

# Whole genome sequence from 3,000-year-old Egyptian emmer wheat reveals dispersal and domestication history



m.f.scott@ucl.ac.uk



@mscott0106

# Introduction

## **First whole genome sequence data from an ancient wheat**

- A museum specimen of **Emmer wheat** from Egypt

## **Dispersal**

- Which modern landraces are **most closely related** to this ancient emmer wheat?

## **Domestication**

- Does this ancient emmer wheat **share a selection history** with modern domesticated emmers?

# Accession Context

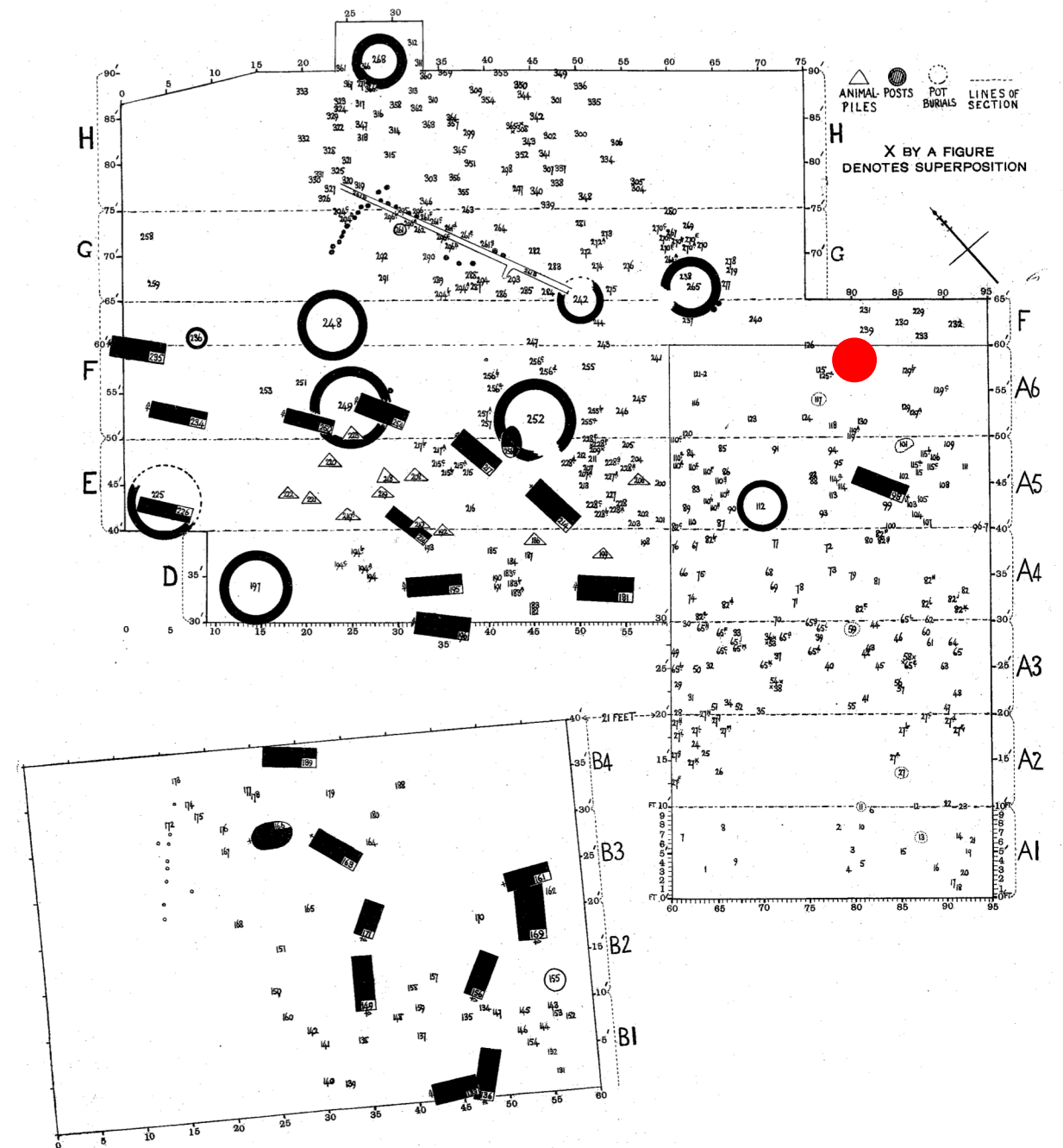
## Hememiah North Spur excavation (1924)

- Predynastic huts, 4400-4000BCE (circles)
- Intrusive Old Kingdom burials, 2686-2181BCE (rectangles)

## Emmer Chaff (red)

- “a blackened patch of hearth on the north-west side, from which we sifted a few grains of a carbonized cereal; from the side of the hearth were collected a few uncarbonized grains and chaff – all these have been determined by Dr. John Percival as grains of Emmer wheat”

Brunton and Caton-Thompson (1928)



# Accession

Stored at **UCL Petrie Museum of Egyptian Archaeology**, UC10164

**Replicated AMS  $^{14}\text{C}$  dating** on two specimens

- Combined two-sigma dates 1130-1000 Cal. BCE
- Mature ancient Egyptian agricultural period

**aDNA extracted from two specimens**

- ~66% and ~31% of reads mapped to reference genome
- One specimen sequenced to **~1.3x coverage** of 10.5Gb genome
- 0.06x coverage from other specimen used to confirm genotyping accuracy of at least 98.6%.

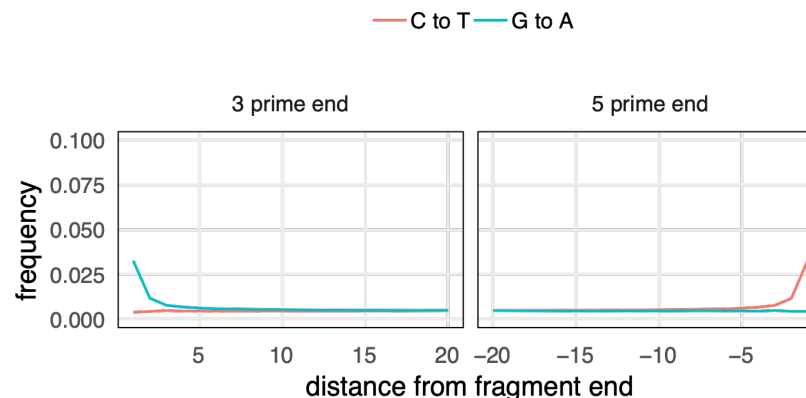




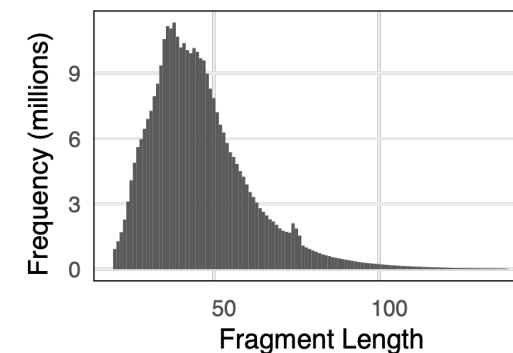
# aDNA statistics

- Characteristic damage patterns and fragment sizes **confirm DNA is ancient**
- Not contaminated by modern bread wheat
- Variants called at **1.4m exonic sites** identified from modern emmer wheat to mitigate errors caused by polyploidy
- **86,593 SNP sites** used for analysis after QC

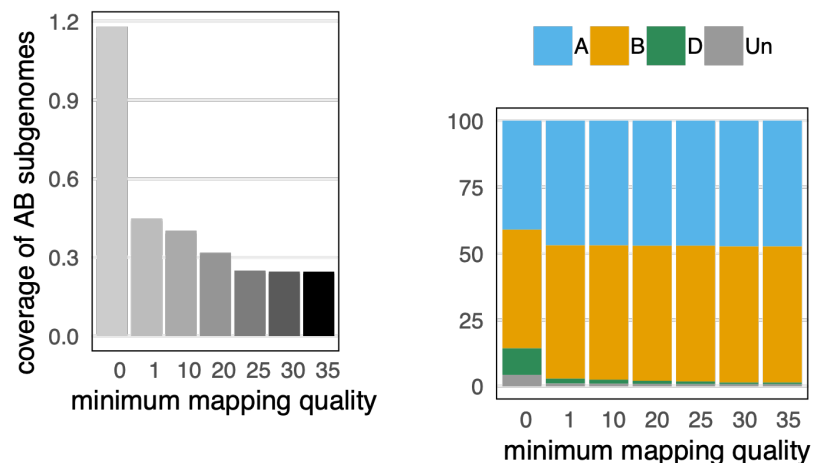
**A** Misincorporations versus Emmer Reference



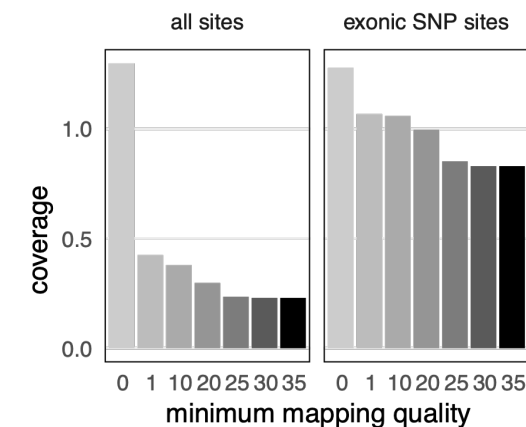
**B** Fragment Sizes



**D** Alignment to Hexaploid Bread Reference



**C** Alignment to Emmer Reference

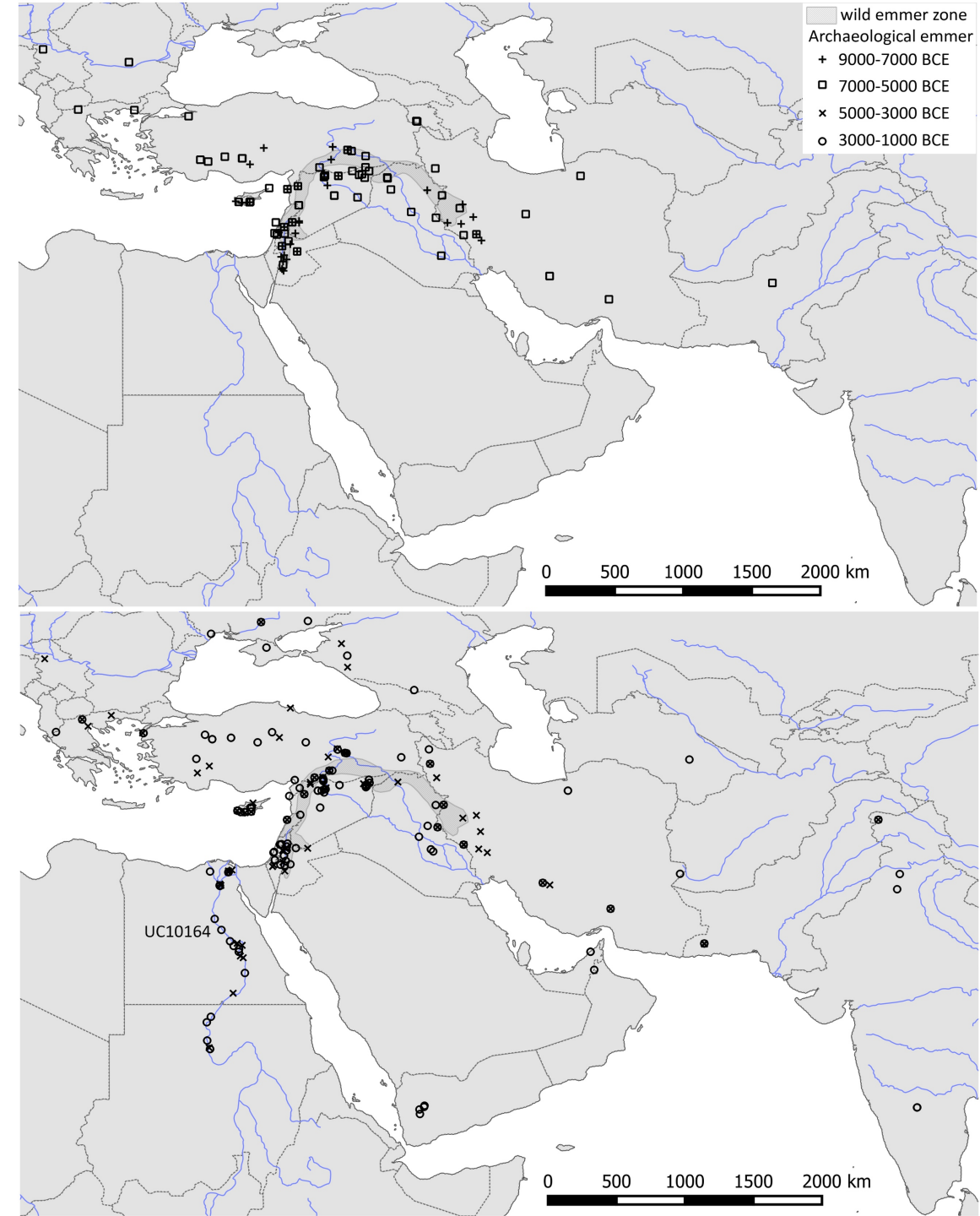


# Emmer Dispersal

## Old world 'founder crop'

- Spread from the Fertile Crescent with Neolithic agriculture
- Eastern dispersal into the Indus valley by 6000 BCE
- Reached Egypt during the 5<sup>th</sup> millennium BCE

Largely replaced by bread wheat and durum wheat between 5000BCE and 1000CE.

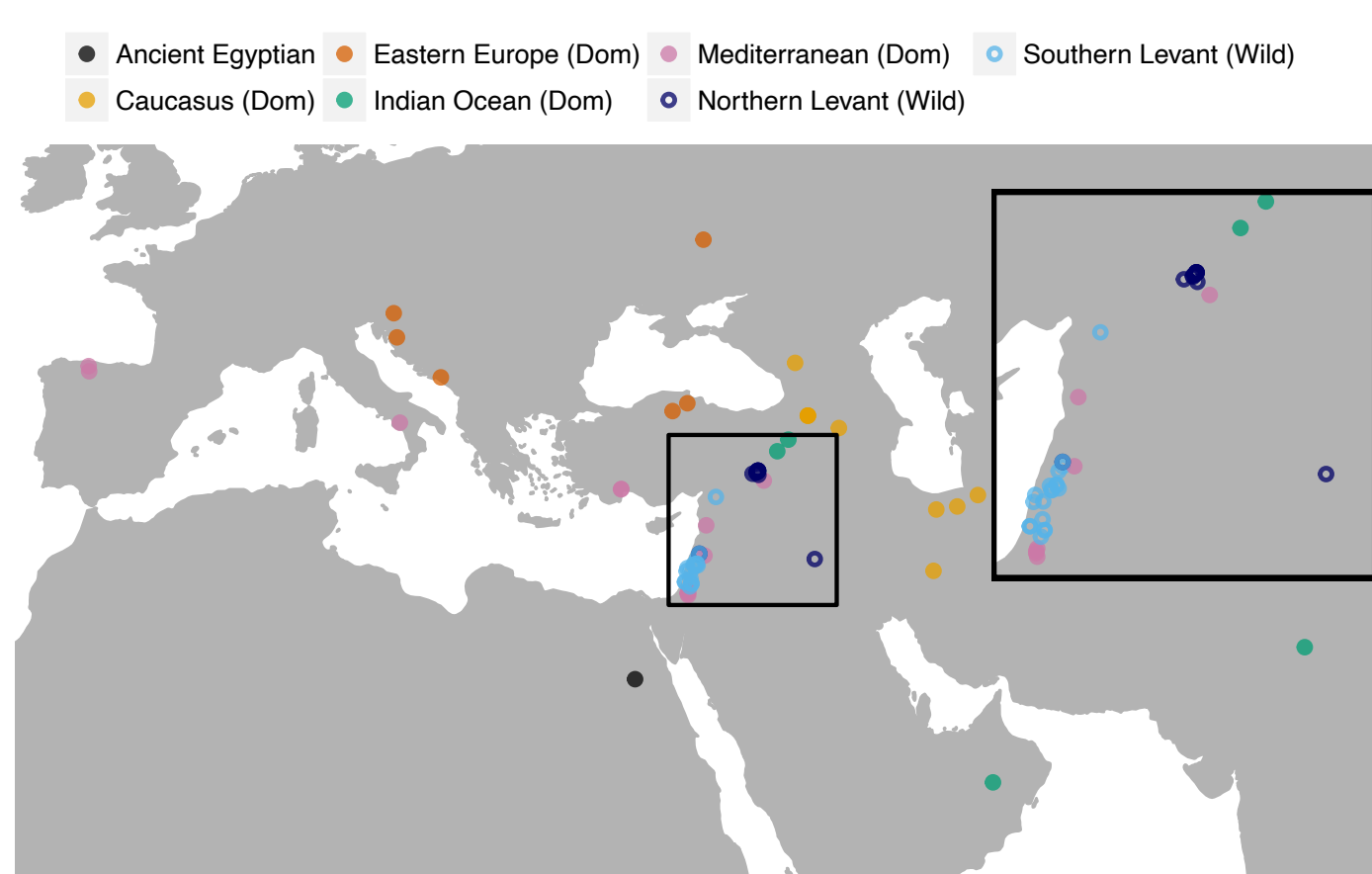


# Emmer Dispersal

**Avni et al (2017)** wild emmer wheat reference genome

- 31 domesticated accessions (filled circles)
- 33 wild accessions (open circles)

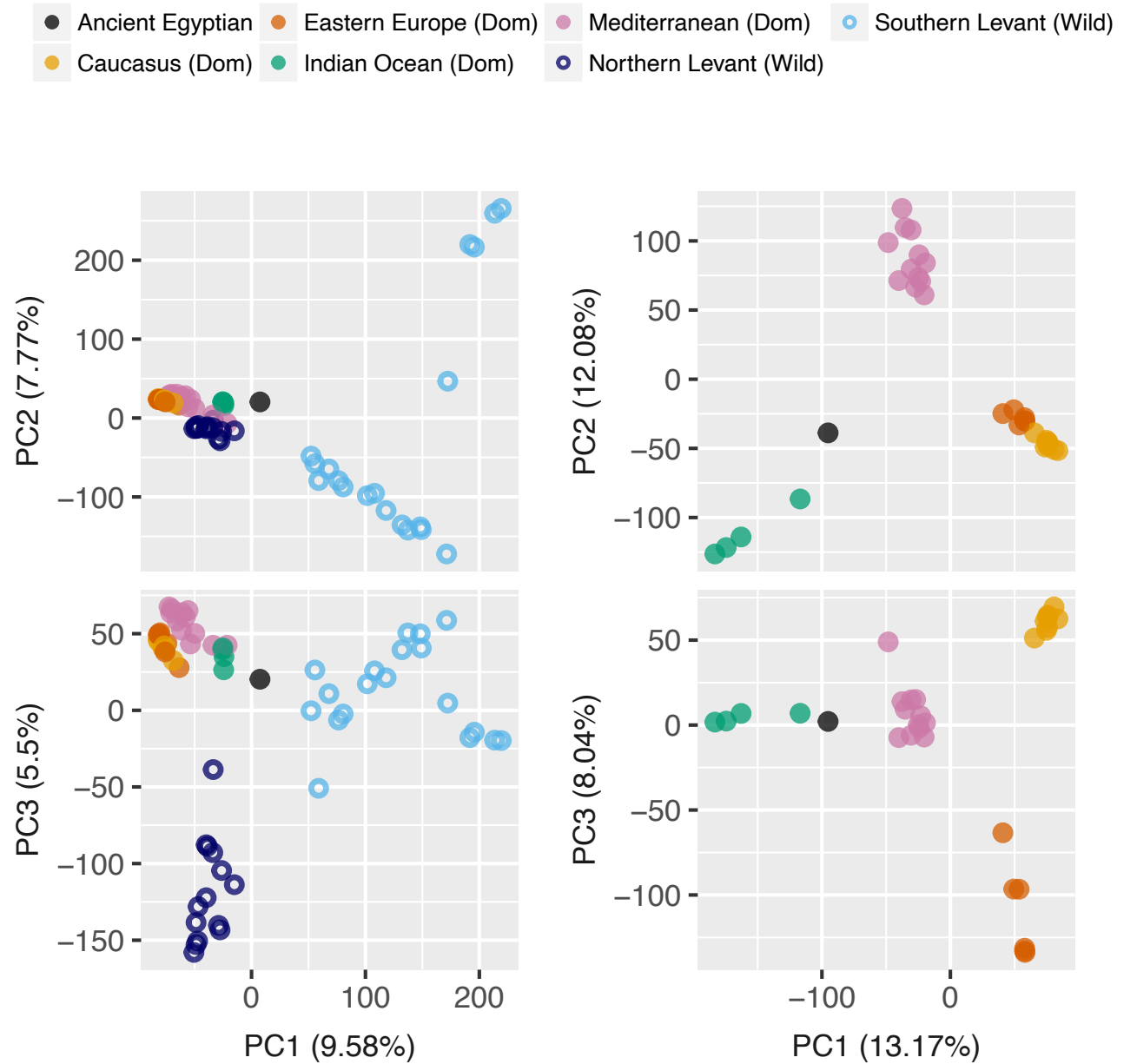
Clustered into subgroups (colours)



# Emmer Dispersal

Ancient Egyptian sample clusters with other **domesticated** samples and closest to the **Indian Ocean** subgroup

Other analyses of similarity support this conclusion

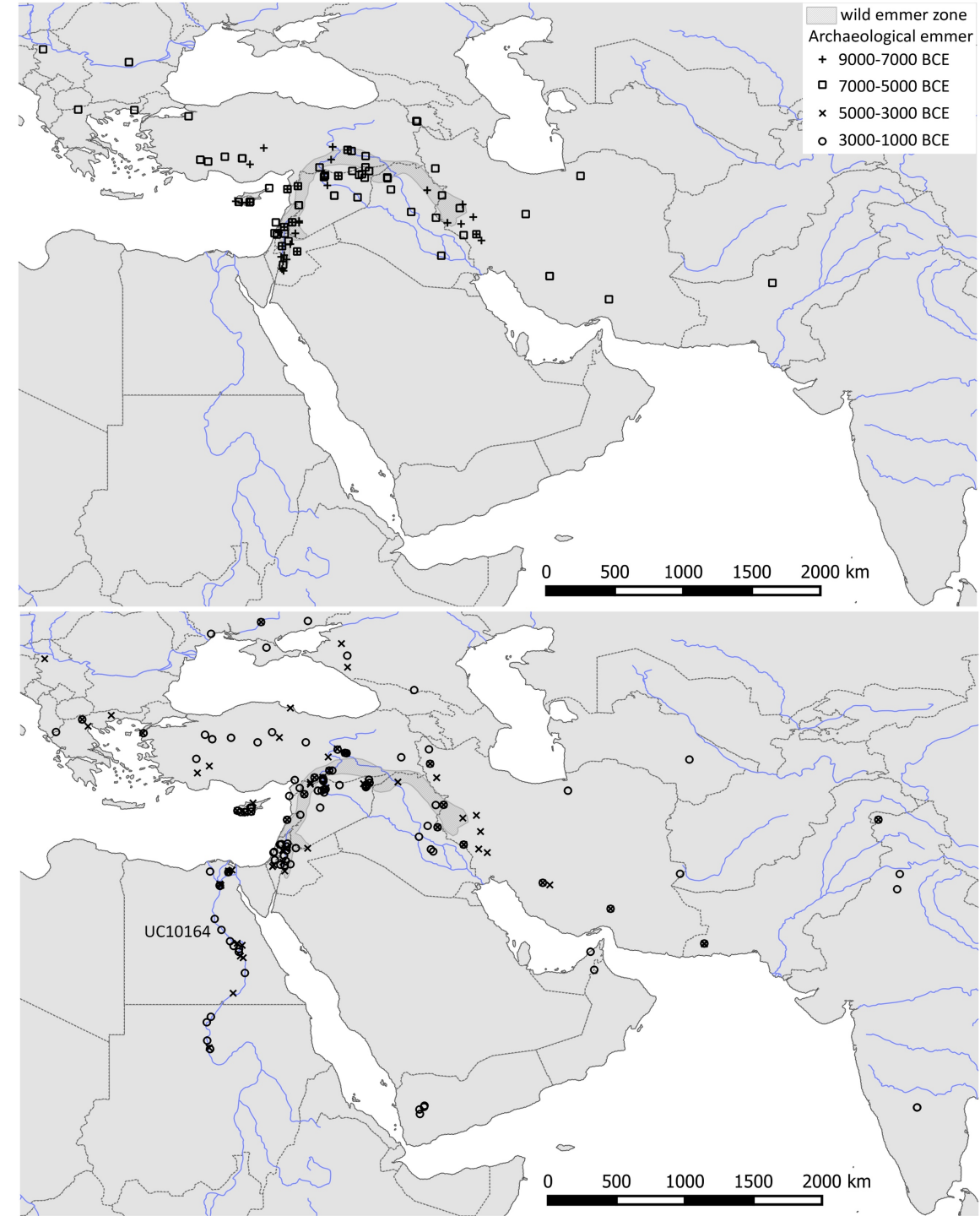




# Emmer Dispersal Conclusions

This links the early eastwards dispersal of emmer wheat into the Indus valley by 6000 BCE with the arrival of emmer wheat into the Egyptian Nile Valley around 4500 BCE.

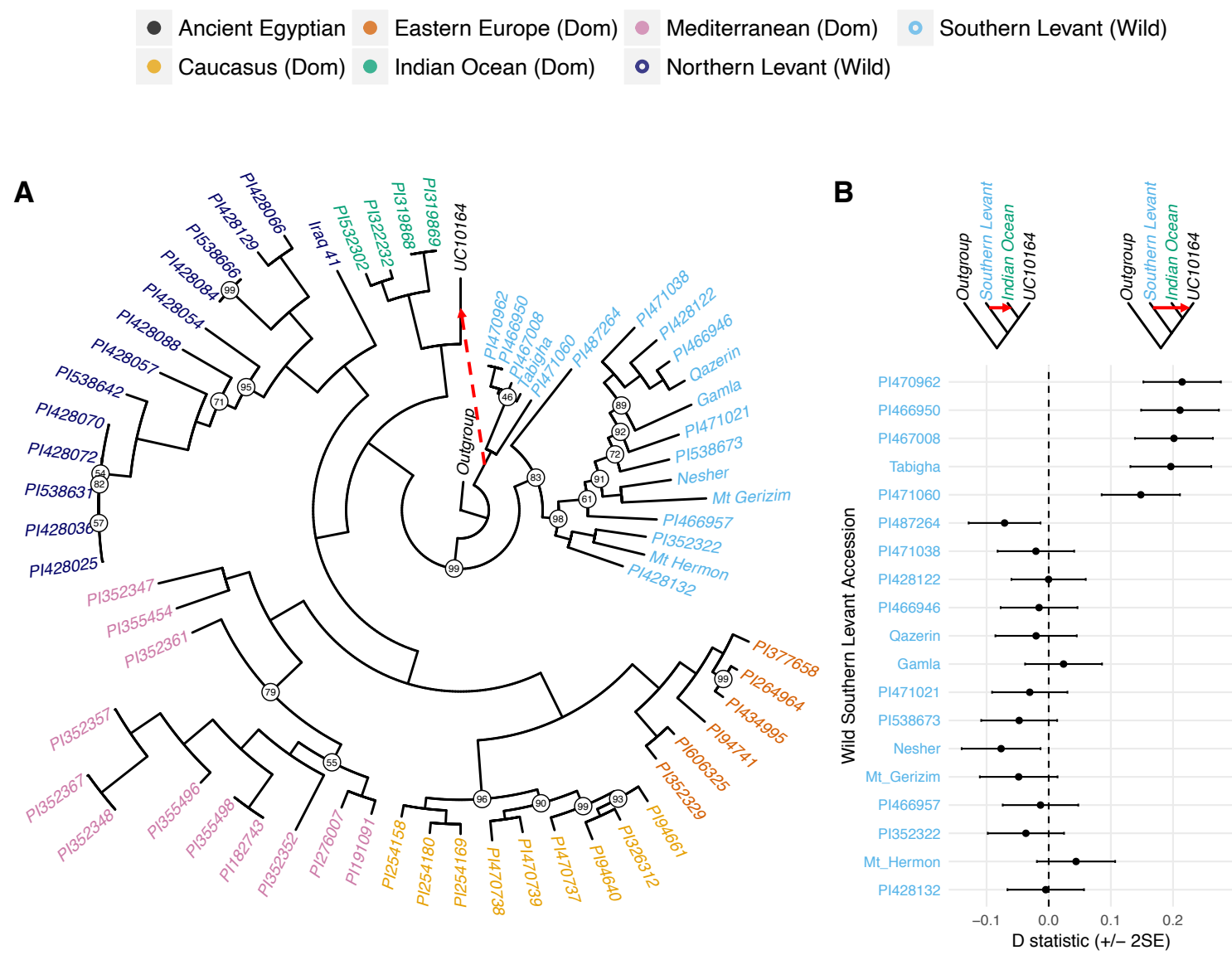
Egyptian emmer wheat was relatively unrelated to emmer wheat dispersal events around the Mediterranean and Transcaucasia.



# Four-population test

Excess of derived alleles shared between UC10164 and some wild emmers from the **Southern Levant**, indicating genetic exchange during dispersal or subsequent contact

Highlights geographically diverse and ongoing genetic contributions from wild to domesticated populations



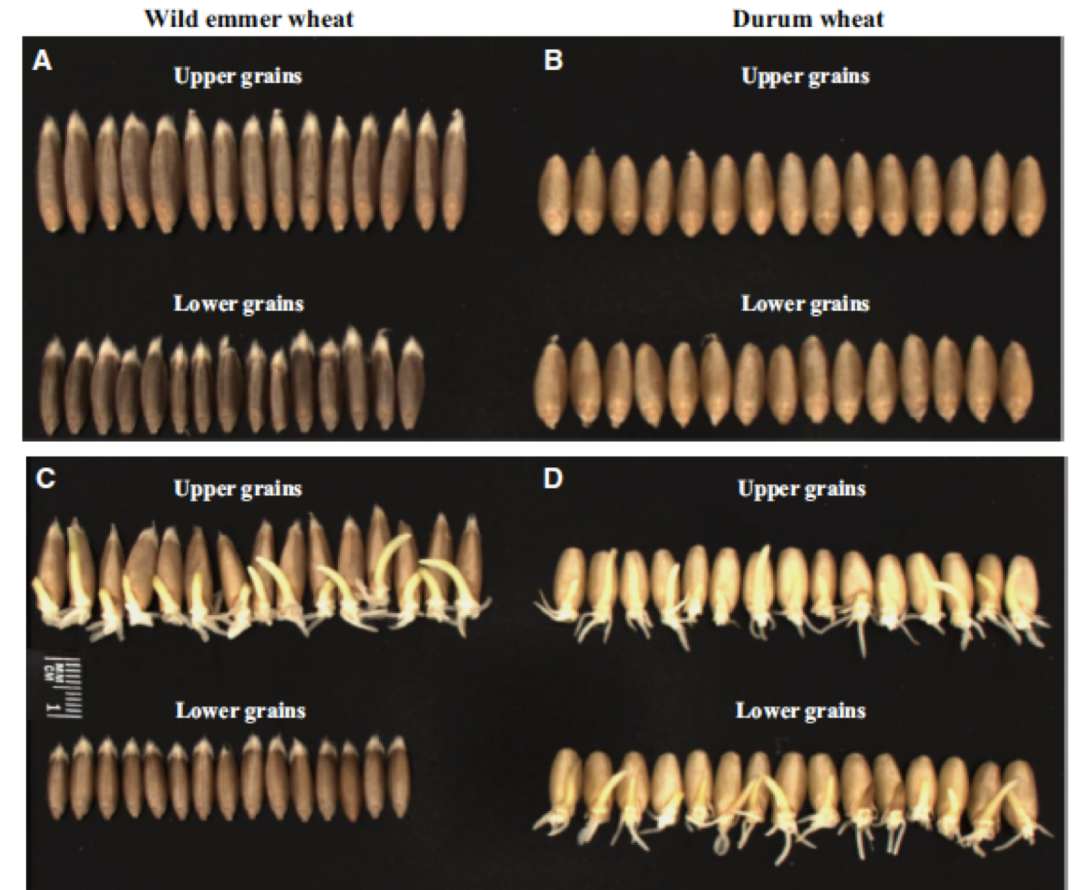
# Emmer Domestication

Quintessential domestication trait is **non-shattering**

Wild emmer wheat spikes shatter while domesticated emmer wheats retain their seeds and are therefore dependent upon humans for dispersal

In domesticated emmer wheats, both seeds in each spikelet are **large** and both **germinate readily**

We looked in regions identified to be associated with these traits



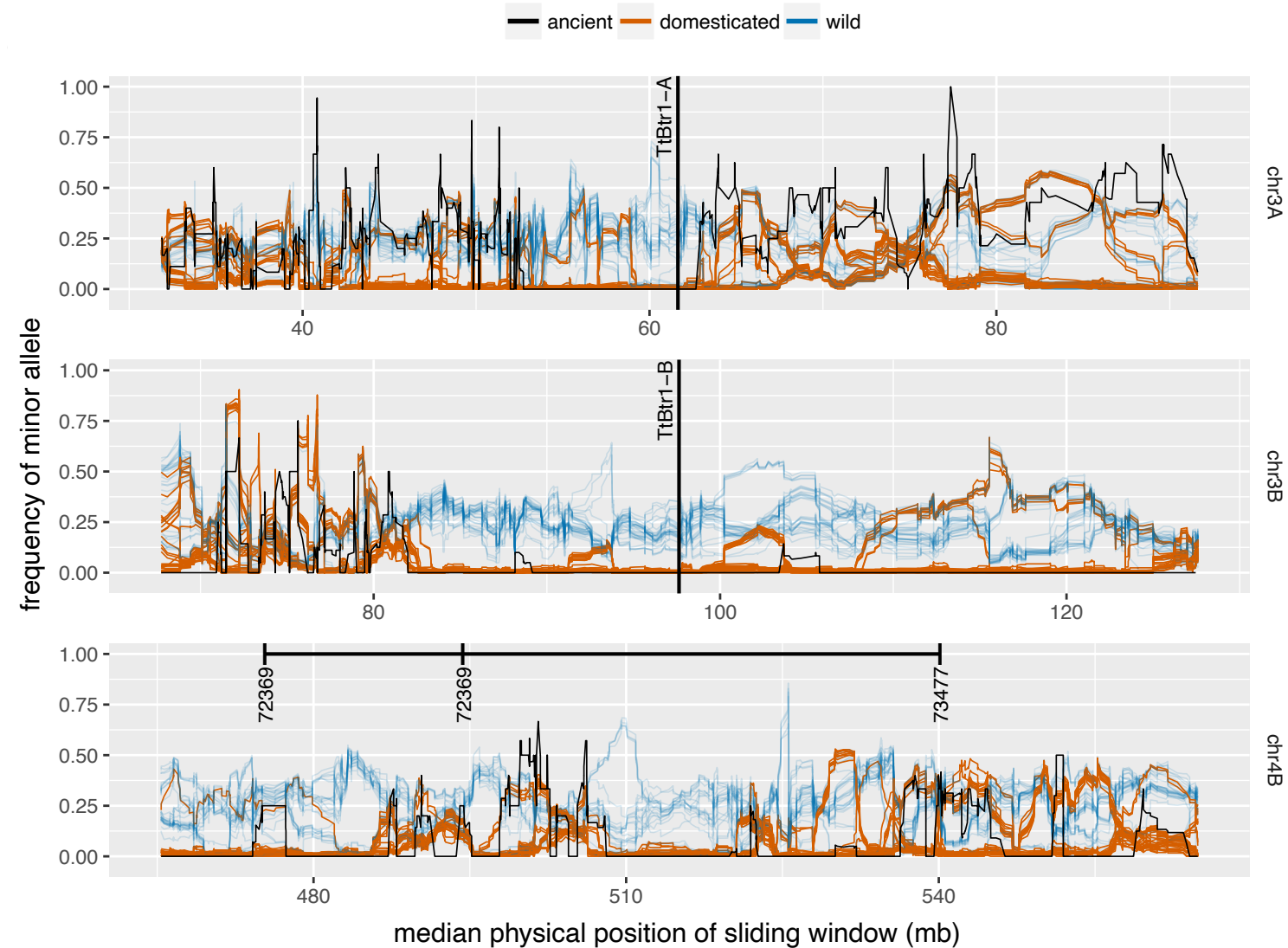
Avni et al. (2017)  
Abbo et al. (2014)

# Emmer Domestication

Region of depressed diversity among domesticated accessions

From estimated selfing rates, recombination rates, and region sizes we estimated selection coefficients in the range of 0.0007-0.0060 (seed size and germination) and 0.002-0.027 (shattering)

**UC10164 carries the domesticated haplotype**





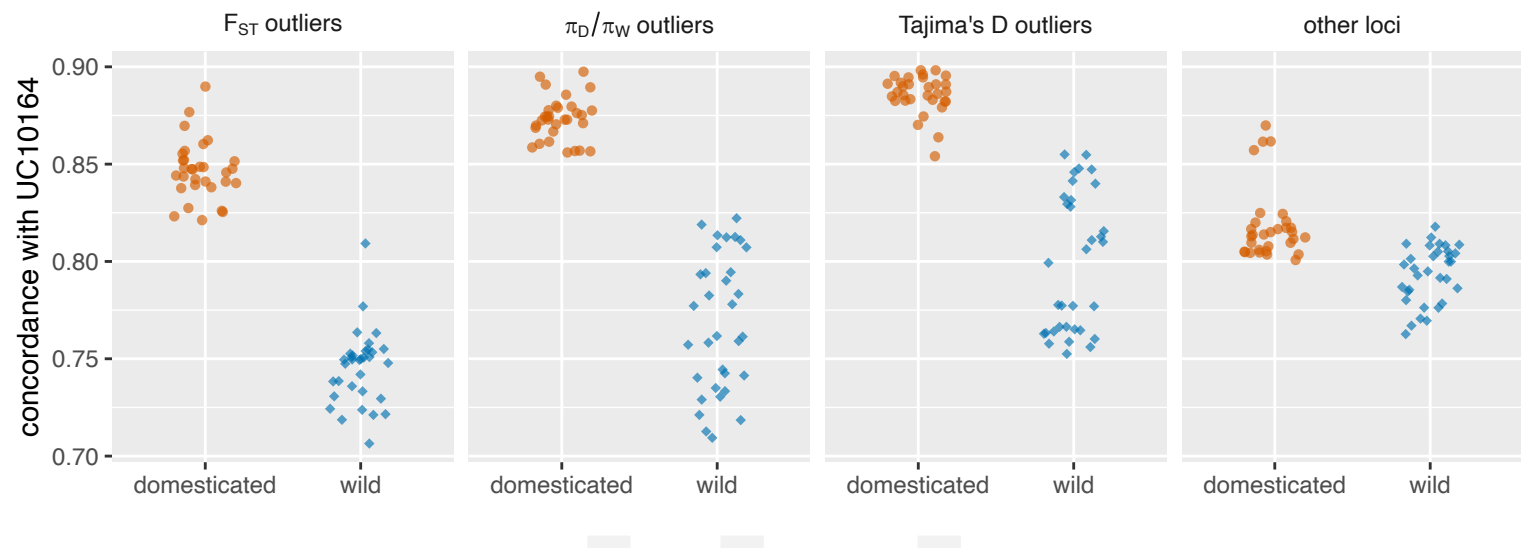
# Emmer Domestication

2mb regions that are 5% outliers in diversity scans, potentially bearing ‘signatures of selection’

Outside these regions, concordance with UC10164 follows the genome-wide pattern

Within, all domesticated accessions have high concordance with UC10164

**UC10164 shares a history of selection with modern domesticated emmers that extends beyond well-characterized QTLs**



# Conclusions

## **First whole genome sequence data from an ancient wheat**

- A museum specimen of **Emmer wheat** from Egypt

## **Dispersal**

- Dispersal to Egypt connected with early eastwards dispersal of emmer wheat
- Evidence of possible introgression from wild emmer wheats

## **Domestication**

- Shares history of selection with modern domesticated emmer wheats