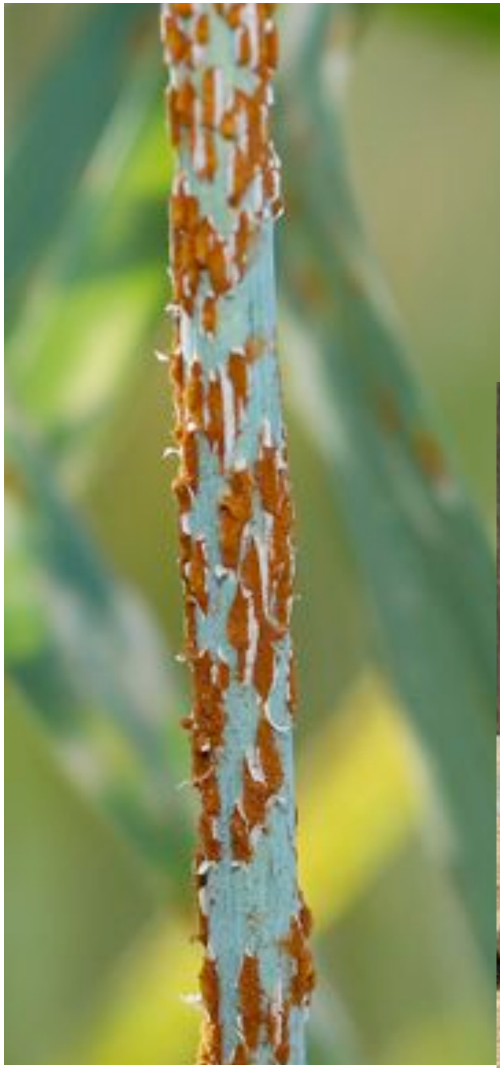
Whole Genome Sequence of *Aegilops sharonensis* Reveals Inconsitency in the *Sitopsis* Section Taxonomy

Burkhard Steuernagel

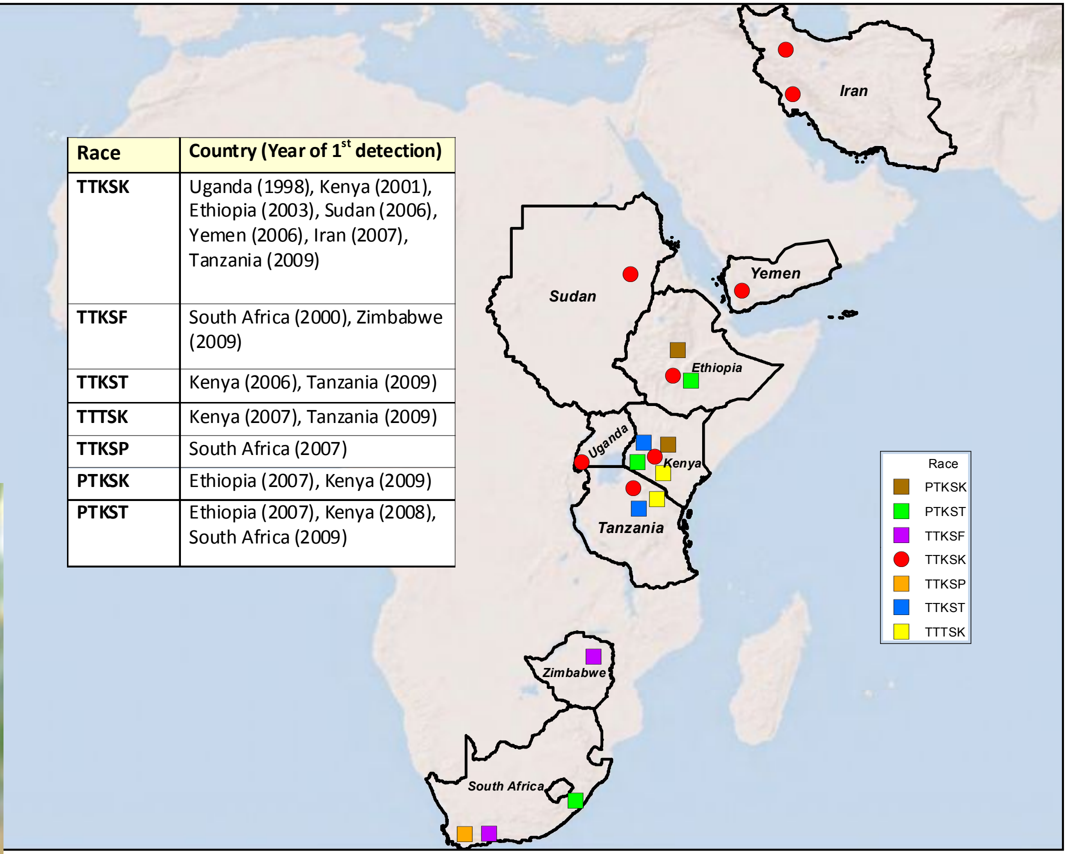
2014-01-11

What has stem rust got to do with a liger?



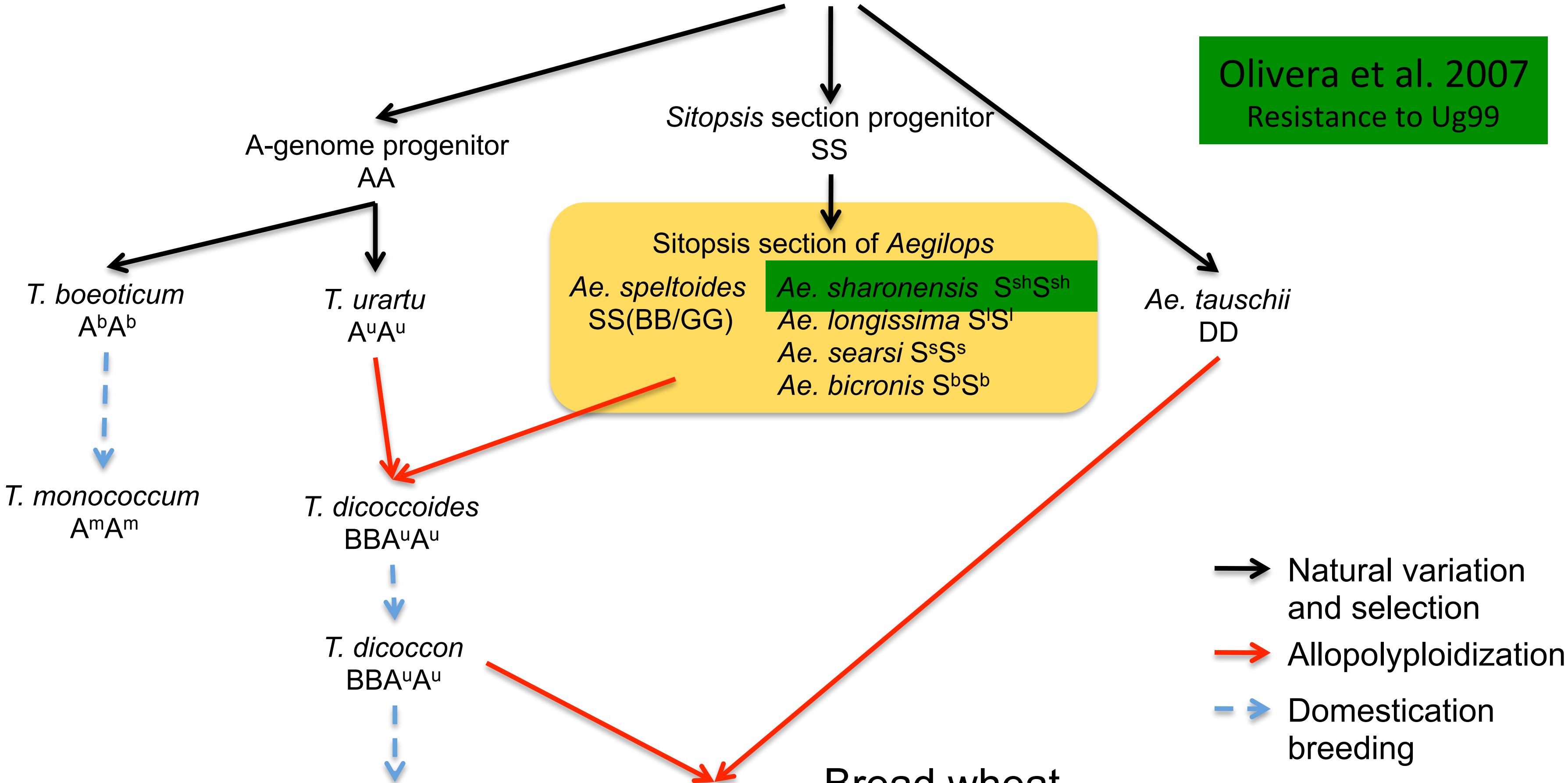
Wheat Stem Rust – A threat from Ug99

- Major *R*-genes from green revolution overcome by isolates from the Ug99 family
- Need for new major *R*-genes



Race	Country (Year of 1st detection)
TTKSK	Uganda (1998), Kenya (2001), Ethiopia (2003), Sudan (2006), Yemen (2006), Iran (2007), Tanzania (2009)
TTKSF	South Africa (2000), Zimbabwe (2009)
TTKST	Kenya (2006), Tanzania (2009)
TTTSK	Kenya (2007), Tanzania (2009)
TTKSP	South Africa (2007)
PTKSK	Ethiopia (2007), Kenya (2009)
PTKST	Ethiopia (2007), Kenya (2008), South Africa (2009)

Wheat Related Germplasm



A-genome progenitor
AA

Sitopsis section progenitor
SS

Olivera et al. 2007
Resistance to Ug99

T. boeoticum
A^bA^b

T. urartu
A^uA^u

Sitopsis section of *Aegilops*

Ae. speltoides
SS(BB/GG)

Ae. sharonensis $S^{sh}S^{sh}$
Ae. longissima S^lS^l
Ae. searsi S^sS^s
Ae. bicronis S^bS^b

Ae. tauschii
DD

T. monococcum
A^mA^m

T. dicoccoides
BBA^uA^u

T. dicoccon
BBA^uA^u

→ Natural variation and selection

→ Allopolyploidization

- - → Domestication breeding

Pasta wheat

T. durum
BBA^uA^u

T. aestivum
BBA^uA^uDD

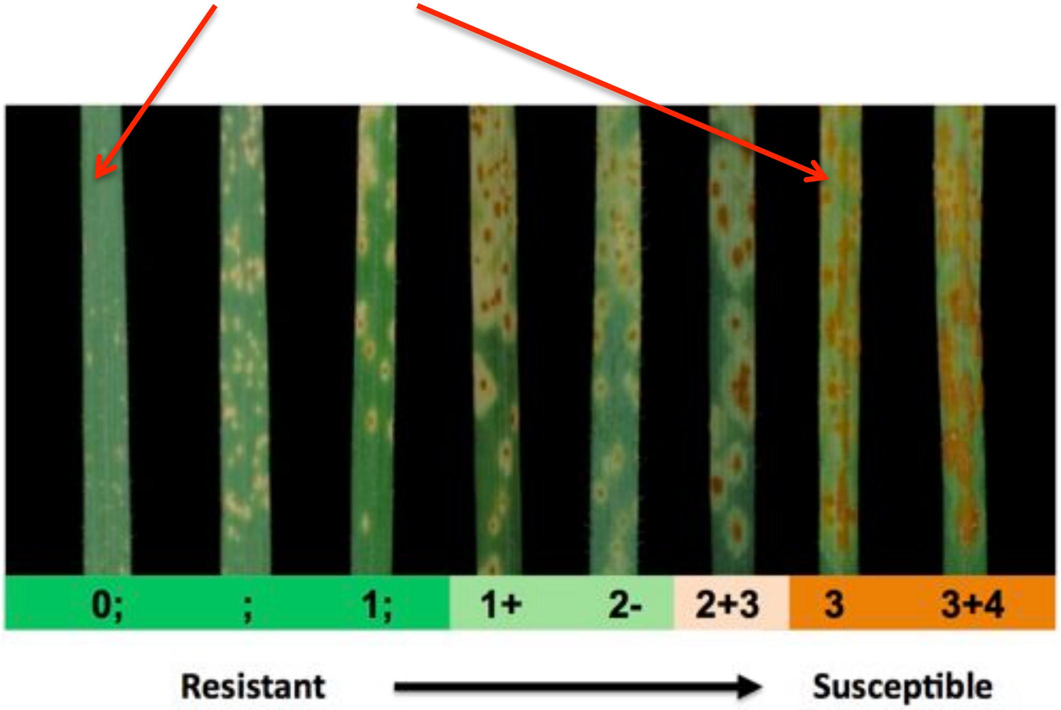
Bread wheat

Adapted by N. Champouret from:
Wang S., *et al.*, (2011) Genome 54:(4) 273-284.
Wild Crop Relatives: Genomic and Breeding Resources: Cereals; By Chittaranjan Kole.

Sequencing of *Aegilops sharonensis*

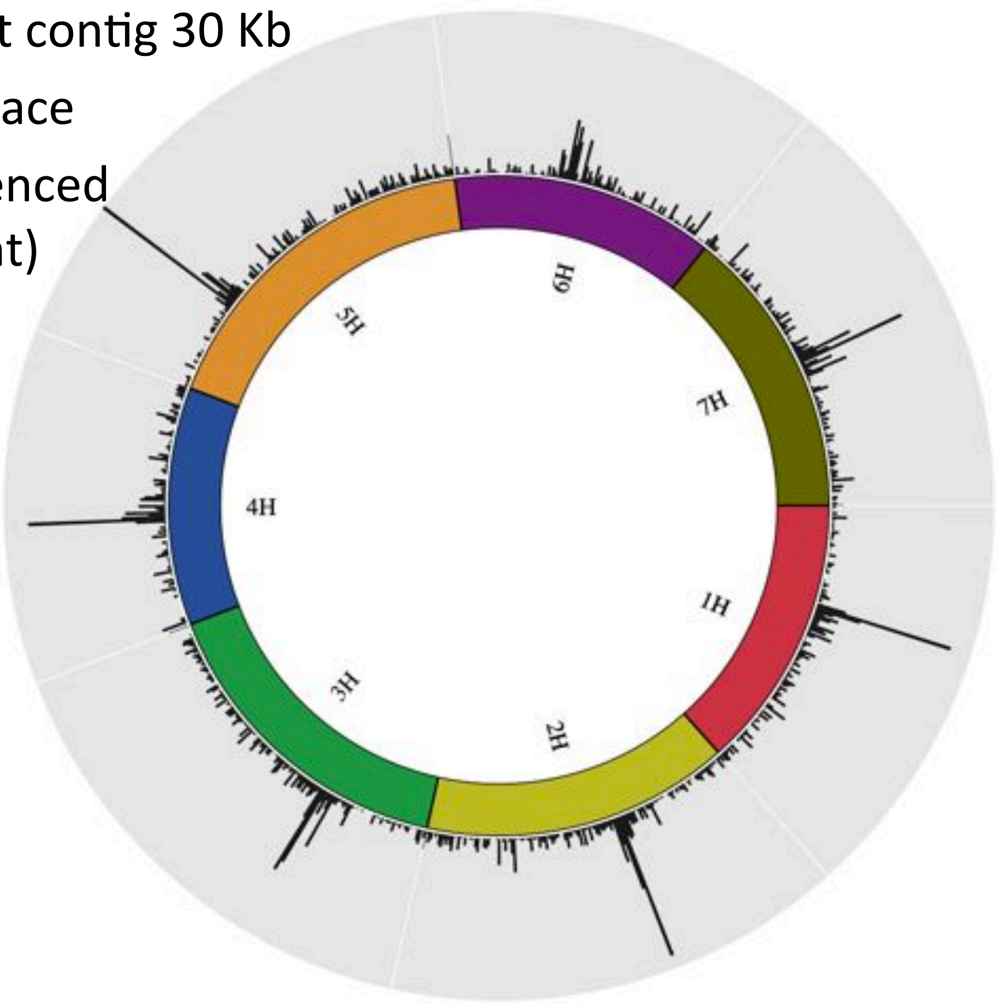
- 7.3 Gb genome, diploid, 7 chromosomes

- Sequencing Genomes of two accessions
  - each ~30x coverage
  - Accessions: 1644 and 2189



Sequencing of *Aegilops sharonensis*

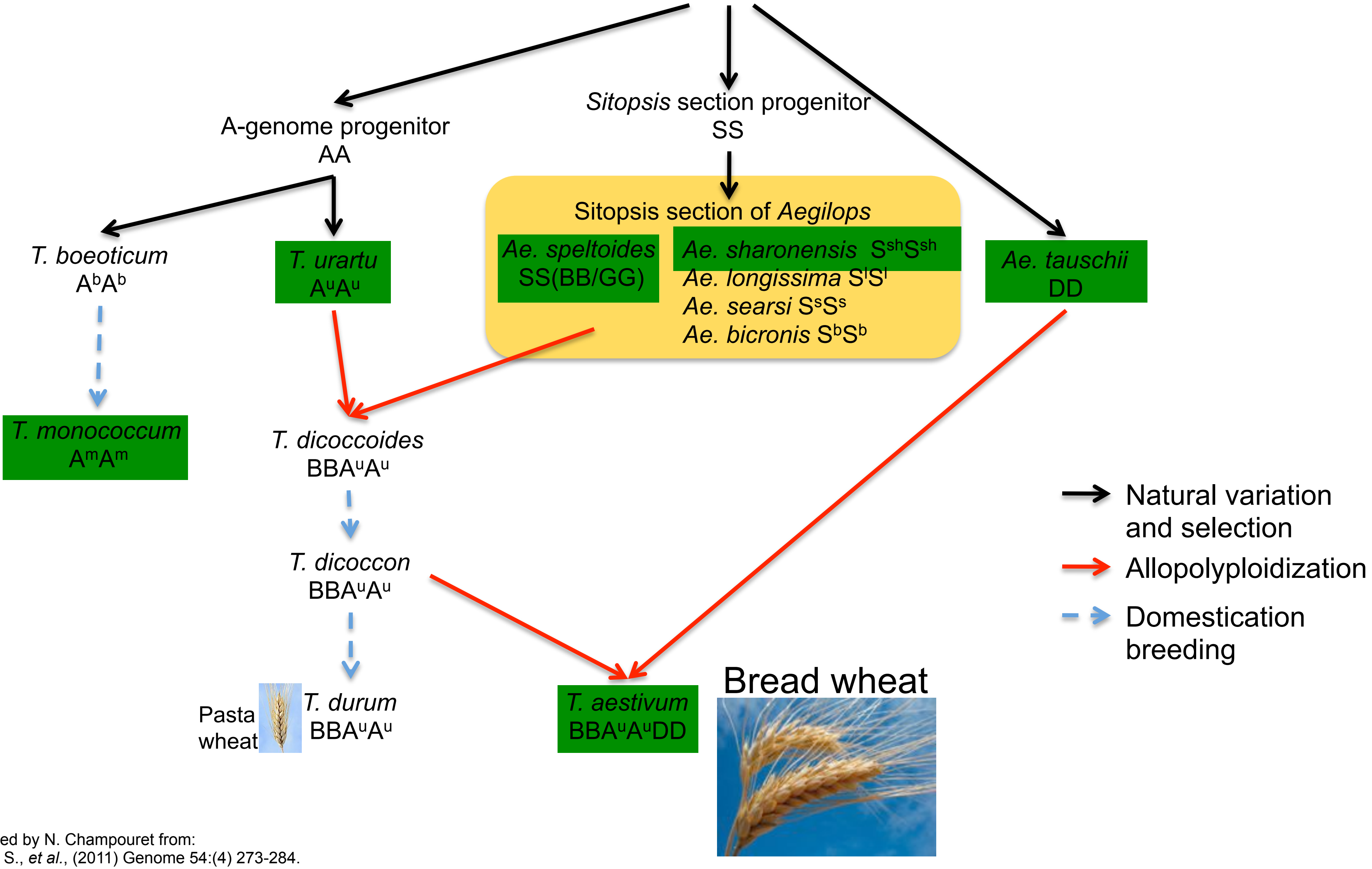
- Assembly
  - 1.5 Gb; very fragmented; largest contig 30 Kb
  - Good representation of gene space
  - Millions of SNPs between sequenced accessions (marker development)
- Anchoring
  - Genetic map in development
  - Synteny to barley



Comparative wheat genomics

- Flow sorting and sequencing of each chromosome arm of hexaploid bread wheat
  Sequencing and assembly of individual chromosome arms
- Whole Genome Sequencing of “progenitors”
  T. urartu, T. monococcum, Ae. speltoides,
  Ae. tauschii, Ae. sharonensis

Wheat Related Germplasm



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Pasta wheat

T. durum
BBA^uA^u

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BBA^uA^uDD

Bread wheat

→ Natural variation and selection
→ Allopolyploidization
⇢ Domestication breeding

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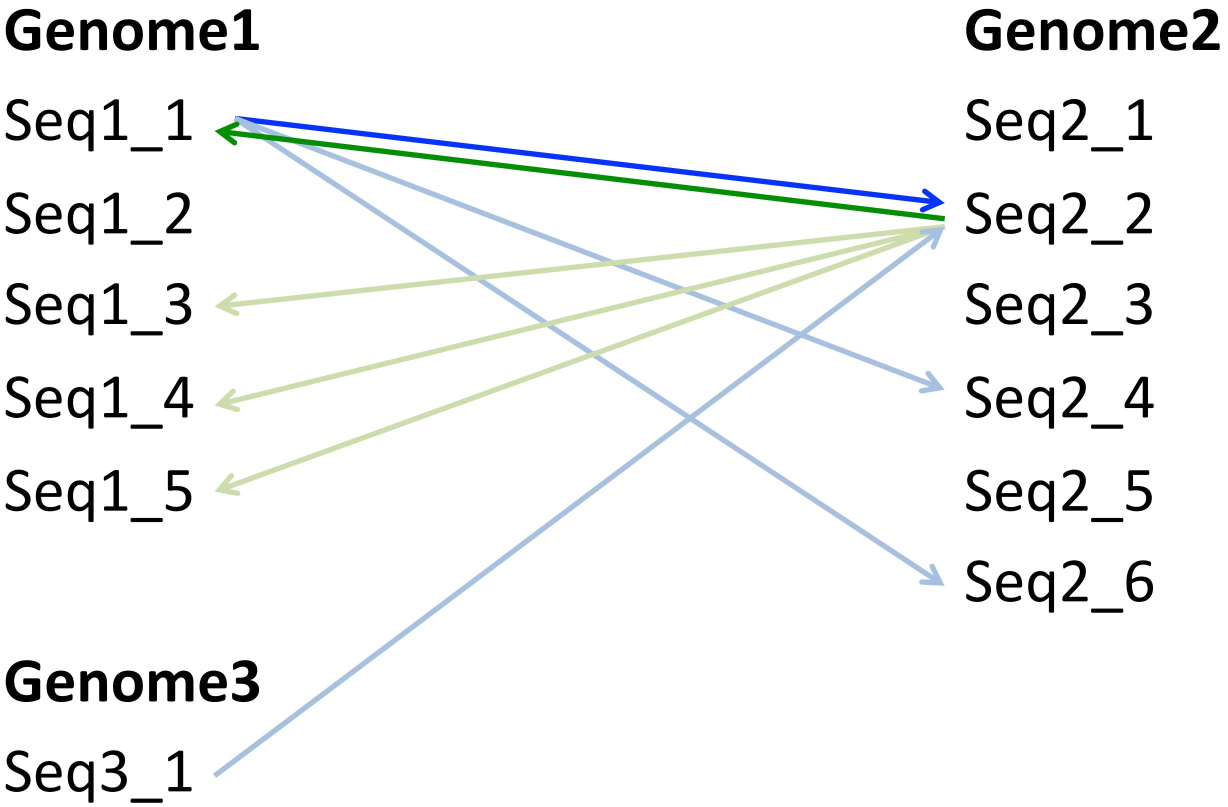
  Sequencing and assembly of individual chromosome arms
- Whole Genome Sequencing of “progenitors”
  T. urartu, T. monococcum, Ae. speltoides,
  Ae. tauschii, Ae. sharonensis
- Compare diploid species by alignment to wheat chromosome arms

What is the relation of *Ae. sharonensis* to wheat?

Bidirectional Best (blastn) Hits

blast hits



Genome1

Seq1_1

Seq1_2

Seq1_3

Seq1_4

Seq1_5

Genome3

Seq3_1

Genome2

Seq2_1

Seq2_2

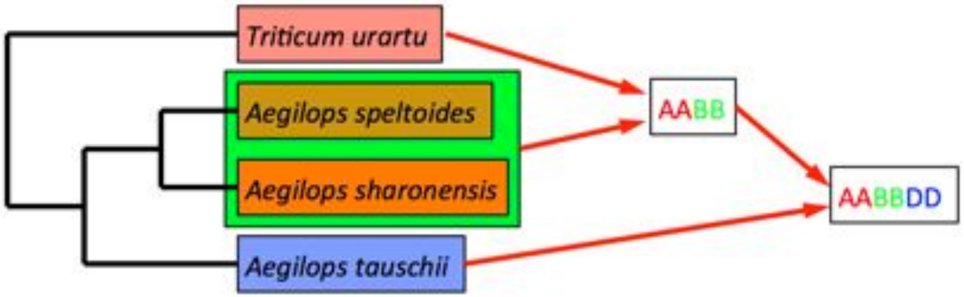
Seq2_3

Seq2_4

Seq2_5

Seq2_6

Aegilops tauschii vs. *Triticum aestivum* arms



Triticum urartu

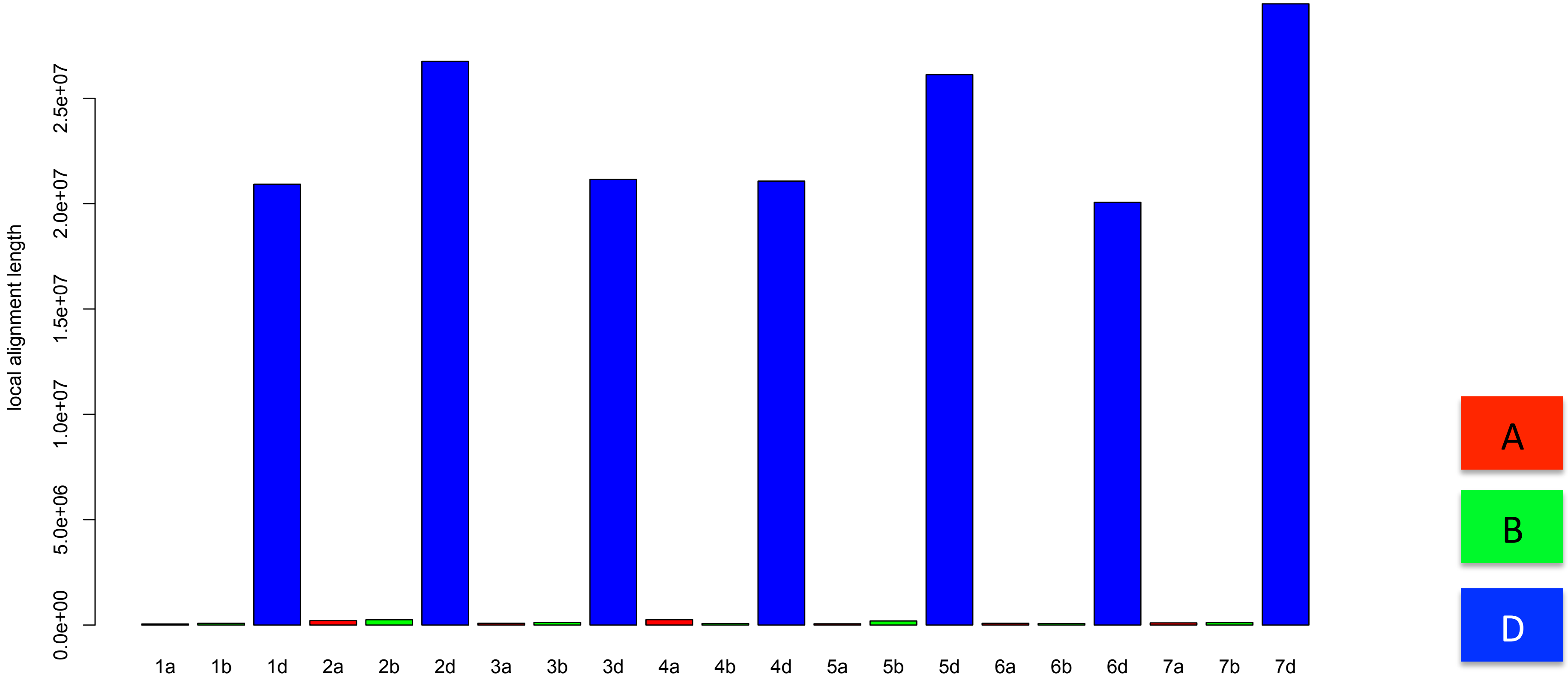
Aegilops speltoides

Aegilops sharonensis

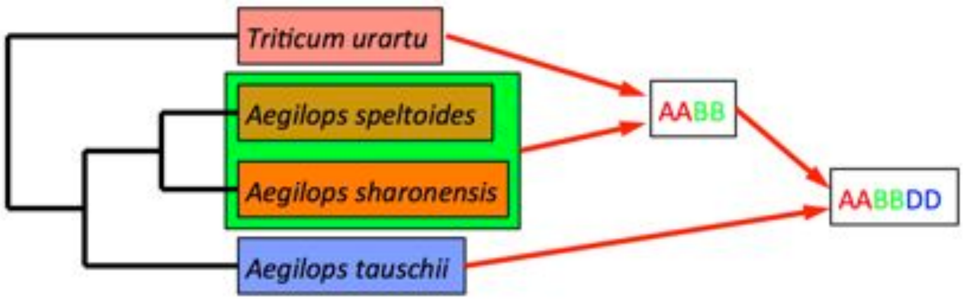
Aegilops tauschii

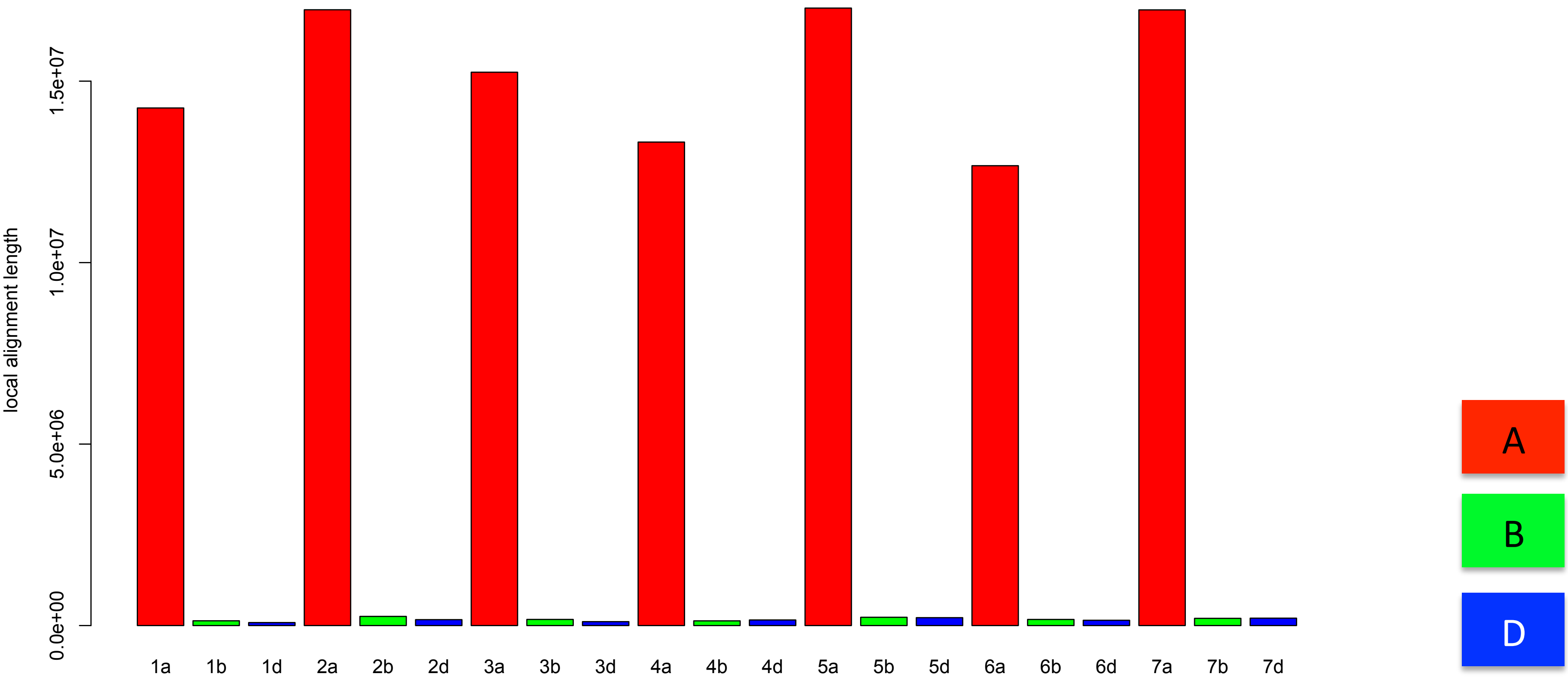
AABB

AABBDD

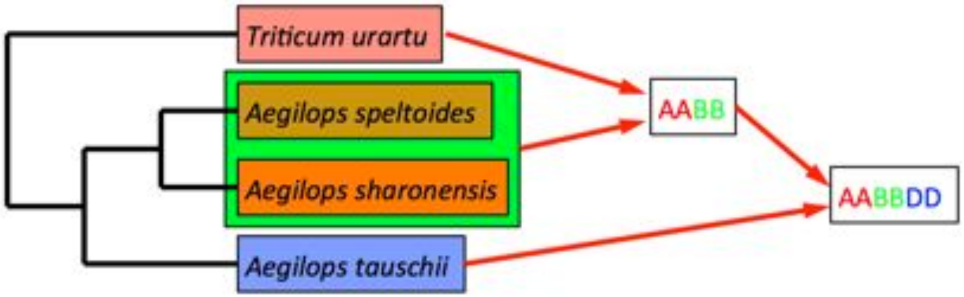


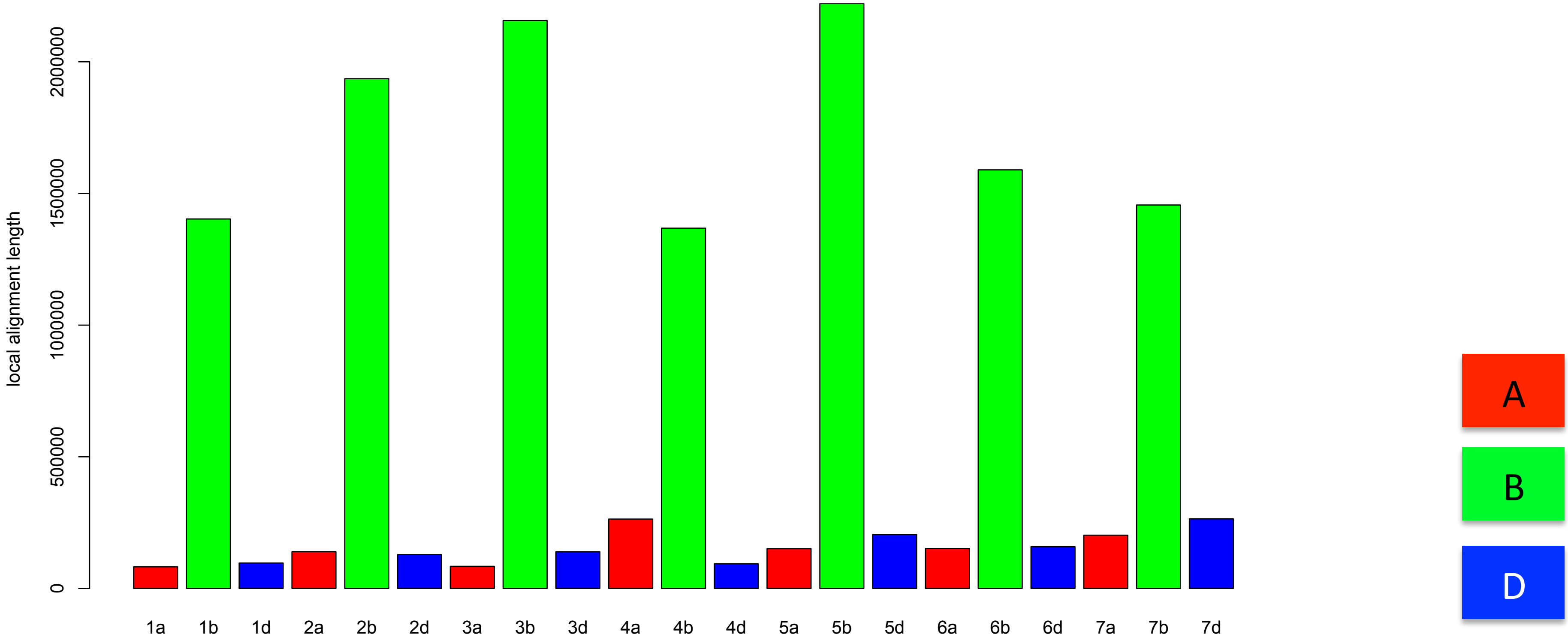
Triticum urartu vs. *Triticum aestivum* arms



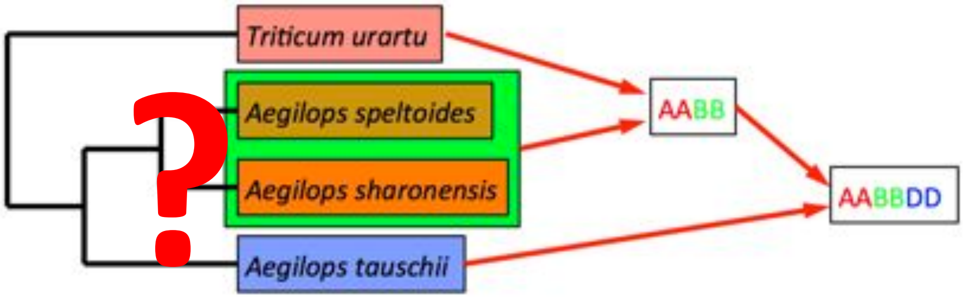


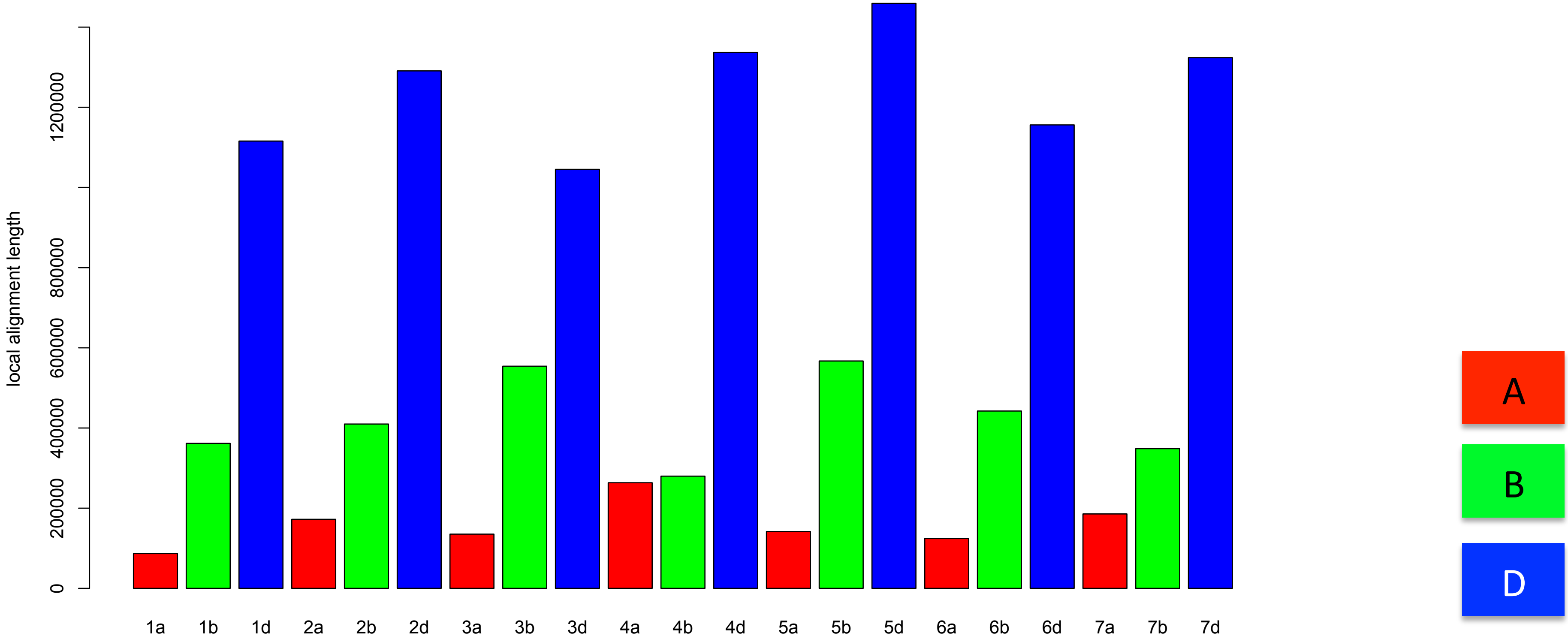
Aegilops speltoides vs. *Triticum aestivum* arms





Aegilops sharonensis vs. *Triticum aestivum* arms





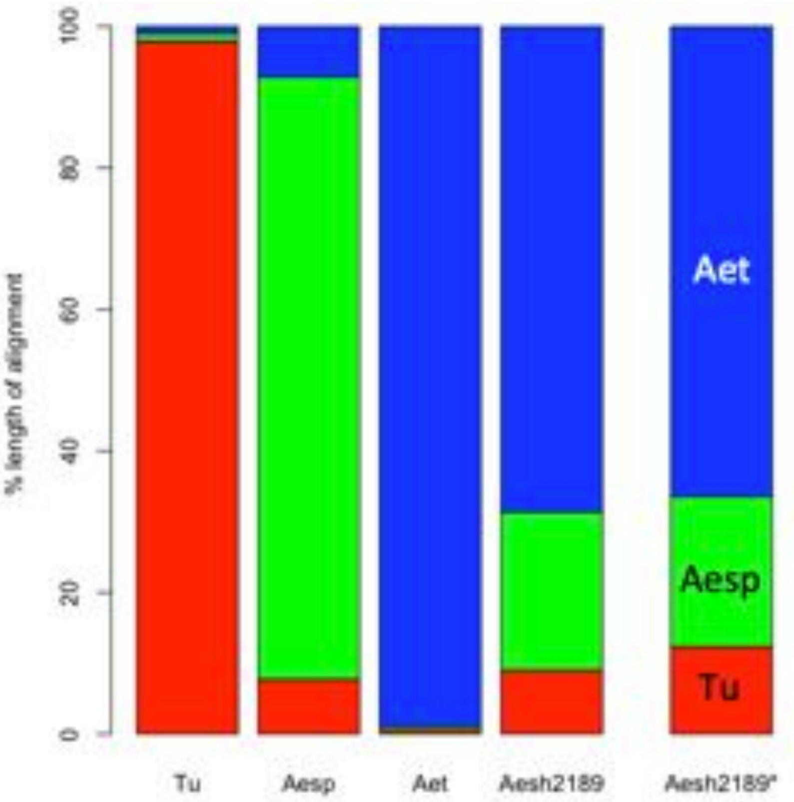
Inconsistency in taxonomic classification of *Sitopsis*

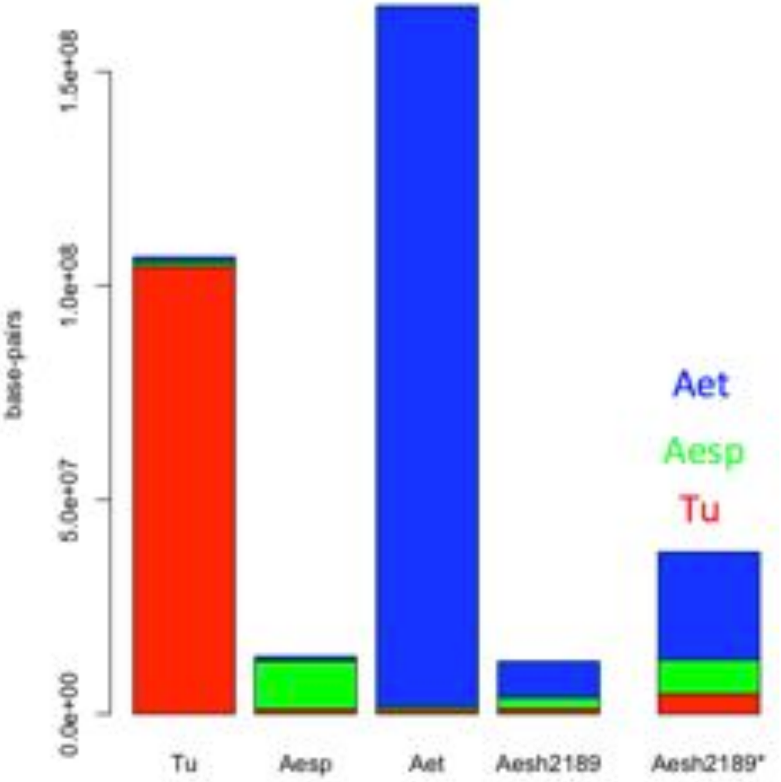
A

B

D

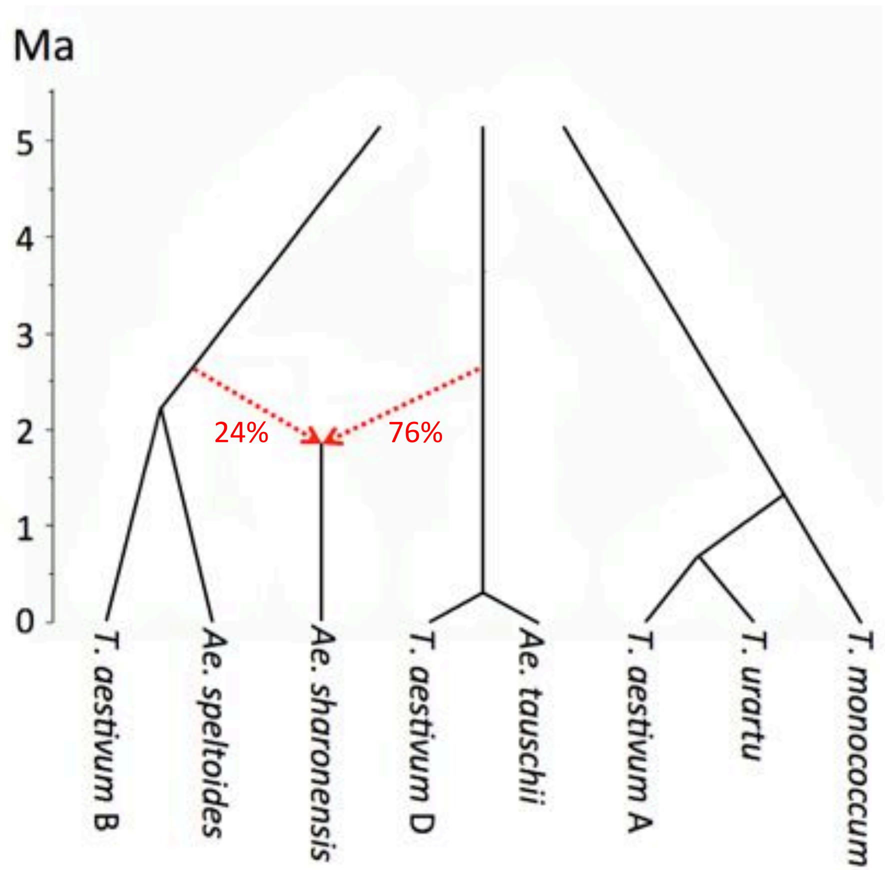
- (*Ae. sharonensis* is clearly not BB progenitor)
- *Ae. sharonensis* is closer related *to Ae. tauschii* than to *Ae. speltoides*.
  → *Sitopsis* Section????





Back to the liger

Aegilops sharonensis is a hybrid species



- Homoploid hybrid speciation
  - progenitor of B and *Ae. speltoides*
  - *Ae. tauschii*
- Taxonomy is man-made

Thomas Marcussen
Simen Rød Sandve
Lise Heier

Summary

- *Ae. sharonensis* sequence resource available

- Enabling comparative genomics for wheat family
  - *Ae. sharonensis* is closer related *to Ae. tauschii* than to *Ae. speltoides*.
    → Inconsistency in *Sitopsis* section

- *Ae. sharonensis* is a hybrid species

Acknowledgements

2Blades Group

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