The Geography of an emerging disease in Delhi

Olivier Telle, CNRS/CPR

CENTRE FOR POLICY RESEARCH

cnrs

INSTITUT PASTEUR

Dengue as an emerging disease

- Big success: Infectious diseases were thought to be controlled in 70 ’s (US Surgeon General, WHO….).
- International crisis due to emerging infectious diseases starting during the 80’s (Aids, Ebola, West Niles…).
- Vector borne diseases are important human health threats: Chikungunya, Zika, Dengue.

- Why such emergence?:
  - Use of antibacterial
  - Global warming ?
  - **Urbanization**

Dengue

4 serotypes

Aedes aegypti & Ae. albopictus
(Ae. polynesiensis -South Pacific)

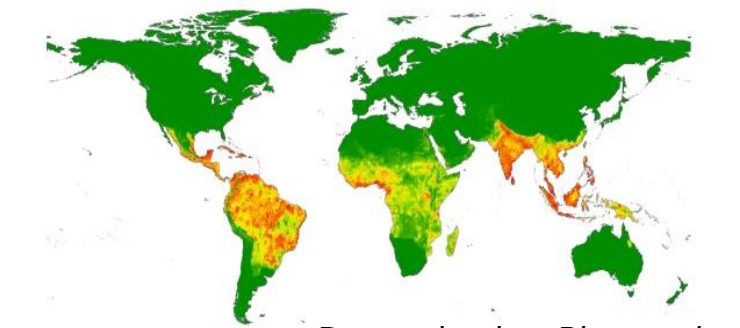
Flaviviridae

Virus	Serocomplex	Clade	Cluster
West Nile	Japanese encephalitis	XIV	Mosquito-borne
Kunjin			
Japanese encephalitis			
Murray Valley encephalitis			
St Louis encephalitis		XI	
Dengue-1	Dengue	IX	
Dengue-3			
Dengue-2			
Dengue-4			
Yellow fever	None	VII	
Central European encephalitis	Tick-borne encephalitis	IV	Tick-borne
Far Eastern encephalitis			
Powassan			
Dakar bat	None	III	No vector

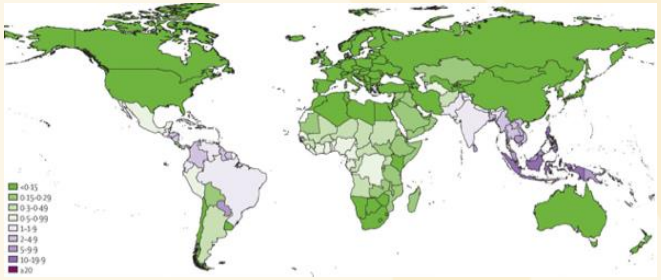
INSTITUT PASTEUR

Dengue burden

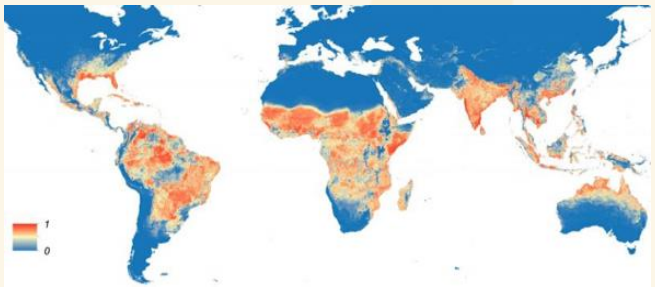
- 2013 Bhatt *et al*
  - 390 million infections
  - 98 million clinical
- 2014 Stanaway *et al*
  - 58 million clinical
- 2015 Kraemer *et al*
  - *Aedes* spp. on all continents
- 2016 Sheppard *et al*
  - Average cost US$ 8.9 billion



Dengue burden, *Bhatt et al*



Dengue burden, *Stanaway et al*

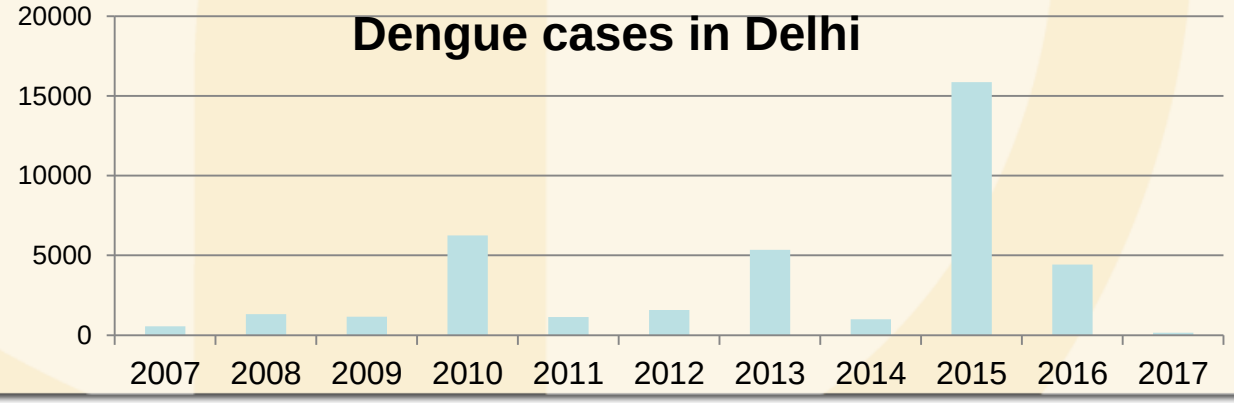


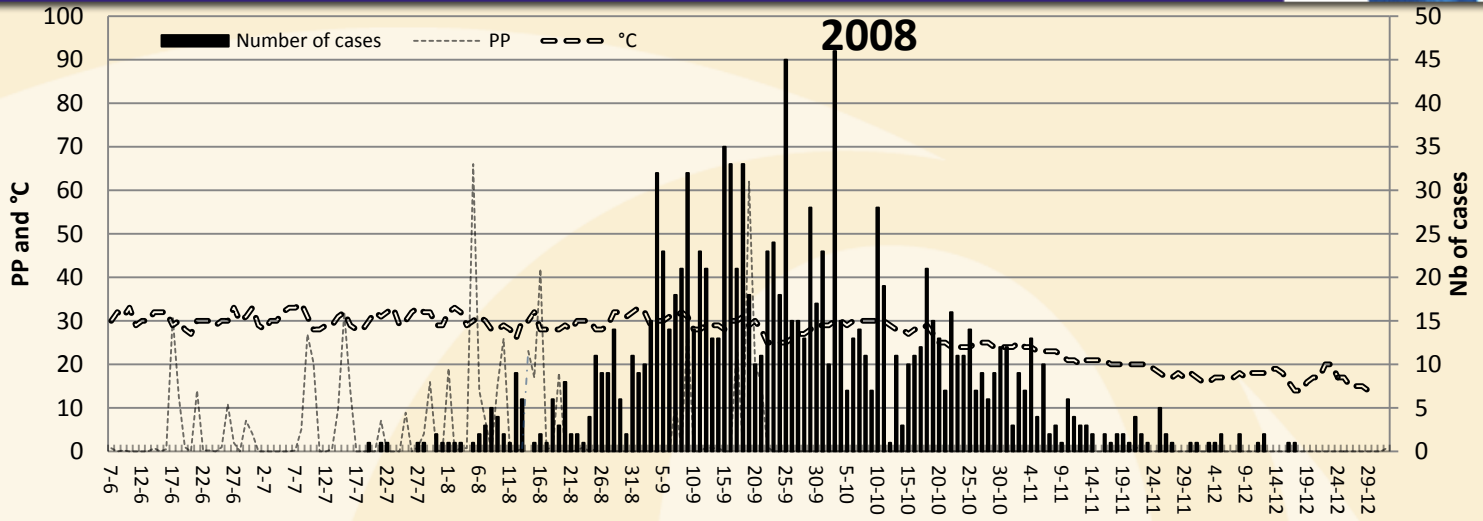
Aedes distribution, *Kraemer et al*

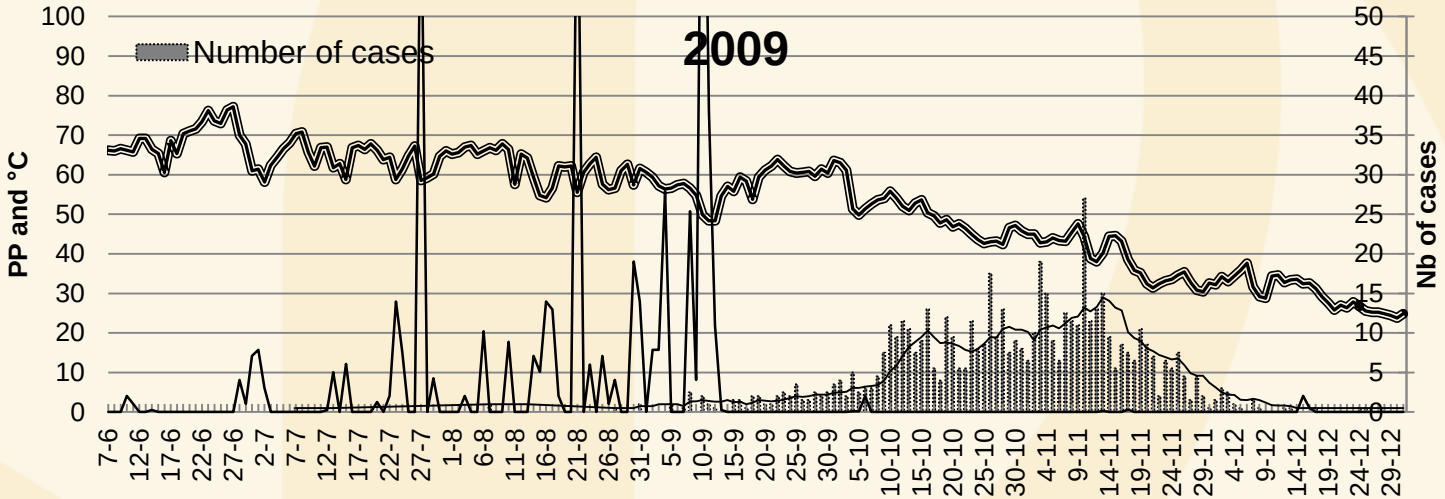
Dengue in India

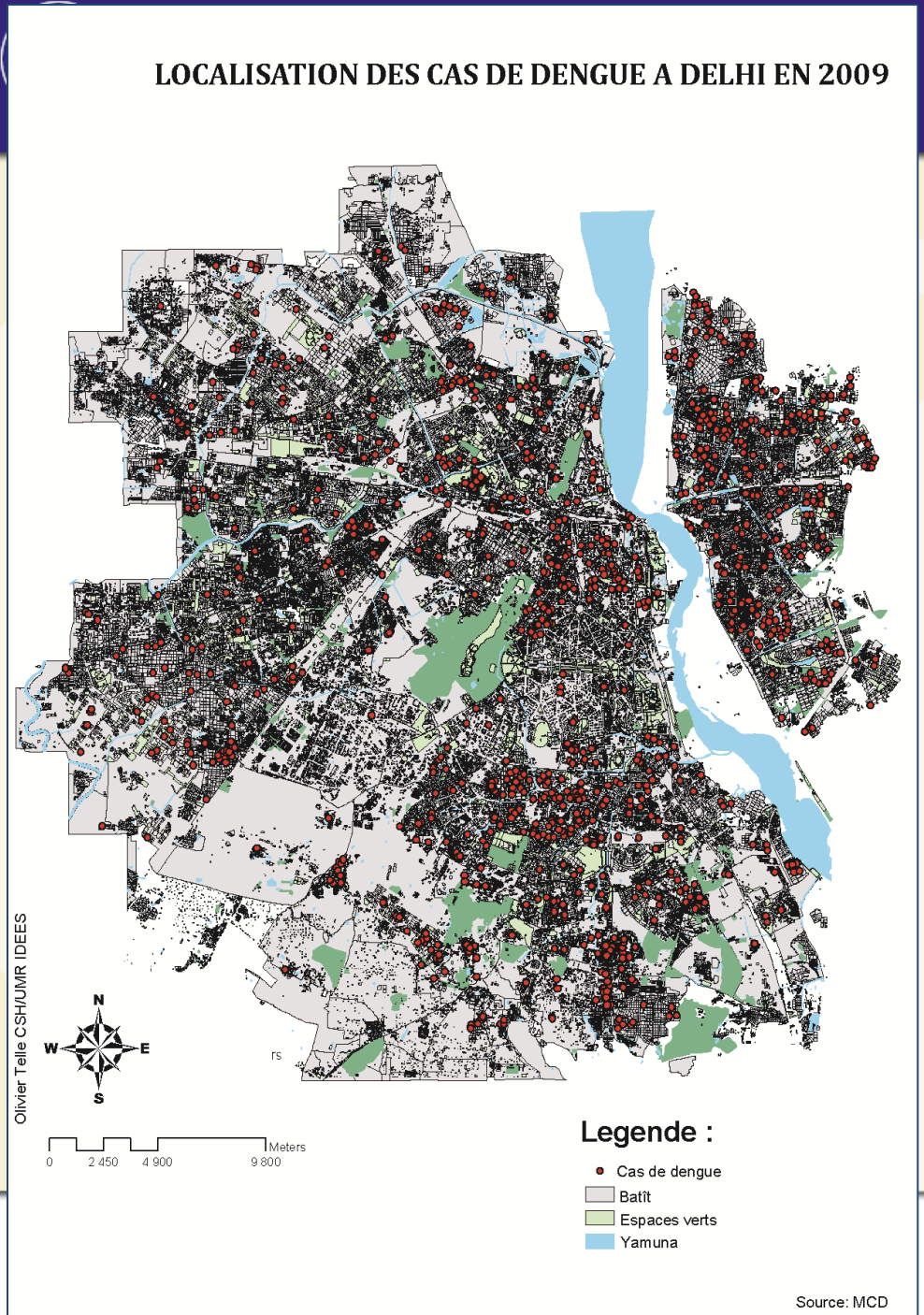
- Dengue in India
  - Spread since the 60's
  - Important diffusion since the 90's
  - Important inequalities in dengue surveillance

- Dengue in Delhi:
  - Identified during the 60's (Balaya and al., 1967)
  - Increased number of cases since 1996
  - 38 sentinel hospitals




2008
Number of cases
PP
°C
PP and °C
Nb of cases


2009
Number of cases
PP and °C
Nb of cases

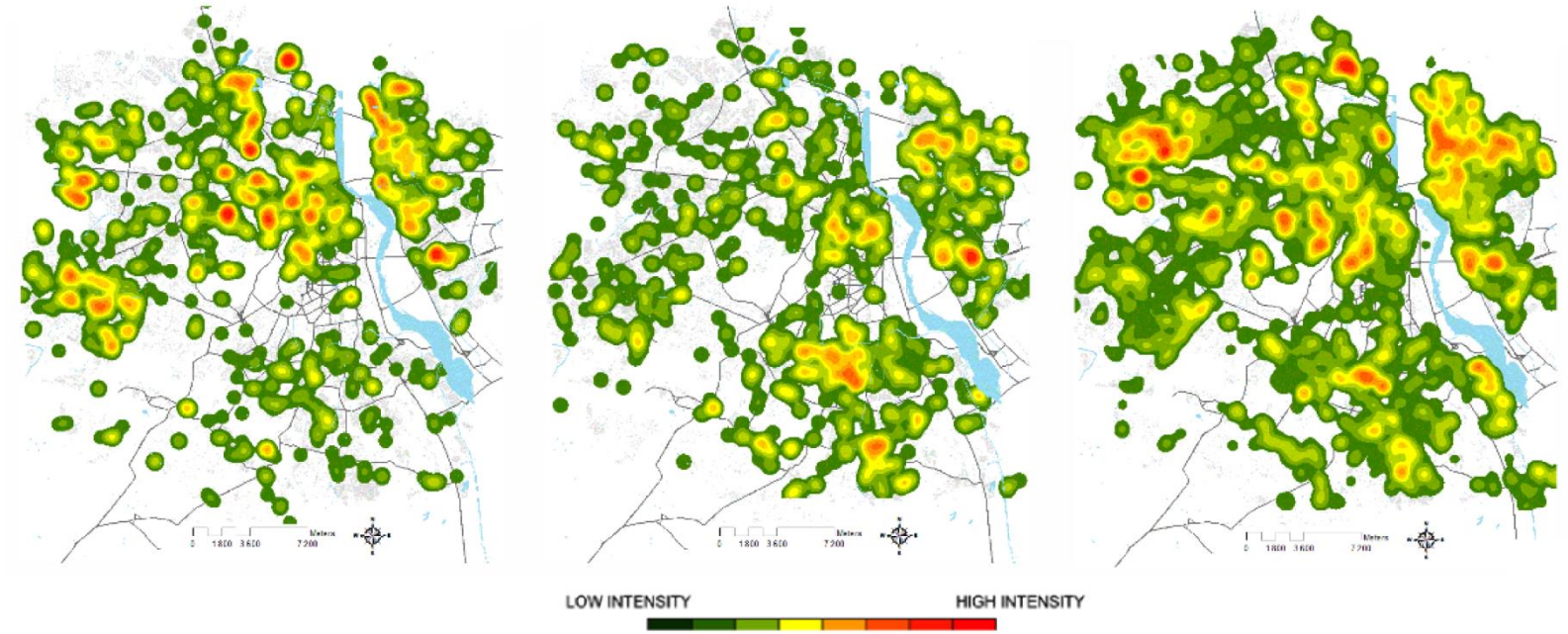


Aims of the study

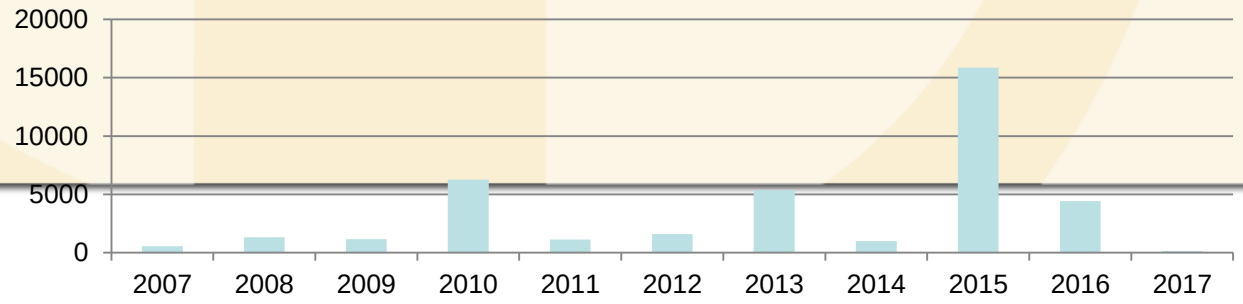
- 1) Understand how dengue spread in the urban area of Delhi:
- 2) Relation between environment (socioeconomical factors) and dengue incidence
- **Method:** Spatial epidemiology, GIS study
- **Data:** Surveillance system and fieldwork study (detection of antibodies in population)

INSTITUT PASTEUR

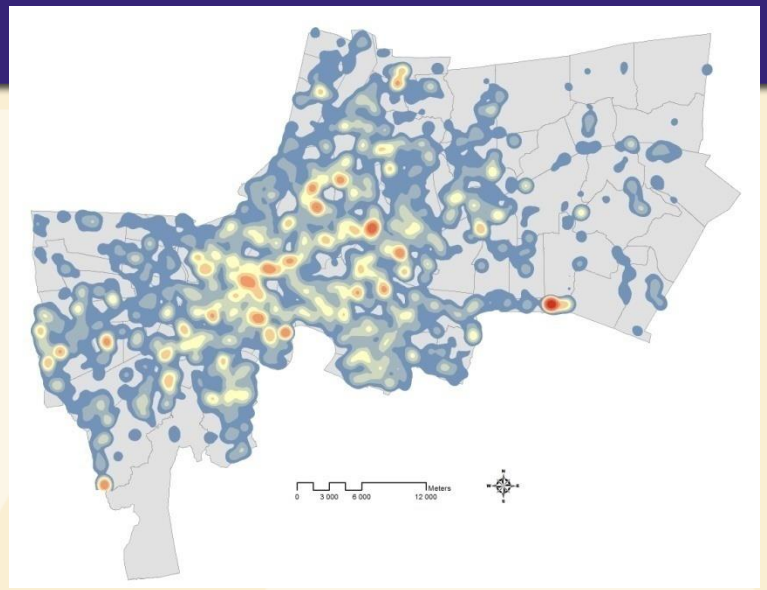
Surveillance system: Density of dengue cases in 2008; 2009 and 2010 (source: Telle O. et al., Plos one, 2016).

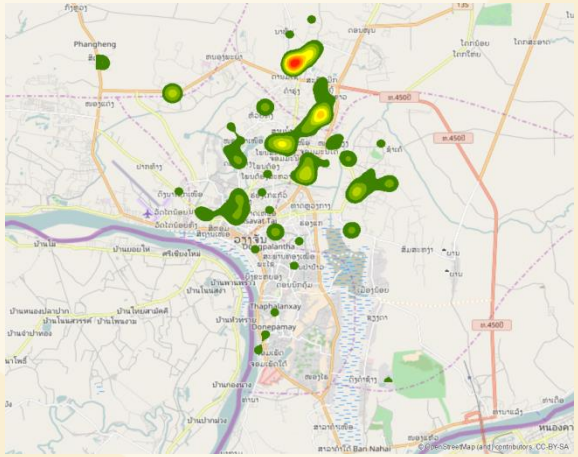


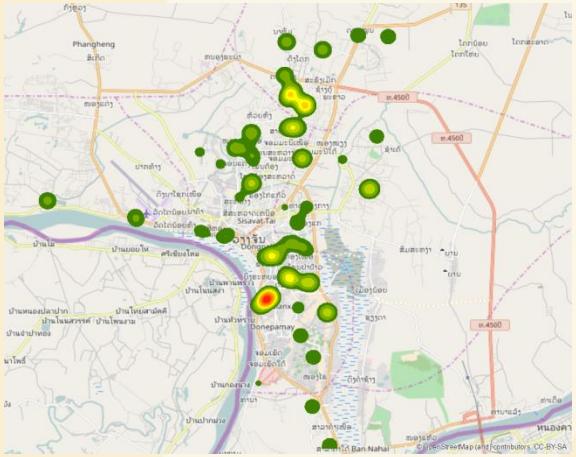
Dengue cases in Delhi

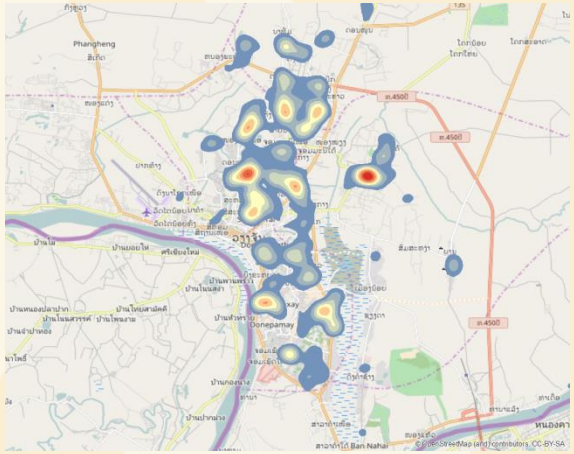


INSTITUT PASTEUR



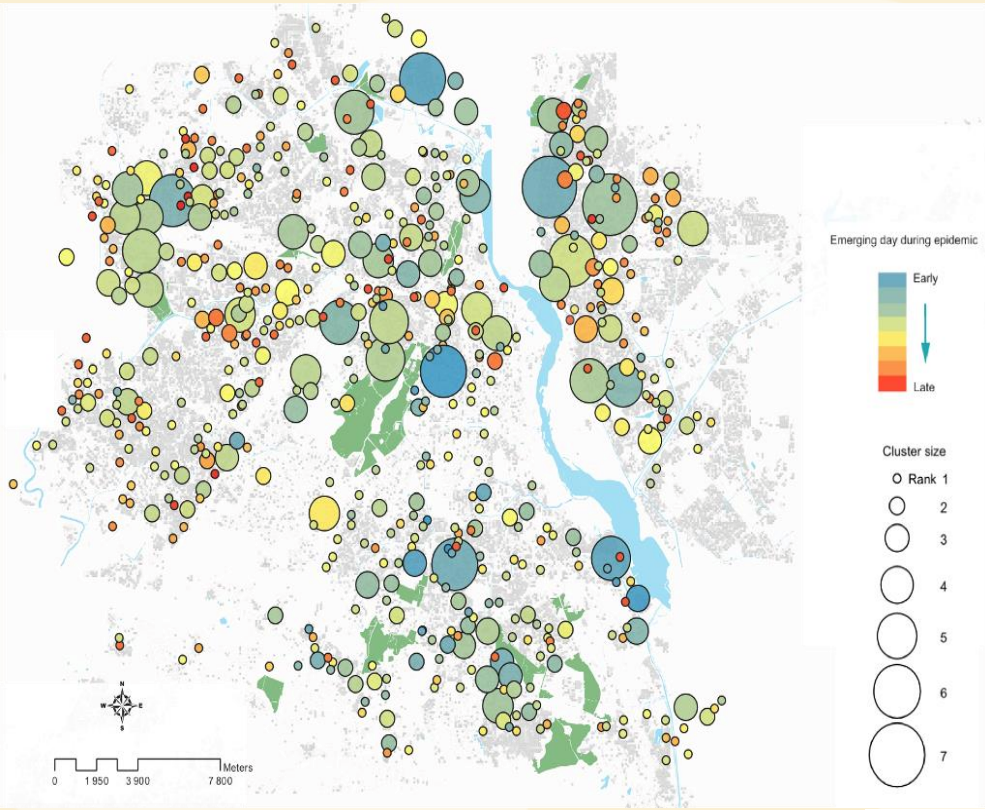


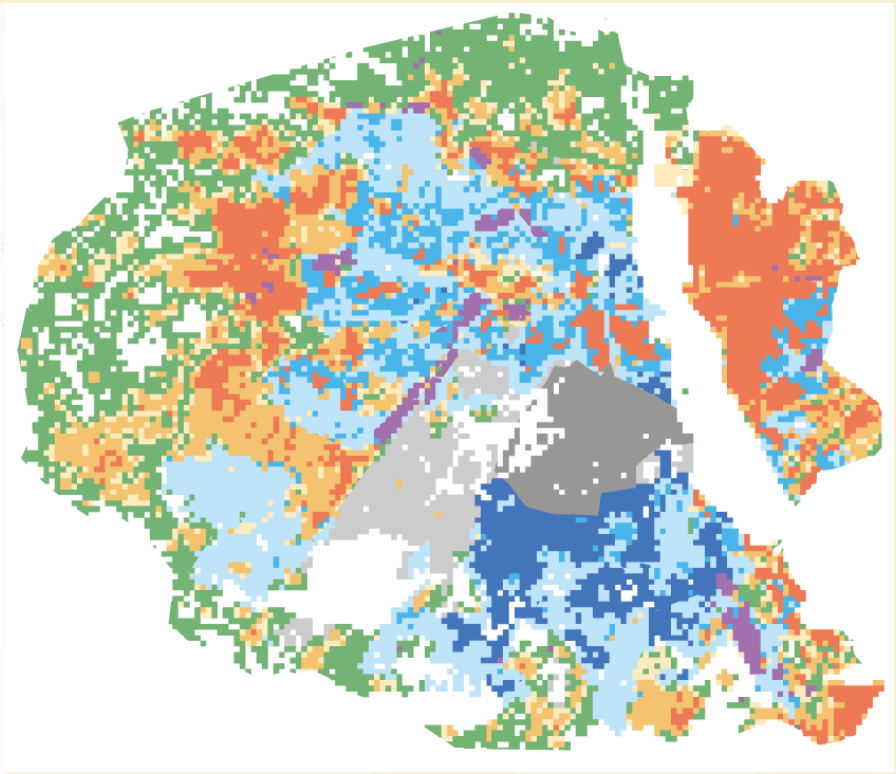




INSTITUT PASTEUR

Relation with environment

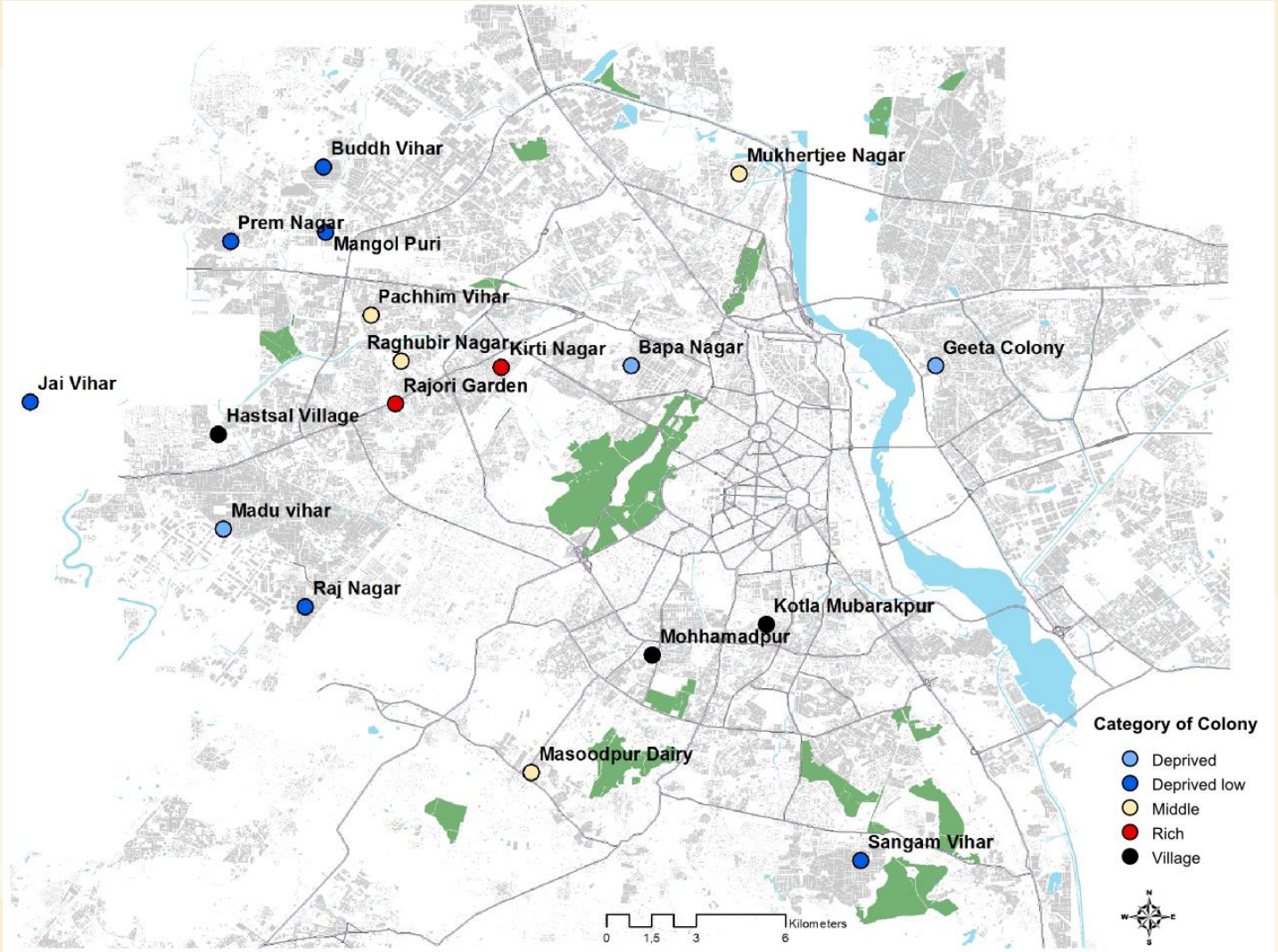




Socio-economic characteristics typology

- Impoverished, low densities
- Impoverished, medium densities
- Impoverished, high densities
- Planned, low densities
- Planned medium densities
- High incomes
- New Delhi (NDMC)
- Cantonment (CBA)
- Industrial
- Rural
- Uninhabited

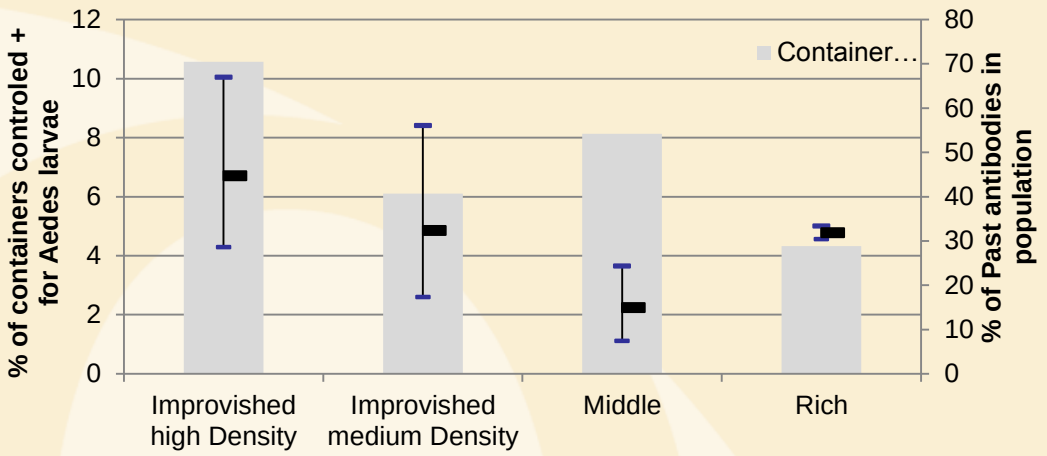
2nd method: fieldwork study and Antibodies detection



INSTITUT PASTEUR

	July November	December March	April-June
Deprived	**0,11**	**0,44**	3,55
Middle	**0,11**	0,56	0,51
High	**0,05**	**0,16**	0,39
Village	**0,13**	0,86	2,53
Deprived low		**REF**	

House index per type of colony during june 2013 till May 2014 (18 colonies sampled).



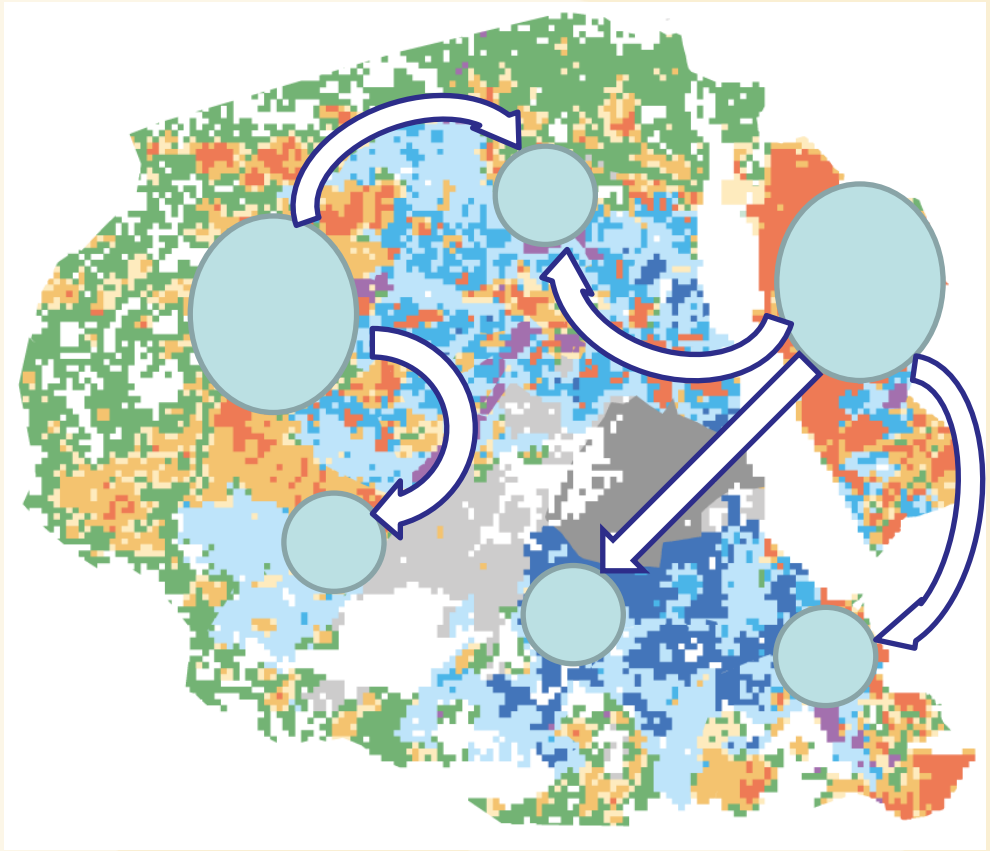
2100 individuals tested in 18 colonies (october 2013). IGM: no impact of typology

Test Positives	NB	%	Symptomatic	Asymptomatic	Category	% Asymptmatic per category
IgG	604	28,42%	-	-	**Past infections**	-
NS1	16	0,75%	3	13	**Primo infections**	81,3%
IgM	23	1,08%	4	19		
NS1+*IgM*	1	0,05%	1	0		
IgM+IgG	118	5,55%	17	101	**Secondary infections**	85,6%
NS1+*IgG*	1	0,05%	0	1		
NS1+*IgM+IgG*	5	0,24%	1	4		
No positives results	**1357**	**63,86%**	**-**	**-**	**-**	
Total	**2125**	**100,00%**	**26**	**138**		**84,1%**

INSTITUT PASTEUR

Are there identifiable migration patterns that go beyond physical distance?

Source-sink structure to Delhi ?



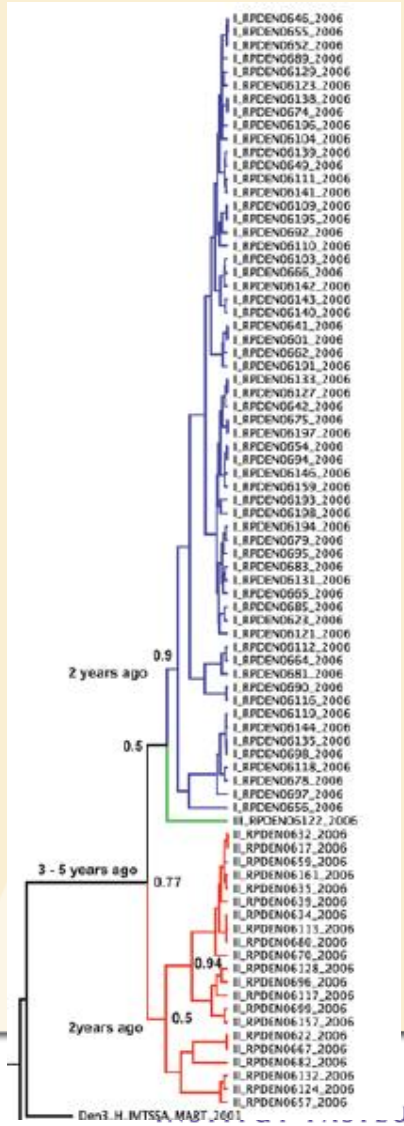
Viral genetics more informative than mobile phones/twitter etc

Genome 11000 bases and mutation rate 10^{-3} per generation (man mosquito man)

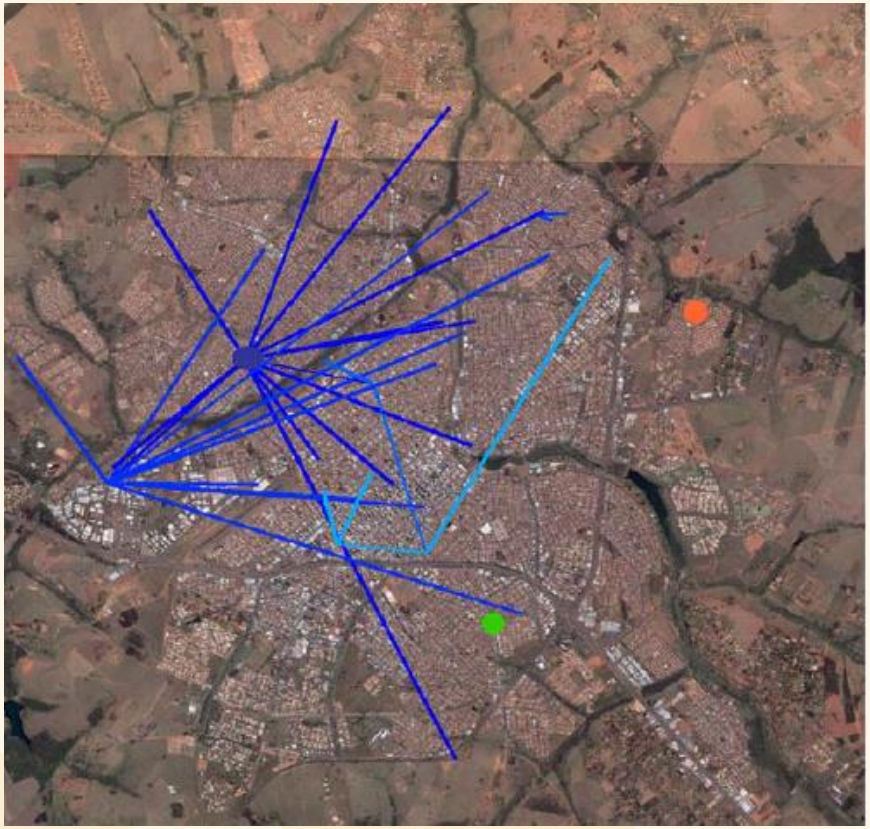
Thus 1-10 mutations per generation

Inferring micro-epidemiology through viral sequencing

Phylogenetic distance tree



Route of viral dispersal inferred through viral phylogenetics



San José de Rio Preto, Brazil. Mondini et al. 2009

- New way to observe virus diffusion
  - Sequencing (tells us about strain mutations)
  - Phylogeography

  Shall be done in routine mode

- How to approach urban mobilities?
  - **Mobile phone use**
  - Big data

Conventional fumigation and larviciding are hard to implement in modern urban cities

Sao Paulo 1940s (Aedes eradication era) and now

INSTITUT PASTEUR

Autodissemination of pyriproxyfen 10% dust

Control of DF/DHF Vector, *Aedes* Mosquito, with Insecticides

Takaaki ITOH

Takarazuka Research Center of Sumitomo Chemical Co. Ltd.
4-2-1, Takatsukasa, Takarazuka, Hyogo 665, Japan

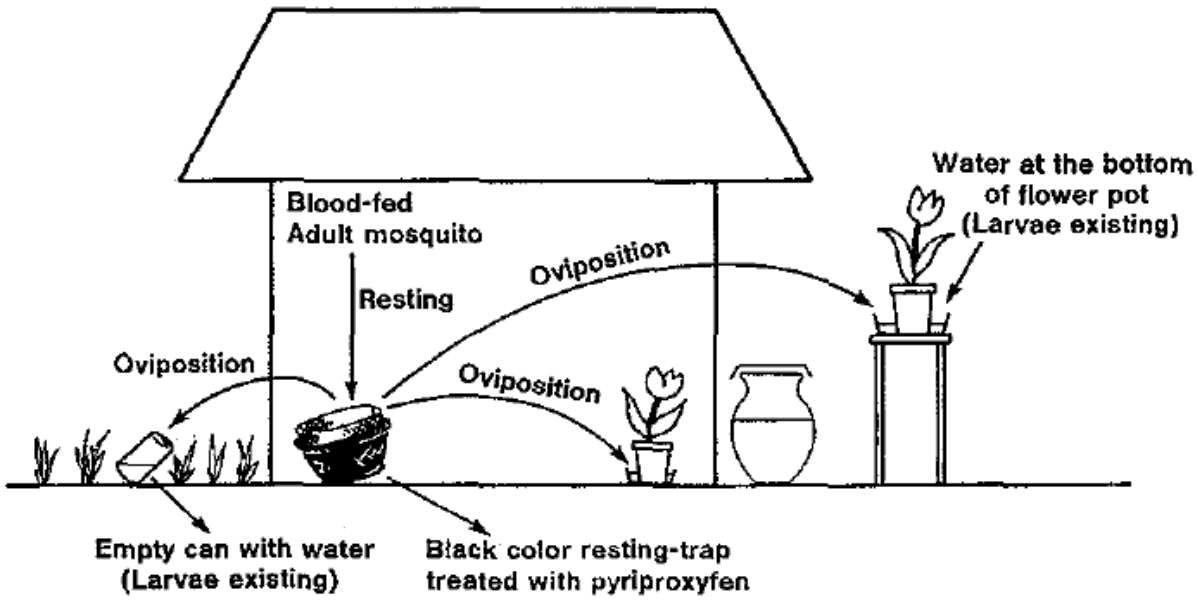


Fig. 4. Utilization of adults of *Aedes aegypti* as a vehicle of pyriproxyfen for small and inconspicuous larval habitats

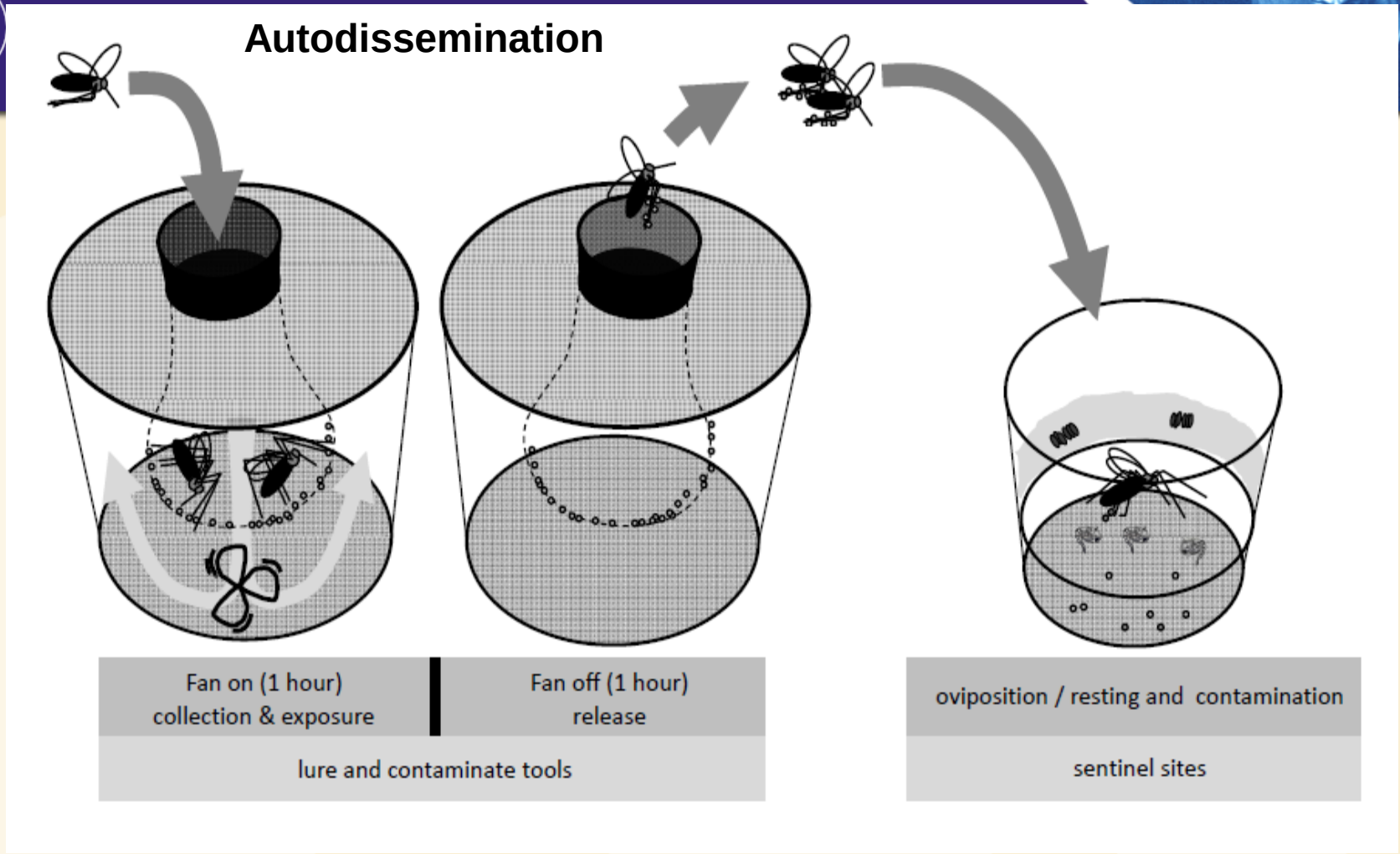


Figure 1. Adapted BG traps for pyriproxyfen dissemination. Trialled in Peru 2010 and Madeira 2014.

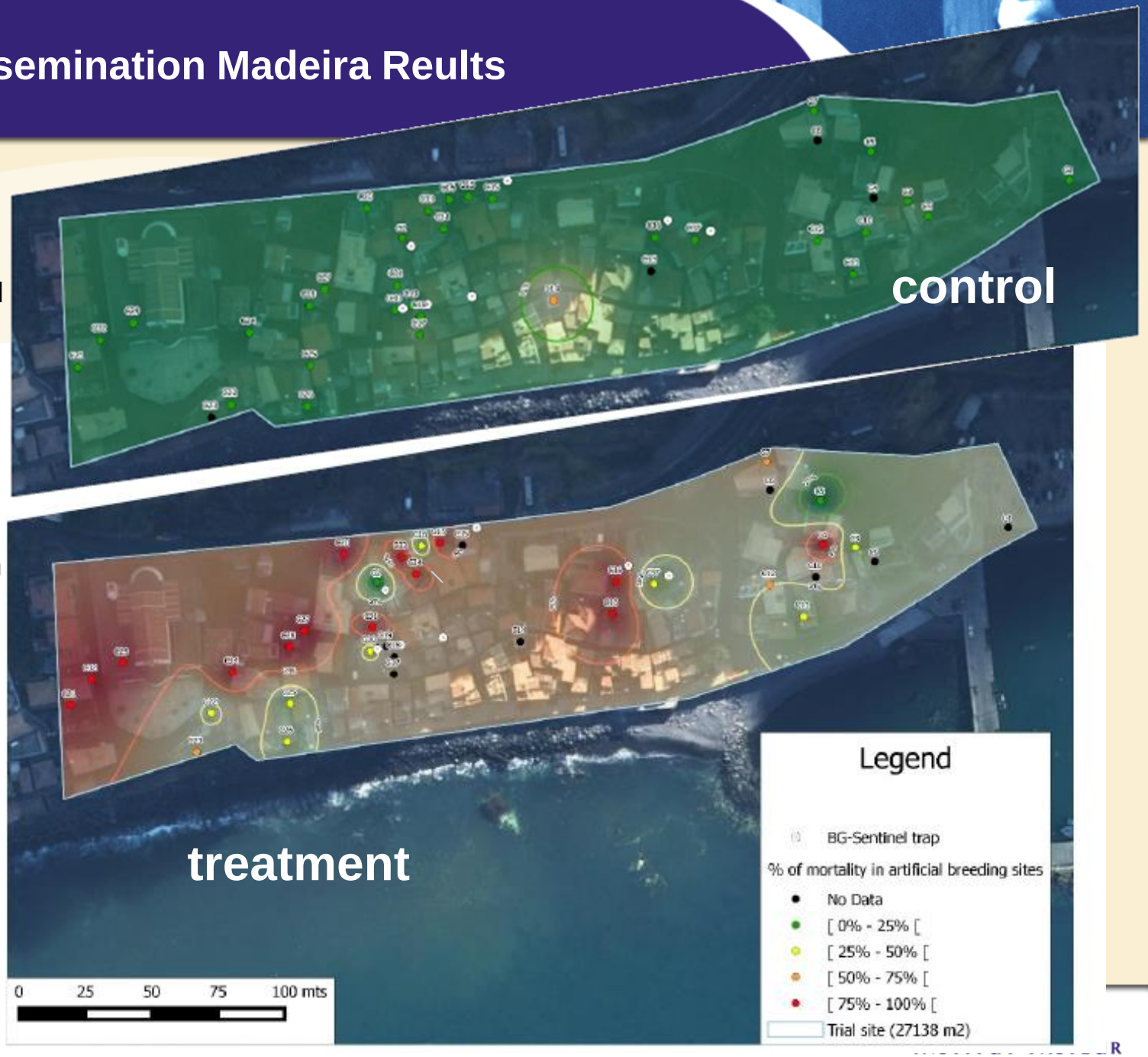
Autodissemination Madeira Reults

White spots are adapted BG traps (6).

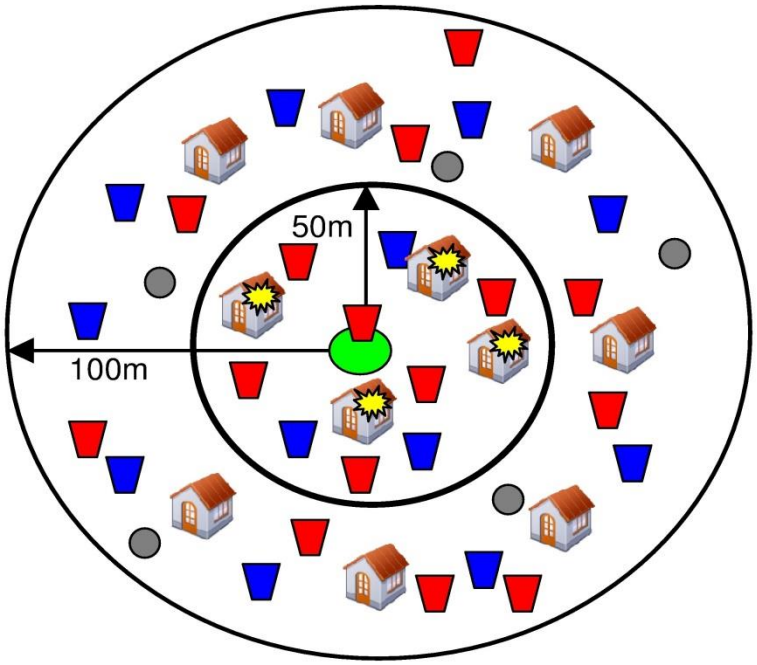
Other spots are sentinel sites (27) suitable for oviposition by contaminated adult females emerging from adapted BGs.

Sentinels are colour coded for impact (green = no impact, red = maximum impact; see legend)

Each sentinel site originally seeded with 20 *Ae aegypti* larvae.



Treatment in and around Dengue index case house



Legend:

- Index dengue case
- Neighbouring house
- Emanator
- Auto-dissemination device
- Gravid Aedes Trap
- Sentinel site for proof of dissemination

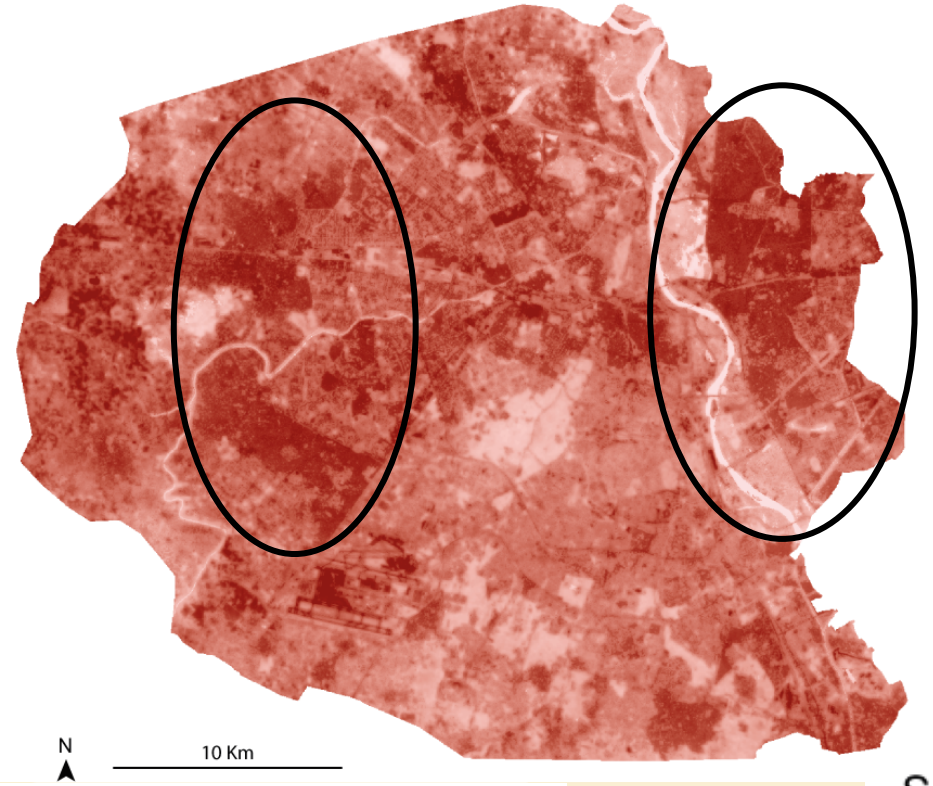
Mobility are important, but complex to understand

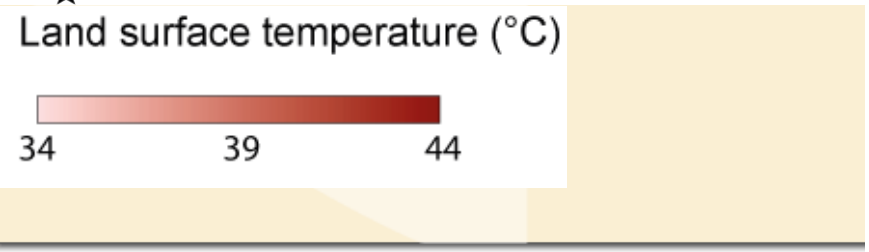
WHAT ABOUT URBAN NICHES?

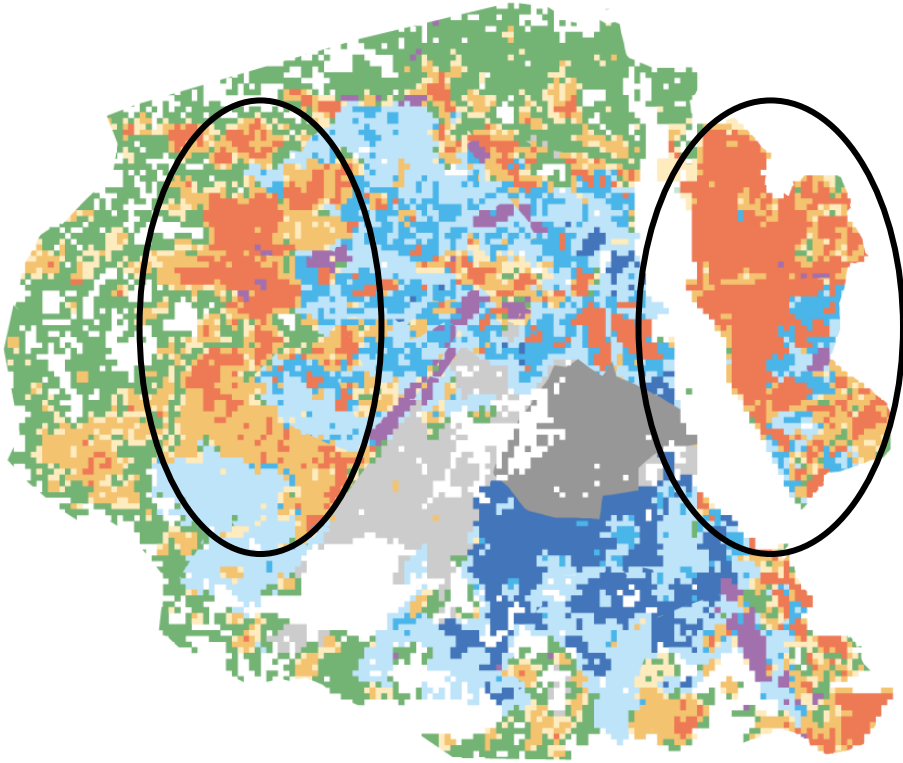
INSTITUT PASTEUR

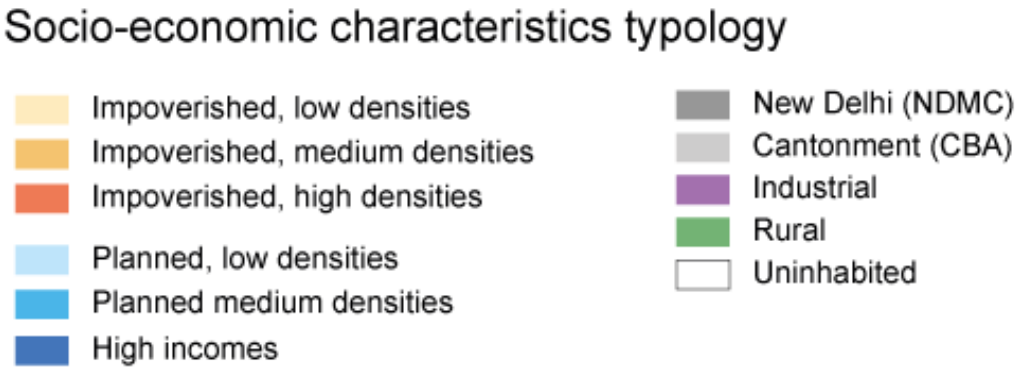
Winter Hotspots and Urban Heat Islands

Poor densely populated areas 5-10°C hotter in winter at night



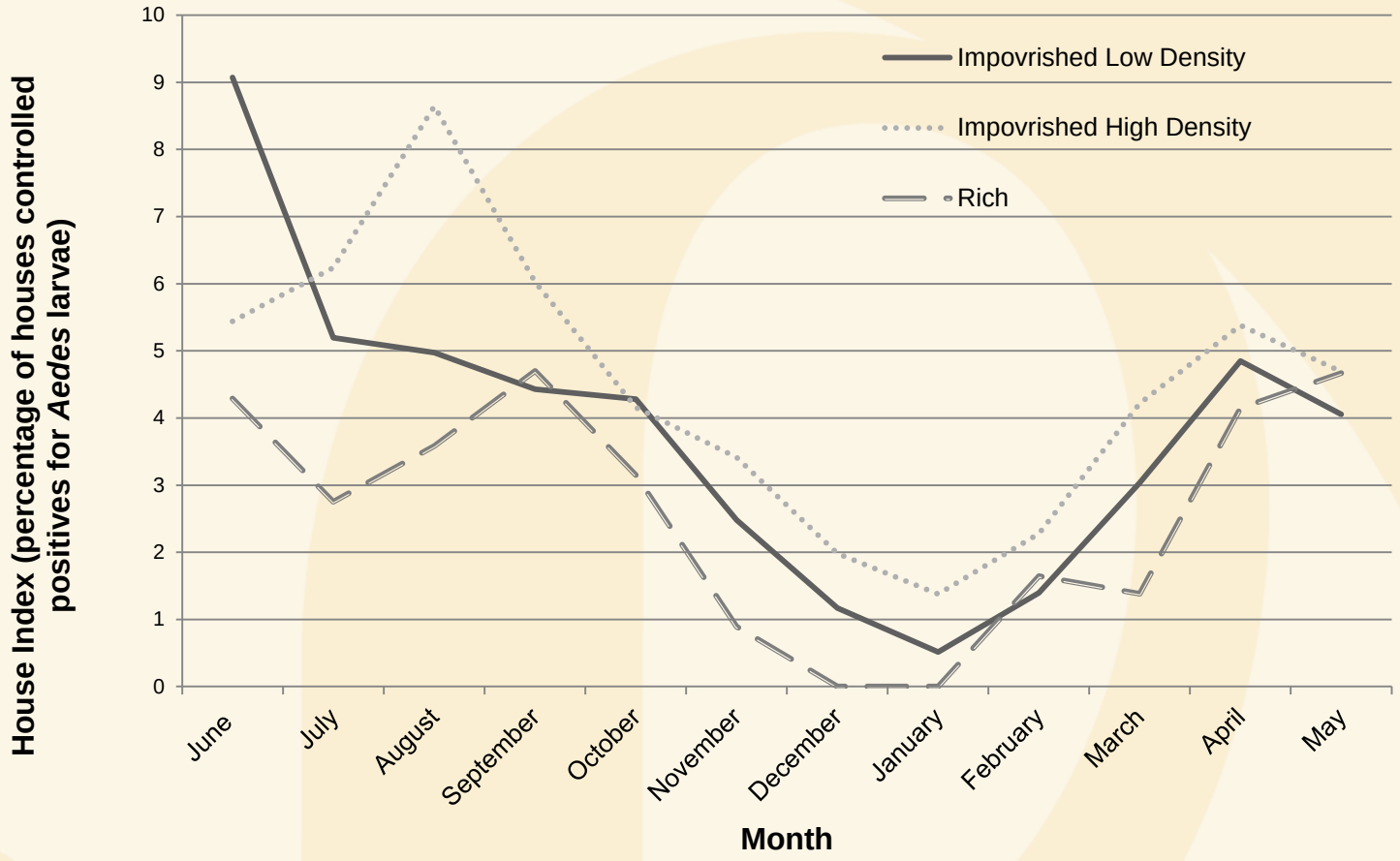




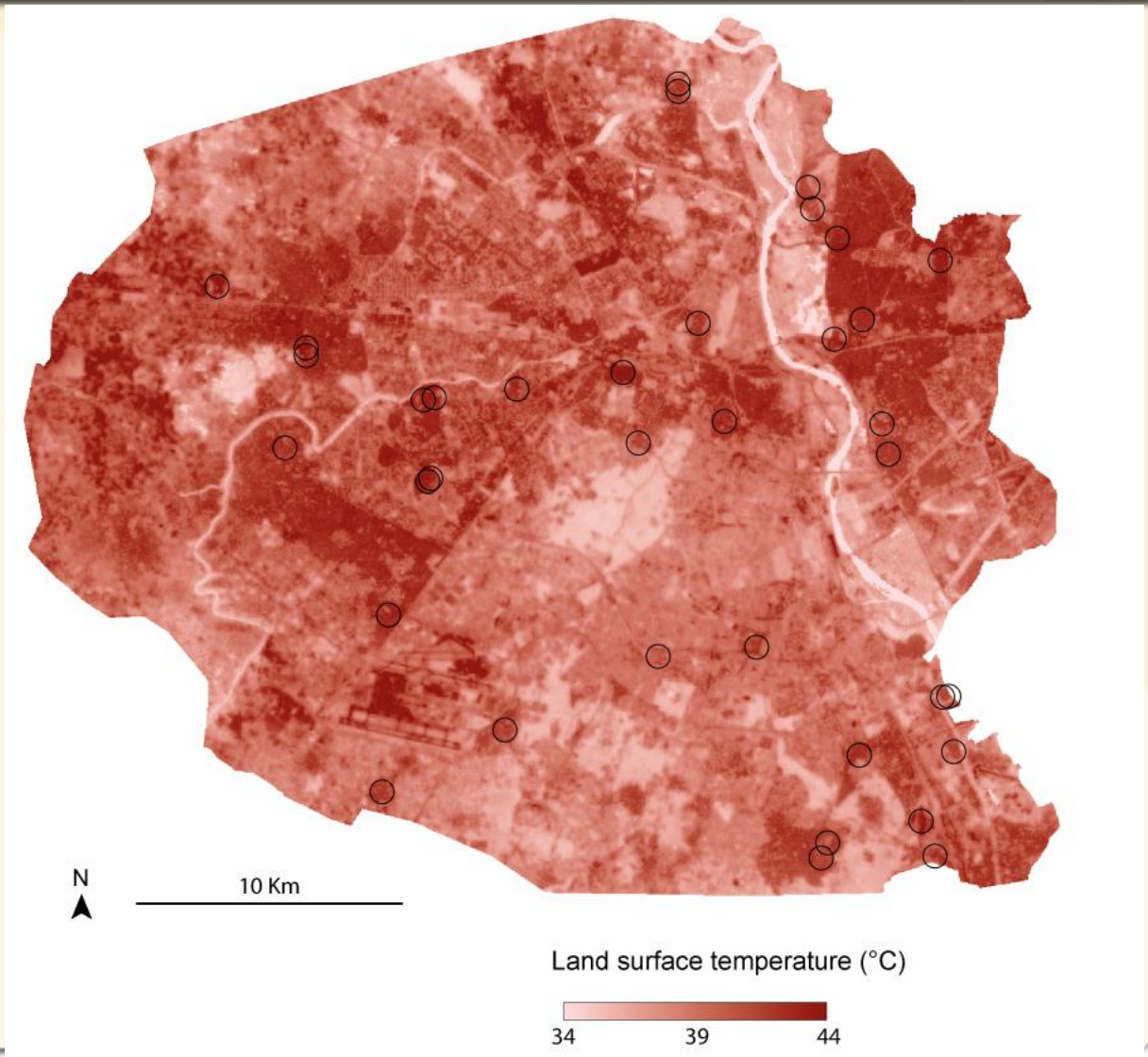


Virus found in mosquitoes in winter – urban hotspots

Presence of mosquito larvae vs socio-economic typology



INSTITUT PASTEUR



UT PASTEUR

Socioeconomic risk for dengue positivity on fiel
(in individual residing in deprived colonies)

IgG	Odds Ratio	P>z	LC	HC
Using repellant every day				
Yes	Ref			
No	1,92	0,03	1,07	3,44
Water acces tap every day				
Yes	Ref			
No	2,31	0,01	1,21	4,41

INSTITUT PASTEUR

Delhi strategy (cold season)

Map dengue clusters

Implement intervention vs. control (clusters/random)

Measure efficacy through Passive Case Detection (Public Health surveillance program)

Very few succes in Dengue control

- New strategies has to be found:
  - Avoid niches at any scale (between and within cities)
  - Short term strategies in phase with administration capacities (surveillance and control)
  - Strengthen intersectorial researches and lab capacities (sequencing, automatic mapping of dengue cases)
  - Think long term and relation between city and virus expansion
  - **Governance of diseases !!**