

A 3,000 year-old Egyptian emmer wheat genome reveals dispersal and domestication history

Michael F Scott



Human societies need food – and that often means wheat

- Most widely grown crop, accounting for 1/5 calories today

First whole genome sequence data from an ancient wheat

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

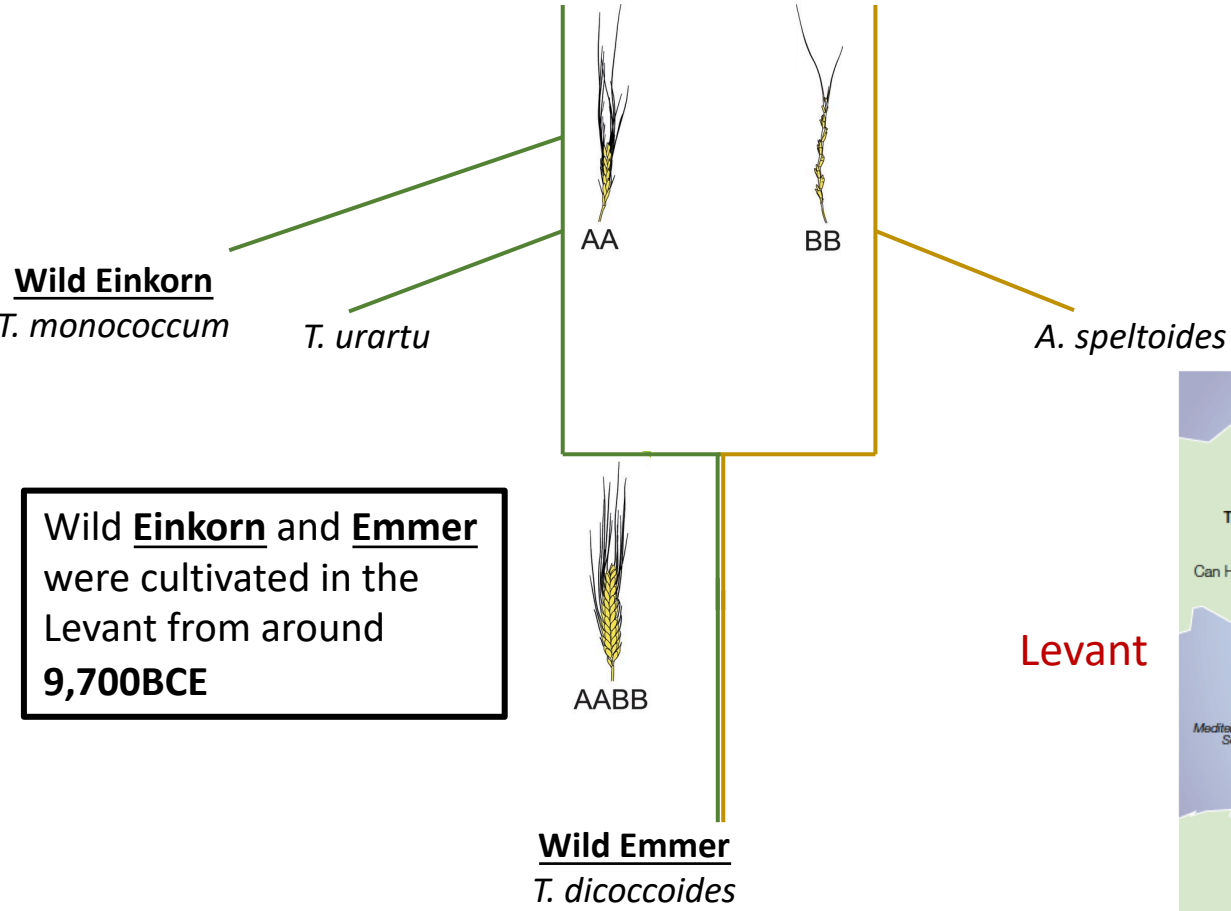
Dispersal

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

Domestication

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

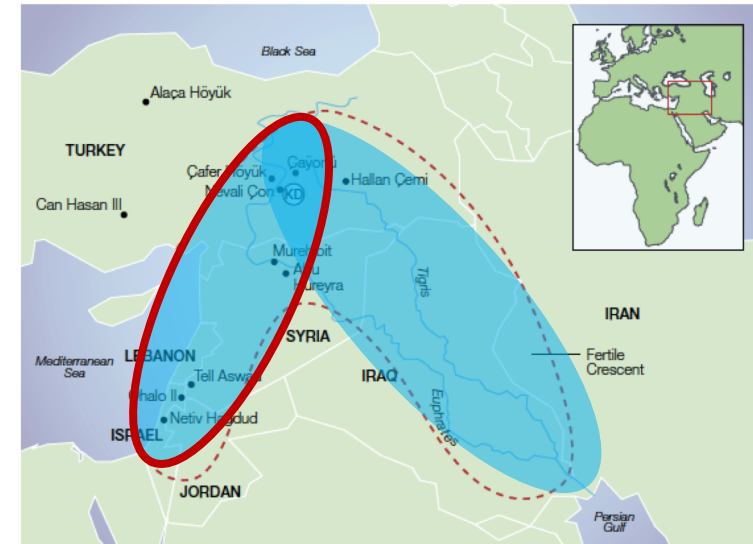
Wild Wheats



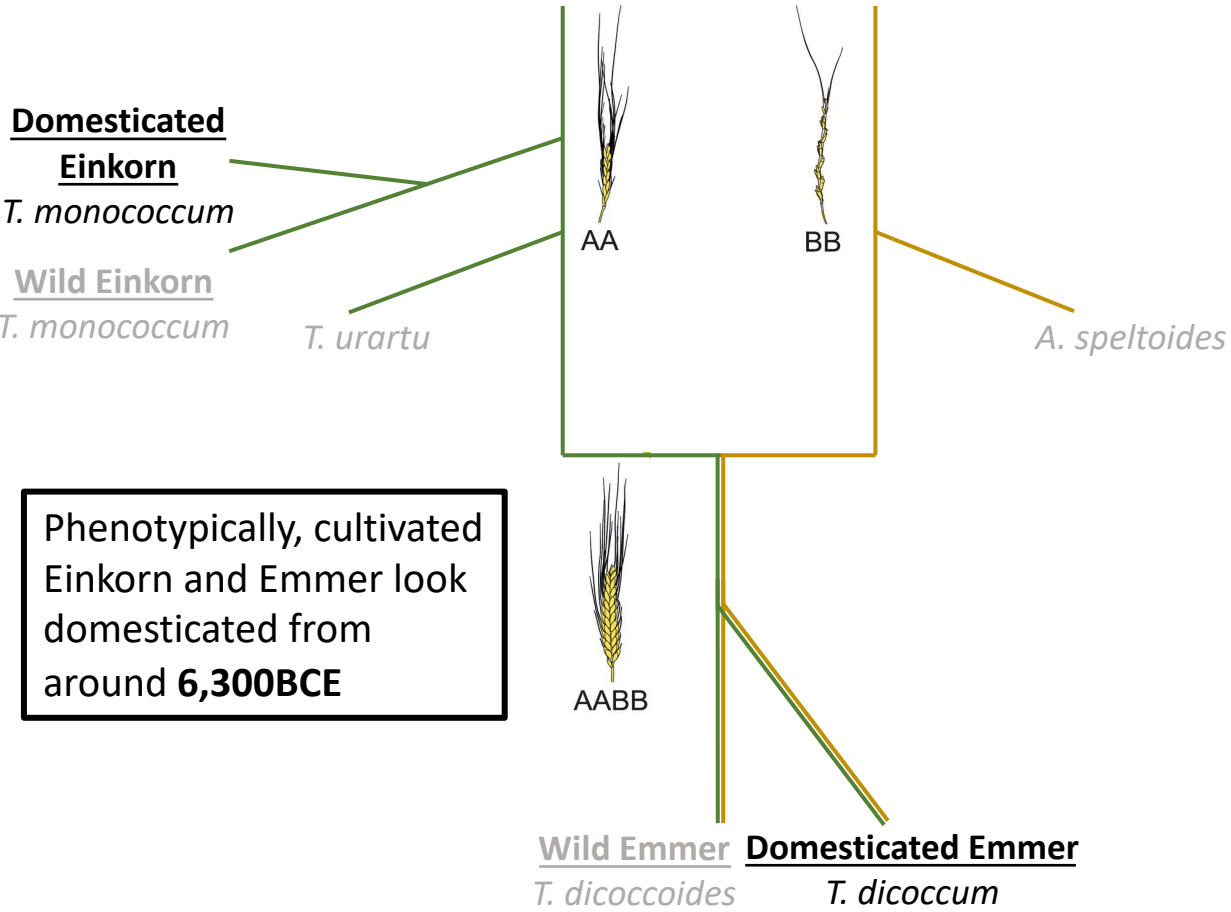
Wild **Einkorn** and **Emmer**
were cultivated in the
Levant from around
9,700BCE

Levant

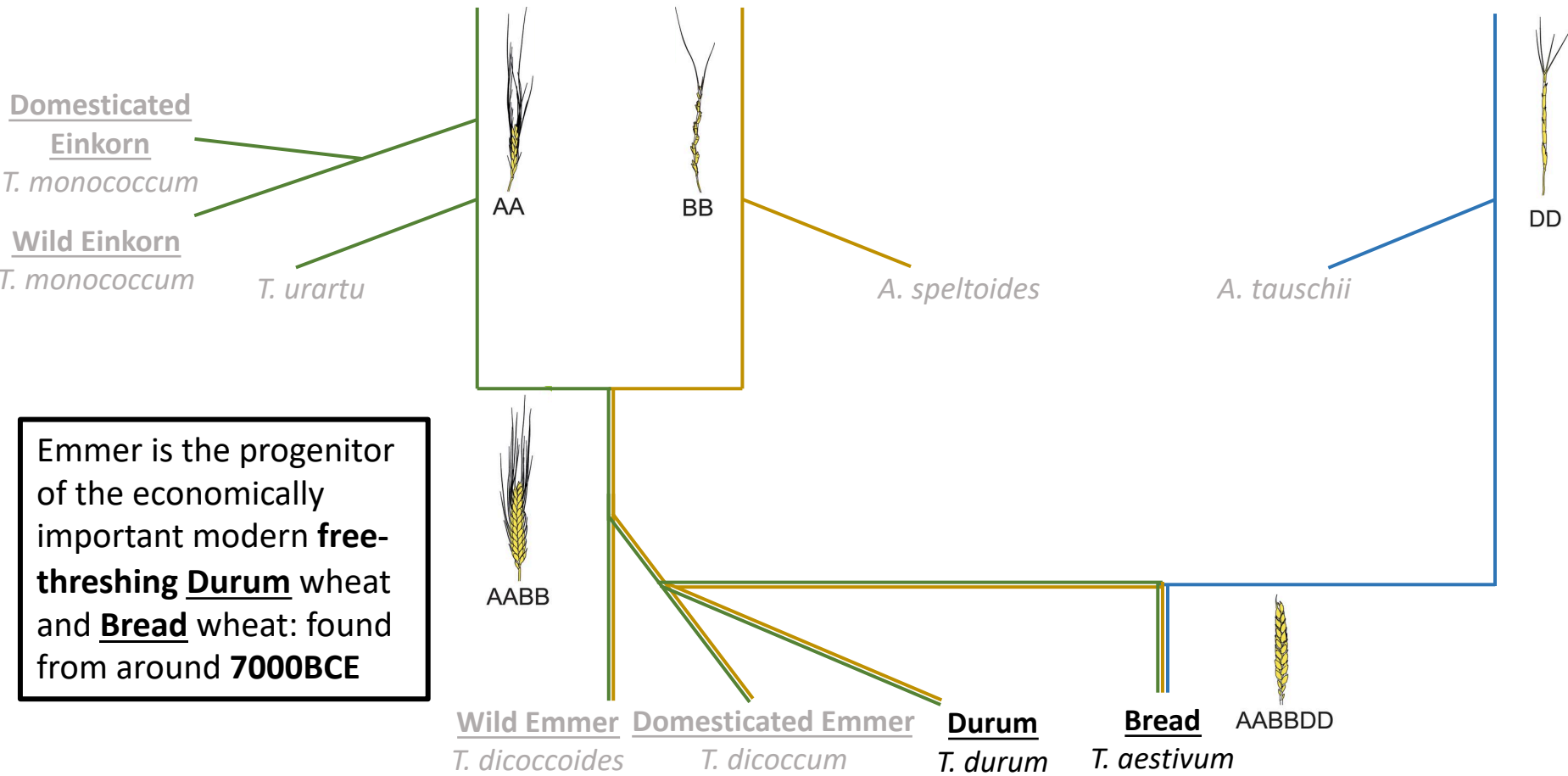
Fertile Crescent



Domesticated Wheats



Free-threshing Wheats



Free-threshing versus hulled

Free-threshing wheats appear **around 7000BCE** but not preferred until between **5000BCE** and **1000CE** in different regions



Free-threshing versus hulled

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Hulled wheats may have been preferred for:

- Hardiness
- Protection of seeds from pest during storage
- Cultural preference/taste

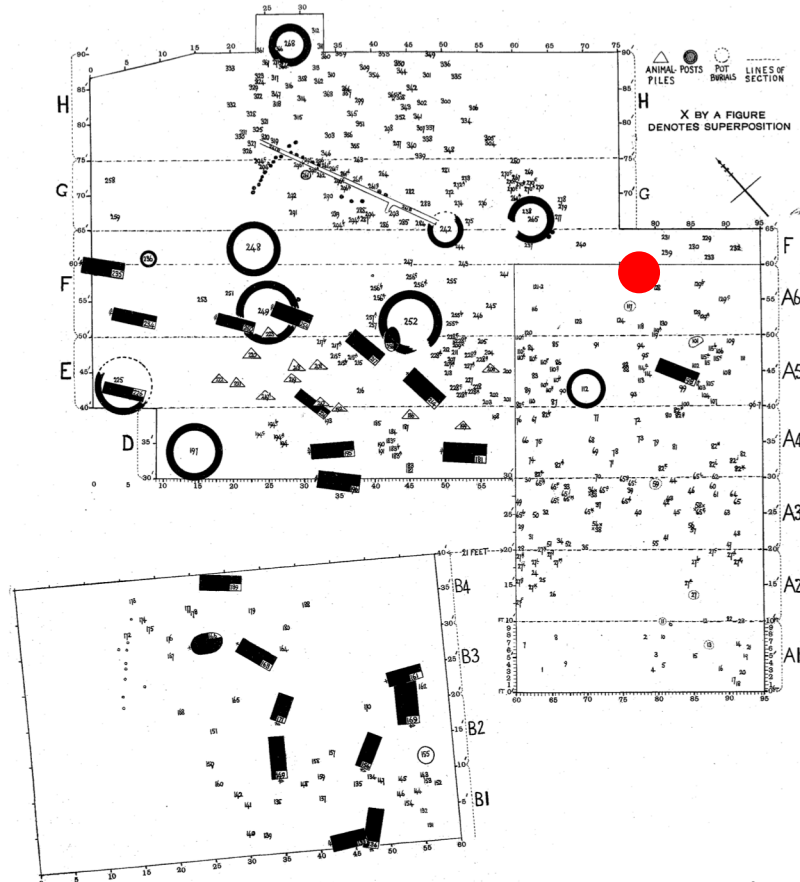


Hememiah North Spur excavation (1924)

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

Emmer Chaff (red)

- Chaff from side of a hearth
- Replicated AMS ^{14}C dating on two specimens to New Kingdom **1130-1000Cal. BCE**



Brunton & Caton-Thompson (1928)

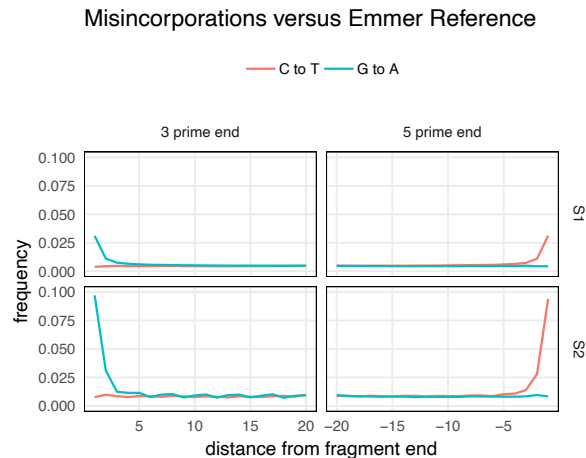
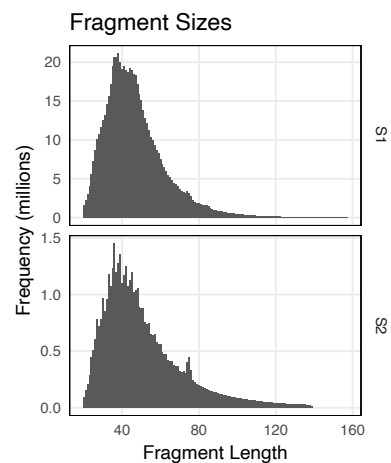


2 mm

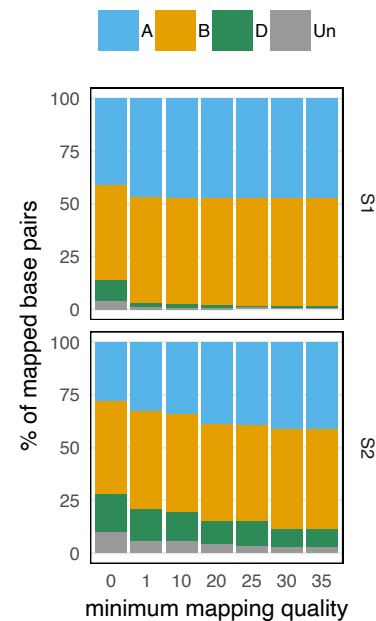


S2 not immersed in bleach

Endogenous content estimates: 66% (of 861m reads) and 33% (of 59.3m reads)



Alignment to Hexaploid Bread

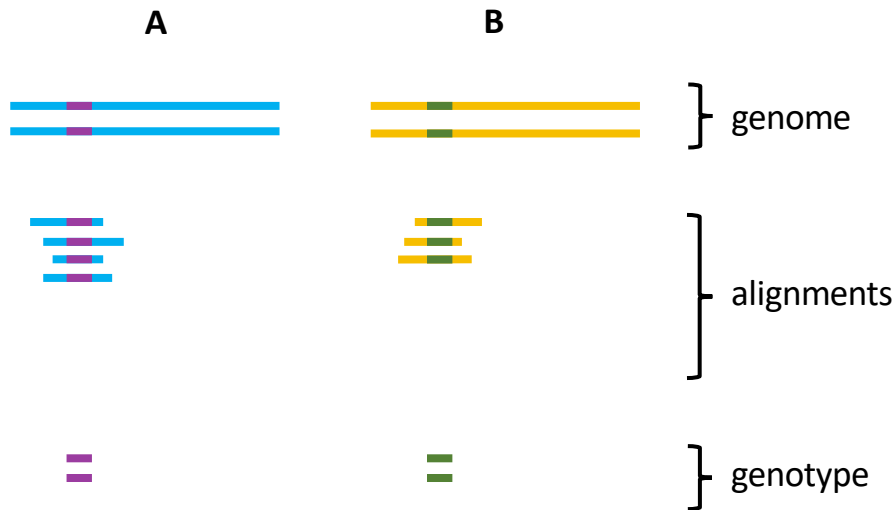


Genotypes called at **1.4m exonic SNP sites** identified
in modern emmer wheats

- Allopolyploid - no sites with multiple called heterozygotes

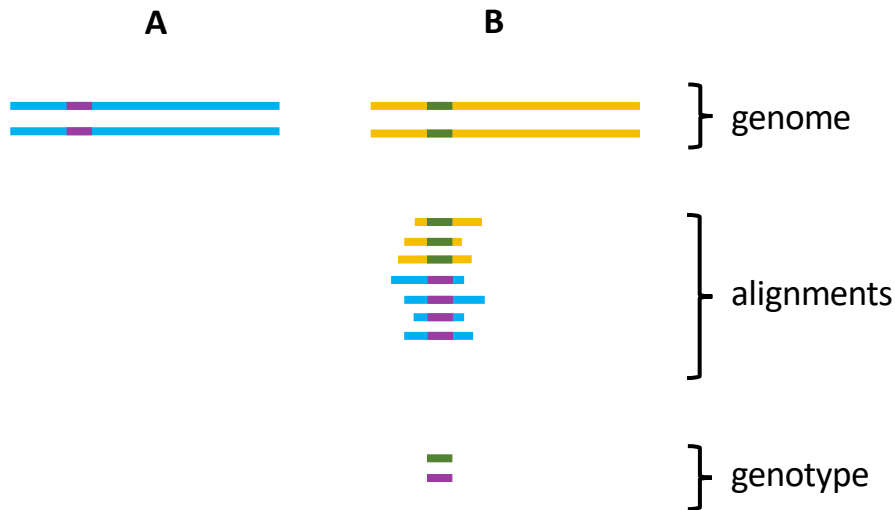
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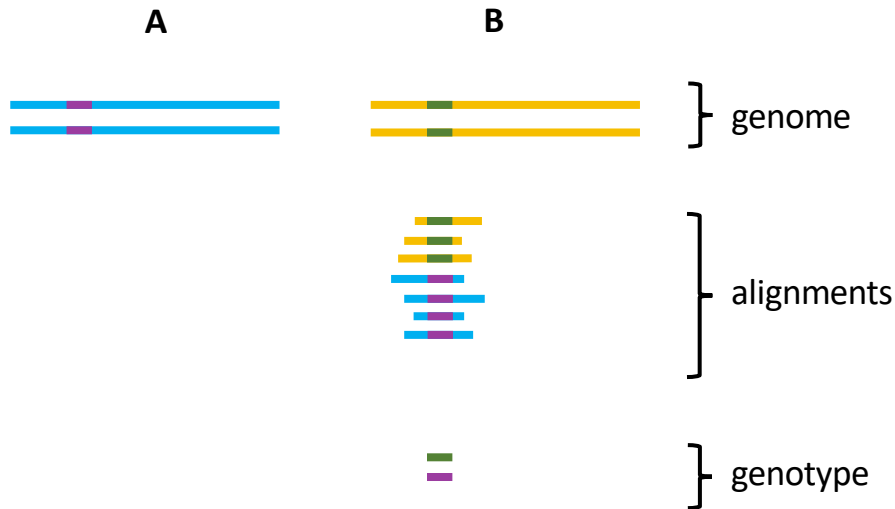
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Genotypes called at **1.4m exonic SNP sites** identified in modern emmer wheats

- Allopolyploid - no sites with multiple called heterozygotes
- ~1.2% heterozygosity based on 3,160 sites with at least 4x coverage, c.f. 0.4%-4.1% in modern samples (mean, 1.4%; s.d., 0.6%).



0.48x coverage of 1.4m exonic SNP sites

- Reference bias correction (Günther & Nettelblad, 2019)
- 93.5% concordance with S2 calls,
80.7% average concordance with modern emmers,
87.4% max.
- **99,078** sites called with at least 2x coverage

Dispersal

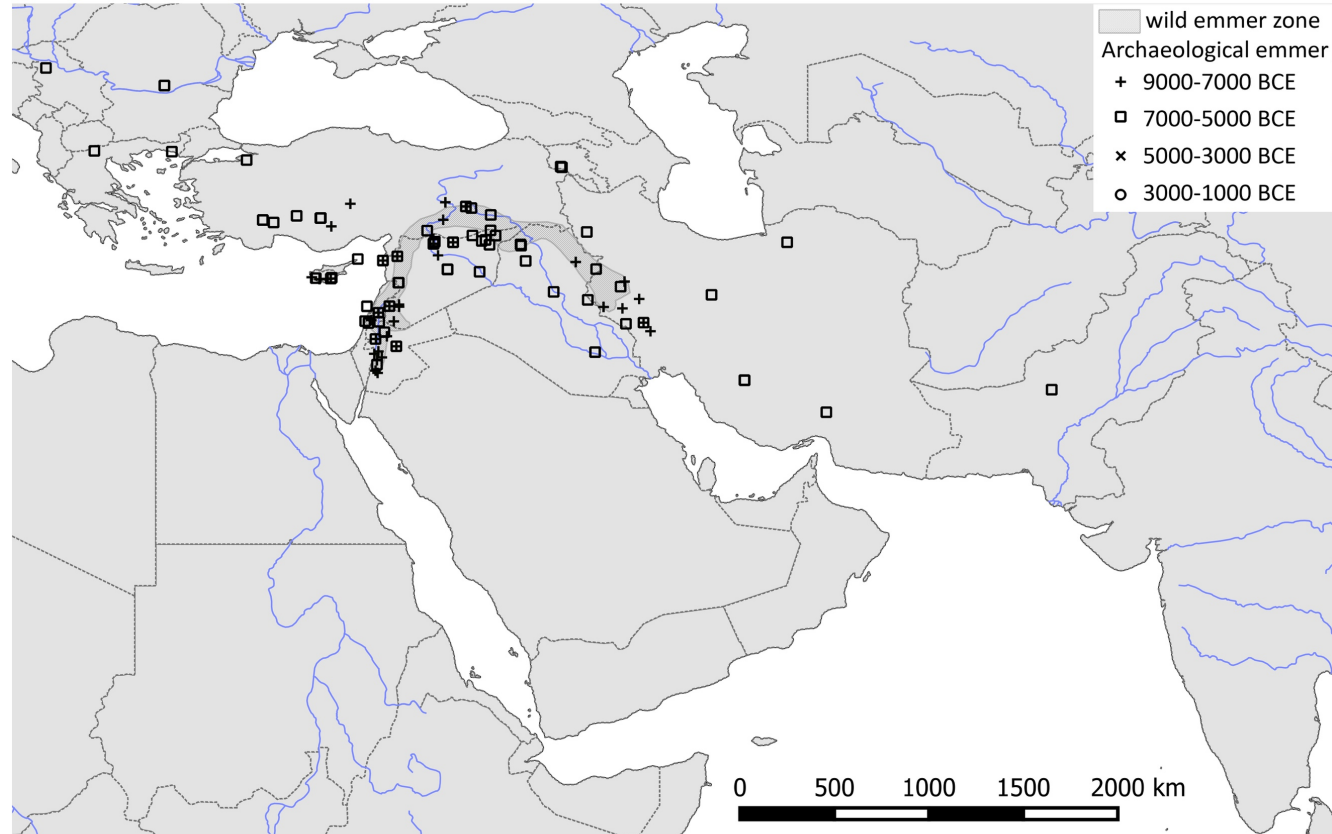
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Domestication

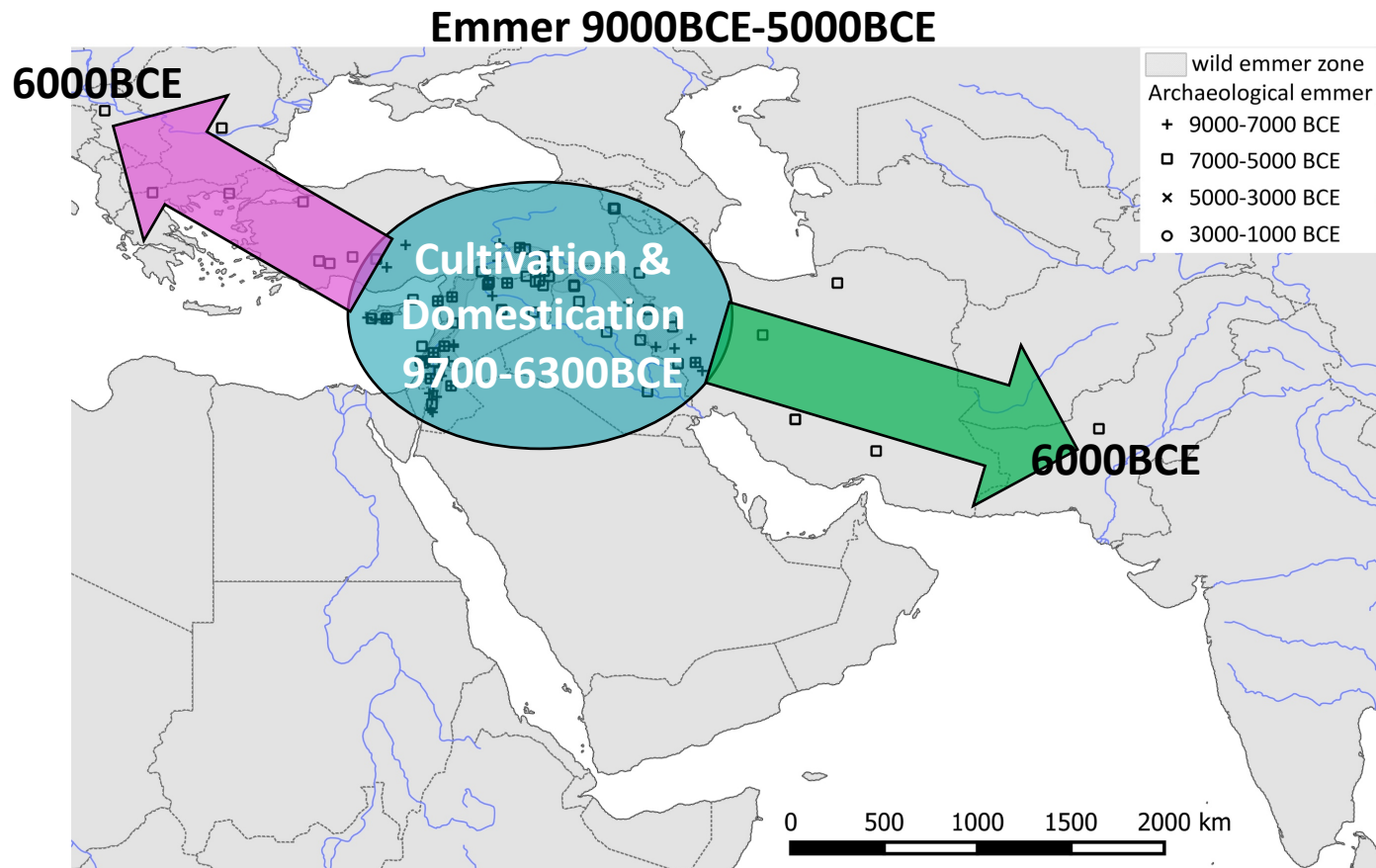
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Emmer Dispersal (Archaeobotanical data)

Emmer 9000BCE-5000BCE

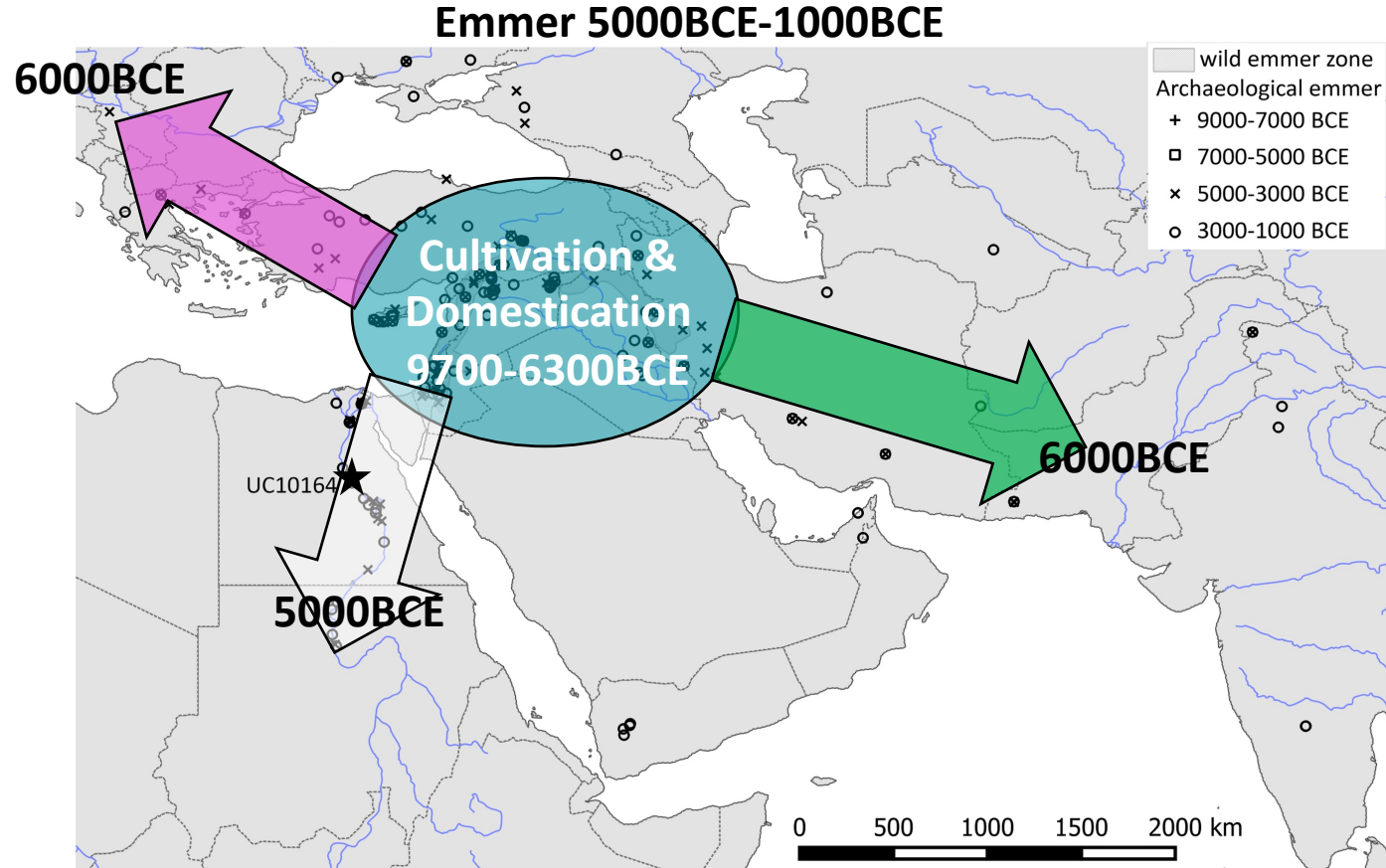


Emmer Dispersal (Archaeobotanical data)

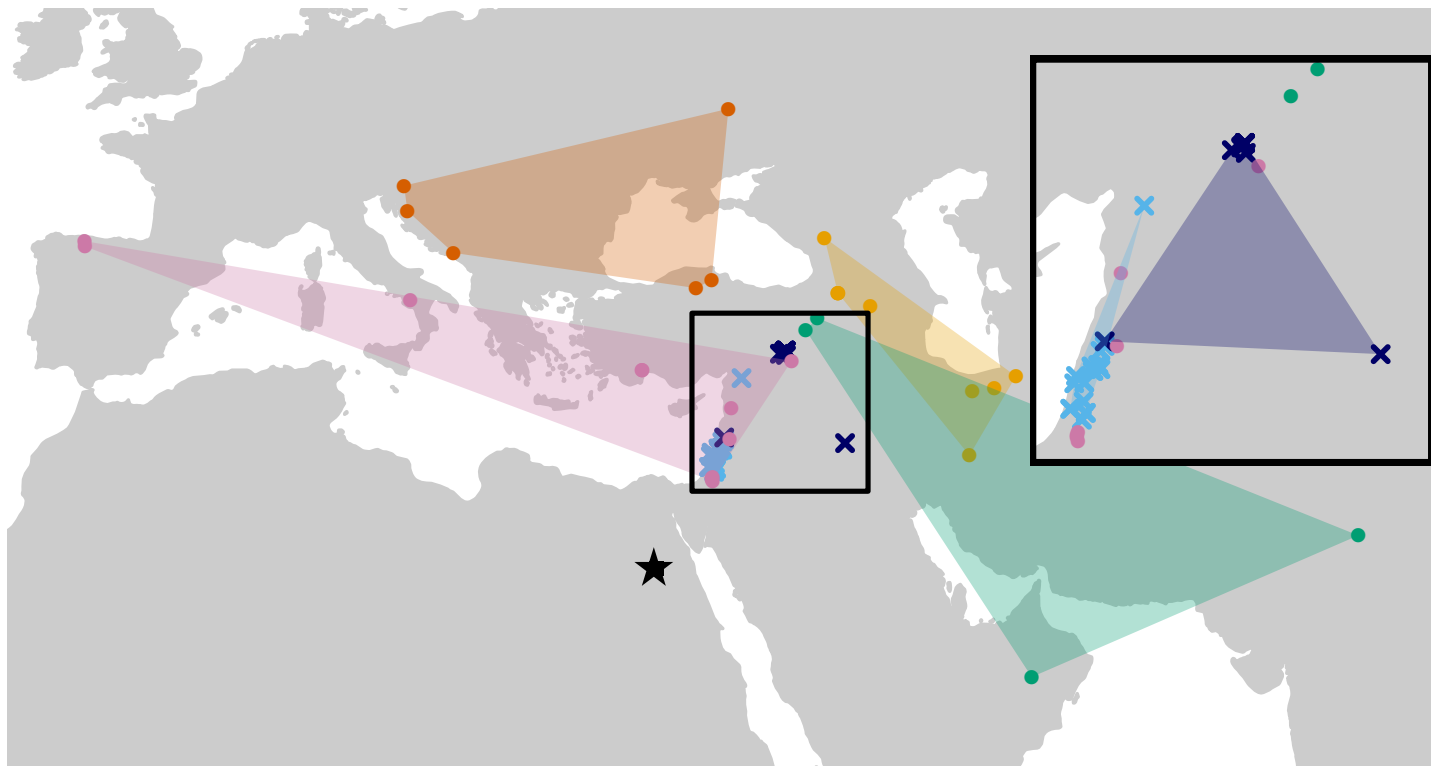


Emmer Dispersal (Archaeobotanical data)

which dispersal event is
ancient Egyptian emmer
connected with?

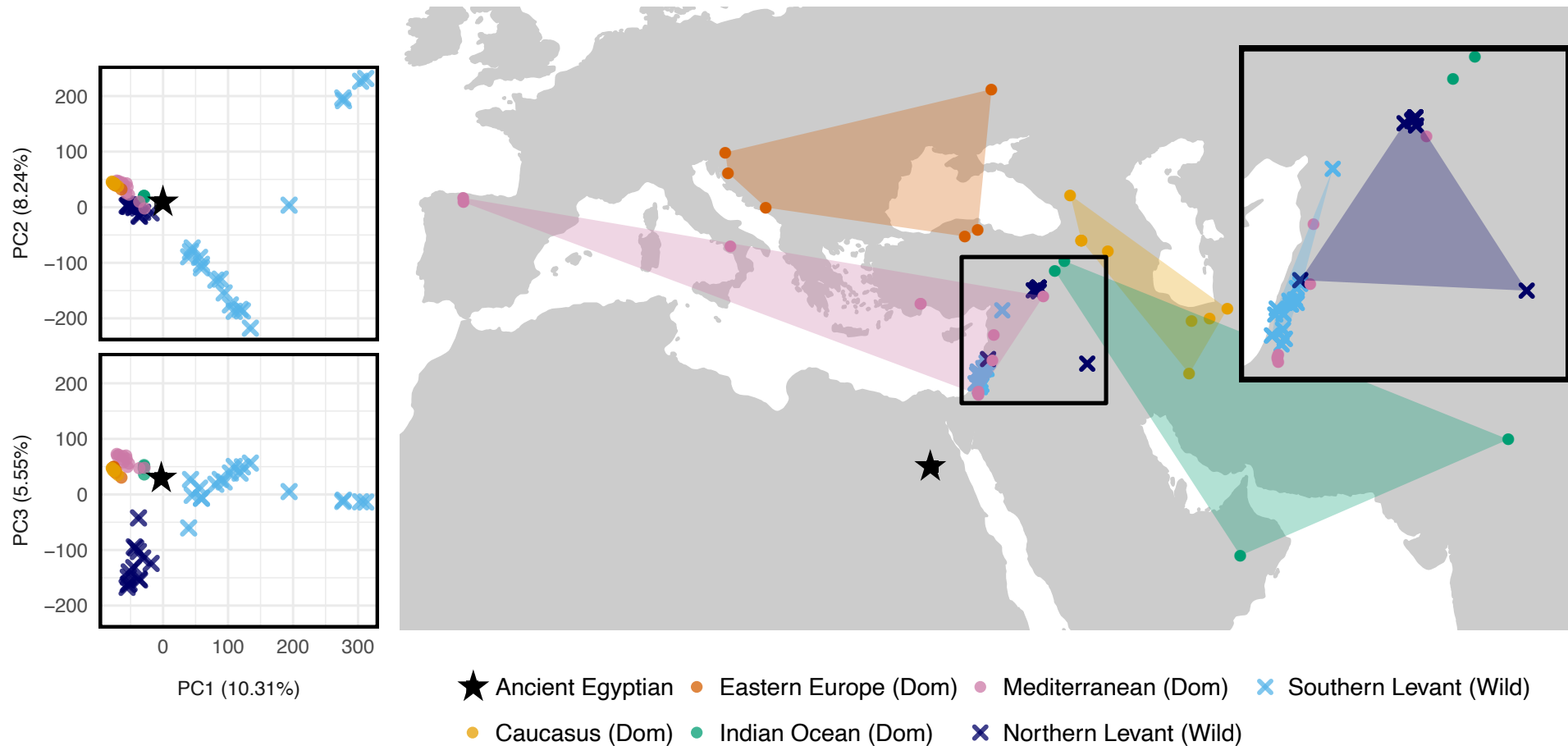


Emmer Dispersal (Genetic data)

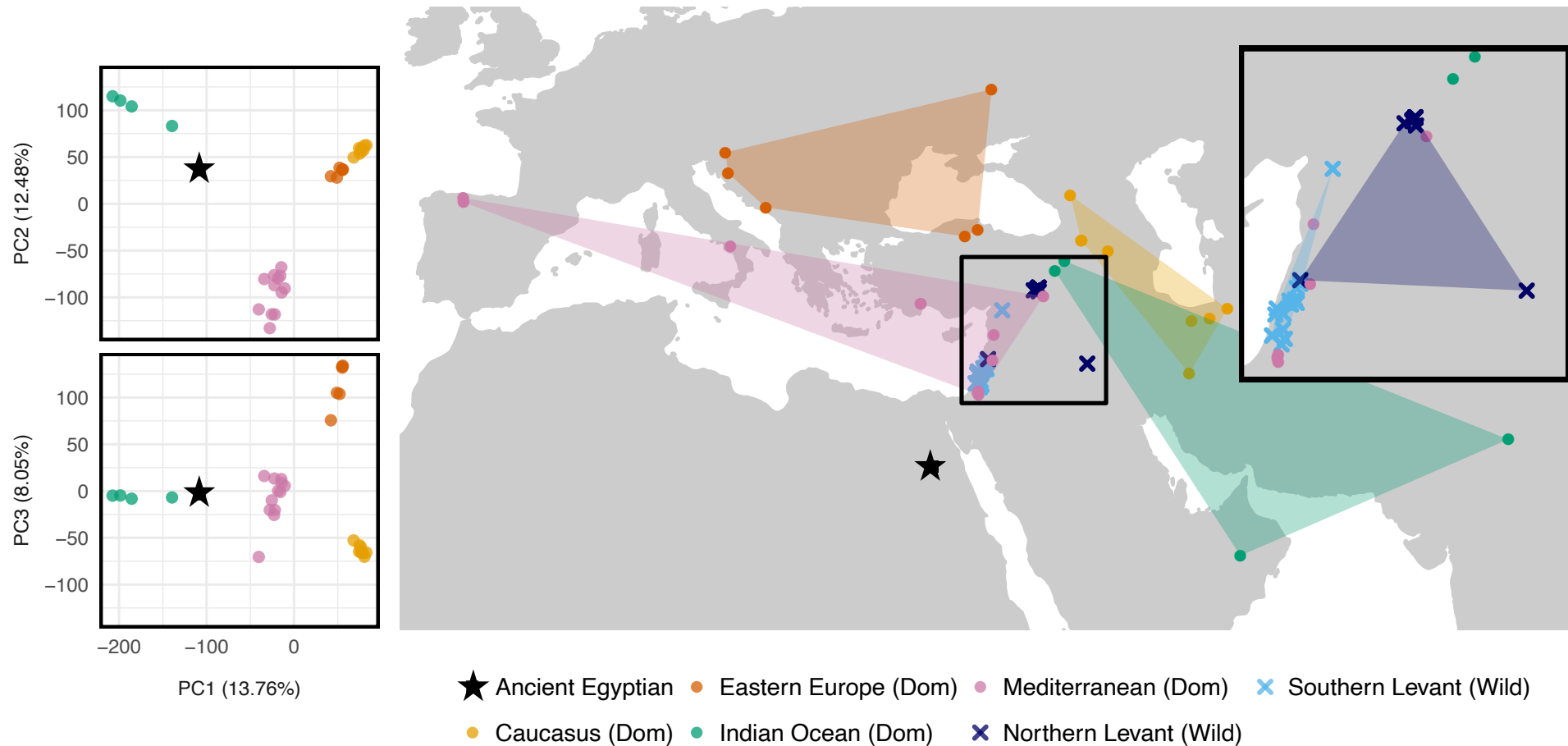


- ★ Ancient Egyptian
- Eastern Europe (Dom)
- Mediterranean (Dom)
- × Southern Levant (Wild)
- Caucasus (Dom)
- Indian Ocean (Dom)
- × Northern Levant (Wild)

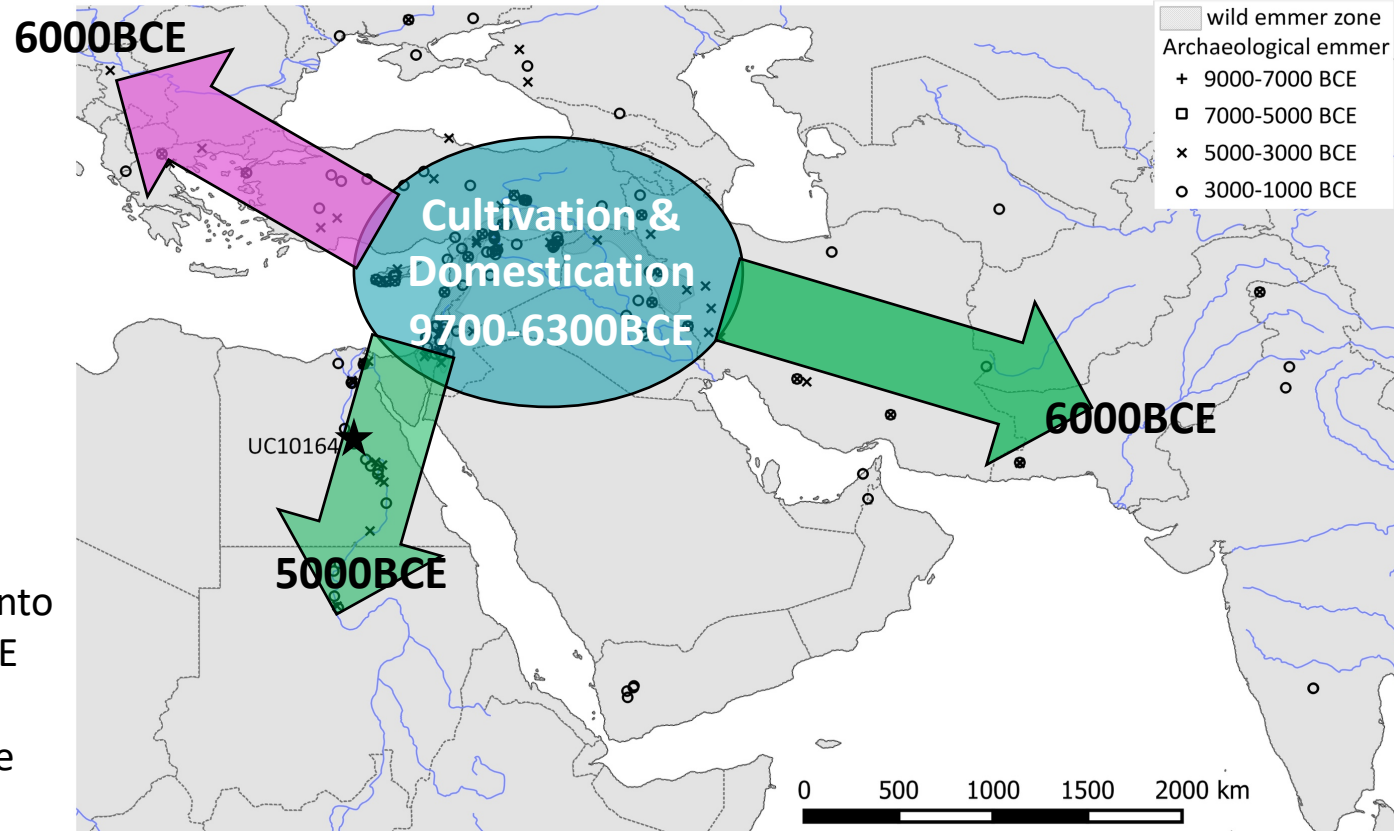
Emmer Dispersal (Genetic data)



Emmer Dispersal (Genetic data)



Emmer Dispersal Conclusions



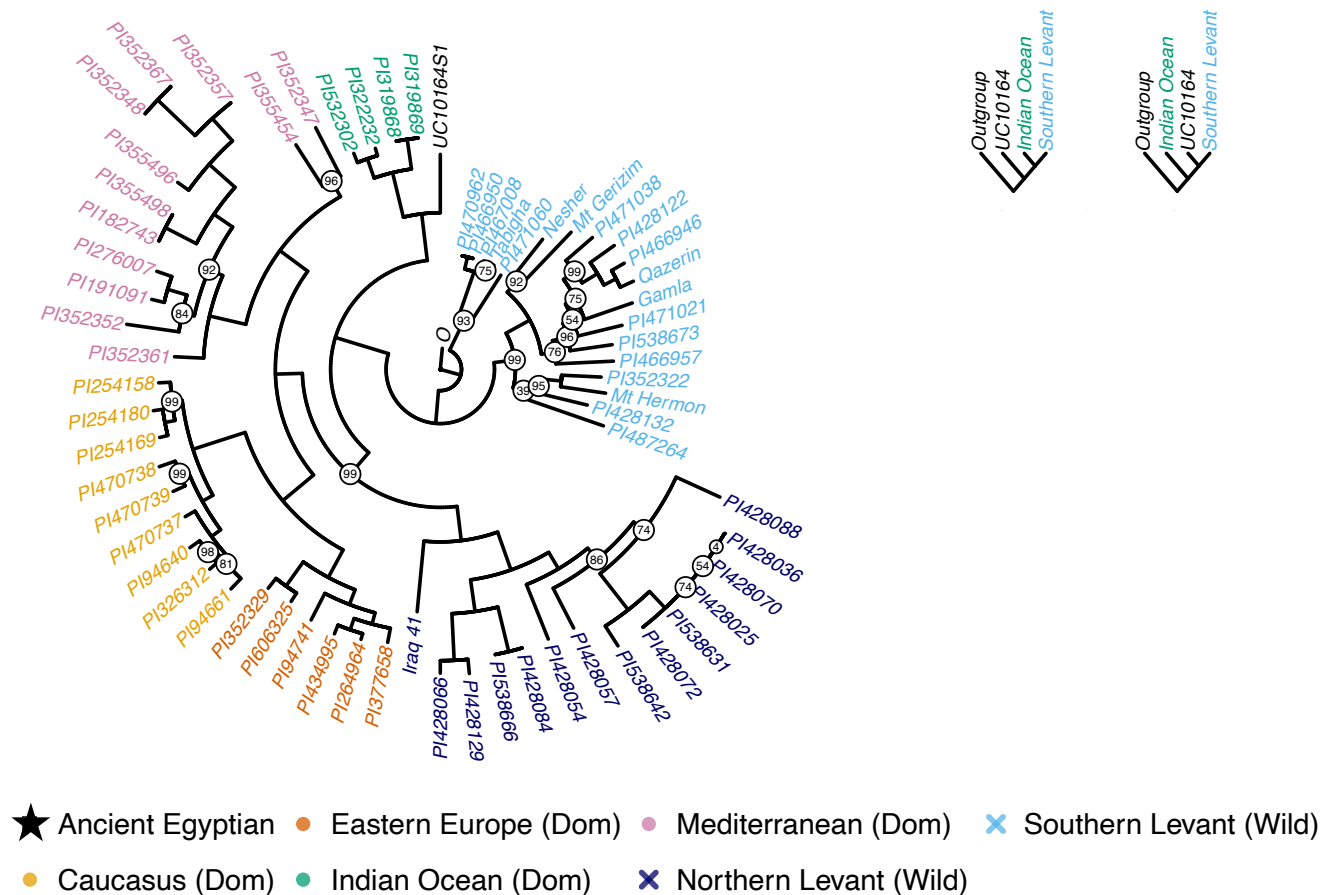
link the early eastwards dispersal of emmer wheat into the Indus valley by 6000 BCE with the arrival of emmer wheat into the Egyptian Nile Valley.

Wild-Domesticated Gene Flow

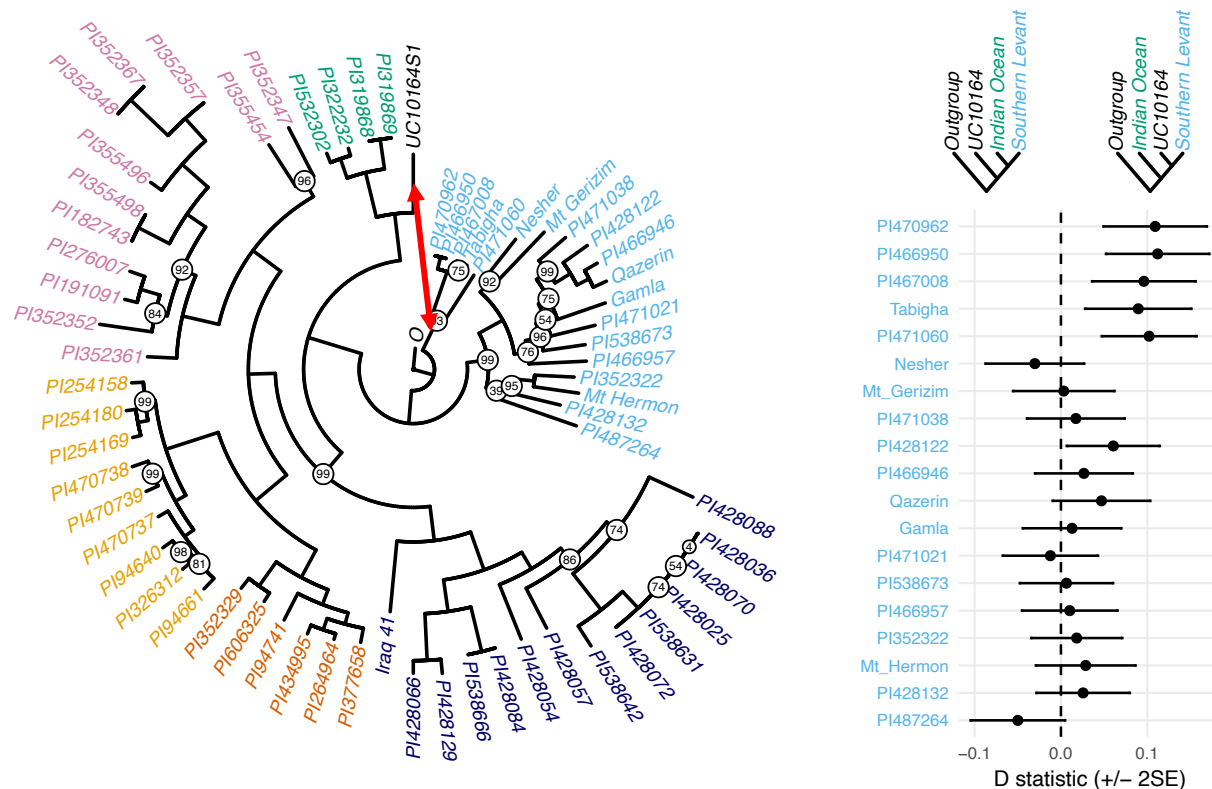
genetic exchange with wild populations?



- ★ Ancient Egyptian
- Eastern Europe (Dom)
- Mediterranean (Dom)
- × Southern Levant (Wild)
- Caucasus (Dom)
- Indian Ocean (Dom)
- × Northern Levant (Wild)



Four Population test



Gene Flow Conclusions

genetic exchange with wild Southern
Levant emmers during dispersal or
subsequent contact



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Emmer Domestication Phenotypes

Definitional domestication trait is **non-shattering**

- domesticated emmer wheats retain their seeds and are therefore dependent upon humans for dispersal



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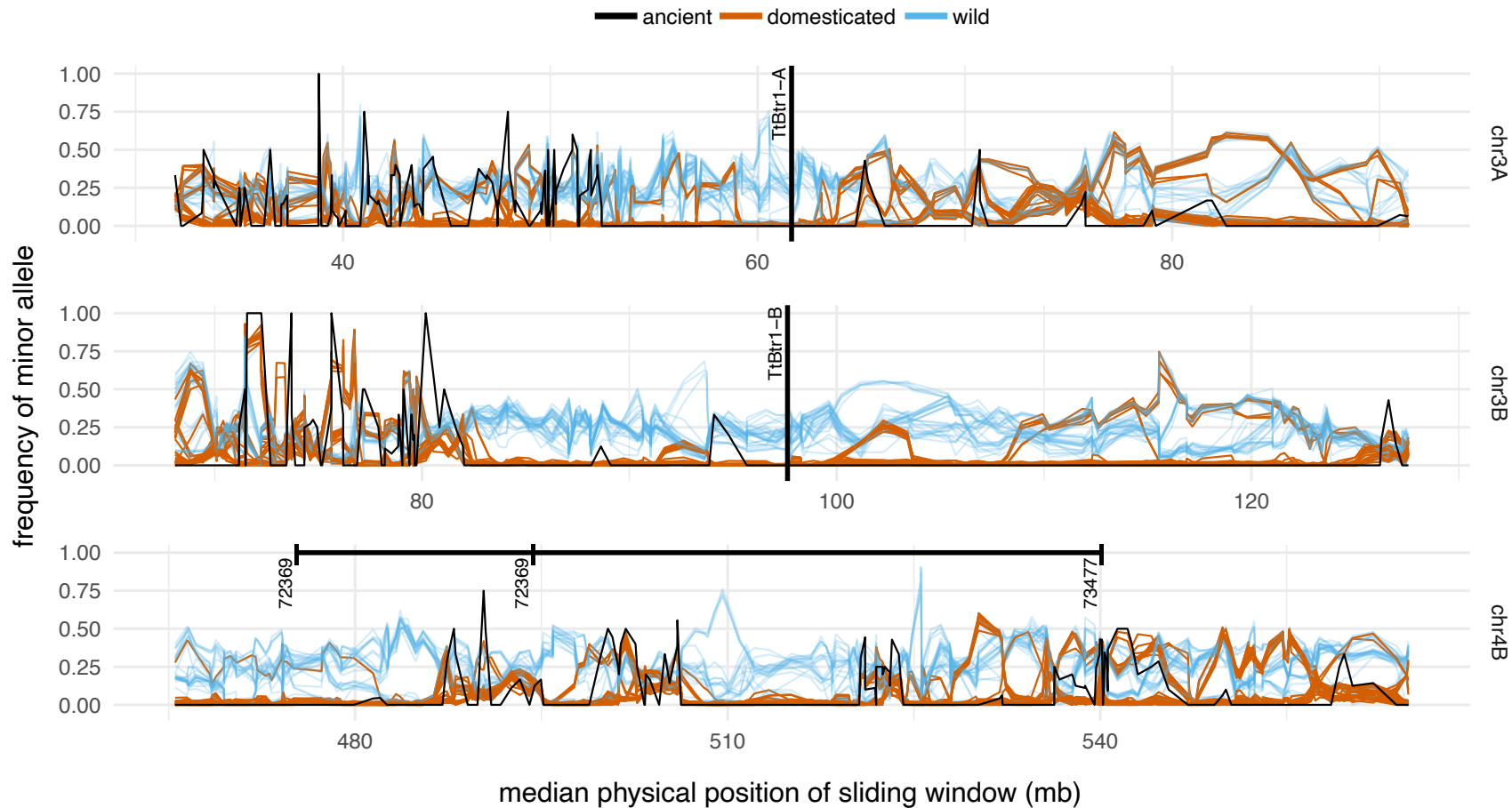
In domesticated emmer wheats, both seeds in each spikelet are:

- large
- germinate readily

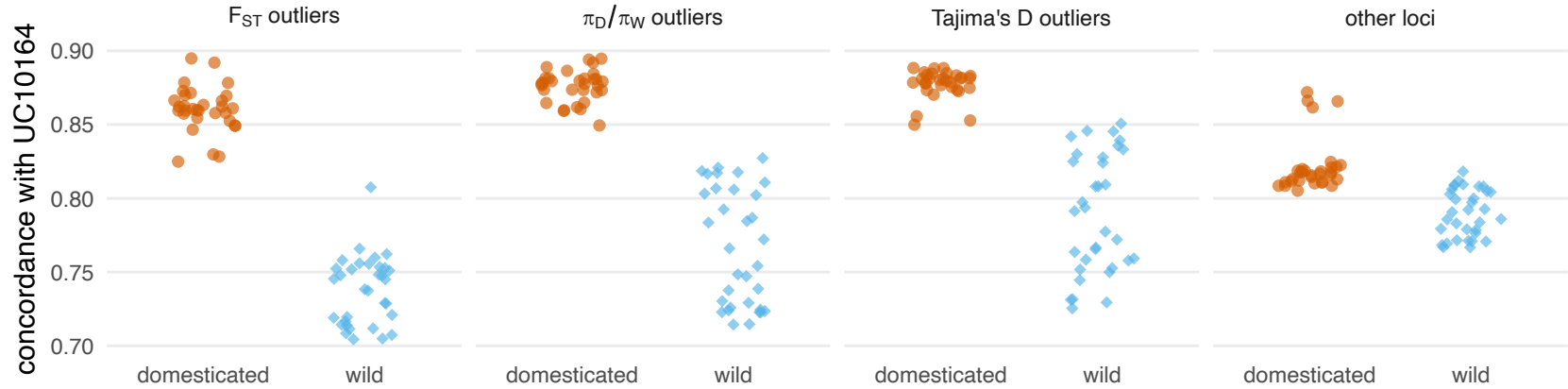


Avni et al. (2017)
Abbo et al. (2014)

Emmer Domestication QTL



Emmer Domestication Selection Scans



Ancient Egyptian emmer shares a history of selection with modern domesticated emmers that includes and extends beyond well-characterized QTLs

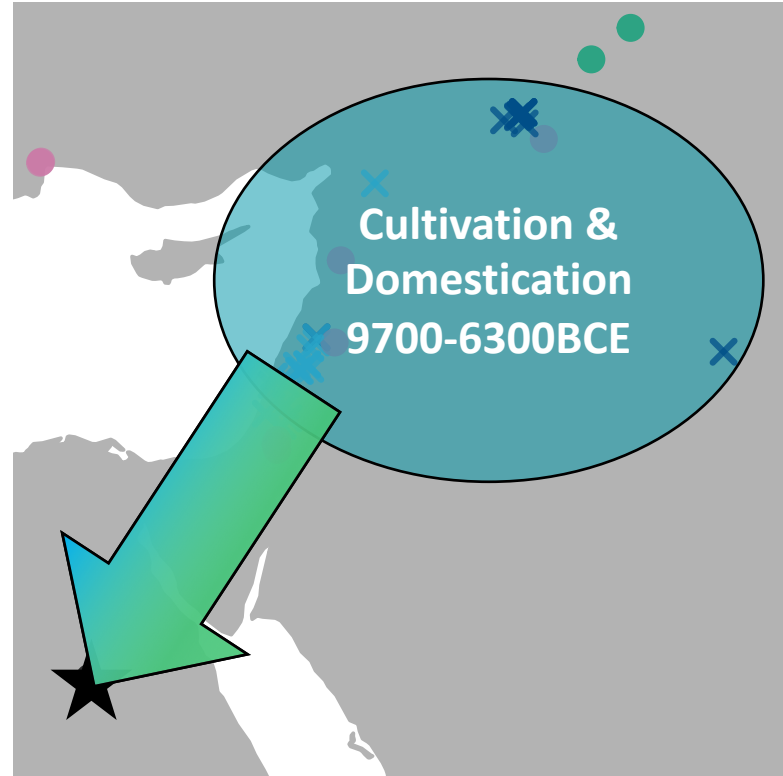
Consistent with archaeobotanical data showing non-shattering fixed in emmer by 6300BCE

Dispersal

- Dispersal to Egypt connected with early eastwards dispersal
- Evidence of gene flow with wild emmer wheats

Domestication

- Shares history of selection with modern domesticated emmer wheats



Acknowledgements



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Alice Stevenson



Mark Thomas



Dorian Fuller



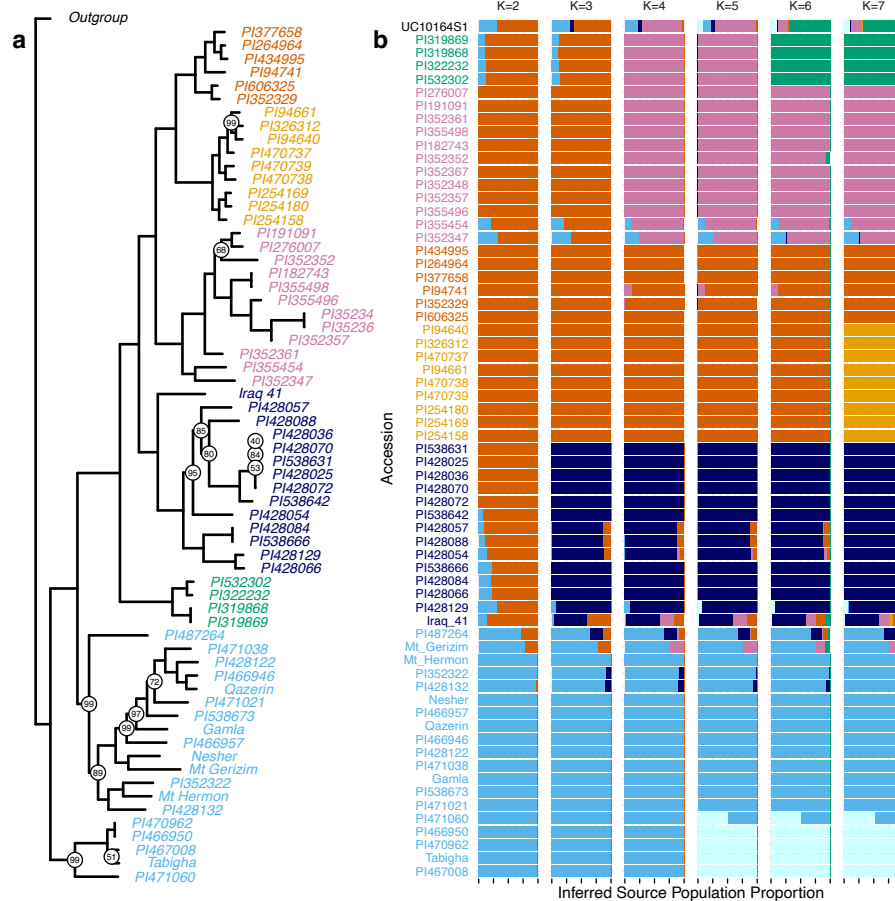
Richard Mott

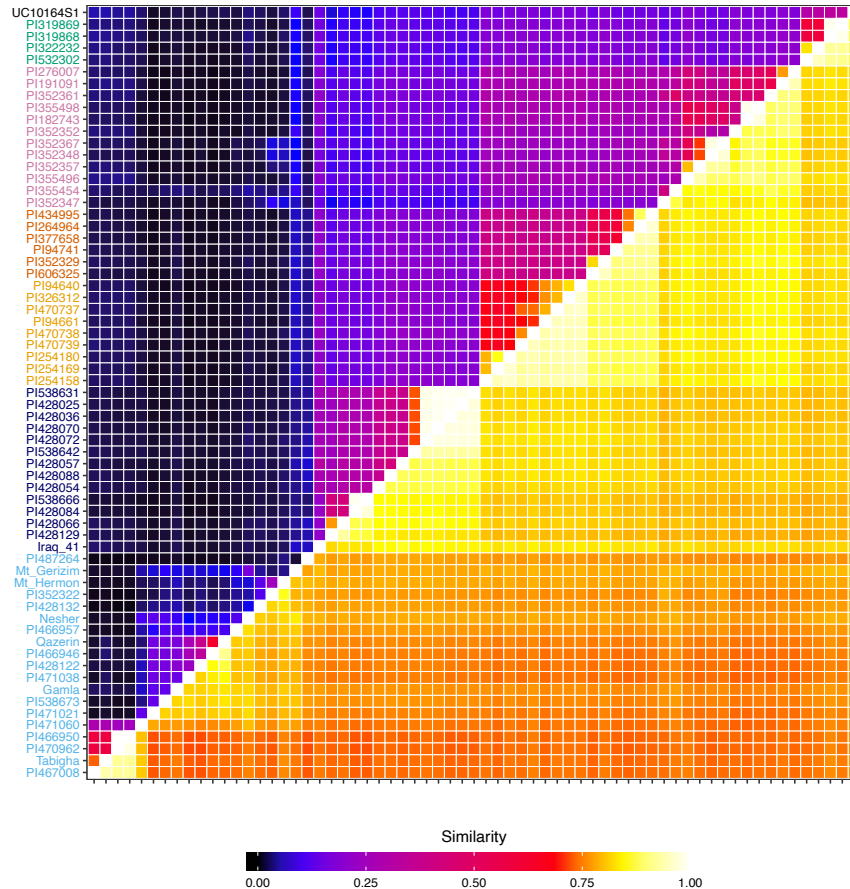
Acknowledgements



Thank you







Region

- No Good Match
- Eastern_Europe
- Mediterranean
- Southern_Levant
- Caucasus
- Indian_Ocean
- Northern_Levant

