

A close-up photograph of several rice panicles (grain heads) in a field. The panicles are green and yellow, showing the developing grains. The background is a soft-focus green field of rice plants.

Genetic modification in the evolution of Rice

- Kshitij Singh
[December 2019]

Introduction

Classification of Rice:

Kingdom: Plantae

Clade: Tracheophytes

Clade: Angiosperms

Clade: Monocots

Clade: Commelinids

Order: Poales

Family: Poaceae

Genus: Oryza

- 430Mb across 12 chromosomes



Introduction

Two main rice species: Out of 24 species, only two are cultivated



https://en.wikipedia.org/wiki/Oryza_glaberrima#/media/File:Reis_-_Sorte_C_voll.jpg

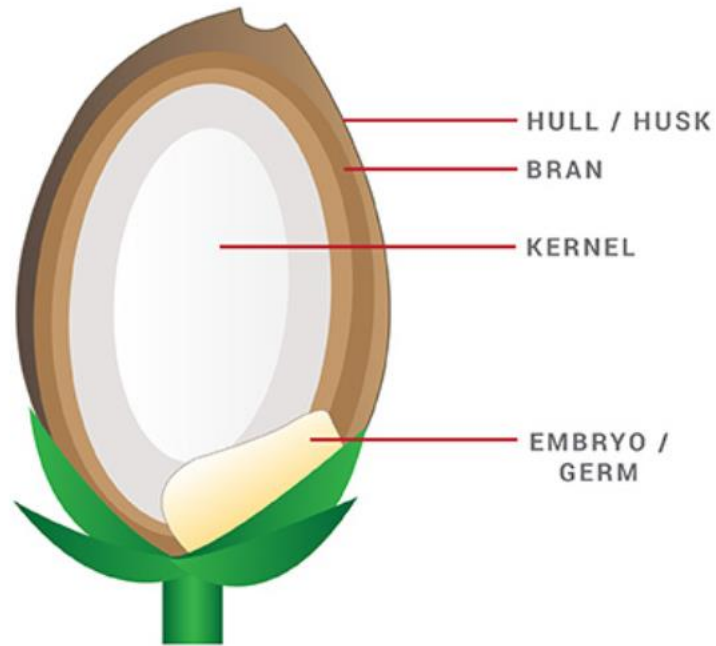
African rice (*Oryza glaberrima*)



<https://www.alamy.com/stock-photo-basmati-rice-oryza-sativa-grains-seen-from-above-germany-122013095.html>

Asian rice (*Oryza sativa*) – *Indica* and *Japonica* subspecies

Introduction



<https://www.newdirectionsaromatics.com/blog/products/all-about-rice-bran-carrier-oil.html>

- **Oldest domesticated cereal**
- **3rd highest crop production worldwide**
- **Short grain or Long grain**
- **Brown rice or White rice**



<http://www.foodhappy.ca/2012/jan/26/brown-rice-vs-white-rice/>

Evolution

- Originated from *O. rufipogon* (noxious weed)



https://en.wikipedia.org/wiki/Oryza_rufipogon#/media/File:Oryza_rufipogon_-_National_Taiwan_University_-_DSC01108.JPG



https://en.wikipedia.org/wiki/Rice#/media/File:Oryza_sativa_of_Kadavoor.jpg

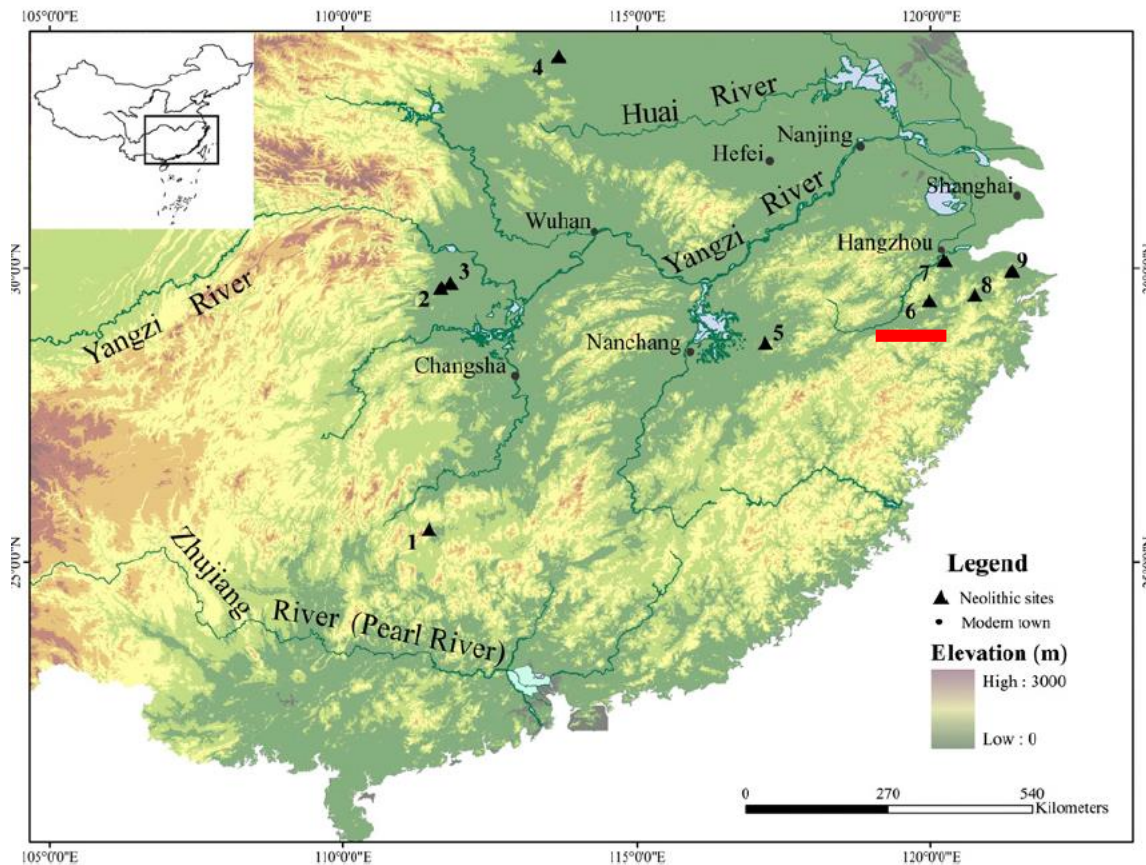
Paper I

- Flotation of archaeological sediments for recovery of macrobotanical remains of plants
 - In flotation technique, you take soil from archaeological site -> put it through a mesh and bubble water from below -> less dense materials float up -> tiny pieces of bone, stone, are left on the mesh
 - Carbonised seed, plant parts are macrobotanicals
- Rice remains recovered from pottery, burnt soil blocks in archaeological sties

Evolution

Early history:

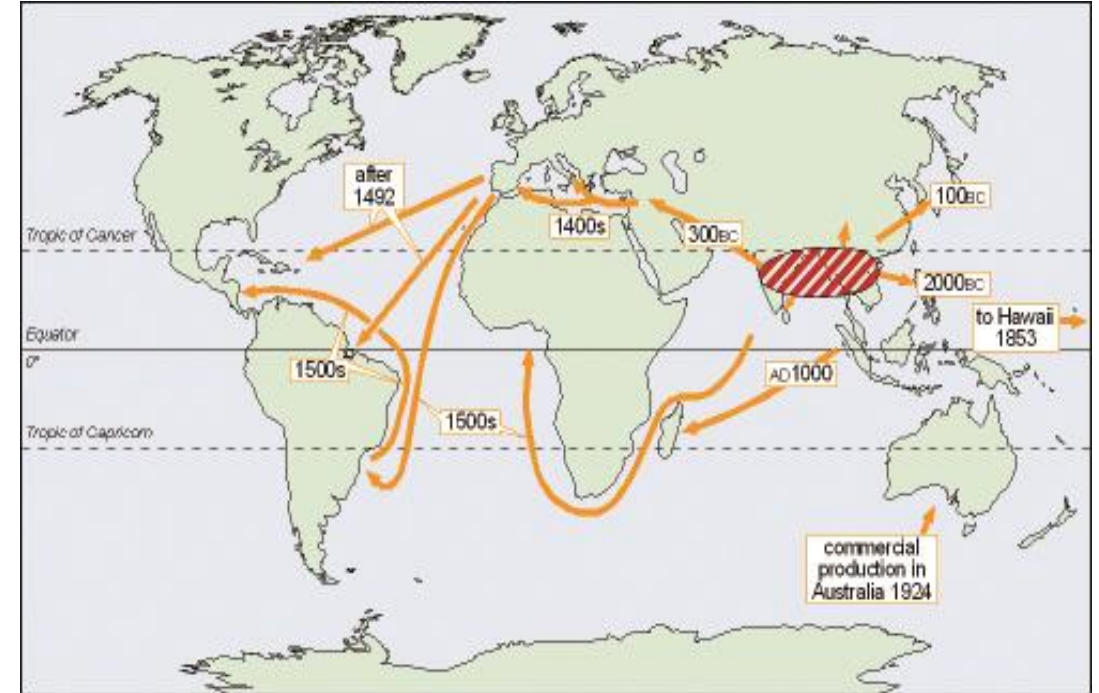
- From China (12,000 BP) in Xianrendong and Diaotonghuan in Jiangxi Province, and **Shangshan** in Zhejiang Province



Evolution

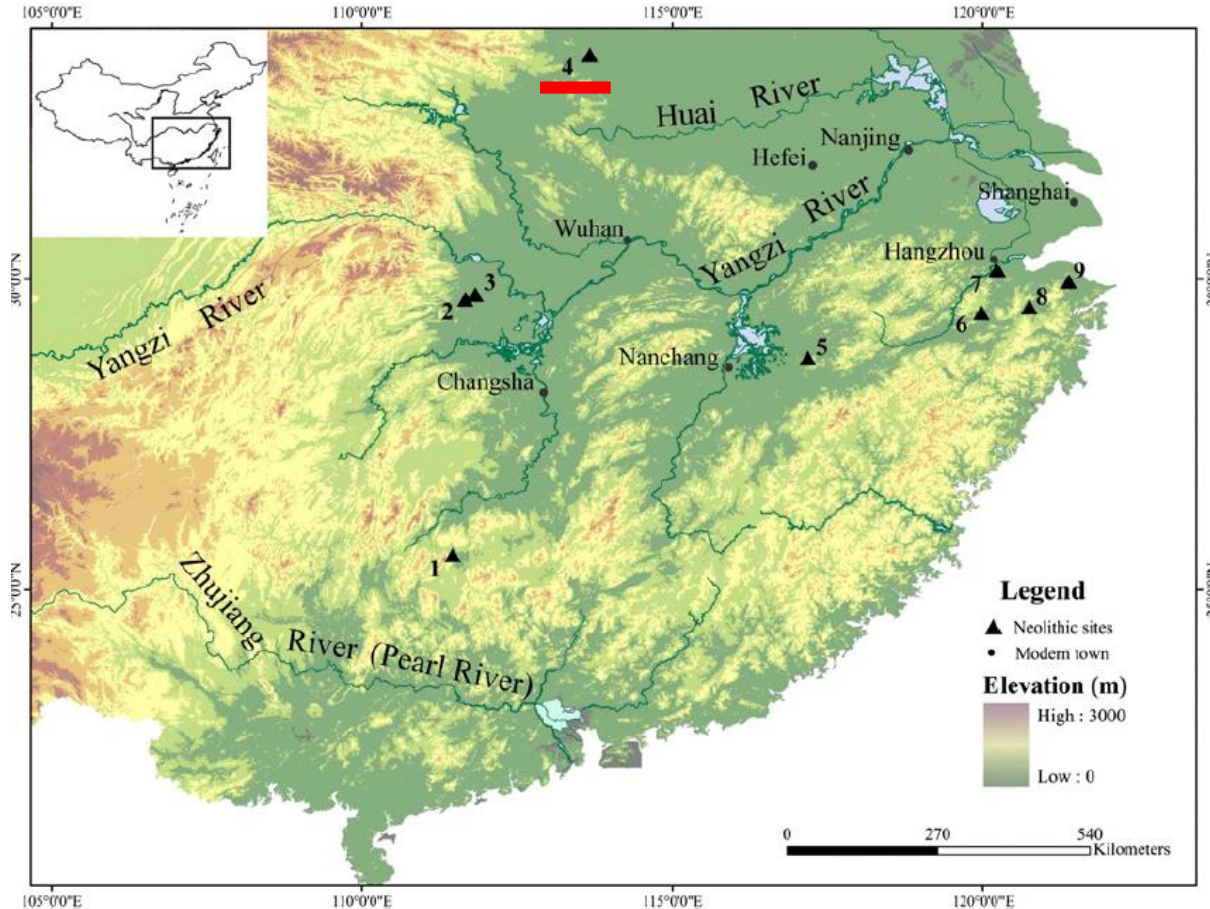
Early history:

- From China (12,000 BP) in Xianrendong and Diaotonghuan in Jiangxi Province, and **Shangshan** in Zhejiang Province



- Gradually moved to Southeast Asia, Persia (Middle East), Europe, Africa and then America
- Shangshan people had high rice demand – early stage of domestication

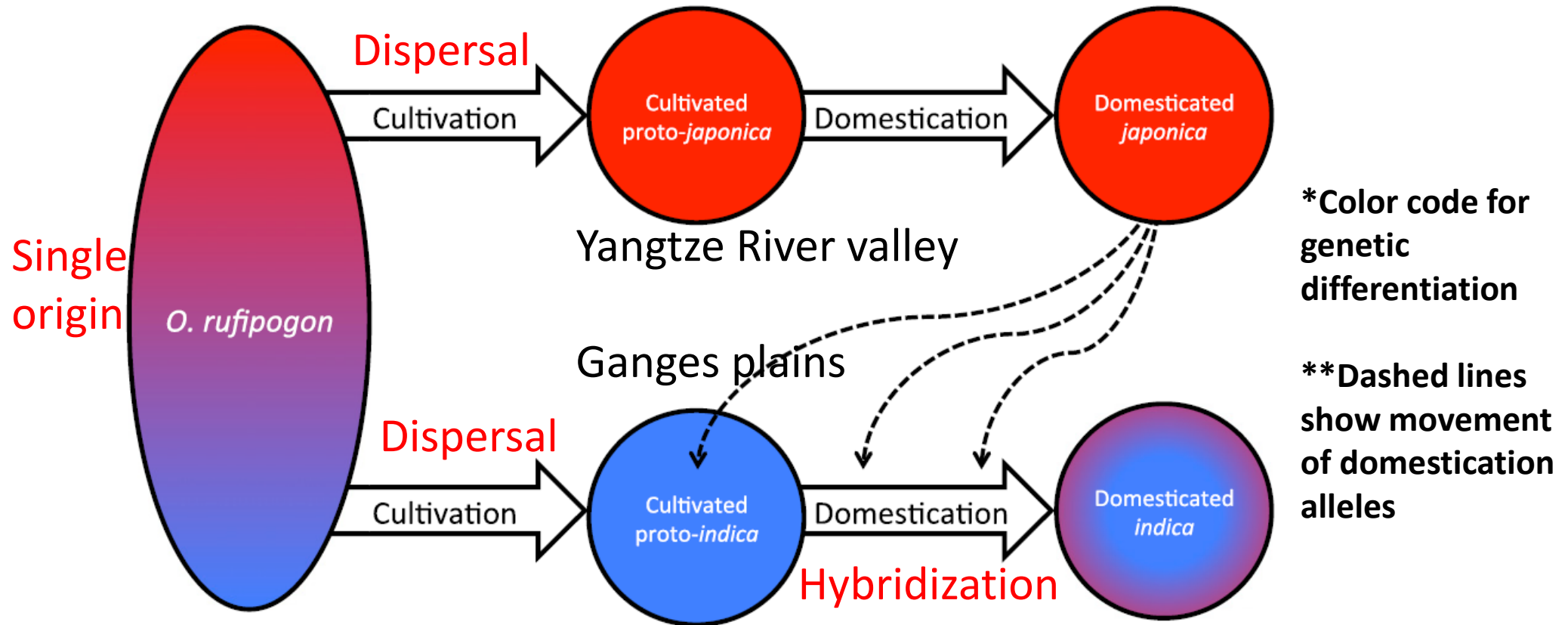
Evolution



Gross and Zhao, 2013

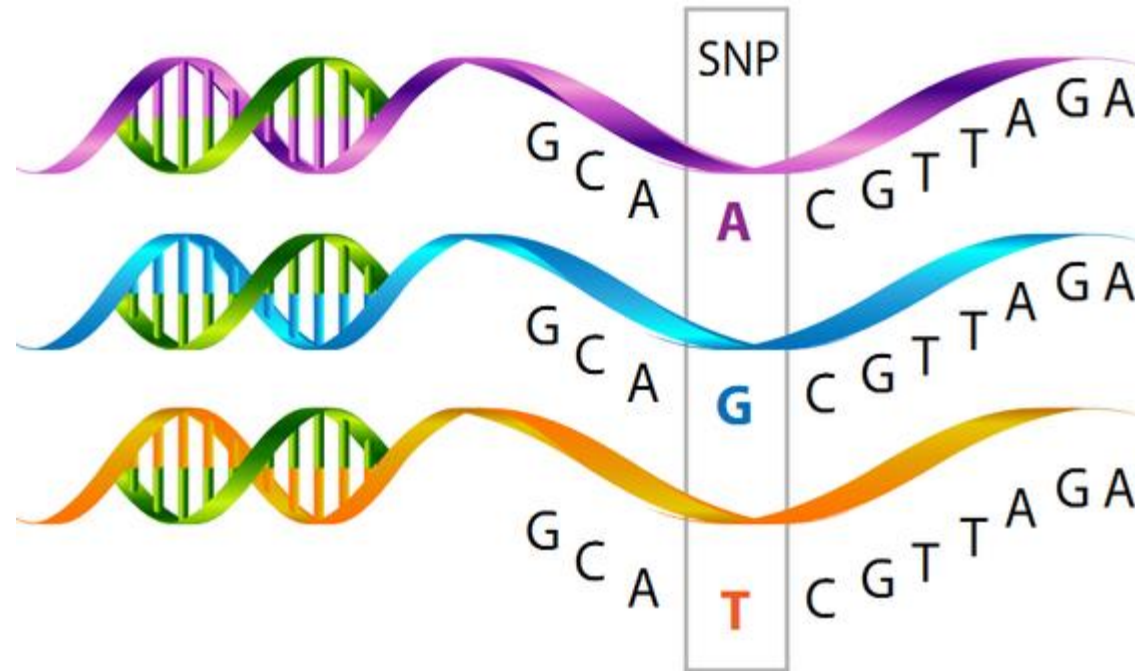
- 125 flotations in Jihau region
- Jihau region (9,000 – 7,800 BP), rice grain phenotypic characteristics similar as modern rice in size and shape
- Rice agriculture established around 8000 BP
- Not the dominant cultivated plant; lotus and chestnut

Evolution



Paper II

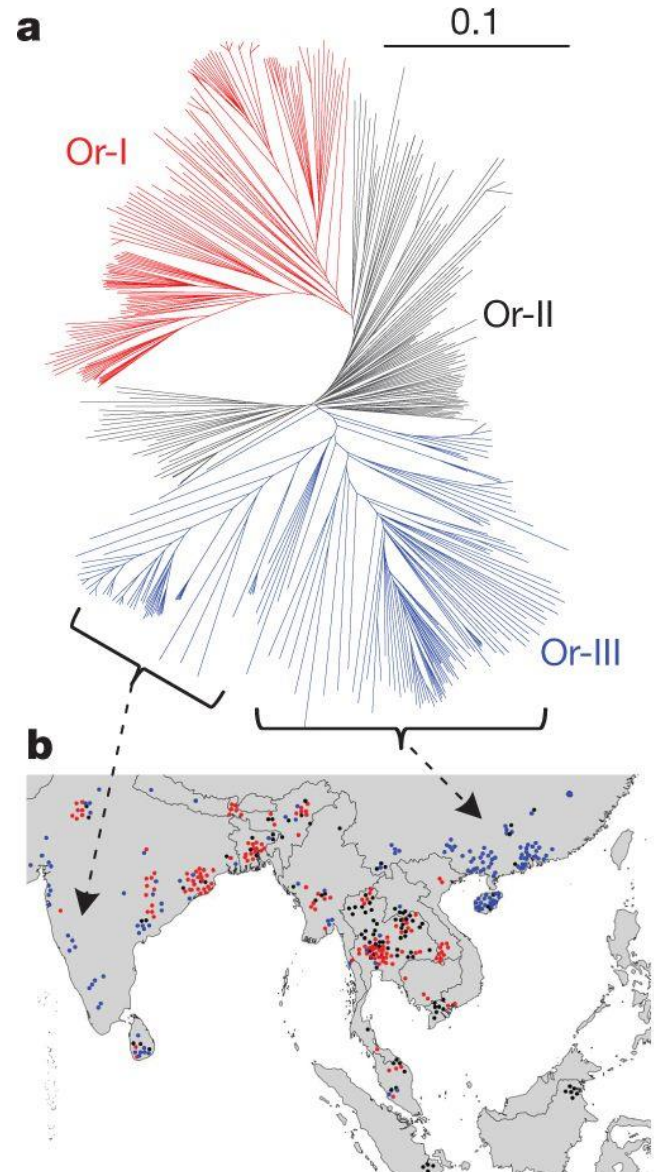
- Single Nucleotide Polymorphism for 630 gene fragments in 446 Wild type *O. rufipogon*, and 1083 *indica* and *japonica* species



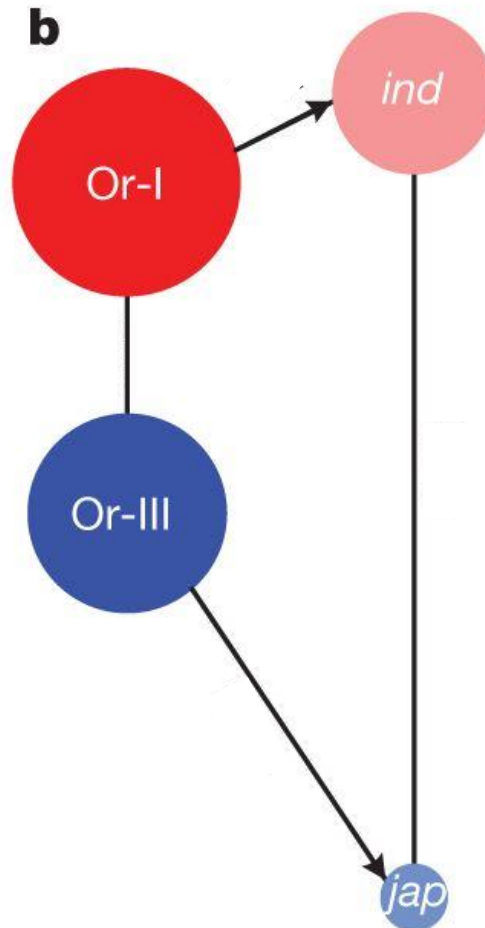
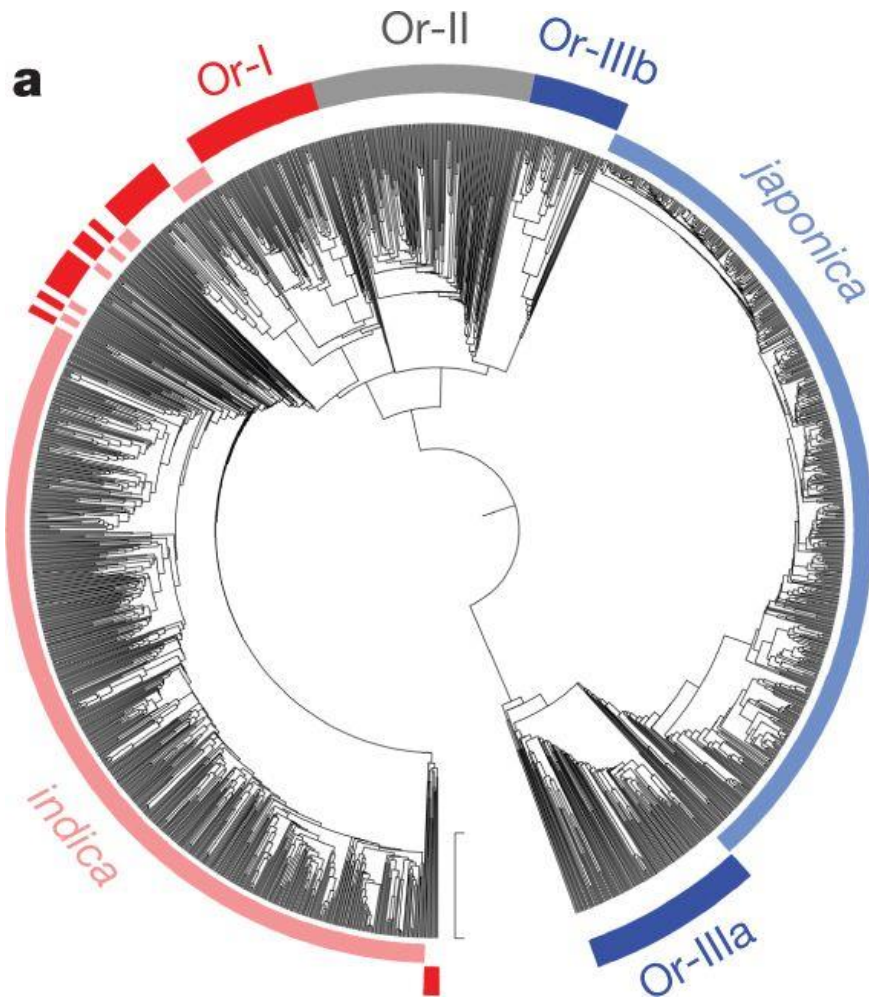
<https://steemit.com/biology/@alv/single-nucleotide-polymorphisms-single-letter-changes-in-dna-provide-road-signs-to-map-human-traits>

Evolution of *O. rufipogon*

- Principal component analysis- three clades of WT
- rice population structure strongly correlated with geographic distribution



Phylogenetic relationships

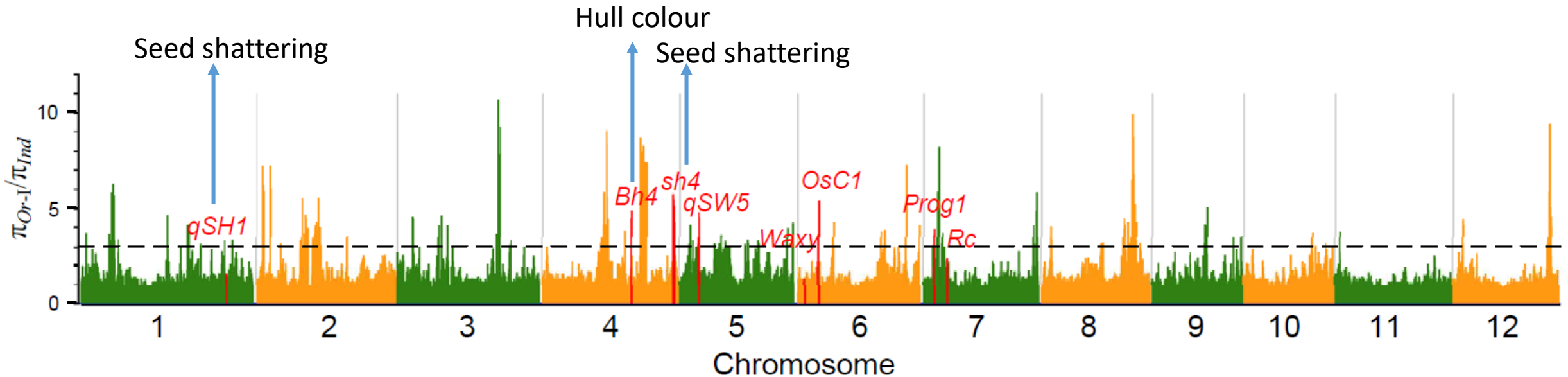


- Whole genome sequencing for 446 WT, and 1083 *O. sativa* : 7,970,359 SNPs
- *indica* contains approximately 75% of the genetic diversity in Or-I
- 33% of the genetic diversity of Or-III persisted in *japonica*

Phylogenetic relationships

- The levels of sequence diversity were calculated in *O. sativa* population (π_c) and *O. rufipogon* population (π_w), respectively, in each 100-kb window, and π_c/π_w was plotted
- Detection threshold/selective sweep was 3.0 (based on permutation tests and software used)

Phylogenetic relationships



Huang et al., 2012

- Whole-genome screens in the population of *O. rufipogon* Or-I and *O. sativa indica*, high positive correlation $R^2 = 0.4$. The loci with known domestication genes are indicated

Phylogenetic relationships

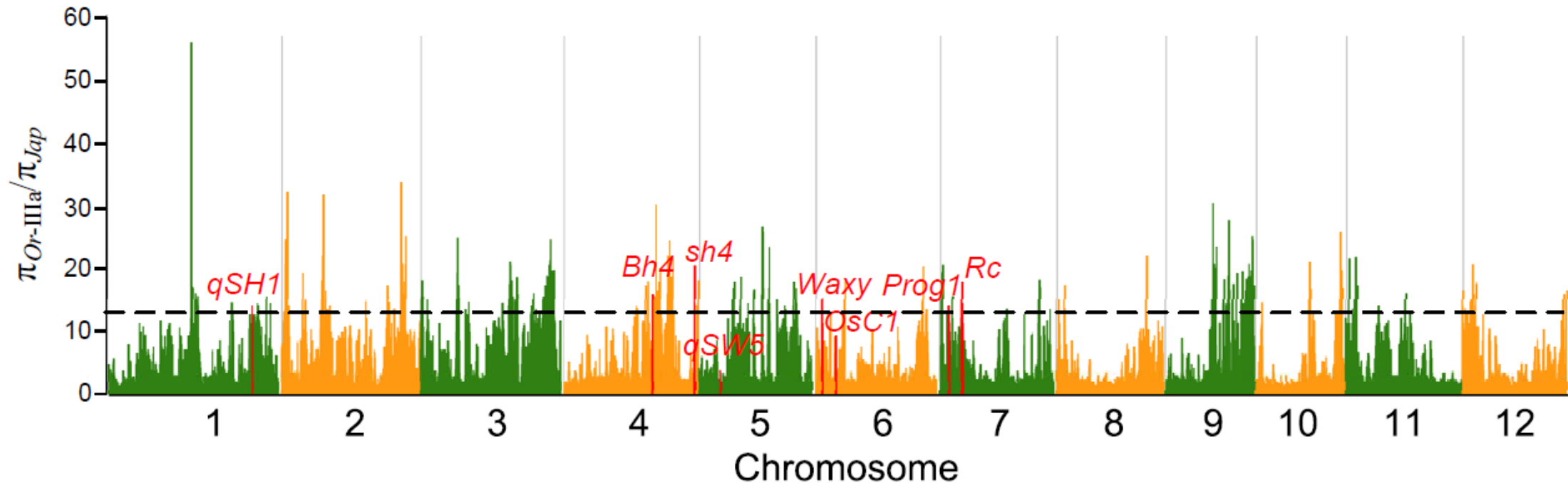
- Seed shattering: Check for natural dispersal of seeds vs human dispersal



wild rice shattering

shattering domesticated rice

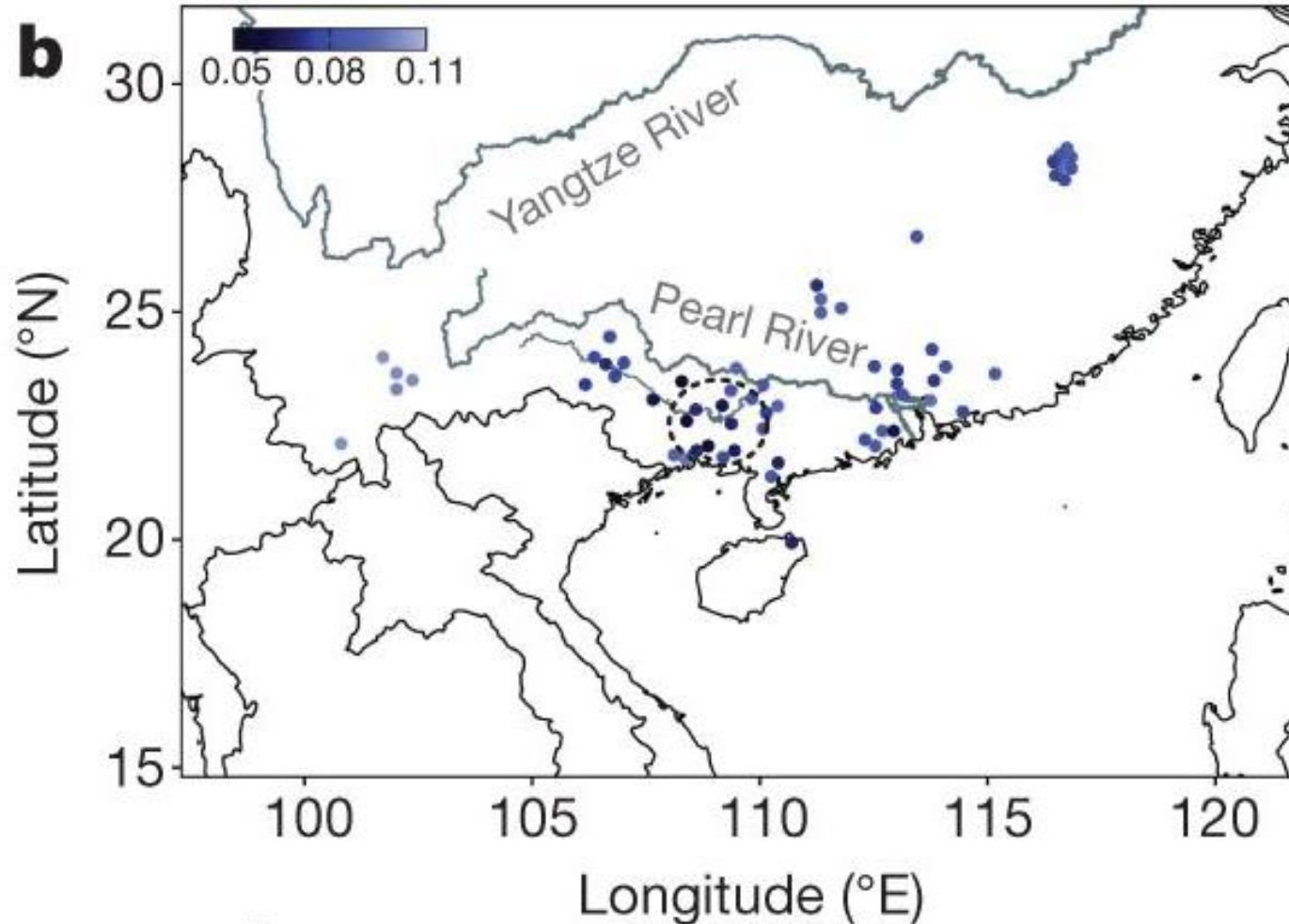
Phylogenetic relationships



Huang et al., 2012

- Whole-genome screens in the population of *O. rufipogon* Or-III and *O. sativa japonica*, high positive correlation $R^2 = 0.5$, detection threshold 15.0

Phylogenetic relationships

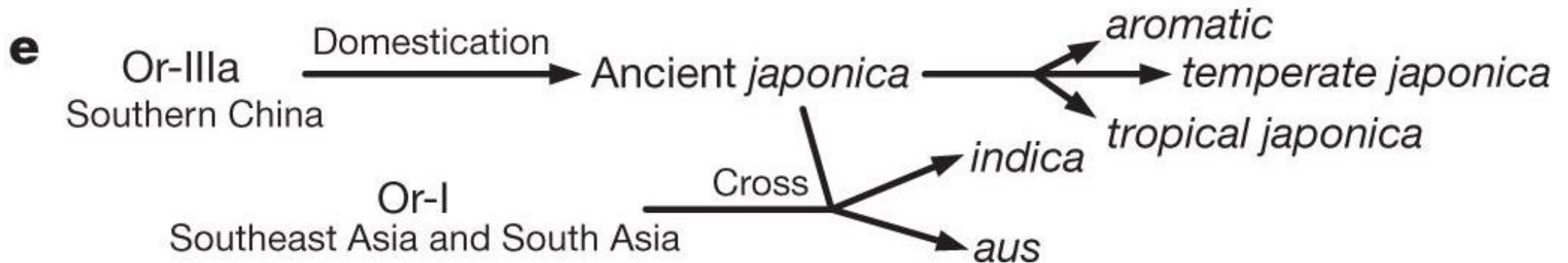


Huang et al., 2012

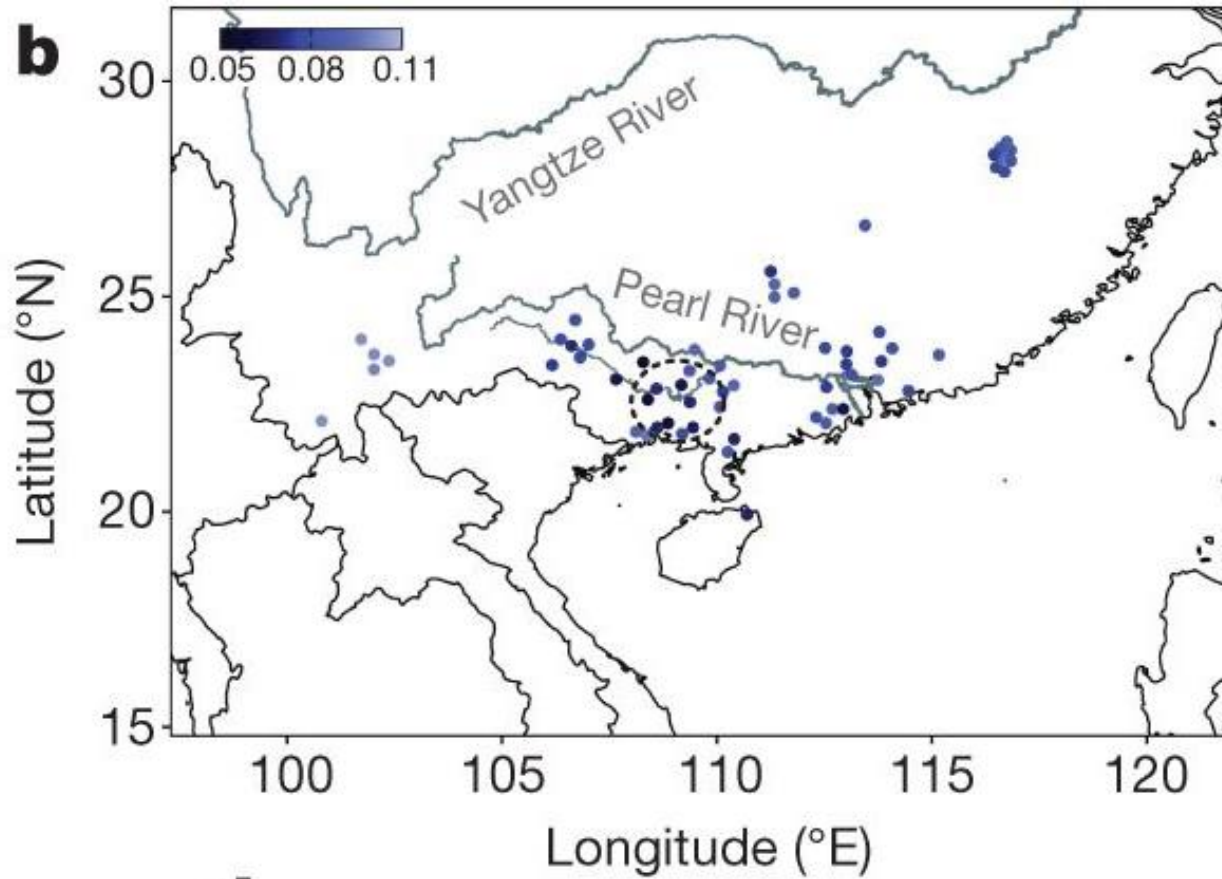
- Calculated the genetic distances between cultivated rice and the wild rice populations from each geographic sampling region through analysis of the genomic regions, **Pearl River: first cultivated rice**

Phylogenetic relationships

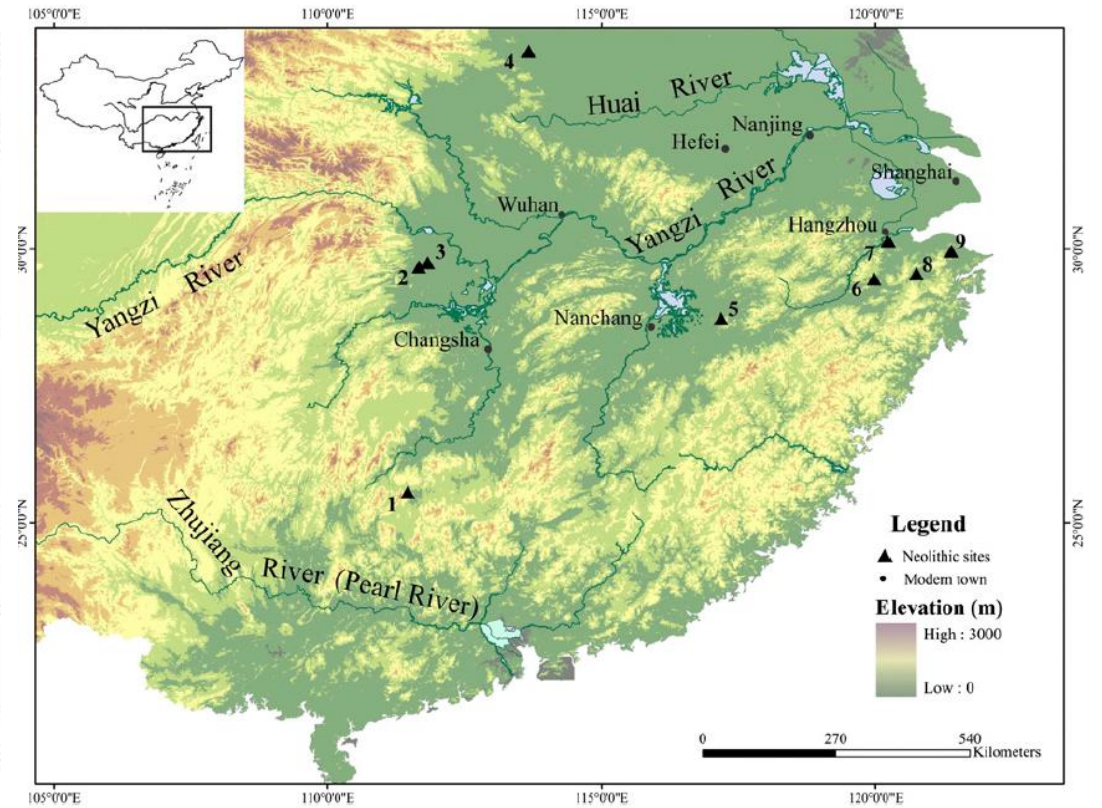
- But they agree *O. japonica* was cultivated first and after subsequent crosses gave rise to *O. indica*.
- Used stimulators to calculate genetic distance between the different clades for stimulated data sets and real data



Summary

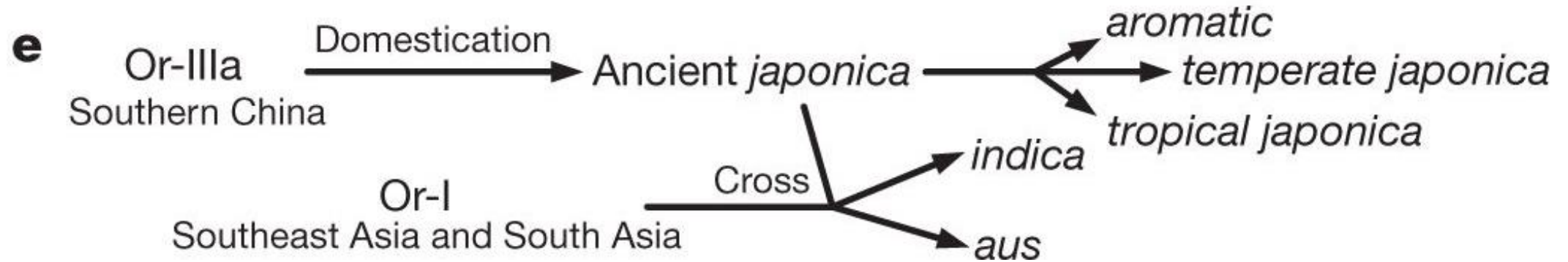


Huang et al., 2012



Gross and Zhao, 2013

Summary



- As early as 1000 BCE, archaeological evidences of wild rice grown in Africa, and it evolved differently from another wild type species- *O. barthii*. No study done on the origin and evolution. 4032 papers on Asian rice evolution, and 103 papers on evolution of African rice.

Questions

Discussion

- Two papers show different data for first evolution and domestication of rice. Which one would be more acceptable based on the method of study?

Thank You

Hypotheses

- (H1) This model suggested that the cultivated rice was domesticated from the annual form first, and the two subspecies *indica* and *japonica* were formed after domestication
- (H2) This model suggested that *indica* and *japonica* were domesticated independently, from different clades of *O. rufipogon*
- (H3) In this model, the two subspecies *indica* and *japonica* were domesticated respectively, and subsequent frequent crosses among the proto-*indica* and proto-*japonica* rice resulted in the shares and fixation of the key domestication alleles.
- (H4) *indica* rice was first domesticated and *japonica* rice was subsequently developed from crosses between *indica* rice and another clade of *O. rufipogon*
- (H5) *japonica* rice was first domesticated and *indica* rice was subsequently developed from crosses between *japonica* rice and another clade of *O. rufipogon*