# Why does the biota of the Madagascar region have such a strong Asiatic flavour?

Ben H. Warren, Dominique Strasberg, J. Henrich Bruggemann, Robert P. Prys-Jones and Christophe Thésbaud

# Background

- Despite Madagascar's extreme isolation from India and proximity to Africa, a high proportion of the biota of the Madagascar region has Asian affinities.

- Biota are the total collection of organisms of a geographic region or a time period.

- This discrepancy (termed  the strangest of anomalies"; Sclater, 1864), along with the longstanding isolation of the Madagascar region, has resulted in the origins of its biota being referred to as "the most difficult enigma in zoological geography" (Cuénot, 1932) and "one of the greatest unsolved mysteries of natural history" (Krause et al., 1997).

# Theory

- It is clear that the position, size and connectivity of continents is under continual change over geological time (Scotese, 2001). Such fragmentation of continents is expected to result in divergence by vicariance; one may expect the biogeographical affinities of continental and continental island biotas to be skewed towards that of the continent (or continental block) to which they were most recently connected (Murphy and Collier, 1997; Sparks, 2004; Sparks and Smith, 2004, 2005).
- A corollary of island biogeographical theory is the prediction that the largest proportion of lineages immigrating into an island or island region will come from the nearest mainland source (MacArthur and Wilson, 1967).

- A significant proportion of biota shows much closer affinities to lineages in Asia (especially India) than to those in Africa (Battistini and Richard-Vindard, 1972; Stoddart, 1984; Cheke and Hume, 2008). Considering the geography of the region from a dispersal perspective, these Asian affinities are surprising given the much greater distance of Madagascar from India (3796 km) than from Africa (413 km).
- Long distance dispersal events may attribute to the biota of Madagascar

# Two factors may have promoted long-distance dispersal events from Asia towards the Madagascar region

- First, the Indian winter monsoon winds blow from the Indian subcontinent towards the Madagascar region. Although these winds are reversed in the Indian summer, other winds blow across the Indian Ocean from the direction of Australia and Indonesia towards the Madagascar region in this season, a path also followed by ocean currents (Goswami and Rajagopal, 2003; New et al., 2005; Cheke and Hume, 2008).
- Secondly, at repeated times of low sea-level in the recent geological past, a chain of islands may have stretched between Madagascar and India, greatly reducing the distance of open ocean to be crossed between India and the Madagascar region.


INDIA
Maldives
Granitic
Seychelles
AFRICA
Chagos
Comoros
Mascarenes
MU
RD
RE
MADAGASCAR
350 km

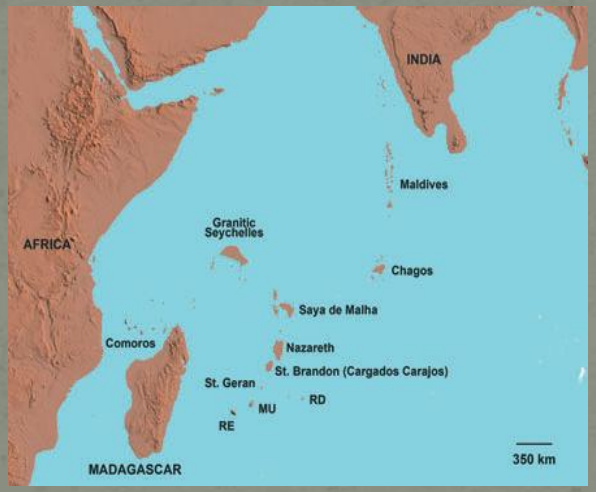
# Results

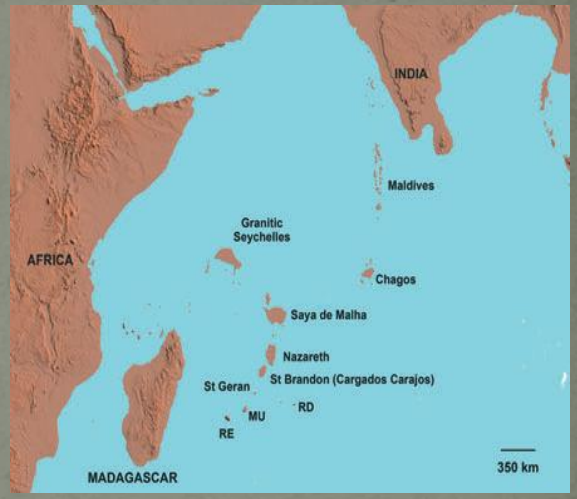
## Geological and bathymetric data

-New data on Indian Ocean sea-level changes support lowstands of up to 145 +/- 5m below present sea level at six episodes in the last 0.5Myr, some of which persisted for up to 50,000 years at a time (Colonna et al., 1996; Rohling et al., 1998; Siddall et al. 2003; Camoin et al., 2004).

- The enlarged size of these islands is likely to have increased the frequency of arrival of waif dispersals, increasing the chances of populations becoming established. Similarly, the enlarged size of these islands would have permitted populations of larger size with an increased potential to serve as the founding population for the colonization of neighboring islands and continents.

# Proposed Islands

# Results

## Molecular Data

- Notwithstanding the important contributions of vicariance in shaping the Asian component of the biota of the Madagascar region, the large majority (78%) of dated Asia-Madagascar region divergences (both animal and plant) post-date the separation of India and Madagascar by a considerable margin (up to 87 Myr).
- The fact that divergence time estimates post-dating Gondwanan separation are based not only on fossil calibrations, but also island and lake calibrations, further strengthens the conclusion that most such divergences are a result of trans-Indian Ocean dispersal, rather than vicariance.

# Predictions

1. Where lineages in the Madagascar region have a sister species with a wide Asian distribution from India eastwards towards Australia, the source population for the lineage colonizing the Madagascar region would have been in India or Sri Lanka, rather than further east.
2. Timings of trans-Indian Ocean dispersal should correspond with timings of sea-level lowstands when the stepping-stone islands would have been emergent.
3. For lineages arriving in the Madagascar region from Asia within the last 10 Myr, the root of the Madagascar region radiation should have been in lowland rather than highland communities.
4. The average time of arrival in the Madagascar region of lineages of Asian origin should be greater for those restricted to high-altitude environments than to those restricted to low-altitude environments.

# Conclusion

- Gondwanan vicariance has undoubtedly had a role to play in the assembly of the modern biota. Nonetheless, the recent (post-Gondwanan) Asian origin of many taxa in the Madagascar region can only be explained by other factors. The most likely of these is a second historical factor: the repeated former existence of a chain of stepping-stone islands between Madagascar and India. However, regional processes-prevailing wind and current directions are also likely to have contributed to the pattern. Evidence that one of these factors was more important than the other is currently equivocal, and further testing is required.

# The End

# References


- http://ashipunov.info/shipunov/school/biol_330/presentations/warren2010_madagascar_biota.pdf