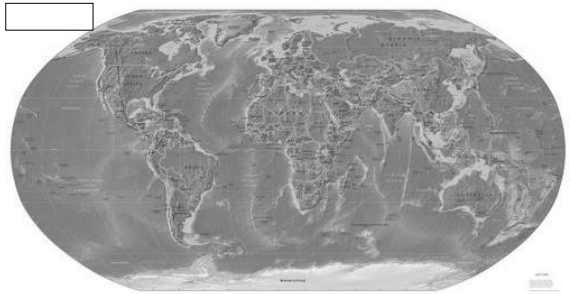
Relationships of Floras (& Faunas)

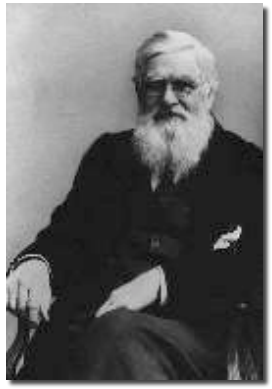
Knowledge of earth and organism histories now permit closer examination of relationships of disjunct floras and faunas.

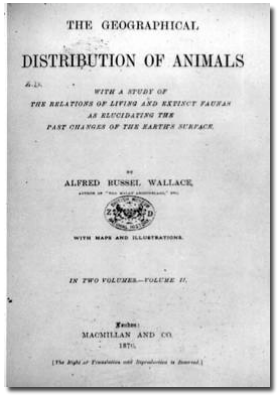
- Southern Hemisphere temperate
- Southern Hemisphere tropics
- the Wallace Line
- Eastern Asian - Eastern North American temperate



The Wallace Line

Alfred Wallace, one of the premier zoobiogeographers, wrote the definitive treatise "*Distributions of Animals*" in 1876 where he summarized the known distributions and causes of their biogeographical patterns




THE GEOGRAPHICAL

DISTRIBUTION OF ANIMALS

WITH A STUDY OF
THE RELATIONS OF LIVING AND EXTINCT FAUNAS
AS ELUCIDATING THE
PAST CHANGES OF THE EARTH'S SURFACE.

BY
ALFRED RUSSEL WALLACE,

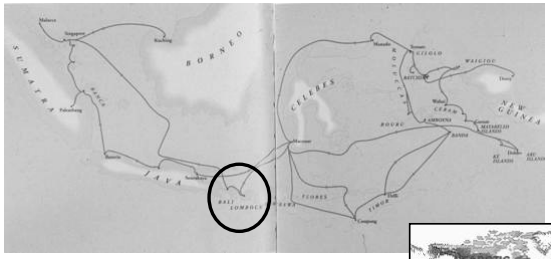
WITH MAPS AND ILLUSTRATIONS.

IN TWO VOLUMES.—VOLUME II.

London:
MACMILLAN AND CO.
1876.

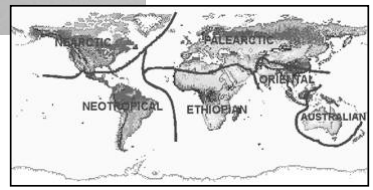
The Wallace Line

Alfred Wallace's main interest was in the vertebrate fauna of the Indo-Malay Archipelago from Asia to Australia where he clearly saw a sharp faunistic break



Probably his most important trip he ever made was a 6 km ferry ride from Bali to Lombok

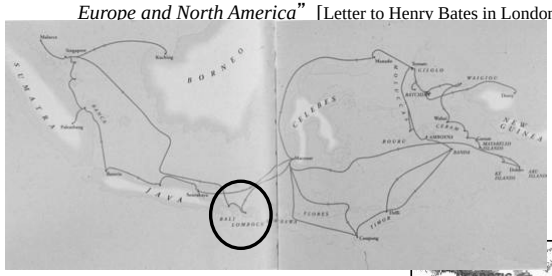
Wallace's trips



Sclater's & Wallace's faunistic regions

The Wallace Line

"*In the archipelago . . . there are two distinct faunas rigidly circumscribed, which differ as much as those of South America and Africa, and more than those of Europe and North America*" [Letter to Henry Bates in London (1858)]



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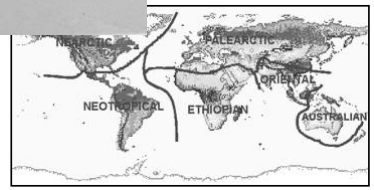
Wallace's trips



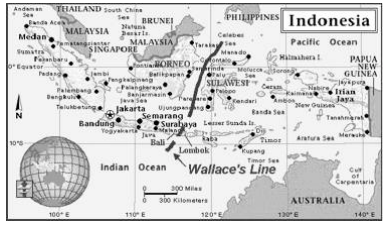
Sclater's & Wallace's faunistic regions

The Wallace Line

"*In the archipelago . . . there are two distinct faunas rigidly circumscribed, which differ as much as those of South America and Africa, and more than those of Europe and North America*" [Letter to Henry Bates in London (1858)]

"*The boundary line often passes between islands closer than others in the same group. I believe the western part to be a separated portion of continental Asia, the eastern the fragmentary prolongation of a former Pacific continent*"

Looking east from Bali across 6 km Lombok Straits

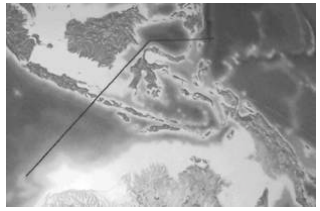


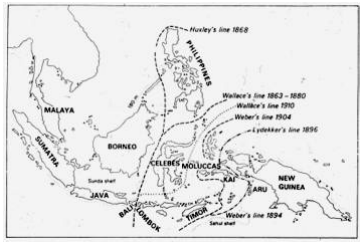
The Wallace Line

Wallace graphically depicts what has since been termed the "*Wallace Line*" in his book by showing birds and mammals that are found in the Oriental (Borneo, left) and Australian (New Guinea, right) sides

Cover plate from *Distributions of Animals*

The Wallace Line





- Wallace Line — the imaginary line separating the Oriental and Australian biotas — extends between Bali and Lombok and between Borneo/Philippines and Sulawesi
- Several other lines have been proposed in the region based on particular groups of animals or plants.
- Main issue with most lines is what do with Sulawesi (Celebes)

The Wallace Line

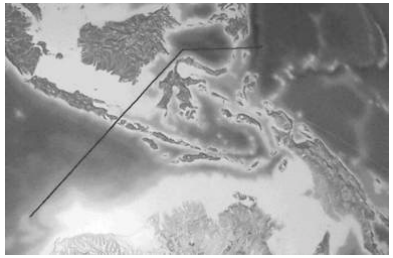
Sulawesi, with its mixture of Oriental and Australian fauna, was so perplexing to Wallace, that he vacillated back and forth on where to place the island

Backbone of Sulawesi

Crested black macaque

Bear cuscus (marsupial)

The Wallace Line

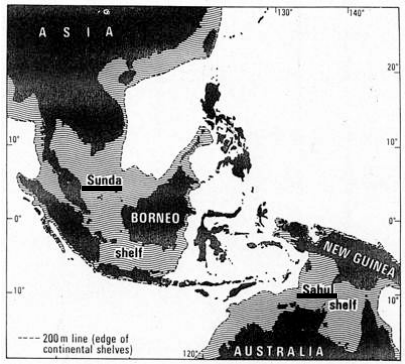


The “Wallace Line” biogeographical riddle was elegantly solved with the continental drift theory of Alfred Wegener and the more recent plate tectonic basis as a mechanism for Earth evolution

Earth and Life Evolve Together

The Wallace Line

Now know that the two regions are different continental plates that have been moving independently — the Asian and Australian plates



The IndoMalay - New Guinea Archipelago area includes island groups mostly confined to either of two continental shelves:

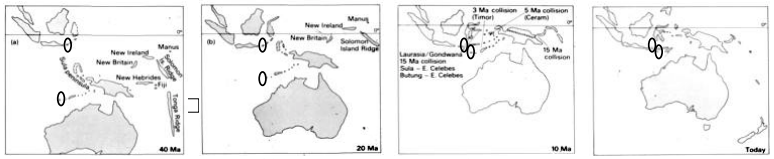
Sunda shelf — Asian

Sahul shelf — Australian

The Wallace Line

Collision of the Australian plate with the Asian plate occurred between 15-5 mya

Note the origins of Bali and Lombok, forming the Wallace Line



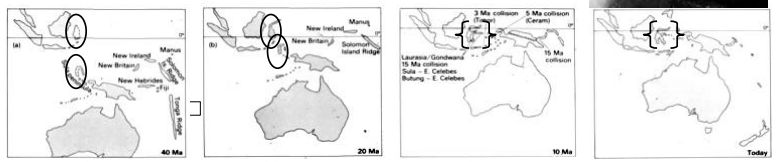
40 mya **20 mya** **10 mya** **Present**

The Wallace Line

Collision of the Australian plate with the Asian plate occurred between 15-5 mya

Note the origins of Bali and Lombok, forming the Wallace Line

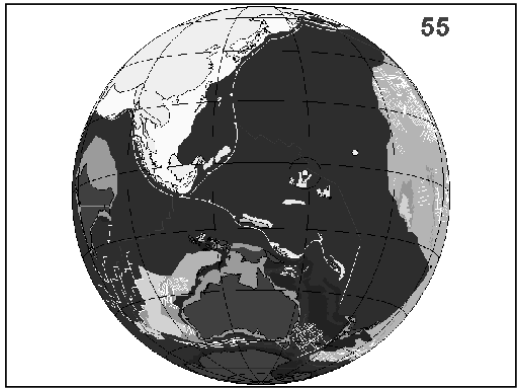
Sulawesi is a hybrid island from both plates!



40 mya **20 mya** **10 mya** **Present**

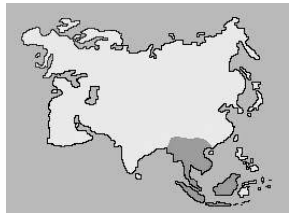
The Wallace Line

Wallace Line Revisited — Plate tectonics, rafting in isolation, and recent contact of Australian and Oriental biota: 55 million year story

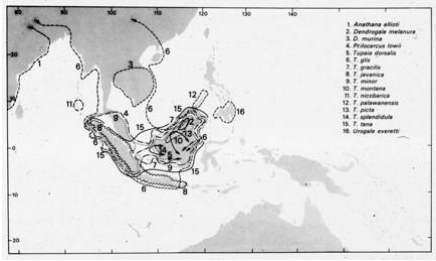


The Wallace Line

Tree shrews (family Tupaiidae) were indicated by Wallace as honoring this biogeographical line. An Asian group whose entire range gets as far east as Bali and Borneo but not to Lombok or Sulawesi



Tree shrew family & individual species distributions



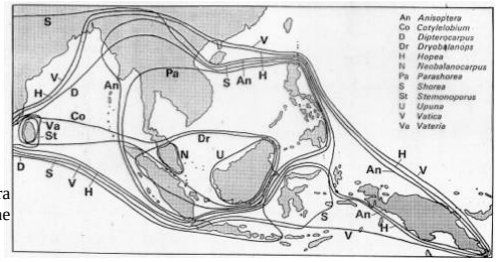
The Wallace Line

Borneo dipterocarp

Do plants honor the Wallace Line?

All but 3 of the genera of Dipterocarpaceae honor the Wallace Line

Surprising considering the winged fruit in the family is designed for dispersal



Distribution of genera of Dipterocarpaceae

A Biogeographical and Phylogenetic Analysis of Dipterocarpaceae: Do They Honor the Wallace Line?

Amelia Krug and Kenneth Sytsma
University Of Wisconsin, Department Of Botany
amelia.krug@gmail.com, kjsytsma@wisc.edu

The family Dipterocarpaceae (Malvales) is divided in to three subfamilies (Dipterocarpoideae, Monotoideae, and Pakaraimoideae) and is pantropical in distribution. Dipterocarpoideae consists of 13 genera and about 475 species, most of which are large trees dominant in the emergent canopy of lowland evergwet rain forests in India and Sri Lanka to West Malaysia (Kajita *et al.*, 1998; **Fig. 1**). The geographic distribution of the majority of these species correlates directly with the biogographic boundary of the Wallace Line; however, some genera including *Anisoptera*, *Hopea*, *Vatica*, *Shorea*, and *Dipterocarpus* have crossed east over the boundary of the line (Whitmore 1981; **Fig. 2**). The goal of this study is to infer whether these species crossed over the Wallace Line subsequent to the collision of the Sunda and Sahul Plates 5-10 Ma, or, earlier and over greater oceanic distances.

Figure 2. Dipterocarp Distribution (with Wallace Line added) - Whitmore, 1981.

Figure 1. Dipterocarp Habit (Blomqvist) and Fruit (Roslal)

Materials and Methods

Taxon Sampling: The cpDNA sequences (*trn*L Intron and *trn*L-*trn*F Intergenic Spacer) of 71 species from the subfamily Dipterocarpoideae, 1 species from the subfamily Monotoideae, and 3 outgroup species were gathered from GenBank and aligned within MacClade 4.08 OX S.

Analysis: Divergence times were estimated within BEAST v1.7.2 using fossil dates and divergence estimates of *Dipterocarpus* (Meijer 1974), Dipterocarpoideae (Dutta *et al.* 2011), Dipterocarpaceae (Appanah *et al.* 1998), and Malvales (Wikstrom *et al.* 2001) obtained from prior studies. Previous analyzation included using PAUP Maximum Parsimony and Maximum Likelihood as beginning phylogenetic estimates.

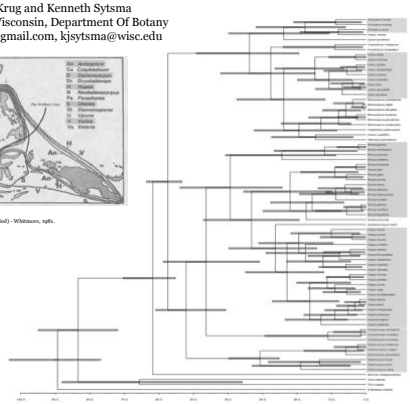


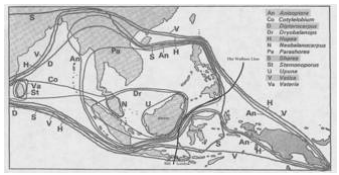
Figure 3. Phylogram of Dipterocarpaceae as inferred from BEAST analysis of cpDNA data showing mean divergence time estimates with 95% highest posterior density (HPD) intervals (blue bars). Arabidopsis thaliana, Tilia kiusiana, and Cistus ladanifer were used an outgroup.

Results and Discussion

With four fossil calibrations (Malvales, Dipterocarpaceae, Dipterocarpoideae, and *Dipterocarpus* fossils) the *Anisoptera* crown node was found to have originated 17.7 million years ago (Ma) (95% CI = 5.9-31.9), the *Dipterocarpus* crown node 30.7 Ma (95% CI = 25.1-39.9), the *Hopea* crown node 22.9 Ma (95% CI = 12.2-35.0), the *Shorea* crown node 22.0 Ma (95% CI = 9.9-35.5), and the *Vatica* crown node 14.8 Ma (95% CI = 6.3-26.2; **Fig. 3**). Our results suggest these five geographically widespread species originated before the Sunda and Sahul plates collided 5-10 Ma. The species within these genera known to have the most widespread distribution include *Anisoptera costata* and *Dipterocarpus kerri* as stated by Meijer 1974. The *Anisoptera costata* crown node was found to have originated 8.8 Ma (95% CI = 1.2-21.0) while the *Dipterocarpus kerri* crown node originated 13.7 Ma (95% CI = 1.5-28.4). These dates suggest the dipterocarp species reaching the farthest east over the Wallace Line originated around the same time as the Sunda and Sahul plate collision.

The shortest distance between the plates after collision is around 20 miles between Bali and Lombok. Most flora and fauna presumably evolved when separated by a sea exceeding 1500 miles and remain drastically different presently in the Eurasian and Australian areas (Schuster 1972). The known species that hopped eastward over the Wallace Line most likely did so over shorter distances while their parent species remained in smaller areas of distribution. For some species, this may not be the case and the parent species are more largely distributed than those recently diverged.

Further research regarding the dispersal capabilities of the dominant two-winged fruit of dipterocarp species and closer study of the topology of large geographically distributed species are needed to clear up discrepancies.



Dipterocarpaceae chronogram

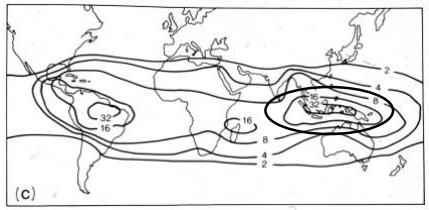
3 genera and 8 species make it to New Guinea on Sahul Shelf . . .

. . . and within last 10 myr – dipterocarps honor Wallace's Line

The Wallace Line

Do palms honor the Wallace Line?

Greatest center of diversity of palms is in the IndoMalay archipelago — how do they respond to the Wallace Line?

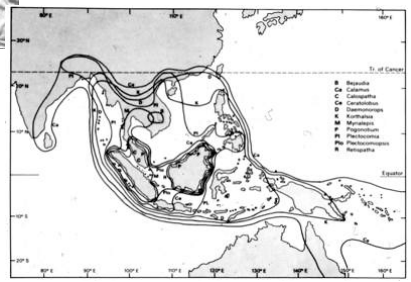


The Wallace Line

Rattan palm

Rattan palms are essentially Asian with all but 3 genera restricted west of Lombok and Sulawesi

For the 3 genera east of Wallace Line, only 1 species each crosses the line



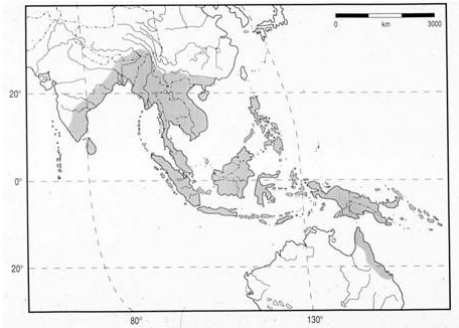
Distribution of different genera of rattan palms

The Wallace Line

fishtail palm

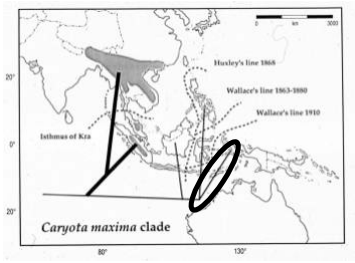
The genus *Caryota* (fishtail palms) is widespread across the IndoMalay - New Guinea region

Does it not support the Wallace Line?



Distribution of *Caryota*

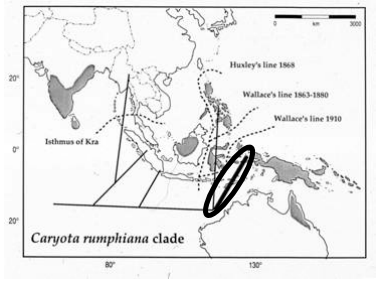
The Wallace Line



Species relationships within two different groups of fishtail palms and their biogeographical distributions

Although fishtail palms appear not to honor the Wallace Line as a genus, only the most recent speciation events in each clade have generated species crossing the line.

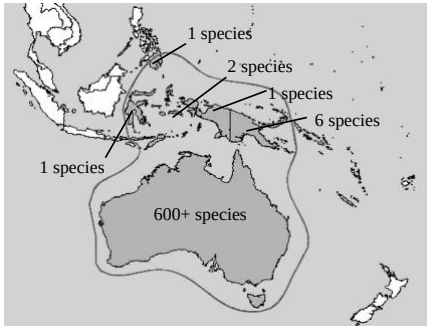
Perhaps these occurred after plate contact occurred.



The Wallace Line

Gum eucalypt

Eucalyptus (Myrtaceae) is an Australian genus and basically honors the Wallace Line from the east



Distribution of *Eucalyptus*