USE OF POPULATION GENETICS TO CHOOSE BETWEEN VECTOR CONTROL STRATEGIES: THE EXAMPLE OF TSETSE IN WEST AFRICA

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Jeremy BOUYER, Thierry de MEEUS

ATELIER CIRAD 04-05 OCT 2011

- A few words on a strange insect vector: the tsetse fly
- What we know on tsetse population structure
- Use of population genetics for control at various scales

LA CLASSIFICATION ZOOLOGIQUE DES GLOSSINES

CLASSE	**INSECTES**
ORDRE	**DIPTÈRES**
SOUS-ORDRE	**BRACHYCERES**
INFRA-ORDRE	**CYCLORRAPHES**
SERIE	**SCHIZOPHORES**
SUPER-FAMILLE	**MUSCOIDEA**
FAMILLE	**GLOSSINIDAE**

Genre		***Glossina***	
Sous-genres	***Austenina* *gr. fusca***	***Glossina* *gr. morsitans***	***Nemorhina* *gr. palpalis***
Espèces	***G. brevipalpis***	***G. austeni***	***G. caliginea***
	G. frezili	***G. longipalpis***	***G. fuscipes fuscipes***
	G. fusca congolensis	***G. morsitans centralis***	***G. fuscipes martinii***
	G. fusca fusca	***G. morsitans morsitans***	***G. fuscipes quanzensis***
	G. fuscipleuris	***G. morsitans submorsitans***	***G. pallicera pallicera***
	G. haningtoni	***G. pallidipes***	***G. palpalis gambiensis***
	G. longipennis	***G. swynnertoni***	***G. palpalis palpalis***
	G. medicorum		***G. tachinoides***
	G. nashi		
	G. nigrofusca nigrofusca		
	G. schwetzi		
	G. severini		
	G. tabaniformis		
	G. vanhoofi		

J. Brunhes - D. Cuisance - B. Geoffroy - J.P. Hervy - J. Lebbe, 1996

Some characterisics of the biology of tsetse

✓ No insecticide resistance reported so far…

✓ Both sexes are haematophagous: they transmit trypanosomes to humans and animals

✓ These insects are pupiparous, and very slow-reproducing (~ 5 descend/female)

✓ La femelle nourrit la larve in utero

✓ The tsetse female is mated very early after emergence, only once in her lifespan

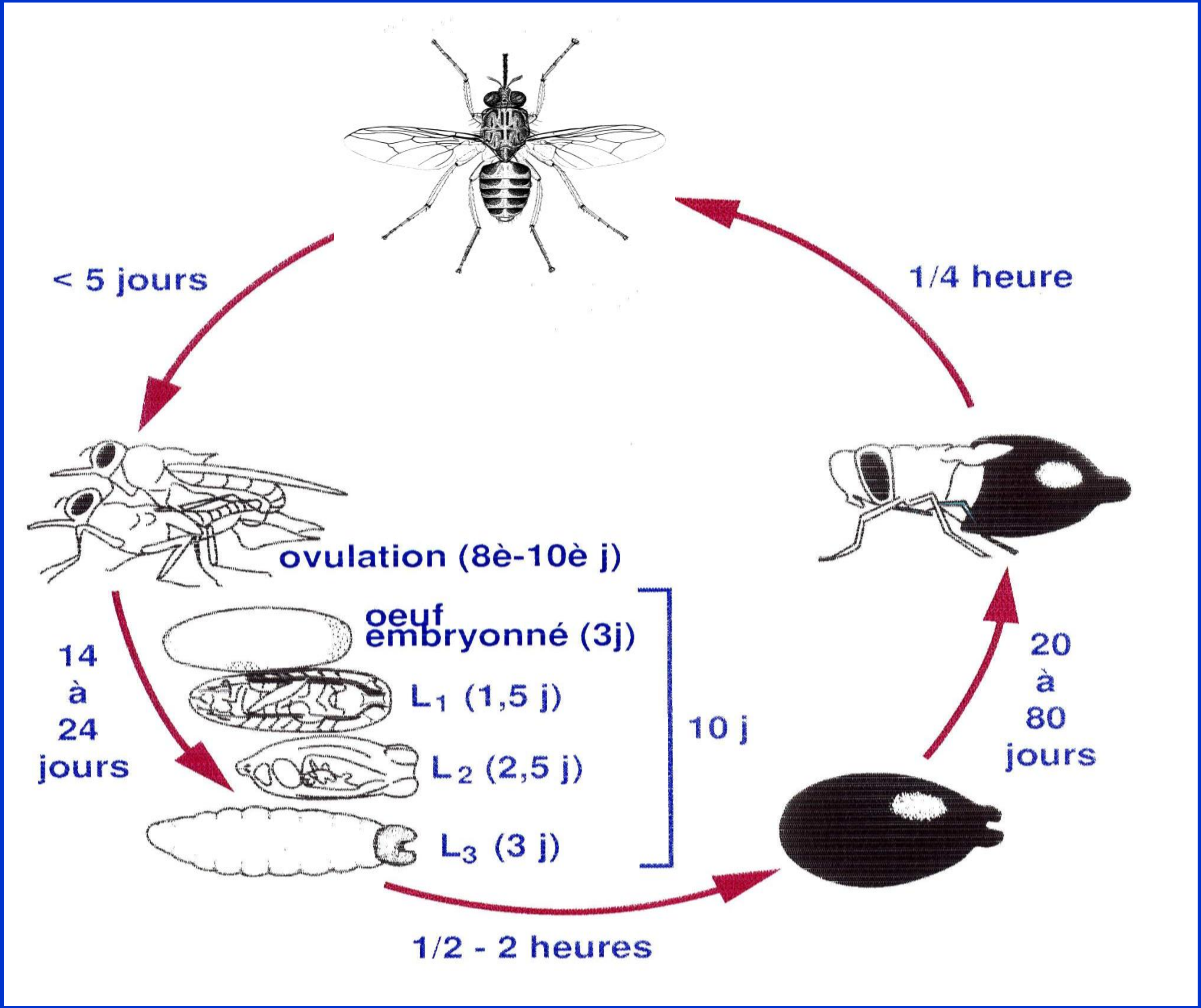
DFID

DFID

DFID

DFID

CYCLE BIOLOGIQUE TSÉ-TSÉ



Glossina palpalis, a key vector

Glossina palpalis : major vector of HAT and also of AAT in West Africa. Described as two allopatric subspecies:

- *G. p. gambiensis*, riverine tsetse of humid savannahs of West Africa

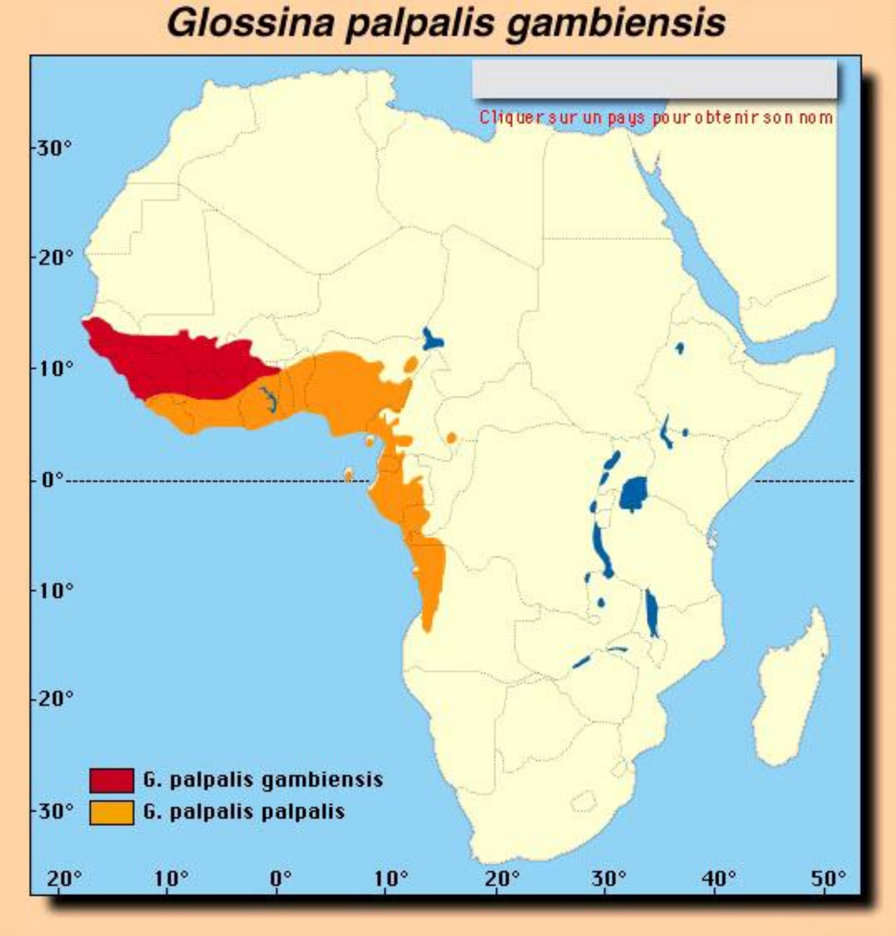
Mainly one dimension dispersal along the rivers (except in humid season)

Except in mangrove in Guinea

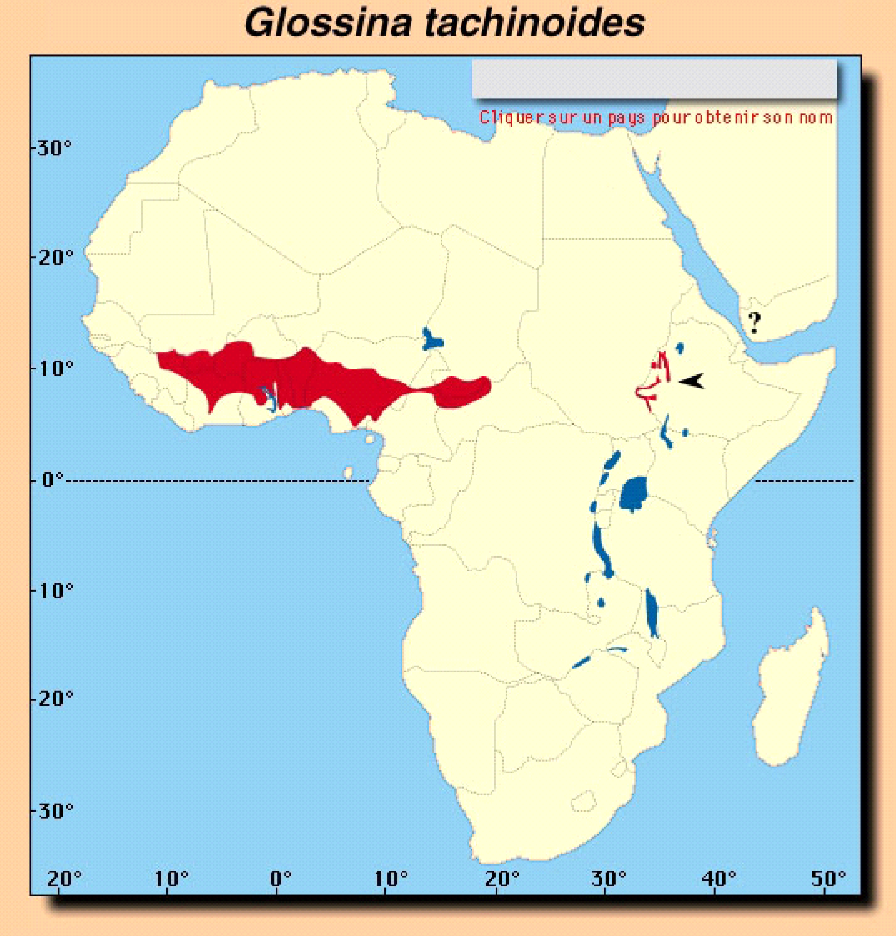
- *G. p. palpalis*, tsetse from coastal, forest and forest-savannah transition zones of West and Central Africa

Due to favourable hygrometric conditions, mainly two dimension dispersal

CARTE RÉPARTITION *G. palpalis* et *G. tachinoides*



Glossina palpalis gambiensis

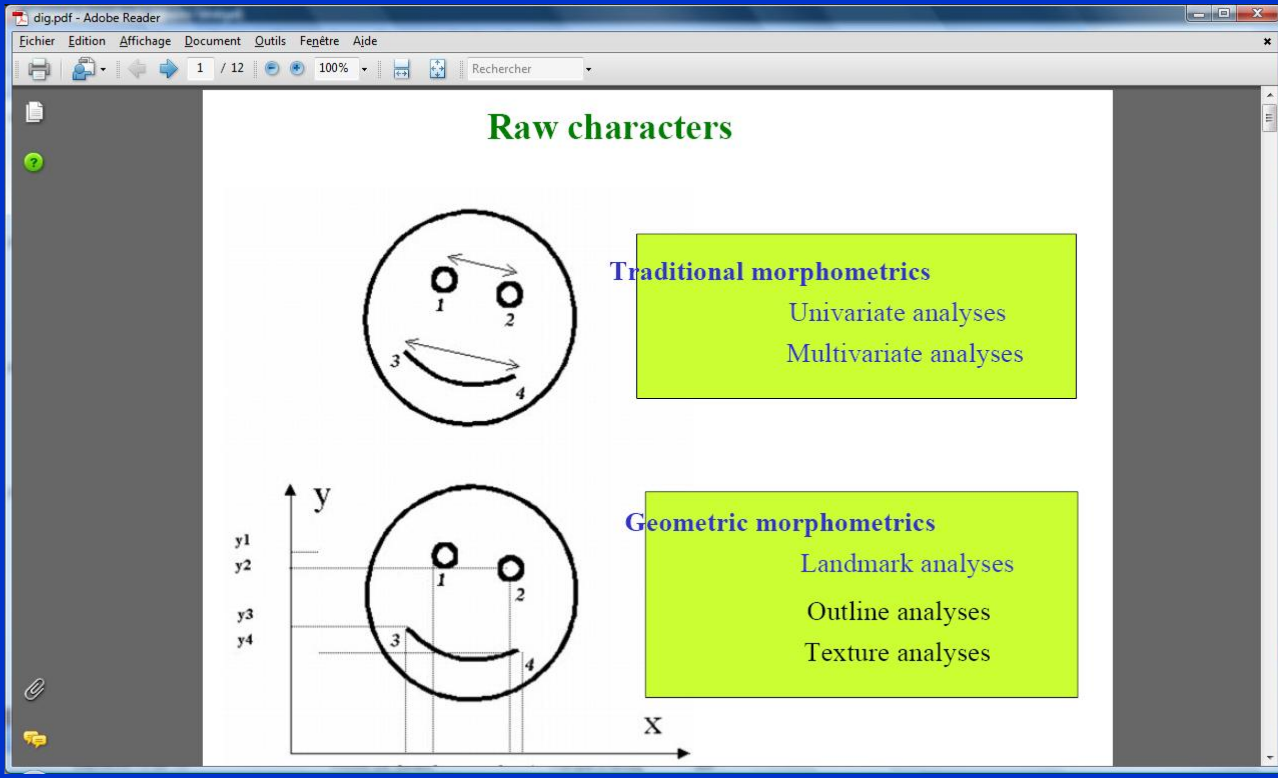


Glossina tachinoides

Source : CD «glossines» IRD-CIRAD

MARKERS USED

- Microsatellite loci (all samples, from 4 to 10 loci)
- Mitochondrial CO1 (Guinea, Senegal)
- Geometric morphometrics (Guinea, Burkina Faso, Senegal)



Raw characters

Traditional morphometrics
Univariate analyses
Multivariate analyses

Geometric morphometrics
Landmark analyses
Outline analyses
Texture analyses

SAMPLING DEVICES

The most commonly used in West and Central Africa:

- Piège biconique Challier-Laveissière (Challier et al., 1973)
- Piège Monoconique Vavoua (Laveissère & Grébaut, 1990)
- Piège Monoconique Lancien (Lancien, 1985)

First results obtained using microsatellites: population structure of *Glossina palpalis gambiensis*

1. *Glossina palpalis gambiensis* in Burkina Faso and *G. p. palpalis* in Ivory Coast: Wahlund effects….with one exception

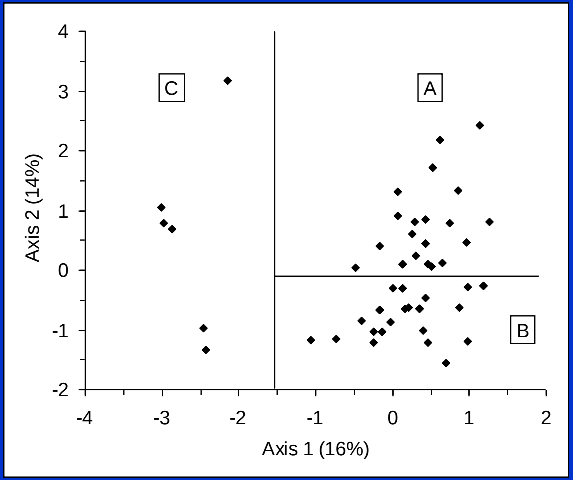
2. *G. p. palpalis* in Cameroon: isolation by distance

3. *G. palpalis gambiensis* in littoral Guinea: panmictic populations

First results obtained using microsatellites: population structure of *Glossina palpalis gambiensis*

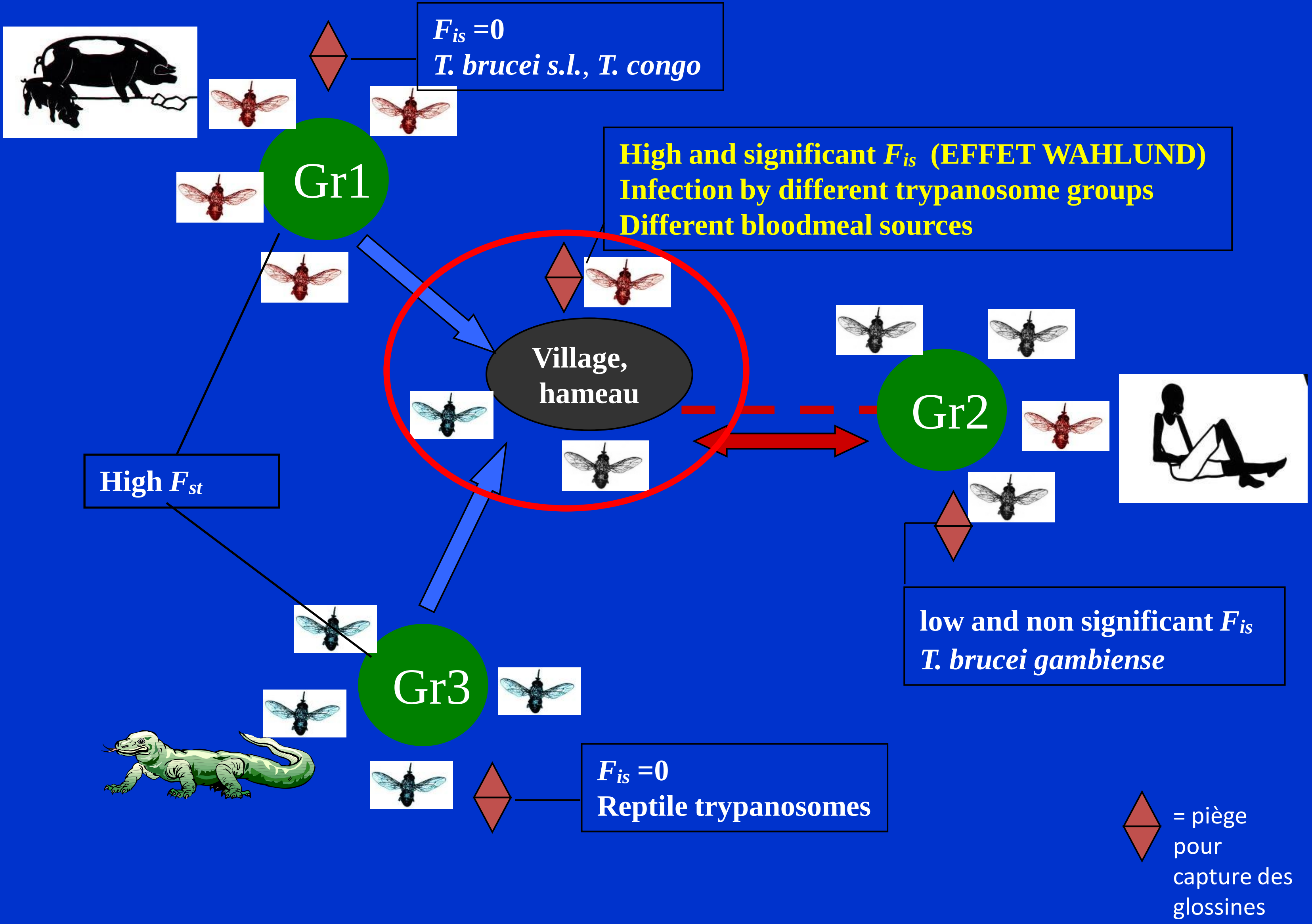
- Preliminary results showed there was genetic structuring of populations at macro (Senegal-BF) (SOLANO *et al.*, 1999 MVE) and microgeographic (Sideradougou) (SOLANO *et al.*, 2000, IMB) scales.

- In Sideradougou, Wahlund effect: our « population » is composed of several different genetic groups (SOLANO *et al.*, 2000, IMB). Different genetic groups not infected by the same trypanosomes, and show different bloodmeal sources.



- Same in the Mouhoun basin, Burkina Faso (BOUYER *et al.*, in 2007 JME; 2009 MOL ECOL)
- and same in *G. palpalis palpalis* in Ivory Coast (RAVEL et al., 2007 IGE)

Population structure of *G. palpalis* in savannah riverine habitats and degraded forests (Burkina Faso and Ivory Coast)



F_{is} =0
T. brucei s.l., T. congo

High and significant *F_{is}* (EFFET WAHLUND)
Infection by different trypanosome groups
Different bloodmeal sources

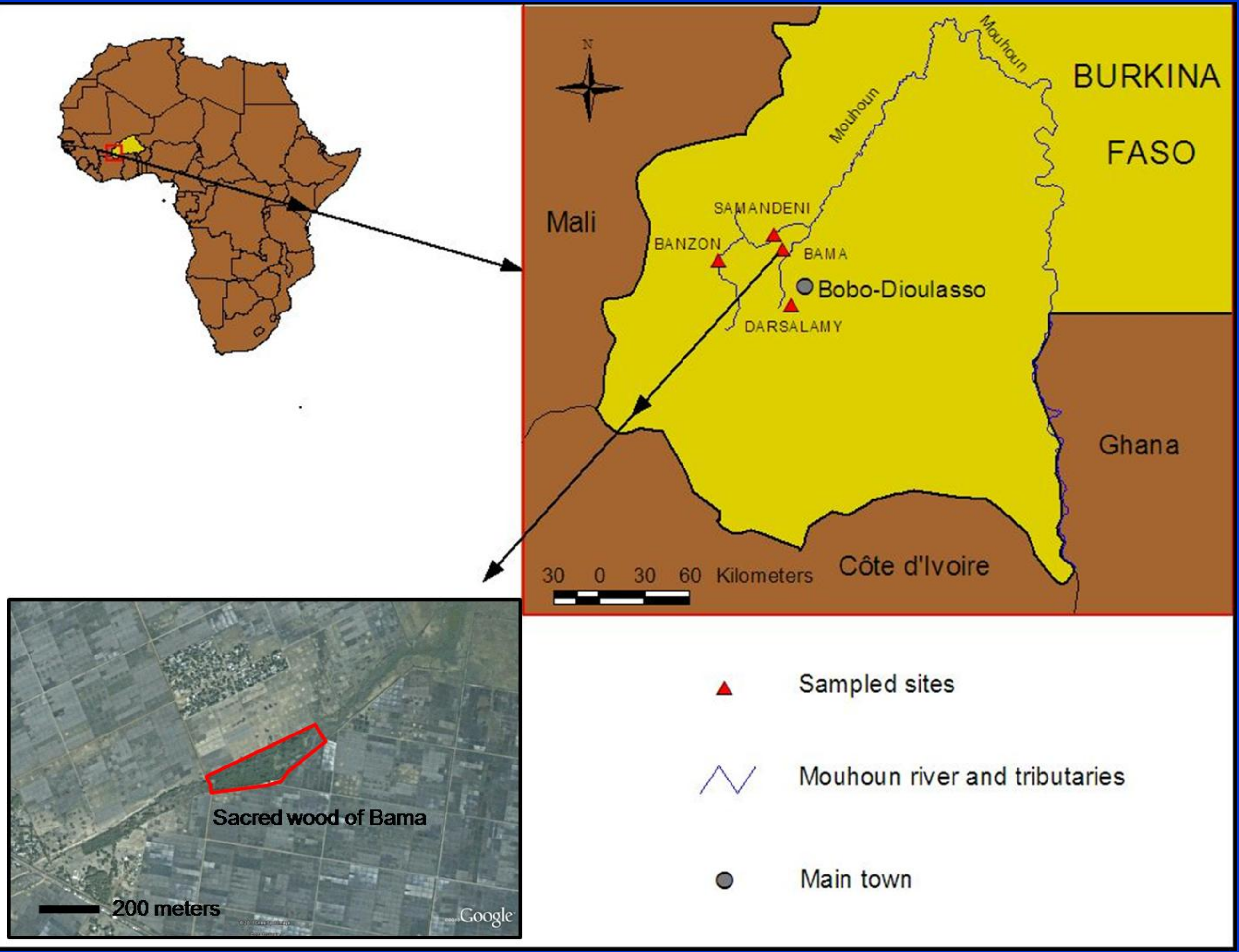
High *F_{st}*

low and non significant *F_{is}*
T. brucei gambiense

***F_{is}* =0**
Reptile trypanosomes

= piège pour capture des glossines

One exception: a panmictic, isolated population of *G. palpalis gambiensis* in Burkina Faso



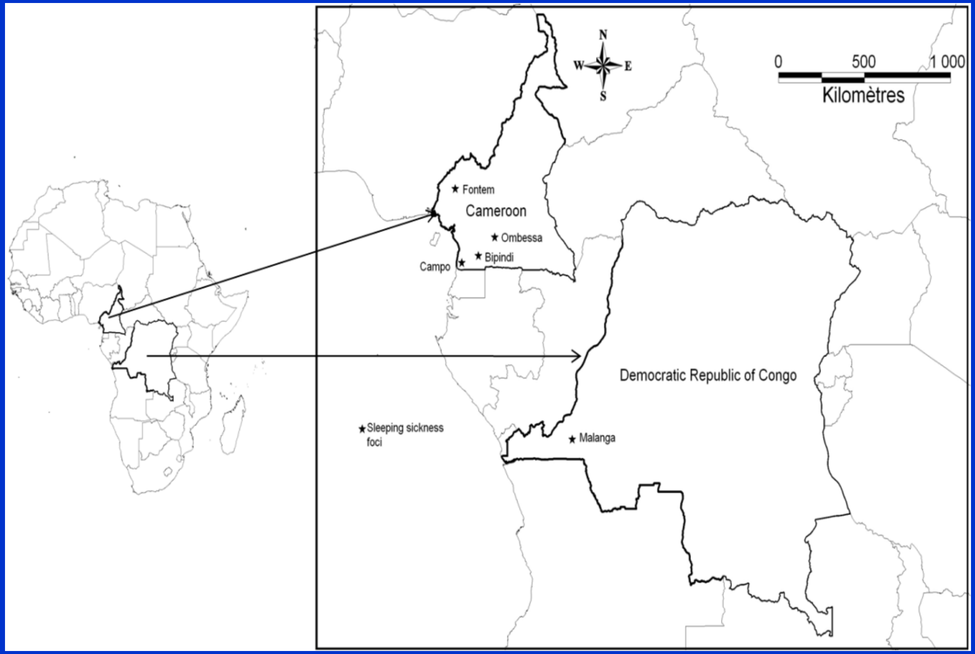
F_{st} between localities of the Mouhoun ~0.03

F_{st} between Bama and Mouhoun ~0.10

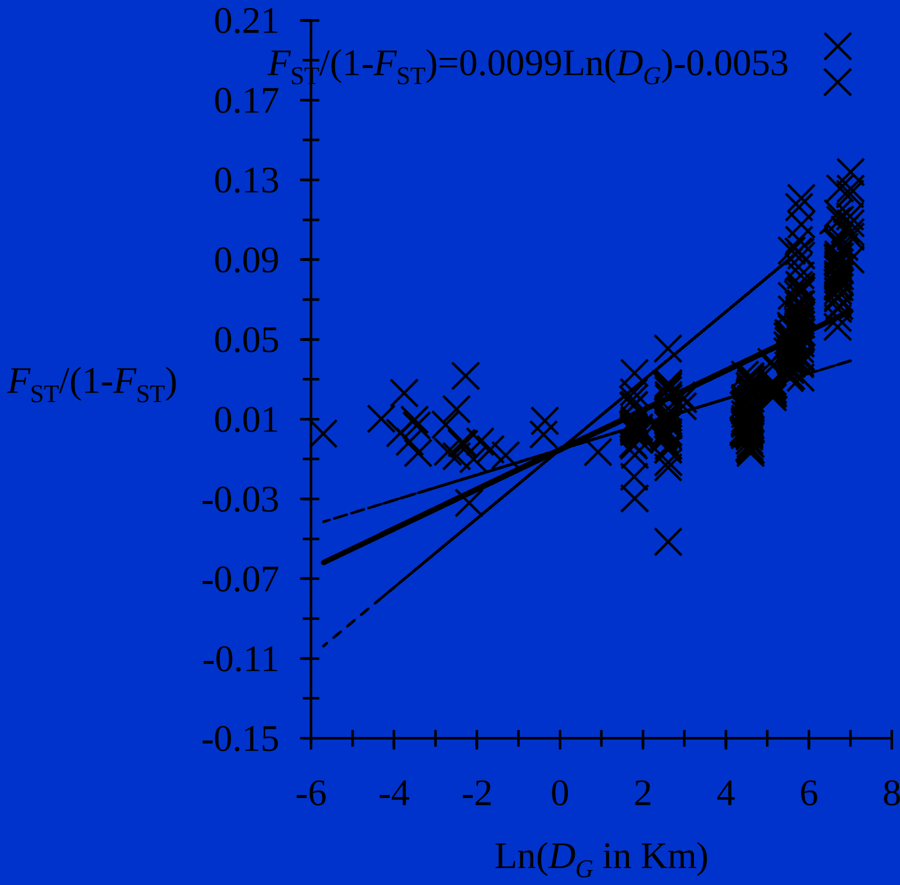
F_{is} not # from 0

Ne ~ 100

Glossina p. palpalis in Cameroon and DRC



MELACHIO et al., P&V 2011



G. p. gambiensis in Guinea Conakry

Panmictic populations with high effective population sizes (Ne ~ 1000)

SOLANO et al., 2009 PLoS Negl Trop Dis

Tsetse control strategies: SUPPRESSION VS ERADICATION

AW/IPM principles (Vreysen et al., 2007)

- ➢ SUPPRESSION: decrease of tsetse density (suppression) to reach a thresold under which there is no more transmission.

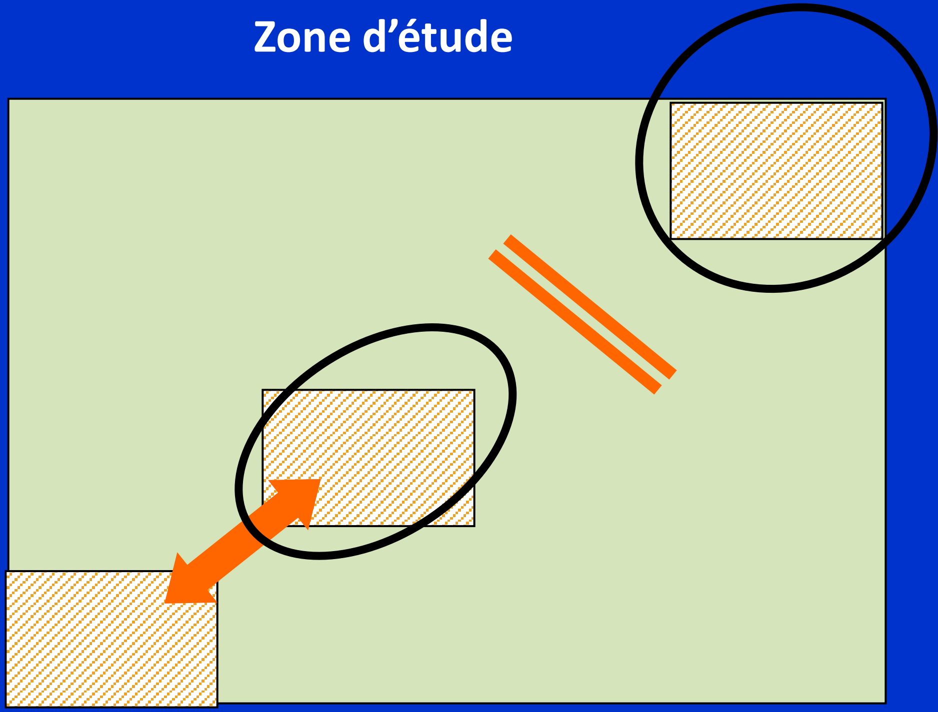
Technically feasible (Laveissière et al. en CI, Lancien en Ouganda…)

- Problem: sustainability → resurgence/reinvasion of treated areas (e.g. de La Rocque et al., 2001).

- ➢ ERADICATION : Objective = 100% suppression, 0 fly, DEFINITIVE.
- Condition: the target population has to be completely covered, and better if isolated (**pop** gen), or isolable

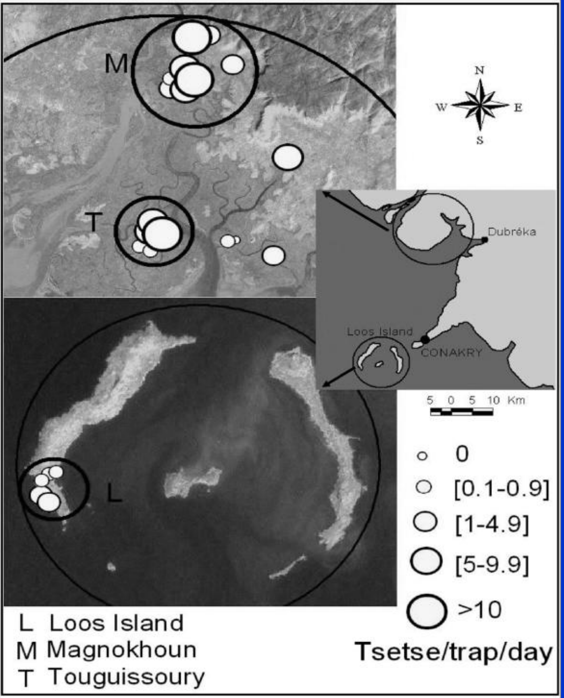
To our knowledge, never done so far in West Africa.

HOW CAN POPULATION GENETICS HELP DECISION ON TSETSE CONTROL STRATEGY?



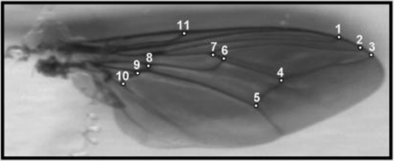
- Contrôle ciblé sur les zones à à risque dans le cas des populations **non isolées** (méthodes participatives: pédiluves, écrans)
- Eradication dans le cas des populations **isolées** (méthodes conventionnelles +- SIT)

G. p. gambiensis in the coastal area of Guinea



Gpg/ focus of Dubreka and Loos islands/ 4000 mm rainfall/

Molecular (4 msat loci + CO1 723 bp seq)) and morphometric (11 LM on w



Population Biology/ Genetics

Genetic and Morphometric Evidence for Population Isolation of *Glossina palpalis gambiensis* (Diptera: Glossinidae) on the Loos Islands, Guinea

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J. Med. Entomol. 43(5): 853–860 (2006)

ABSTRACT Allele frequencies at four microsatellite loci, and morphometric features based on 11 wing landmarks, were compared among three populations of *Glossina palpalis gambiensis* (Diptera: Glossinidae) in Guinea. One population originated from the Loos islands separated from the capital Conakry by 5 km of sea, and the two others originated from the continental mangrove area close to Dubreka, these two groups being separated by ≈30 km. Microsatellites and wing geometry data both converged to the idea of a separation of the Loos island population from those of the mangrove area. Although occasional contacts cannot be excluded, our results support the hypothesis of the Loos population of tsetse flies being a completely isolated population. This situation will favor a sequenced intervention against human African trypanosomosis and the possibility of an elimination of tsetse from this island.

KEY WORDS *Glossina palpalis*, microsatellite DNA, geometric morphometrics, wings, Guinea

Human African trypanosomosis (HAT, or sleeping sickness) is showing some signs of declining due to recent efforts on case detection and treatment, notably in Central Africa (Jannin 2005). However the situation in West Africa is much less clear, and Guinea and Côte d'Ivoire are thought to be the two countries most affected by this disease (Camara et al. 2005, Kaba et al. 2006). Guinea has a long history of sleeping sickness, which was particularly prevalent in the years 1930–1940 (Brengues et al. 1964). Current data show prevalences up to 2–5% in villages of the coastal mangrove area (Dubreka focus) (Camara et al. 2005). The Loos islands are completely separated from this mangrove area of the mainland. The situation of HAT in these islands is not currently known, but there are historical reports of the disease: in 1942, a medical survey conducted by Med. Cap. Héricord detected 30 patients. In 1944, out of 1,924 inhabitants who were registered from the islands, 1,627 were visited, and 16 cases were detected (15 on Kassa island and one on Fotoba island). After that, little information has been available except for seven cases originating from these islands between 1971 and 1987; these cases were passively detected and treated in Dubreka. It is not known whether the disease was autochtonous or was imported from other localities.

In West Africa, HAT is mainly transmitted by the tsetse fly species *Glossina palpalis* Van der Planck (Diptera: Glossinidae). Control of tsetse can be achieved through a variety of techniques, including traps, insecticide impregnated targets, live-baits, sequential aerial spraying, and sterile male release (Cuisance et al. 1980). Generally, however, the tsetse populations then tend to recover, due to either flies surviving the initial interventions, migrant flies coming from untreated regions, or both. To achieve and sustain local elimination of a target fly population, it is therefore preferable to define the area of intervention to include an entire panmictic fly population, such that natural immigration from neighboring localities is of low likelihood. This end is most readily achieved for isolated island populations, as shown by the elimination of *Glossina pallidipes* Austin from the Island of Principe in 1914 (Da Costa et al. 1916), and the elimination of *Glossina austeni* Newstead from Unguja Island of Zanzibar in 1997 (Vreysen et al. 2000). But for most mainland populations of tsetse, the geographical limits of target tsetse populations are less easily definable. Application of population genetics techniques can reveal the existing level of population differentiation in tsetse, providing guidance on the distribution of genetically defined subpopulations. In essence, the

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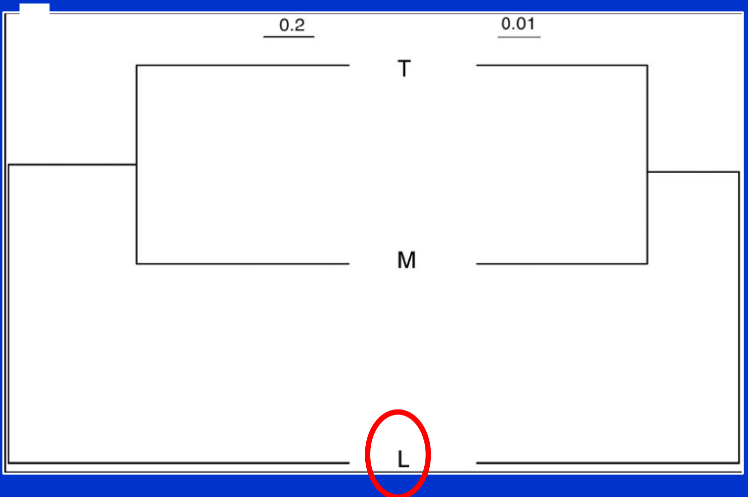
« Data from molecular (microsatellites, mitochondrial) and from wing geometry both converged to the idea of a separation of the Loos island population from the mainland. Although occasional contacts cannot be excluded, our working hypothesis is that the Loos population of tsetse flies is a completely isolated population. » **CAMARA *et al*., 2006, JME.**

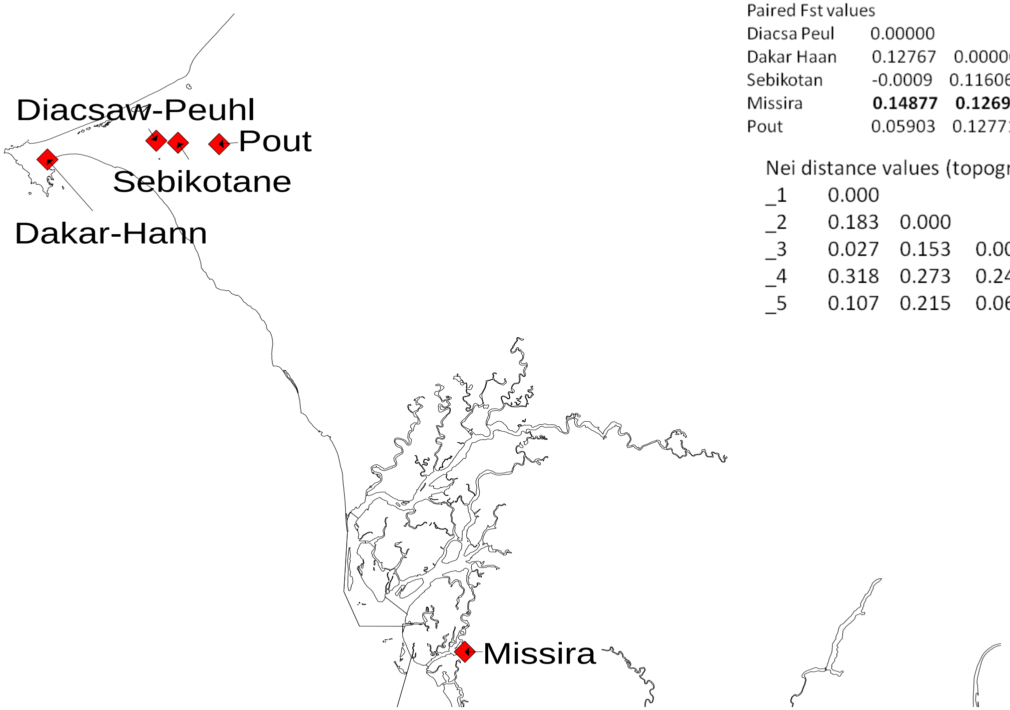
Tsetse eradication program on Loos islands (NCP): feasibility



UPGMA tree on genetic distances based on wing morphometry (on the left, Mahalanobis distance) and on microsatellite DNA loci (on the right, Cavalli-Sforza and Edwards distance) of the three tsetse populations.

G. p. gambiensis in Sénégal

Eradication project of *G. p. gambiensis* in the Niayes using the Sterile Insect Technique (SIT). Only if there is genetic isolation between the Niayes and other tsetse infested areas



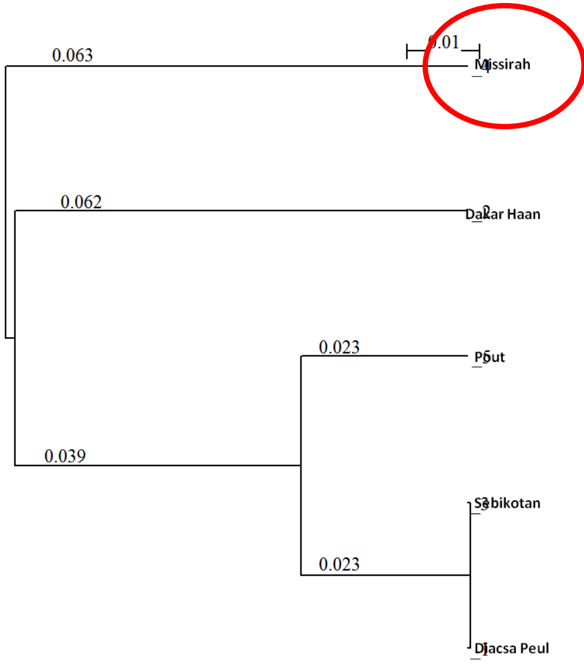
Source : B. Sall, J. Bouyer

Paired Fst values

Diacsa Peul	0.00000				
Dakar Haan	0.12767	0.00000			
Sebikotan	-0.0009	0.11606	0.00000		
Missira	**0.14877**	**0.12694**	**0.13632**	0.00000	
Pout	0.05903	0.12771	0.03169	0.09330	0.00000

Nei distance values (topography of tree is the same)

_1	0.000				
_2	0.183	0.000			
_3	0.027	0.153	0.000		
_4	0.318	0.273	0.248	0.000	
_5	0.107	0.215	0.067	0.239	0.000

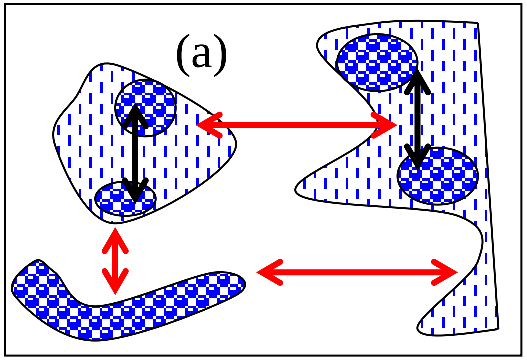


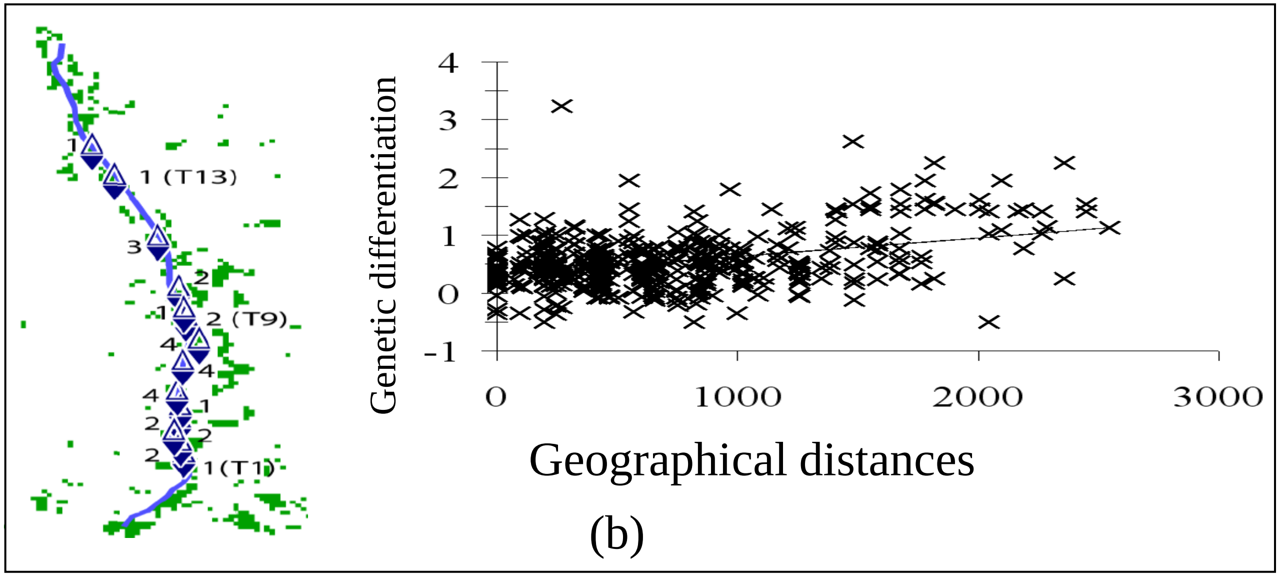
Both morphometrics and microsatellites showed a high and significant genetic differentiation (Fst=0.12, p<0.0001) between the Niayes and the South of the country: Eradication can be contemplated (see presentation of J. BOUYER).

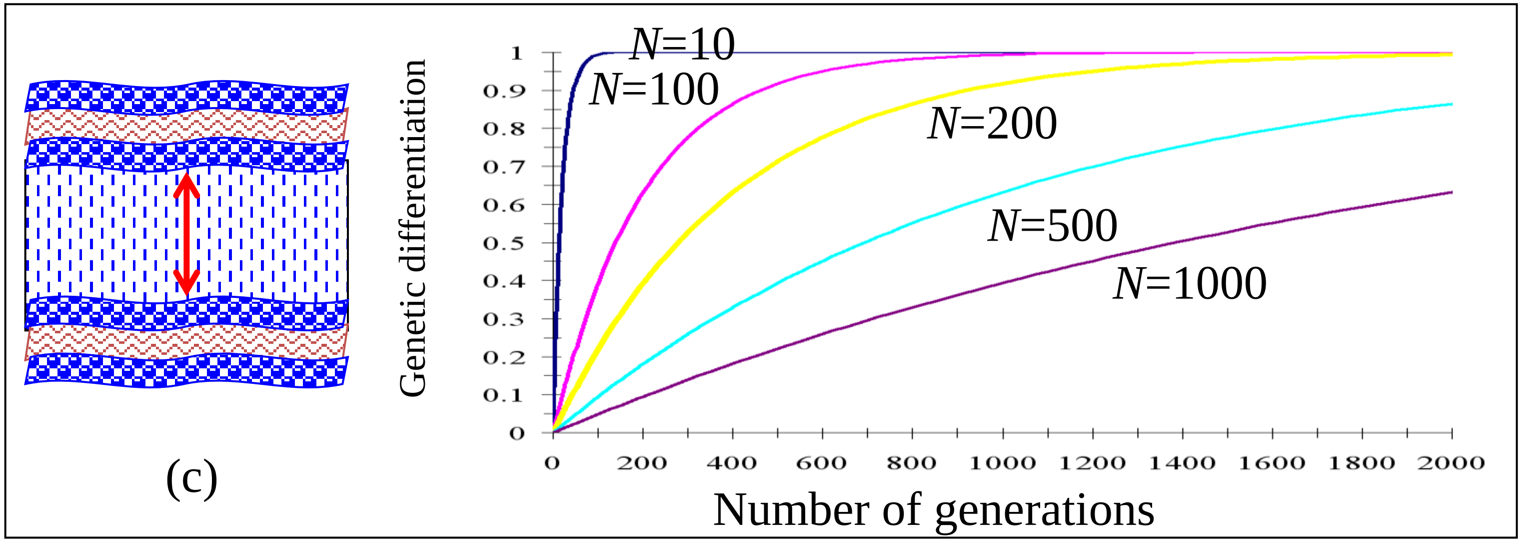
Solano et al., 2010, PLoS Negl Trop Dis.

Is genetic differentiation in *G. palpalis gambiensis* and *G. tachinoides* related to river basin origin?

Isolation by distance was significant for both species across river basins, and dispersal of *G. tachinoides* was ~3 times higher than that of *G. p. gambiensis*. Thus, the data presented indicate that no strong barriers to gene flow exists between riverine tsetse populations in adjacent river basins, especially so for *G. tachinoides* (Bouyer *et al*., 2010 IGE; Koné *et al*., 2011 MVE)







Solano P, Ravel S, de Meeus T (2010) Trends in Parasitol

WHAT REMAINS TO BE DONE IN TSETSE GENETICS FOR TSETSE CONTROL?

- ALL…

- Better markers…HOPE: Tsetse genome released next days
- Better answers: Ne? Wahlund? Fis? Species or subspecies…
- Better greographical coverage
- Better species coverage

etc.

But above all: USE of TSETSE CONTROL in sleeping sickness control strategies


Merci beaucoup
J. BOUYER

and Thank you to

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FSP-REFS (MAEE), SCAC Conakry, Abidjan, Ouagadougou

INCO-DEV (EU)

FAO-AIEA

LTTRN

Vestergaard-Frandsen

…

CIRAD for invitation to this workshop

…

ALLEZ LES BLEUS!