biennial report highlights

2010–2011

icipe

African Insect Science for Food and Health

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icipe biennial report highlights 2010–2011

ISBN: 92 9064 227 X

Published by

icipe Science Press
P. O. Box 72913-00200
Nairobi, Kenya
Tel: +254 (20) 8632000
Fax: +254 (20) 8632001/2
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Acronyms and Abbreviations

AAT	African animal trypanosomosis
BCED	Behavioural and Chemical Ecology Department
BeCA	Biosciences Eastern and Central Africa hub
BMZ	Federal Ministry for Economic Cooperation and Development
DBM	diamondback moth
GIZ	Gesellschaft für Internationale Zusammenarbeit
GMO	genetically modified organism
GPS	global positioning system
HAT	human African trypanosomosis
ILRI	International Livestock Research Institute
IPM	integrated pest management
KEMRI	Kenya Medical Research Institute
MOLD	Ministry of Livestock Development
MOPH&S	Ministry of Public Health and Sanitation
R&D	research and development
SDC	Swiss Agency for Development and Cooperation
SOS	save our souls (international Morse code distress signal)
WHO	World Health Organization

MESSAGE FROM THE DIRECTOR GENERAL

Prof. Christian Borgemeister, Director General, *icipe*

Too often, people use the word 'momentous' to describe what amounts to every day occurrences. But, we at *icipe* feel extremely justified to describe the official inauguration of the Martin Lüscher Emerging Infectious Diseases Laboratory on 16th September 2011, as a momentous occasion. This lab complex, which is based at the Centre's headquarters in Kasarani, Nairobi, is no doubt the biggest investment in research and development infrastructure since the late Prof. Thomas Risley Odhiambo founded *icipe*. Yet, the brick and the mortar, as well as the high tech equipment that make up this complex, valuable as they are, are in reality symbols of much more priceless investments.

When we look at this facility, we think of the incredible human capacity and talent that *icipe* has amassed in its 40 years of existence. As any homebuilder will attest, construction schedules are little more than wishful thinking. Indeed, the building of our laboratory is the result of a long and adventurous journey, which was supposed to take six months but lasted two years. The successful set-up of the complex, therefore, represents the conviction, commitment and versatility of individuals at *icipe*—scientists, administration and technical staff—who wholeheartedly embraced the journey with all its twists and turns, which, among others, transformed our Director of Finance and Administration into a hybrid between a structural engineer, an architect and a lab designer.

When we look at the emerging infectious diseases (EID) lab, we also see the goodwill of the development partners who have stood by *icipe* since inception, and those who have joined us along the way. They include the Government of Switzerland through its Swiss Agency for Development and Cooperation (SDC), Google.org, the philanthropic arm of Google Inc., and the German Government (through its Federal Ministry for Economic Cooperation and Development [BMZ] and the German Gesellschaft für Internationale Zusammenarbeit [GIZ] who have provided us with financial resources for the lab.

Above all, we believe that the new EID lab will bring hope for Africa's poorest people, through the promise of developing the much needed solutions to tackle the growing problem of infectious diseases on the continent.

Earlier this year, *icipe* marked yet another exciting moment when our resident dipterist, Robert Copeland, together with colleagues from South Africa, re-discovered the "terrible hairy fly", a species that had long been the holy grail among dipterists. This accomplishment created excitement among researchers worldwide, prompting a global media frenzy. In this publication, Robert Copeland

gives us a first hand account of the voyage to the expansive, hot and dry eastern region of Kenya.

In recent decades, research and development has become a high-stakes venture, which requires global partnerships. However, these networks are not easy to establish, or to maintain. For this reason, *icipe* highly values its mutually productive collaboration with Rothamsted Research UK, one of the oldest research institutions in the world. As Baldwyn Torto explains, this partnership that is now approaching 30 years, has enormously contributed to the advancement of scientific knowledge as well as food security.

In 1994, the Iowa-based World Food Prize, founded by the late Nobel Laureate Norman Borlaug, established a youth institute to increase awareness of the organisation's mission among young people within its home state. One of the activities of the youth institute is the Borlaug–Ruan International Internship Programme, which provides an eight-week hands-on experience for high-school students at leading research centres in Africa, Asia, Latin America and the Middle East. In 1995, *icipe* started to hosted interns from the programme. We are delighted to have contributed in moulding these young people, and to share testimonials regarding their experience.

The stories that we have featured in this report bear out the words of the German Ambassador to Kenya, H.E. Margit Hellwig-Boette, during the opening of the EID lab, when she observed:

> "And apart from the state-of-the-art research, *icipe* also fulfills another important task: It is the home base for researchers and scientists from Europe, Africa and Latin America; it creates a globalised 'research family'; and it does all this in a developing country in Africa, namely Kenya. This shows that high tech research can be done in Africa. The continent has much more to show than drought-stricken areas and bad infrastructure—institutes like *icipe* show the world what the future of Africa looks like!"

Photo: Fredrick Chichi Makhulo

HUMAN HEALTH—EID LABORATORY

icipe Launches East Africa's First Emerging Infectious Diseases Laboratory

On 16th September 2011, the Martin Lüscher Laboratory for Emerging Infectious Diseases was officially inaugurated at the icipe headquarters in Duduville, Kasarani in Nairobi. In the interview below, Director General, Prof. Christian Borgemeister, discusses the significance of this impressive facility, which puts icipe on the path towards becoming a centre of excellence in emerging infectious diseases.

Photo caption: The front view of the Martin Lüscher Emerging Infectious Diseases laboratory, at the *icipe* headquarters in Kasarani, Nairobi.

Q. What has led to *icipe's* growing interest in emerging infectious diseases?

A. Over the years, diseases such as yellow fever, dengue, Rift Valley fever, o'nyong'nyong virus, Crimean Congo haemorrhagic fever and the chikungunya fever, have placed a huge burden on East African countries. The incidence of these diseases is increasing, not just in East Africa, but in many regions of the world as well. This is due to several factors such as climate change, increasing agricultural activity and changes in the dynamics within the ecosystems. In addition, the growing movement of people and livestock across regions is contributing to the wider distribution of the vectors that transmit emerging infectious diseases. The best example of this shift is the continental spread of chikungunya. Previously a rather obscure disease from the Lake Victoria region, now driven by globalisation and climate change, the disease is present on various islands in the Indian Ocean, southern India and northern Italy to name a few. Another example is West Nile virus, which prior to its 'landing' on the shores of Long Island outside New York in 1991, was exactly restricted to its name, the Western Nile region.

A critical issue is that the knowledge regarding these diseases, as well as the ways in which they can be diagnosed, prevented and treated is limited and is mostly contained in institutions in developed countries. After the 2006/07 outbreak of Rift Valley fever, *icipe* felt challenged to diversify its research and capacity building programmes, to join the East African, and indeed the global community, in seeking solutions for emerging infectious diseases.

Q. How has this goal developed since then?

A. We had two lucky breaks in our endeavour. The first was linking back with Dr Rosemary Sang, an alumna of the ARPPIS programme, who is now arguably the foremost arbovirologist in East Africa. Dr Sang is based at the Kenya Medical Research Institute (KEMRI), one of *icipe*'s longest standing scientific collaborators in Kenya. Second, we rather serendipitously came across Google.org, the philanthropic arm of Google Inc. In October 2007, I visited the offices of Google.org in San Francisco, USA to explore options of support towards starting research in arboviral diseases. The discussions with Google.org gave impetus

Photo: *icipe*

H.E. Jacques Pitteloud, Swiss Ambassador to Kenya, officially cutting the ribbon to inaugurate the Martin Lüscher Emerging Infectious Diseases Laboratory. Switzerland, through its Swiss Development Cooperation, has supported icipe since the centre's inception 40 years ago.

Prof. Dr Nicolas Lüscher admires the statue of his father, the late Prof. Martin Lüscher, which has taken its place of pride in the new complex, which is named after this famous scientist and great friend of icipe.

Photo: *icipe*

to further deliberations between *icipe* scientists and like-minded colleagues in other institutions in Kenya. Together, we explored the most strategic approach to bridge the knowledge gap in emerging infectious diseases. We agreed that an appropriate way towards our overall goal would be to conduct a pilot study on Rift Valley fever. Based on this idea, in 2008, Google.org confirmed that it would provide US$ 5 million to an *icipe*-led consortium, bringing together 4 national programmes under the Ministry of Public Health and Sanitation (MOPH&S) and the Ministry of Livestock Development (MOLD), Kenya Medical Research Institute (KEMRI) and the International Livestock Research Institute (ILRI) to implement the project. With Google.org's visionary support we established two state-of-the-art surveillance and early detection analytical platforms. One is now operational at the BeCA, hosted on the campus of our collaborators at ILRI, and at *icipe*'s Duduville campus.

Q. Why was Rift Valley fever selected as the pilot study?

A. RiftValley fever was selected as the initial model because the disease is recognised by the general population and key decision makers in East Africa as a critical constraint to health, and agricultural and economic development. Moreover, Rift Valley fever implicates all major actors in emerging diseases—from the health, veterinary, wildlife and vector implementation and research communities. It, therefore, provides an opportunity for the key stakeholders to acquire the skills involved in controlling a multi-sectoral emerging disease challenge. There are important gaps in the understanding of Rift Valley fever that limit early warning and response efforts. There is also limited understanding of the distribution and dynamics of the virus between epidemics. In recent years, various genomics and knowledge management technologies and approaches have been developed globally, which can play a key role in the research required to address these issues.

Q. Why was there a need to build a laboratory specifically for emerging infectious diseases?

A. The need for a specialised emerging infectious diseases (EID) laboratory is based on the World Health Organisation (WHO) requirements. WHO has classified

infectious diseases under the risk groups two to four. This classification is based on the level of risk of the pathogens, or agents as they are referred to, posed to the researchers and technicians handling them. The categorisation also takes into account the threat that the agents could have on the environment. It also considers the severity of illness that the pathogens cause and the availability of vaccine or treatment options. The most significant way through which these pathogens may cause adverse effects is through the inhalation of the viruses from droplets or aerosols generated by infectious agents when the specimens are being manipulated. Additionally, it is important that the agents do not fall into the hands of people who would choose to use them to harm others deliberately. Therefore, a specialised laboratory is necessary to provide appropriate containment, at Biosafety levels 2 to 3, to protect laboratory workers, the environment and for bio-security purposes.

Q. What opportunities and challenges has *icipe* faced in constructing the EID laboratory?

A. The laboratory complex is no doubt the biggest investment in R&D infrastructure since the late Thomas Odhiambo founded *icipe*. Construction of a facility of this level requires considerable investments in infrastructure, equipment, and other resources. Fortunately, we were able to allocate some money from our core funds, which enabled us to start work on the laboratory in November 2009. In September 2010, we received additional funding from the Swiss and German governments. The project also depended on the immense conviction and collaboration between colleagues from *icipe*'s administration, technical and scientific departments, spearheaded respectively by Roger Finan, Abdul Razaq, Rosemary Sang, Dan Masiga, Baldwyn Torto and Jandouwe Villinger. The laboratory construction was completed and handed over to *icipe* on 27th June 2011. In late 2010, we started to place orders for various types of laboratory equipment that would ensure good microbiological practice. We have received most of this equipment and are in the process of installing it in the laboratory.

Photo: *icipe*

icipe Director General, Prof. Christian Borgemeister welcoming H. E. Margit Hellwig-Boette, the German ambassador to Kenya to the inauguration ceremony of the Martin Lüscher Emerging Infectious Diseases laboratory. The government of Germany donated some of the equipment for the laboratory.

Dr Rosemary Sang pointing at a biosafety cabinet (not shown) while explaining to visitors the use of the equipment installed in the laboratory.

Photo: *icipe*

Q. Overall, what is the significance of the laboratory?

A. The first and most important significance of the EID laboratory is that it will enable us to complete the Rift Valley fever project. The EID laboratory will also enable *icipe* to implement research activities on other arbovirus diseases in East Africa. In fact, scientists at *icipe* have already started putting together proposals to fundraise for several studies. We will also be able to support other researchers in Kenya and in the East African region to respond to public health emergencies. Therefore, the EID laboratory at *icipe* will help to prevent the loss of human lives, and the multiple negative, direct and indirect, impacts on the quality of life caused by emerging infectious diseases, particularly among the poor in Africa. It also puts *icipe* on the path towards becoming a Centre of Excellence in emerging infectious diseases, joining the few existing laboratories on the continent that provide such a resource.

Q. Please give us some background on the official name of the EID laboratory.

A. The facility will officially be known as the Martin Lüscher Laboratory for Emerging Infectious Diseases. The late Prof. Lüscher was a long-term friend and supporter of *icipe*. Indeed, he served as the Centre's first Director of Research. In addition, Prof. Lüscher was one of the world's most distinguished termite research scientists, and through this expertise, he made remarkable contribution to *icipe* and to environmental sciences in Africa. We are delighted to honour him by associating his name to such a remarkable facility.

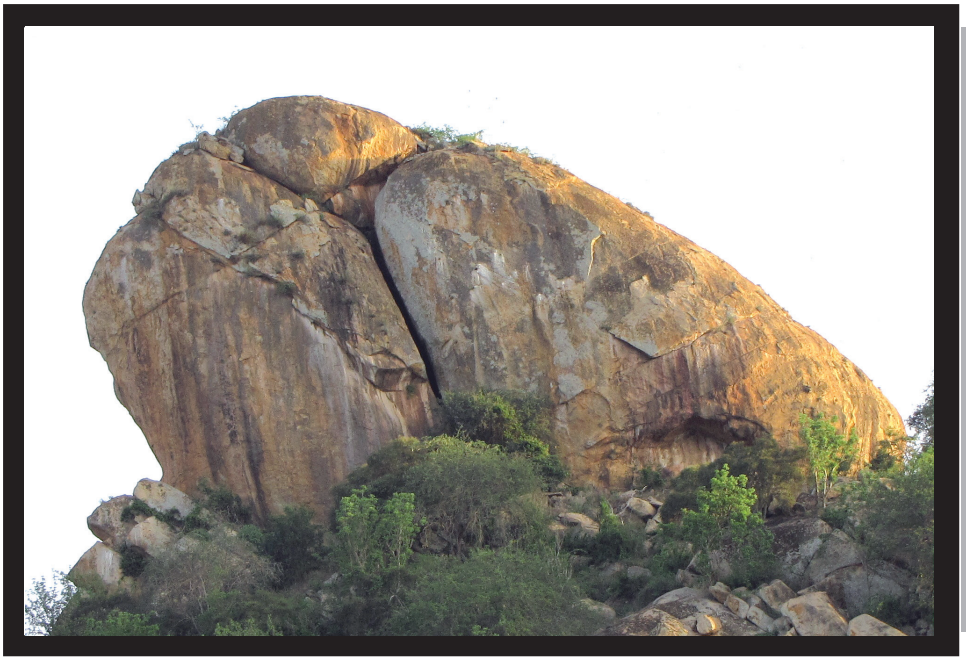

Photo: *Robert Copeland*

Environmental Health–Insects

Eureka!: The "Terrible Hairy Fly" Re-Discovered

In November 2010, a team of icipe and South African scientists re-discovered the "terrible hairy fly", a species that had long been the holy grail among dipterists. The discovery created excitement among researchers worldwide, as well as a global media frenzy. Robert Copeland, who headed the search for the fly, gives us a first hand account of this achievement.

Photo caption: *The north face of the cleft boulder that is the type locality of* Mormotomyia hirsuta. *The fly was found in the bat guano on the ground directly beneath the small oblique crack located about a third of the way in from the right edge of the photo. Bats could also be heard within this crack.*

In 1933, Harry Barron Sharpe collected specimens of an unidentified fly from a large, cave-like boulder at Ukasi Hill, in Garissa, Kenya. At the time, Sharpe was the District Commissioner of the expansive, hot and dry eastern region of the country. Like many of his administrative colleagues in the colonial service, he was also a naturalist. Sharpe forwarded the specimens to Major E. E. Austen for examination. Austen immediately recognised the strangeness of the two male flies he had received. The flies had non-functional, strap-like wings, eyes that were greatly reduced in size, long, spider-like legs and a dense covering of yellowish hairs. Austen was confident enough to create a new family, Mormotomyiidae, in which to place the fly. Thus, Austen made the first description of *Mormotomyia hirsuta*, the "terrible, hairy fly".

To date, the species remains the only member of the family, and has been collected only on one other occasion, also from Ukasi Hill. That collection was made in 1948 by the famous Kenyan naturalists, Victor Gurner Logan van Someren and his son Gurner Robert Cunningham van Someren. Since then, *Mormotomyia* has not been seen, prompting some to call it the world's rarest fly; more technically, the world's only representative of the rarest family of flies.

Besides its bizarre appearance, *Mormotomyia hirsuta* is of great importance to scientists because its phylogenetic position within the classification of the higher Diptera— the fly family—remains a mystery. DNA from these earlier collections is too degraded to use in the molecular analyses that would have addressed this question. Moreover, due to its rare sightings it was feared that the fly might have become extinct. As a result, finding the terrible hairy fly has long been the holy grail for dipterists.

Some years ago, we were fortunate to get in touch with Quentin Luke, the noted Kenyan botanist, who had not only heard of the site where the fly had been collected, but also provided us with GPS co-ordinates for it. With these data, in July 2008, I organised a short expedition—consisting of colleagues from the United States National Museum of Natural History, the Smithsonian Institution and the Iziko Museums of Cape Town, South Africa—to Ukasi. At that time, we did not find the elusive fly, but we noted the presence of two rock formations that fitted the description of the type locality of the fly. We were also aware that the van Somerens had made their collection of the fly during or just after a heavy rainfall. The rain torrents had washed out *Mormotomyia* eggs in bat guano, on which the hatched larvae feed, out of the fly's cave-like home. We speculated that our failure to find the fly on this occasion was related to the seasonality of its development.

Photo: *Robert Copeland*

Dr Copeland and his colleagues from icipe and National Museum Bloemfontein, South Africa, assisted by community members from around Ukasi Hill collecting specimens of Mormotomyia *at the foot of the boulder where the fly resides.*

Dr Copeland on the stone staircase, right inside the cave-like cleft boulder on Ukasi Hill, which is the home of the terrible hairy fly.

Photo: *Robert Copeland*

At the end of November 2010, during the short rainy season, I returned to Ukasi Hill along with Bruno Le Ru, Christophe Plantamp, Leonard Mmasava and Juliet Muriuki from *icipe* and Ashley Kirk-Spriggs from the National Museum, Bloemfontein, South Africa. We arrived mid-afternoon and it was blazing hot. After setting up our tents at the base of the hill, we were too excited to wait until the morning to make the climb, so we started up the southern side of the hill with an angry sun on our backs. Near the top, at the base of a large cleft boulder, we stopped to rest in a lovely shaded area on the eastern side of the hill and to enjoy the cool air. I went ahead from there, around to the northern, shaded side of the boulder. And there they were, the terrible hairy flies, scurrying along on the vertical walls of the boulder and across the bat guano that had accumulated on the ground at its base. Initially, I was reluctant to conclude that they were the real *Mormotomyia*. When they moved, they appeared to be small sun spiders (solifugids). However, a quick count of legs dispelled any doubts and I was overtaken by a true eureka moment.

The large *kopje* (boulder) that *Mormotomyia* calls home is 20 to 25 metres in height. This boulder has a cleft straight through it from top to bottom, north to south, with a narrower opening on the north side. The north side also has some large oblique cracks in its wall, which are not found elsewhere on the boulder. At that time of year, the sun was far to the south, so that the precise area where we found the flies was continuously in the shade. This is probably the second-most important factor in making the microhabitat so favourable (The first being the presence of substantial amounts of bat guano in which the larvae develop). Bats roost inside the cave-like cleft, and in some of the oblique cracks. The guano accumulates on the floor of the cave and in the oblique crack. We also found guano on rock shelves that are arranged inside the cleft like a 'stairway', the result of a large rock slab breaking off from the top of the boulder and smashing into pieces as it crashed against the cleft walls that narrow below; the pieces wedging themselves inside the cleft.

We had hired four assistants to help us ferry 20 litres of water up the hill, anticipating the need to wash out the flies if our visit wasn't favoured with an afternoon torrent. But we didn't need the water after all. The guano itself was somewhat dry, but not desiccated, and in places very thick, conditions obviously favourable to larval development. Heavy rains had fallen about two weeks before our visit and had washed the topmost layers of guano out of the cleft and from some of the cracks. For the first two to three metres outside the cave, the ground is nearly flat. Therefore, instead of the guano being

washed down the hill, it rests at the base of the rock.

Soon after our discovery of the terrible fly, our entire party was busy collecting specimens. Adult flies were running all over the guano and on the face of the rock, and their larvae and puparia were also present in abundance. With the sun setting, we scampered down the hill, planning to climb up again the following day. At our camp, we had a celebratory meal of "*kuku na ugali*" (stewed chicken and cornmeal mush).

The next day, on arrival at the site, we found hundreds of adults climbing the rock face, apparently they were heading off to the mother load of guano in the cave. Most of these were teneral (newly emerged adults) and had clearly just emerged from the accumulated guano. Later that day, Ashley went round to the other side of the *kopje* where the cleft has a wider opening and found a few adults there. Being on the sunny side of the rock at this time of the year and not having a substantial flat area where washed out guano could accumulate, this spot appeared much less favourable for the flies; perhaps better during the long rains (April–May) when the sun would be on the northern side and this second spot would be in the shade. This supported our ideas on the relation between the terrible hairy fly, the rain and the position of the sun.

We obtained plenty of material to save specimens of *Mormotomyia hirsuta* in 95% ethanol, and forwarded this material to molecular taxonomists for further studies. Some of the important questions we wanted to answer included where the species fits into the Diptera Tree of Life (i.e. its phylogenetic relationships) and how much genetic variability there is in the Ukasi population. The data from our collection has already raised new questions. First, measurements of the specimens show that *Mormotomyia* exhibits pronounced sexual size dimorphism but, unlike most insects that are dimorphic, the males, not the females, are the larger sex, by about 50%. Second, while, in males, body part measurements of the head and thorax were correlated strongly with leg length, they were independent of leg length in females (because of shrinkage, abdomens could not be reliably measured). An interesting implication is that, for females, growth of the head and thorax is uncoupled from that of the abdomen and legs. Presumably, in conditions favourable to larval development with sufficient quantities of moist guano, the head and thorax of the flies reach a critical size. After this point, the genetic and physiological mechanisms controlling the growth of the imaginal discs for these body parts are inhibited, while those of the abdomen (and contents) continue to be active. This would account for the production of females with larger abdomens maximising fecundity, but proportionately smaller heads and thoraces.

Photo: *Robert Copeland*

An adult male Mormotomyia, *distinguished by its strap-like wings.*

An adult female Mormotomyia hirsuta.

Photo: *Robert Copeland*

Surprisingly, the molecular data showed genetic variability within the fly population to be relatively high and comparable to that of populations of other dispersal-limited invertebrates that exist in relative, but not complete, isolation, from other breeding populations. This raises the question of the mobility of *Mormotomyia*. Its surrounding environment is especially hostile and bat caves are uncommon and widely separated and the species has probably lost the ability to fly because the probability of finding a suitable habitat is so low that the fully winged condition has been selected against. Yet, *Mormotomyia* appears particularly unsuited for hitching a ride on bats or birds. It has none of the adaptations shown by other fly families that are phoretic on bats, i.e. flattened body form and clasping tarsal claws.

By finding *Mormotomyia* we were able to take the first photographs (and movies) of living specimens of both sexes. These images will be used in the chapter on Mormotomyiidae for the forthcoming Manual of Afrotropical Diptera.

We now plan to pursue funding to search for other potential habitats of *Mormotomyia* in the many small hills of Kitui and Mwingi districts. Are there other sites with the same species or, perhaps, other *Mormotomyia* species? We also want to trap bats at Ukasi to confirm the species responsible for the larval medium and to examine live bats to see if *Mormotomyia* adults use them for dispersal. We have also met with the director, Museums and Monuments of the National Museums of Kenya, to begin the process of gazettement of Ukasi Hill as a Kenyan Biodiversity heritage site, and to encourage ecotourism involving the local community.

The rediscovery of *Mormotomyia hirsuta* received an enormous amount of global media coverage, boosted by coverage by the Thomson Reuters news agency. The ensuing media frenzy focused not only on the rediscovery of the long-lost species, but also put dipterology and insect studies in the public eye. We are proud of this achievement. After all, it is not often that a humble fly finds a place in the pages of the *Washington Post*, to mention just one!

Photo: Santiago Escobar

Partnerships–*icipe*/Rothamsted Research, UK

North and South

Over the years, icipe has developed a mutually productive collaboration with Rothamsted Research, one of the oldest research institutions in the world. Below, Dr Balwdyn Torto, the Head of the icipe Behavioural and Chemical Ecology Department reports on the nature of this exemplary partnership.

When *icipe*'s founding director, Prof. Thomas Odhiambo first proposed the idea of the Centre 40 years ago, one of its most enthusiastic supporters was Sir John Pringle, a UK scientist who was famous for his studies on the physiology of flight in insects. Sir Pringle became intensely involved in *icipe*, serving on the Centre's first

Photo caption: (Clockwise from left**)** Lord David Sainsbury listens as Prof. John Pickett, Rothamsted Research, UK, explains a point about the Push-Pull strategy during a visit to *icipe*-Mbita Thomas Risley Odhiambo Campus, Kenya in April 2010. Also in the picture are Mr Laurence Cockcroft (second right) from the Gatsby Foundation, Prof. Zeyaur Khan (right), *icipe*, and Hon. Julius Arunga (in the background), member of parliament for Suba.

Governing Council and as the Chairman of the Programme Committee. He also helped to build a close relationship between *icipe* and the British scientific community, especially through the Royal Society where he was a member. Upon Sir Pringle's death in 1982, the Royal Society decided to commemorate him by establishing the Sir John Pringle Exchange Fellowship between *icipe* scientists and UK research institutions.

Among the first recipients of this fellowship was Prof. Ahmed Hassanali, who was at the time heading *icipe*'s Behavioural and Chemical Ecology Department (BCED). The BCED evolved from the Chemistry and Bioassay Research Unit (CBRU), one of the first three laboratory units to be established at *icipe*. The mandate of the CBRU was to identify anti-insect bioactive compounds from plant sources for use in integrated pest management (IPM) programmes. The BCED encompassed this mission, adding onto it research in environmentally sound methods to reduce or suppress pest populations. BCED also incorporated studies on ways to increase and conserve populations of beneficial insects, for instance natural enemies and honeybees. The central focus of BCED is to identify, formulate and evaluate pheromones, kairomones, allomones and hormones that mediate the behaviour of insects and arthropods. This mix of research allows scientists in the department not only to contribute to various multidisciplinary programmes within the Centre, but also outside *icipe* to find practical solutions to pest problems.

The Sir John Pringle Exchange Fellowship enabled Prof. Hassanali to spend three months at Rothamsted Research, one of the oldest agricultural research institutions in the world. While there, Prof. Hassanali worked with a team under the leadership of Prof. John Pickett, which was focusing on aspects of mosquito chemical ecology and insect feeding deterrents.

"John had just joined Rothamsted Research and during my visit, we immediately saw an opportunity for further collaboration. My visit therefore marked the beginning of a vibrant collaboration between *icipe* and Rothamsted," explains Prof. Hassanali.

In 1989, scientists from Rothamsted Research travelled to Nairobi to participate in the *icipe* Annual Scientific Conference. In the next four years, Rothamsted enhanced *icipe*'s research in anti-insect bioactive natural products, by providing nuclear magnetic resonance (NMR) analysis, a critical chemical research component that requires specialised technique and equipment.

But the most defining moment for the *icipe*–Rothamsted relationship came in 1994, when

Photo: *icipe*

Prof. John Pickett (right) with Prof. Ahmed Hassanali (left) and the late Dr Leonard Otieno, leader of the Tsetse Research Programme (centre) inspecting a tsetse trap in the mid-1980s in Lambwe Valley, South Nyanza, Kenya. This was Prof. Pickett's second visit to icipe, to explore potential areas of collaboration between Rothamsted Research, UK, and the centre's Behavioural and Chemical Ecology Department.

icipe scientist Dr Baldwyn Torto (left) pictured with Prof. John Pickett (right) of Rothamsted Research, UK, who is also the Chairman of icipe's Governing Council. In 2000, Dr Torto spent nine months as an International Fellow at Rothamsted Research, Harpenden, UK.

Photo: *BCED*

the Gatsby Charitable Foundation agreed to fund a project spearheaded by Prof. Hassanali and his *icipe* colleague, Prof. Zeyaur Khan, and Profs John Pickett and Lester Wadhams from Rothamsted Research. The project involved the investigation of the ecology of stemborers, the major insect pest of maize and sorghum in eastern and southern Africa. Together, the scientists discovered that introducing a carefully selected mix of forage plants into maize fields had a dramatic effect on cereal yields and total farm output, resulting in a technology now known as 'push–pull', which makes use of natural plant chemicals that drive insect pests away from the crop and attract them to other host plants that withstand stemborer attack better than maize. Besides, push–pull's two perennial companion crops, Napier grass and desmodium, are nutritious for dairy cows, and desmodium substantially reduces damage from striga, a destructive parasitic weed. In short, the push–pull system can improve food security and farm income in an environmentally friendly way, making it an ideal ingredient in the long-term struggle to reduce hunger and poverty in Africa. To date, over 50,000 smallholder farmers in East Africa have adopted this technology.

"Insect behaviourists and chemical ecologists agree that promising IPM tactics based on plant chemicals frequently fail because they are too narrowly based. They often target a single chemical and a single phase in the life cycle of a single pest species. The *icipe*–Rothamsted approach makes use of a wider range of behaviour-modifying chemicals produced by both plants and insects. It introduces nature's built-in checks and balances into a man-made environment—such as a maize field—by manipulating the habitat, and relying on a carefully selected combination of companion crops planted around and among the maize plants," explains Prof. Hassanali.

The journey towards push–pull was a step-by-step discovery that had field and laboratory components, to understand the multiple interactions among cultivated crops (such as maize and sorghum), wild hosts, various stemborers (e.g. *Chilo partellus* and *Busseola fusca*), and natural enemies affecting the dynamics of pest populations and their pest status. The laboratory components of this project involved identifying behaviour-modifying semiochemicals produced by the cultivated and wild hosts, and a few selected non-host plants of the targeted stemborers. Scientists from BCED and the Biological Chemistry Department at Rothamsted jointly investigated this aspect of the project. Prof. Pickett and his team at Rothamsted Research helped to piece the puzzle together by investigating the nature of the plant chemicals (known as semiochemicals), which attract or repel stemborer moths. Using a combination of scientific techniques, they discovered six host plant volatiles that attract female stemborer moths to lay their eggs. Next, they investigated the volatiles produced by the intercrop plants— the 'push' component of the technology.

The success of push–pull strengthened the partnership between *icipe* and Rothamsted Research. In 2000, when working as a scientist in the BCED, I was awarded the Rothamsted International Fellowship, a programme that was initiated in 1993 to celebrate the 150th anniversary of the founding of Rothamsted Research. It enables scientists from developing and emerging countries to carry out research projects for six to 12 months in collaboration with partner scientists at Rothamsted Research. I worked at Rothamsted Research for a year, on a number of projects including elucidating the chemical basis of the interaction between sorghum panicles and the pollen beetle *Astylus atromaculatus*, a notorious pest of the crop in South Africa. In collaboration with colleagues at Rothamsted and Prof. Johnnie van den Berg at the North-West University, South Africa, we successfully evaluated the influence of visual and olfactory cues on field trapping of the beetle in that country.

In the same year, two PhD students from *icipe*, Muniru Tsanuo Khamis and Linnet Gohole were also visiting Rothamsted to work on aspects of their PhD projects and spent a few months in John Pickett's lab. Linnet's doctoral programme, a partnership between Moi University (Kenya), the Wageningen Agricultural University (The Netherlands) and *icipe*, demonstrated the altitude specificity of nonatriene, an SOS volatile chemical produced by molasses grass. This work is important in understanding the biochemical mechanism of the push–pull interaction.

In 2007, the research partnership between *icipe* and Rothamsted was broadened to include studies on blood-feeding insects, including mosquitoes, vectors of malaria, and tsetse, which transmit human African trypanosomosis (HAT) and African animal trypanosomosis (AAT). The malaria work, which is funded by NESTech, focuses on developing new repellents against mosquitoes. (The NESTech Fund was created through a University Challenge Fund award from the office of Science and Technology, Scottish Enterprise and the universities of Aberdeen, Dundee and St Andrews and is run by Caledonia Capital Managers on behalf of the three universities.) HAT is a neglected tropical disease with about 300,000 cases reported annually in Africa. Currently, the treatments available for the disease are ineffective, and have horrendous side effects. Our research, which is supported by the Gates Foundation and coordinated by colleagues at the University of Liverpool, aims to develop odour baits to lure tsetse vectors of the disease into traps.

Within this expanded focus, *icipe* and Rothamsted International have enhanced staff exchange programmes and joint capacity building activities. For instance, Dr Serge

Dr Sarah Dewhirst (extreme right) pictured with staff of the icipe Tsetse Project at the icipe-Mbita Thomas Risley Odhiambo Campus, as they prepared to board a boat across the massive Lake Victoria, to conduct research in Lambwe Valley on the adjacent shore.

Participants from across Africa in an International Group Training Course in Mass Spectrometry and Organic Synthesis held in October 2010, at icipe-Nairobi, Kenya, with the lead trainer Dr Tony Hooper (front row, second left) from Rothamsted Research, UK and staff from icipe BCED and other guests.

Photo: *icipe*

Kuate, a postdoctoral researcher at *icipe* spent a year at Rothamsted to work on the Striga project to understand the biosynthesis of a novel compound, isochaftoside, isolated from *Desmodium* which showed extremely high radicle growth inhibition of striga at very low concentrations. Also, two BCED postgraduate students Xavier Cheseto and Polycarp Lutta spent a month in Dr Tony Hooper's laboratory at Rothamsted to learn certain organic synthetic techniques pertaining to their research projects. In turn, Dr Tony Hooper participated as a lecturer in the International Group Training Course in Mass Spectrometry and Organic Synthesis organised by BCED in October 2010 at *icipe*'s Duduville campus in Nairobi.

Over the years, scientists from Rothamsted Research, especially Profs Pickett, Wadhams and Dr Hooper have made regular visits to *icipe* and partnering with national research institutes. Other Rothamsted scientists have spent long periods of time for research at *icipe*, for example Dr Sarah Dewhirst working with *icipe*'s Dr Morris Omolo on HAT control at the Thomas Odhiambo Campus, at Mbita Point, on the shores of Lake Victoria.

The partnership between BCED and Rothamsted has yielded several joint research funded projects, and facilitated scientific exchanges and the sharing of knowledge and capacity building programmes in IPM in the two institutions. Furthermore, more than 50 scientific peer-reviewed papers have emerged from this partnership, showing that the two groups are committed to finding affordable and user-friendly answers to pest problems of small-holder farmers in Africa.

Photo: *Rachael Cox*

Capacity Building—The Borlaug–Ruan International Interns

Nurturing Young Scientific Talent

In 1994 the Iowa-based World Food Prize, founded by the late Nobel Laureate Norman Borlaug, established a youth institute to increase awareness of the organisation's mission among young people within its home state. An extension of the youth institute, the Borlaug–Ruan International Internship Programme provides an eight-week hands-on experience for high school students at leading research centres in Africa, Asia, Latin America and the Middle East. Since 1998, icipe has hosted 13 interns from the programme. Below, four of the interns share their first hand account of their time at the Centre.

Photo caption: Aside from understanding *icipe*'s research and encumbering issues of food security and health, the Centre also ensures that the World Food Prize interns get to experience other aspects of Kenya. Here, World Food Prize intern Rachael Cox (left) is pictured with Susan Kariuki, *icipe*, during a trip to Lake Nakuru, which is world famous for its flamingoes (seen in the background).

Rachael Cox – Diamondback Moth (DBM) Project

I had dreamt of travelling to Africa for a long time. Therefore, I was delighted to be accepted for a Borlaug–Ruan internship at *icipe*. However, I wasn't exactly thrilled to learn that I would be working with insects; six-legged creatures are not among my favourite companions! Nonetheless, I was willing to take a chance.

And so in the summer of 2005, I left my home in Ames, Iowa, as a new high school graduate to work on an insect known as the diamondback moth (DBM), working with Dr Bernhard Löhr, Mr Gatama Gichini (a senior research assistant), and several graduate students.

The first weeks at *icipe* involved learning about the DBM project, to familiarise myself with subjects previously unknown to me: biocontrol, integrated pest management (IPM), parasitoids and the life cycle of the DBM. This period also included learning about cabbage and kale farming, pests of crucifer plants as well as other tropical crops, and helping to collect data for determining the prevalence of the pest in the farmers' fields. I learned to identify whiteflies, various species of aphids, other pests and diseases, and to determine whether or not pests had been parasitised.

My research project was on the egg mortality of DBM. Based on a general outline from the DBM team and additional reading about egg parasitoids and cage studies, I started to design the methodology for the experiment. However, in the beginning, I was unsure of the purpose of my research, and how all the separate research bits on DBM completed the goals of the project and the overall mission of *icipe* of ensuring food security. It took a lot of further reading to figure all these issues out. With input and suggestions of Dr Löhr, graduate student Caleb Momanyi and Mr Gichini, I finalised my methodology and started the set-up for DBM to lay their eggs on kale plants. However, I discovered major flaws in my methodology for the oviposition process, necessitating a complete revision to make it more efficient and more field-based.

My second study was on the effects of rainfall on egg mortality, including constructing a device for the purpose, in consultation with Dr Löhr, Mr Gichini, and assistance from technicians at *icipe*. It was impossible to build a state-of-the-art device that monitored exact flow and velocity of water, but my design was adequate and economically appropriate for the purposes of the study.

Photo: *Rachael Cox*

Rachael Cox, pictured in a kale farm in Kenya, during her World Food Prize internship at icipe, in the Diamondback Moth Project.

A kale plant damaged by diamondback moth larvae. During her internship Rachael was able to understand the relationship between icipe's work in controlling this destructive pest and the overall food security and health issues in Africa.

Photo: *Rachael Cox*

Not many 18-year-olds have had the chance to travel half-way around the world and work at an international research centre. My time at *icipe* was invaluable. It allowed me to better understand how a research centre functions and the role it plays in the international development community. The combination of adventures, research and interaction with Kenyan people and culture gave me a fuller experience than I had imagined.

Rachael is now married with the last name "Ohde". She earned her undergraduate degree in agronomy at Iowa State University (ISU). She studied at the University of Wisconsin-Madison for a period of time and then transferred back to ISU where she is currently earning her masters degree in agronomy.

Alex Ayers – Tsetse Research Programme

In my studies, I had learnt about the various diseases present in Africa. I was, therefore, overjoyed when my application was accepted and I was assigned an internship at *icipe*, to work with Dr Rajinder Saini, the leader of the Tsetse Research Programme, in Nguruman, a region populated by the Maasai.

Dr Saini recommended that I learn about the Maasai culture as I would be working with them. I learned that they are a semi-nomadic people who live under a communal system, and about the importance of livestock—cattle, goats, and sheep—to them, which is embodied in a prayer: *"Meishoo iyiook enkai inkishu o-nkera"*; "May Creator give us cattle and children".

The *icipe* researchers had identified one potent synthetic repellent. They had also showed that the skin of waterbucks had several compounds which made them repellent to tsetse, especially *Glossina pallidipes* and *G. morsitans morsitans*. The waterbuck repellent compounds were, however, not identified. The repellent compounds had been shown to significantly reduce the tsetse catches by up to 80% on cattle.

The Ngu trap is a simple, safe and economical cloth trap for the capture of biting flies (tsetse, horse flies, deer flies and stable flies). It was developed at *icipe*'s Nguruman Field Station as an environment-friendly alternative to the use of insecticides, following many years of research on appropriate and sustainable technology for African farmers.

I was assigned two tasks. The first was to evaluate whether the waterbuck repellent performed better than the synthetic repellent, and to compare it with a combination of the two. By using a Latin square design experiment I was able to determine the variables that perform best. Using NGU traps baited with cow urine and acetone as control, I compared the number of flies caught to the number of flies attracted in presence of the repellents alone or in combination. I concluded that the repellents mask the attractants released by the cattle. I did not observe any real difference between the three repellent treatments, i.e. the synthetic and the waterbuck repellents as well as the combination of the two, though the waterbuck repellent compounds were slightly more repellent.

My second task was to evaluate farmers' knowledge of the effects of the tsetse flies. I conducted interviews in Nguruman and Mombasa. Many of the farmers were aware about the tsetse. However, they were concerned about the high dosages, as well the effectiveness, of available drugs. Some of the farmers used smoke as a method of controlling the flies.

I will always remember my time as a Borlaug–Ruan International intern with pride. I learned a lot, as well as the things that people in developed countries take for granted. Kenya is a beautiful country but it has many challenges. In future, I hope to be a member of the scientific community that finds ways to help ensure food security, protect the environment, and alleviate poverty.

He earned an undergraduate degree in agricultural business at Iowa State University (ISU) in 2009 and is now working on a masters degree in political science through ISU but is living in Washington DC.

Megan Srinivas – 'Push-Pull' Project

"Only solitary men know the full joys of friendship," wrote Willa Cather in 1931, in her novel, *Shadows on the Rock*. The true sentiment of this quote came to me in 2003, when I spent two months in Kenya, as a Borlaug–Ruan intern at *icipe's* Thomas Odhiambo Campus in Mbita Point, western Kenya.

I first spent some time in Nairobi, where I was continuously warned of the solitude I would experience in the station, located on the shores of Lake Victoria, far away from the 'civilisation' of a big city. However, as my host and mentor, Dr Zeyaur Khan and I

Photo: *Alex Ayers*

Alex Ayers pictured conducting an interview on the impact of the tsetse menace at a home at the Kenyan coast, during his World Food Prize Internship at icipe in 2004.

During her World Food Prize internship at the icipe in 2003, Megan Srinivas was warmly embraced by the community members around the icipe-Mbita Thomas Risley Odhiambo Campus where she was based. She is pictured with some of her new 'brothers' and 'sisters'. Megan received the John Chrystal Award for the outstanding research she conducted through the programme.

Photo: Megan Srinivas

drove closer to the Campus, my excitement grew and my curiosity took over from the apprehension I had been feeling. Young children and grown-ups waved as we drove by, and I felt completely welcome.

My research was on the inter-relation between education and food security. My first mission was to understand the culture, the lifestyles and most importantly, the people around Mbita. After several visits to various villages and farms, I created a questionnaire with the help of Dr Khan and Matilda Auma Ouma, an ecological trainer in the *icipe* Technology Transfer Unit. The questions related to several aspects of the lives of farmers in Suba District including health, agronomic and socio-economic factors in relation to education. I then interviewed a sample of male and female farmers representing the two groups: those currently participating in *icipe*'s 'push-pull' programme and those not participating.

I spent the first four weeks of my research making visits to farmers in various villages throughout Suba District. Everyday, as we drove along the same roads, I would see familiar faces that would cry out, *"Ichionaday, mzungu"* (how are you, white person)? Being an Indian with black hair and brown skin, I had never imagined that I would be referred to as a white person! I was able to pick up some Luo, and I would wave back, and reply, *"Achiomabehr! Errow cammano* (Great! Thank you!)."

The results of my research established *icipe* as the main source of information on the new agricultural technologies and methods for both groups of farmers. However, in general, male farmers seemed to have more access to information than the females did. In most households, the male head of the household was by far more educated than the female counterpart. However, in the few households where women were well educated, the household income and food production were much higher. My study suggested a correlation between formal education and successful farming in the region. This led me to conclude that the success of a household was quite dependent on the level of education of the women.

One major threat faced by the people of Suba is malaria, which then affects food production since sick people cannot work. The first step in preventing malaria transmission is to understand the disease; how it is spread, as well as basic information about the mosquito vectors. However, the farmers seemed not to have adequate information on these issues.

Based on these findings, my recommendation was that, in addition to formal education, practical education in specific skills was also important. I also identified the need for extension services, as well as the need to empower women.

I never felt lonely or bored in Mbita. In fact, the solitude allowed me to learn new things and participate in local community activities. On my first night in Mbita, wandering around the beautiful scenery, I 'discovered' a small grove of trees that sat upon a soft rolling hill that led down to the edge of Lake Victoria. The community members soon gave me a Luo name; Akinyi, which means 'child of the morning', and my much-loved spot came to be known as "Akinyi's Cove". This cove became my favourite spot to write, read, talk with friends or to just watch the beautiful landscape. It gave me the perfect view of the "Magic Town". Every night, immediately after the sun fell below the horizon, a plethora of fishermen would sit atop of the lake to catch the *omena* fish. They would hang small lanterns on their boats to light their way in the darkness. This beautiful city of lights that emerged every night upon the lake would disappear before the first streaks of sun cut through the early morning sky.

During my two-month adventure in Mbita, I made many memories and friends. Although I had left my mother, father and brother behind in America, in Mbita the entire village became my family. I had a 'mother' calling my room every night to make sure I had eaten my dinner. I had a 'father' ensuring that I ate my vegetables. I had 'sisters' and 'brothers' making sure that I was never lonely.

Megan graduated from Harvard University in 2009 as a cum laude graduate with an A.B. honors degree in human evolutionary biology and with three minors: global health policy, Spanish and Latin American studies. She is currently a class of 2013 M.D. candidate at the University of Iowa Carver College of Medicine in Iowa City, Iowa, USA.

Zachary Stewart–Malaria Vectors Research Programme

I have spent my entire life on a farm in Harlan, Iowa. I have always been interested in science, entomology, and medicine and always hoped that one day I would be able to use these interests to help others. I graduated from Harlan Community High School

Photo: Zachary Stewart

Zachary Stewart, who was a World Food Prize intern in the icipe Mosquito Control Project in 2007, poses with a group of children. Zachary's study found that the lakeshores are among the largest and major breeding sites of mosquitoes.

Zachary Stewart interviewing a young mother from a randomly selected sample to understand the level of knowledge on mosquitoes and malaria in households around the Lake Victoria region.

Photo: Zachary Stewart

in 2007 and will be attending Creighton University to major in both chemistry and biology in the pre-medicine programme .

When I first heard about the World Food Prize international internship programme, I was really interested in it and the opportunities that it offered, but I was unsure of how it fitted in with my interests. In October 2006, I attended the Youth Institute and was amazed by the accomplishments of former interns.

I was delighted to be accepted for an internship at *icipe* working on malaria, its vectors and how the disease affects Africa's food security. My internship was under the mentorship of Dr Hortance Manda at the *icipe* Thomas Odhiambo campus in Mbita. I spent the first few weeks in Mbita familiarising myself with the "ins and outs" of mosquitoes. For instance, on how to identify the different species of malaria-carrying mosquitoes, how to rear mosquitoes, as well as their life cycle. I mostly dealt with mosquitoes like *Culex* spp., *Anopheles gambiae* s.s., *A. funestus* and *Mansonia* spp. Dr Manda and her team collected mosquitoes from people's homes and outdoors for random testing on the type of plants mosquitoes feed on. Fructose is the only sugar found in plants and not humans, so if the mosquito contained fructose, then it had fed on plants. I was able to perform this part of the experiment.

I also learned how to identify the malaria parasite, *Plasmodium falciparum*, and prepare slides with blood samples for examination. The first blood sample I collected was my own! I prepared the thick and thin slides and allowed them to dry. I dipped the thin slide in methanol and allowed it to dry. I then placed both slides in a blue dye for ten minutes to stain the blood cells. I observed the blood cells, and what did I see? The odd little ring structure with a black dot on it, indicating the presence of *P. falciparum*. I thought that I must have done something wrong, so I asked one of the clinical doctors to counter-check. He confirmed that I had the malaria parasite, but it was in low numbers, probably because of the anti-malarial pills that I had been taking.

My research project aimed to understand the relationship between the community and the malaria vectors. Dr Manda designed a questionnaire for me to interview community members in 40 randomly selected homes on their knowledge of malaria and mosquitoes, the preventative methods they used, and how malaria affects their families.

The survey showed that, although community members were aware of basic mosquito control methods, there was an absence of community-level clearing of breeding sites. This study also showed that the large and major breeding sites are located in and around public areas, for instance, the lakeshore and roadway culverts.

In addition, I conducted some experiments in the laboratory, which showed that larger pools of water produce stronger and healthier mosquitoes that are more likely to carry the malaria parasite. I also found that mosquitoes prefer areas with high levels of chloride coming from human waste and human interaction.

My experience as a Borlaug–Ruan intern changed my life. I was able to 'get my feet wet' in the science fields I am interested in. I now realise that food security is not always an issue of food production and harvesting technologies. I also learned that the malaria menace affects not just the health of individuals, but the economy, society and agriculture as well.

I became very good friends with several graduate students. Some were studying economics, others engineering, and some sciences. I was impressed by the projects they were working on and the impact on food and health security. They really made an impression on me for my future college goals.

Zachary graduated in spring 2011 with a bachelor of science degree in biology from Creighton University in Omaha, Nebraska, USA. He is currently studying infectious disease control at the London School of Tropical Medicine in pursuit of his doctor of public health degree (Dr.PH.)

icipe is a unique and advanced research and training organisation working to improve the lives and livelihoods of people in Africa. Because insects and other arthropods have a major impact in almost every area of their physical well-being and prosperity, ***icipe*** is making its contribution by continuing to improve the plant, animal, human and environmental health of, primarily, smallholder farmers and disadvantaged urban dwellers in Africa.

ISBN: 92 9064 227 X