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

Christian Borgemeister, CEO icipe

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

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)
general facts

- 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)
- 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, Luf, NIH, USDA etc.)
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.).

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**general facts**

- **4H paradigm**
  - R&D on human, animal, plant & environmental health
  - Common denominator: insects/arthropods

**true African menace**

- Transmission of trypanosomes causing nagana in livestock (annual losses > $ 6.5 billion)
- Human African Trypanosomiasis (hat) (> 500,000 cases/yr)
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 trapping technologies not well suited for pastoralists. Need for a moving technology.

Basis: repellency.

- 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.
- 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)

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 km²

<table>
<thead>
<tr>
<th>Location (block)</th>
<th>Treatments</th>
<th>No. of pastoralists</th>
<th>No. of cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pengo</td>
<td>Push-Pull (WR)</td>
<td>22</td>
<td>68</td>
</tr>
<tr>
<td>Kizibe</td>
<td>Push (WR)</td>
<td>21</td>
<td>128</td>
</tr>
<tr>
<td>Mktongani</td>
<td>Push (SR)</td>
<td>19</td>
<td>96</td>
</tr>
<tr>
<td>Mangawani</td>
<td>Push (WR)</td>
<td>26</td>
<td>141</td>
</tr>
<tr>
<td>Mswavi</td>
<td>Pvl</td>
<td>20</td>
<td>140</td>
</tr>
<tr>
<td>Mkuni</td>
<td>Control</td>
<td>21</td>
<td>115</td>
</tr>
<tr>
<td>Katiglii</td>
<td>Pvl</td>
<td>32</td>
<td>176</td>
</tr>
<tr>
<td>Maakia</td>
<td>Control</td>
<td>21</td>
<td>153</td>
</tr>
<tr>
<td>Kidongo</td>
<td>Push-Pull (SR)</td>
<td>20</td>
<td>111</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>221</strong></td>
<td><strong>1,225</strong></td>
</tr>
</tbody>
</table>
**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

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**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: G. f. attracted by host odours
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

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)

<table>
<thead>
<tr>
<th></th>
<th>Empty</th>
<th>Ox</th>
<th>Lizard</th>
<th>Human</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (M)</td>
<td>13.2</td>
<td>15.2</td>
<td>19.3</td>
<td>15.1</td>
<td>ns</td>
</tr>
<tr>
<td>Females (F)</td>
<td>6.8</td>
<td>9.0</td>
<td>13.3</td>
<td>8.3</td>
<td>*</td>
</tr>
<tr>
<td>M+F</td>
<td>21.3</td>
<td>24.6</td>
<td>32.6</td>
<td>23.3</td>
<td>*</td>
</tr>
</tbody>
</table>

\* significant at \(P < 0.05\)

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


Work-in-progress:
- Odour collection, GC-MS analysis, followed by bio-assays
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.

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.

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.
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.

- 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

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
Anopheles mosquitoes most important insect worldwide Yet very little known on basic biology & ecology

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.

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

- 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
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

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

New surveillance & diagnostic tools urgently needed

The Martin Lüscher Emerging Infectious Diseases Laboratory
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BSL-2, 2+ and BSL-3 labs + BSL-2 insectaries

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

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
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.

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.
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

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

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
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
truffles than of anophelines??)
Better understanding of ecology
(esl. chemical ecology) &
behaviour of pests & vectors can
lead to new + highly efficient
control strategies

......lessons learnt

Last but not least
GOOD SCIENCE IS KEY!

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www.icipe.org