Alison K.S. WEE
Assoc Prof, Plant Ecophysiology & Evolution Lab
College of Forestry, Guangxi University

Prof Edward Webb, Prof Tadashi Kajita, Prof Kunfang Cao

MANGROVES IN A CHANGING WORLD: From population genetics to ecological genomics

NUS National University of Singapore
Chiba University 千葉大学
Guangxi University 广西大学


ONE
Gene Flow
TWO
Species identity
THREE
Adaptation

ONE

GENE FLOW IN A FRAGMENTED LANDSCAPE

Mating system analysis (Pollen)

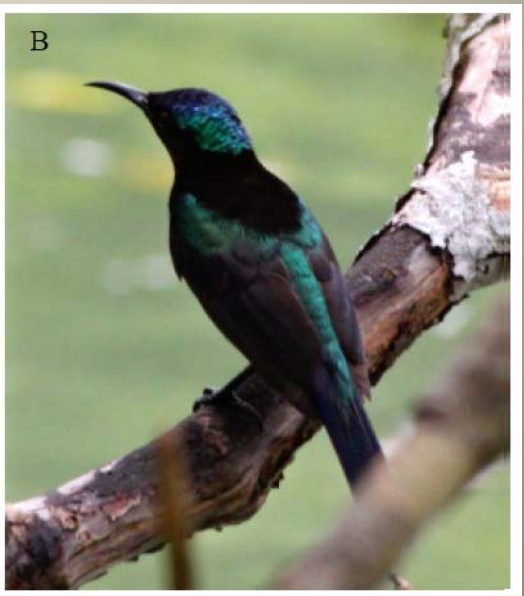
AKS Wee, SY Low, EL Webb

Aquatic Botany 2014

Pollinator availability

Bruguiera gymnorhiza

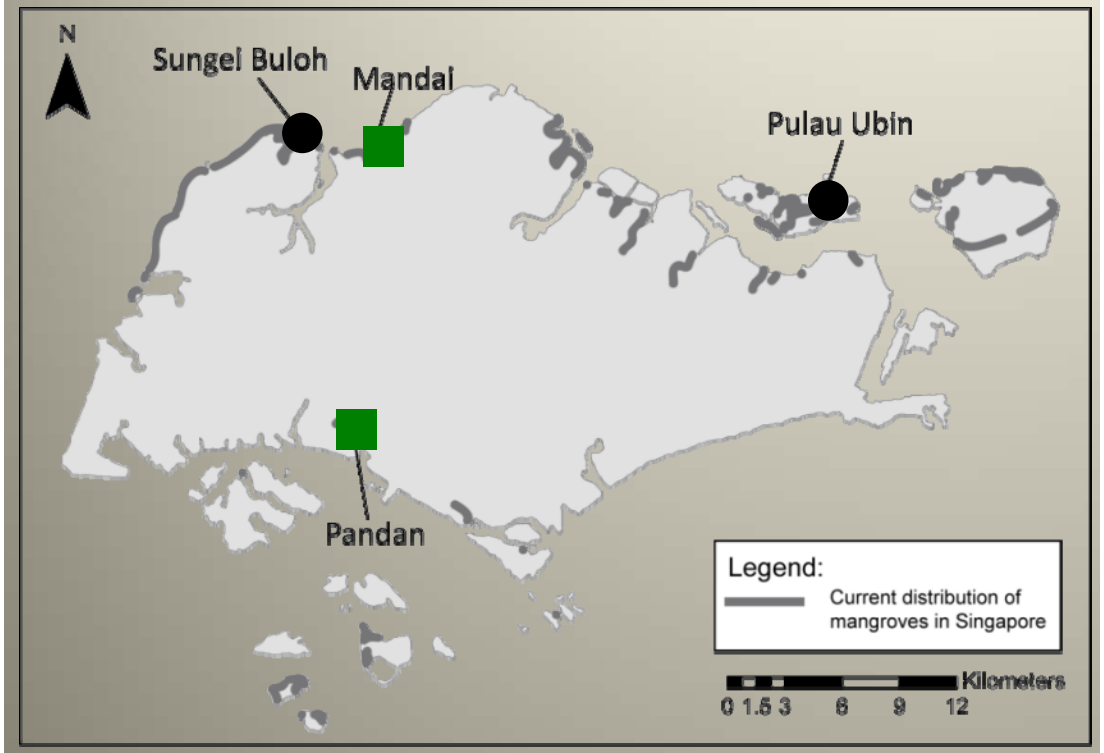
What is the relationship between pollinator availability and fruit set in different forest settings?



(A) *Nectarinia jugularis* (B) *Nectarinia calcostetha*

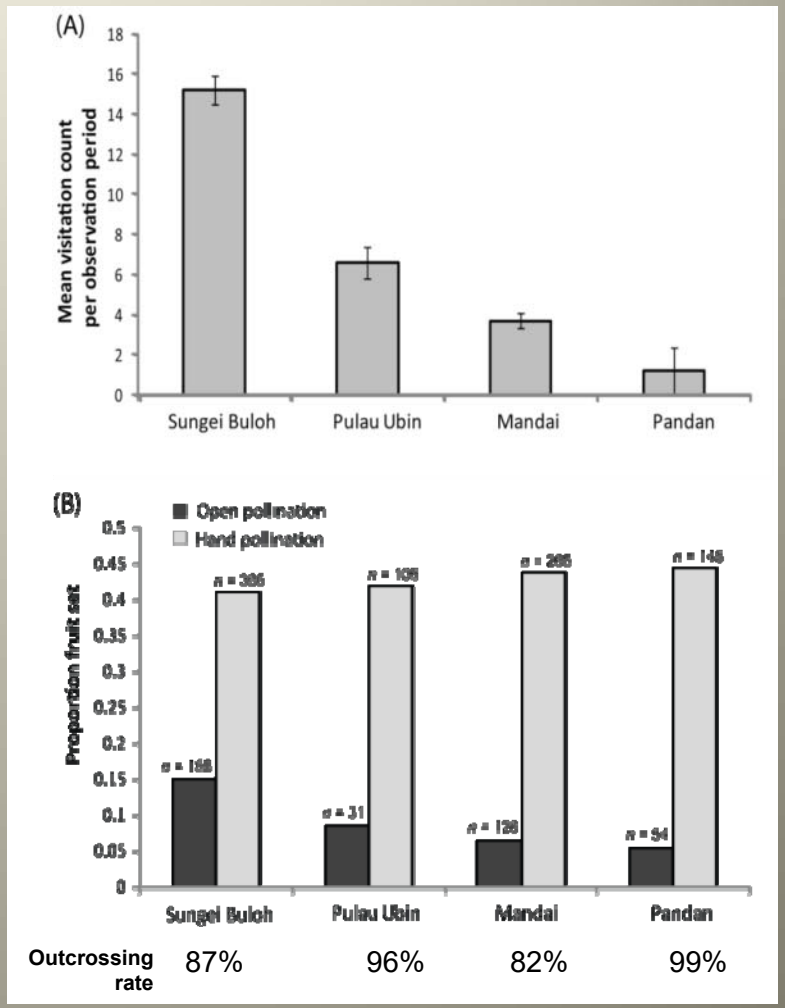
Pollen limitation was detected in all sites.

B. gymnorrhiza has an effective internal mechanism to counteract inbreeding depression under pollen limitation.



Larger patch; protected area

Smaller patch; unprotected area



(Wee *et al.* Aquatic Botany 2014)

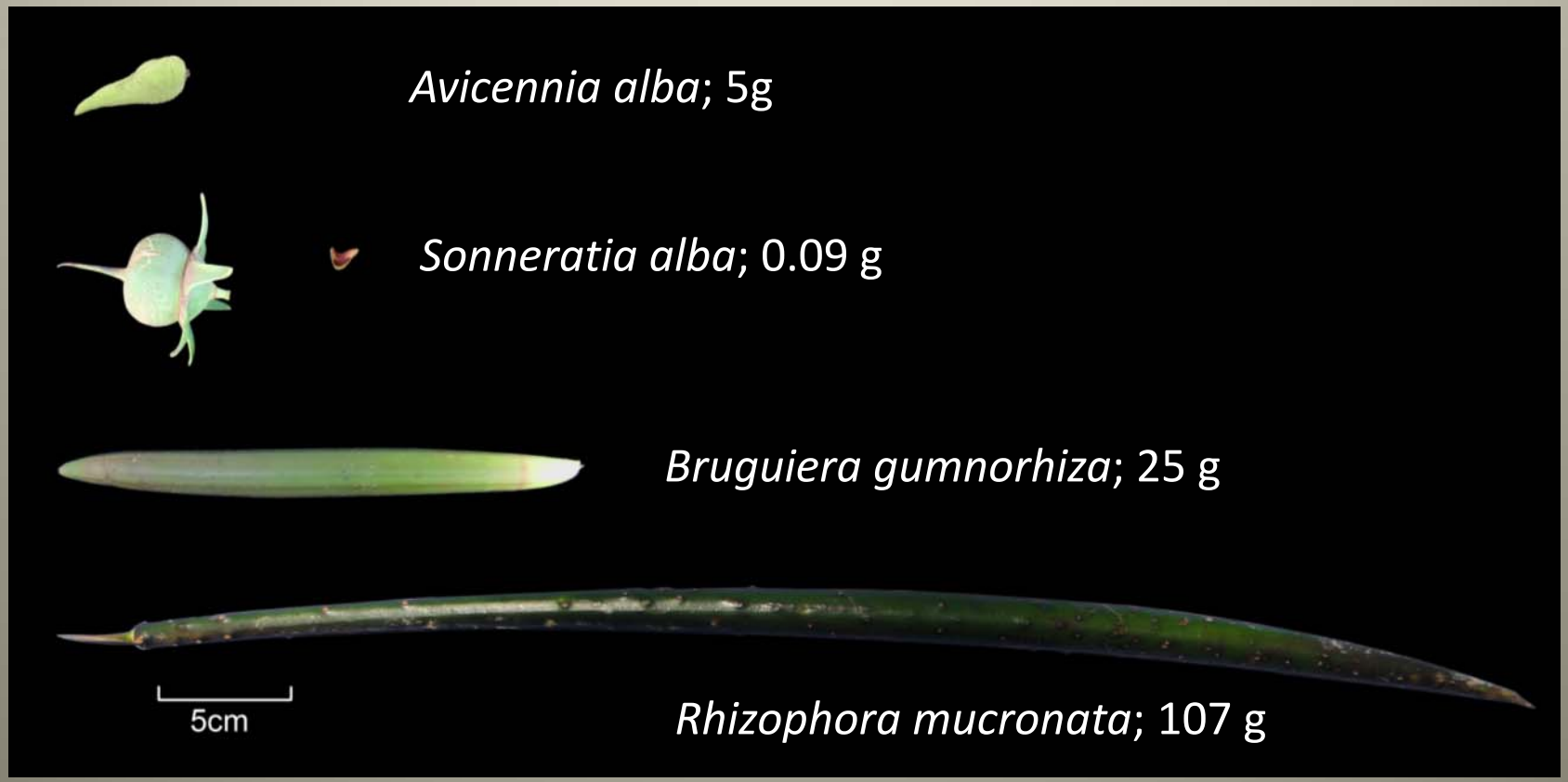
Comparative Phylogeography (Propagule)

AKS Wee, AME Noreen, J Ono, K Takayama, PP Kumar, HTW Tan, MN Saleh, T Kajita, EL Webb

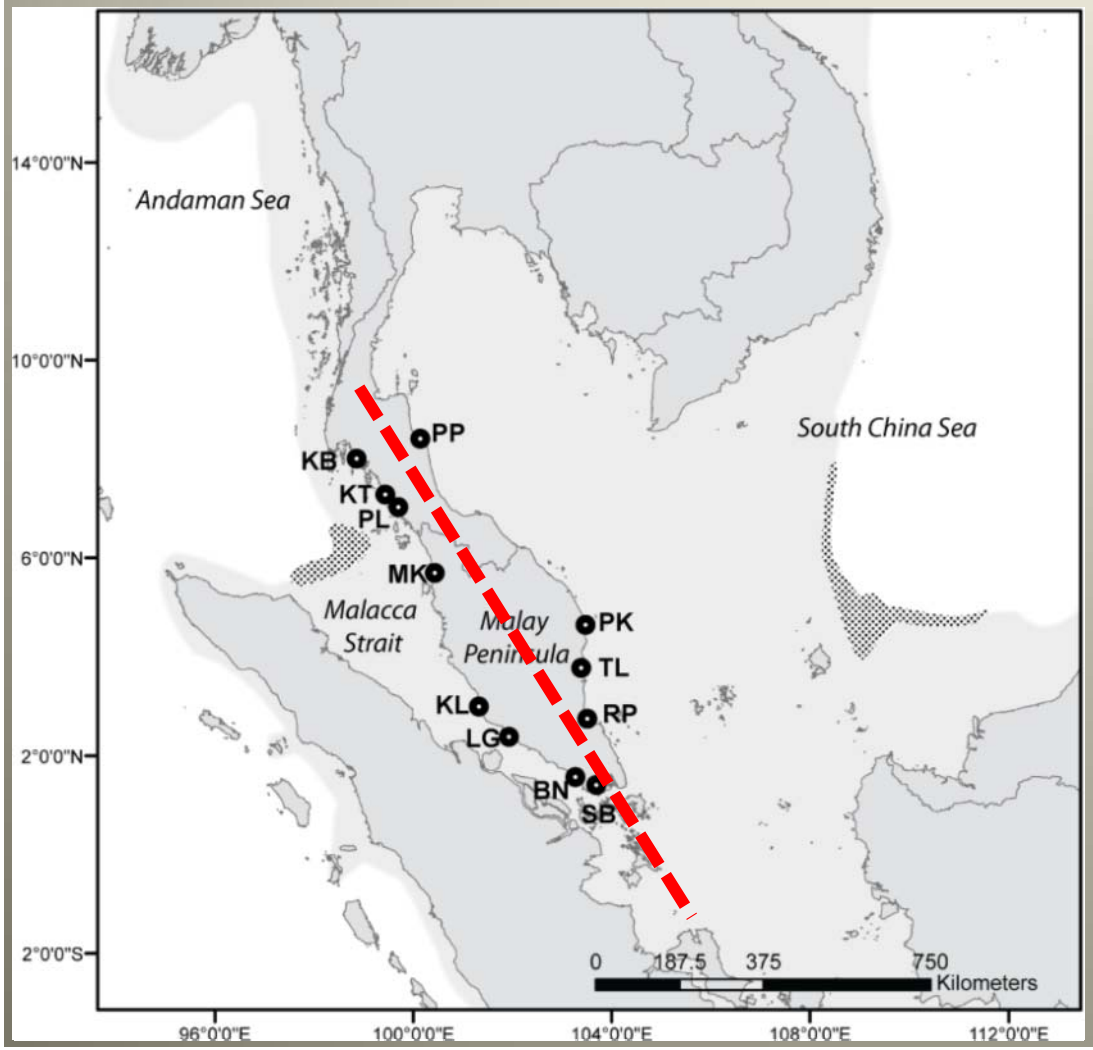
In preparation

Dispersal capability

Is there a congruence in phylogeography across species with different dispersal capabilities?



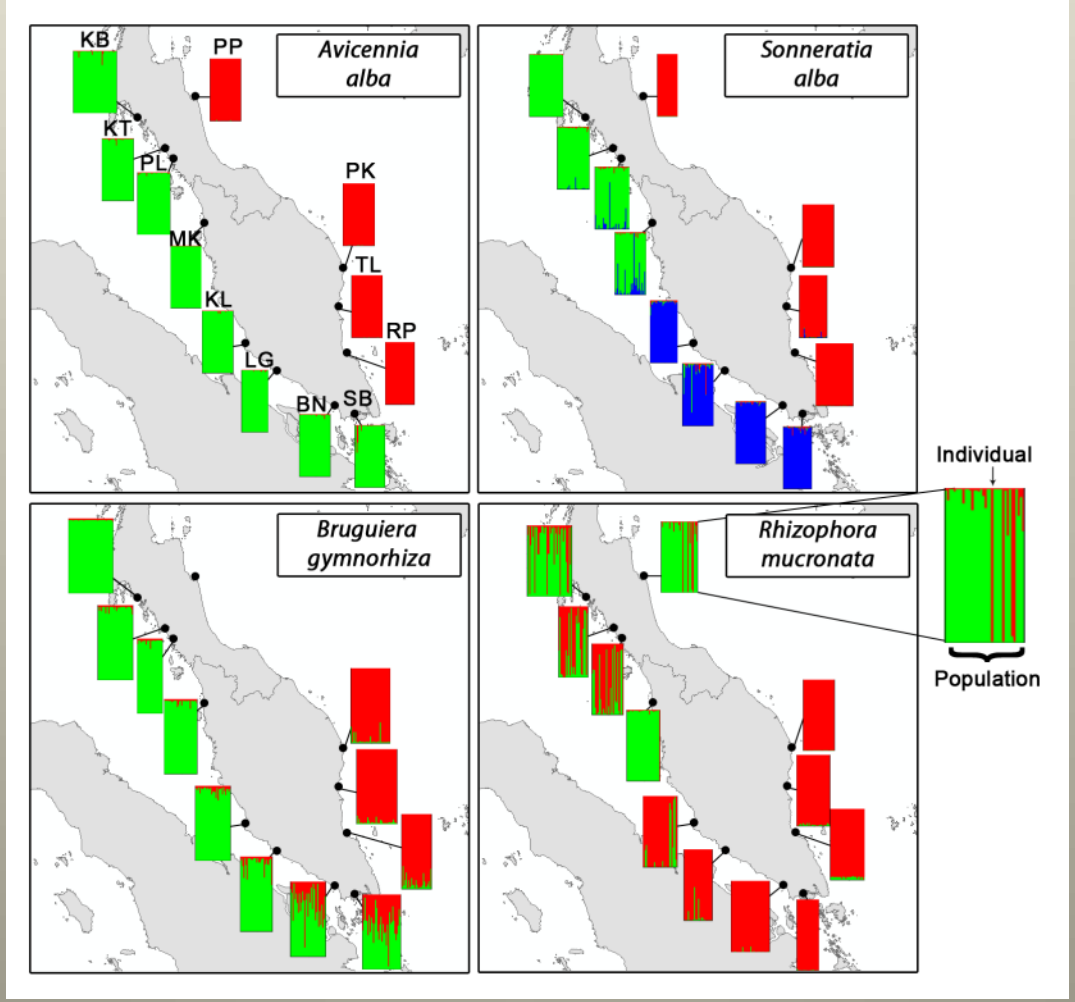
The Malay Peninsula = Biogeographic barrier



The east-west divide across the Malay Peninsula was found in many mangrove species, including:

Lumnitzera racemosa
(Su *et al.*, 2006)
Ceriops tagal
(Liao *et al.*, 2007)
Bruguiera gymnorhiza
(Inomata *et al.*, 2009)

The east-west divide was not congruent across species on a finer scale.



(Wee *et al.* in preparation)

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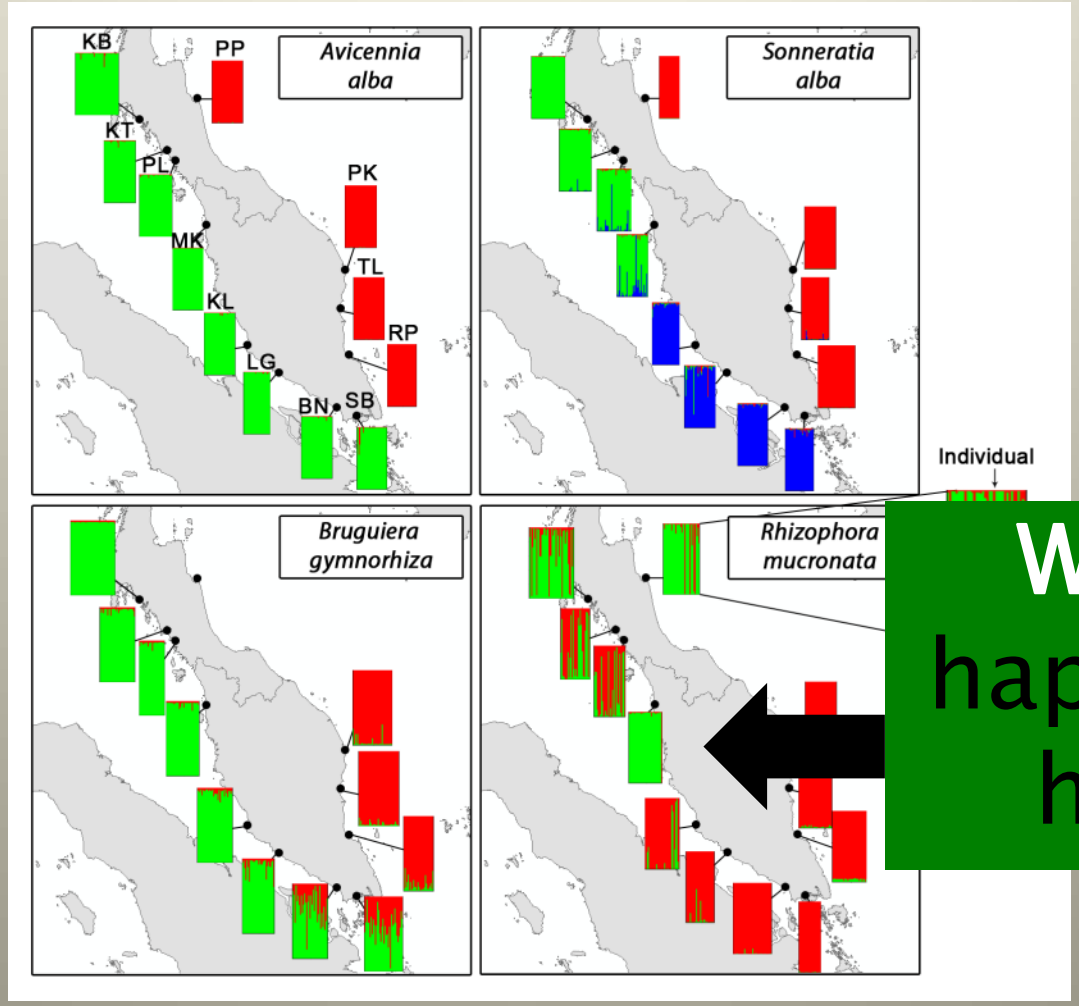


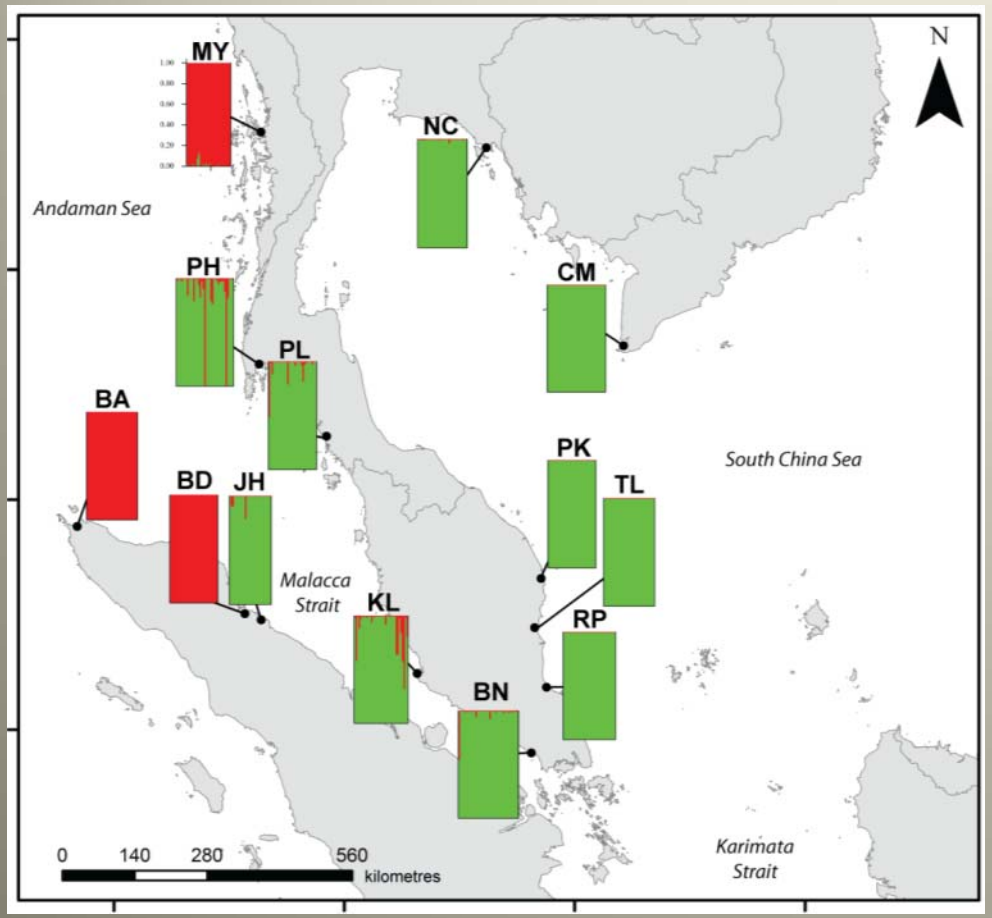
(Wee *et al.* in preparation)

Biogeography

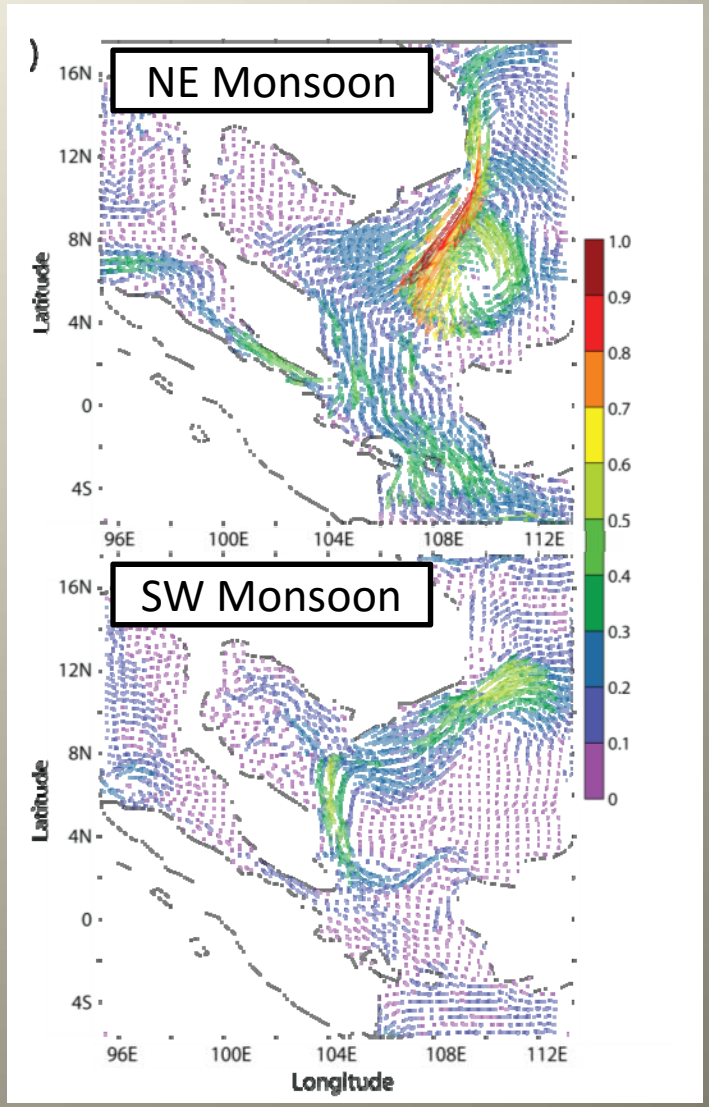
AKS Wee, K Takayama, T Asakawa, B Thompson,
Onrizal, S Sungkaew, NX Tung, MN Saleh, KK Soe, HTW Tan,
Y Watano, S Baba, T Kajita, EL Webb

Journal of Biogeography 2014

Distinct genetic divide detected between Andaman Sea and Malacca Strait, concordant with ocean circulation patterns.



(Wee *et al.* J. Biogeog. 2014)



TWO

SPECIES IDENTITY

Phylogenetics

J Ono, JWH Yong, K Takayama, MN Saleh, **AKS Wee,** T Asakawa, OB Yllano, SG Salmo III, M Suleiman, NX Tung, KK Soe, SH Meenakshisundaram, Y Watano, EL Webb, T Kajita

Conservation Genetics 2016

Bruguiera hainesii (CR)

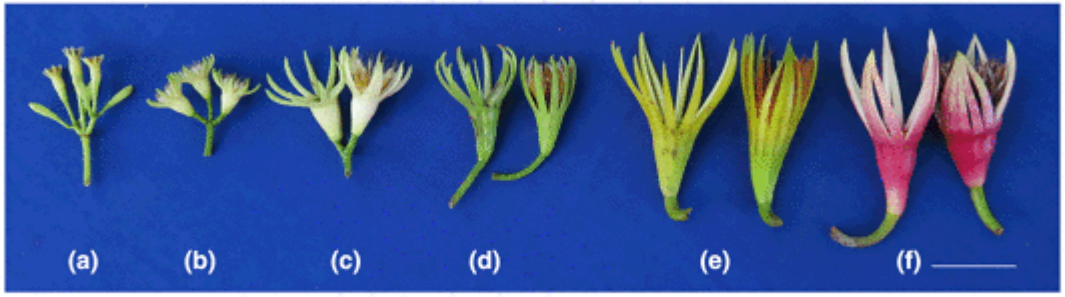
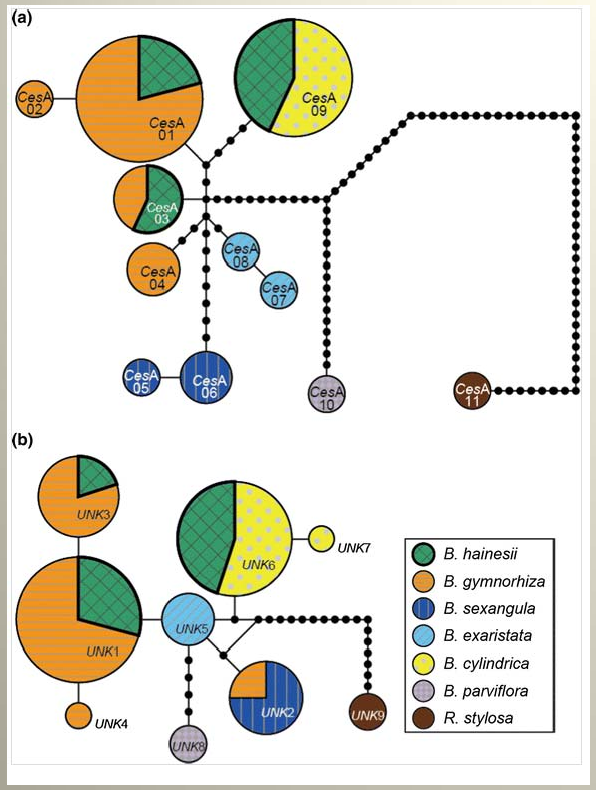
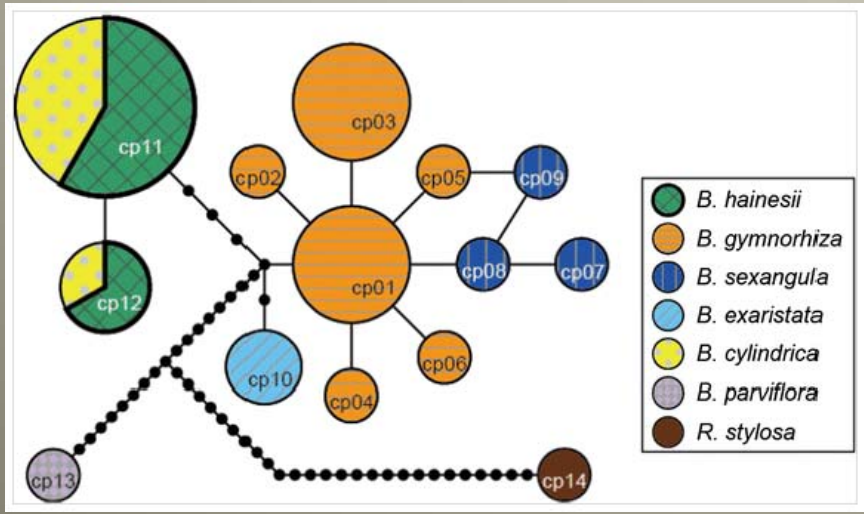


Fig. 1 Flowers of six species of genus *Bruguiera*. **a** *B. parviflora*, **b** *B. cylindrica*, **c** *B. hainesii*, **d** *B. exaristata*, **e** *B. sexangula*, **f** *B. gymnorhiza*. *Scale bar* = 2 cm

What is its genetic background and the evolutionary relationships with other Bruguiera species?

(Ono et al. Cons Gen 2016)



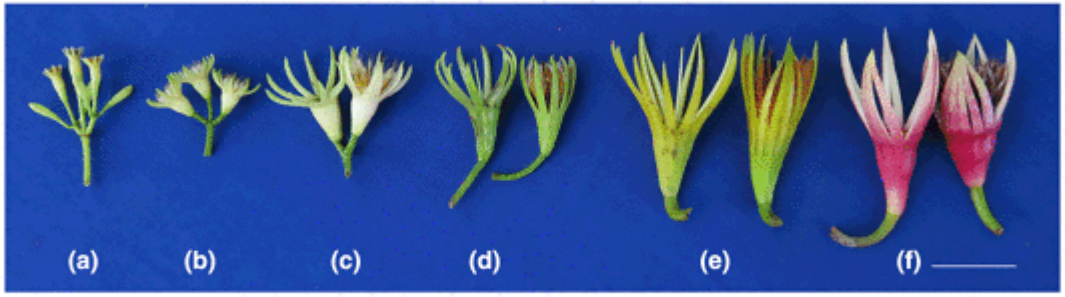


B. hainesii heterozygous in nuclear genes, shared with *B. cylindrica* and *B. gymnorhiza.*

B. hainesii shared cpDNA haplotypes with *B. cylindrica.*

(Ono et al. Cons Gen 2016)

Bruguiera hainesii (CR)



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It's a HYBRID!!!

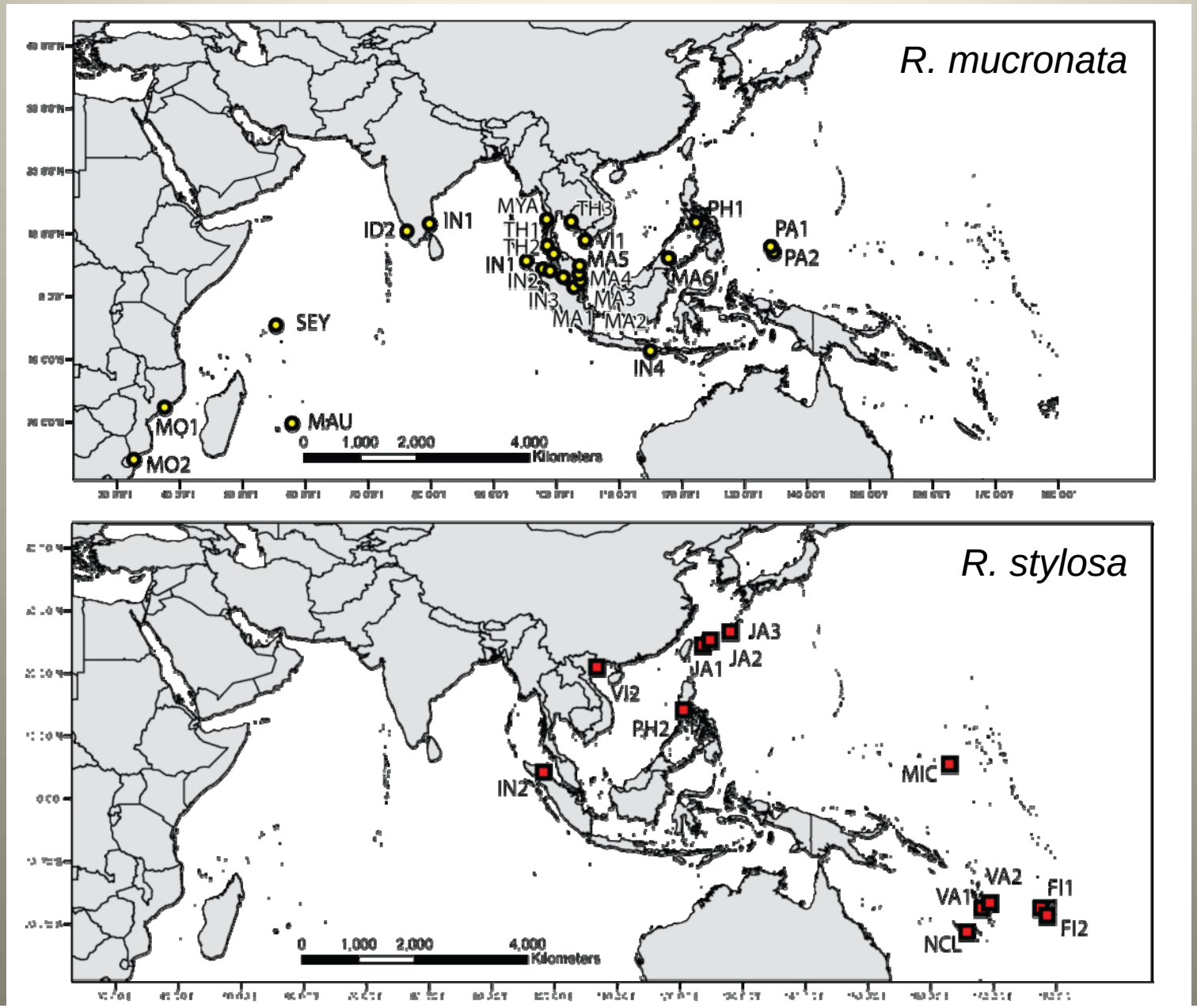
IUCN status?

(Ono et al. Cons Gen 2016)

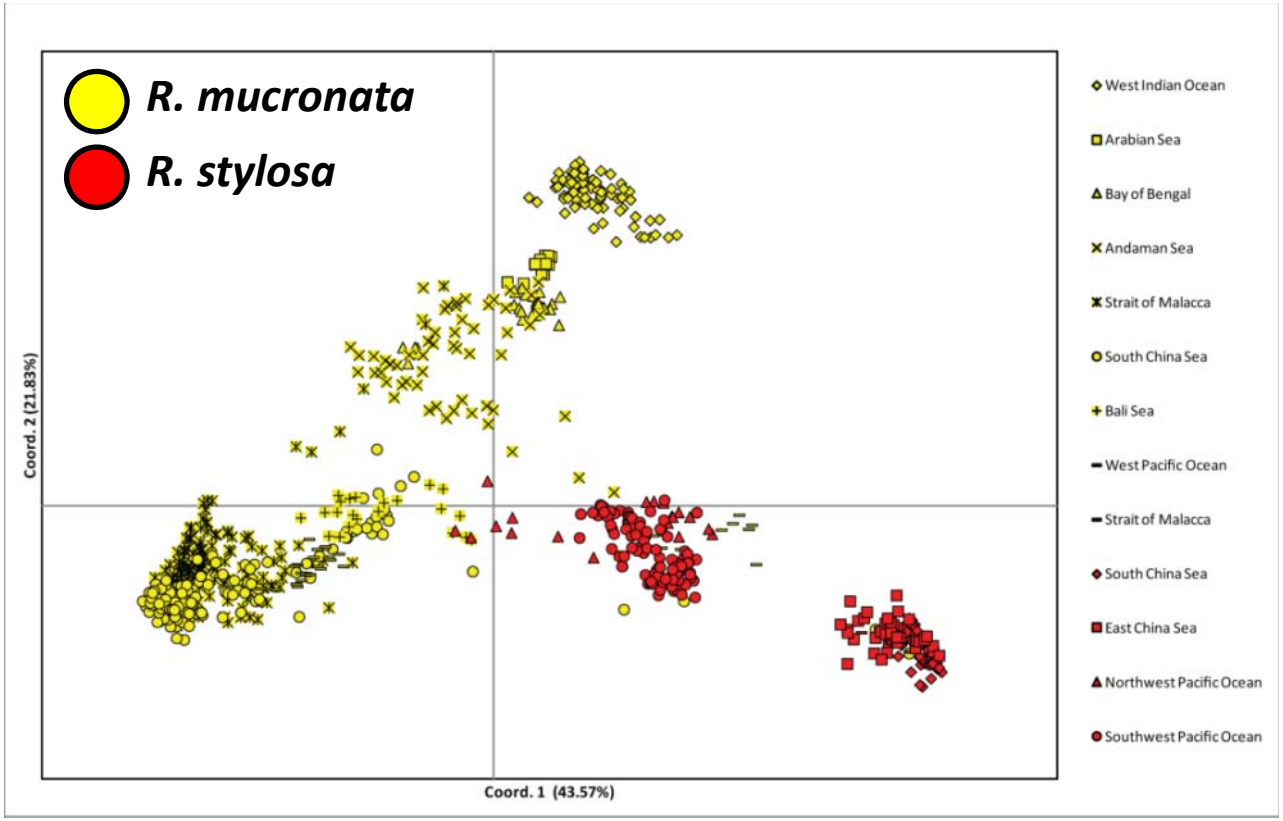
Rhizophora mucronata and *R. stylosa*

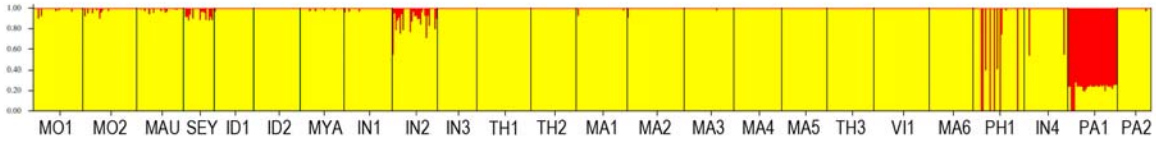
(1) What is the degree of genetic distinctiveness between these two species?
(2) Does their genetic structure correspond to oceanic regions?

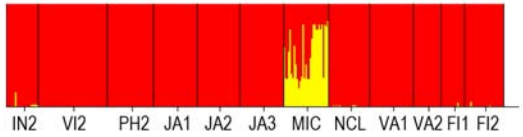
Study sites


R. mucronata
ID2
IN1
MYA
TH3
TH1
TH2
VI1
MA5
IN1
IN2
IN3
MA4
MA
MA3
MA1
MA2
MA6
PH1
PA1
PA2
SEY
IN4
MO1
MO2
MAU
0 1,000 2,000 4,000
Kilometers
R. stylosa
JA3
JA2
JA1
VI2
PH2
IN2
MIC
VA2
VA1
FI1
FI2
NCL
0 1,000 2,000 4,000
Kilometers

The two species are genetically distinct, but potential hybridization or introgression was detected between them.

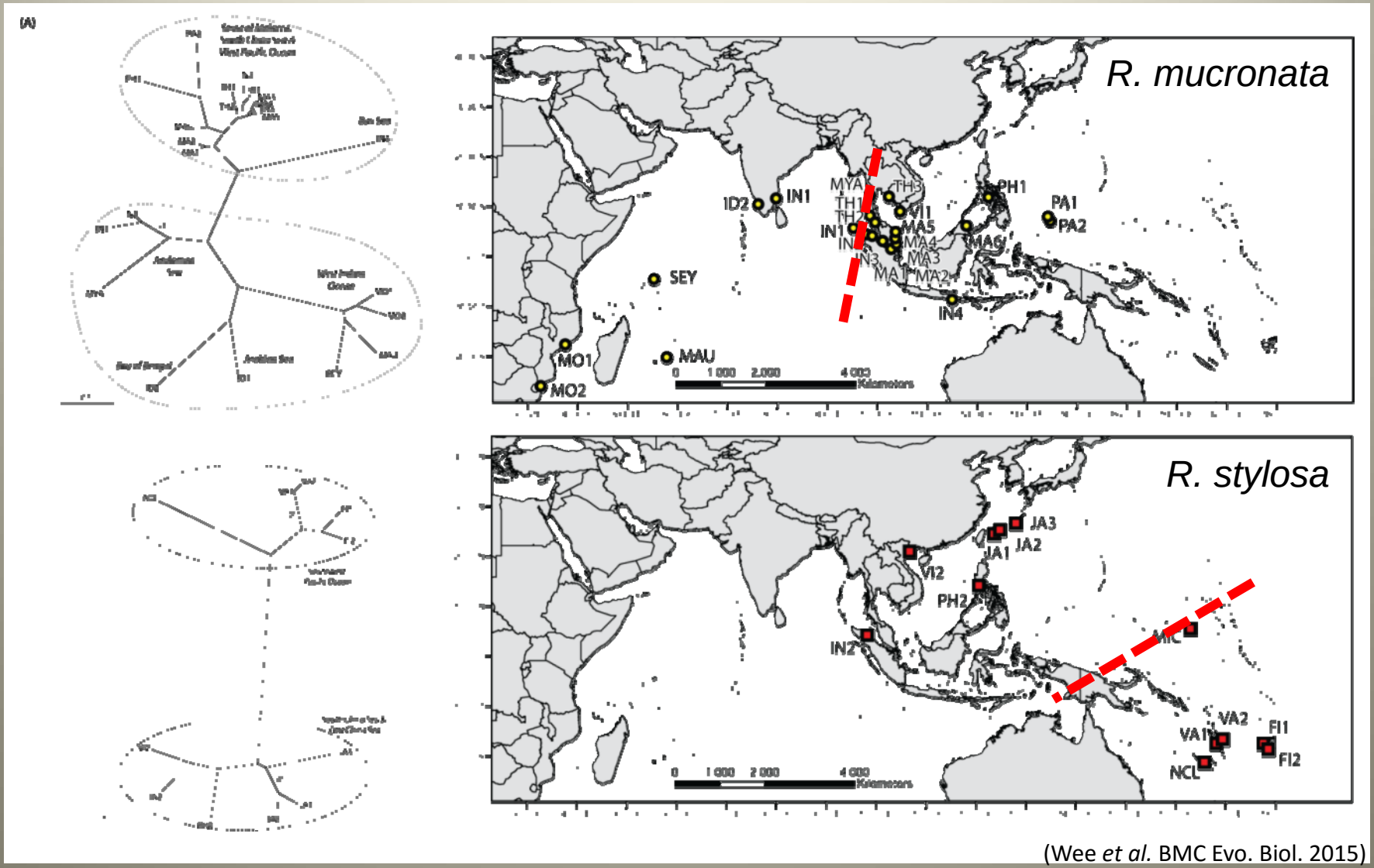






(Wee *et al.* BMC Evo. Biol. 2015)

Strong genetic structure between oceanic regions was detected in both species



(Wee *et al.* BMC Evo. Biol. 2015)

THREE

ADAPTATION

Poleward expansion

PNAS

Poleward expansion of mangroves is a threshold response to decreased frequency of extreme cold events

Kyle C. Cavanaugh[a,b,1], James R. Kellner[b], Alexander J. Forde[c], Daniel S. Gruner[d], John D. Parker[a], Wilfrid Rodriguez[a], and Ilka C. Feller[a]

[a]Smithsonian Environmental Research Center, Smithsonian Institution, Edgewater, MD 21037; [b]Department of Ecology and Evolutionary Biology, Brown University, Providence, RI 02912; [c]Graduate Program in Behavior, Ecology, Evolution, and Systematics, University of Maryland, College Park, MD 20742; and [d]Department of Entomology, University of Maryland, College Park, MD 20742

Edited by George M. Woodwell, Woods Hole, MA, and approved November 22, 2013 (received for review August 20, 2013)

Regional warming associated with climate change is linked with altered range and abundance of species and ecosystems world- ecologically and economically important of these coastal ecosystems, providing food and habitat to a diverse array of ter-

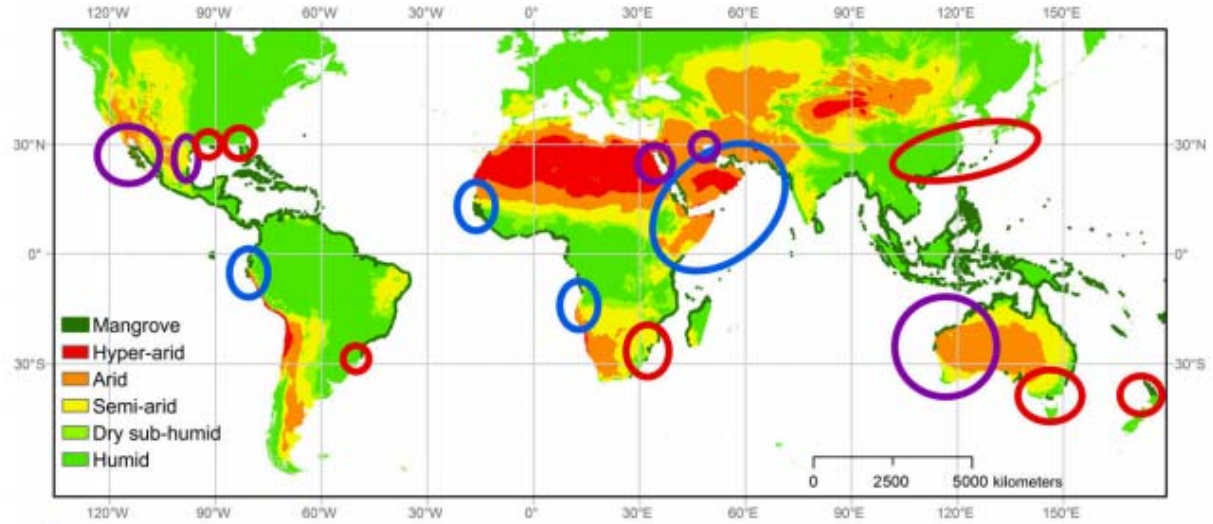


Fig. 6 Coastlines where we expect that abrupt ecological transitions in coastal wetlands occur across macroclimatic gradients. Mangrove data comes from Giri *et al.* (2011b). Aridity data come from the Global Aridity Index (Trabucco & Zomer, 2009).

Osland et al. 2016

Phenotypic (e.g. tree stature) differences along latitudinal gradient

High latitude (Japan) Low latitude (Malaysia)

Brugueira gymnorhiza

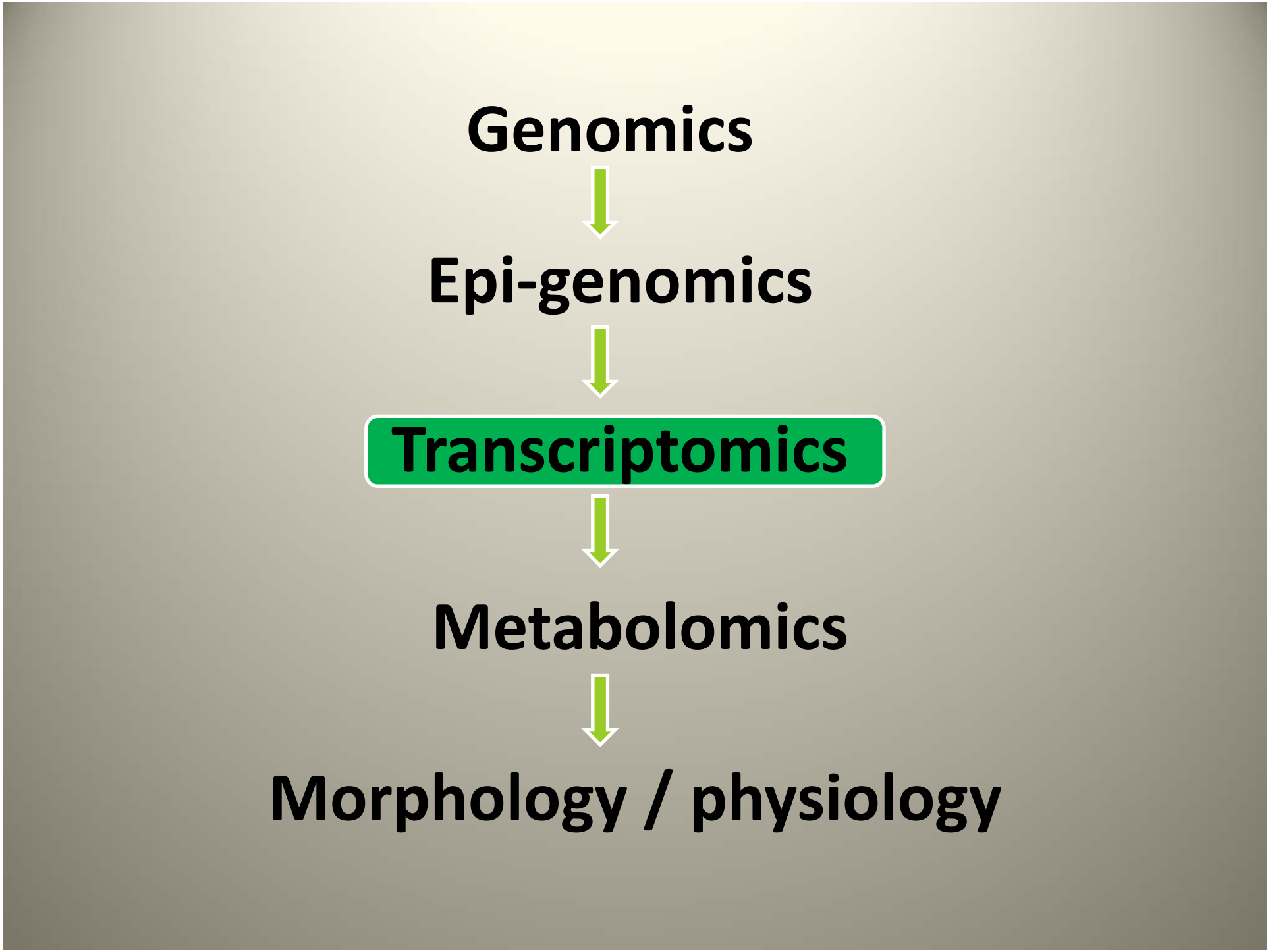
Rhizophora stylosa

Natural adaptive variation?

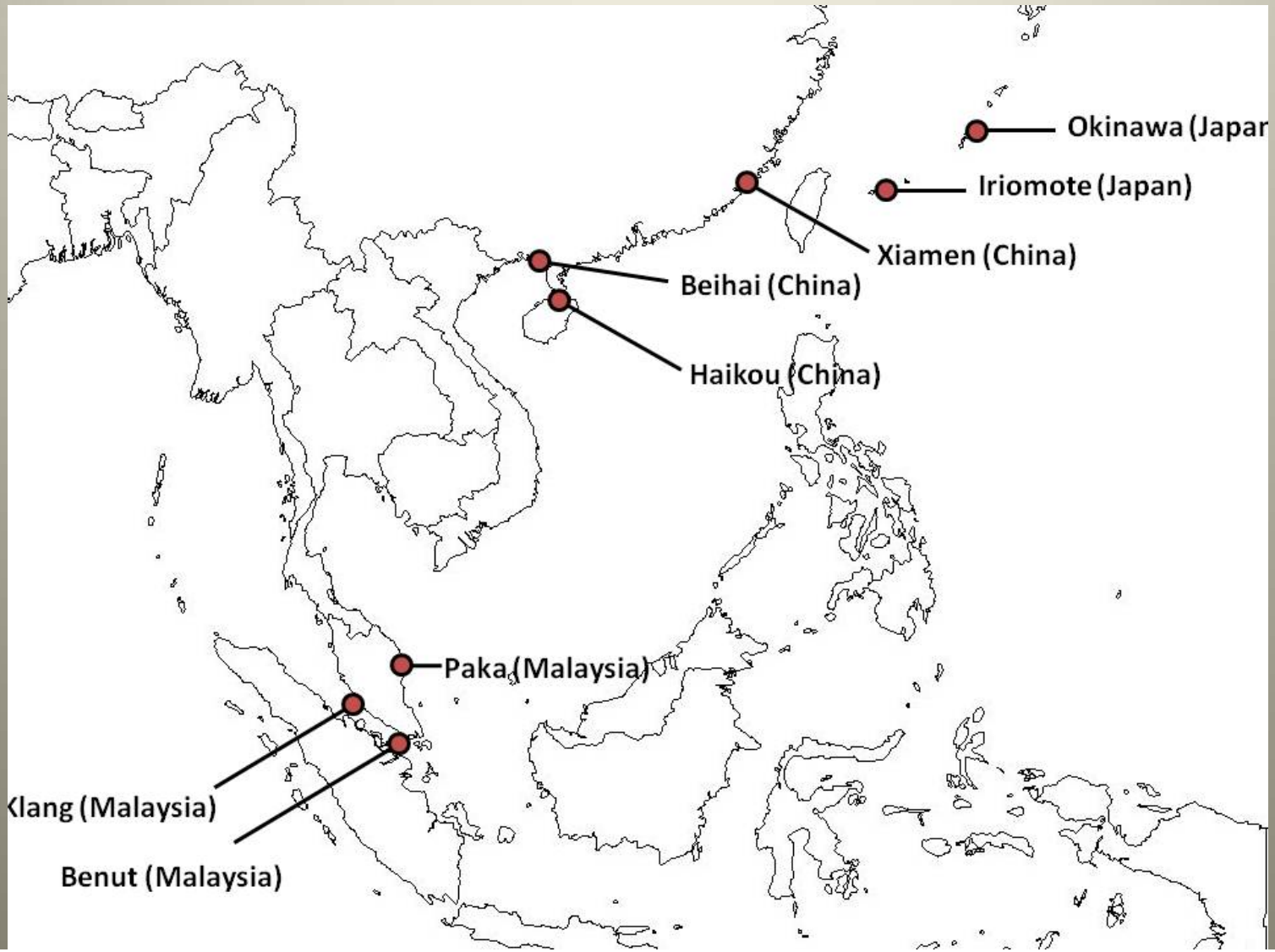
Phenotypic plasticity?

Next Generation Sequencing

The age of the -omics has arrived!


Genomics
Epi-genomics
Transcriptomics
Metabolomics
Morphology / physiology

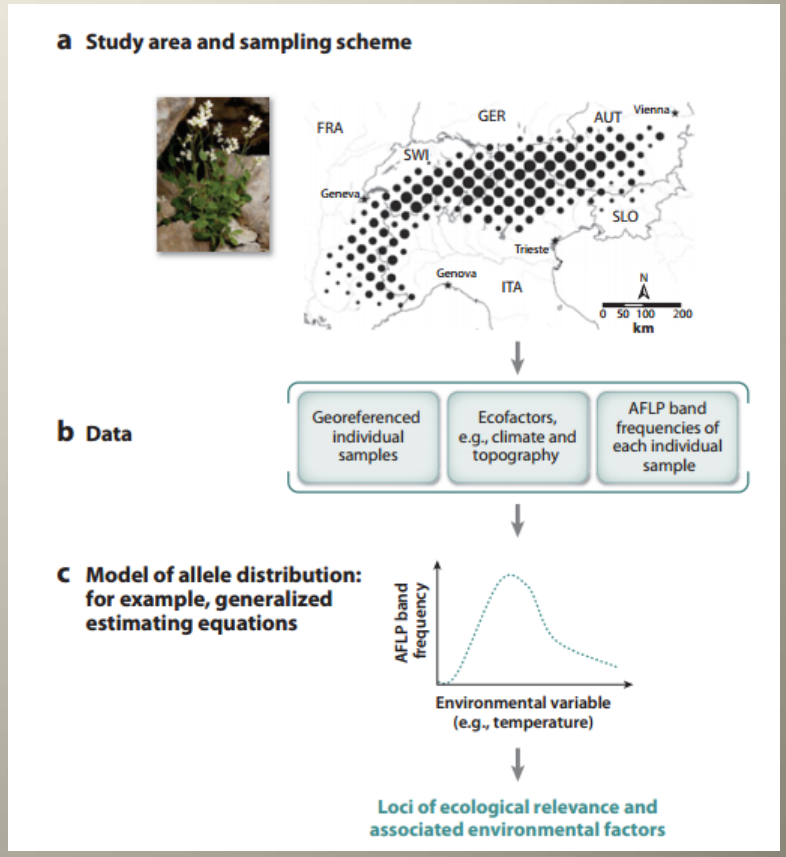
Study sites
Study species: Bgym & Rsty



Natural adaptive range: Bgym & Rsty
Determine natural adaptive variation

1. What is the range of morphological/physiological adaptation in natural populations?

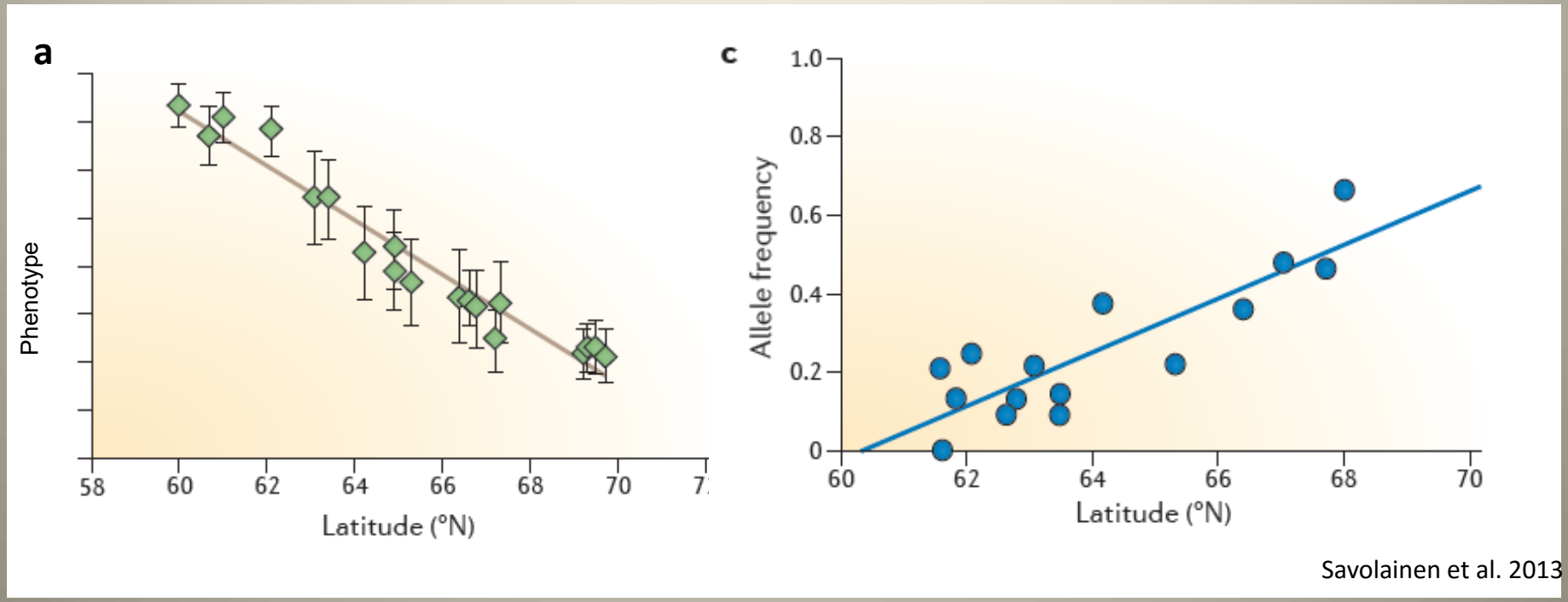
2. Specifically, which environmental factors best explains the morphological/physiological trait differences among natural populations along latitudinal gradient?



Schoville et al. 2012

Phenotypic plasticity: Bgym & Rsty

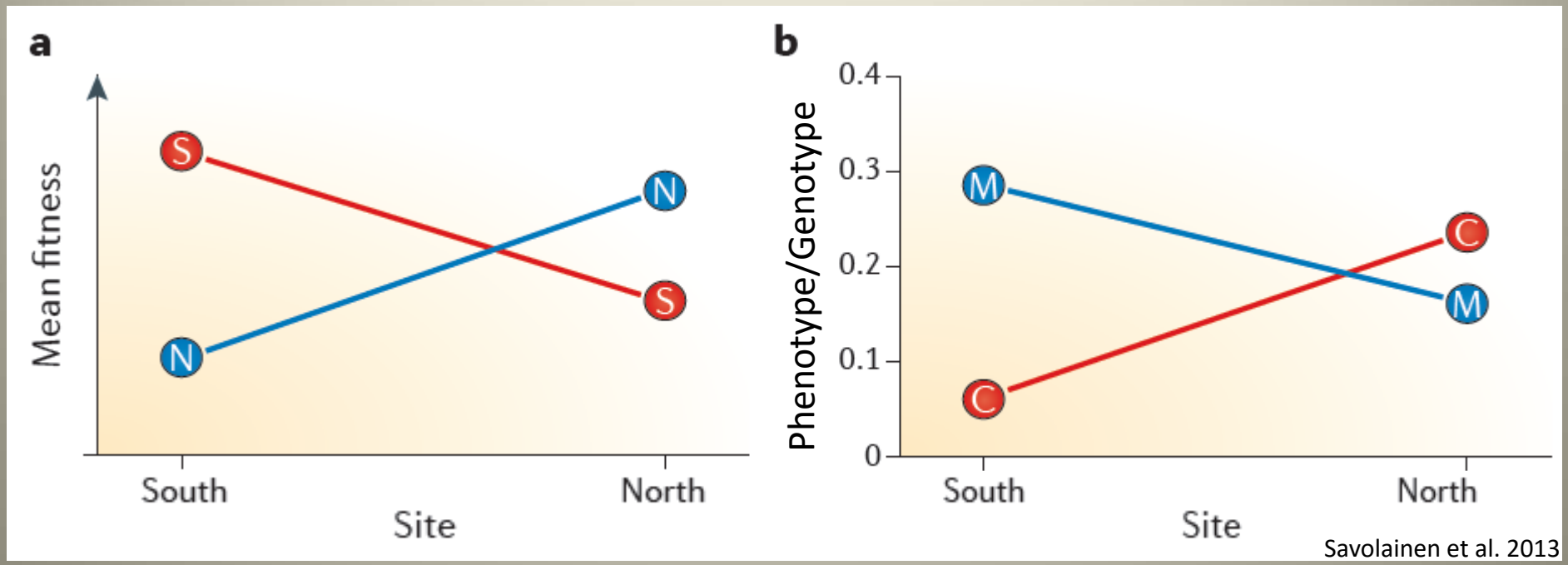
Determine extent of local adaptation



Savolainen et al. 2013

1. Do populations of *B. gymnorhiza* and *R. stylosa* show home-site advantage across different latitude?
2. Are the morphological and life-history differences observed in situ caused by phenotypic plasticity to latitude, population differentiation or both?
3. Does natural selection on variable morphological traits differ across latitude and contribute to home-site advantage?

Phenotypic plasticity: Bgym & Rsty
Common garden trial
Reciprocal transplant (?)



Savolainen et al. 2013

DISTRIBUTION AND ECOLOGICAL SIGNIFICANCE OF CLIMATIC ADAPTATION

International collaborations

International collaborations

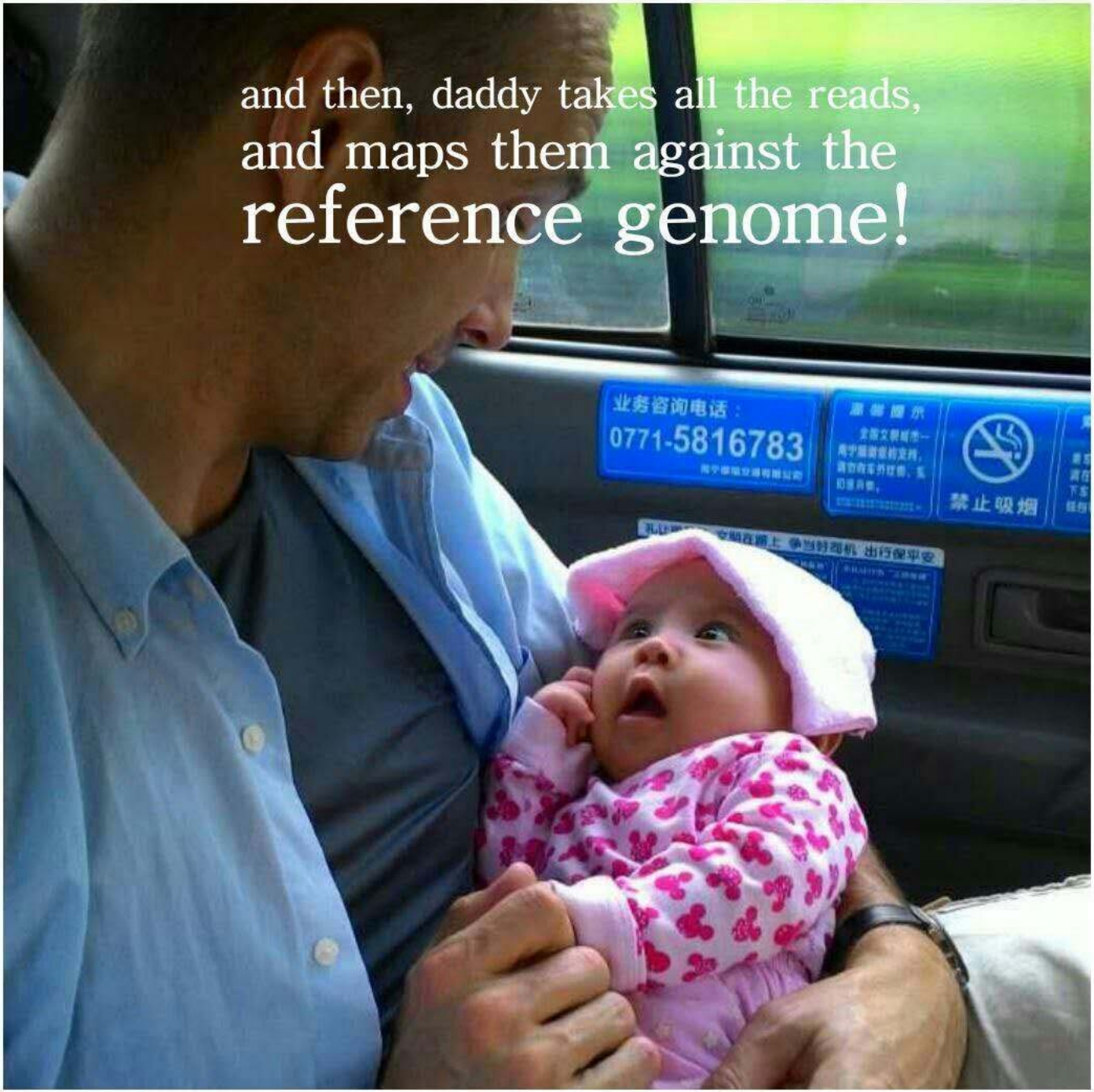
Acknowledgement

Asst. Prof. Edward Webb and Assoc. Prof. Tadashi Kajita

Dr Annika Noreen, Assoc. Prof Dan Friess,
Dr Tay Ywee Chieh, Dr Bijoy Thompson

Lab collaborators: Plant Systematics Lab, Chiba University, Japan; Dr Koji Takayama; Mr Junya Ono, Research Network for Conservation Genetics of Mangrove, Mr. Jasher Chua

Field collaborators: Assoc. Prof. Nittharatana Paphavasit; Asst. Prof. Chanyut Sudtongkong; Dr Mohd Nazre Bin Saleh & Pn. Latifah Zainal Abidin


and then, daddy takes all the reads,
and maps them against the
reference genome!
业务咨询电话：
0771-5816783
禁止吸烟

THANK YOU