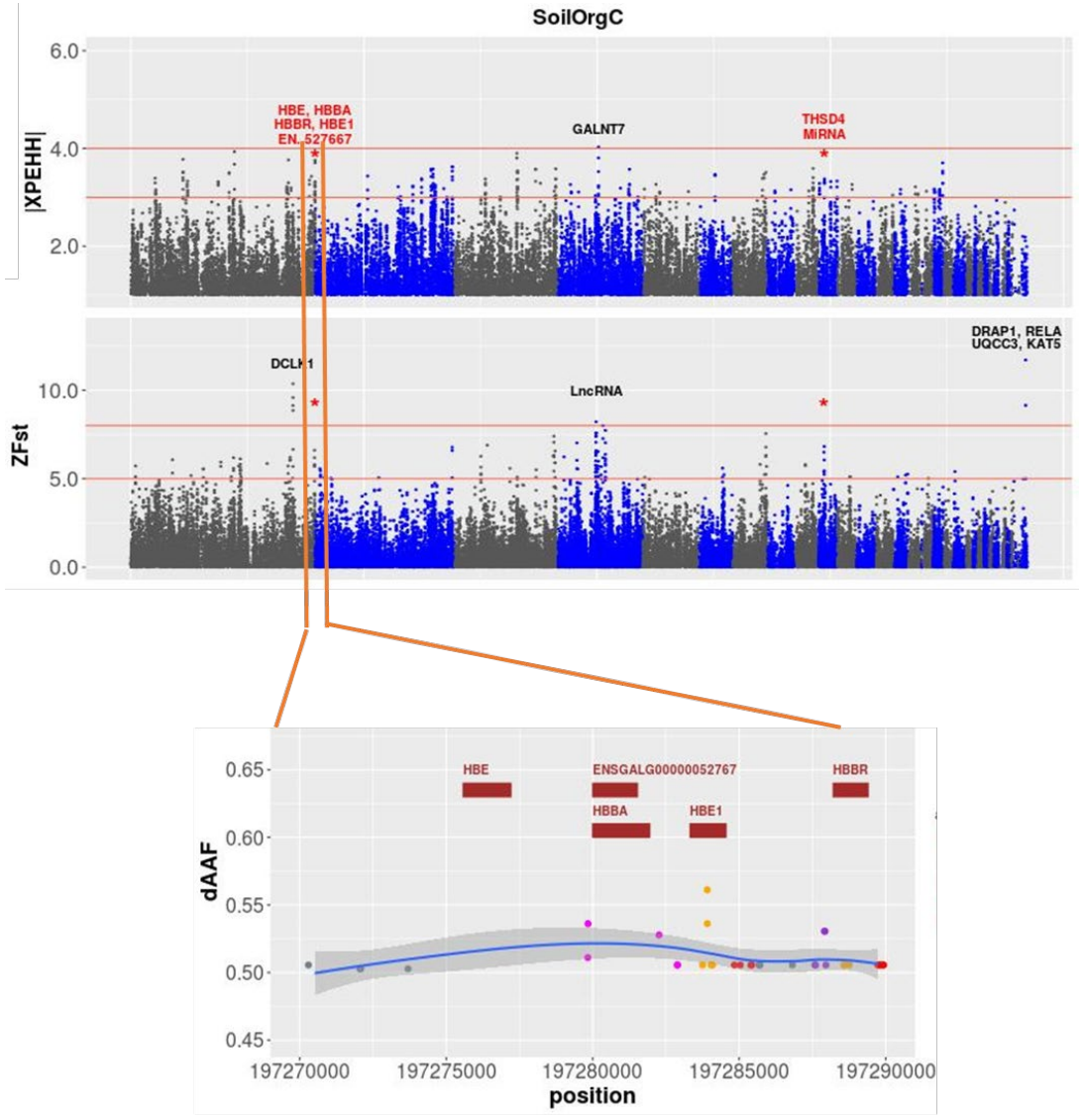
Extreme population comparison *cont*….

Adaptation to drought



Adaptation to scavenging conditions: natural food type & availability



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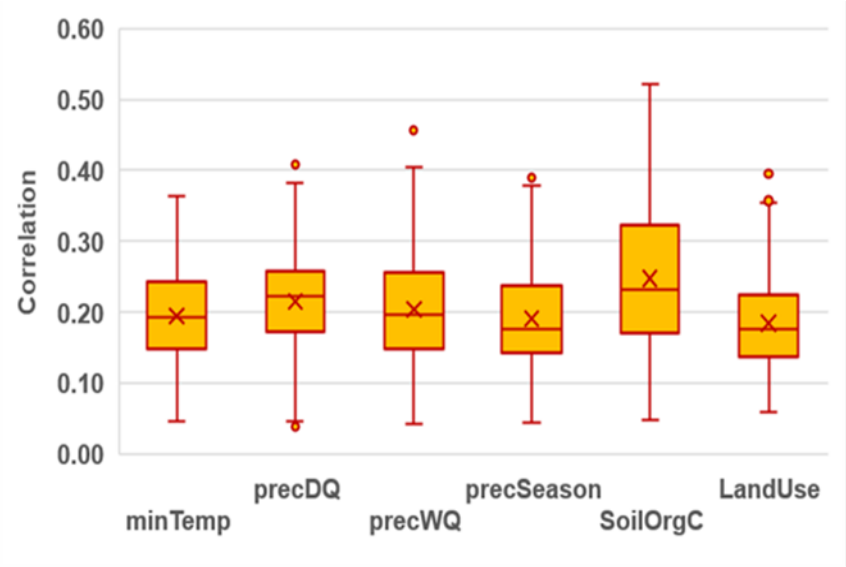
Important findings: genotype-environment association

- Detected candidates showed week to moderate correlation with environment (max. r=0.52)
- The strong candidates detected in extreme population comparison were not detected by RDA
  - The strongest candidates possibly appear under extreme environmental pressure and not necessarily have a linear relationship across environmental gradients – (G X E interaction)



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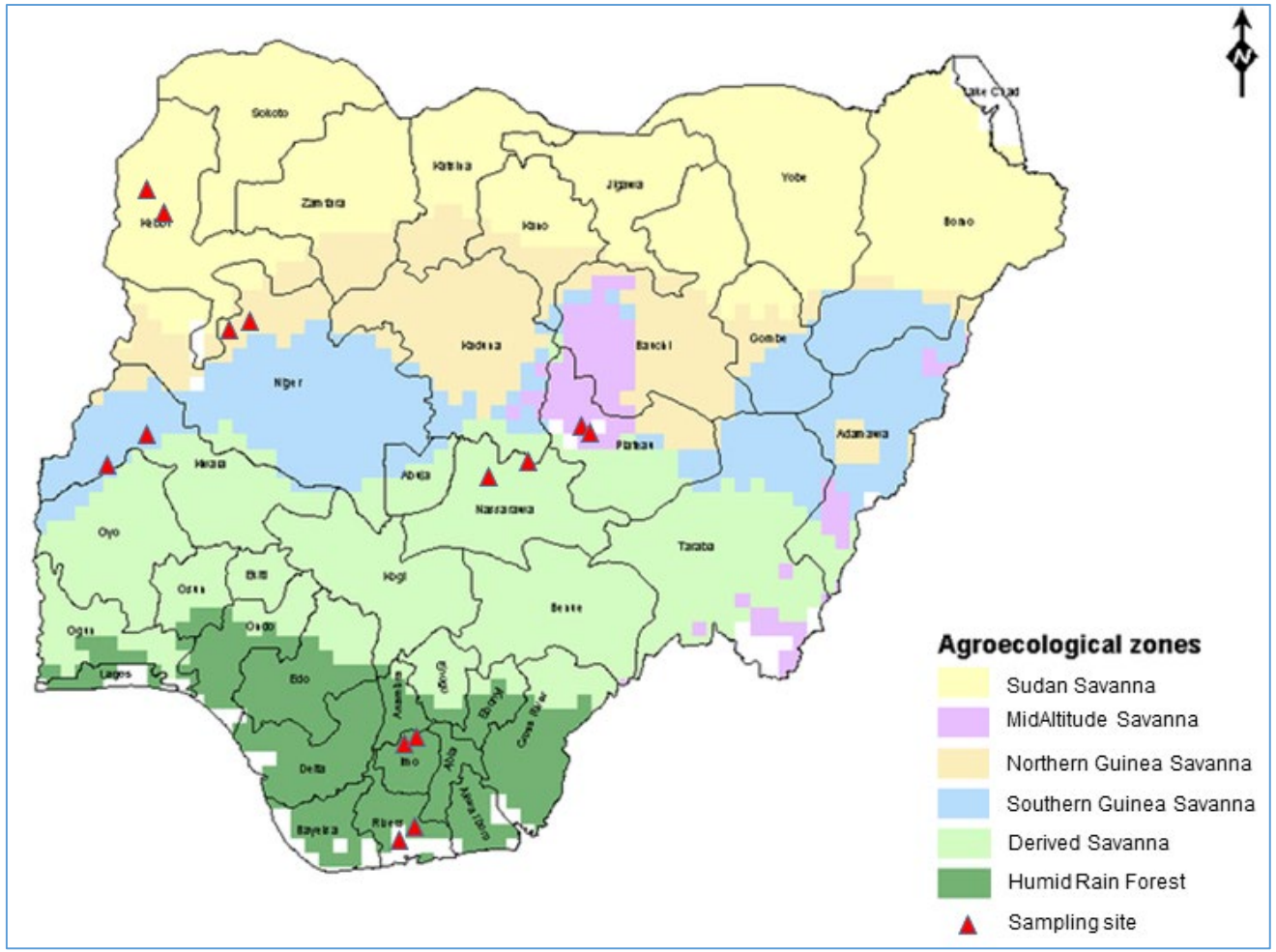
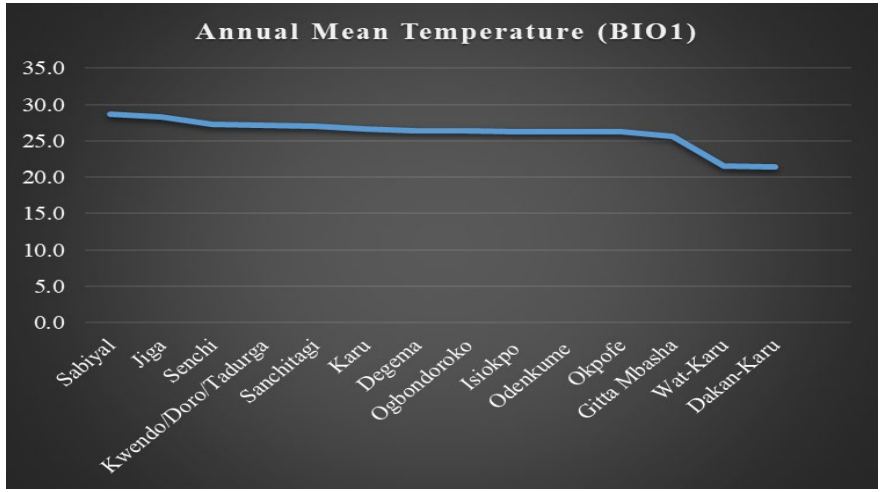
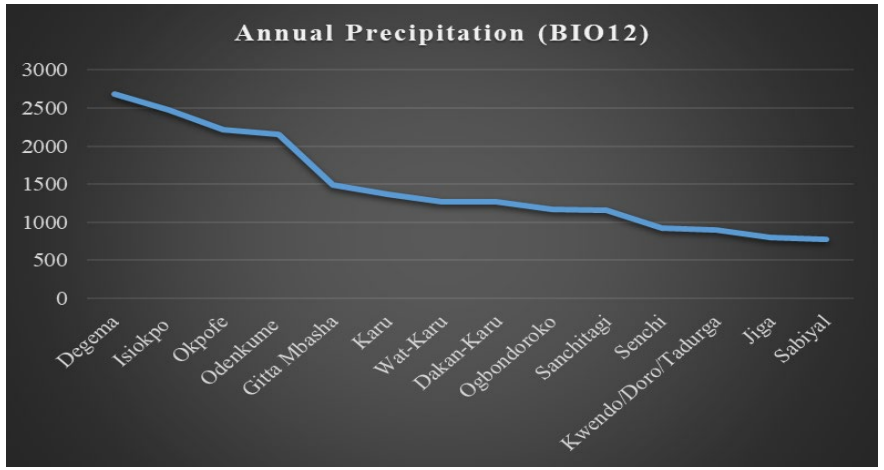
Analysis for heat stress adaptation: Nigeria







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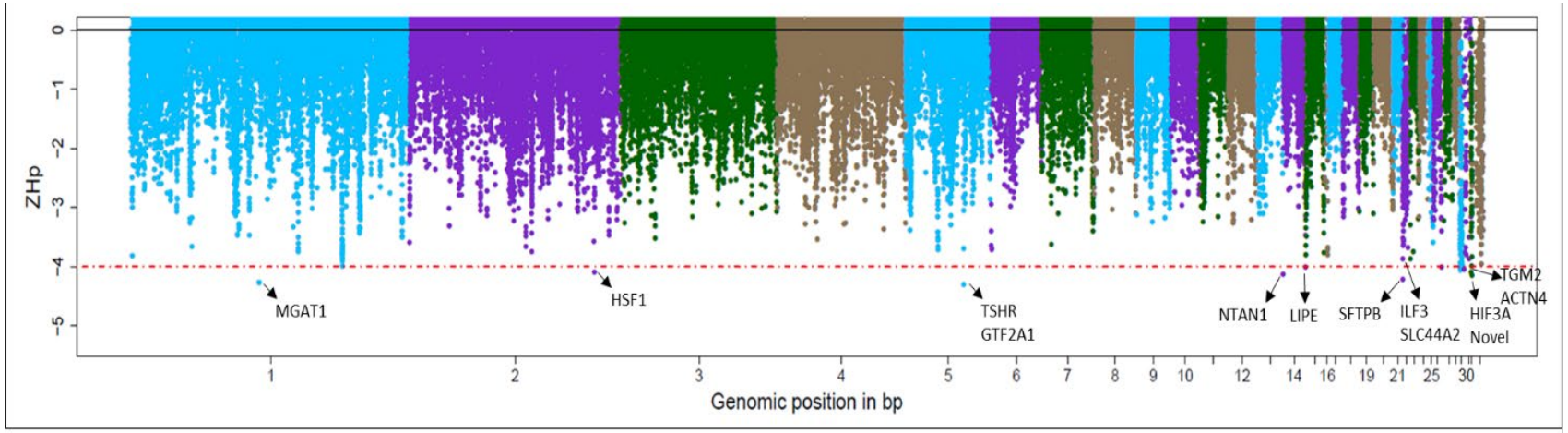
Heat stress adaptation *cont…*



Sweep regions	Genes and function
Chr5: 41000000-41020000	***TSHR***: Possible role in thermo-tolerance; ***GTF2A1:*** Transcriptional activation
Chr22: 40000-60000	***SFTPB:*** Encodes a pulmonary surfactant protein; role in respiratory gaseous exchange by respiratory system
Chr2: 131020000-131040000	***3 LncRNAs:*** Regulatory functions ***HSF1:*** Heat shock factor 1 (nearby to the sweep region)
Chr30: 1030000-1060000	***OLFM2:*** regulation of smooth muscle cell differentiation; ***PIN1:*** many functions including regulation of neuronal apoptotic process, transcriptional regulation; ***UBL5***: stress responsive transcription factor;
Chr14: 16010000-16030000	***LIPE:*** Lipid metabolism
Chr1: 90830000-90860000	Gene void region; nearest gene 87Kb; ***MGAT1:*** Oxidative stress response

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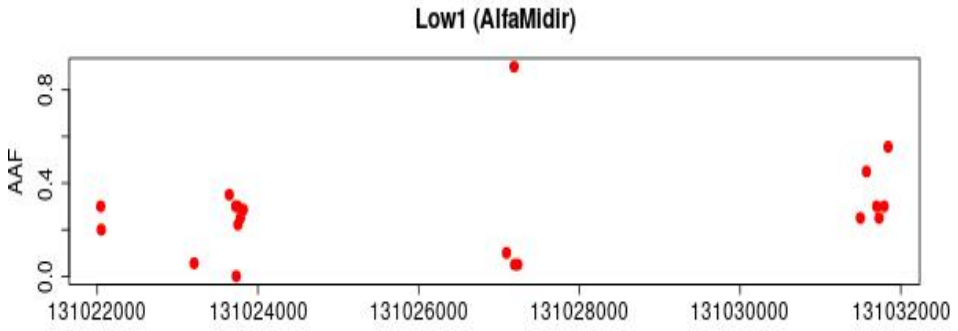
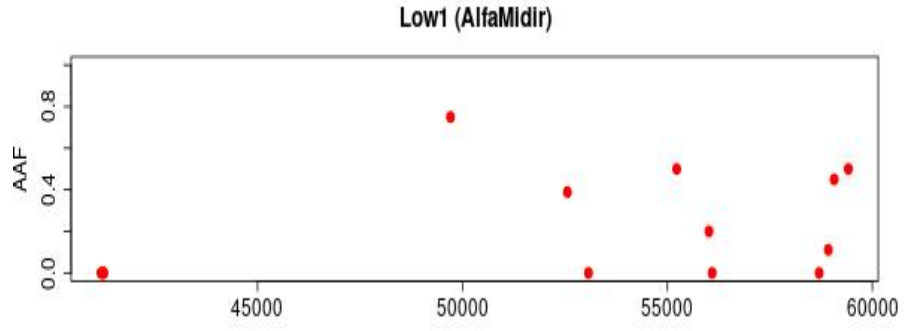
SNP allele frequency pattern in heat stress candidates in Ethiopian extreme populations

Chr2: 131020000_131040000 (HSF1 gene nearby)

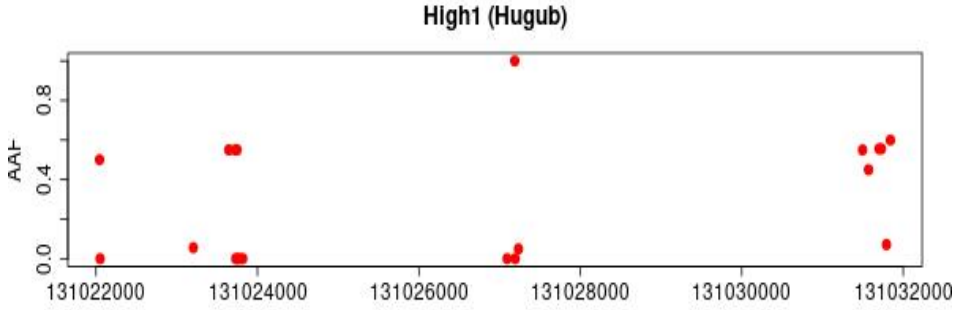
Chr22_40000_60000 (SFTPB gene)

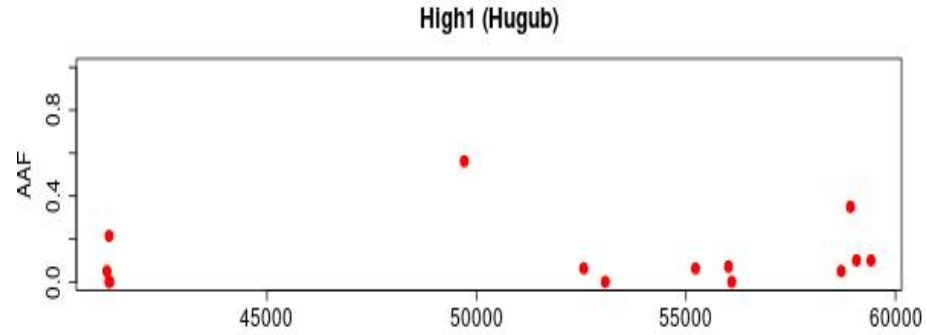
Low temperature population





High temperature populations





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Heat shock protein (HSP) genes

- A recent study observed ***HSP70*** and ***HSP90*** genes are overexpressed in local Brazilian poultry breeds adapted to heat stress compared to commercial broilers.
- But we did not find any allele frequency differentiation in or around these genes between Ethiopian extreme populations.

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PLoS One. 2017 Oct 11;12(10):e0186083. doi: 10.1371/journal.pone.0186083. eCollection 2017.

Heat stress induces expression of HSP genes in genetically divergent chickens

Haniel Cedraz [1], Juliana Gracielle Gonzaga Gromboni [1], Antonio Amandio Pinto Garcia Junior [1], Ronaldo Vasconcelos Farias Filho [2], Teillor Machado Souza [1], Eduardo Ribeiro de Oliveira [1], Elizangela Bonfim de Oliveira [2], Carlos Souza do Nascimento [3], Camila Meneghetti [1], Amauri Arias Wenceslau [1]

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PMID: 29020081 PMCID: PMC5636143 DOI: 10.1371/journal.pone.0186083

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Abstract

Background: Chickens are animals that are sensitive to thermal stress, which may decrease their production level in terms that it affects feed intake and thus, decreasing body weight gain. The Heat Shock Factors (HSF) and Heat Shock Proteins (HSP) genes are involved in the key cellular defense mechanisms during exposure in hot environments. Aimed with this study to analyze the expression of HSF1, HSF3, HSP70 and HSP90 genes in two local breeds (Peloco and Caneluda) and a commercial

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Heat stress adaptive genes possibly are controlled by regulatory elements including epigenetic regulation

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Thank you

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