Study of the **epidemic risk** linked to rodents in **rural communes of the Sahel**

Development and implementation of
an EcoHealth-type observatory in Dodel - Senegal.

Jean LE FUR, Moussa SALL & Christophe DIAGNE

Journées ObsMICE, Niamey 30 nov. 2022

1.- Context and problematics

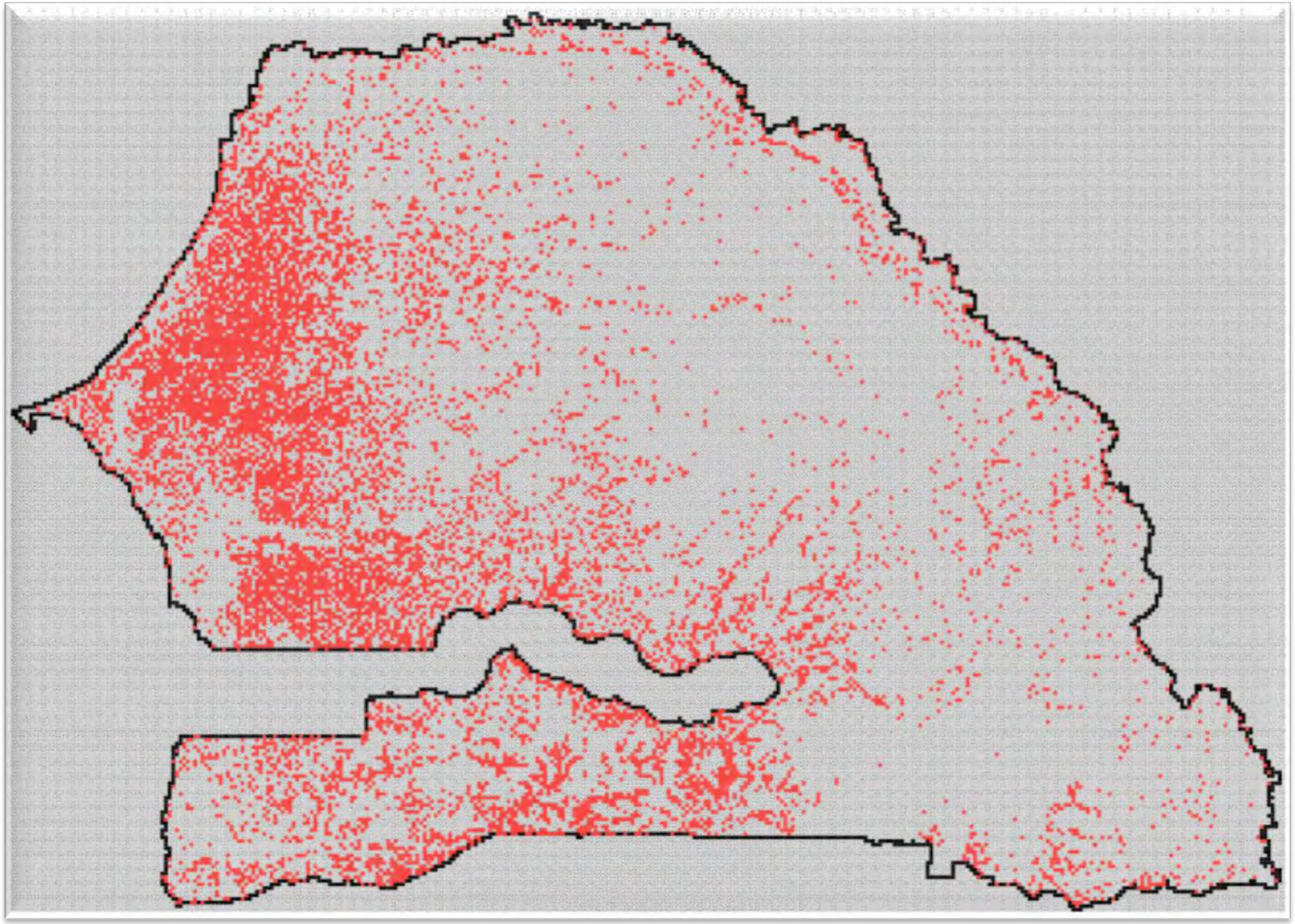
A) the epidemic risk in rural communities

B) The approach for tackling the epidemic risk

A) Rurality is 52% of the population in Senegal

- Small towns and villages have unique traits and dynamics,
- especially when it comes to how epidemic risks spread

- One red dot = one rural community (source P.Handshumacher, Chancira program)



Weekly markets are potentially hotspots for the spread of diseases

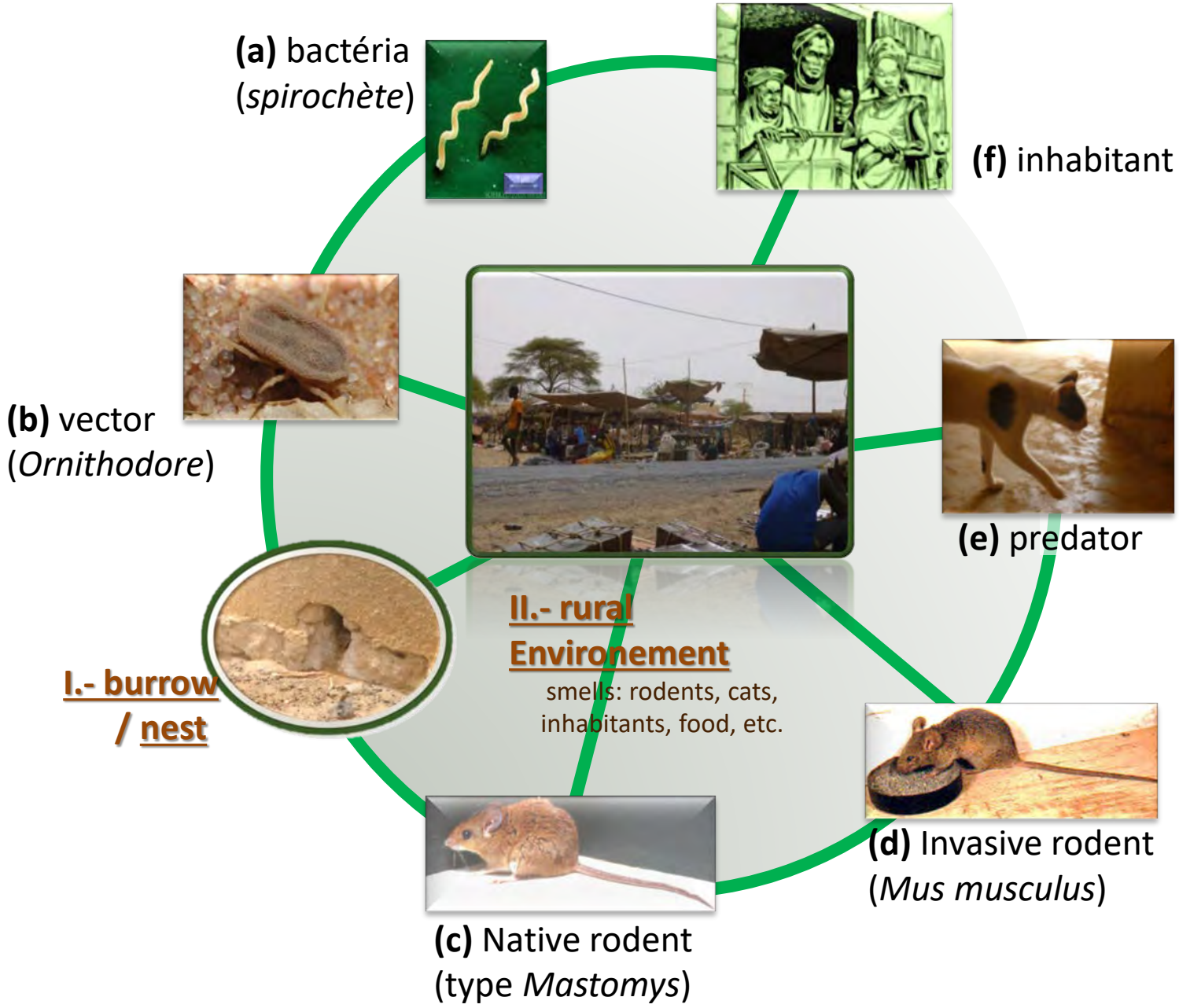
Dwellings are more open spaces than in urban areas with particular contamination risk characteristics.

Lifestyle is more laid back

B) Tackling the epidemic risk

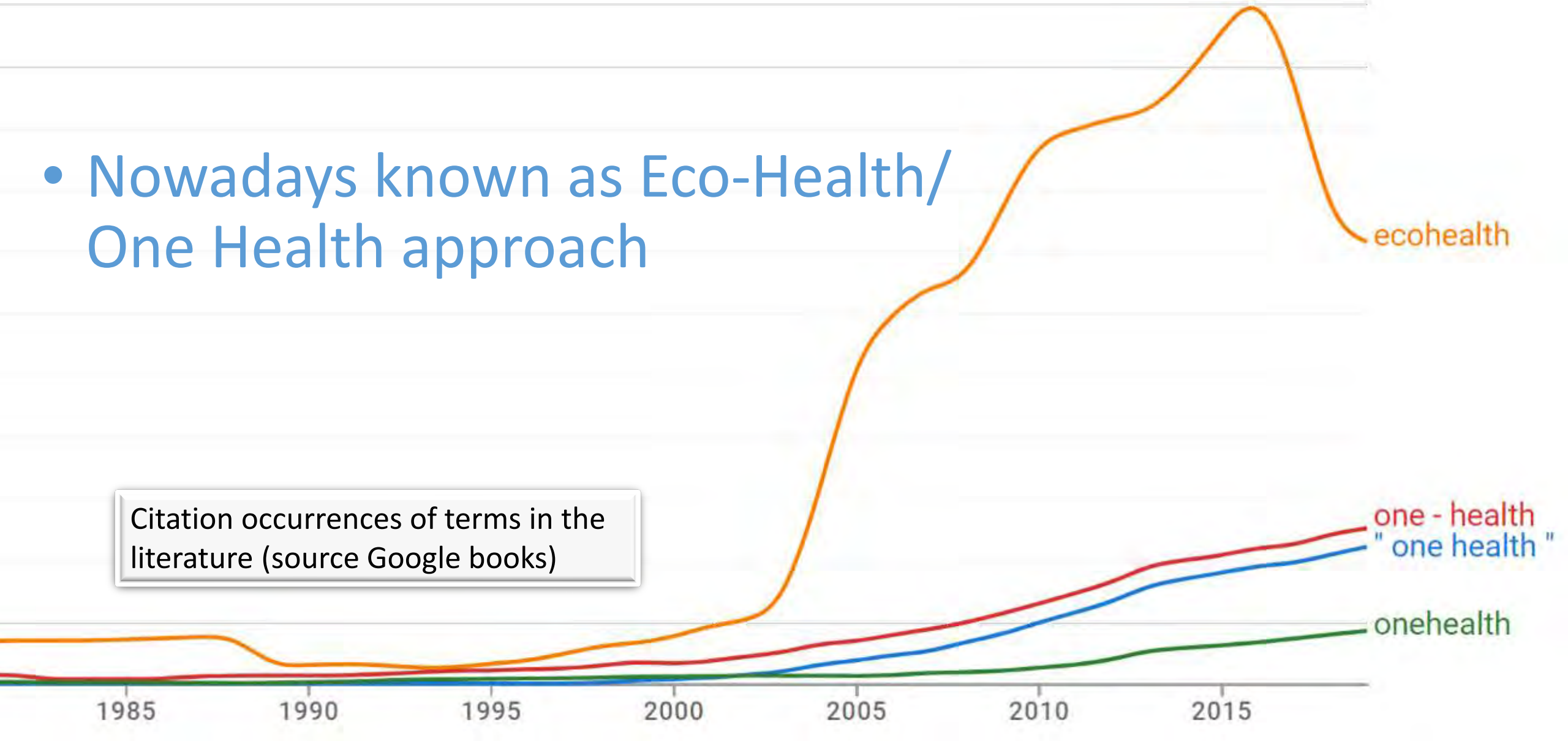
- Necessitates a global (systemic, multi-level, interdisciplinary) approach

(*Von Bertalanffy, 1968, De Rosnay, 1975* ☺)



B) Tackling the epidemic risk

- Nowadays known as Eco-Health/ One Health approach



Citation occurrences of terms in the literature (source Google books)

However building OneHealth/EcoHealth implementation raises questions

- **Translating One Health into action is urgent** (*Lefrançois et al., The Lancet, 2022*)
- De One Health à Ecohealth, cartographie du **chantier inachevé** … (*Morand et al., IDDRI Sciences Po, 2020*)
- Enhancing research integration to **improve One Health actions**: learning lessons from neglected tropical diseases experiences (*Rotureau et al., BMJ, 2022*)

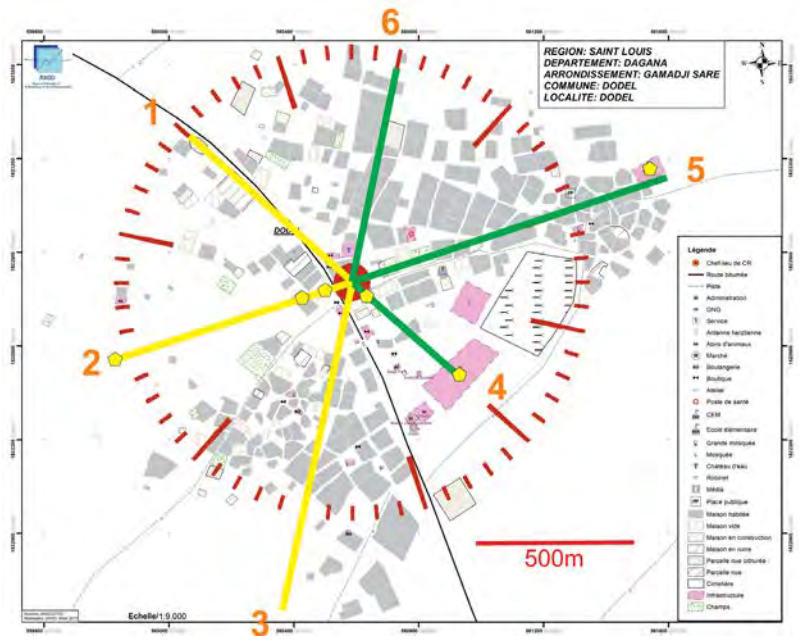
Etc.

« *Observatoire EcoHealth Dodel* » scientific project

Proposal:

1. Development of a methodology for an EcoHealth approach to rodent-related epidemic risk in Sahelian rural communities
2. based on the use of an integrative model as a medium for
   a. multidisciplinary data and knowledge collection
   b. inclusive interaction
   c. continuous improvement of the observatory design

1.- Acquisition Multi-thématique sur le terrain



2.- Modèle de Simulation: intégrateur de données pluridisciplinaires

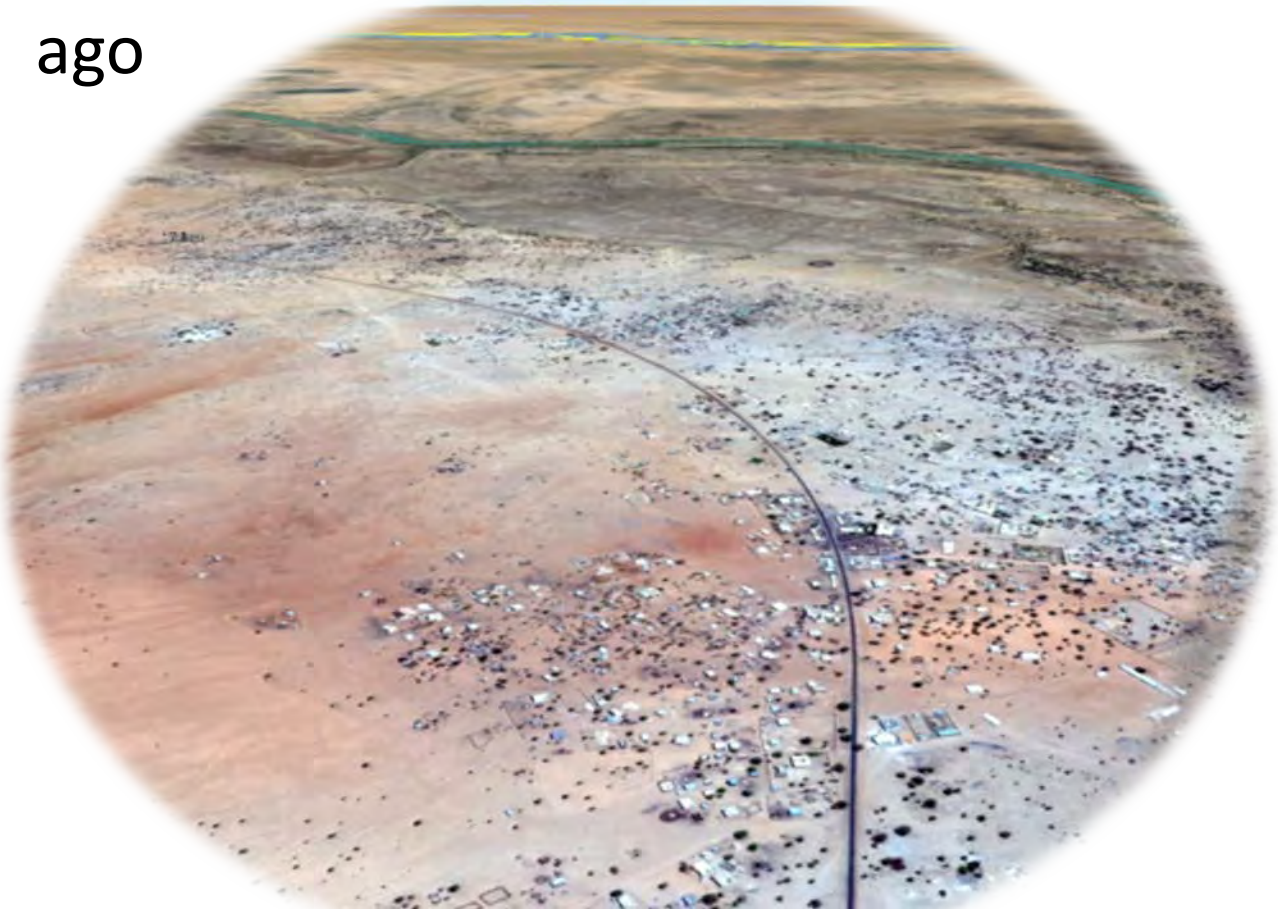
3.- Modèle de simulation: médiateur

4.- Modèle de simulation: orientation protocoles observatoire

Restitutions systématiques et circonstanciées pour échanges population-recherche

The pilot site: Dodel Sénégal

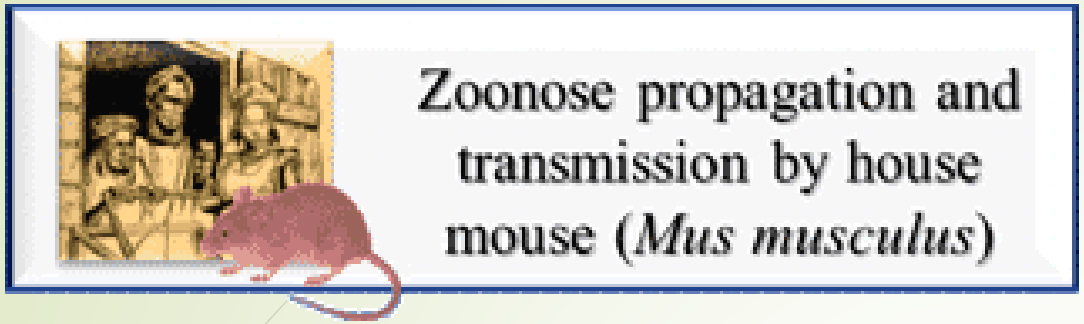
- archetypal rural commune of the Senegalese Sahel
- 50,000 inhabitants
- Place of the house mouse ‘invasion front’ ten years ago



The epidemic risk studied

Tick-borne disease: borreliosis

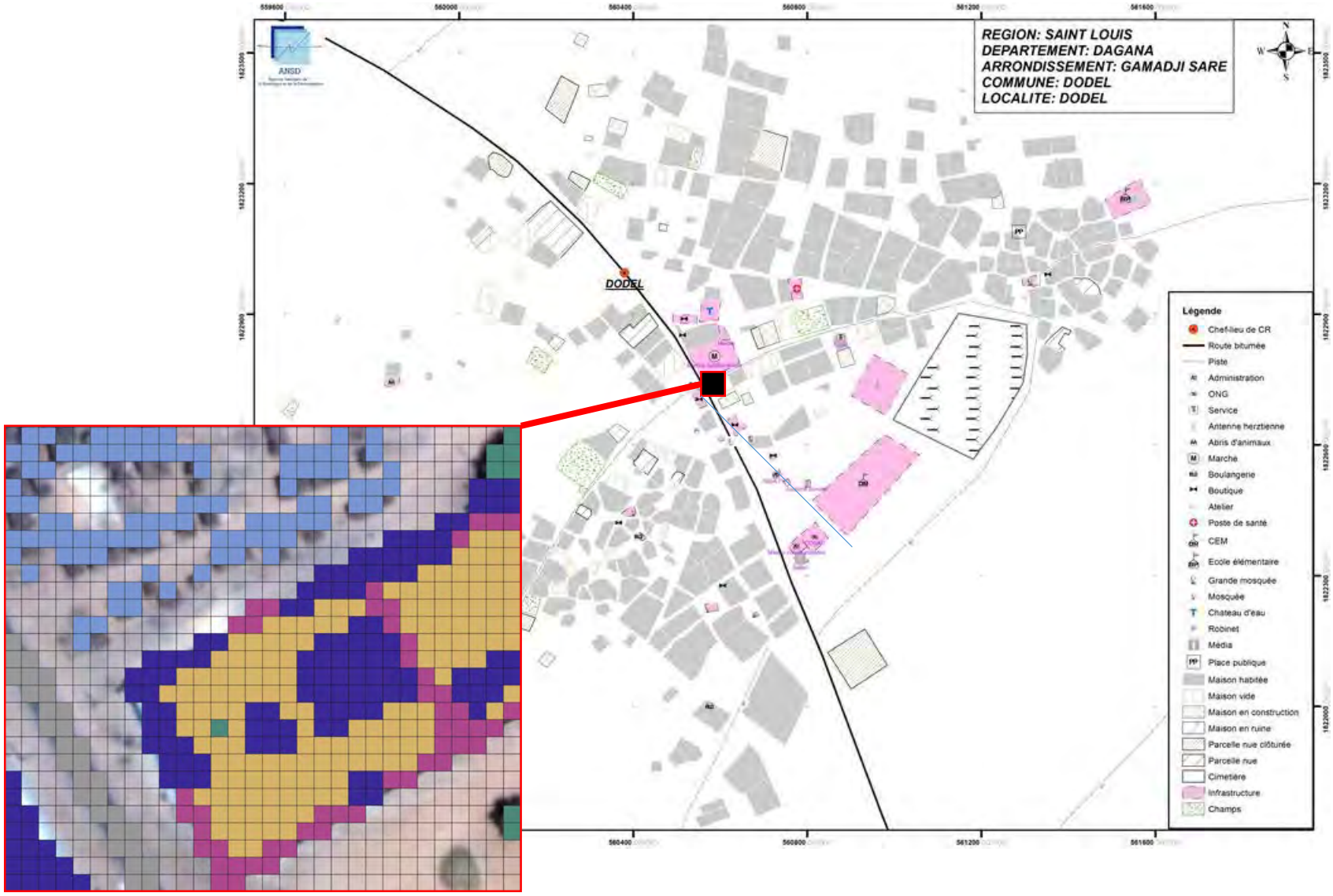
- Pathogen: bacteria (*B. crocidurae*)
- Vector: onithodore tick (*O. sonrai*)
- Reservoir: rodents (*Mus musculus*)



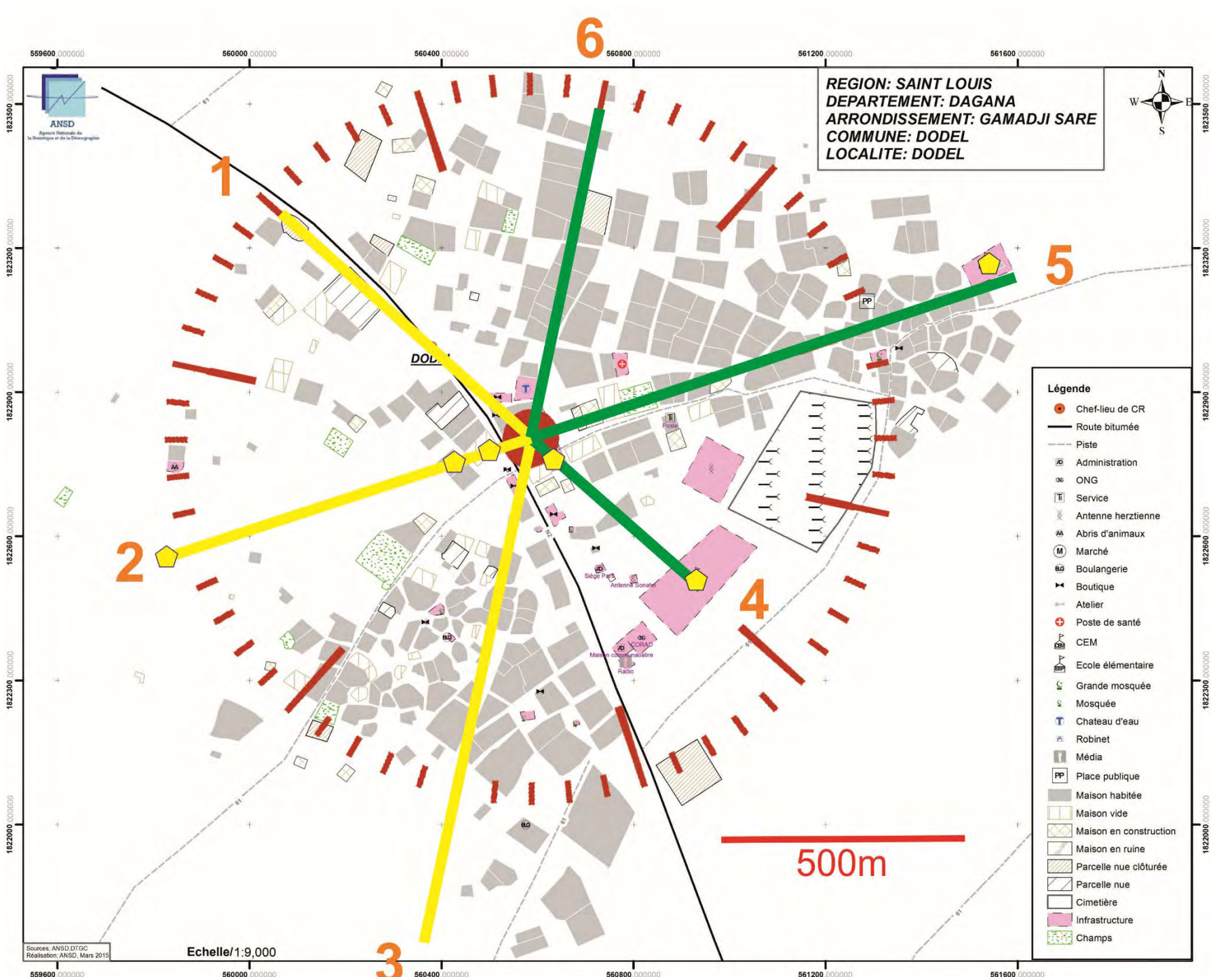
2.- implementation and results

Detailed mapping of Dodel town center and homes surveyed

Detailed digitization of the site to study the dynamics of colonization



Design of a radial sampling protocol with two successive sampling teams (for ticks and rodents)

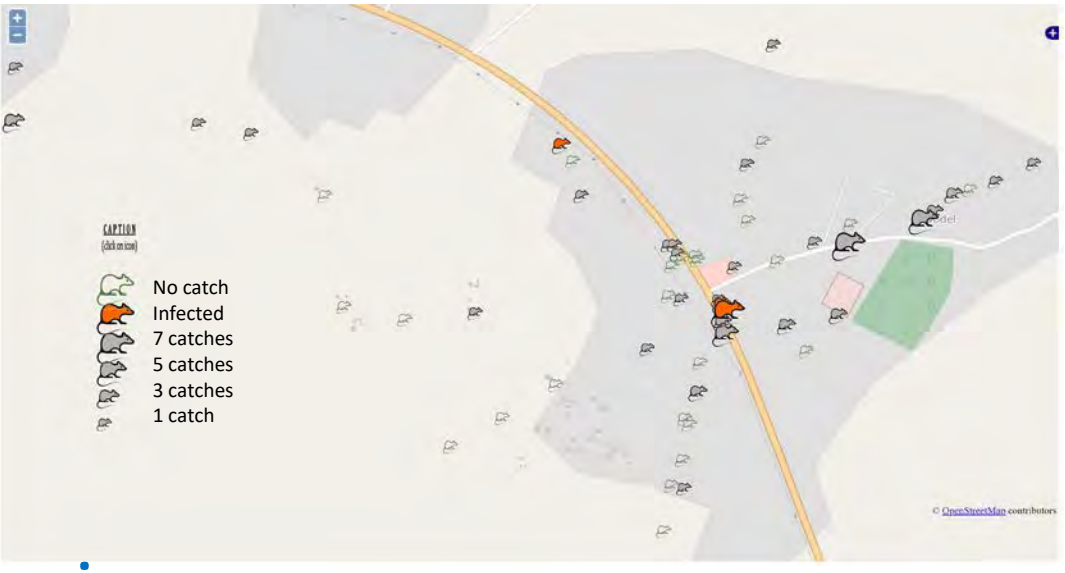


Results available by dwellings and by room

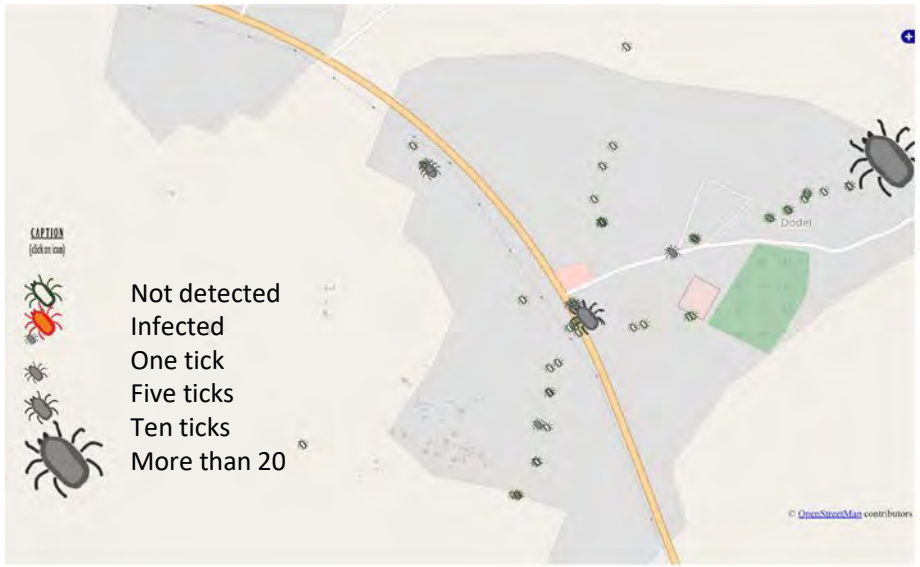
Mouse catches by dwelling

Mouse catches by room

Results available for rodents, ticks, cats and bacteria



mice



ticks

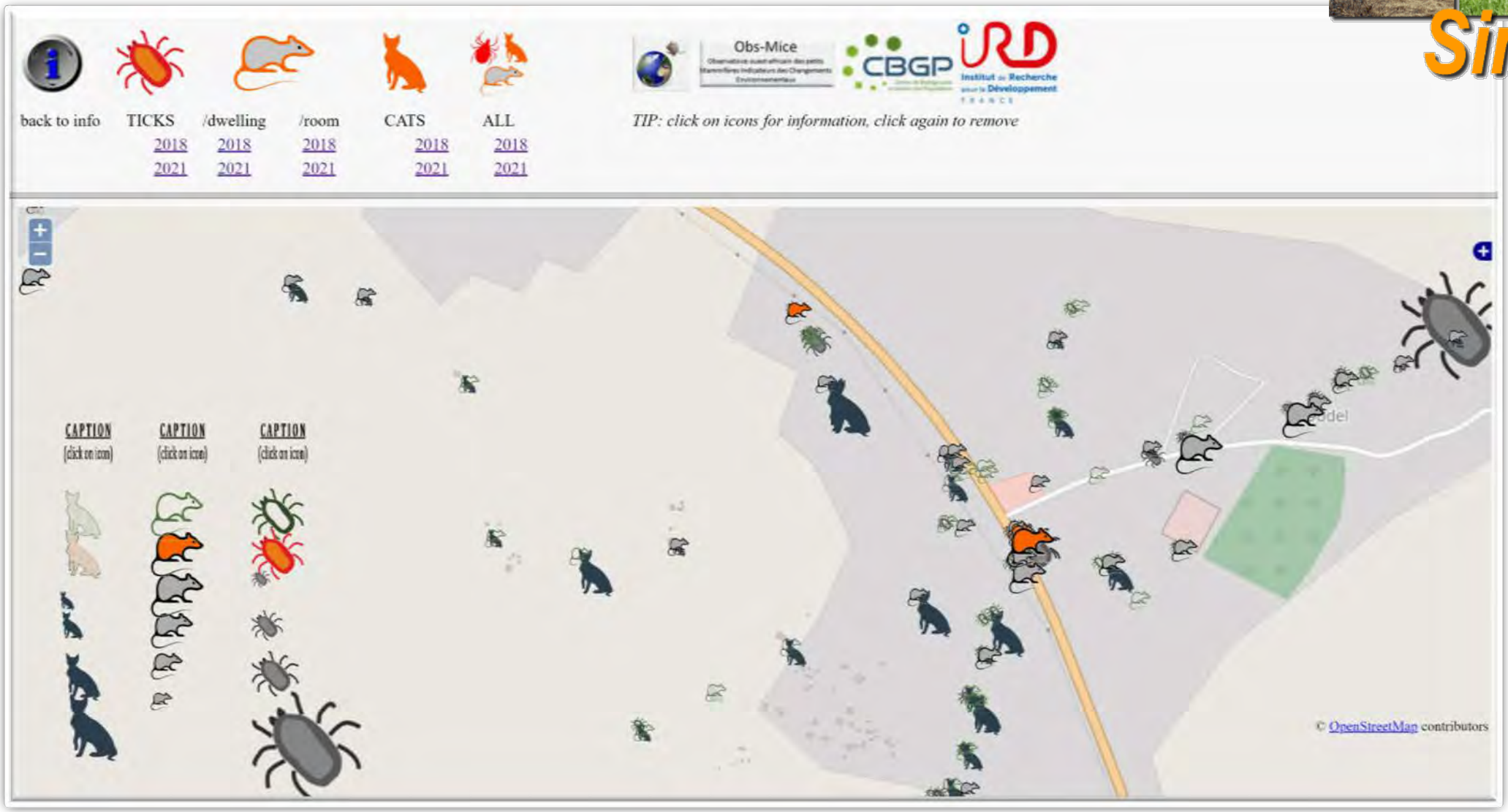
cats

Complete sampling session realized each four years

Nov. 2018 session

Nov. 2021 session

Interactive mapping available on internet



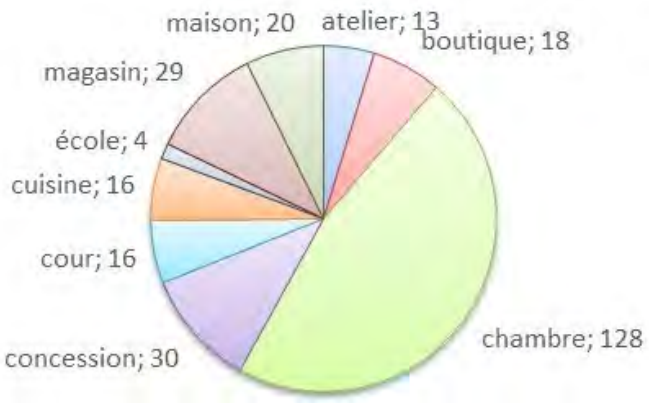
http://simmasto.org (Keywords: borreliosis, CEA-MITIC, CERISE project, Dodel (rural municipality), EcoHealth, Felis catus (cat), house mouse, Mus musculus, Obs-Mice, Ornithodoros sonrai (tick), protocol, rodent, Sahel, sampling, Senegal, Senegal river valley, trapping, village, West Africa /)

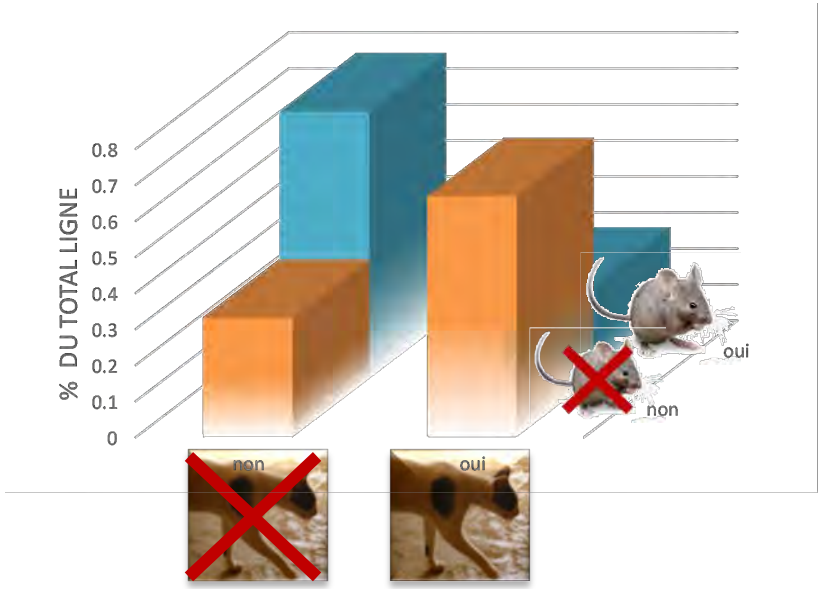
Survey of housing conditions (274 places covered)

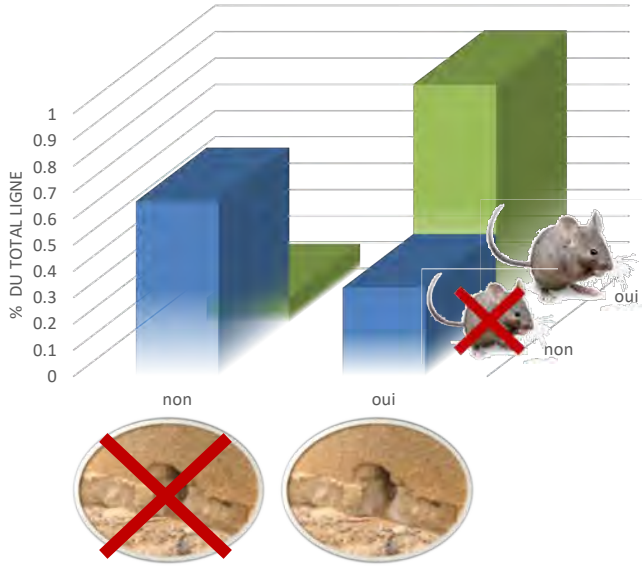
Examples of favourable environments for mouse survival

Examples of crevices (favorable to ticks)

Housing conditions (274 places covered)







terriers

Census of human population diel activity

id	Lieu	Début	Fin	activité : lieu TC: chaleur / TF: fraicheur
7004	Chambre	00:00	09:00	dormir : TC: cour; TF: chambre
7004	atelier (413)	09:00	00:00	aller au travail: atelier (413)

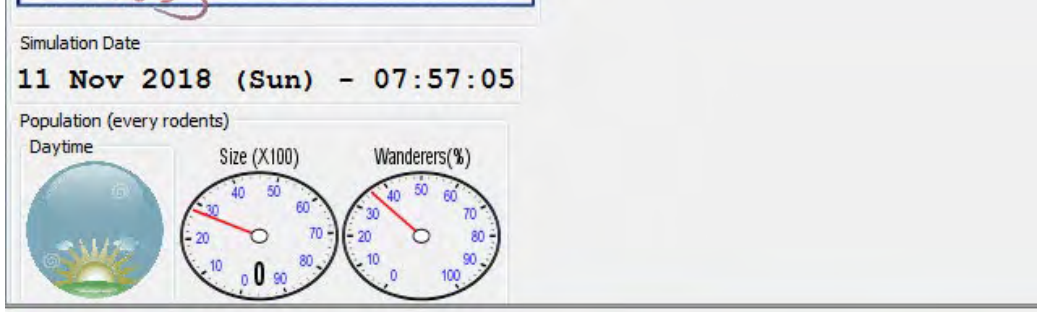
Shortest declaration

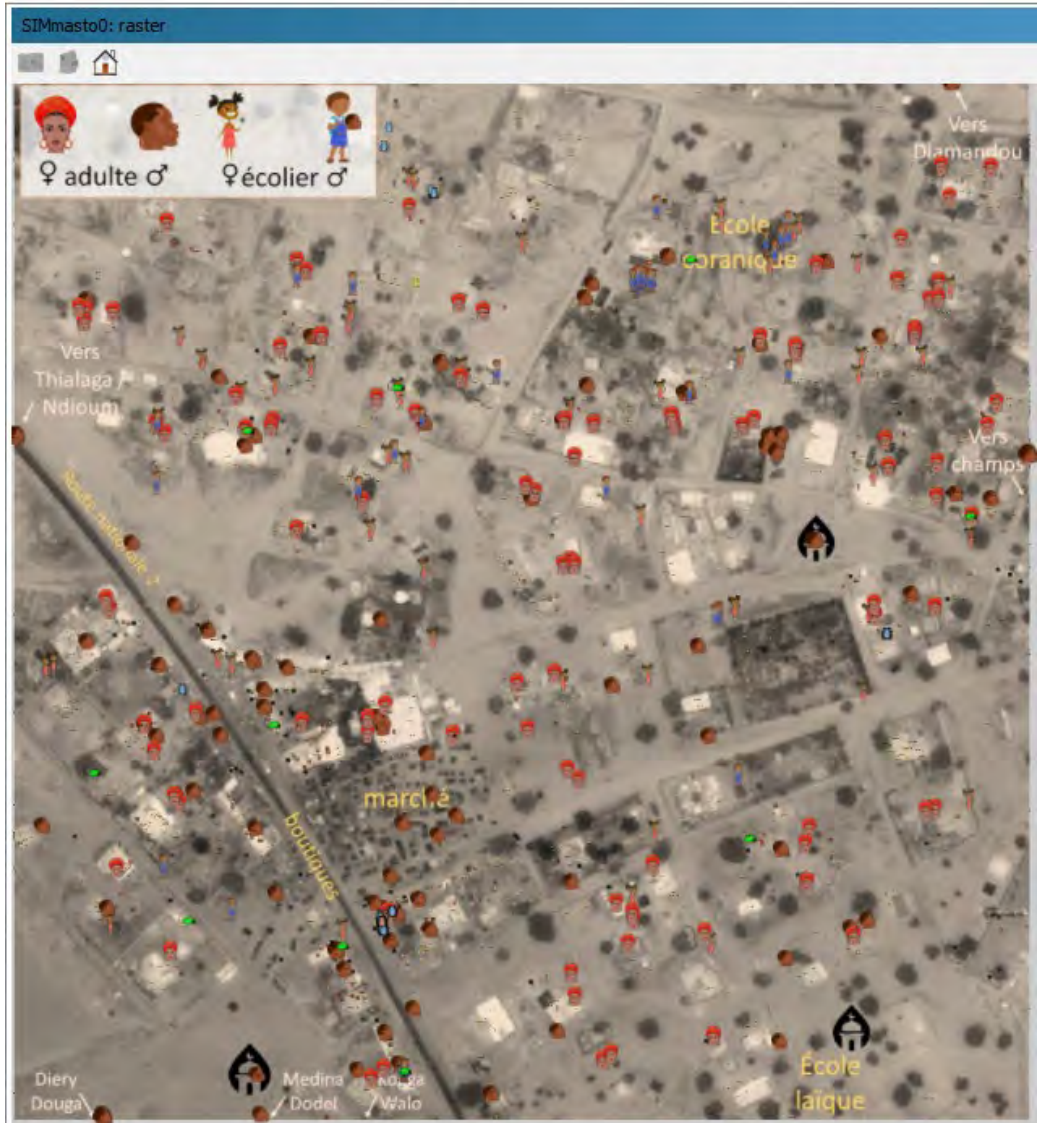
id	Lieu	Début	Fin	activité : lieu TC: chaleur / TF: fraicheur
1304	veranda	00:00	07:00	dormir: véranda
1304	chambre	07:00	07:30	prière: chambre
1304	chambre	07:30	09:00	dormir: chambre
1304	cour	09:00	10:00	tache ménagère: cour
1304	salon	10:00	11:00	petit déjeuner: salon
1304	marché	11:00	11:20	aller au marché : marché
1304	chambre	11:20	11:50	dormir : chambre
1304	chambre	11:50	12:00	regarder la télé: chambre
1304	cour	12:00	14:00	repos : cour
1304	véranda	14:00	15:00	déjeuner : véranda
1304	cour	15:00	16:00	repos : cour
1304	Gallé Baba	16:00	18:28	école coranique : Gallé Baba
1304	cour	18:28	19:30	palabrer: cour
1304	cuisine	19:30	21:00	préparer diner: cuisine
1304	cour	21:00	21:30	diner : cour
1304	cour	21:30	00:00	palabrer: cour

Longest declaration

Integrative simulation modelling (1/3)

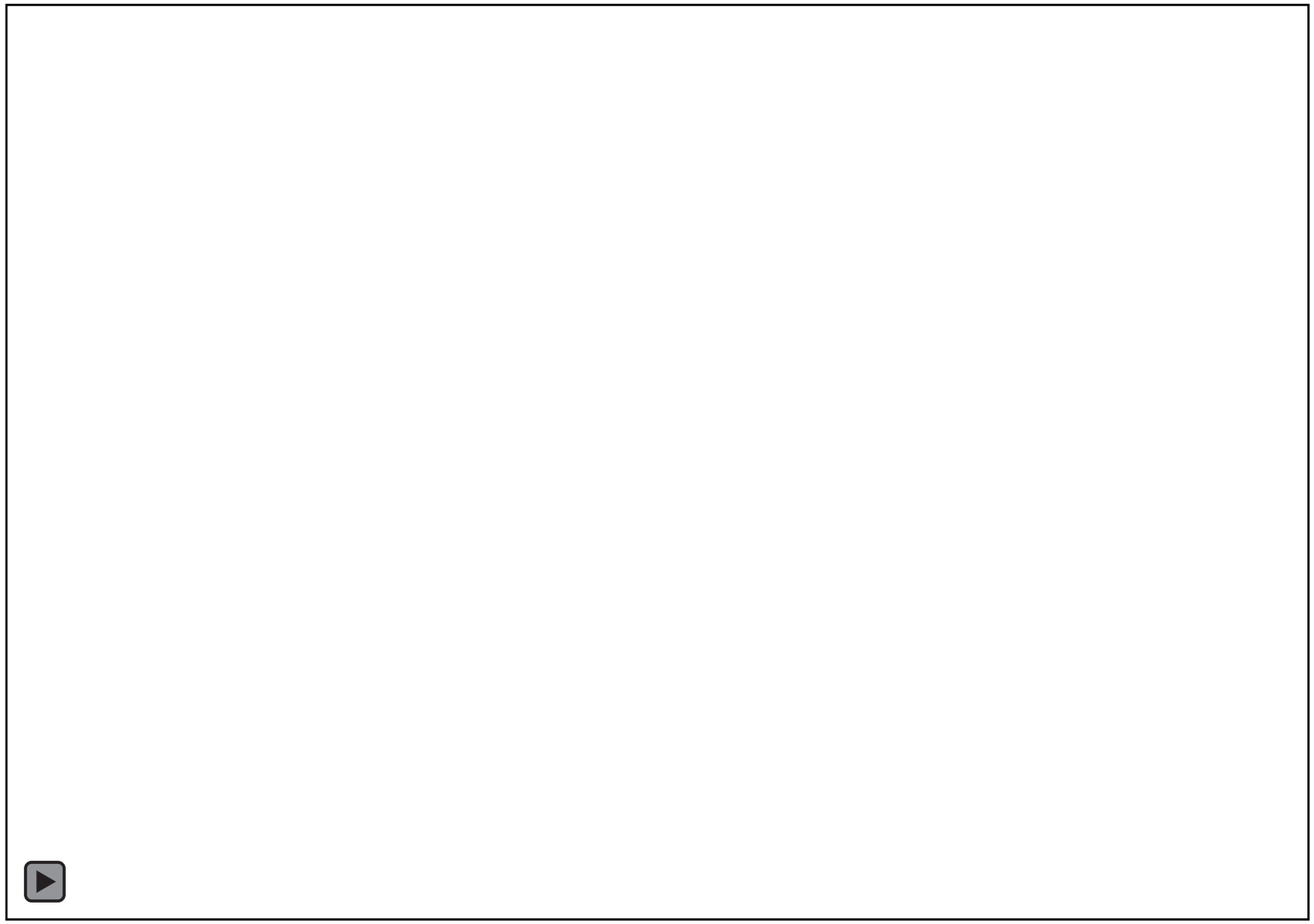
Observed diel activity





Integrative simulation modelling (2/3)

Behaviour of rodents inside homes



Integrative simulation modelling (3/3)

Tick – mouse (reservoirs) relationships

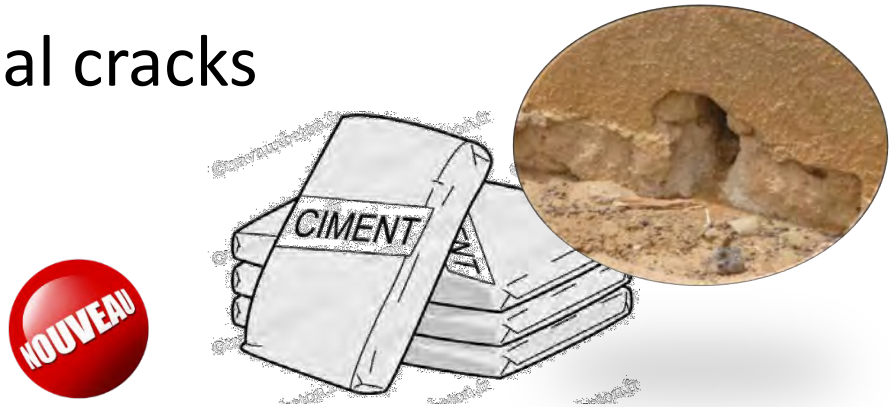
…to be continued

Inclusive approach for settling and improving the observatory

- Systematic restitutions of previous works

-> positive consequences

- helping residents seal cracks

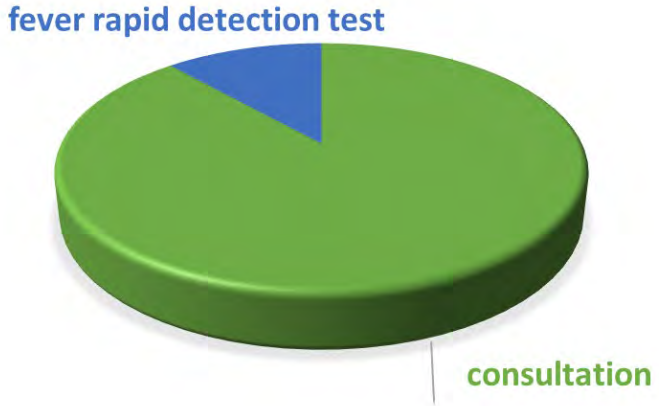


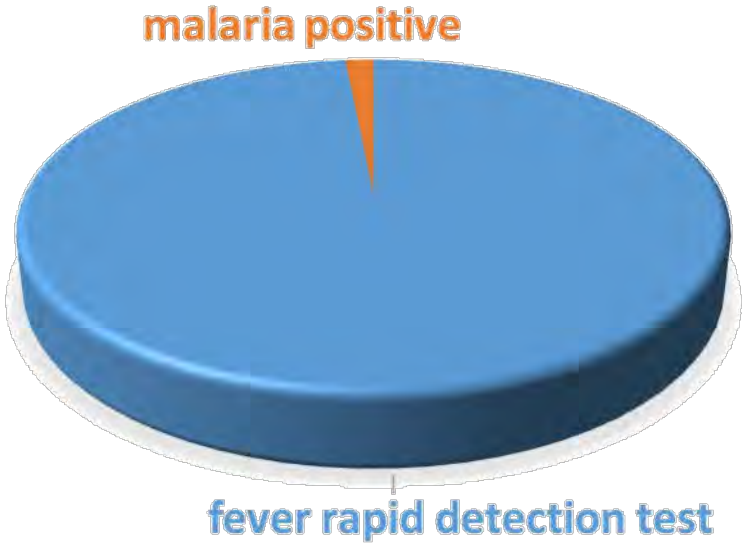
-> continuous improvement of the protocol

Continuous improvement of the protocol

- Data retrieval from village clinic :

- Children / adults / pregnant women
- Consulting / malaria rapid test / malaria positives
- Monthly data retrieved on request





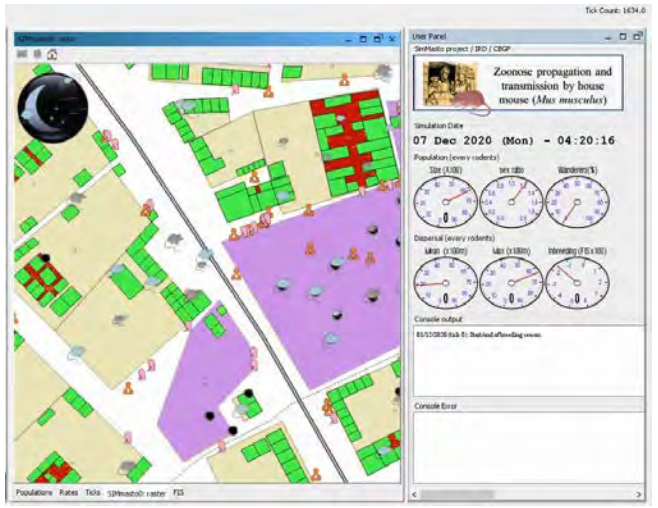
Overall mean 2018-2021 (20,063 medical consultations)

Data source: MINISTÈRE DE LA SANTÉ ET DE L'ACTION SOCIALE
Data portal: DHIS2

3.- conclusion and perspectives

Conclusion

- A simulation model is a powerful medium for
  - designing,
  - conducting,
  - improving
  - and communicating



An EcoHealth approach

- Both a **rich** (multi-components) **and light** approach (one campaign each ¾ years)
- The approach deployed in Dodel Senegal is intended to and appears to be generalized for the study of epidemic risk in <u>rural African communities</u> (has to be tested)

PERSPECTIVES

- ENHANCE AND DEVELOP COMMUNICATION WITH POPULATION
  (IN THE FOOTSTEPS OF CERISE PROJECT)

- *KEEP ON WITH REGULAR (2/3 YEARS) FOLLOW-UP*
- *PUBLISH*

- 2023
  1. CHANGING PI: J.LE FUR -> C.DIAGNE
  2. SUBMIT M.SALL (PHD.) FOR A POST-DOC IN MODELLING
  3. OTHER ? ☺

Acknowledgements

Funding

1 **Dépt. EcoBio**

2 **CBGP, axe 3 : Écologie et évolution des zoonoses**

- Systématique écologie
- Interactions hôte parasite
- Modélisation

3 **Observatoire ouest-africain des petits Mammifères Indicateurs des Changements Environnementaux**

4 **FRB**

Cerise project

5 OCEA MITIC

Centre d'Excellence Africain Mathématiques Informatique et TIC

Hosting

Laboratoire Commun

BIOPASS

Biologie des Populations Animales Sahélo- Soudaniennes

Collaborating

Experts Sud (IRD-Sénégal)

VITROME

Epidémiologie médicale

PRODIG UMR 8586

Géographie humaine

Université du SUD - UGB

- Section sociologie / UFR LSH
- Section informatique / UFR SAT

Village de Dodel

- Maire et Chef de Village
- O.Labgar, poste de santé
- R.Dia, O.Sall agents de Développement

Training

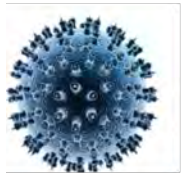
- masters (2), PhD. (1)

Merci de votre attention ☺

Crédit photo:
Moussa

Host-parasite interactions – Comparative approach in natural populations

Gastrointestinal helminths
(morphology + CO1 sequencing)



Viruses
(serological assays)

Bacteria
(16S Metagenomics)

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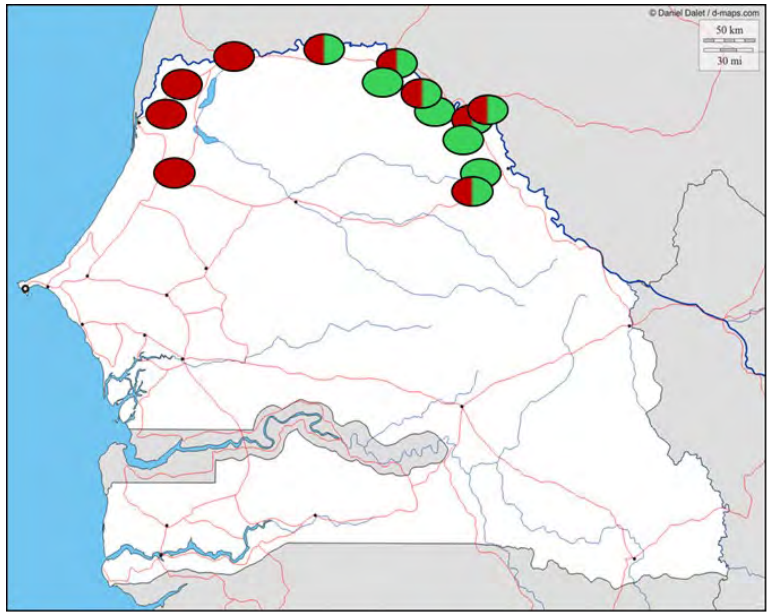
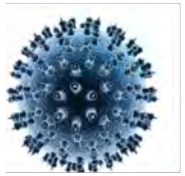


House mouse

Mastomys erythroleucus

- Long-established invasion (> 100 years)
- Invasion front (< 30 years)
- Non-invaded sites

Gastrointestinal helminths
(morphology + CO1 sequencing)



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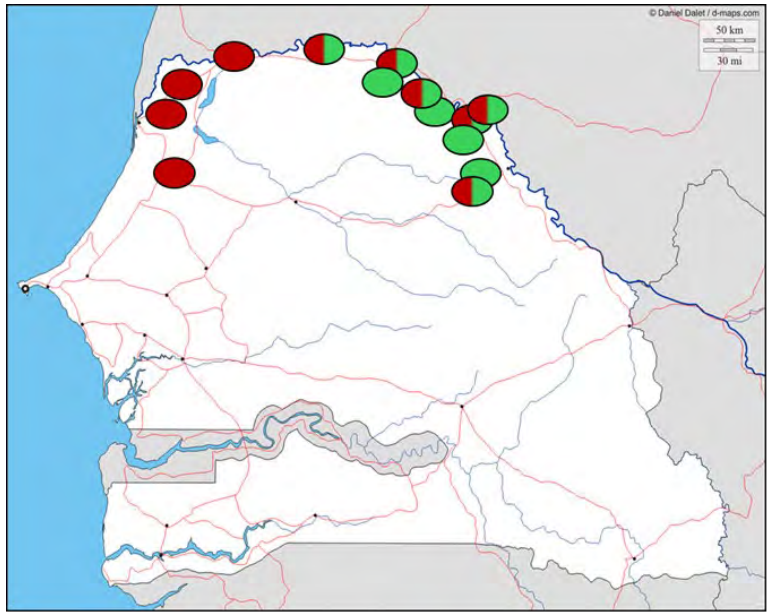

House mouse

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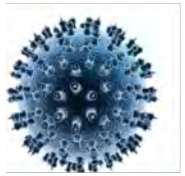
- Long-established invasion (> 100 years)
- Invasion front (< 30 years)
- Non-invaded sites

➢ Standardised sampling / Spatio-temporal surveys
(20 adult rodents / population)

➢ Lab assays
- cf. below

➢ Data analysis
(multivariate approaches, generalized linear mixed models, etc.)

Gastrointestinal helminths
(morphology + CO1 sequencing)



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Biol Invasions
https://doi.org/10.1007/s10530-020-02304-7

ORIGINAL PAPER

Association between temporal patterns in helminth assemblages and successful range expansion of exotic *Mus musculus domesticus* in Senegal


International Journal for Parasitology

Parasites and invasions: changes in gastrointestinal helminth assemblages in invasive and native rodents in Senegal


frontiers in Veterinary Science

Same Invasion, Different Routes: Helminth Assemblages May Favor the Invasion Success of the House Mouse in Senegal

Mus musculus domesticus
(n = 22)

Mastomys erythroleucus
(n = 25)

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(n = 22)

→ *Aspiculuris tetraptera* (prevalence: 4.5%)
→ *Mathevotaenia symmetrica* (9.1%)

→ *Aspiculuris africana* (56%)
→ *Mathevotaenia symmetrica* (40%)

Mastomys erythroleucus
(n = 25)

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(morphology + CO1 sequencing)

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2013

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Mus musculus domesticus
(n = 22 → **37**)

→ *Aspiculuris tetraptera* (prevalence: 4.5%) → ?
→ *Mathevotaenia symmetrica* (9.1%) → ?

2013

2017

→ *Aspiculuris africana* (56%) → ?
→ *Mathevotaenia symmetrica* (40%) → ?

Mastomys erythroleucus
(n = 25 → **7**)

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Mus musculus domesticus
(n = 22 → **37**)

→ *Aspiculuris tetraptera* (prevalence: 4.5%) → **2.7%**
→ *Mathevotaenia symmetrica* (9.1%) → **29.7%**

2013

2017

→ *Aspiculuris africana* (56%) → **14.3%**
→ *Mathevotaenia symmetrica* (40%) → **42.9%**

Mastomys erythroleucus
(n = 25 → **7**)

Viruses
(serological assays)

VECTOR-BORNE AND ZOONOTIC DISEASES
Volume 17, Number 10, 2017

DOI: 10.1089/vbz.2017.2135

SHORT COMMUNICATION

Serological Survey of Zoonotic Viruses in Invasive and Native Commensal Rodents in Senegal, West Africa

Christophe A. Diagne,[1–3] Nathalie Charbonnel,[4] Heikki Henttonen,[5] Tarja Sironen,[6] and Carine Brouat[1]

TABLE 1. RESULTS OF INDIRECT FLUORESCENT ANTIBODY TEST PER RODENT SPECIES AND GEOGRAPHICAL SITE (THE GEOGRAPHICAL COORDINATES ARE PROVIDED)

				Mastomys erythroleucus			Mastomys natalensis			Mus musculus domesticus			Rattus rattus		
	Sites	*Latitude (N)*	*Longitude (W)*	N	n	*S (%)*	N	n	*S (%)*	N	n	*S (%)*	N	n	*S (%)*
Mouse invasion road	Aere Lao	16.40	−14.32	20	0	0	—	—	—	21	0	0	—	—	—
	Dagathie	15.62	−16.25	—	—	—	—	—	—	20	1 (H)	5	—	—	—
	Dendoudi	15.39	−13.53	22	—	0	—	—	—	18	0	0	—	—	—
	Doumnga Lao	16.33	−14.22	20	1 (M)	5	—	—	—	—	—	—	—	—	—
	Diomandiou walo	16.49	−15.00	14	0	0	—	—	—	—	—	—	—	—	—
	Dodel	16.48	−14.42	20	0	0	—	—	—	20	0	0	—	—	—
	Galoya	16.07	−13.85	14	1 (O)	7.1	—	—	—	21	0	0	—	—	—
	Lambango	15.46	−13.53	20	0	0	—	—	—	—	—	—	—	—	—
	Lougue	16.06	−13.91	21	1 (M)	4.8	—	—	—	22	1 (M)	4.5	—	—	—
	Mbakhana	16.08	−16.36	—	—	—	—	—	—	22	0	0	—	—	—
	Ndombo	16.43	−15.70	—	—	—	—	—	—	20	1 (H)	5	—	—	—
	Sare Maounde	15.98	−13.91	9	0	0	—	—	—	—	—	—	—	—	—
	Thilene	16.26	−16.18	—	—	—	—	—	—	20	0	0	—	—	—

Bacteria
(16S Metagenomics)

SCIENTIFIC REPORTS

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eived: 17 May 2017
epted: 12 October 2017

Ecological and sanitary impacts of bacterial communities associated to biological invasions in African commensal rodent communities

Host species	Sites	*Bartonella*	*Borrelia*	*Ehrlichia*	*Mycoplasma_1*	*Mycoplasma_3*	*Orientia*
M. m. domesticus	DAG (LI)				29.2 [13.9–50.0]		54.2 [34–73.3]
	MBA (LI)		3.8 [0.2–18.8]	7.7 [4.0–25.0]	11.5 [3.2–30.4]		
	NDB (LI)	4.8 [0.3–23.3]					38.1 [19.7–60.0]
	THL (LI)				21.1 [7.5–44.6]	11.5 [3.2–30.4]	11.5 [3.2–30.4]
	AEL (IF)		4.0 [0.2–19.6]		48.0 [29.6–68.3]		28.0 [13.4–48.0]
	CRB (IF)		3.7 [0.2–18.1]		3.7 [0.2–18.1]		11.0 [3.1–29.2]
	DEN (IF)			33.3 [14.2–60.3]			6.7 [0.4–30.2]
	DOD (IF)				10.0 [1.8–32.0]		40.0 [20.9–63.0]
	LOU (IF)		20.0 [8.2–40.0]	20.0 [8.2–40.0]			4.0 [0.1–26.5]
Ma. erythroleucus	AEL (IF)			20.0 [7.1–42.4]	5.0 [0.2–24.4]	45.0 [24.2–68]	
	DEN (IF)		13.6 [3.28- 33.8]	9.1 [1.6–29.1]	40.9 [22.2–61.7]	77.3 [54.7–90.6]	
	DOD (IF)			25.0 [10.4–47.5]		5.0 [0.3–24.4]	
	LOU (IF)	5.0 [0.3–24.4]	25.0 [10.4–47.5]	55.0 [32.0–75.6]			
	DIW (NI)	38.5 [16.6–65.8]		30.8 [11.3–58.6]	53.8 [26.1–77.6]		
	DOL (NI)		10.0 [1.8–32.0]	15.0 [4.2–37.2]		30.0 [14.0–52.5]	
	LAM (NI)	9.5 [1.7–30.5]	33.3 [15.9–55.5]	33.3 [15.9–55.5]	28.6 [13.3–50.6]	52.4 [30.5–72.4]	
	SAM (NI)		22.2 [4.11–55.8]	33.3 [9.8–67.7]			