Summary

We developed a spatial and temporal model to predict the population dynamics of the two main mosquito vectors (Aedes vexans and Culex pipiens) involved in the Rift Valley fever virus transmission. Covering an area of 11x10 km around the villages of Barkedji and located in the Ferlo Valley (Northern Senegal), the study area is characterized by a complex and dense network of ponds that are filled during the rainy season (from July to mid-October). These ponds are the main mosquito breeding sites in the area. The vector population dynamics model combines a spatial and temporal hydrodynamic model with a mosquito population model. The hydrological model uses daily rainfall as input to predict spatial and temporal changes in pond surfaces. Output is then fed into the mosquito population model to predict vector population dynamics. This approach allows predicting how mosquito abundance varies in space and in time.

The Rift Valley Fever in Senegal

- Rift Valley Fever (RVF) is an arbovirus caused by a Phlebovirus (Bunyaviridae).
- Main RVF vectors in Senegal are Aedes vexans and Culex pipiens species mosquito (Fonnerou et al., 1993; Cools, 1999).
- Main hosts are ruminants (sheep, goats and cattle).
- Temporary ponds are favorable for RVF transmission.

Aedes vexans population model

\[ \frac{dN}{dt} = \alpha - \beta N \]

- \( \alpha \): Infection rate
- \( \beta \): Mortality rate

Cx. pipiens population model

\[ \frac{dN}{dt} = \alpha - \beta N - \gamma N \]

- \( \alpha \): Infection rate
- \( \beta \): Mortality rate
- \( \gamma \): Natural mortality rate

General model description

- Input:
  - Ponds:
    - Spatial distribution: Drainage network
    - Temporal dynamics: Pond level
- Output:
  - Mosquito population abundance model
    - Simulation model: Culex and Aedes vectors
  - Data: Culex and Aedes population counts

Results

- Model validation for 2002 and 2003
  - We have validated the model with the field data (Cx. pipiens and A. vexans) collected during the rainy seasons of 2002 and 2003.
  - The results have been validated for the year 2002 and 2003 with field data.

Conclusion and Perspectives

- Simulation results were similar to Cx. pipiens and A. vexans observations in time and space. Models were able to simulate the impact of rainfall patterns on mosquito populations. Long pauses in rainfall were favorable for Aedes vexans and conversely, frequent rainfall are more appropriate for the development of a high Cx. pipiens population.
- In subsequent steps, these models will be coupled with a mosquito diffusion model to test the impact of different parameters (vegetation density, host compound location, pond distribution) on mosquito spread in space and time around their breeding sites.
- Results of this work will be useful to design better prevention and control programmes for vector-borne diseases.

References

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- CIRAD-French Agricultural Research Center for International Development, Bâtiment Campus, 34080 Montpellier Cedex, France.
- UMR TETIS (Terroirs, Ecosystèmes, Ressources Séquestrées et Produires d’Intérêt National) et Unité de Recherche en Environnement, 500 route de J.-F. Breton, 34033 Montpellier Cedex 02, France.
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Study area

- Covering an area of 11x10 km around the village of Barkedji, the study area is characterized by a complex and dense network of ponds filling during the rainy season (from July to mid-October). Located in the Ferlo region, the climate is Sahelian with 3 seasons:
  - a dry, cold season from November to March,
  - a dry, hot season from April to June,
  - a rainy season from June to November with annual rainfall ranging from 100 to 500 mm.

DATA

- During the rainy season in 2002 and 2003, mosquitoes have been collected every 20 days using sheep-baited traps (Photos). Sheep-baited traps in Barkedji area (Fert, 14’07’ W, 15’28’ N). Three temporary ponds, Niaka, Barkedji and Furdj, have been chosen according to ecological and structural criteria (Fert, 1987). A trap was laid a few meters from the pond bank. Trapping sessions were carried out between 6 pm and 6 am on three consecutive days to account for daily fluctuations in mosquito abundance.

Figure 2 shows the total numbers of trapped mosquitoes. For this study, we have used only the trap closed to the pond to measure the capacity of each pond to produce mosquitoes.