The evolutionary genomics of domestication

--An example from rice

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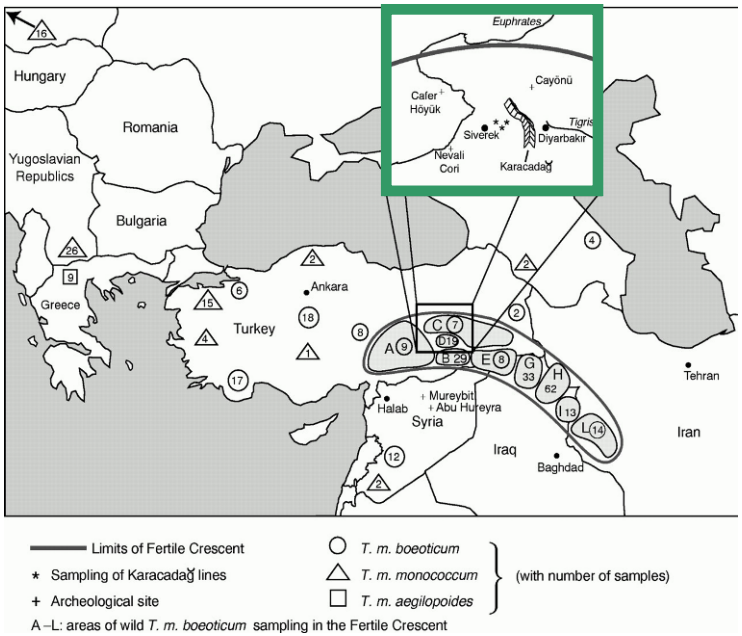
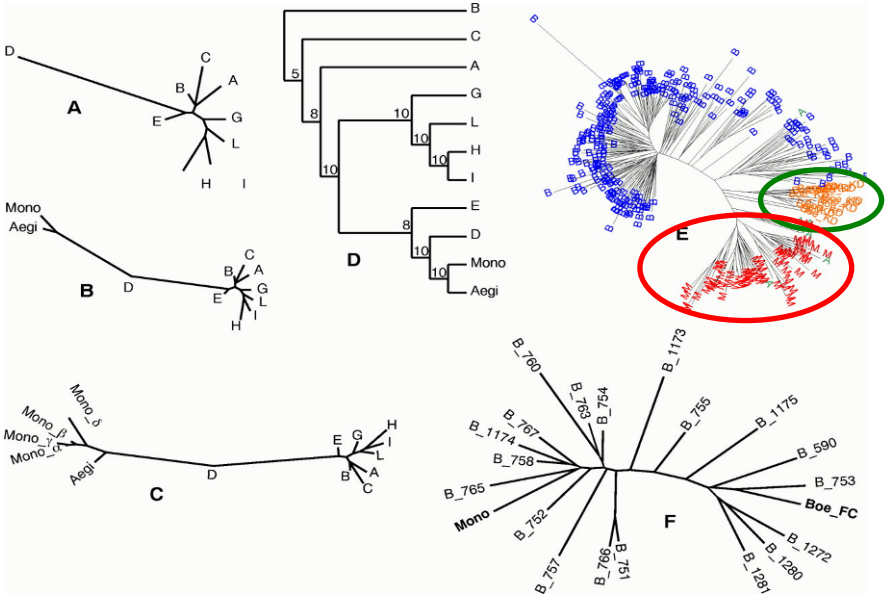
Evolutionary genetics of domestication: phylogeography

- Based on ‘neutral’ molecular markers,
- Genotype a large sample of domesticates and their wild relatives
- Where did domestication occur?
- How often was a species domesticated?
- When was the species domesticated?

Example: Einkorn wheat

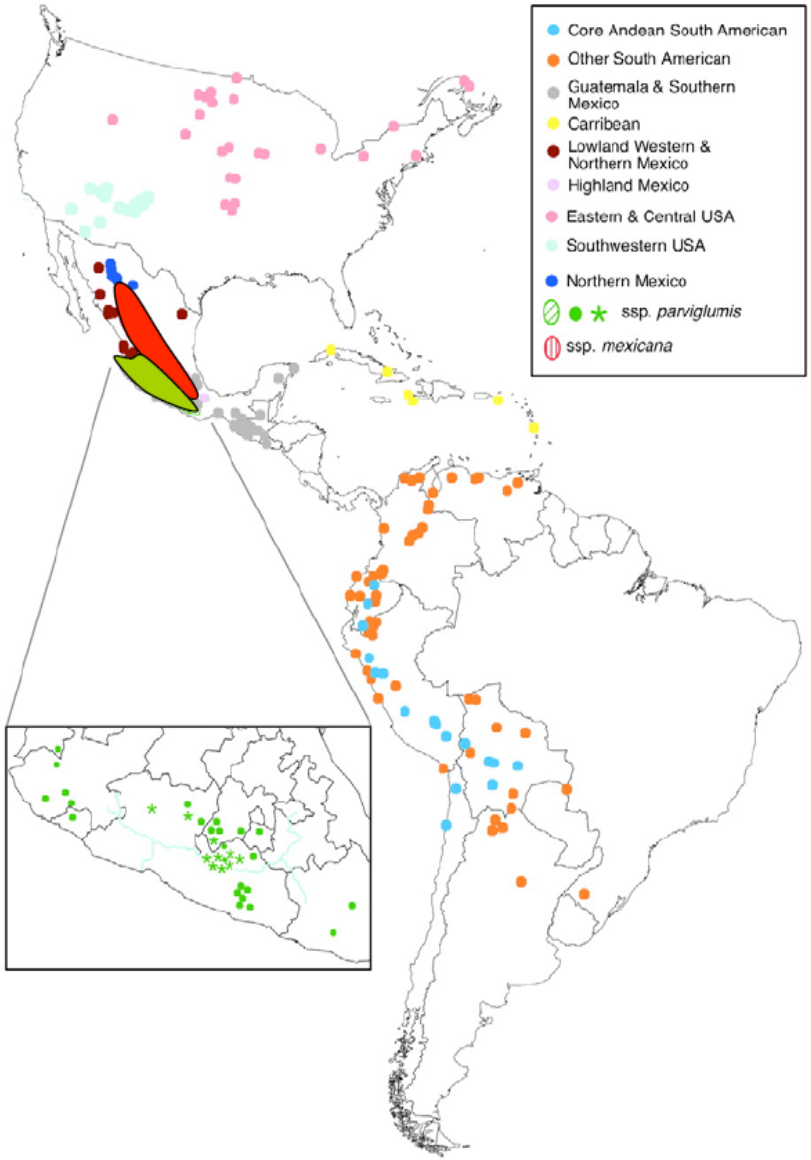




- Domesticated in the Karacada mountains (southeast Turkey)
- Single domestication event
- Archaelogical evidence suggests domestication ~9600 YBP

Heun et al., 1997 Science 278:1312

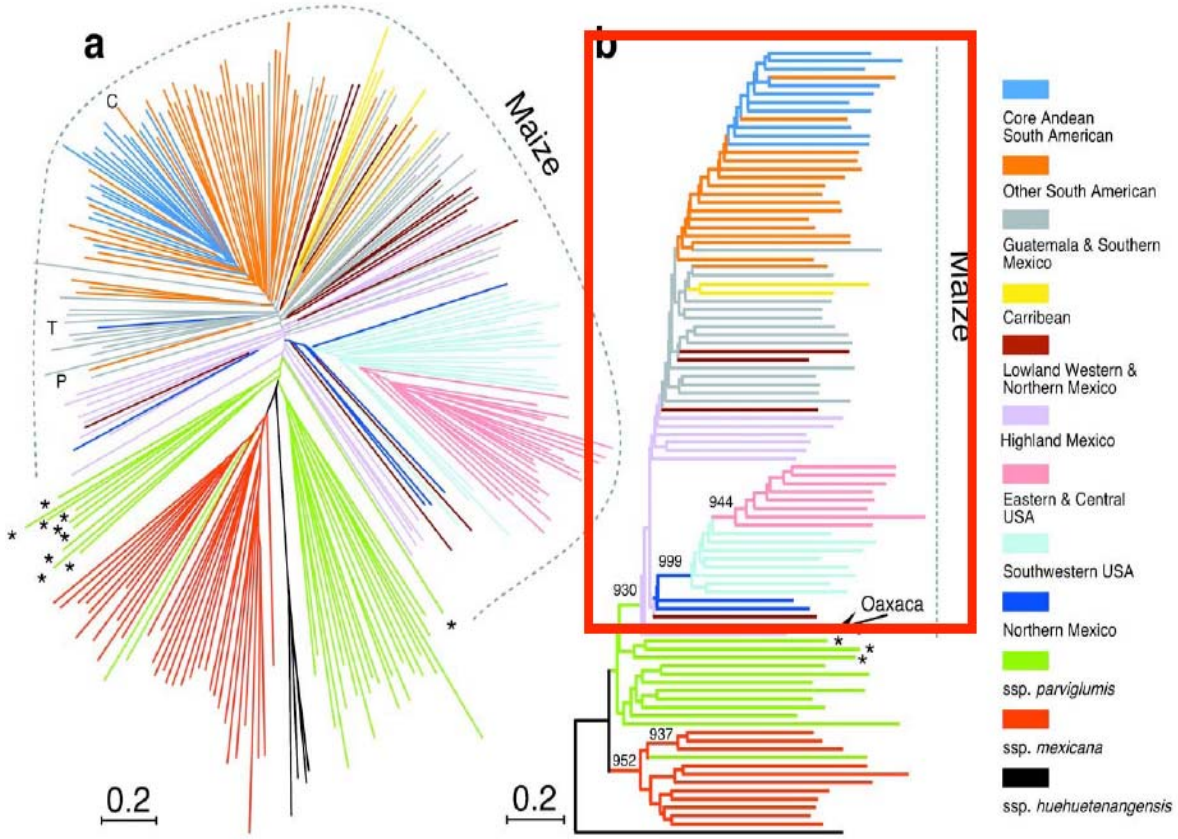
Example: Maize Domestication



- 99 SSR loci
- 193 maize accessions teosinte
- *Zea mays* ssp. *mexicana*
- *Zea mays* ssp. *parviglumis*

Matsuoka *et al.* (2002) Proc. Natl. Acad. Sci. USA 99, 6080-6084

Phylogeographic Study of Maize Domestication



- Single Domestication event
- Domesticated from *Z. mays* ssp. *parviglumis*
- Location: Mexican highlands
- Time: ~9000 YBP
  Archaelogy ~6000 YBP

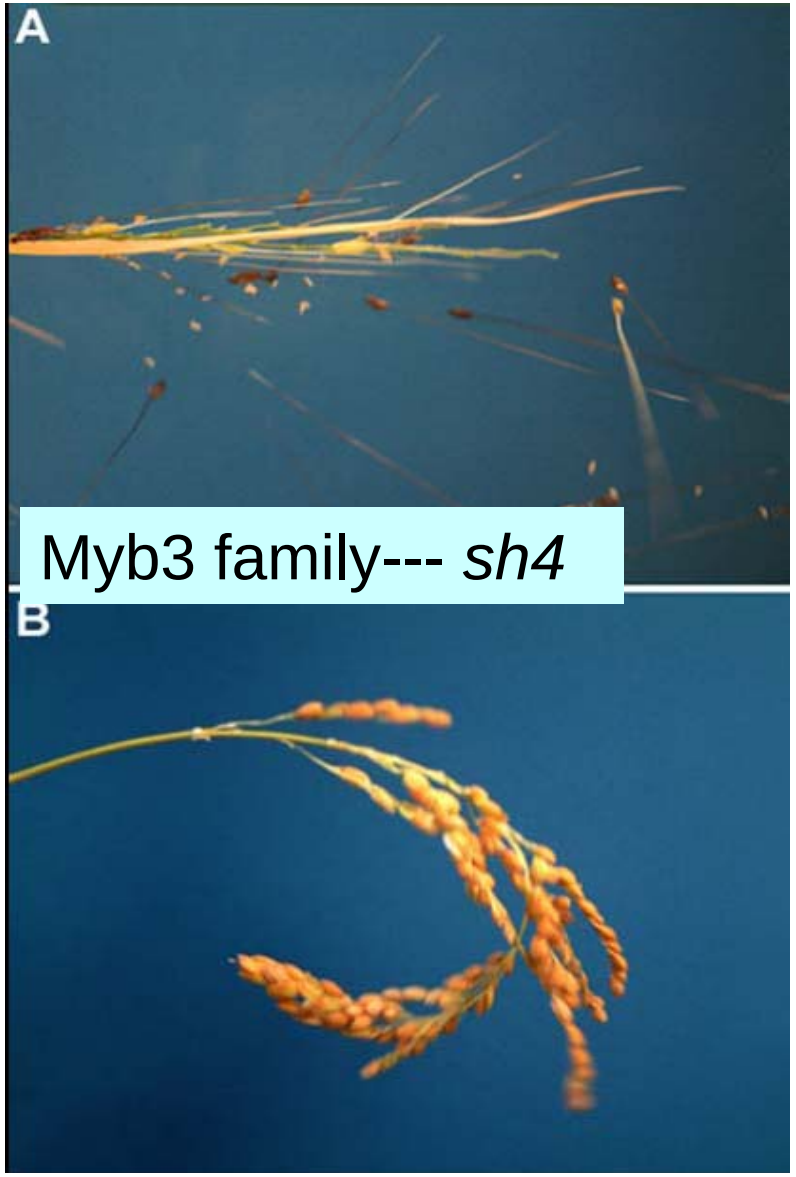
Matsuoka *et al.* (2002) Proc. Natl. Acad. Sci. USA 99, 6080-6084

domesticated crops and animals are not like their wild progenitors

seed shattering

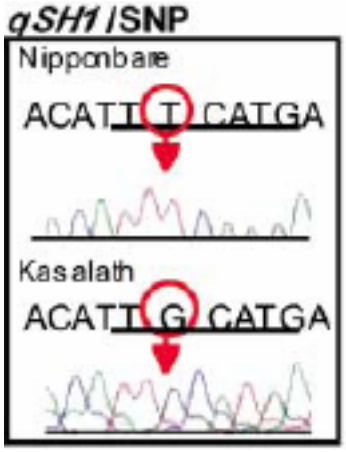
in the wild, the pods open naturally and the seeds fall off, since that is how the plant is meant to reproduce; but in a domesticated crop, the pods must remain shut or there is nothing for us to eat

Rice domestication by reducing shattering



Li *et al. Science*, 2006: 1936-1939

An SNP caused loss of seed shattering during rice domestication



ABI3 family

Kinishi et al 2006,Science,312:1392-1396

Evolutionary genetics of domestication: *fw2.2*

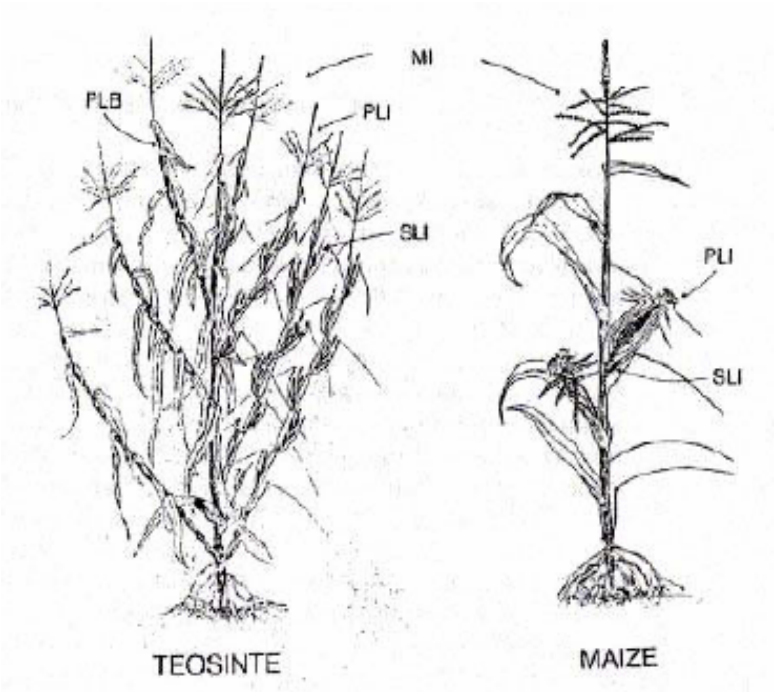
- 300-fold difference in fruit weight between wild and cultivated tomato
- QTL studies based on wild X cultivated cross

Frary *et al.*, Science 2000 289:85

Evolutionary genetics of domestication: maize

- Inflorescence architecture
- Seed coat
- Plant architecture

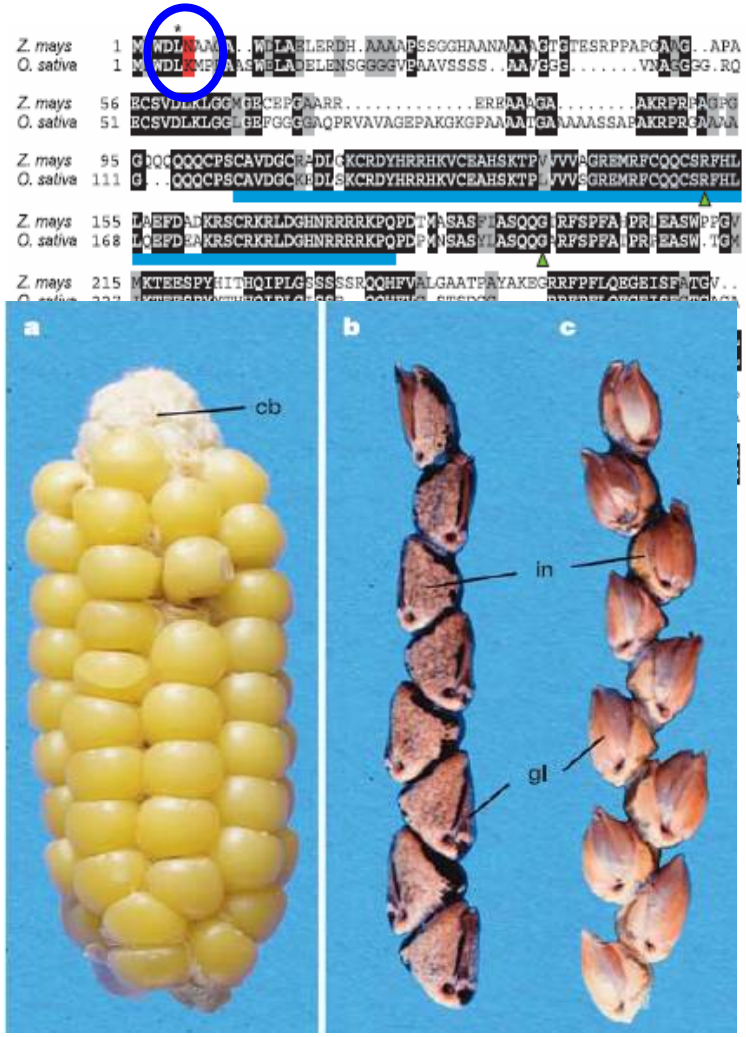
www.panzea.org



TCP family--

teosinte branched 1 (*tb1*)

Doebley *et al*., *Nature* 1997 386, 485 - 488
Wang *et al*., *Nature* 1999 398:236



SBP family --

teosinte glume architecture 1 (tga 1)

Wang *et al*., Nature 2005: 714-719

Only 2-4% of genes have been subjected to artificial selection in maize genome

www.panzea.org

Wright et al.Science,2005,308:1310-1314

An example from rice

Asian cultivated rice

O. sativa ssp. *japonica*

O. sativa ssp. *indica*

Normile & Pennisi. *Science*, Apr 5, 2002: 32-36

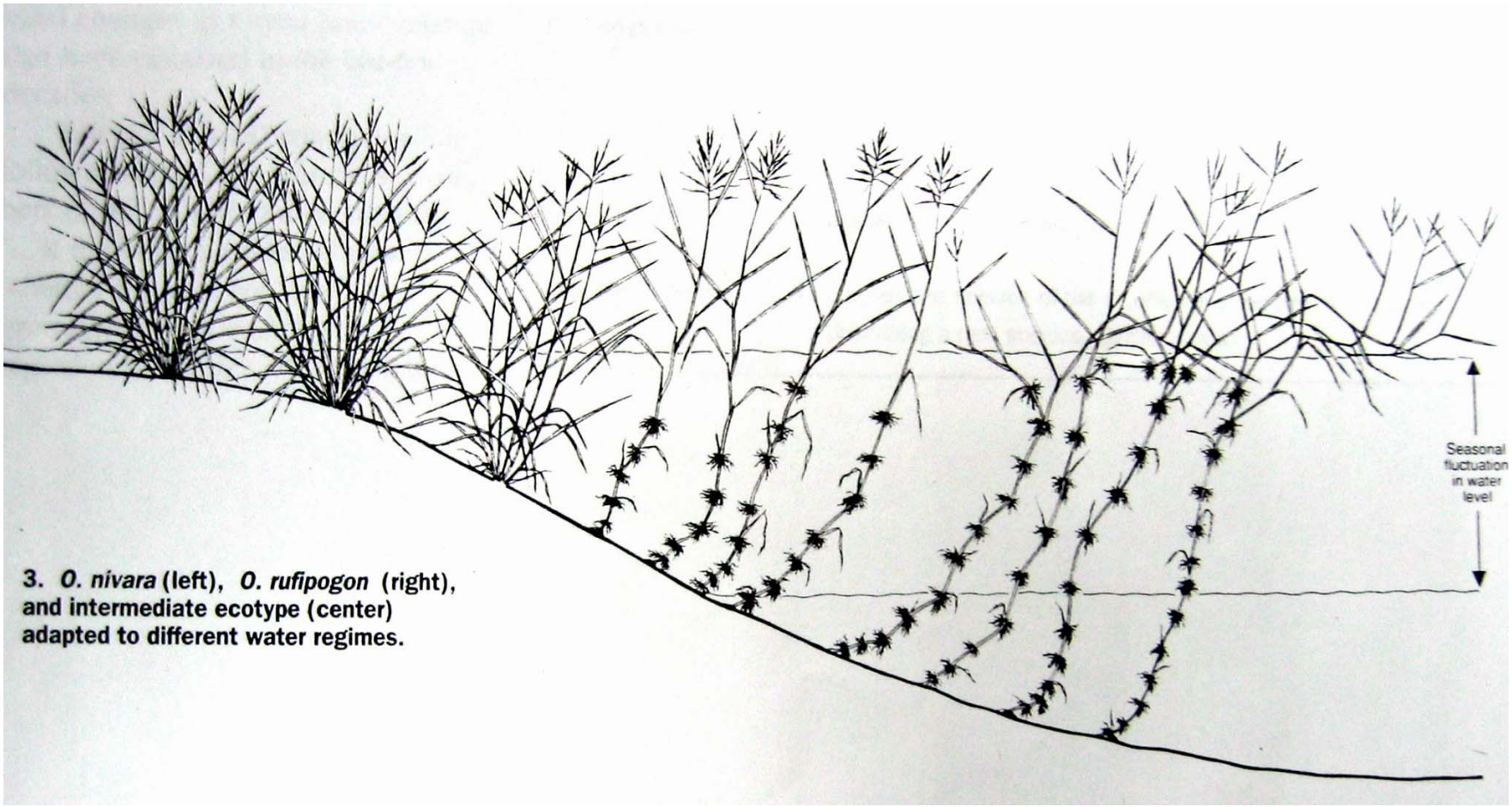
progenitors of cultivated rice

O.rufipogon

O.nivara

Pictures from:www.knowledgebank.irri.org/wildRiceTaxonomy

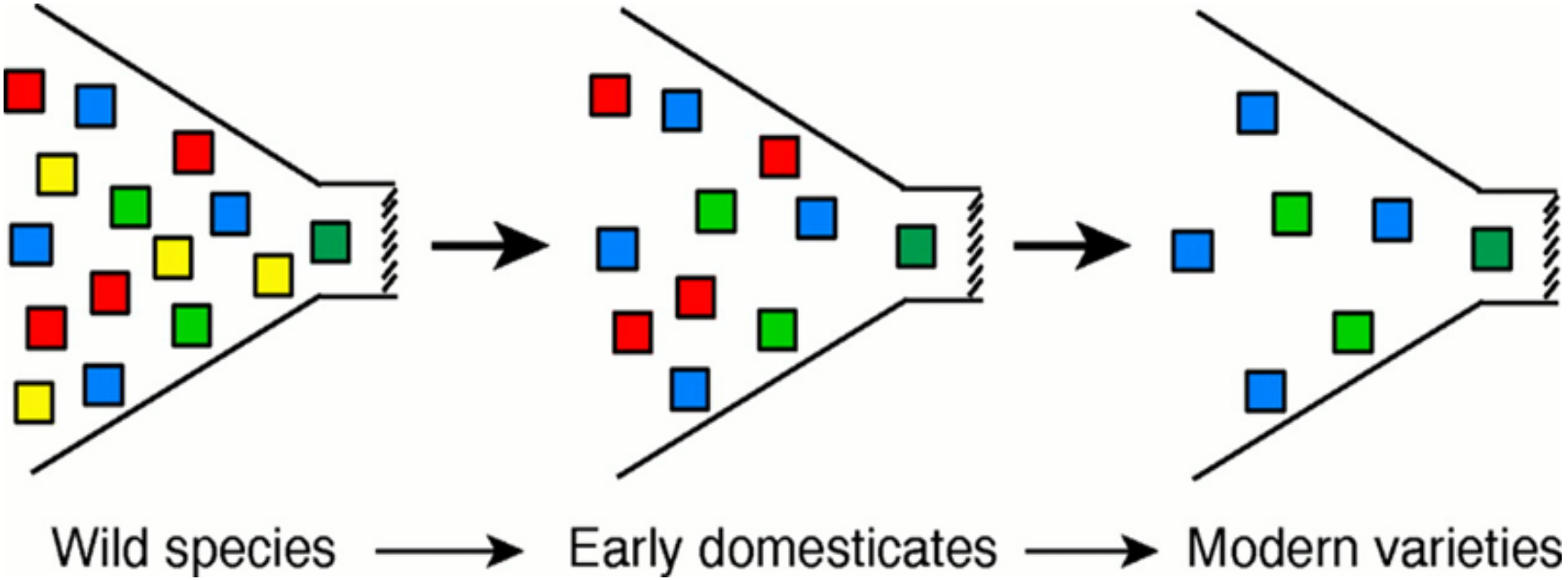
Habitat of *O. rufipogon* and *O. nivara*



3. *O. nivara* (left), *O. rufipogon* (right), and intermediate ecotype (center) adapted to different water regimes.

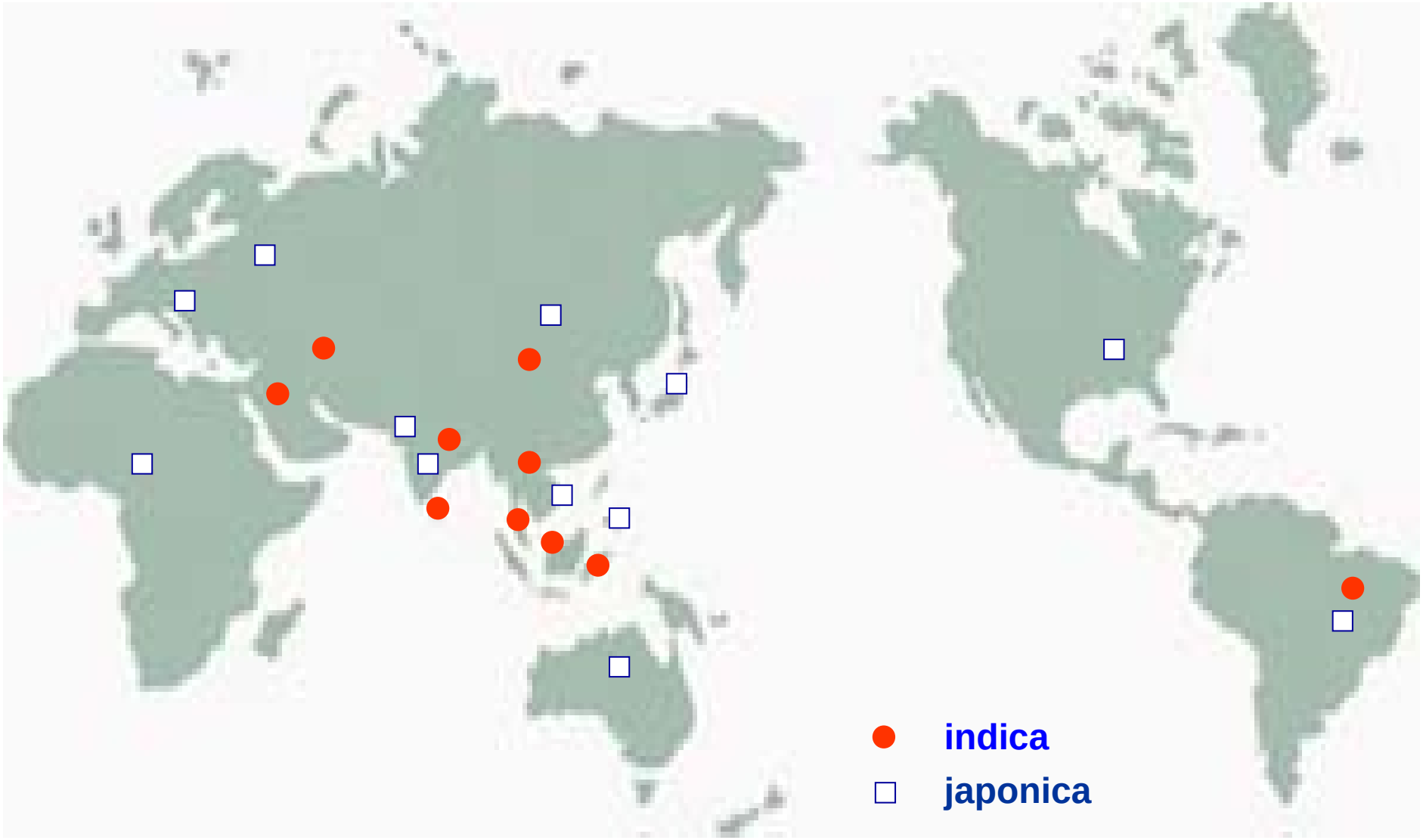
Vaughan DA. 1989. The wild relatives of rice

Genetic bottlenecks imposed on crops during domestication and through modern breeding practices

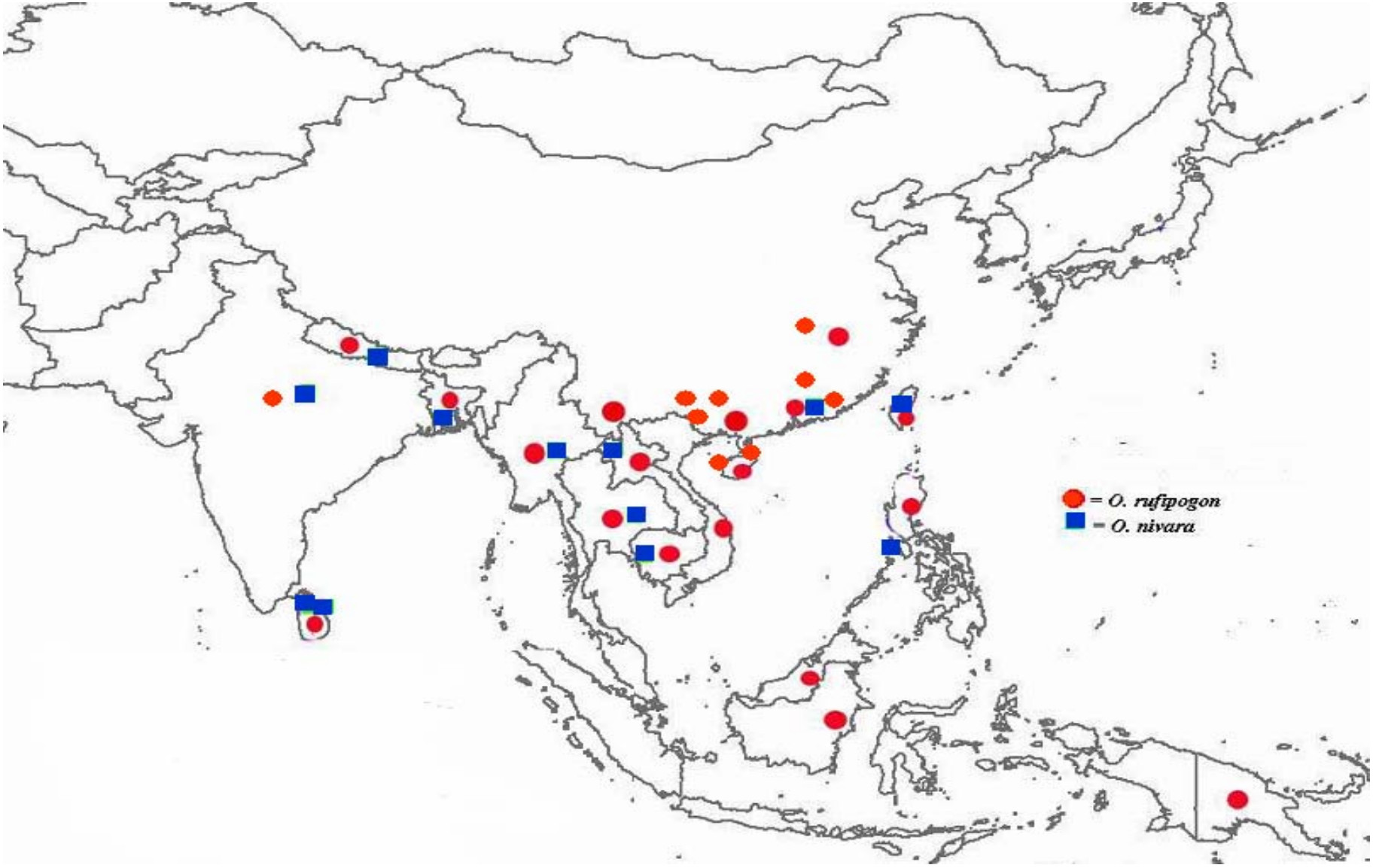


Tanksley & McCouch. 1997. *Science*: 1063-1066

Cultivated rice sampling



Sampling of wild rice



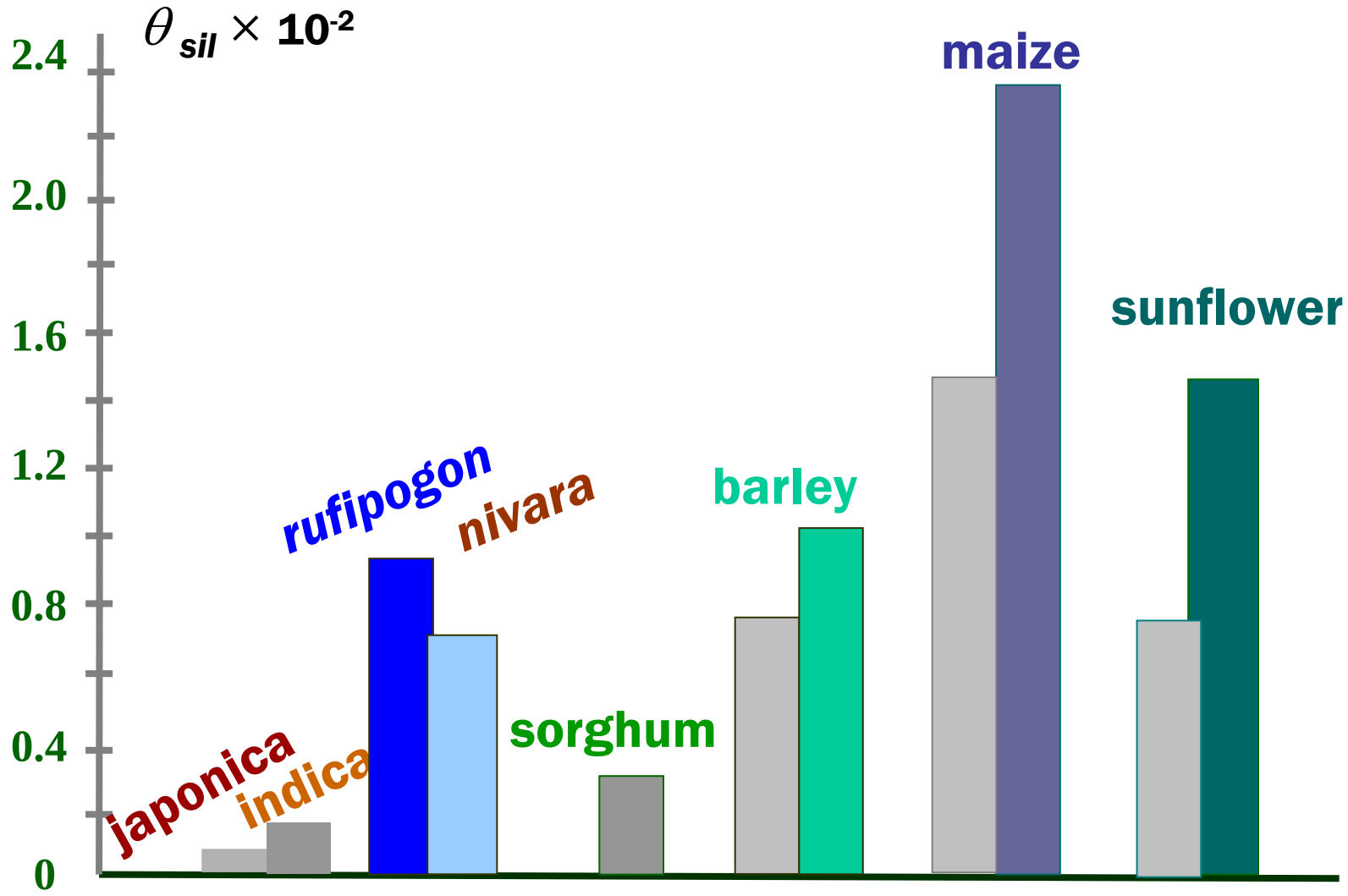
Extent of the regions analyzed

Locus	*Chromosome*	*Total*	*Coding (bp)*	*Non-coding (bp)*
Adh1	11	853	0	853
CatA	2	610	0	610
Cbp1	12	824	317	507
GBSSII	7	624	139	485
Ks1	4	941	481	460
Lhs1	3	1057	161	896
Os0053	2	738	149	589
SSII	10	917	73	844
TFIIA γ-1	1	971	75	896
Waxy	6	544	179	365
Total		8079	1574	6505

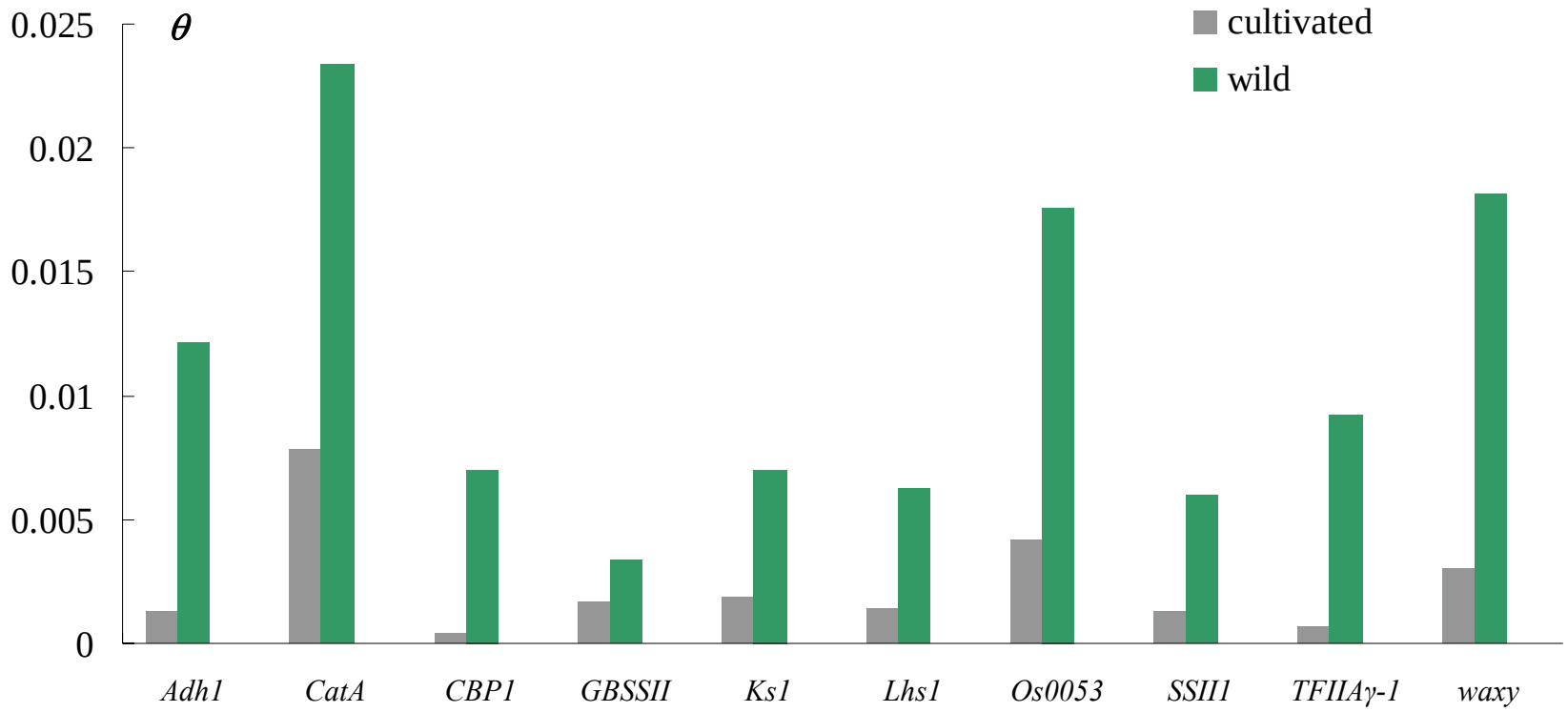
Methods

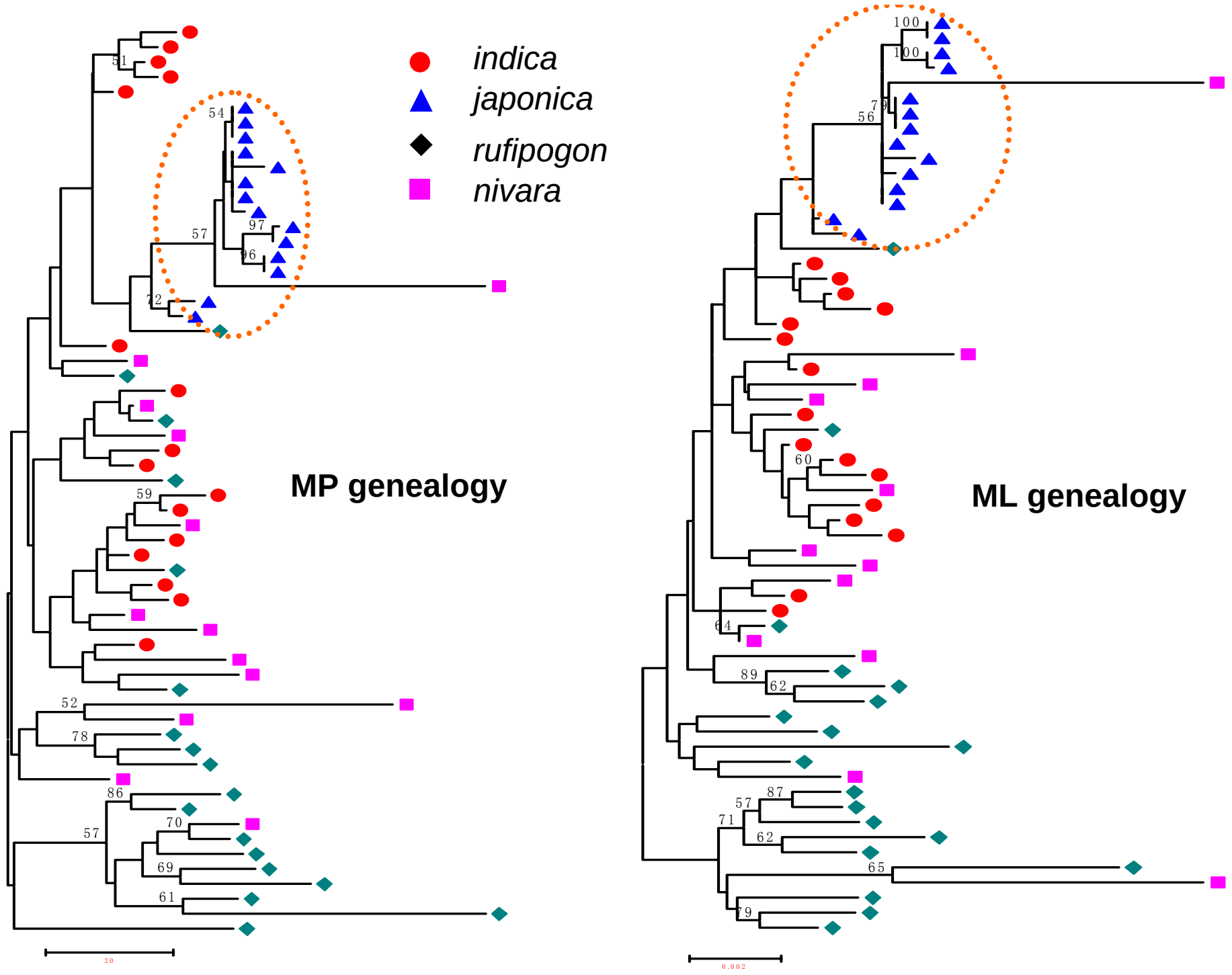
- cultivated rice: PCR sequencing
- wild rice: PCR sequencing
  Cloning and sequencing

result


$\theta_{sil} \times 10^{-2}$
2.4
2.0
1.6
1.2
0.8
0.4
0
japonica
indica
rufipogon
nivara
sorghum
barley
maize
sunflower

Comparison of nucleotide diversity of the cultivated and wild rice at ten loci

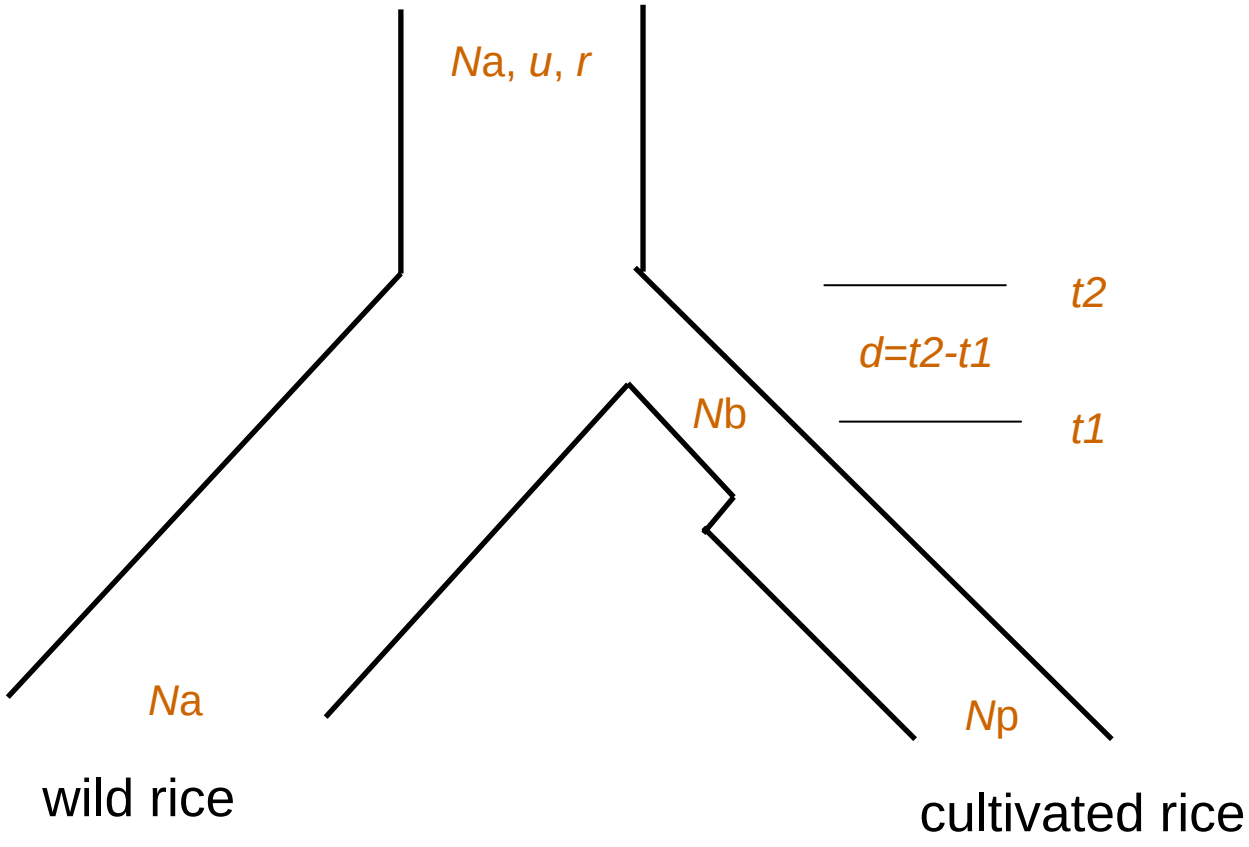



indica
japonica
rufipogon
nivara
MP genealogy
ML genealogy
51
54
57
97
96
72
59
52
78
86
70
57
69
61
20
100
100
75
56
60
64
89
62
87
57
71
62
65
79
0.002

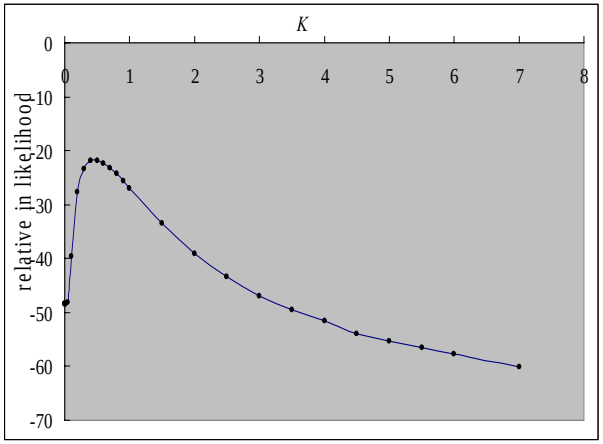
constraint analysis

Tree	*-lnL*	*Diff -lnL*	*P*	*Significantly worse*
***Best ML*-tree**	16044			
indica	17736	1692.03	<0.001	Yes
japonica	17212	1167.98	<0.001	Yes
rufipogon	17852.2	1808.21	<0.001	Yes
nivara	17872.4	1828.46	<0.001	Yes

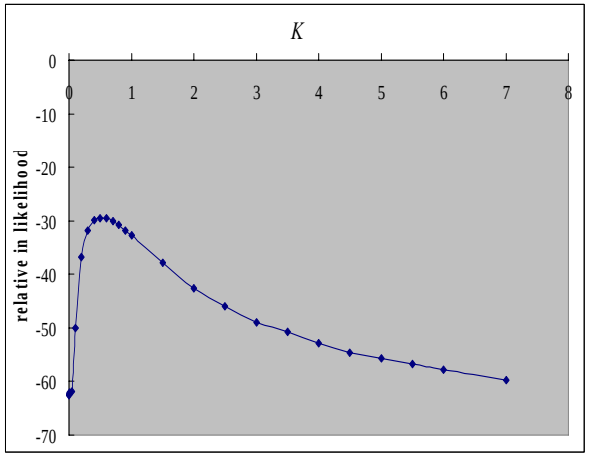
Coalescent simulation



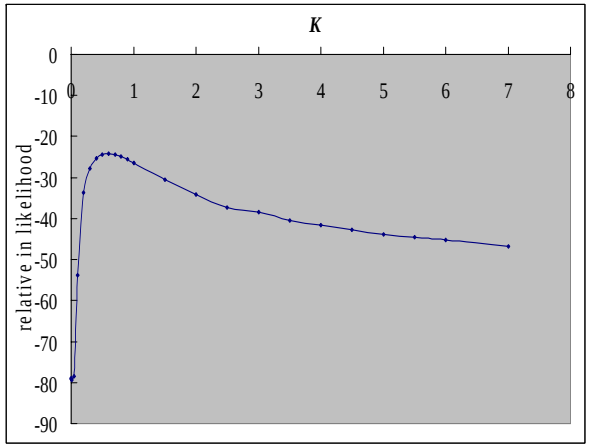
severe bottleneck in rice



S

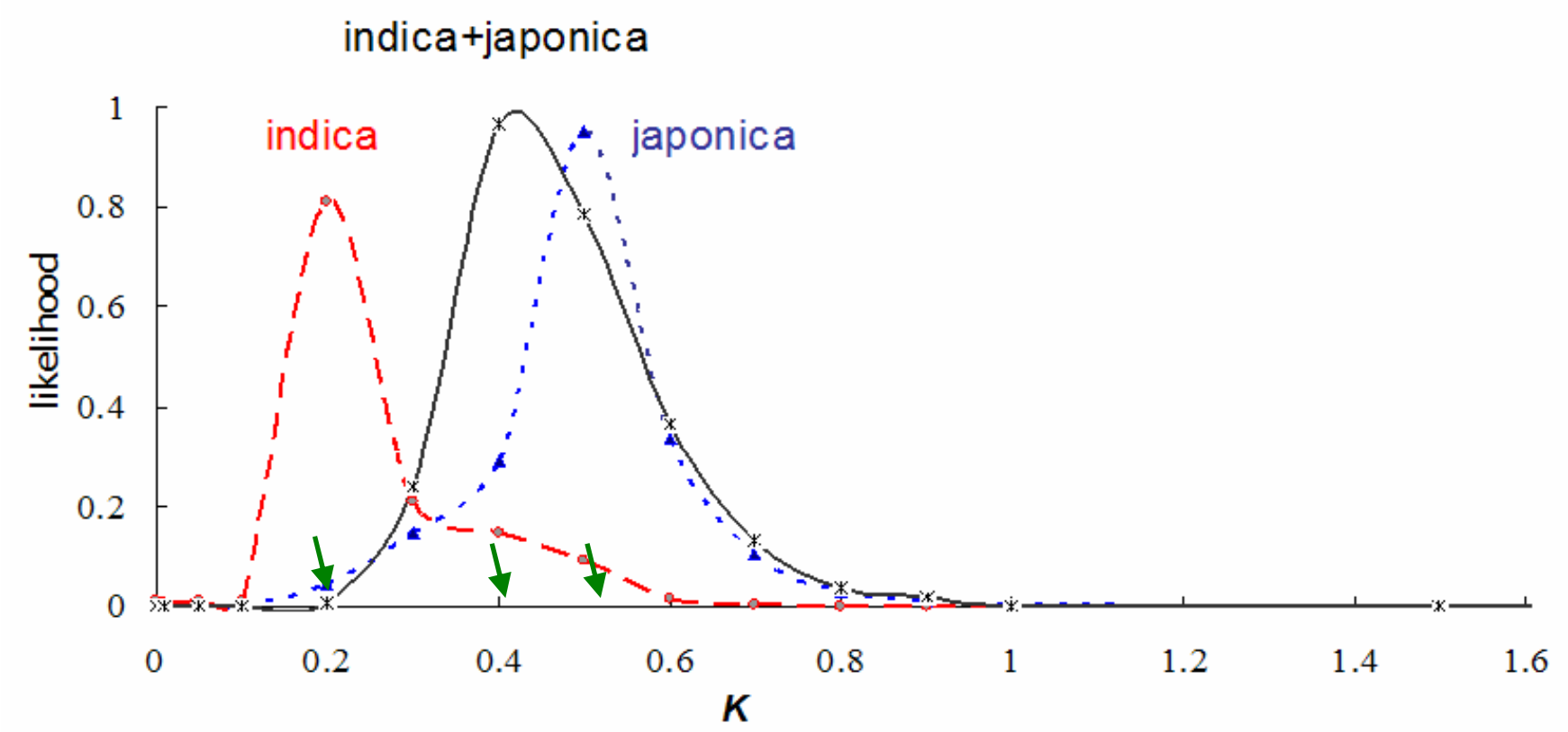


θ



π

The severity of bottleneck in rice domestication



Conclusions

• Wild populations are crucial for understanding domestication
• Studies of domestication phylogeography are common, and answer the question “Where?”
• nucleotide variation
wild rice： comparable levels of other wild species
cultivated rice: low, only 20% to 10% of the wild species
• coalescent simulation detected a severe domestication bottleneck and demonstrated only 1500 individuals in the founding population if the initial domestication event occurred over a 3000-year period

thank you

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