# Update of distribution of two *Stegomyia* in Madagascar


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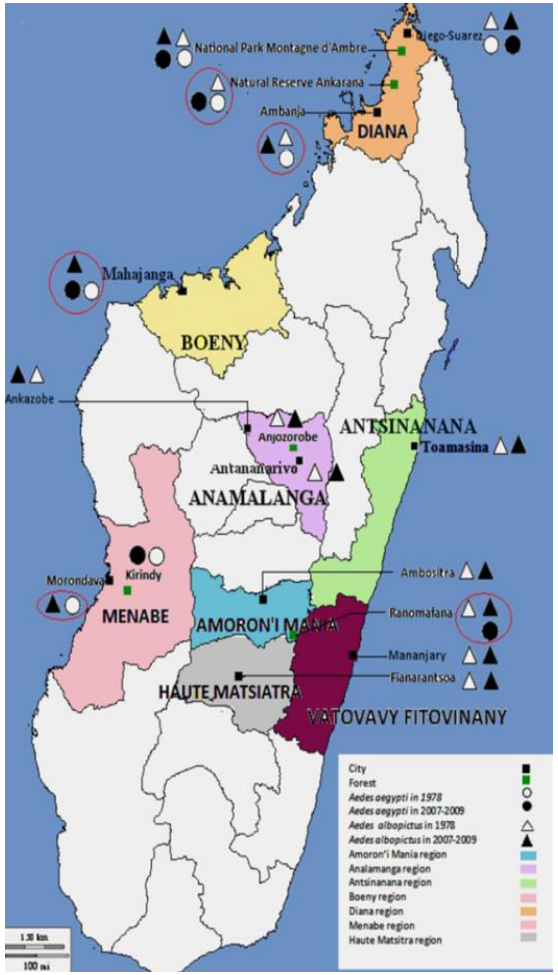
# Context

- *Aedes albopictus* and *Aedes aegypti* are major vectors of some arboviral diseases.
- These two species have been involved in arbovirus outbreaks worldwide
- *Ae. albopictus is considered as* the primary vector of most recent outbreaks in the Indian Ocean.
- In Madagascar, outbreaks of DEN and CHIK fevers emerged in the east coast of Toamasina on January 2006

# Distribution of *Aedes aegypti* and *Aedes albopictus* in the past


Fontenille et Rodhain 1989



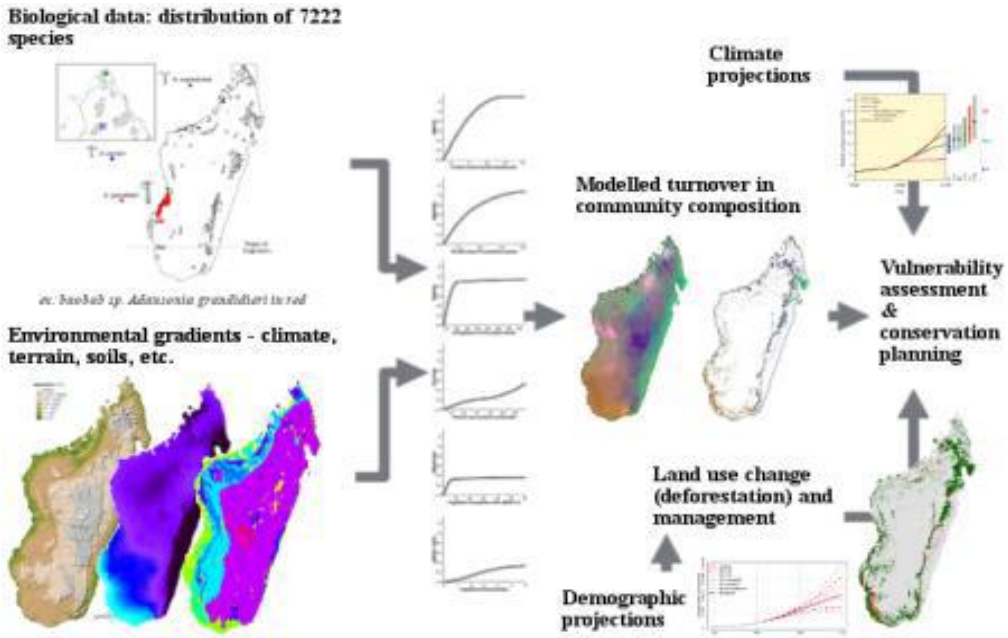

Raharimalala et *al*. 2011

# Objectives

- Update the distribution of *Aedes aegypti* and *Aedes albopictus* in the island of Madagascar.
- Test the *speciesaltas R packages to develop species distributions maps*
- Produce scenarios of biodiversity evolution under climate change (2080)
- Determine the variables implicated to their distribution

# Methodology

- Collect specimens (larvae and adult) in 25 districts of Madagascar,
- Based on a current project in *Eulemur albifrons* (*BioSceneMada*), *the idea is to apply this open-source methodology in entomology.*




*https://bioscenemada.cirad.fr

## Methodology

# SpeciesAtlas

- **Framework**

1)Prepare the environnement: installation of the package

2) Derive and select the relevant environnemental variables (already avalaible in the script)

3) Loading the presence points

4) Select the variables used for modelisation

5) Building and predicting by Species Distribution Models for the selected species

4) Combine all the results (# models, # species) for creating the maps

5) Apply land use change and climate change scenarios for distribution future

- 1 “individual” is one - or several – observation(s) in a 1 km cell Data

# Methodology SpeciesAtlas

## ❑ Environnemental datasets used:

For current distribution: Madaclim data

For future distribution: Worldclim data

## ❑ These variables are tested:

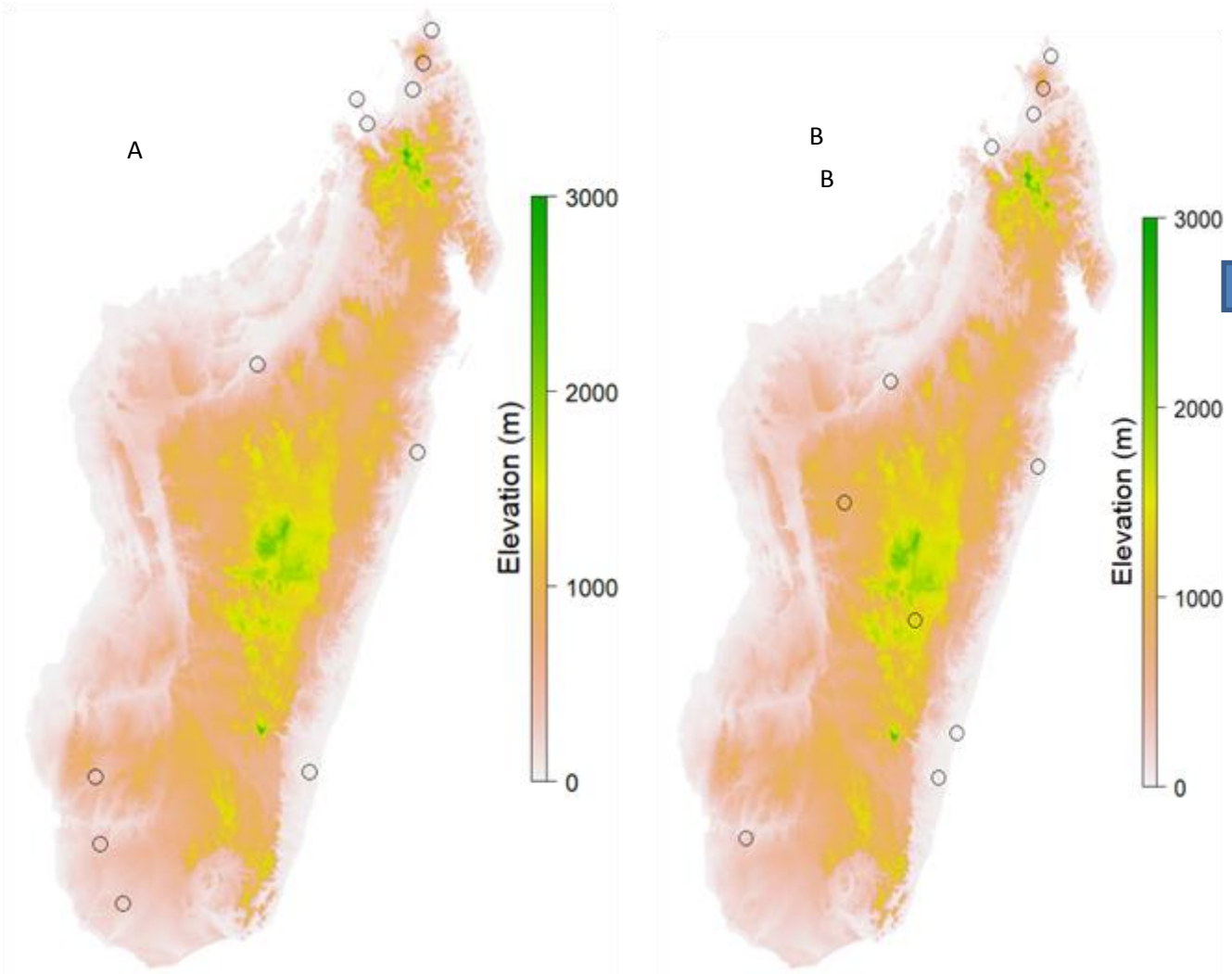
- Mean annual rainfall (mm)
- Mean annual temperature (°C)
- Rainfall seasonality (mm)
- Temperature seasonality (°C)
- Climatic water deficit (mm)
- Forest cover (%)

## Methodology

**5** Species Distribution Models **SDMs** were applied and their outputs combined to calculate the species distribution map

- ❑ Random Forest (RF)
- ❑ Maxent (MaxE)
- ❑ Artificial Neural Network (ANN)
- ❑ Generalized Additive Model (GAM)
- ❑ Generalized Linear Model (GLM)
- ❑ Theses models run using the package *BioMod2 (model parameterization and ensemble forecasting)*

# Results




**Distribution of *Aedes aegypti* (A) and *Aedes albopictus* (B) in terms of altitude**

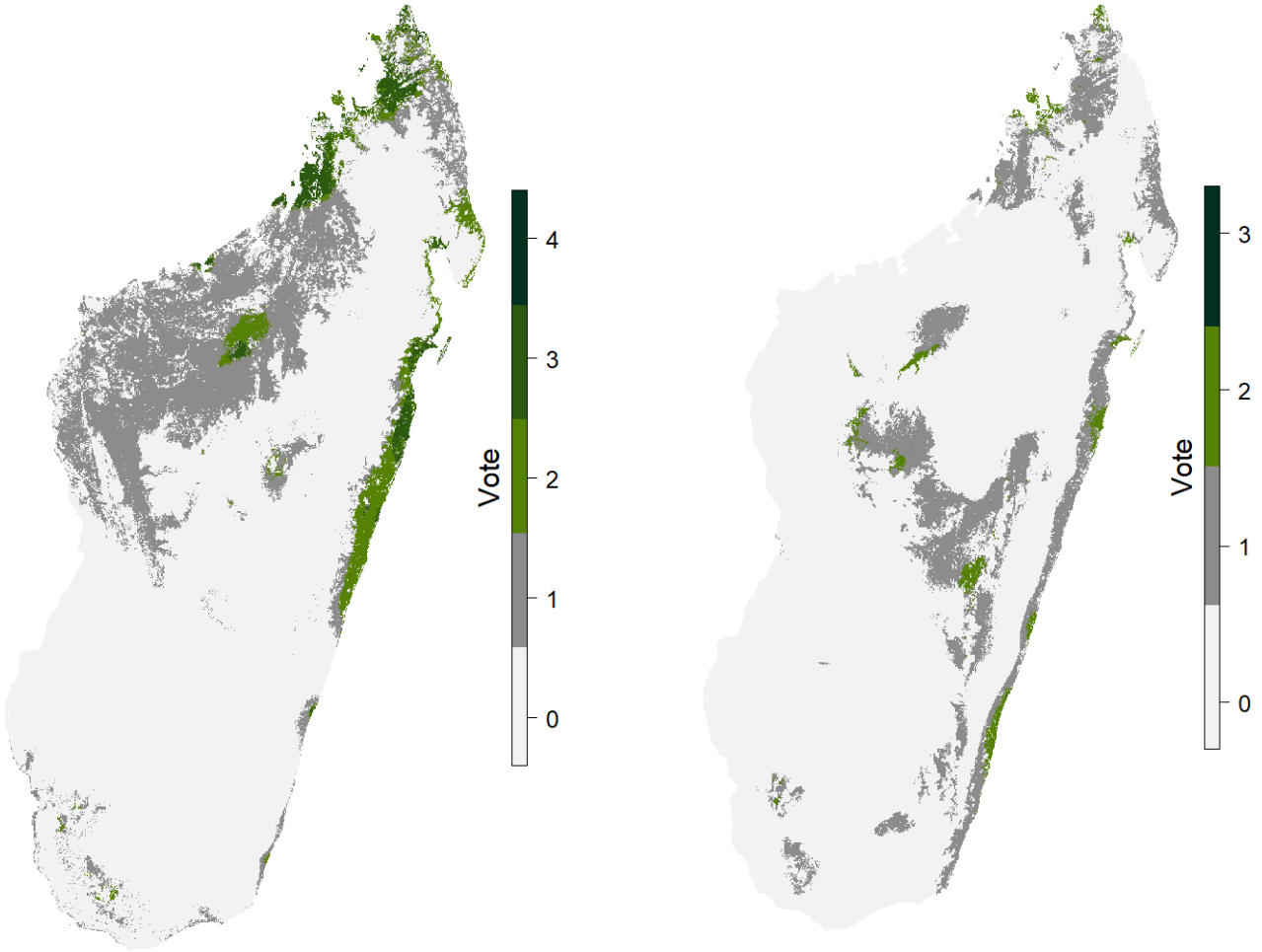
**Number of vote => number of model that predict a presence of the species**

**hidden white** to **light pink:** low than 1.000 m
**Orange to yellow**: 1.000 m to 2.000 m
**Green**: above 2.000m

# Results

**Current area**: *Aedes aegypti* = **3036 Km²** and *Aedes albopictus* = **60804 Km²**

## Current distribution




**Grey areas**: less favourable areas
**dark grey**: favourable area
**Green areas**: most favourable areas

**Current distribution of *Aedes aegypti* (A) and *Aedes albopictus* (B)**

# Results

- Understanding current distribution of the species
- Analyse the variable's range and importance in the model

***Variables importance (rank) according to the SDMs* from *Aedes aegypti***

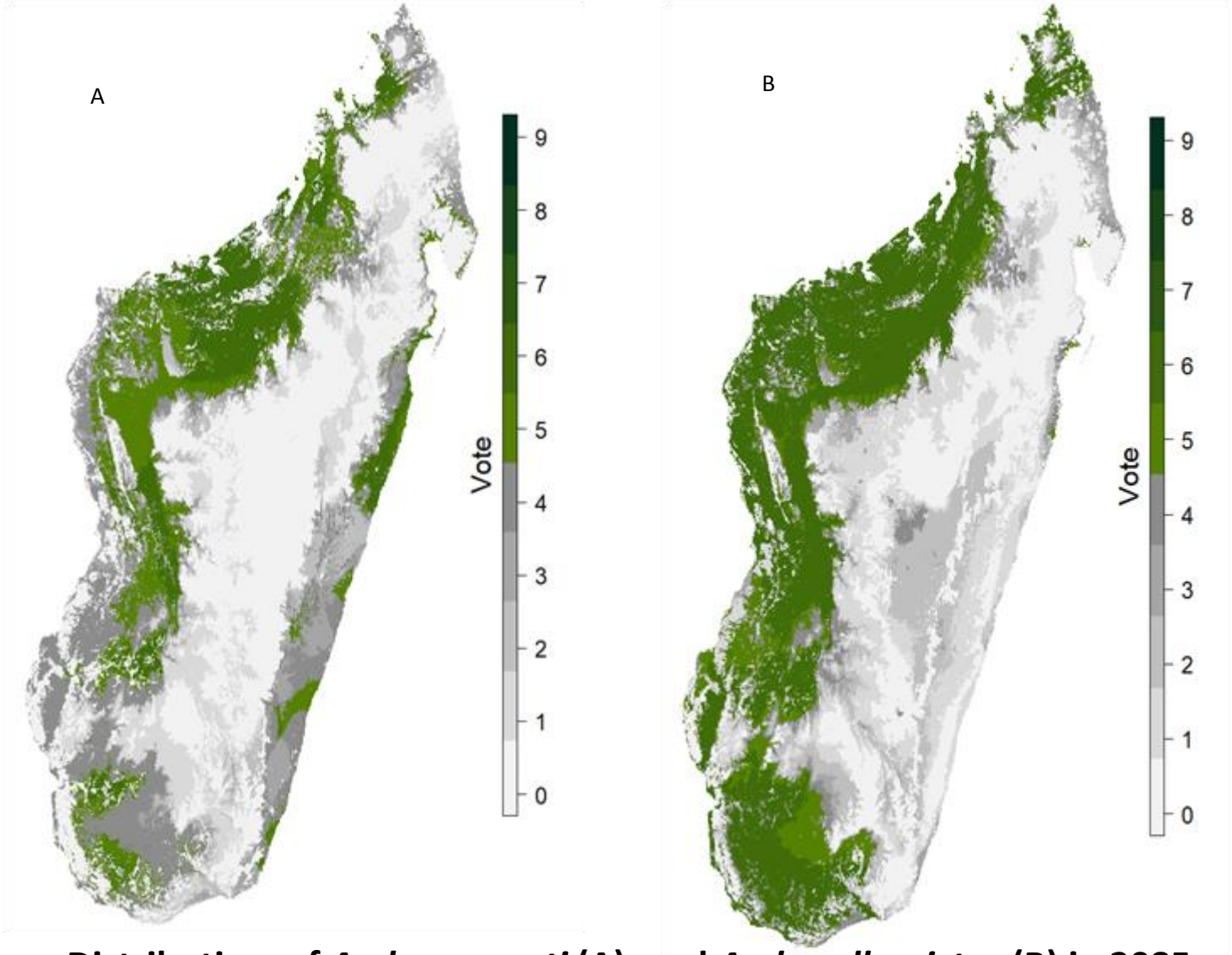
| | GAM <dbl> | RF <dbl> | ANN <dbl> | mean.rank <dbl> | rank <int> |
|---|---|---|---|---|---|
| temp | 0.995 | 0.614 | 0.921 | 2.000000 | 1 |
| tseas | 0.435 | 0.782 | 0.793 | 3.000000 | 4 |
| prec | 0.379 | 0.626 | 0.933 | 2.666667 | 2 |
| pseas | 0.554 | 0.228 | 0.779 | 4.333333 | 5 |
| cwd | 0.742 | 0.611 | 0.832 | 3.000000 | 4 |
| foret | 0.240 | 0.013 | 0.337 | 6.000000 | 6 |

***Variables importance (rank) according to the SDMs* from *Aedes albopictus***

| | GAM <dbl> | RF <dbl> | ANN <dbl> | mean.rank <dbl> | rank <int> |
|---|---|---|---|---|---|
| temp | 0.027 | 0.428 | 0.594 | 4.333333 | 5 |
| tseas | 0.386 | 0.761 | 0.789 | 2.000000 | 1 |
| prec | 0.564 | 0.663 | 0.337 | 3.333333 | 4 |
| pseas | 0.476 | 0.318 | 0.751 | 3.333333 | 4 |
| cwd | 0.656 | 0.464 | 0.387 | 2.666667 | 2 |
| foret | 0.368 | 0.015 | 0.380 | 5.333333 | 6 |

# Results

## Species Distribution map in 2080




**Distribution of *Aedes aegypti* (A) and *Aedes albopictus* (B) in 2085**

# Discussion

Using speciesatlas  is an innovation in the field of entomology.

The ecological niche of *Aedes aegypti* appears to be in the low-lying areas confirmed that its species appeared in the low-lying of 900 meters (Fontenille and Rodhain, 1989).

Aedes albopictus occurs in all four bioclimatic zones confirming the study by Raharimalala et al. 2011

Both species are abundant in northern of Madagascar, which could lead to a risk of epidemic in this area. Chikungunya and dengue was reported in this area (Randrianasolo et *al.* 2010)

Temperature and precipitation  could affected the  distribution of *Aedes aegypti* as reported in the study of  Chen et *al*. en 2009 , Reinhold et *al.* 2018 (11). Climatic water deficit and seasonnality of temperature, can explain his occurrence in the eastern.

The future distribution of these species would not be affected by climate change as

# Conclusion

- Concurrent with this expansion, *Ae. aegypti* has become very scarce.

- Range expansion of *Aedes albopictus* in the west and south, and *Aedes aegypti* in western of the island without leaving its previous range.

- The parameters ecological and environmental linked to their distribution are mainly temperature and precipitation

- The future distribution of these two species could indicate an area of important sympatry in the west of Madagascar