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African Insect Science for Food and Health

***How science can contribute to poverty alleviation in Africa* – examples and lessons learned**

Christian Borgemeister, CEO *icipe*

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general facts

A *centre of excellence* in Africa—for research and capacity building in insect science and its applications

An *intergovernmental organization* — charter signed by 13 countries worldwide

~400 staff total, 50 PhD scientists, visiting scientists and PDFs, always ~ 50–70 MSc & PhD students in residence

An organization with a *unique history* — genesis in Africa, 40+ yrs old

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general facts

Africa-focused - Current activities in 24 African countries

Collaborative work in Middle East, South America, Asia

International HQ in Nairobi

Several field stations across Kenya & in Port Sudan, country office in Ethiopia (planned for Rwanda and DRC)

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general facts - where we work

general facts

Africa-focused - Current activities in 24 African countries

Collaborative work in Middle East, South America, Asia

International HQ in Nairobi

Several field stations across Kenya, including TRO campus in Mbita Point (Lake Victoria) & in Port Sudan, country office in Ethiopia (planned for Rwanda and DRC)

general facts

Numerous partnerships in Africa – NARS, NGOs, CBOs, and especially African Universities (>34 – capacity building one of ***the*** key achievements of *icipe*)

Strong partnerships with European research institutions (Rothamstead, MPI Jena, Inst Pasteur, LSHTM, LSTM, WUR, Oxford, SLU, Univ Glasgow, Imperial Col, KTH, etc.)

and North American R&D partners (McGill, UC Riverside, Yale, UC Davis, Univ Birmingham, UoF, NIH, USDA etc.)

general facts

Core-funding mainly from Governments of Sweden, Switzerland, UK, Germany, France & Kenya

Core increased by approx. 80% in last 7 years, paralleled by substantial increases in restricted income

Core to restricted ratio approx. 35:65

2011 budget $19.8 m (forecast 2012 $25 m; 2005 $9 million); strategic reserve $ 4.5 m (2005 - $250k); lean management structure (0.8 of every $1 goes into R&D + capacity building)

Project funding from various development (EU, BMZ, MoFA Finland & NL etc.) and science oriented donors (Welcome, NSF, NIH, BMGF, Google.org etc.)

general facts

4H paradigm

R&D on *human, animal, plant & environmental health*

Common denominator *insects/ arthropods*

tsetse

True African menace

Transmission of trypanosomes causing *nagana* in live stock (annual losses > $ 6.5 billion) and *Human African Trypanosomiasis (hat)* (> 500,000 cases/yr)

tsetse - nagana

For savannah species (vectors of *nagana*) *icipe*'s NGU trap based on combination of visual & olfactory cues can reduce flies by >90% in ~ 2 years

Yet one stops & they come back

Solution community-based

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tsetse - nagana

Trapping technologies not well suited for pastoralist

Need for a *moving technology*

Basis repellency

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tsetse - nagana

- Waterbuck are present in tsetse habitats but not fed upon
- Refractoriness is mediated by repellents
- Waterbuck repellent blend (WRB) reduces fly catches by 70% and feeding efficiency >95%
- Allomones from these animals may be useful in protecting cattle from tsetse attack
- 5-component WRB identified *(patent application)*

Cows in waterbuck clothing

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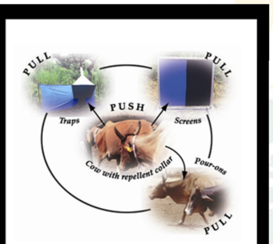
tsetse - nagana

- New dispenser model (KIRDI/*icipe* ii) derived from *icipe* prototype developed
- Basically 2 dispensers are combined into 1 with 1 common reservoir
- 2 tygon tubes are joined to form 1 tube from which constant release rate is achieved
- Tubing is protected with a metallic casing to minimize damage *(patent application)*

tsetse - nagana

Integration of repellents with other tsetse control tactics – evaluation of **'push-pull'**

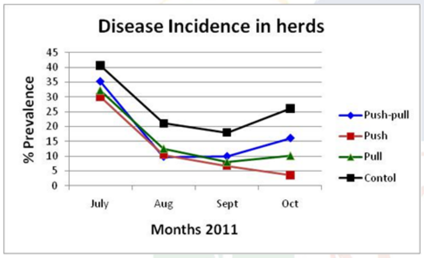


10 sites on the outskirts of Shimba Hills National Reserve have been selected - area > 100 km^2

tsetse - nagana

Location (block)	Treatments	No. of pastoralists	No. of cattle
Pengo	Push-Pull (WR)	22	68
Kizibe	Push (WR)	21	128
Mkongani	Push (SR)	19	96
Zunguluka	Push-Pull (WR)	19	117
Mangawani	Push (WR)	26	141
Mawiya	Pull	20	140
Mkanda	Control	21	115
Katangini	Pull	32	176
Msulwa	Control	21	133
Kidongo	Push-Pull (SR)	20	111
Total	-	221	1,225

tsetse - nagana



tsetse - nagana

- Animals more settled when grazing
- Animals grazing much closer to park fence than before without being disturbed by flies
- Animals grazing early morning & late evenings
- Herdsmen stopped lighting fires to smoke away flies
- Drug (trypanocides) use declined
- More pastoralists demanding to be included in trials
- >95% pastoralists report that repellents are very effective

tsetse - hat

> 500,000 *hat* cases/yr in Africa

Drugs very old, rather inefficient & can have significant side effects

Vector control among the most promising intervention techniques

90% of blood meals of *G. f. fuscipes* from monitor lizards

Working hypothesis *Gff* attracted by host odours

tsetse - hat

- Trials on Chamaunga island in Lake Victoria
- Comparing 6 lizards vs. 1 ox & 1 human + empty control
- Odours from metallic cube (containing sources) blown over black-cloth covered electric grid

tsetse - hat

	Empty	Ox	Lizard	Human	*P*
Males (M)	13.2	15.2	19.3	15.1	ns
Females (F)	6.8	9.0	13.3	8.3	*
M+F	21.3	24.6	32.6	23.3	*

* significant at $P < 0.05$

Lizard odour increase catch for female (x1.9; $P < 0.05$) and to lesser extend male flies (x1.5; ns)

Human and cattle odours no significant effect (catch indices of x1.1 – x1.3)

Omollo et al. PLoS Neglected Diseases (2009)

tsetse - hat

Work-in-progress:

Odour collection, GC-MS analysis, followed by bio-assays

malaria

Malaria kills more people in Africa (>1,000,000/yr) especially children (5,000/day) than any other disease

Tremendous impact on all aspects of live, including agriculture productivity

icipe develops integrated malaria programs that include vector control using environmentally techniques

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malaria

In 3 pilot ecologies, a coastal town, East African highlands, and a high-input agricultural environment *icipe* & partners test development of participatory integrated control strategies for malaria

Informing & training of communities is paramount

Approach tailor made for the different ecologies

Aim is to show as proof of concept that integrated malaria control can substantially reduce disease burden

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malaria

Identification & subsequent control of breeding habitats of mosquitoes crucial for success of integrated control

In East African highlands often pits of brick makers are key breeding sites for malaria-transmitting mosquitoes

Sadly families or the brick makers are often among the first victims of malaria

Environmental management (e.g. drainage & introduction of larvivorous fish) & application of botanicals like Neem considerably reduced malaria incidence

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malaria

In urban Malindi very often abandoned pools during the off-season turned out to be the main breeding sites for mosquitoes

Environmental management + larval control initiated by *icipe* & its partners led to drastic reduction in malaria incidences in the communities

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malaria

- Increasingly important interactions between human health & agriculture
- In Mwea irrigation scheme of Central Kenya integration of soybean crop in usual rice-rice rotation drastically reduced vector populations, improved soil, provided farmers with additional income from soya, & increased yield of subsequent rice crop
- Improved timing of fertilizer considerably affected vector dynamics
- Better knowledge on spatial & temporal dynamics of vectors allow for optimal timed larvicide (*Bti*) applications

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malaria

Key factors for success:

(i) identification of breeding habits (most men-made)
(ii) larval control (*Bti*, botanicals)
(iii) adult control (ITNs, IRS, repellent)
(iv) environmental management
(v) public awareness
(vi) intra- & inter-sectorial collaboration
(vii) capacity building

Substantial reduction in morbidity (25-50%) in the different ecologies with 12-24 months

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malaria

Anopheles mosquitoes most important insect worldwide

Yet very little known on basic biology & ecology

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mosquitoes – plant feeding

Conventional wisdom *Anopheles* mosquitoes is neither limited by sugar nor affected by it, thus sugar-feeding is trivial & not important for life history

If true, then plant-feeding no role in disease epidemiology

Yet many open questions, for instance what about males?

Our work show with field & lab evidence that plants play vital role in *An. gambiae* biology, their vectorial capacity, & possibly malaria transmission

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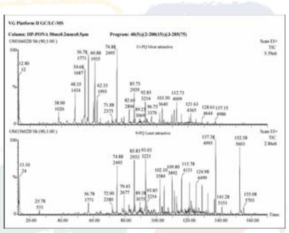
mosquitoes – human odours



GC-MS profiles of the most and least least attractive person

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mosquitoes – human odours

Potential usages:

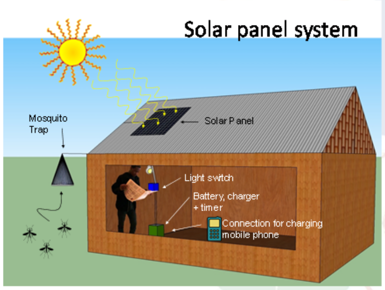
- New surveillance tools
- Combination with control using auto-dissemination approach
- Mass trapping?

mosquitoes – SolarMal

Objective

Demonstrate proof of principle for elimination of malaria from Rusinga Island using LLINs + case management, combined with mass trapping of mosquito vectors

mosquitoes – SolarMal



- Panels to power (i) light, (ii) cellphone charger, & (iii) odour-baited mosquito traps
- Envisaged to cover approx. 7,000 households on island
- Partnership with WUR, Swiss Tropical Institute & funded by *COmON* foundation

mosquitoes – beyond malaria

Horn of Africa 'hotbed' of arboviral (emerging infectious) diseases

Hardly any capacity in the region

Knowledge on vector taxonomy, biology & ecology at best dismal, often non-existing

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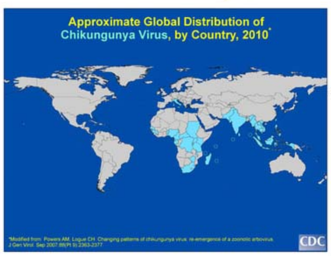
mosquitoes – beyond malaria



Chikungunya and West Nile Virus examples illustrating potential of such emerging infectious diseases (EIDs)

New surveillance & diagnostic tools urgently needed

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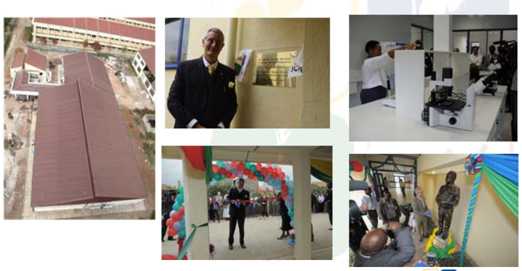
mosquitoes – beyond malaria

The Martin Lüscher Emerging Infectious Diseases Laboratory



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mosquitoes – beyond malaria

The Martin Lüscher Emerging Infectious Diseases Laboratory

BSL-2, 2+ and BSL-3 labs + BSL-2 insectaries

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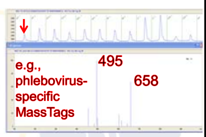
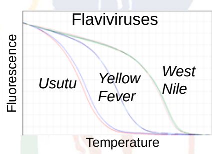
mosquitoes – beyond malaria

Screening for arboviruses

Multiplex MassTag PCR: screen with family-specific primers



High Resolution Melting (HRM) Analysis: identifies specific viruses based on unique melting profiles



Next generation sequencing: full viral genome sequencing

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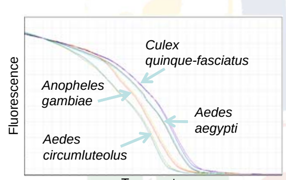
mosquitoes – beyond malaria

Identification of cryptic species and population differences of mosquito vectors.

Tool: HRM



Recent findings: a great diversity of mosquitoes have the potential to transmit Rift Valley Fever (RVF) Virus

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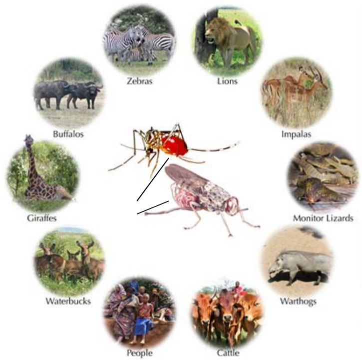
mosquitoes – beyond malaria



- Humans?
- Wildlife?
- Livestock?
- Mixed meals?

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mosquitoes – beyond malaria

RVF vector lure developed from a blend of chemicals derived from host animals increases mosquito captures by ~ 70% compared to conventional trapping system

Trapping system captures only mosquitoes, therefore target specific

R&D took >3 years

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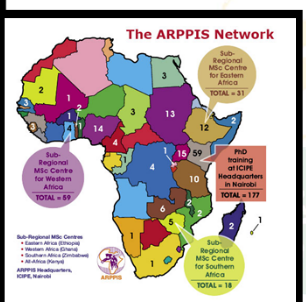
capacity building



ONE cornerstone of *icipe*'s capacity building activities is *ARPPIS* (African Regional Postgraduate Program in Insect Science)

Founded in 1983 *ARPPIS* oldest & most productive capacity building network in Africa

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capacity building

icipe together with its 34 African University partners is training a cadre of young scientists in *ARPPIS*

PhD – so far >350

At *ARPPIS* 3 sub-regional Centers at Universities of Legon-Accra (Ghana), Addis Ababa (Ethiopia), and Harare (Zimbabwe) and at *icipe*'s HQ
MSc – so far >150

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capacity building

Offer opportunities to African and non-African students with self-funding (DRIP)

Help modernize African University curricula & facilities

Offer professional development opportunities for Visiting Scientists (among others in collaboration with AAS & TWAS)

Technology transfer through training of trainers, special short courses, community participation at farmers/ community level

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lessons learnt

Genuine participation of all stakeholders (incl. communities, partners from public & private sectors etc.)

Symmetrical cooperation between national/ regional & international research partners

Necessitates often sig. investment in capacity building (both human & in research hardware, e.g. EID lab)

Interdisciplinary research approach, involving social scientists, paramount

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…….lessons learnt

There are NO silver bullets

For instance vector control needs to be embedded as 1 component in disease management systems

Ecological understanding of key plant pests and/ or disease vectors still insufficient (*why do we know so much more about fruitflies than of anophelines??*)

Better understanding of ecology (esp. chemical ecology) & behaviour of pests & vectors can lead to new + highly efficient control strategies

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…….lessons learnt

Last but not least
GOOD SCIENCE IS KEY!

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acknowledgements

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thank you
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