A mapping tool to assess entomological risk related to *Aedes albopictus*
(Life+ project n°LIFE08/ENV/F/000488)

Myriam CROS[1], Annelise TRAN[2,3], Marie DEMARCHI[4], Guillaume LACOUR[1], Grégory L'AMBERT[1], Jean ALFONSI[5] and Paul-Mathieu GIBERGUES[5]

[1] Entente Interdépartementale pour la Démoustication du littoral méditerranéen (EID Méditerranée), Montpellier, France. [2] CIRAD, UPR AGIRs, Montpellier, France. [3] CIRAD, UMR TETIS, Montpellier, France. [4] Maison de la télédétection, Montpellier, France. [5] Service lutte anti-vectorielle et démoustication, Conseil Général de Corse du Sud (LAV - CG Corse du Sud), Ajaccio, France.

19th European Society for Vector Ecology Conference. 13-17th october 2014, Thessaloniki, Greece

The control of vector mosquitoes is an activity for which the socio-economic, health and environmental stakes are high. In France, this mission was entrusted to specialised public operators. These operators need decision-making tools to evaluate efficacy, health and environmental risks pertaining to the current control strategies.

The IMCM-LIFE08 ENV/F/000488 project proposed the development of technical and methodological tools for an integrated mosquito control management. One of the five tasks of this project (Task #4) was dedicated to geomatic engineering. A methodology and tool for mapping retrospective and predictive entomological risk tied to *Aedes albopictus* were developed and tested in 3 towns of the south of France. This tool uses a temporal model of dynamics of *Ae. albopictus* populations (Step 1) asynchronously coupled to a GIS extension to spatialize the temporal dynamics (Step 2).

Step 1 Temporal modelization of dynamics of *Ae. albopictus* populations

The model is derived from the deterministic model developed by Cailly et al. (2007)[1]. Based on a system of ordinary differential equations, it has been adapted to the biological characteristics of *Ae. albopictus* in France for the Mediterranean biogeographical region (Tran et al. 2013)[2].

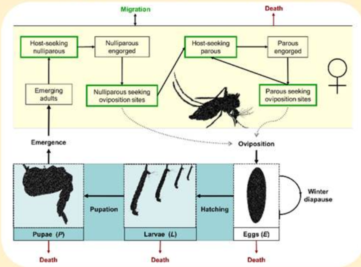
Nearly twenty parameters were determined from laboratory and field data obtained mainly on local populations.

Data source

- Meteorological data : temperature & precipitation (daily mean values)
- Laboratory data
- Field data

Parameter	Definition	Value
β1	Number of eggs laid by ovipositing nulliparous females (per female)	95
β2	Number of eggs laid by ovipositing parous females (per female)	75
κL	Standard environment carrying capacity for larvae (larvae ha−1)	250,000
κP	Standard environment carrying capacity for pupae (pupae ha−1)	250,000
σ	Sex-ratio at the emergence	0.5
μE	Egg mortality rate (day−1)	0.05
μL	Minimum larva mortality rate (day−1)	0.08
μP	Minimum pupa mortality rate (day−1)	0.03
μem	Mortality rate during adult emergence (day−1)	0.1
μA	Minimum adult mortality rate (day−1)	0.02
μr	Adult mortality rate related to seeking behavior (day−1)	0.08
TE	Minimal temperature needed for egg development (°C)	10.4
TDDE	Total number of degree-day necessary for egg development (°C)	110
γAem	Development rate of emerging adults (day−1)	0.4
γAh	Transition rate from host-seeking to engorged adults (day−1)	0.2
γAo	Transition rate from oviposition site-seeking to host-seeking adults (day−1)	0.2
TAg	Minimal temperature needed for egg maturation (°C)	10
TDDAg	Total number of degree-days necessary for egg maturation (°C)	77
tstart	Start of the favorable season	10 Mar
tend	End of the favorable season	30 Sept

Temporal model of dynamics of *Ae. albopictus* running on Scilab



Model output's

- E Eggs
- L Larvae
- P Pupae
- Aem Emerging adults
- A1h Host-seeking nulliparous
- A1g Nulliparous engorged
- A1o Nulliparous seeking oviposition sites
- A2h Host seeking parous
- A2g Parous engorged
- A2o Parous seeking oviposition sites

Step 2 Spatialization of *Ae. albopictus* population's temporal dynamics

Two criteria (vegetation and land use) are used for spatialized temporal dynamics of *Ae. albopictus*. They are determined on the basis of field expertise in urban surveillance set up by EID Méditerranée in Nice since 2008. Indeed the presence of vegetation and type of land use will affect the number of potential breeding sites : discontinuous urban fabric medium density with gardens or green spaces will be more favorable to the development of the tiger mosquito than dense continuous urban fabric without green spaces.

Data source	Geomatics treatments / data standardization	Layer
RapidEye image IRC orthophotography	Use of remote sensing to extract vegetation frame layer. Object-oriented classification (segmentation and neural network) to determine 4 classes (not vegetated, herb layer, shrub layer and tree layer).	Frame vegetation layer
GMES Urban atlas land use data	Assigning a coefficient favorability *Ae. albopictus* presence of each class of land ranging from 1 to 5.	Urban favorability layer
Output model A2h	Formatting the output A2h (Host seeking parous).	Ah2 data
Census data of the human population Touriscal statistical data GMES Urban atlas land use data	Monthly spatial distribution of human population numbers of resident and non-resident. Assigning a factor presence for morning and evening for each populations categories.	Vulnerability layer

GIS plug-in QGIS

Frame vegetation first level → Frame vegetation second level → Final frame vegetation

Geomatics treatments are applied to the vegetation layer frame to create a layer operable to generate the hazard map :

* Fusion vegetated selected class
* Function expansion erosion set to the activity field of *Ae. albopictus*
* Selection of vegetated surfaces representative

Hazard map

Selecting a period (day, week, month ...). Crossing between the layers frame final vegetation and urban favorability, modulation by seasonal coefficient determined by the model data for the selected period.

Risk map

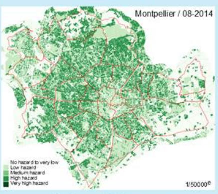
Crossing hazard map and vulnerability map

Vulnerability map

Selecting a period (month)

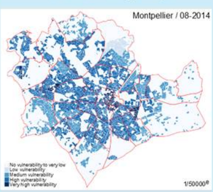
Results and Operationnal use

Hazard map

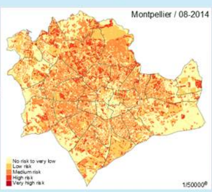


The hazard map represents the cartography of the probability of *Ae. albopictus*' presence. The tool can thus simulate the evolution of its abundance during the season and to some extent predict it.

Vulnerability map



Risk map



The intersection of these two maps enables us to define the **contact areas** between the vector (*Ae. albopictus*) and the host (humans), to qualify them in terms of **entomological risk** and to follow their evolution through time.

All Q-GIS plug-in outputs are mapped on large scale (1/10000e) and can be currently used for the towns of Montpellier, Nice and Porto-Vecchio such as decision –making tool to prioritize and optimize :

* vector control actions
* communication and prevention activities for the local authorities

The census data of the human population and tourist offices allows us to represent spatially the population density (vulnerability map). This density is modulated according to the peaks of aggression by *Ae. albopictus* in the day (morning and evening)

Prospects

Improving the definition of vulnerability.
Census data have the disadvantage of not reflecting the actual zone during peak attendance of aggression. It would be interesting to use geolocation data from GSM to better target at-risk geographic areas.

Extending the use to other towns in the Mediterranean biogeographical region.
The extension depends on the availability of land and satellite image data.

Adapting the model of population dynamics in other biogeographic zones.
Indeed currently the model is considered robust for the Mediterranean area (validation data ovitraps network monitoring Nice) but it would suit the continental and Atlantic biogeographical zones.

Synchronizing the temporal model to its spatial component to reduce processing time and minimize handling of data.

References :

[1]Cailly et al.. A climate-driven abundance model to assess mosquito control strategies. Ecol Model 2012, 227, 7-17.

[2]Tran et al.. A Rainfall- and Temperature-Driven Abundance Model for Aedes albopictus Populations. Int. J. Environ. Res. Public Health 2013, 10, 1698-1719.

ENTENTE INTERDEPARTEMENTALE POUR LA DEMOUSTICATION DU LITTORAL MEDITERRANEEN

Direction des Moyens et des Systèmes d'information, Service de l'information Géographique
165 avenue Paul-Rimbaud 34184 Montpellier Cedex 4
Tél: 04 67 63 67 63 - Fax: 04 67 63 54 05
E-mail: eid.med@eid-med.org - Website http://www.eid-med.org and http://www.lifeplusmoustique.eu/ - for contacting the authors: mcros@eid-med.org