The eradication of the tsetse fly *Glossina palpalis gambiensis* from the Niayes of Senegal using an area-wide integrated pest management approach that includes the release of sterile males

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Overview

• The tsetse and trypanosomosis problem
• Tsetse eradication in the Niayes, Senegal using a Phased conditional approach (PCA)
  – Organisational frame work (Government)
  – Feasibility studies
  – Pre-operational phase
  – Operational phase
• Achievements
• Conclusions
The problem

Distribution of *Glossina* spp in Africa

- The Tsetse fly – Africa’s Bain
- 36 countries – 10 million km²

- 165 million cattle in Africa
- only 10 million in tsetse infested areas
- 50 million cattle at risk
- Direct losses: **US$ 0.6 – 1.2 billion**
  EACH YEAR
- Responsible for separation of crop farming and livestock production

- 60 million people at risk
- 3-4 million people: surveillance
- 300,000 – 5000,000 infected (10%)
The target area in Senegal: Niayes

- Good climatic conditions
- Trypanosomosis = main constraint
- Tsetse eradication = to create a suitable sanitary context for innovation
History of tsetse control in the Niayes of Senegal

✓ **1970-1980**: tsetse control in the Niayes (Dr Touré)
  ✓ Insecticide (spray)
  ✓ Bush clearing
✓ **1980-1999**: No activities
✓ **1999-2003**: 2 surveys confirmed presence of tsetse (locale population or reinvasion from other tsetse infested areas? and trypanosomosis

New project with a new approach and new tools
Phased Conditional Approach (PCA)

1. Organisational framework (Government)
   a. Training of technical field and insectary staff

2. Feasibility studies
   a. Entomological, parasitological and serological baseline data collection
   b. Population genetics, socio economics, environmental study

3. Pre-operational phase
   a. Establishment of insectary (dispersal centre in Dakar)
   b. Research at IPCL: transport protocol of male sterile pupae (from Burkina Faso and Slovakia to Senegal)
   c. Pilot release (ground and air) (3 years)
   d. Development of distribution model

4. Operational phase
   a. Suppression
   b. Release of sterile males
   c. Monitoring of project progress.

External Review
PCA1: Organizational frame work

Division of Vet Services
Coordination of the project

Institut Sénégalais de Recherches Agricoles/Centre International en Recherche Agronomique pour le Développement
Operational Research Insectary

Vet agents
Entomological surveys
Suppression

Coordination Unit
1 meeting / month

Dedicated personal
Entomological surveys
SIT

Field results
Adaptive Management Approach

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
Technical advice

IAEA Department of Technical Cooperation
Technology transfer + financial support

Third FAO–IAEA International Conference on Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques, Vienna 22-26 may 2017
PCA1: Preparation

- 16 field and insectary staff trained
- CIRDES
- Tsetse ecology and biology
- Workshop to plan baseline data collection
- Equipment: traps, microscopes, binocular microscopes, sampling material,...
PCA 2: Entomological base line data

• A grid with 5 x 5 km cells to cover the entire target area (total: 294 grids,)
  • Dividing of the area in teams
  • Organisation of the teams
• Development of vegetation maps
• Initial surveys to associate vegetation types with preferred tsetse habitat
• Selection of trapping sites using GIS and RS
PCA 2: Entomological base line data

Gallery forests          Riparian tickets          Swamp forests

Palm tree plantations    Tree orchards          Mangroves

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PCA 2: Entomological base line data

Mapping of suitable habitat – selection of trapping sites

GIS – RS: suitable habitat (525 km²) > 700 trapping sites

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PCA 2: Entomological base line data

- 1 species: *Glossina palpalis gambiensis*
- 3 populations: Hann, Kayar and Pout
- Densities could be very high locally
- Populations appeared to be isolated

- 55/294 grids infested (1375 sq. km out of 7350)
PCA 2: Entomological base line data

Information about population dynamics
- Apparent densities in different seasons and different ecosystems
- Natural abortion rates

Evolution of the natural abortion rate
PCA 2: Parasitology base line data

Cattle
Mean prevalence
Buffy coat: 2.01%
Serology:
T. vivax 28.68%
T. congolense 4.36%
T. brucei brucei 0.3%

Strong relationship with tsetse
PCA 2: Population genetics study

- 3 markers
  - Microsatellites
  - Mitochondrial DNA
  - Wing morphometrics

- Niayes tsetse populations were genetically isolated from the nearest population in the South
- No exchange of genes
PCA 2: Socio-economics study

- ~6.4 million Euro until 2016 (~€ 6400/km²)

Distribution of the costs by partner (left) and component (right).
PCA 2: Socio-economics study

- One traditional system based on trypanotolerant cattle
  - annual cattle sales €74 (s.d. 38) per head
- Two other livestock keeping systems using more productive breeds (improved meat & improved milk production)
  - annual cattle sales were €250 (s.d. 513) per head
  - herd size 45% smaller
- Increase of animal sales: €2800 / km² /year (total cost €6400/ km²)
PCA 2: Socio-economics study

Rate of Return (IRR) of 19.1% and payback period of 13 years

Rate of Return (IRR) of 9.8% and payback period of 18 years

Years after the beginning of the project
PCA 2: Environmental impact study

Permit from the Ministry of environment obtained
Light and transitory impact on non target species

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PCA 3: Establishment of a dispersal centre/insectary in Dakar

- Mass-rearing & irradiation in Centre International de Recherche-Développement sur l’Elevage en zone Sub-humide, Burkina-Faso & Slovakia Academy of Sciences, Slovakia / FAO-IAEA Insect Pest Control Laboratory, Austria
PCA 3: Development of a transport protocol

- Transport of pupae, not adults
- Sex sorting to keep females (colony stability)
PCA 3: Development of a transport protocol

- Impact of low temperatures (10, 12.5 and 15 ºC) for various periods of time & irradiation & transport on the quality of sterile males
- Parameters assessed: emergence rate, survival, insemination capacity and field competitiveness
- Development of a quality control test
PCA 3: Development of a transport protocol

Transport through express mailing services using phase change materials
PCA3: Pilot Release of Sterile Males

- Trial releases on the ground and with boxed sterile males
- Mortality: releases twice a week
- Dispersal rates: swath widths of 250 m between the flight lines
- Very good competitiveness: ratio 10:1 gives a reduction in fertility > 80%
PCA3: Pilot Release of Sterile Males

Maps of predicted competitiveness
PCA3: Development of distribution models to inform control

Using species distribution models to optimize vector control in the framework of the tsetse eradication campaign in Senegal

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PCA4: Sequential eradication

Strategy developed using data from the feasibility study:
- Isolated population – opted for Eradication
- High fly densities – need for suppression (insecticide impregnated traps, pour ons)
- Fragmented nature of the habitat – required the sterile insect technique

Preoperational phase: tools tested (transport, release system,...)

Phased approach – 3 blocks
PCA4: Sequential eradication

zonesurveillance par blocks

1  (11)
2  (21)
3a (12)
3b (11)

Suppression  Eradication  Entomological monitoring

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PCA4: Sequential eradication

Optimization of control based on distribution models: targeting suitable habitats

Dicko, A.H., et al. (2014) Using species distribution models to optimize vector control: the tsetse eradication campaign in Senegal. PNAS.
PCA4: Sequential eradication

Aerial and ground release of sterile males

Ground release

Aerial release with machine

Release machine

Aerial release with boxes
PCA4: Sequential eradication

Monitoring system
Block 1: 24 monitoring traps (once a month)
Block 2: 72 monitoring traps (twice a month)
Block 3: 45 monitoring traps (twice a month)
PCA4: Sequential eradication

Achievements
Impact on tsetse populations

1-3.4 insecticide impregnated targets/km²
+ 10 and 100 sterile males/km² unsuitable vs suitable habitat respectively
Impact on disease prevalence in sentinel herds

Blood collection

Examination of samples

Buffy coat
Progressive replacement of trypanotolerant breeds by improved breeds

Djakoré cross-bred with Holstein and Montbéliard

2010   2040
Environmental impact

2 out of 10 non target species (Cetoniina species) slightly affected by the suppression methods: Pachnoda interrupta in Kayar (block 1) and P. marginata in Pout (block 2)

Both species reached the reference situation (2009) after 2 years
Weaknesses and strengths

Weaknesses

- Human resources: Only few staff members are fully dedicated to the project
- Financial challenges
- Lack of sterile flies: project extended over expected deadline

Strengths

- Strong support from FAO/IAEA, CIRAD, USDA
- Strong team management
- Strong involvement of the staff (field and insectary)
- Very good working environment
Conclusions

- Benefits of the campaign already huge
- Change in sanitary context already perceived -> strong innovation anticipated
- The change of socio-technical regime accelerated after the eradication process
- Reduction of cattle size and integration between agriculture and cattle breeding promoted
Thanks!