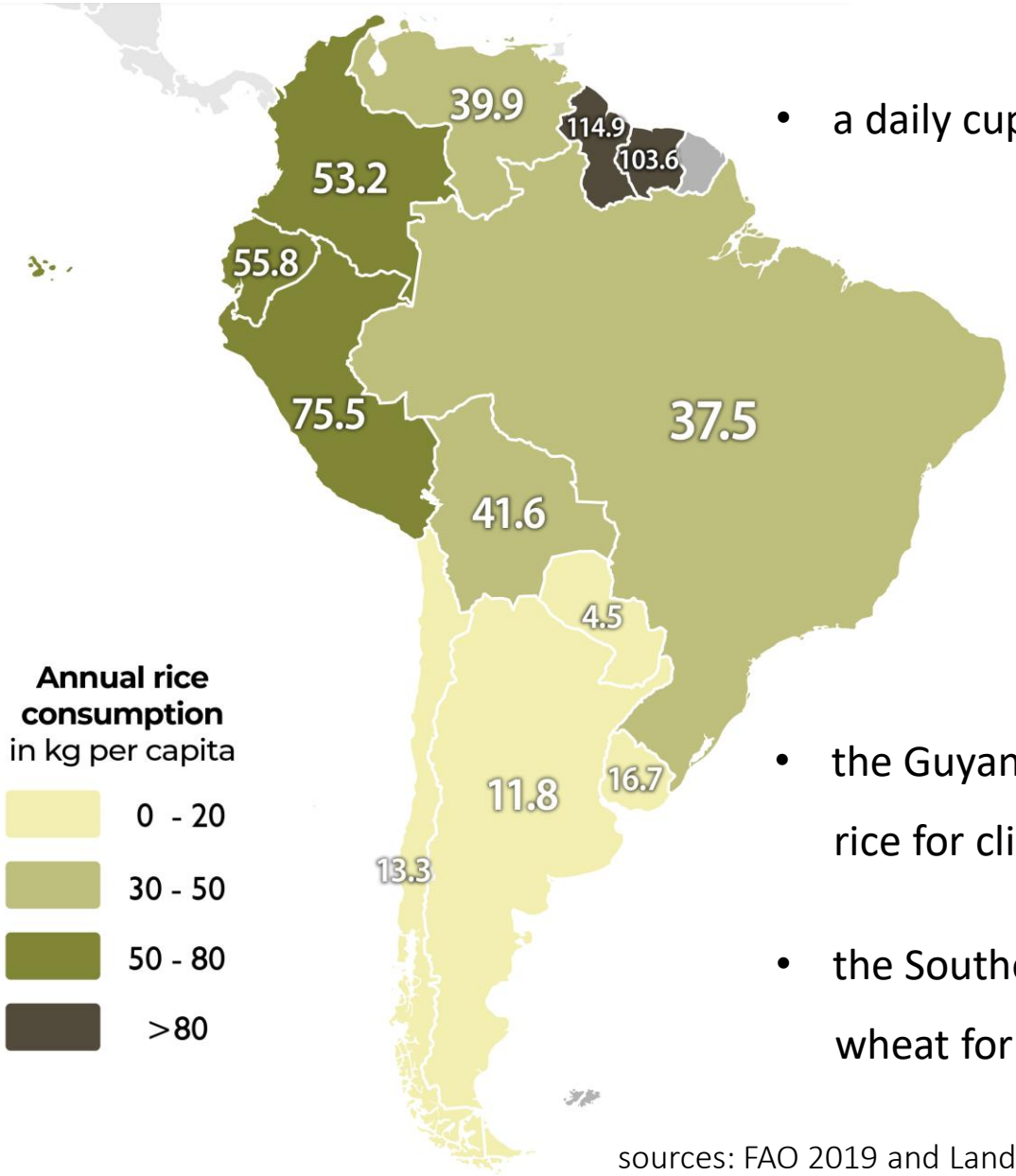
It is five minutes to midnight, Mrs. Rice! : thoughts on American *Oryza*

D.G. Debouck

Cali @ Bogotá, 27 October 2022

Consumption of rice in South America in kg per person



- a daily cup of 100 g gives 36.5 kg/ year

role of good varieties and the private sector to keep prices low throughout the year

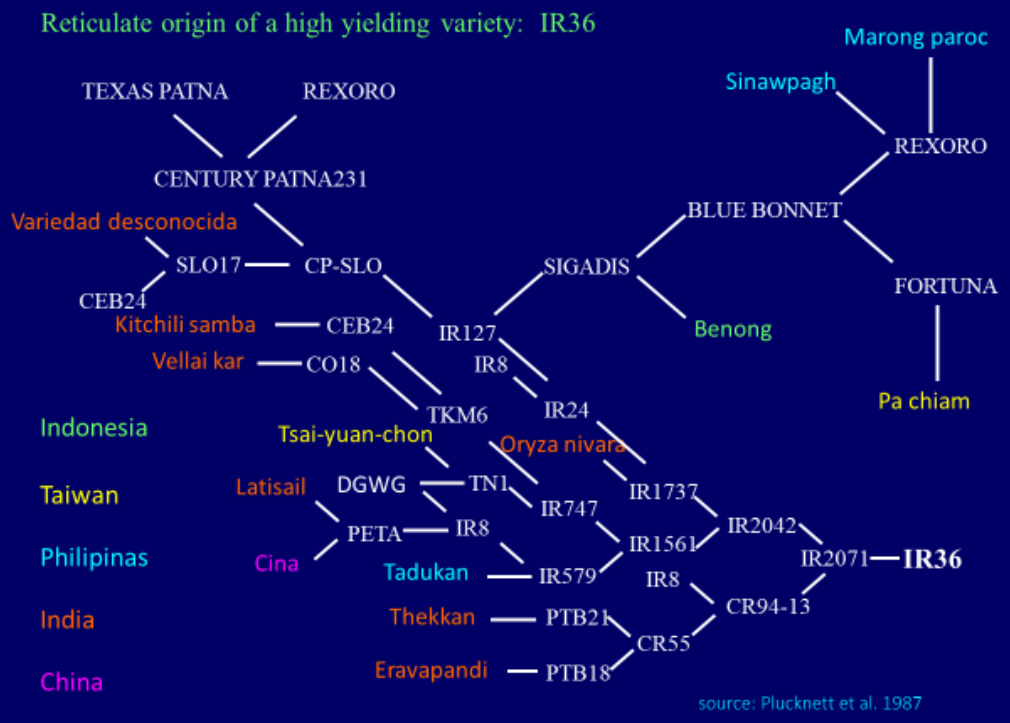
- the Guyanas keep a diet based on rice for climatic and cultural reasons
- the Southern Cone keeps a diet based on wheat for climatic and cultural reasons

sources: FAO 2019 and Landgeist 2022

What does the case of IR36 tell us

in the 1980s it was estimated that over 10% of the world's rice land was sown with this one variety

fuente: Davidson 2006



- the genes of interest come from modern varieties and from landraces
- the date of their coming into being does not matter
- the genes of interest come from various geographic areas, quite unpredictable
- the genes of interest come from the species being improved and others
- the genes of resistance to Grassy Stunt Virus come from *Oryza nivara* only

additional information: Evenson & Gollin 2003, Hargrove et al. 1988

Trait	germplasm
sources of CMS	*glumaepatula* (AA), *rufipogon* (AA)
QTLs for yield increase	*rufipogon* (AA)
resistance to Grassy Stunt Virus	*nivara* (AA)
resistance to Tungro Virus	*latifolia* (CCDD), *rufipogon* (AA)
resistance to bacteriosis	*longistaminata* (AA)
resistance to blast	*longiglumis* (HHJJ)
resistance to leafhopper	*officinalis* (CC)
tolerance to acid soils	*brachyantha* (FF)
tolerance to drought	*australiensis* (EE)
tolerance to shade	*granulata* (GG)
tolerance to low temperatures	*granulata* (GG)
tolerance to salinity	*coarctata* (HHKK)

sources: Atwell et al. 2014, Brar & Khush 1997, Ikeda et al. 1994, Jena 2010, Khush 1997, Khush et al. 1990
Khush & Ling 1974, McCouch et al. 2007

Tropical America (4?) **Africa (7)** **Asia (13)** **Australia (2)**

Oryza: a genus with 26+ species

Diploid species (16)

Tropical America (4?)	Africa (7)	Asia (13)	Australia (2)
glumaepatula (AA)	*glaberrima* (AA)	*sativa* (AA)	*meridionalis* (AA)
	barthii (AA)	*nivara* (AA)	*australiensis* (EE)
	longistaminata (AA)	*rufipogon* (AA)	
	punctata (BB)	*officinalis* (CC)	
	eichingeri (CC)	*rhizomatis* (CC)	
	brachyantha (FF)	*granulata* (GG)	
		meyeriana (GG)	

Parodi 1933:
Oryza subulata

Tetraploid species (10)

Tropical America (4?)	Africa (7)	Asia (13)	Australia (2)
alta (CCDD)	*punctata* (BBCC)	*longiglumis* (HHJJ)	*schlechteri* (HHKK)
latifolia (CCDD)		*malampuzhaensis* (BBCC)	*minuta* (BBCC)
grandiglumis (CCDD)		*ridleyi* (HHJJ)	*coarctata* (HHKK)

sources: Jena 2010, Nishikawa et al. 2005, Vaughan & Sitch 1991, Vaughan & Morishima 2003, Vaughan et al. 2003

From: *Species Plantarum*

by Carl Linnaeus, 1753, page 333

HEXANDRIA TRIGYNIA. 333

ciminibus 5 vidi; at in vivis circiter 6 Loefling. Si hujus ordo naturalis ſit n. XL, numerus naturalis erit ſtaminum ſex, ſi vero XLII, erit quinque.

ORYZA.

1. ORYZA. *Bauh. pin.* 24. *theatr.* 479. *Cam. epit.* 192. *ſativa. Dod. pempt.* 509. *Catesb. car.* 1. *p.* 14. *t.* 14. *Hort. cliff.* 137. *Mat. med.* 174. *Roy. lugdb.* 58.
Habitat forte in Æthiopia, *colitur in* Indiæ *paludoſis.* ⊙

ATRAPHAXIS.

1. ATRAPHAXIS ramis ſpinoſis. *Hort. cliff.* 138. *ſpinoſa. Roy. lugdb.* 409.
Atriplex orientalis, frutex aculeatus, flore pulchro.

Cultivated in the swamps of India; possibly in Ethiopia

Reported as annual

the unique species reported by Linnaeus, also in 1762

but curiously there is no definition of the genus nor the species!

Oryza sativa L.

source: Hitchcock 1950

the name for the Asian rice crop, domesticated twice in E Asia from *O. rufipogon*

Oryza glaberrima Steudel

From: *Synopsis Plantarum Graminearum*

by Ernst Gottlieb Steudel, 1855, page 3

patula; spiculis sparsis pedicellatis; glumis valvulisque muticis. Leersia latifolia. *Willd.* herb. 2|. Madagascar.

13. O. GLABERRIMA. *Steud.* Caule simplici cum omnibus partibus glaberrimo, striato; foliis lanceolato-linearibus vaginisque longissimis striatis, margine carinaque laevissimis; panicula contracta racemosa; axibus triquetris laevissimis; spiculis alternis, glaberrimis, vix pedicellatis, glumis apice subglanduloso obtusiusculo, omnibus muticis. Legit *Jardin* in Guinea.

14. O. PREHENSILIS. *Nees.* (Fl. Afr. austr. I. 194 sub: Maltebrunia.) Culmo ramosissimo; foliis subsessilibus hirtis margine carinaque aculeolis recurvis armatis; panicula

glumes awnless!, usually dark colored; reddish caryopses

no collection number, no precise location, but *fide* Portères 1955:

a collection made by Désiré Édélestan Jardin in 1845-48

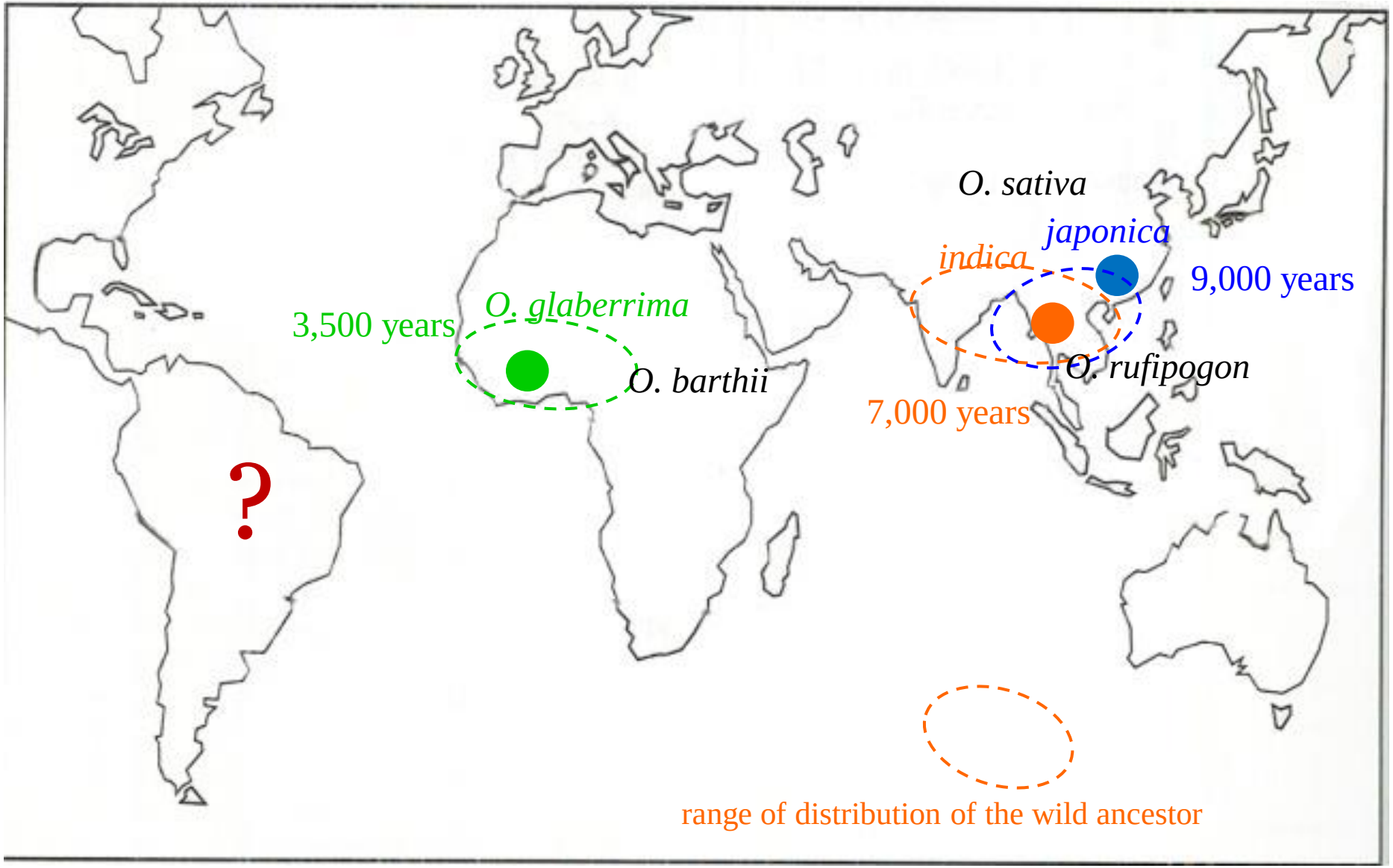
collected in the Los Islands (off Guinea Conakry)

could have "no. 9" as collecting number

the name for the African rice crop, independently domesticated in W Africa from *O. barthii*

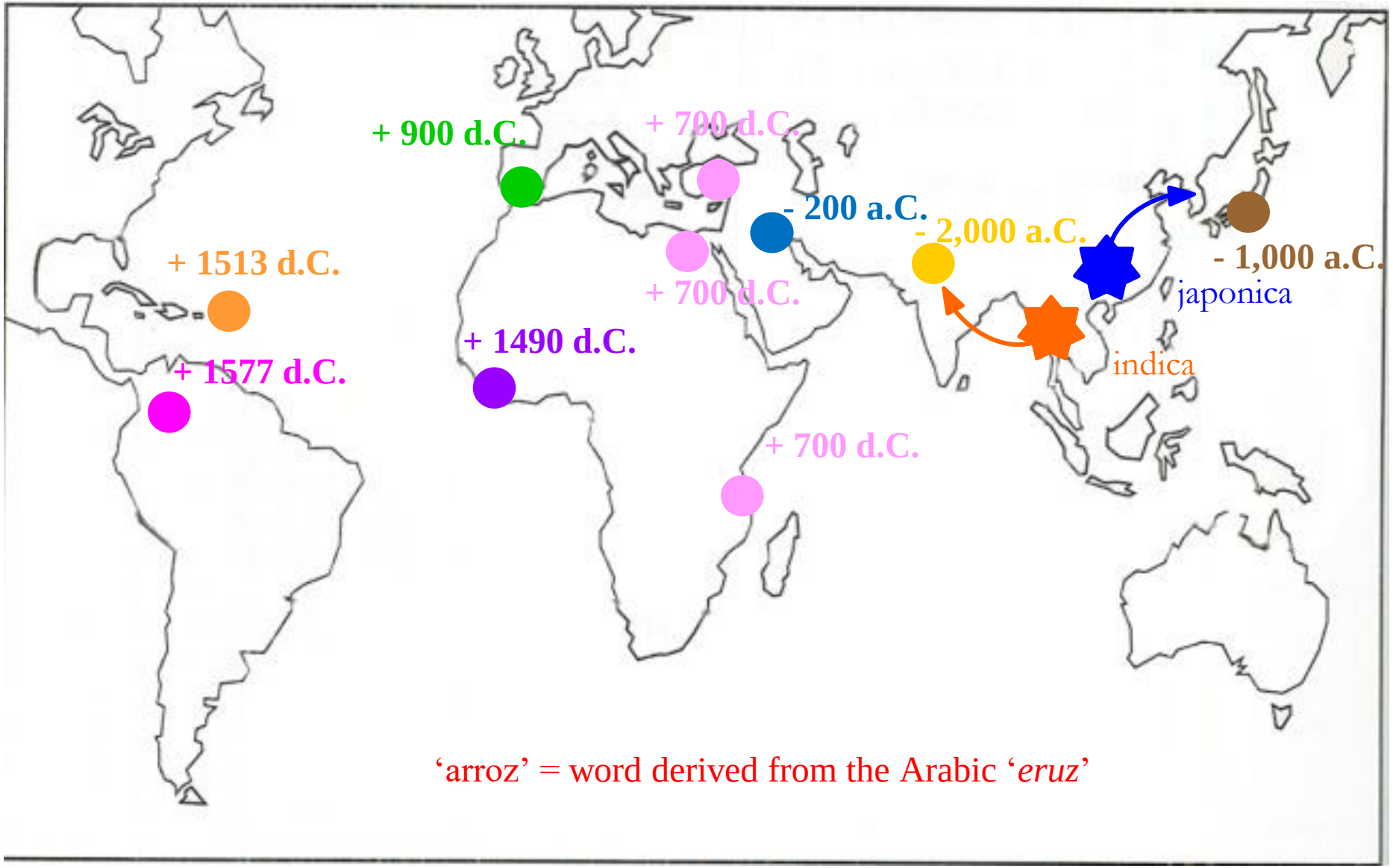
additional information: Portères 1950, 1955, Van Andel et al. 2016, Wang et al. 2014

Areas and dates of domestication (b.P.)



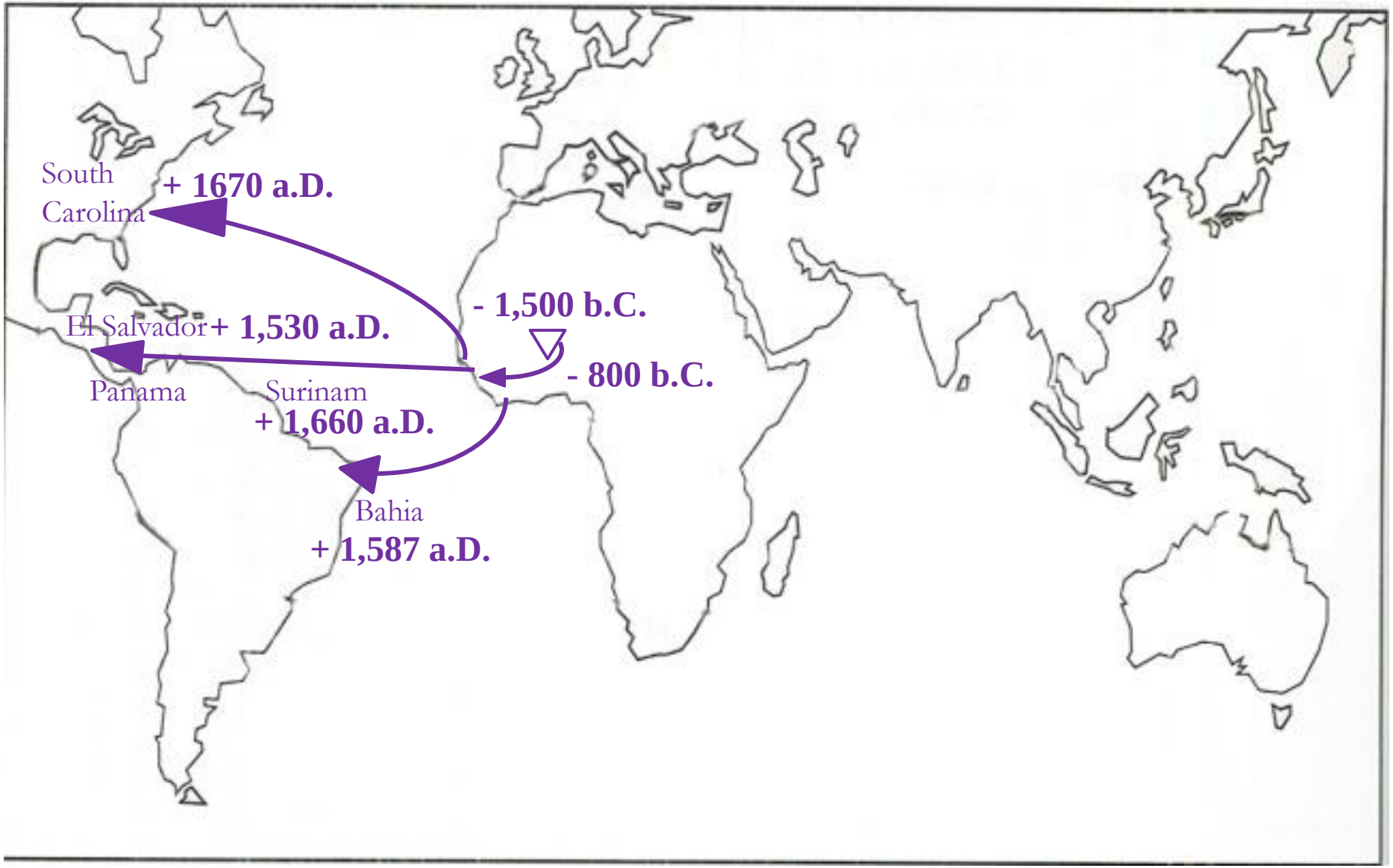
sources: Cheng et al. 2003, Choi et al. 2017, Civán et al. 2015, Gross & Zhao 2014, Gutaker et al. 2020, Londo et al. 2006
Molina et al. 2011, Vaughan & Morishima 2003, Vitte et al. 2004, Wang et al. 2014

The migrations of *O. sativa*



sources: Besançon & Second 1984, Carney 2001, Linares 2002, Patiño 1969, Sauer 1993

The migrations of *O. glaberrima*

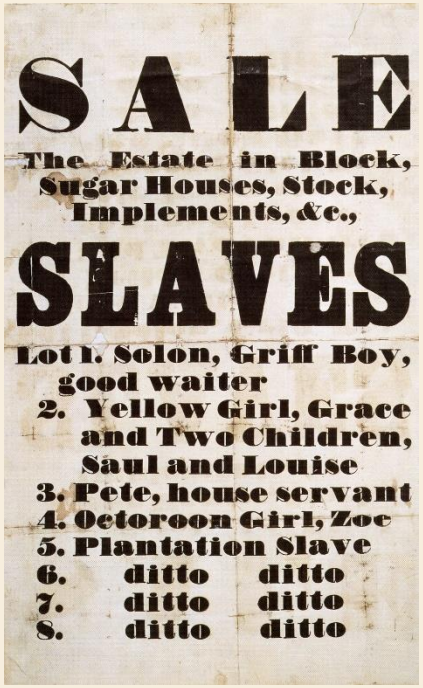


sources: Carney 2001, 2005, Linares 2002, Portères 1950, 1976, Van Andel 2010, Van Andel et al. 2016, 2019

Introduction of slavery and irrigated rice system in the New World

daily logbook of Captain Samuel Gamble coast of Guinea-Conakry in 1793-1794

add, Alabama, 1850


SALE

The Estate in Block, Sugar Houses, Stock, Implements, &c.,

SLAVES

Lot 1. Solon, Griff Boy, good waiter
2. Yellow Girl, Grace and Two Children, Saul and Louise
3. Pete, house servant
4. Octoroon Girl, Zoe
5. Plantation Slave
6. ditto ditto
7. ditto ditto
8. ditto ditto

- arrival of first slaves into Hispaniola in 1505 and in South Carolina in 1670
- documentation about *Oryza glaberrima* in South Carolina in 1696 and in Surinam in 1800
- documentation about *Oryza glaberrima* in French Guyana in 1938 and in El Salvador in 1959

Forced migration of people from western Africa estimated at 9.5 millions in 1505-1888

Contrast between rice and sugarcane cropping systems for slavery conditions

sources: Carney 2001, Littlefield 1991, Mintz 1991, Portères 1955, 1960, van Andel 2010

The evidence brought by phytoliths

- minutos crystals of silicium present in the tissues of grasses
- if appropriately selected they can help identify genera and species
- the crystals found in the glumes separate *Oryza sativa* from the wild taxa

sources: Pearsall 1989, Thomasson 1987, Zhao et al. 1998

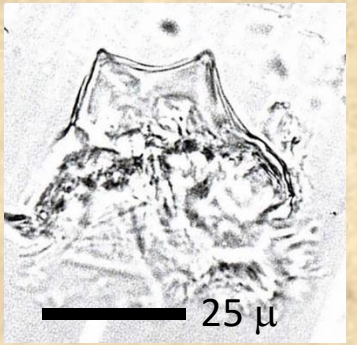


foto: Zhao

Archaeological findings in Monte Castelo:

- ✓ rice phytoliths analyzed: those of the glumes
- ✓ size of rice phytoliths increases since 4,000 years b.P.
- ✓ density of rice phytoliths increases during that period
- ✓ presence of maize phytoliths during the same period
- ✓ presence of carbon: straw burning after the harvest?
- ✓ tentative identification: *O. glumaepatula*, that thrieves nearby

fuente: Hilbert et al. 2017

Harvest of wild rice, *Zizania aquatica*, in the Great Lakes of North America

this harvest method does not promote the increase in seed size

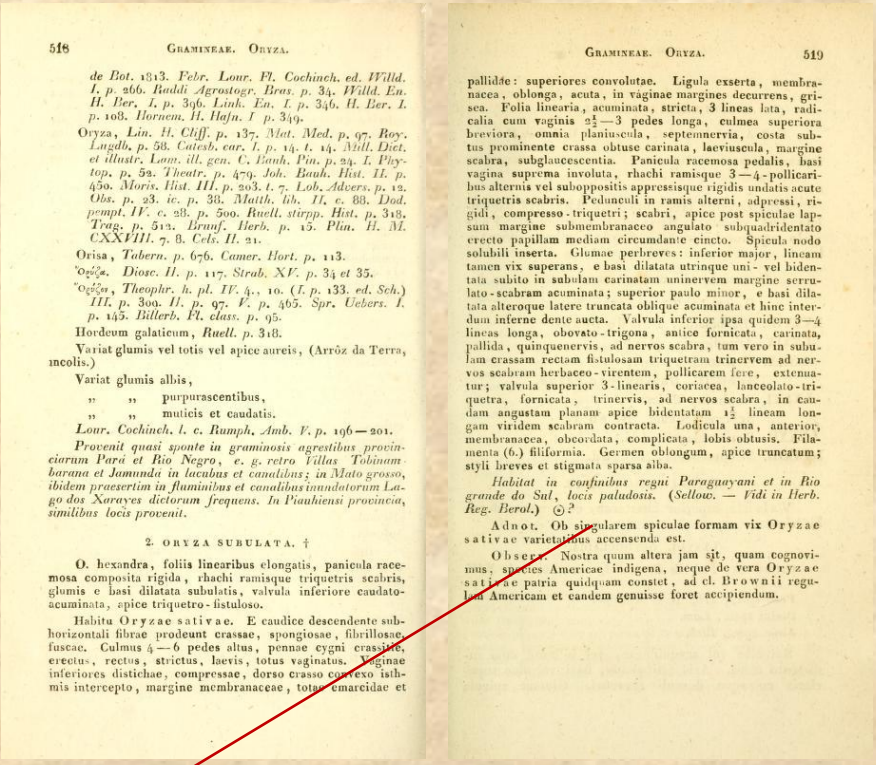
source: Stickney 1896

Ojibwa women of Eastern Wisconsin in September

Oryza subulata Nees

From: *Agrostologia Brasiliensis*

by Christian Gottfried Nees, 1829, pages 518-9



518 GRAMINEAE. ORYZA.

de Bot. 1813. *Febr. Lour. Fl. Cochinch. ed. Willd. I. p.* 266. *Raddi Agrostogr. Bras. p.* 34. *Willd. En. H. Ber. I. p.* 396. *Link. En. I. p.* 346. *H. Ber. I. p.* 108. *Hornem. H. Hafn. I p.* 349.

Oryza, *Lin. H. Cliff. p.* 137. *Mat. Med. p.* 97. *Roy. Lugdb. p.* 58. *Catesb. car. I. p.* 14. *t.* 14. *Mill. Dict. et illustr. Lam. ill. gen. C. Bauh. Pin. p.* 24. *I. Phytop. p.* 52. *Theatr. p.* 479. *Joh. Bauh. Hist. II. p.* 450. *Moris. Hist. III. p.* 203. *t.* 7. *Lob. Advers. p.* 12. *Obs. p.* 23. *ic. p.* 38. *Matth. lib. II. c.* 88. *Dod. pempt. IV. c.* 28. *p.* 500. *Ruell. stirpp. Hist. p.* 318. *Trag. p.* 512. *Brunf. Herb. p.* 15. *Plin. H. M. CXXVIII.* 7. 8. *Cels. II.* 21.

Orisa, *Tabern. p.* 676. *Camer. Hort. p.* 113.

Ὄρυζα. *Dioscor. II. p.* 117. *Strab. XV. p.* 34 *et* 35.

Ὄρυζα, *Theophr. h. pl. IV.* 4, 10. (*I. p.* 133. *ed. Sch.*) *III. p.* 300. *II. p.* 97. *V. p.* 465. *Spr. Uebers. I. p.* 145. *Billerb. Fl. class. p.* 95.

Hordeum galaticum, *Ruell. p.* 318.

Variat glumis vel totis vel apice aureis, (Arrôz da Terra, incolis.)

Variat glumis albis,

„ „ purpurascentibus,

„ „ muticis et caudatis.

Lour. Cochinch. l. c. Rumph. Amb. V. p. 196—201.

Provenit quasi sponte in graminosis agrestibus provinciarum Pará et Rio Negro, e. g. retro Villas Tobinambarana et Jamunda in lacubus et canalibus; in Mato grosso, ibidem praesertim in fluminibus et canalibus inundatorum Lago dos Xarayes dictorum frequens. In Piauhiensi provincia, similibus locis provenit.

2. ORYZA SUBULATA. †

O. hexandra, foliis linearibus elongatis, panicula racemosa composita rigida, rhachi ramisque triquetris scabris, glumis e basi dilatata subulatis, valvula inferiore caudato-acuminata, apice triquetro-fistuloso.

Habitu Oryzae sativae. E caudice descendente subhorizontali fibrae prodeunt crassae, spongiosae, fibrillosae, fuscae. Culmus 4—6 pedes altus, pennae cygni crassitie, erectus, rectus, strictus, laevis, totus vaginatus. Vaginae inferiores distichae, compressae, dorso crasso convexo isthmis intercepto, margine membranaceae, totae emarcidae et

GRAMINEAE. ORYZA. 519

pallidae: superiores convolutae. Ligula exserta, membranacea, oblonga, acuta, in vaginae margines decurrens, grisea. Folia linearia, acuminata, stricta, 3 lineas lata, radicalia cum vaginis $2\frac{1}{2}$—3 pedes longa, culmea superiora breviora, omnia planiuscula, septemnervia, costa subtus prominente crassa obtuse carinata, laeviuscula, margine scabra, subglaucescentia. Panicula racemosa pedalis, basi vagina suprema involuta, rhachi ramisque 3—4-pollicaribus alternis vel suboppositis appressisque rigidis undatis acute triquetris scabris. Pedunculi in ramis alterni, adpressi, rigidi, compresso-triquetri; scabri, apice post spiculae lapsum margine submembranaceo angulato subquadridentato erecto papillam mediam circumdante cincto. Spicula nodo solubili inserta. Glumae perbreves: inferior major, lineam tamen vix superans, e basi dilatata utrinque uni- vel bidentata subito in subulam carinatam uninervem margine serrulato-scabram acuminata; superior paulo minor, e basi dilatata alteroque latere truncata oblique acuminata et hinc interdum inferne dente aucta. Valvula inferior ipsa quidem 3—4 lineas longa, obovato-trigona, antice fornicata, carinata, pallida, quinquenervis, ad nervos scabra, tum vero in subulam crassam rectam fistulosam triquetram trinervem ad nervos scabram herbaceo-virentem, pollicarem fere, extenuatur; valvula superior 3-linearis, coriacea, lanceolato-triquetra, fornicata, trinervis, ad nervos scabra, in caudam angustam planam apice bidentatam $1\frac{1}{2}$ lineam longam viridem scabram contracta. Lodicula una, anterior, membranacea, obcordata, complicata, lobis obtusis. Filamenta (6.) filiformia. Germen oblongum, apice truncatum; styli breves et stigmata sparsa alba.

Habitat in confinibus regni Paraguayani et in Rio grande do Sul, locis paludosis. (*Sellow. — Vidi in Herb. Reg. Berol.*) ☉?

Adnot. Ob singularem spiculae formam vix Oryzae sativae varietatibus accensenda est.

Observ. Nostra quum altera jam sit, quam cognovimus, species Americae indigena, neque de vera Oryzae sativae patria quidquam constet, ad cl. Brownii regulam Americam et eandem genuisse foret accipiendum.

source: Nicora & Rúgolo 1987

specimen collected by Friedrich Sellow (s.n.) in E Paraguay

also present in Rio Grande do Sul in Brazil

type lost in Berlin ("Vidi in Herb. Reg. Berol.") in 1943?

considered as *Oryza* by Chevalier (1932), Parodi (1933) and Roschevicz (1931)

From: *Mémoire sur les Graminées*

by Nicaise Augustin Desvaux, 1813, page 77

mis sub-lenticularibus, pilosius culis. *Colitur in* Indiâ.

2. Orysa latifolia, Desv. caule elato; foliis lanceolatis acutis glaberrimis, ligula occultata brevissima; panicula laxa maxima, ramis verticillatis, glumellis pilosis ovatis minutis, arista brevissima. *Habitat in* Carolina, insulâque Portorici.

Cette espèce est parfaitement distincte par ses feuilles et la disposition de ses rameaux, de toutes les variétés du riz cultivé : mais elle se rapproche de la variété ζ pour la forme des glumelles.

according to Albert Spear Hitchcock (1927) this is an error;

therein he claimed it to be present in Brazil and Ecuador

specimen collected by Louis Ventenat in Puerto Rico

possibly around Laguna de Piñones east of San Juan

(65º 56'W, 18º 24'N) in 1790-1800

according to Chevalier (1932) this specimen is not the type

Oryza latifolia Desvaux

From: *Oryzeae monographice describuntur*

by Alice Prodoehl, 1922, page 233

Paraguay, bei Itape (Balansa nr. 270).

12. Oryza grandiglumis Prod. nov. spec. - Oryza sativa var, grandiglumis Döll in Mart. Flor. Brasil. II.2. (1871) 8.

Valida, certe metralis vel ultra. Culmi teretes, laeves, cum nodis glabri. Vaginae culmi quam internodia longiores vel raro breviores, nervo medio haud distincto praeditae obtuse carinatae, margine nunc raro glabrae nunc saepius pilis longis pubescentibus instructae, fauce subauriculatae. Ligulae breves, in fibrillas tenues solutae vel basin usque fissae. Laminae basi paullo rotundatim contractae, lanceolatae, nervo medio pervalido apicem versus evanescente praeditae, suberectae, membranaceae, margine pilis erectis scabrae, utraque facie praesertim apicem versus scabriusculae, usque ad 0,36 m longae. Inflorescentia longe stipitata, multiflora, dense panniculata, late pyramidata, suberecta, usque ad 0,25 m longa; axi validissimo, angulato, ad inflorescentiae insertionem lanato cet. glabro. Ramuli perlongi (ad 0,15 m) inferiores densissime conferti superiores remotiusculi, scabri, saepe ad ⅓ - ½ longit. steriles. Spiculae strictae, pedicellis paleas usque ad ½ aequantibus, apice paullo incrassatis stipitatae, per anthesin patulae. Glumae 2 superiores paleas ad 5/6 aequantes, vel iis subaequilongae, profunde sulcatae, lanceolatae, ad carinas setosulae, scabriusculae, mucronatae, coriaceae, punctato-striatae. Paleae item punctato-striatae, profunde sulcatae, ad carinas setosulae; inferior a latere visa lanceolata, scabriuscula, longe ciliatim mucronata; superior angustior, paullo mucronata, subfalcata, margine zona hyalina instructa. Stamina 6.

Brasilien (Riedel nr. 1261).

Oryza grandiglumis (Döll) Prodoehl

source: Kew Herbarium 2022

Collected by Ludwig Riedel as 1261 in Matto Grosso, Brazil

possibly collected on bank of river Guaporé in April 1828

(15º 10'S, 59º 45'W), between Matto Grosso and Cuiabá

holotype in WIR Saint Petersburg, Russia; isotype in K Kew, England

originally described by Döll (1871) as a variety of *O. sativa*

From: *The grasses of British Honduras and the Petén . . .*

by Jason Richard Swallen, 1936, page 156

Oryza alta Swallen

2. *Oryza alta* Swallen sp. nov.

Oryza latifolia var. *grandispiculis* Chevalier. Rev. Bot. Appl. 12: 1027. 1932 (in part). Two specimens are cited, *Dahlgren* and *Sella* 60 collected at Boa Vista, Pará, Brazil, and *Morong* 949 collected near the Pilcomayo River, Paraguay. The first better fits the description.

Perennis; culmi erecti, 3-4 m. alti, glabri; vaginæ internodiis breviores, auriculatæ, marginibus hispido-ciliatæ; laminæ planæ, acuminatæ, 25-80 cm. longæ, 20 to 28 mm. latæ, scaberulæ, marginibus scabris; ligula membrancea, hispido-ciliata, 5 mm. longa; panicula 30-40 cm. longa, languida, ramis ad 15 cm. longis basi nudis; spiculæ 8-9 mm. longæ, appressæ; glumæ acuminatæ, lunatæ, 4 mm. longæ; lemma carina et marginibus hispidis; arista scabra 2-3 cm. longa.

Perennial; culms erect or leaning, 3 to more than 4 m. tall, glabrous; sheaths shorter than the internodes, auriculate, glabrous, the margins usually hispid-ciliate; ligule membranaceous, lacerate to hispid ciliate, 5 mm. long; blades flat, acuminate, 25 to 80 cm. long, 20 to 28 mm. wide, scaberulous, the margins scabrous-serrulate; panicles open, drooping, 30 to 40 cm. long, the branches rather distant, densely pilose in the axils, naked on the lower half, the lower whorled, as much as 15 cm. long; spikelets 8 to 9 mm. long, appressed on the short branchlets, the lateral short-pedicellate, the terminal long-pedicellate; glumes lunate, narrow, acuminate, 1-nerved, about half as long as the spikelet; lemma minutely pitted, hispid on the keels and margins, unsymmetrically narrowed at the summit to a short scabrous beak, terminating in a scabrous or somewhat appressed-hispid awn 2 to 3 cm. long; palea slightly longer than the lemma, similar in texture, terminating in a hispid beak about 1 mm. long.

Type in the U. S. Nat. Herb. Nos. 1614041 and 1614042, collected in water, margin of the Amazon at Obidos, Pará, Brazil, July 19-20, 1934, by *Jason R. Swallen* (No. 5116).

Swamps, margins of rivers and lakes, British Honduras, Brazil, and Paraguay.

BRITISH HONDURAS. Stann Creek District: Stann Creek, *Schipp* 889.

BRAZIL. Pará: Obidos, *Swallen* 5116. Boa Vista, Tapajos River, *Swallen* 3186; *Dahlgren* and *Sella* 60. Pará, *Myers* 2646.

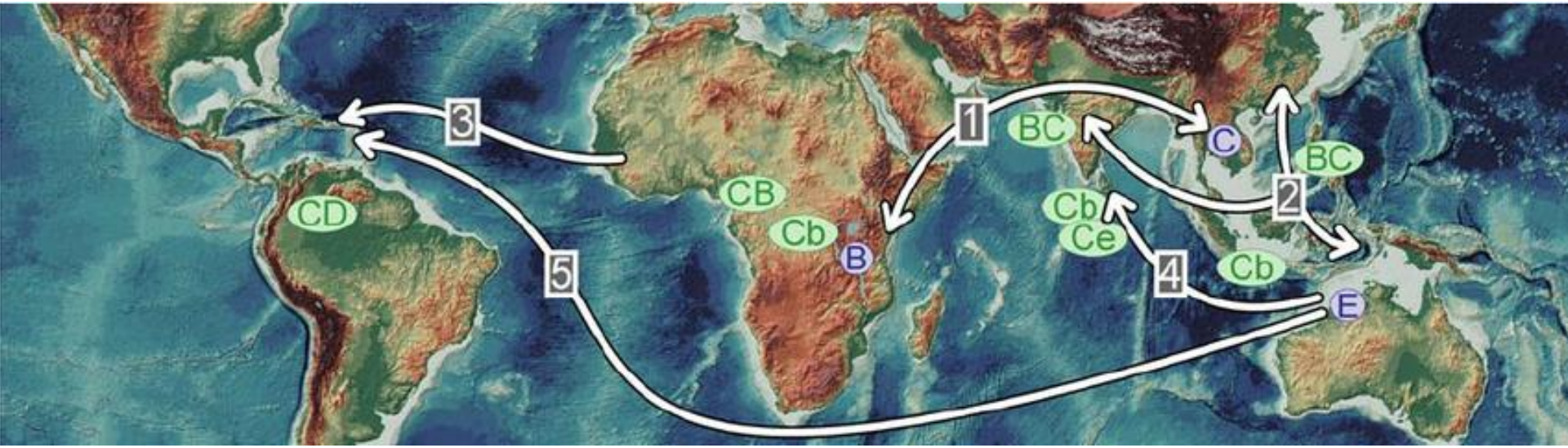
PARAGUAY. Lake Ypacaray: *Hassler* 12602, 12602a.

source: US National Herbarium 2022

it is a wild species because of shattering

collected by JR Swallen as 5116 near Obidos (1º 56'S, 55º 29'W), state of Pará, Brazil in July 1934

The CCDD genome in tropical America explained by G. Second and G. Rouhan (2008)

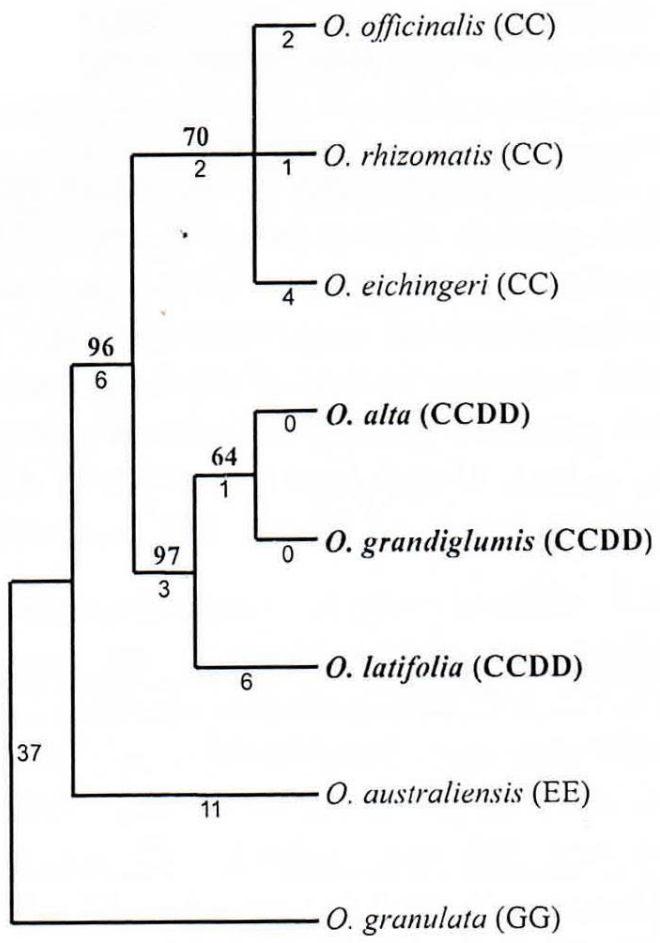


source: Second & Rouhan 2008

- Donor of the C genome: *O. officinalis* (CC) of tropical Asia (India to New Guinea)
- D genome not found so far in the whole genus, thus no DD species
- D genome seems related to the E genome, found only in *O. australiensis* (the sole EE species so far)
- C x E cross: F1 is completely sterile in pollen and seed; equal chromosomal pairing at meiosis only 38%
- **all** *Oryza* materials are post-Columbian introductions (only *Rhynchoryza subulata* is ancient)
- all *O. glumaepatula* (A genome) would be weeds derived from *O. glaberrima* and/ or *O. sativa*
- the D genome never exists, the E changed as pollen contributor when allopolyploidization occurred
- *O. latifolia* came first and the other two CCDD differentiated over the last 350 years

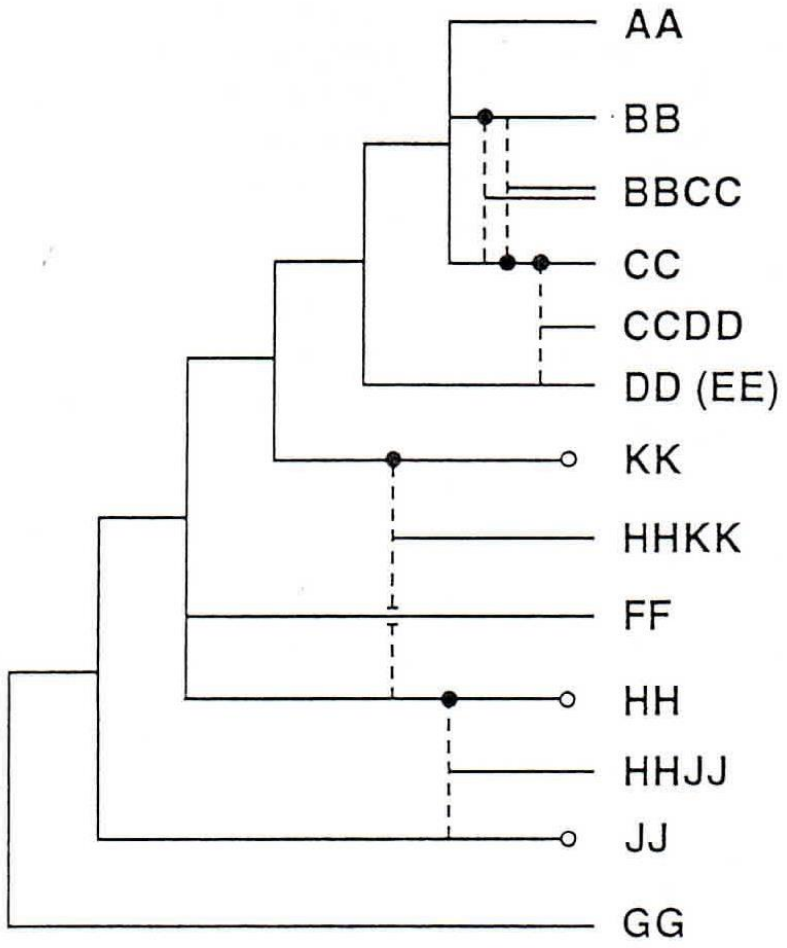
sources: Katayama 1982, Second 1989, Second & Rouhan 2008, Vaughan & Morishima 2003

Parsimonious tree on 2 cpDNA fragments



source: Bao & Ge 2004

Hypothesis based on 3 gene phylogenies



source: Ge et al. 1999

- the AA genome would be the one of most recent diversification
- the EE genome would be at the root of the CCDD genome
- *O. latifolia* would precede *O. alta* and *O. grandiglumis* (with 3 plastotypes: Dally & Second 1990)

Oryza glumaepatula Steudel

From: *Synopsis Plantarum Graminearum*

by Ernst Gottlieb Steudel, 1855, page 3

ramoribus flavescentibus; panicula magna; aristis brevibus; semine oblongo majusculo glutinoso plerumque albissimo, nigro vel rubro. Habitat in aquosis et in siccis. ⊙ Cochinchina.

5. O. GLUMAEPATULA. *Steud.* Foliis linearibus elongatis margine retrorsum scabris in lamina glabris; panicula racemoso subcontracta; glumis lanceolatis erecto-patulis albidis; valvulis setoso-hispidis, altera mutica altera aristata, aristis longissimis fructibus oblongis. O. sativa. *Hochst.* in Hrbo. *Hostm.* nr. 1195. ⊙ Culta in Surinam.

6. O. PUNCTATA. *Kotschy* (in litt.). Foliis linearibus glauco-viridibus margine laminaque retrorsum scabris; panicula racemosa subcontracta; glumis lanceolatis subad-

reported as annual

Culta in Surinam, not crescens in Surinam: cultivated?!

collected by F. W. Hostmann as 1195 in 1840 (?)

spikelets falling apart, thus wild!

not a *glaberrima*: long awn, glumes straw color

Multiple crosses between wild *Oryza* of AA genome

Brasil

Guyana F

Surinam

Australia

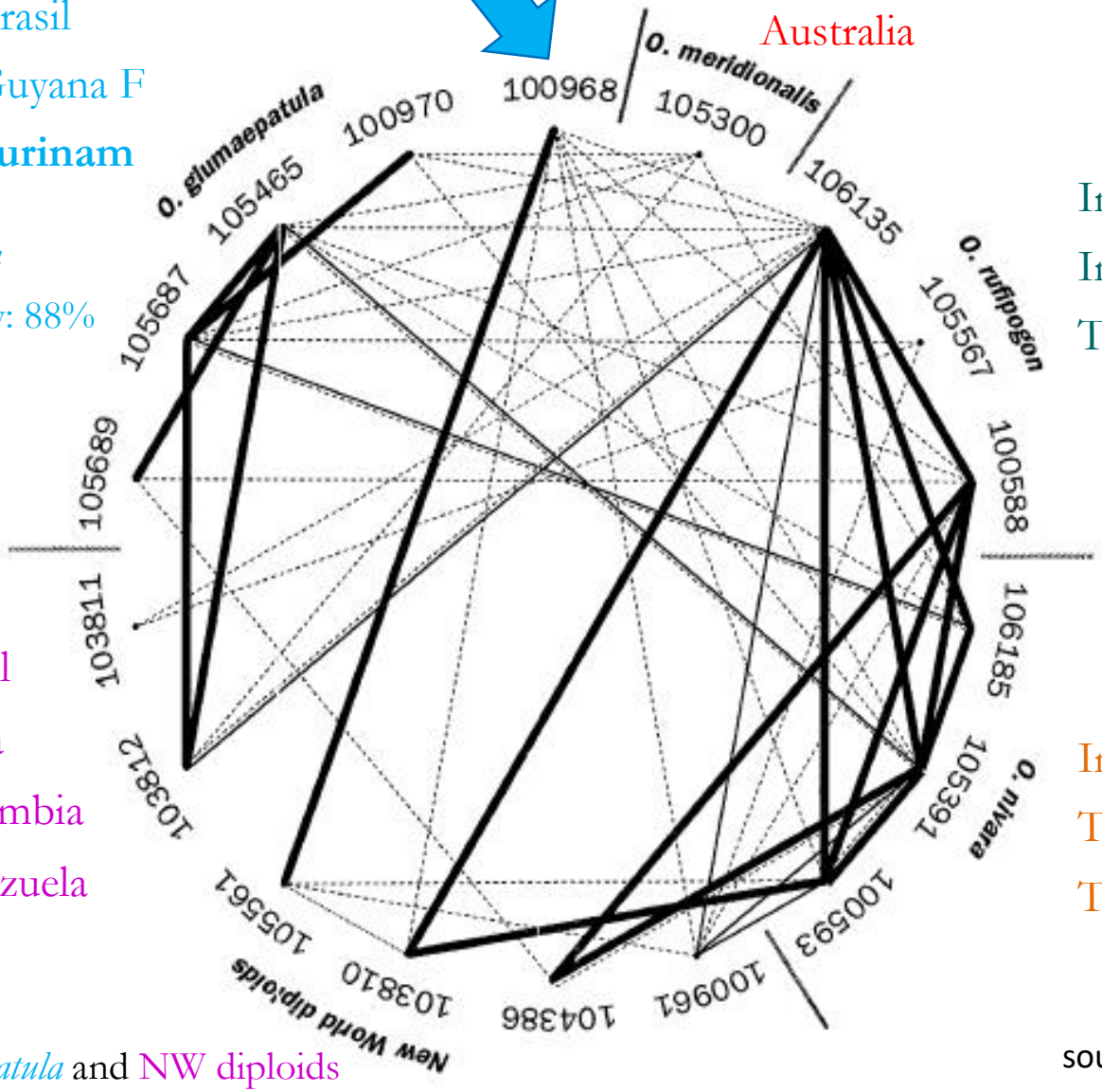
India

Indonesia

Taiwan

within *glumaepatula*

F1 spikelet fertility: 88%



Brasil

Cuba

Colombia

Venezuela

India

Thailandia

Taiwan

between *glumaepatula* and NW diploids

F1 spikelet fertility: 0.3-87%

within New World diploids

F1 spikelet fertility: 0.2-4%

source: Naredo et al. 1998

Spikelet fertility

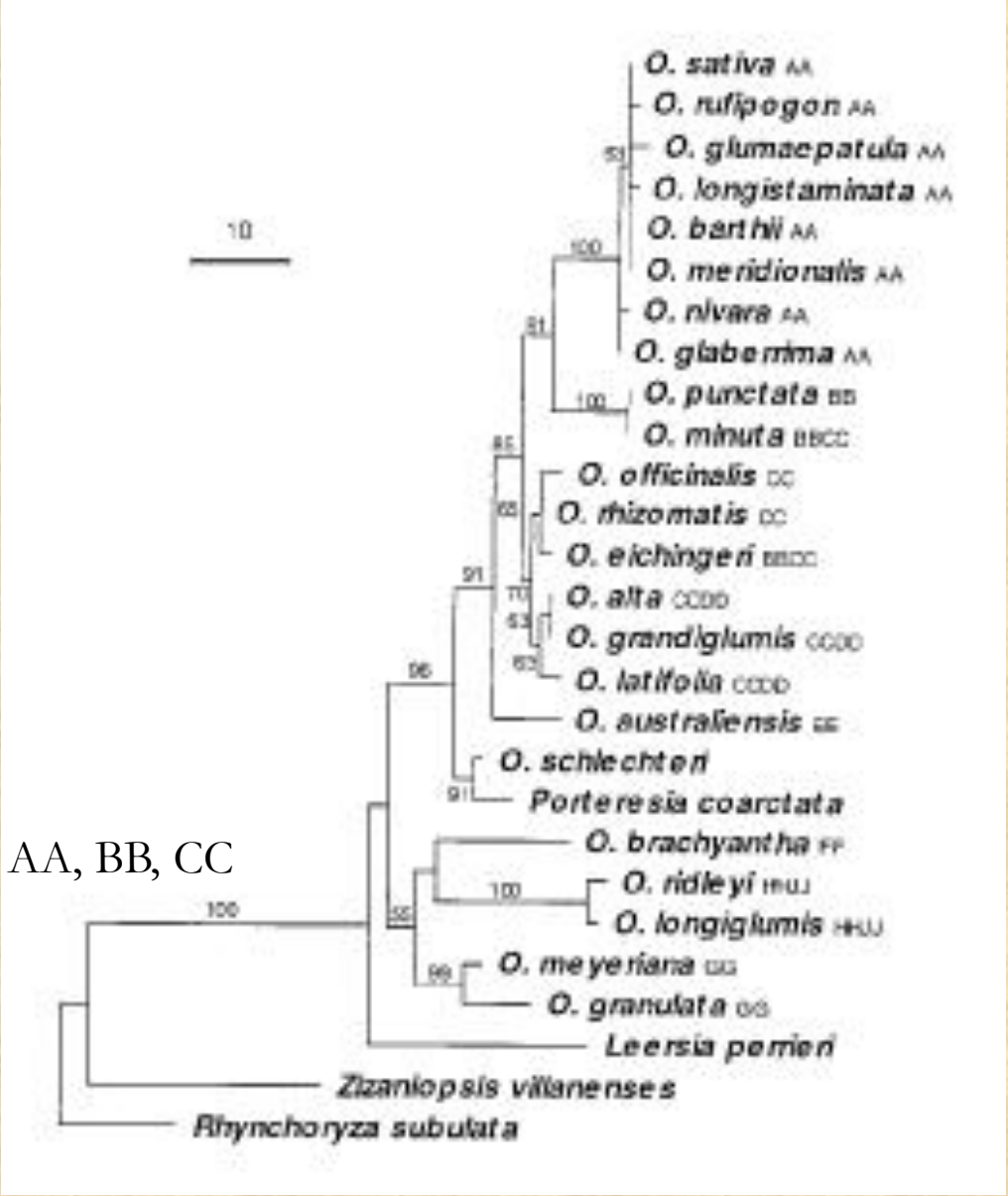
0 – 4.9%

5 – 20%

>20%

Most parsimonious tree from cpDNA *mat*K gene

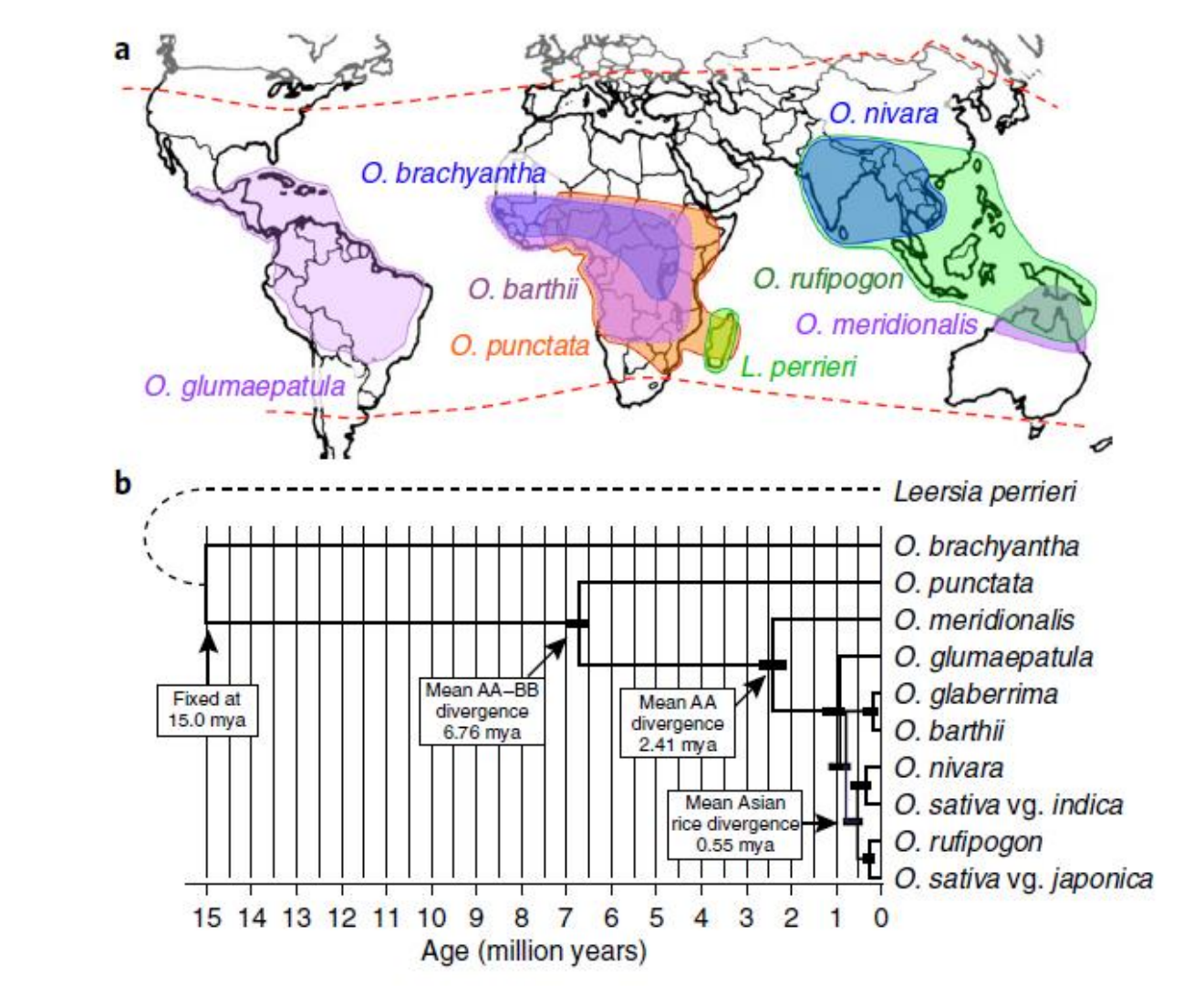
- cpDNA maternally inherited in rice
  (Corriveau & Coleman 1988)
- *O. subulata* seems a true outgroup
- *P. coarctata* should be back in *Oryza*
  (Ge et al. 2002)
- *O. latifolia* would be the root of CCDD
- *O. alta* and *O. grandiglumis*: sister species
- *O. australiensis* (EE) would be the root of AA, BB, CC
- all AA species of recent divergence



source: Ge et al. 1999

Phylogeny of AA rice genomes

- *O. meridionalis* would be separating from the rest of AA 2.4 mi years ago
- *O. meridionalis* (Australia) would be the root of the rest of AA
- *O. glumaepatula* of 1 mi years has affinities with *O. barthii*
- *O. nivara* would separate from *O. rufipogon* 0.5 mi years ago

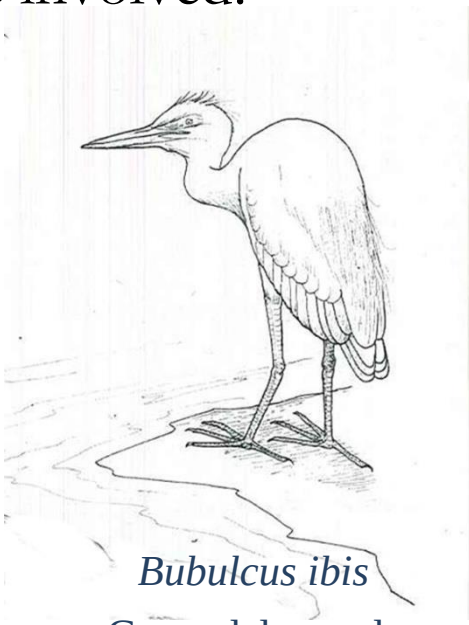


source: Stein et al. 2018

American *Oryza* (AA and CCDD): would birds be involved?

Have birds brought the AA and/ or CC genome from Africa?

"Se encuentra en terreno seco . . . siguiendo a los arados en busca de insectos y otros pequeños animales. Oriunda de África, esta especie ha invadido todo el continente americano.", H Alvarez-López, 1999, p. 30.



Bubulcus ibis

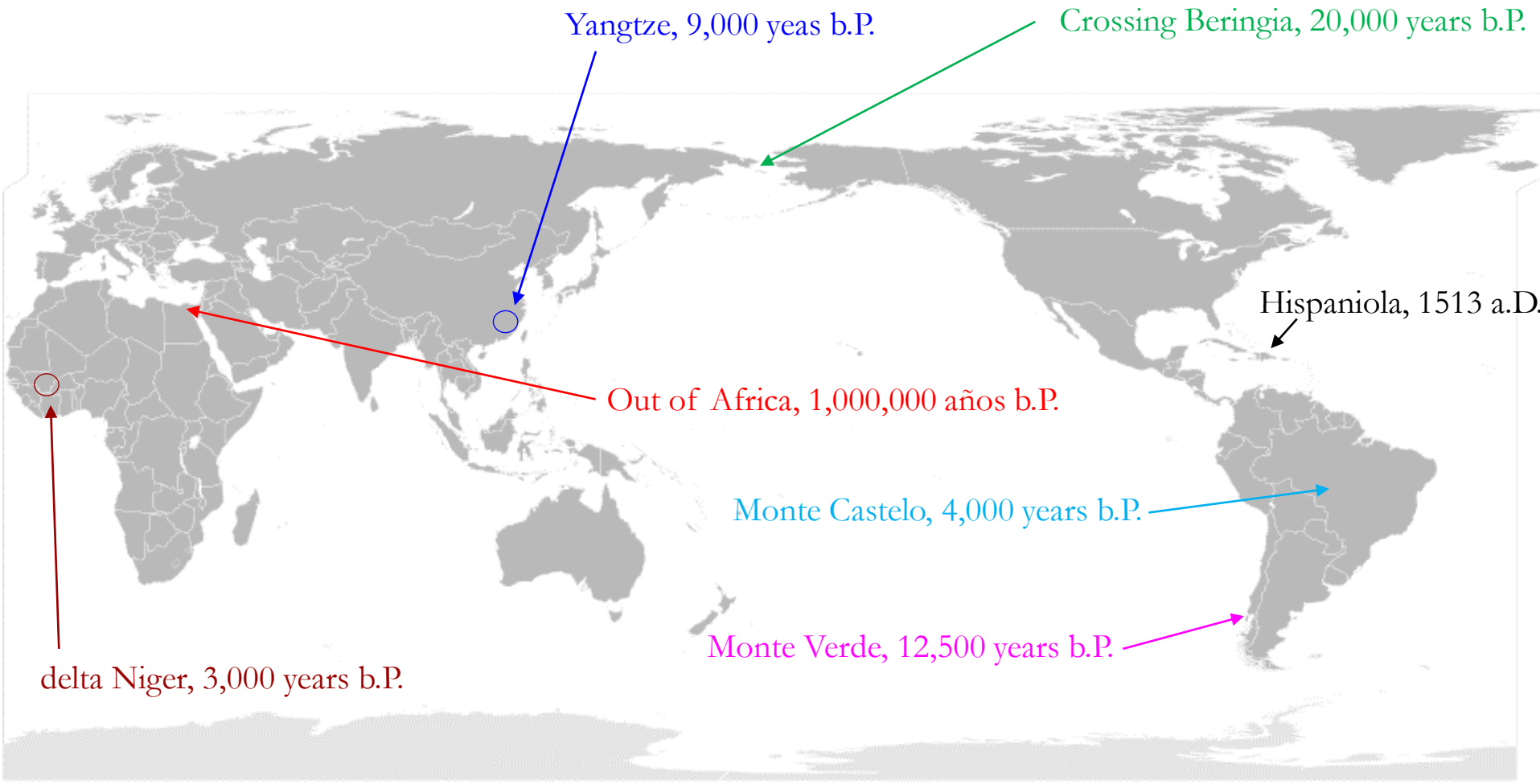
Garza del ganado

"Su lugar de origen es África, de donde llegó a Colombia a fines de la década de 1910, tal vez arrastradas por una tormenta", C U Hurtado, 2002, p. 223.

"First reported in Colombia in 1917 . . . An invader from the Old World . . . ", Hilty & Brown, 1986, p. 66.

low probability, because migratory birds are not seed eaters, they eat flying (insects) and migrate from temperate to the tropics or N-S (poor weather for their food)

American *Oryza* (AA and CCDD): re-thinking the scenario



- the first human migration into the Americas could not have introduced rice
- ages and inheritance of diversity markers do not fit within an evolution over 400 years

sources: Dillehay et al. 2015, Gutaker et al. 2020, Hilbert et al. 2017, Sauer 1993, Wang et al. 2014, Wells 2003

A few concluding remarks

- *O. latifolia* shows higher diversity between populations as compared to *O. alta* and *O. grandiglumis* (expected because of its wide distribution) (Aggarwal et al. 1996)

- "the three CCDD Latin American tetraploid species are independent species", also crossability barriers and high F1 sterility (Aggarwal et al. 1996)

- *O. glumaepatula* is not a red rice escaped from cultivation; existing for 1 mi years, from S Mexico to S Brazil *O. glumaepatula* displays significant molecular variation

- *O. glumaepatula* is not genetically compatible with other New Word diploids; in the latter some might be red rices, others are different biological entities

⇨ we certainly need a better sampling of non cultivated *Oryza* in the Neotropics

⇨ we also need molecular clocks for the CCDD species

⇨ in many watersheds of LAC (including 4 in Colombia) it is five minutes to midnight!

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Muchas Gracias

información adicional: d.debouck@cgiar.org

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