Annual Report 2015

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icipe
African Insect Science for Food and Health

Anteon shimbanum is one of many interesting new species discovered recently by *icipe*. Named after the Shimba Hills (along the Kenyan coast) where it was collected, *A. shimbanum* is a Dryinidae, a wasp family whose members are parasitoids of larvae of *Auchenorrhyncha* bugs, particularly planthoppers.

Annual Report 2015

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Cover photo: *Anachrysis* sp. nov., female: *Anachrysis* species are members of the subfamily **Amiseginae**, which belongs to the **Chrysididae** family, the jewel wasps. This undescribed species was collected by *icipe* and partners in the dry *Acacia/Commiphora* savanna of eastern Kenya, becoming the first record of this subfamily outside of southern Africa. Photo: *icipe.*

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2015 at

39%
increase in the Centre's restricted funding, with USD 34.9M committed in 2015, up from USD 25.2M in 2014.

143
peer reviewed journal articles published in 2015, surpassing the record set in 2014.

175
postgraduate scholars were in various stages of their research training at *icipe*.

33
African countries that *icipe* is working in.

25
postgraduate scholars based at *icipe* completed their studies in 2015.

48
training courses and workshops conducted for 26,482 participants during 2015.

5
patents were in progress.

257,990
community members were implementing *icipe*'s crop pests and disease vectors management strategies.

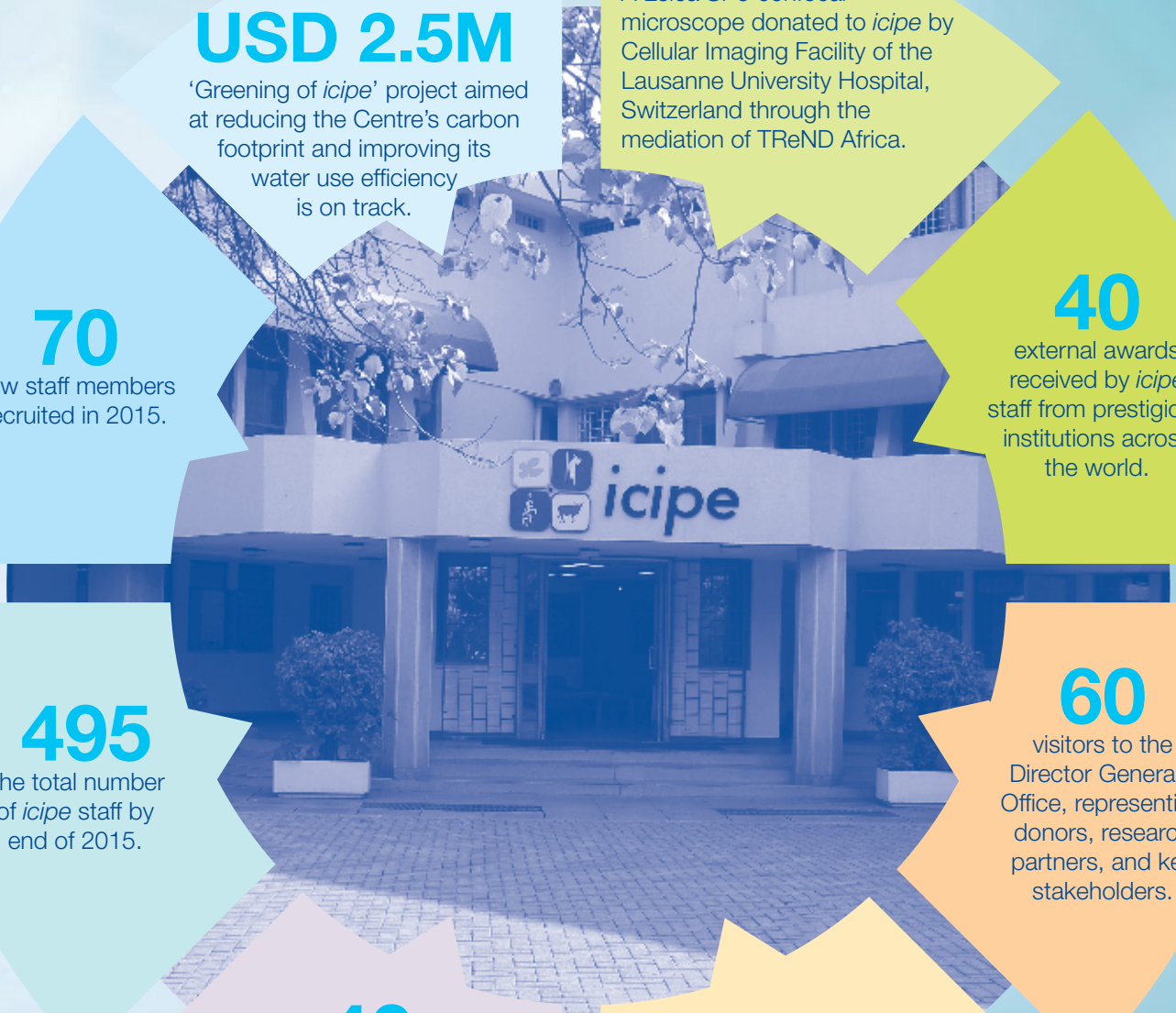
a glance

USD 2.5M
'Greening of *icipe*' project aimed at reducing the Centre's carbon footprint and improving its water use efficiency is on track.

A Leica SP5 confocal microscope donated to *icipe* by Cellular Imaging Facility of the Lausanne University Hospital, Switzerland through the mediation of TReND Africa.

70
new staff members recruited in 2015.

40
external awards received by *icipe* staff from prestigious institutions across the world.



495
The total number of *icipe* staff by end of 2015.

60
visitors to the Director General's Office, representing donors, research partners, and key stakeholders.

40
Number of Director General's strategic global and regional engagements with key stakeholders.

20,000 and 30,000 unique e-journals and e-books, respectively now available to *icipe* through free online access.

Foreword

Message from the Chair, *icipe* Governing Council

Globally, 2015 was a significant year that marked the end of the United Nations Millennium Development Goals (MDGs), and the launch of their successor, the Sustainable Development Goals (SDGs). Alongside the rest of the world, we at *icipe* take advantage of this transition to reflect on our achievements and future plans against the background of these two global visions.

Inaugurated in 2000, the MDGs were a set of eight goals that formed "the world's time-bound and quantified targets for addressing extreme poverty in its many dimensions – income poverty, hunger, disease, lack of adequate shelter, and exclusion, while promoting gender equality, education and environmental sustainability".

icipe can attest to having used its unique position as Africa's leading insect science institution to contribute towards the achievement of the MDGs. The Centre's 4H research themes (Human Health, Animal Health, Plant Health and Environmental health) resonate with a range of developmental issues beyond their titles. *icipe*'s innovative plant health strategies, including the push–pull technology and integrated pest management approaches for horticultural and staple crops, increase food security and safety, while also improving household and national incomes, and the environment. The Centre's technologies to control livestock diseases have a similar impact, and the human health research reduces the economic and social burden posed by insect transmitted diseases, while enabling communities to play a productive role in development. The Environmental Health Theme addresses biodiversity conservation, as well as livelihoods improvement through sustainable commercial and beneficial insects farming, leading to thriving enterprises.

As a result, *icipe* has contributed to MDG 1: Eradicate extreme poverty and hunger; MDG 2: Achieve universal primary education; MDG 3: Promote gender equality and empower women; MDG 6: Combat HIV/AIDs, malaria, and other diseases; MDG7: Ensure environmental sustainability; and MDG 8: Develop a global partnership for development.

Prof. Dr Bill S. Hansson
Chair, *icipe* Governing Council

The 17 SDGs are intended to advance the global developmental momentum generated by the MDGs. In the same spirit, *icipe* aims to build on its distinct strengths, and sees itself in a good position to contribute significantly to eight SDGs: Goal 1: No poverty; Goal 2: Zero hunger; Goal 3: Good health and well-being: Goal 5: Gender equality; Goal 12: Responsible consumption and production; Goal 13: Climate action; Goal 15: Life on land; Goal 17: Partnerships for the goals.

The Centre aims to continue its unique approach of scientific excellence for development, which focuses on consultative engagement with national and international research institutions, communities, the private sector, policymakers, and development partners across the globe. As demonstrated in this report, this strategy helps *icipe* to translate broader global visions into locally acceptable, affordable, and effective science-led sustainable technologies, to improve the quality of life of people across Africa.

Preface

Message from the *icipe* Director General

This annual report presents *icipe*'s achievements in 2015, which was indeed a year of significant accomplishments at the Centre.

We have endeavoured to cover our activities as comprehensively as possible. In accordance, this report opens with an infographic capturing, in figures, the key milestones achieved by the Centre in regard to resource moblisation, peer-review publications, capacity building, research and private sector partnerships, awards received by the Centre and its team, participation in international events, our visitors, and the progress in the 'greening of *icipe*' initiative. These accomplishments are then discussed in greater detail in the first chapter entitled **Leadership and Management**.

The rest of the publication is organised around six sections. The first four present activities within the Centre's 4H research themes: Human Health, Animal Health, Plant Health, and Environmental Health. The other two sections report on developments within the Insects for Food and Feed programme and the Social Sciences and Impact Assessment Unit.

In the section on **Human Health**, we demonstrate *icipe*'s contribution to the fight against malaria through integrated vector management (IVM) projects in Kenya and Ethiopia, and research on the behaviour and ecology of mosquito vectors of malaria. The report also discusses the Centre's studies on Rift Valley fever and yellow fever, and contributes knowledge for the control of other emerging infectious diseases.

The section on **Animal Health** reports *icipe*'s activities in the control of animal trypanosomiasis, including the upscaling of the innovative tsetse repellent collar, and on advancing knowledge on tsetse flies and trypanosomes, the disease's vectors and parasites, respectively. Also discussed in this section is *icipe*'s new research projects on camel trypanosomiasis, ending the illegal bushmeat trade while controlling the transmission of zoonotic diseases, and contributing towards improving the Somaliland milk value chain.

Dr Segenet Kelemu
Director General, *icipe*

In the **Plant Health** section, we focus on *icipe*'s progress in disseminating its fruit fly integrated pest management (IPM) packages in Kenya and Tanzania, while also introducing the technologies in Ethiopia for the first time. Other activities include the development and implementation of IPM strategies for vegetable and staple food crop pests, and the generation of knowledge for the control of postharvest losses.

Under the **Environmental Health** section, the report outlines activities in *icipe*'s Beneficial and Commercial Insects Programme, including efforts to establish an African bee breeding line with various advantageous traits, new projects for improved beekeeping and pollination services in four island nations off the eastern and south-eastern coast of Africa and in Zanzibar, and development of a remote sensing methodology for bee health. We also discuss the progress towards creating value chains to enhance silk farming in Africa. In addition, we highlight the selection of the Muliru Community Enterprise by

SWITCH Africa Green Programme as a case study for promoting green economy and sustainable consumption and production practices in Africa.

At the end of each 4H chapter, we have included a profile of the Theme's leader, with the intention of familiarising our stakeholders with our team.

In the **Insects for Food and Feed** section, we discuss our contribution towards the global quest to advance the use of insects for food and feed. In the **Social Science and Impact Assessment Unit** section, we outline the studies conducted by the Unit, while building its own capacity to ensure the availability of evidence and knowledge for more effective Centre activities.

We thank our dedicated teams, donors and partners, and look forward to another productive year.

MANAGEMENT AND LEADERSHIP

A range of operations overseen through the offices of the Director General, the Director of Research and Partnerships, and the Director of Finance and Administration support *icipe*'s research activities. These three offices encompass, among other activities, administration of scientific research, grant and partnerships management, resource mobilisation, facilities and assets management, and the legal and communications functions.

***icipe* core donors:** Aid for Africa, USA; Federal Ministry for Economic Cooperation and Development (BMZ), Germany; Ministry of Higher Education, Science and Technology, Kenya; Swiss Agency for Development and Cooperation (SDC), Switzerland; The Swedish International Development Cooperation Agency (SIDA); and UK Aid, Government of the United Kingdom.

Resource mobilisation

In 2015, *icipe* made significant progress in resource mobilisation around a strategy of increasing the Centre's restricted funding while diversifying the range of its development partners. The Centre obtained USD 34.9 million restricted funding, which represents a 39% increase compared to USD 25.2 million secured in 2014. The Centre continued to receive strong support from longstanding development partners and welcomed new ones, some of whom are highlighted below.

- With support from the European Union (EU) and the International Fund for Agricultural Development (IFAD), *icipe* launched a EUR 15M programme titled 'Integrated Biological Control Applied Research Programme (IBCARP)', to support the adoption of the Centre's technologies and strategies for improved cereal, horticultural and livestock productivity by an estimated 350,000 additional farmers and pastoralists in Kenya, Ethiopia and Tanzania.

- The Biovision Foundation for Ecological Development continues to support *icipe*, with funding amounting to approximately USD 2M per year being used for disseminating knowledge (primarily through the Farmer Communication Programme), carrying out activities on integrated vector management (IVM) for mosquitoes and malaria, and strengthening commercial insects activities.

- The MasterCard Foundation made a USD 10.35M commitment towards creating employment opportunities for young people in Ethiopia through *icipe*'s beekeeping and silkworm farming activities.

- *icipe* became a grantee of the Partnerships for Enhanced Engagement in Research (PEER) programme, which is administered by the National Academies of Science (NAS), and is supported by the United States Agency for International Development (USAID), jointly with several United States Government (USG)-supported agencies, to initiate a project towards ending illegal bush meat trade in East Africa.

- Through a grant to be administered through the United Nations Office for Project Services (UNOPS), *icipe*-supported community-based conservation activities around Kakamega forest, which focus on the commercial production of medicinal plants, will be up-scaled as a case study under the SWITCH Africa Green Programme.

- In November 2015, the Federal Ministry for Economic Cooperation and Development (BMZ), Germany, approved a EUR 1.2M funding for a new project within *icipe*'s fast rising Insects for Food and Feed Programme.

The Steering Committee of the EU-funded IBCARP during a meeting at *icipe* in 2015.

Partnerships and product commercialisation

icipe Director General signing a partnership contract with Chris Kolenberg, Director, Kenya Biologics Limited.

icipe's partners can be categorised into three. The first category includes universities and national and international research institutes that collaborate with, and/or sub-grant *icipe*, thereby augmenting the impact of the Centre's work. The second category consists of private sector partners, who play a vital role in the commercialisation of *icipe*'s technologies. The third category consists of a range of development partners involved in the dissemination and uptake of *icipe*'s technologies, including government departments, non-governmental organisations (NGOs) and community based organisations (CBOs). In 2015, *icipe* continued to work with these partners, and also welcomed new ones.

Private sector partners

Real IPM Ltd, Kenya: *icipe*'s most prominent public–private partnership agreement is with Real IPM Limited, a Kenyan-based company that has taken on the task of introducing *icipe* biopesticides into markets across Africa. The company's footprint on the African continent is increasing, leading to wider availability and impact of *icipe* products. Real IPM is in negotiations, with registrations underway, which would lead to commercialising *icipe* technologies in Europe, North America, and Asia.

So far, Real IPM has commercialised the following *icipe* biopesticides:

- ICIPE 69 (marketed as Real Metarhizium) has been registered in Tanzania for the control of fruit flies on papaya.
- ICIPE 69 (marketed as Campaign® and Real Metarhizium) has been registered for the control of mealybugs and thrips on roses, cucumber, tomato and other crops in Ethiopia, Kenya, Ghana, and South Africa. Registration of the biopesticide is in progress in Canada, Europe, South East Asia, and West Africa.
- ICIPE 78 (marketed as Achieve®) has been registered in Kenya, where it is active against red spider mites, for use on papaya, roses, cucumber, and tomato. Registration of the biopesticide is in progress in Ghana and South Africa.

Groupe Éléphant Vert, Switzerland: *icipe* signed a collaborative agreement with Elephant Vert, a Swiss Company that operates on an international scale with physical presence in Europe, Morocco, and West Africa. Elephant Vert S.A. also holds equity in Real IPM Kenya that have licensing agreements for the commercialisation of a range of *icipe*-developed biopesticides (ICIPE 69, ICIPE 78, ICIPE 7 and ICIPE 62). This partnership opens the way for *icipe*-developed technologies to be commercialised across Africa and globally, including North America, Europe and Asia.

Kenya Biologics Limited, Kenya: In October 2015, *icipe* signed a partnership agreement with Kenya Biologics Limited for the establishment of a commercial pilot processing plant to produce food bait for the management of fruit flies in Kenya. It is anticipated that the plant will be operational by mid-2016. The facility will be equipped through a grant to *icipe* by BMZ/GIZ.

Research partners

Rothamsted Research, United Kingdom: *icipe* entered into a cooperation agreement with Rothamsted Research, UK, a longstanding strategic partner in *icipe's* Push–Pull Programme. The arrangement aims to establish a strategic collaborative programme between the two institutions, which includes the function of *icipe* as a regional hub for Rothamsted Research's activities in Africa.

Agroscope, Switzerland: In March 2015, *icipe* signed a memorandum of understanding (MoU) with Agroscope, the Swiss Confederation's centre of excellence for agricultural research. The chief executive officers of both institutions endorsed the convening of a joint proposal development workshop to be held in January 2016.

Alexander von Humboldt Foundation, Germany: In December 2014, *icipe* and the Alexander von Humboldt (AvH) Foundation, Germany, signed an MoU, which sets out collaborative arrangements to promote research excellence, build capacity for development, enhance academic cooperation between scientists from Africa and Germany, and strengthen the AvH network in Africa. Based on the MoU, in 2015, Dr Daniela Kneissl, the AvH Head of Africa and Middle East Division visited *icipe*.

***icipe* SCRC – Kenya:** Since July 2010, *icipe* has served as the Stockholm Convention Regional Centre for capacity building and the transfer of technology (*icipe* SCRC-Kenya), under the Stockholm Convention on Persistent Organic Pollutants (POPs), as one of the

Participants from *icipe* and Rothamsted Research (UK), during a workshop convened at the Centre to discuss collaborative activities.

Agreement signing between *icipe* and Agroscope, Switzerland. Left to right: Mr Gatigwa Kimana, Director of Finance and Administration, *icipe*; Prof. Dr Michael Gysi, CEO Agroscope; Dr Segenet Kelemu, Director General, *icipe*; Dr Jean-Philippe Mayor, Deputy Head of Agroscope.

16 Stockholm and 7 Basel Regional Centres, located in Africa, Asia and the Pacific, Central and Eastern Europe, Latin America and the Caribbean, and Western Europe. In this role, *icipe* works with a range of partners to build capacity and transfer technology to African member states on alternatives to the use of POPs in the management of disease vectors and pests, and biodiversity and environmental conservation. In May 2015, *icipe* participated in the meetings of the Conferences of the Parties to the Basel, Rotterdam and Stockholm conventions. Based on an evaluation report submitted by *icipe* to the Stockholm Convention Secretariat in December 2014, *icipe* SCRC-Kenya scored 94%. As a result, more than 160 countries that are members of the Stockholm Convention endorsed *icipe* SCRC-Kenya for a further four-year period, from 2016 –2019.

In November 2015, the *icipe* SCRC-Kenya hosted a workshop on sound life-cycle management of DDT, which was organised by the Secretariat of the Stockholm Convention, in close cooperation with the World Health Organization (WHO). The three-day workshop aimed at fostering participants' understanding towards enhanced capacity at national level for evidence-based decision-making for disease vector control, for sound management of DDT and for efficient reporting to the Convention. The workshop also focused on consideration of non-chemical and other sound environmental management practices to enhance the sustainability of reduced reliance on DDT for disease vector control. The workshop was attended by 36 participants from 16 African countries in Africa, including Botswana, Comoros, Eritrea, Ethiopia, Ghana, Mauritius, Morocco, Mozambique, Namibia, Senegal, South Africa, Swaziland, Zambia, Democratic Republic of the Congo, Tanzania and Kenya, and four facilitators, one each from the Basel, Rotterdam and Stockholm Convention (BRS) Secretariat, the WHO, Wageningen University, The Netherlands and *icipe*, as well as one presenter from Iran.

FAO Reference Centre: *icipe* is designated as a Food and Agriculture Organization of the United Nations (FAO) Reference Centre for vectors and vector-borne animal diseases. FAO Reference Centres are institutions selected by the Director General of FAO, to provide specific independent technical or scientific advice on issues related to its mandate. The Centres are chosen on the basis of their high level scientific expertise, commitment to capacity building, and provision of services. Selected institutions must also have demonstrated ability to contribute to capacity building in their areas of expertise. *icipe* was designated as a Reference Centre of FAO after a thorough evaluation of its mandate, main activities, and competencies in vector-borne animal diseases.

Development partners

New push–pull IPM partners: *icipe* enhanced its partnerships for the dissemination of the push–pull technology with One Acre Fund in Kenya and Uganda, Plantwise (a CABI-led initiative), World Vision, and Project Concern International (PCI) in Kenya and Tanzania; which, as discussed later in this report, has led to target-specific and cost-effective dissemination pathways for push–pull.

Cirad/IRD, France: *icipe* has long-standing collaborative arrangements with Cirad, the French agricultural research and international cooperation organisation working for the sustainable development of tropical and Mediterranean regions, and with the Institut de recherche pour le développement (IRD). Scientists from these two organisations are either hosted by *icipe*, or spend significant amounts of time each year working within the Centre's facilities. *icipe* and these two partners are evaluating ways of broadening their relationship to access synergistic and complementary skills, and to better integrate the visiting scientists into the Centre's existing activities or future priority areas.

Towards this goal, in February 2015, *icipe* Director General, Dr Segenet Kelemu, visited Cirad to explore further opportunities for collaboration. In March 2015, a team from Cirad made a reciprocal trip to finalise the renewal of the MoU. In September 2015, Dr Emilie Delétré, a Cirad researcher, joined *icipe* on a 2-year appointment to contribute to the development of innovative pest management strategies to reduce chemical pesticide use on vegetables.

University of Amsterdam, The Netherlands: *icipe* is exploring a partnership with the University of Amsterdam in the area of insect elicitors, based on the University's cutting edge research combining disease and pest resistance through common plant defence elicitors.

Jomo Kenyatta University of Agriculture and Technology, Kenya: *icipe* has extended its MoU with Jomo Kenyatta University of Agriculture and Technology covering a broad range of activities.

Among the innovations that *icipe* aims to secure is one relating to bee health in Africa.

Patent applications

icipe has commenced on patenting its innovations. Below are some of the patent applications that were filed or are in progress in 2015. *icipe* is also seeking partners to commercialise the products in question.

Composition and methods of controlling a bee pest: The patent was filed in Kenya in September 2015, and the validation of the product has been initiated in other African countries that have serious bee pest and disease problems.

Repellent composition for insects and other arthropods: A patent application, to be co-owned by *icipe* and Kenyatta University, Kenya, has been filed.

Insect repellent compositions and methods of use: The patent application was filed by Wageningen University, The Netherlands on behalf of Vanderbilt University and Yale University (both in the USA), and *icipe*.

Antimicrobial agents produced by *Xenorhabdus griffiniae* starin xn45: A patent application was filed in May 2015, to be co-owned by *icipe*, Kenya Agricultural and Livestock Research Organisation (KALRO), University of Nairobi, and Trek Science (all in Kenya).

Composition and methods of controlling larvae (provisional): A request for a utility model wholly owned by *icipe* has been filed.

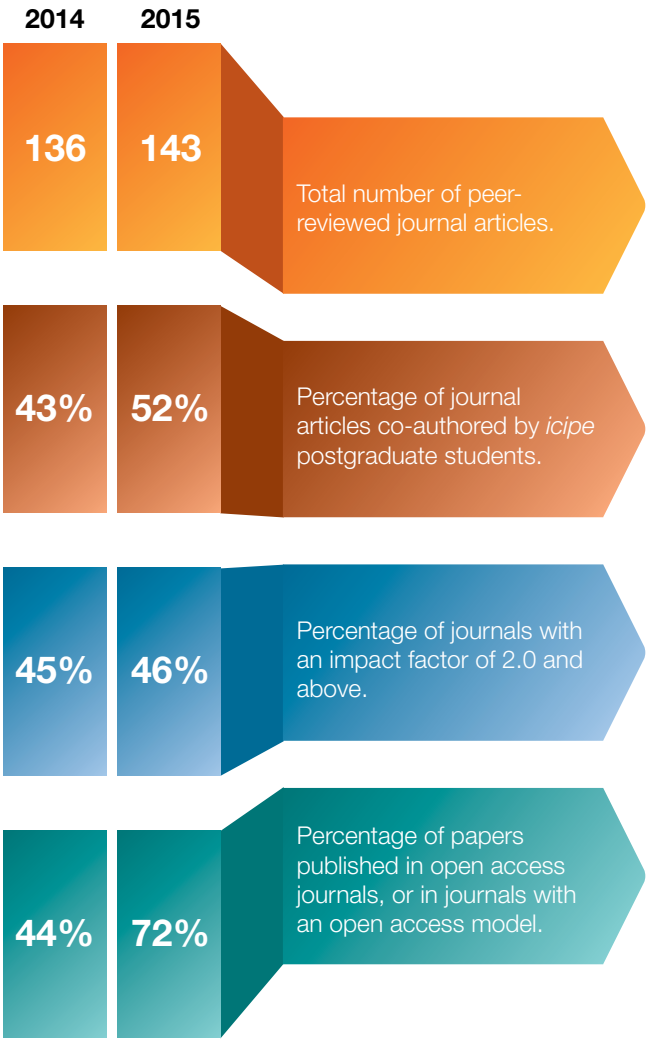
Communications

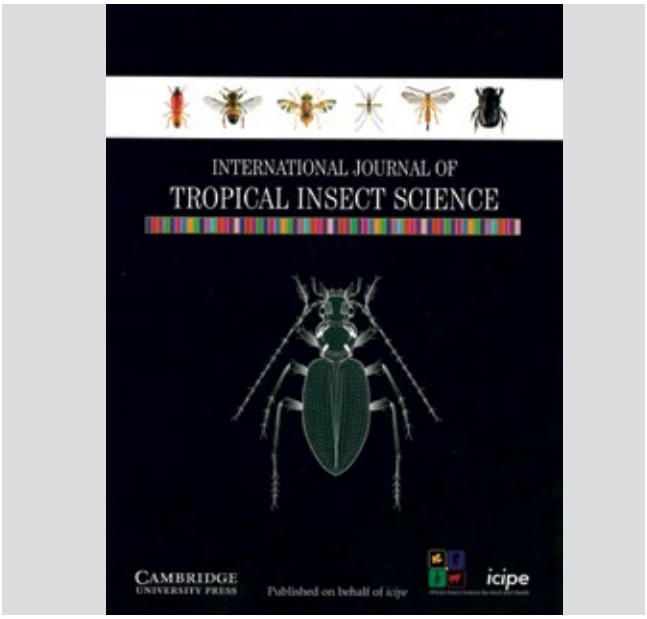
icipe registered significant progress in scientific communication to peer communities, through journal articles and a range of products, tools, and channels aimed towards the Centre's broader range of stakeholders.

Journal articles

In 2015, *icipe* published 143 peer-reviewed journal articles, surpassing the record that the Centre set in 2014. Of the articles, 72% were published in open access or in journals with an open access model. The overall impact factor of journals where *icipe*'s papers are published increased. Almost half of the journal articles were co-authored by *icipe* graduate students.

Summary of 2015 vs. 2014 publications statistics





First Impact Factor of the International Journal of Tropical Insect Science

The International Journal of Tropical Insect Science (IJT), which is published by Cambridge University Press (CUP) on behalf of *icipe,* is the only journal devoted exclusively to the latest research on tropical and sub-tropical insect science.

Some of the benefits of publishing in IJT include, but are not limited to, rapid and high quality peer-review process and the widest possible global dissemination of the published papers by CUP.

For the past three years, extensive effort has been made to ensure that IJT obtains an Impact Factor rating. The first Impact Factor of the IJT was published in June 2015, in the Thomson Reuters Journal Citation Reports® (JCR).

IJT attained an encouraging Impact Factor of 0.419, a good start which places the journal in position 76 out of 92 journals in the entomology subject category.

IJT is now online with EISSN: 1742-7592. As a result of the impact factor, submissions and subscriptions have increased, and the journal's readership has widened.

Media coverage

In 2015*, icipe* continued to enhance its relations with the media in Kenya, East Africa and internationally.

Kenyan media: The Centre was featured in all key Kenyan print and electronic media, and in a range of emerging blogs and online platforms being administered by local journalists.

Regional media: *icipe* obtained coverage in key regional publications such as *The EastAfrican*, a weekly newspaper that is circulated in the Great Lakes Region of Africa, including Tanzania, Uganda and Rwanda.

International media: *icipe* received extensive international coverage including on CNN International, the *New Scientist*, *The Guardian*, *SciDev.Net*, *The Scientist*, *The Washington Post*, CBS News, Fox News, Al Jazeera, and *National Geographic*.

In addition, the Director General's participation in Trieste Next 2015, and strong support from TWAS, The World Academy of Sciences, led to extensive coverage in the Italian and European media. A significant portion of the coverage received was as a result of efforts by the Centre's Communications Unit, which generated a variety of news and feature articles. In addition, the Unit produced a quarterly e-bulletin, which has proven to be a great source of information for the Centre's stakeholders.

Social media presence

icipe continued to enhance its social media presence, registering an increasing number of engagements from development partners, end-users, journalists, and the general public.

Sample of *icipe*'s media coverage in 2015

Facilities and assets

Upgrade of field stations

***icipe* Nguruman Station:** In July 2015, a three-month refurbishment of the *icipe* Nguruman Field Station, which involved significant improvements in laboratories, offices and the guesthouse, was completed.

Arthropod Containment Level - 2 (ACL-2) facility: *icipe* completed the construction of the Level 2 facility at the *icipe* Thomas Odhiambo Campus, Mbita, on the shores of Lake Victoria.

The facility features a mosquito-proof, state-of-the-art insectary and laboratory space attached to a large double-walled screen house that will be used for research on conventional and novel genetic strategies to control mosquitoes.

An expert from the Centers for Disease Control and Prevention (CDC), USA has conducted an audit to assess the biocontainment and regulatory compliance of the facility.

New equipment

Confocal microscope: The Cellular Imaging Facility of the Lausanne University Hospital (Switzerland) made a donation of a Leica SP5 confocal microscope to *icipe*, an event mediated through TReND Africa. Confocal microscopes allow the stacking of sections and creating of 3-D images of specimens.

The Leica SP5, installed in *icipe*'s Emerging Infectious Diseases (EID) laboratory, is the first operational confocal in East Africa.

This microscope will enable the Centre's researchers to acquire optical sections of specimens without background noise and image degradation. There are two major benefits to having such an instrument for *icipe* research staff. First, it will boost the quality and potential of research at the Centre, and second, staff trained in the field of confocal microscopy will have greater employability, thus facilitating their career advancement.

Launch of the Leica SP5 confocal microscope in *icipe*'s Emerging Infectious Diseases (EID) laboratory.

Greening of *icipe*

In 2013, *icipe* successfully applied for funding to green its operations, from the Swiss Agency for Development and Cooperation (SDC). The initiative revolves around the three thrusts discussed below, which are aimed at reducing the Centre's carbon footprint, and improving its water use efficiency.

Decrease in clean water consumption through rainwater and conserving: *icipe* instituted a range of water saving initiatives, including the installation of water tanks with a total capacity of 250,000 litres, that will soon be doubled to 500,000 litres. More efficient water taps are being installed across the Centre, including sensor systems for toilets.

A new water cooling system has been fitted within the Centre's Animal Rearing and Containment Unit, which enables the water used in the facility to be recycled, leading to the saving of 50,000 litres of water per month. These activities are supported by efforts towards early detection of faulty water pipes, allowing timely repairs, and preempting water spillage.

Decrease in energy consumption through intelligent energy saving measures. In September and October 2015, *icipe* replaced fluorescent tubes with LED lights across Duduville Campus. Already, a reduction in energy consumption has been observed.

Sustainable energy supply and decrease in dependency on diesel fuel through use of solar photovoltaic and thermal systems. *icipe*'s solar power project has made significant progress, and is expected to be completed in 2016. The Centre plans to generate electricity on its Duduville Campus, and to both generate and capture solar power at the Mbita campus.

Landscaping: As part of its efforts to reduce its carbon footprint, *icipe* has embarked on an extensive exercise of planting trees and other flowering plants on its Duduville Campus.

These plants have transformed the landscape, and attracted a diversity of bird and insect species.

Nurturing scientific leadership and recognising excellence

New appointments

icipe has embarked on a process of strategic recruitment, which, in the short term, will fill in skills and capacity gaps, and in the long term, enable the Centre to further develop its succession plan. In 2015, *icipe* appointed 13 professional staff and 57 support staff, including the Head of *icipe* Ethiopia Office, and the Head of the Social Science and Impact Assessment Unit.

Development of early career scientists

The Centre considers it vital to nurture emerging scientific talent, to ensure that *icipe* has the best scientific capabilities and future leadership. The Centre's strategy includes:

- **Developing a talent pipeline** to identify potential science leadership in early career scientists, and put in place the necessary plans to help them reach their full potential. The talent pipeline also provides critical information to allow the Centre to address issues of succession planning.
- **Revamping of the early career scientists training programme**, by introducing a range of courses (including leadership, communications, and proposal and publications writing), through partnerships with a range of organisations, including AWARD (African Women in Agricultural Research and Development) and the Crawford Fund, Australia.
- **Developing a mentorship programme** for early career scientists to provide them with a forum to discuss career-related issues and share experiences.

Awards and honours

In 2015, *icipe* staff members and students received many prestigious external and internal awards and recognitions. A complete list of the awards and awardees is in Annex 1.

Edith Chepkorir, a PhD student at *icipe*, was one of the recipients of the 2015 L'Oréal–UNESCO Regional Fellowships for Women in Science in Sub-Saharan Africa.

Some 2015 staff awardees

Dr Segenet Kelemu, Director-General, *icipe*, was invited to serve on the National Science and Technology Council of the Republic of Rwanda. She is being featured in an upcoming book on science and technology for Africa's development in a chapter devoted to highlighting the research, teaching, and leadership accomplishments of selected individuals who have contributed much to Africa.

At the 26th General Meeting of The World Academy of Sciences (TWAS) held in Vienna, Austria, 19 November 2015, members attending the meeting elected the Director-General as a Fellow of TWAS for her role in the advancement of science in developing countries. The ceremony will be held at the 27th TWAS General Meeting in 2016.

Tel Aviv University has decided to give the Director-General an honorary doctorate in recognition of her pioneering role for women scientists in Africa, and for many other ecological agricultural achievements; her pioneering role for women scientists in Africa; her leadership in the fight for providing new solutions for ecologically responsible food crop production, especially by local, small-scale farmers in Africa; her commitment in directing the major effort, through international collaboration; and for the transformation of African agriculture into self-sustainment that will meet the goals of feeding the people. The award ceremony will be on 19 May, 2016.

Prof. Zeyaur Khan, Leader of the *icipe* push–pull programme, was awarded the prestigious Louis Malassis Prize for Outstanding Career in Agricultural Development, awarded in March 2015 during a special session of the 3rd Global Science Conference on Climate-Smart Agriculture in Montpellier, France by the Agropolis Foundation. Prof. Khan was recognised for his leadership of the push–pull, a technology developed over the past 20 years by *icipe*, Rothamsted Research, United Kingdom, and partners in eastern Africa. This simple cropping strategy simultaneously addresses the five key constraints of cereal–livestock mixed production systems in Africa.

Prof. Baldwyn Torto, Head of the Behavioural and Chemical Ecology Unit, will be a plenary speaker at the 2016 XXV International Congress of Entomology. Baldwyn has also been selected to serve as a member of the African Academy of Sciences (AAS) Commission on Sciences Education, one of four commissions that the AAS has established to build capacity and set the agenda for science in Africa. The others focus on women in science, Africa's science heritage, and Pan-African Science Olympiads.

In addition, the AAS selected him to serve on the jury for the award of the African Union (AU) Prizes.

Ms Fiona Nelima Mumoki, a Research Assistant in the Molecular Biology and Bioinformatics Unit (MBBU), was named an African Women in Agricultural Research and Development (AWARD) Postgraduate Fellow for 2015. In March 2015, Fiona commenced PhD studies at the University of Pretoria, South Africa, through a training fellowship from the Organisation for Women in Science for the Developing World (OWSD).

HUMAN HEALTH THEME

The *icipe* Human Health Theme aims to contribute towards the reduction, elimination and eradication of vector-borne diseases by generating knowledge and developing effective and sustainable tools and strategies to control vectors and break the cycle of disease transmission. It is the Centre's aim that such approaches can be integrated into other disease management efforts. *icipe* is conducting research on malaria, and on neglected tropical diseases and emerging infectious diseases, including Rift Valley fever, yellow fever, and dengue fever.

35
Journal articles

29
Postgraduate students

78,270
Community members involved in integrated vector management programme and Solarmal project

Donors: Biovision Foundation for Ecological Development, Switzerland; European Union; Global Environment Facility (GEF)/United Nations Environment Programme (UNEP); *icipe* core donors; R. Geigy Foundation, Switzerland; Swedish International Development Cooperation Agency (Sida); Swiss National Science Foundation; National Institutes of Health (NIH), USA; United States National Science Foundation (NSF); Wellcome Trust, UK.

Malaria research

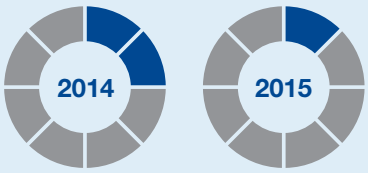
Malaria IVM

The *icipe* integrated vector management (IVM) programme, which is being implemented in Kenya and Ethiopia, evaluates chemical and non-chemical methods of vector control. These include long-lasting insecticide-treated nets (LLINs), larviciding with *Bacillus thuringiensis israelensis* (*Bti*), environmental management (e.g. sanitation around houses, for instance draining stagnant water), and community education and mobilisation (for instance through schools health clubs).

Assessing IVM impact: In 2015, *icipe* focused on assessing the impact of its IVM strategies on the health of communities, their socio-economic status, and the environment. The goal is to use the evidence and lessons learned to promote the IVM approach. In addition to the results shown below, a user-friendly IVM decision-analysis support tool developed by *icipe* and multi-sectoral working groups established by the Centre and partners, has helped embed IVM principles in health and non-health policies in Kenya and Ethiopia.

Malaria decline as a result of *icipe* IVM interventions

Malindi, Kenya



Malaria prevalence reduced to **3.7%** in 2015 from **7.5%** in 2014

Tolay, Ethiopia

Malaria prevalence in children in areas where the *icipe* IVM is being implemented was half that of children in experimental control situation.

Gender and malaria: A study on the role of gender in malaria preventive behaviour conducted in Nyabondo and Malindi counties, Kenya, showed that access to public health information, knowledge on malaria prevention, and on the causes and transmission processes of the disease, significantly increases the number of practices (e.g., environmental management, and use of LLNs, repellents and insecticides) adopted by households, whether headed by men or women. These findings suggest that universal policy tools can be used to promote uptake of malaria IVM for all households.

Chemical Ecology

Lead to plant-based lure: *icipe* studies led to the identification of a simple and affordable chemical, with potential towards developing a plant-based lure that could be deployed outdoors to monitor malaria mosquito vectors.

Invasive weeds and malaria: In 2015, *icipe* published results of a study showing that *Parthenium hysterophorus*, a highly aggressive invasive plant known within the region as famine weed, could increase malaria incidents in East Africa. *Parthenium* has the ability to sustain the malaria-transmitting mosquito, *Anopheles gambiae*, by extending its life even in the absence of a blood meal.

> "Our research has established that invasive plants could potentially contribute to the transmission of malaria."

Prof. Baldwyn Torto, Head, Behavioural and Chemical Ecology Unit

This publication attracted widespread regional and international media coverage, and raised global awareness on the threat posed by invasive weeds on public health in general, prompting the convening of the First Global Conference on Invasive Plants and Malaria, held in Kenya in December 2015. Organised by the Centre for Agriculture and Biosciences International (CABI), with support from the Bill & Melinda Gates Foundation, the forum brought together invasive plant specialists, ecologists, chemical ecologists, modellers and entomologists.

OviART research

Oviposition attractant for gravid malaria vectors: A study conducted by the OviART research group, a multinational team bringing together researchers from *icipe*, the London School of Hygiene & Tropical Medicine, the KTH Royal Institute of Technology, Sweden, and the UK's Durham University, identified and evaluated an oviposition attractant for *Anopheles gambiae*.

In a world first, the team found that a naturally-occurring chemical known as cedrol, which is found in mosquito breeding sites near Lake Victoria, Kenya, attracts pregnant malaria-transmitting mosquitoes. The chemical could be used in 'attract-and-kill' traps for female mosquitoes, preventing them from laying eggs.

SolarMal project concluded

In 2015, *icipe* in collaboration with Wageningen University and Research Centre, the Netherlands, and the Swiss Tropical and Public Health Institute concluded the two-year-long SolarMal project, which was funded through the 'Food for Thought, Thought for Food' campaign of the Wageningen University Fund.

The objective of the project was to reduce the malaria burden on Rusinga Island, western Kenya, through mass trapping of outdoor mosquitoes using a proof of principle concept that uses odour-baited traps driven by solar power. To lure host-seeking malaria mosquitoes, the solar powered mosquito traps (SMOTs) are baited with a synthetic odour blend that mimics human odour. Since the SMOTs are also a source of clean lighting energy, they pre-empt the use of kerosene-powered lamps, thereby providing additional health benefits to users.

Approximately 4358 households have benefitted from the SolarMal project. Monitoring of mosquito numbers, species composition, malaria prevalence and incidence, and socio-economic implications was conducted. More than 20 Rusinga residents were trained in the installation of the SMOTs, and links are being made with Kenyan solar power providers to ensure a stable supply of the trap components.

> "The SolarMal project has contributed towards sustainable malaria control, presenting a tool that also has socio-economic benefits through the provision of solar energy."
>
> *Dr Daniel Masiga, Coordinator, SolarMal project*

Results

- The number of malaria carrying mosquitoes in houses using SMOTs is lower than in houses without the traps.
- Malaria parasite levels in people living in households using SMOTs are lower than in those living in households without the traps.
- There is reduced kerosene use with possible reduction in upper respiratory tract infections and kerosene-related accidents.
- Children are able to study at home during the evenings due to availability of lighting from the SMOTs.
- The technology is encouraging a savings culture, with an approximate 100 women groups (consisting of 20 individuals) pooling together to save towards the maintenance of SMoTs.

Household members watch as a SolarMal project representative fits a SMOT on their house on Rusinga Island, western Kenya.

Spirovector project

Globally, insect-endosymbionts are emerging as a promising alternative in vector management strategies. Insect endosymbionts are microbes (generally bacteria), that live inside the cells or body of an insect host, and are continually transmitted from mother to offspring.

They have significant impacts on the interaction between their host insects and other pathogens; because, to promote their own survival, the microbes often 'assist' their host insects in the defence against the pathogens. As such, microbes can potentially be used to make vectors more resistant to pathogens, thus preventing the transmission of vector-borne disease.

In 2015, *icipe* with support from R. Geigy Foundation, Swiss National Science Foundation, and Wellcome Trust (UK), made progress towards controlling insect-vectored diseases in Africa using insect endosymbionts.

Activities included establishing an effective and accurate screening procedure for *Spiroplasma* bacteria in insect vectors, leading to the identification of several new endosymbionts of significant interest.

> We have discovered two distinct *Spiroplasma* strains in *Anopheles arabiensis*, the major vector of *Plasmodium falciparum*, the major malaria parasite here, which could potentially be exploited in mosquito and malaria control.

Dr Jeremy Herren, Leader, Spirovector Project

Predatory arthropods

The research on predatory arthropods, which is conducted through collaboration between *icipe* and the University of Canterbury, New Zealand, focuses on cognitive specialisation of arthropods, with jumping spiders being the primary subject.

These studies are conducted with awareness of the potential relevance to wider *icipe* research concerns, including malaria-related research.

> Our research poses a question as to whether mosquito terminators can be exploited for biological control of malaria vectors, especially in view of predominant fear and loathing of spiders.

Prof. Robert Jackson, Leader, Research on Predatory Arthropods

Mosquito terminators

In 2015, the researchers published an invited paper in the *Journal of Arachnology*, consisting of a comprehensive review of their research over the years, of the only two spider species known to specifically target mosquitoes, *Evarcha culicivora* and *Paracyrba wanlessi*.

The research review focuses on what is known about the biology of *E. culicivora* and *P. wanlessi*, and it highlights the ways in which these mosquito terminators can help us understand what is meant by 'predatory specialisation'.

Malaria programme research partners:

Kenya Medical Research Institute (KEMRI); Ministries of health in Kenya and Ethiopia; national agricultural research institutes, non-governmental organisations, private sector partners, farmers, and farmer groups; University of Pretoria, South Africa; Duke University, USA; Biovision Foundation for Ecological Development; World Health Organization-Regional Office for Africa (WHO-AFRO); PUMMA Community group in Malindi and MOCON community group in Nyabondo, Kenya; Addis Ababa University (Aklilu Lemma Institute of Pathobiology); Millennium Institute, USA; Wageningen University, the Netherlands; Swiss Tropical and Public Health Institute; Rusinga Island community.

Neglected tropical diseases and emerging infectious diseases

Neglected tropical diseases (NTDs), a diverse group that includes parasitic (such as human African trypanosomiasis) and viral ailments (such as dengue and chikungunya fever) that prevail in tropical and subtropical conditions, mainly affect populations living in poverty, thus posing a huge burden to public health and impeding poverty reduction and socioeconomic development. The incidence and outbreaks of emerging infectious diseases (EIDs), such as viral haemorraghic fevers (yellow fever, Rift Valley fever, and Crimean-Congo haemorrhagic fever) is increasing, not just in Africa, but in many regions of the world. *icipe* maintains a strong research focus aimed towards improving understanding of vector and disease ecology, as well as dynamics of neglected tropical diseases and emerging infectious diseases.

The Centre uses a range of approaches, including surveillance, genomics, bioinformatics, and geographical information systems.

Rift Valley fever research

In 2015, *icipe* continued studies in its Martin Lüscher Emerging Infectious Diseases Laboratory towards improving strategies for the prediction and preparedness against outbreaks with devastating economic impact, using Rift Valley fever (RVF) as a model.

A primary aim is to determine local and regional factors that are key in RVF outbreaks, and use them to design a high resolution prediction model.

Ongoing activities

- Monitoring of nomadic livestock movement patterns in some high and medium RVF risk zones in Kenya, and associated RVF virus activity.
- Assessing socio-cultural norms, knowledge, attitudes, and practices that impact RVF transmission among diverse communities.
- Vector sampling to assess RVF vector diversity, distribution and abundance, and virus circulation.
- Mapping RVF vectors and virus circulation.
- Assessing exposure of the RVF virus among associated populations.

Socio-cultural norms, knowledge, attitudes and practices, and RVF transmission

Results of a study by the *icipe* Social Science and Impact Assessment Unit carried out in Ijara County, Northeastern Kenya showed that many people are engaging in risky practices that could contribute to Rift Valley fever (RVF) transmission. Such practices include handling aborted animals without taking protective measures, keeping animals inside the homestead, consuming uncooked/unpasturised milk, treating sick animals on their own, and disposing of livestock carcasses improperly. Other practices include low use of bednets and low levels of awareness on the role vectors play in disease transmission. These results underscore the need for strategies to create awareness and promote sustainable practices to prevent RVF.

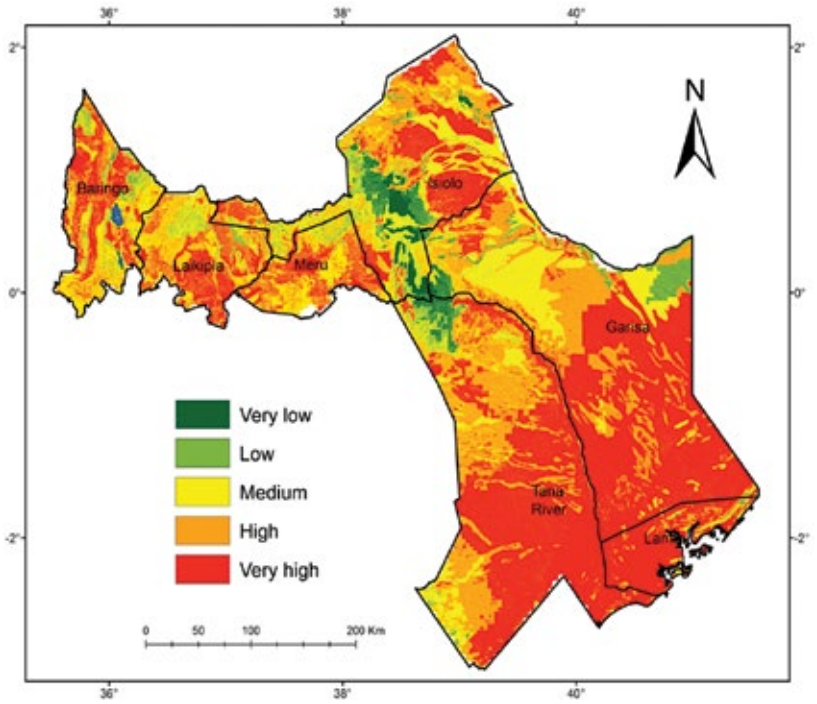
Rift Valley fever

Rift Valley fever (RVF) is an EID that severely affects livestock and humans, mostly pastoral communities. In Kenya, early warning systems are needed to facilitate the institution of countermeasures against the disease, for timely response, and to mitigate against the impact of outbreaks. Existing approaches on modelling RVF outbreaks are based on flood prediction and satellite-based information on rainfall, temperature, and vegetation greenness. However, in 2006, predictions of a RVF outbreak were issued only after the rains and flooding had occurred. More information based on epidemiological and demographic data, and a better understanding of environmental factors, ecology of RVF virus, and the socio-economic environment, are required to fine-tune such models, in order to develop practical and timely early warning systems and appropriate countermeasures.

RVF risk map: The Geo-Information Unit developed an advanced and explicit RVF risk map in northern Kenya that decision makers can use to assess regions where pastoral communities are most vulnerable to RVF while migrating with their livestock.

The map uses time-series evapotranspiration data, which has proven to be more sensitive to RVF mosquito habitat characteristics than the commonly used vegetation 'greenness' proxy.

RVF probability and risk zones based on wetness potential and seasonal wetlands



Yellow fever research

icipe's goal is to identify and assess the risk of transmission and outbreaks of yellow fever in parts of Kenya classified in the World Health Organization's International Health Regulations (IHR) (2005) as being at high and medium risk for yellow fever transmission.

> "We aim to establish and maintain focused surveillance activities of yellow fever towards recommending an affordable vaccination strategy based on scientific evidence."
>
> *Dr Rosemary Sang, Consultant Scientist*

Ongoing studies

- Surveillance targeting vectors, and primate and human samples.
- Evaluation and analysis of ecological parameters.
- Sample screening and confirmation using virological tools.
- Vectorial capacity experiments.
- Data entry and analysis.

Yellow fever

Yellow fever is an acute viral haemorrhagic disease transmitted by infected mosquitoes of the *Stegomyia* subgenus. The first ever outbreak of yellow fever in Kenya occurred between 1992 and 1995. This outbreak was controlled through mass vaccination in 1993, which was repeated in 2003. Routine vaccination has been instituted only in five of the affected districts. Yellow fever endemicity, maintenance mechanism, vector ecology, and the possible role of epizootic cycles remain unresolved in Kenya; thus, it is difficult to prioritise vaccination preventive measures in a cost-effective manner.

Sampling for yellow fever.

Neglected tropical diseases and emerging infectious diseases research partners:

Ministry of Agriculture, Livestock and Fisheries, Kenya; Umeå University, Sweden; Swedish University of Agricultural Sciences (SLU); Division of Disease Surveillance and Response, Ministry of Public Health and Sanitation, Kenya; University of Nairobi, Kenya; Kenya Medical Research Institute (KEMRI); Kenya Wildlife Service (KWS); Institute of Primate Research, National Museums of Kenya.

ANIMAL HEALTH THEME

The *icipe* Animal Health Theme focuses on the development of integrated strategies and tools for control of vectors of animal diseases, to enhance livestock health and productivity; and ultimately, the livelihood of farmers. Research activities are geared towards detailed understanding of vector behaviour, population ecology, and vector–host and vector–parasite interactions. Current research is on tsetse flies (vectors of trypanosomiasis, which is known as nagana in animals), and ticks (which, among other diseases, transmit East Coast fever).

16
Postgraduate students

2000
Cows currently protected with the *icipe* tsetse repellent collar

Donors: Biovision Foundation for Ecological Development, Switzerland; Consortium for National Health Research (CNHR), Kenya; UK Aid, UK Government; European Union; German Research Foundation (DFG); *icipe* core donors; International Atomic Energy Agency (IAEA); Swedish International Development and Cooperation Agency (Sida); National Science Foundation (NSF), USA; United States Agency for International Development's Partnerships for Enhanced Engagement in Research (USAID-PEER) programme; The Wellcome Trust, UK.

Tsetse and trypanosomiasis research

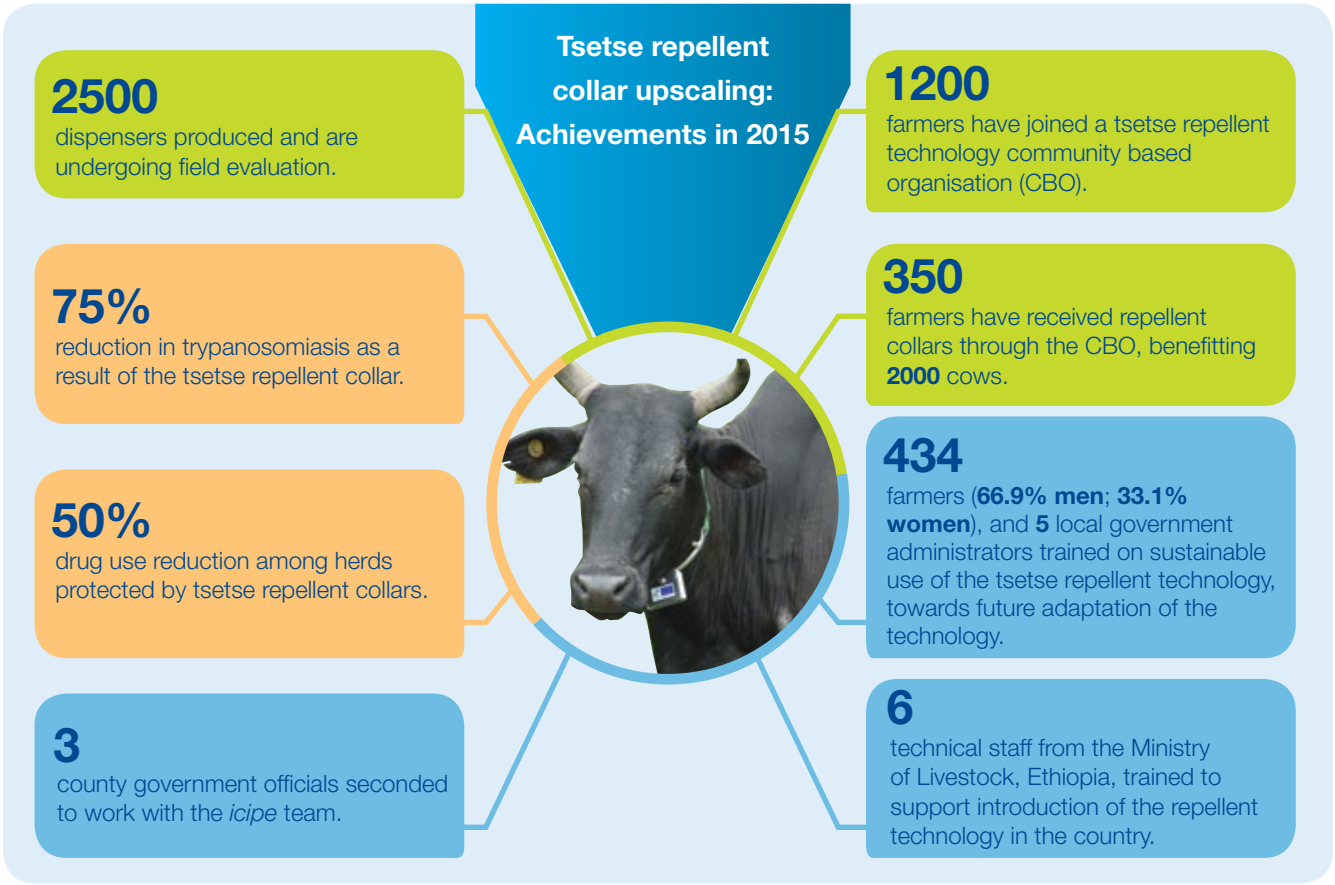
Tsetse flies, which are unique to Africa and occur in 36 sub-Saharan African (SSA) countries, are the main vectors of trypanosome parasites that cause trypanosomiasis (known as nagana in animals). The overall negative economic impact of nagana on the agriculture and livestock sectors is estimated at USD 4.75 billion per annum. Nagana also has implications for food security and for socio-cultural aspects, as livestock are interlinked with health, wealth, and social status in many communities.

Tsetse repellent collar technology

Over the past years, *icipe* has developed an innovative repellent collar technology for the control of savanna tsetse flies and trypanosomiasis. The collars contain a blend of chemicals identified from waterbuck, an animal that is present in tsetse fly infested areas but which is not fed on by the flies. Worn around the neck of cattle, the repellent collars provide substantial protection to cattle.

Through the Integrated Biological Control Applied Research Programme (IBCARP) funded by the European Union (EU), *icipe* is collaborating with private sector partners to scale-up the mass production and rollout of the tsetse repellent collar to tsetse-infested countries in Africa. The repellent technology is also being evaluated for riverine tsetse, the vectors of human sleeping sickness. Further, *icipe* is investigating the incorporation of repellents in push–pull strategies for more cost-effective barriers to stop flies from reinvading tsetse-controlled areas, which is a major hindrance in the sustainable control of tsetse and trypanosomiasis. Like waterbuck, zebras are not fed upon by tsetse flies, thus the semiochemical basis of this refractoriness is being investigated.

New commercialisation partner: In 2015, *icipe* made a collaborative arrangement with a private sector partner in Europe for the research and development, and scale-



up of the tsetse repellent collar. This partnership has led to identification of new suitable material that has been used to develop prototypes, which are now undergoing further research to support the development of new cheaper repellent collar dispensers.

Technology upscaling: Pending the new dispensers, *icipe* has commissioned a local entrepreneur to produce the Centre's current dispensers, which are now available to farmers at a lower cost. In Kenya, *icipe* has started up-scaling the repellent technology in five locations in Shimba Hills along the Coast and soon similar upscaling will be undertaken in Ethiopia.

African trypanosomes swimming

The ability of trypanosomes to travel in the body fluids (and also in the tsetse) is essential to the survival of the parasite. Their movement is generated by the beat of the flagellum, a whip-like appendage attached to their surface.

> "African trypanosomes are incessant swimmers. They do not stop, and are constantly moving in the bloodstream and tissue spaces of mammalian and tsetse fly hosts. Their continuous movement is thought to be part of a survival strategy. *icipe*'s goal is to understand the movement of trypanosomes as a way of developing novel control tools for trypanosomiasis."

Dr Joel Bargul, Postdoctoral Fellow, Molecular Biology, Bioinformatics, and Biostatistics Unit

It is thought that, as a result of the force generated as the parasite moves through the blood, antibodies from the host that are attached to the surface are taken to the flagellar pocket and internalised. Once inside the parasite, they are degraded, and the components recycled for use; therefore, understanding the movement of trypanosomes could provide information towards developing novel control tools for diseases.

In 2015, *icipe* completed a study to compare and characterise the movement and behaviour of four trypanosome species that infect livestock, namely *Trypanosoma vivax*, *T. brucei*, *T. evansi,* and *T. congolense*. Although the mechanism that propels the flagellar is the same in all trypanosome species, *icipe*'s research, in collaboration with the University of Würzburg, Germany, established that different species have distinct swimming patterns, speeds, and flagellar wave frequencies.

The Centre's research also showed that cell morphology and motility in trypanosomes is a species-specific adaptation that could determine the ability of the parasites to populate specific tissues in the mammalian host. The preliminary data also suggests that the ability to clear antibodies is similar in all trypanosomes, irrespective of the significant variations in swimming speeds.

Tsetse fly genes identified

In 2015, *icipe* published findings identifying the genes responsible for chemical sensing in tsetse. The researchers reported their surprising discovery that although tsetse fly species differ in their responses to animal odours, they all use the same set of genes to find hosts (humans or animals) on which to feed.

Because tsetse use chemical sensing to survive (to find food, places to lay their larvae, and mates, as well as to escape from enemies), these results indicate a possible way to manipulate their behaviour, and to design appropriate control strategies.

Tsetse and trypanosomiasis research partners:

University of Würzburg, Germany; University of Maryland, USA; Mount Kenya University, Kenya; University of the Western Cape, South Africa; Yale University, USA; Biotechnology Research Institute, Kenya Agricultural and Livestock Research Organisation (KALRO).

Camel trypanosomiasis

Camel trypanosomiasis (commonly known as surra) is a non-tsetse-transmitted animal trypanosomiasis, which results from infection by mostly *Trypanosoma evansi.* The disease is debilitating and a major cause of morbidity of up to 30%, and a mortality of around 3% in camels. Estimates of direct impact of the disease are over USD126 million annually.

There is limited understanding of the actual vectors involved in surra transmission, and no vector control technologies are available. There is also poor diagnosis of the disease, as well as increasing resistance to drugs. In many cases, animals are simply allowed to die when they become infected with surra.

Activities in 2015

Through the Integrated Biological Control Applied Research Programme (IBCARP) funded by the European Union (EU), *icipe* activities:

- Started with the recruitment of relevant staff and establishment of three monitoring sites in Kenya, leading to acquisition of baseline data.
- Next, sentinel camel herds were recruited in these sites, and basic screening for identification of the vectors involved in the transmission of trypanosomes, and the disease status in camels started.

> *icipe*'s objective is to develop effective attractant and repellent management technologies for biting flies that transmit surra similar to those we have developed for tsetse flies.
>
> *Dr Rajinder Saini, Principal Scientist, Animal Health Theme*

Camel trypanosomiasis research partners:

University of Würzburg, Germany; University of Maryland, USA; Mount Kenya University, Kenya

Zoonotic diseases

Zoonotic diseases are infectious diseases of animals that can be transmitted to man. These diseases can be caused by viruses, bacteria, parasites, and fungi. They are transmitted through coming into contact with fluids such as blood, saliva, and urine, or through eating and drinking food contaminated with faeces from an infected animal, or through the bite of an infected arthropod vector, often a tick or a mosquito.

icipe aims to develop approaches that interrupt transmission or interfere with vector survival through studies of vector ecology and vectorial capacity, genetics and genomics, and response to host odours in terms of attraction and repellency.

Ending bushmeat trade

In East Africa, illegal bushmeat trade is a severe problem, with adverse impact on wildlife conservation efforts as well as the transmission of zoonotic diseases. In 2015, with support from the USAID-PEER programme, *icipe* started a project to contribute towards ending bushmeat trade in the region. The initiative:

- Builds on a recent approach that is unique and cost-effective (the high resolution melting analysis) that was developed by *icipe* for rapid identification of diverse blood-meal host DNA sequences in blood-fed mosquitoes.
- Will adapt this tool to provide the forensic evidence required to prosecute wildlife and bushmeat traders, and facilitate large-scale surveillance of wildlife products.
- Will monitor changes in vector blood-feeding patterns, before and after wildlife translocations, to identify potential impact on disease transmission.

Zoonotic diseases research partners:

Kenya Wildlife Service; Tanzania National Parks; National Museums of Kenya; Smithsonian Institution, USA.

Improving Somaliland milk value chain

Somaliland has a large livestock resource base consisting of camels, cattle, sheep, and goats, which are primarily raised for meat and milk. Although there is increasing demand for these products in the country, a number of constraints exist in the value chain. These include scarcity of fodder, animal health problems, inadequate support services, low technical capacity, low governance and coordination mechanisms, low phyto-hygienic standards or processes to obtain quality milk, poor infrastructure, and high temperature and humidity, which lead to rapid spoilage and reduced milk quality.

icipe is leading a multidisciplinary team, including the Food and Agriculture Organization of the United Nations (FAO) and the Somaliland Ministry of Livestock, with the support of the European Union (EU), which aims to address challenges along the milk value chain, through the provision of training, as well as capacity and infrastructure development, together with community engagement and education.

> "Our objective is to enhance the Somaliland milk value chain through research and development, capacity building, and strengthening governance and rehabilitation of the milk market, to increase income generation and employment for actors along the value chain, especially women and youth, and to reduce food insecurity."

Dr Chris Prideaux, Director of Research and Partnerships

icipe's primary research and development focus within the project is on farm activities that help increase the health status of animals, as well as address the availability, and nutritional content of food and fodder. During 2015, many of the project activities were hampered by an extensive drought that impacted much of the region, which also served to intensify the need for animal food and fodder, and effective health interventions.

Activities in 2015

- *icipe* started to disseminate in Somaliland, its highly innovative push–pull technology, which among other benefits, also provides high quality fodder.

  The climate-smart push–pull technology has been well-received in the country, because of the drought-tolerant nature of *Brachiaria*, a type of fodder grass that is used as an intercrop in the technology.

- The Centre tested and disseminated a bioacaricide derived from *Metarhizium anisopliae* for tick control.

- *icipe* started activities to scale up the Centre's technologies to control biting flies and surra in camels, in collaboration with 2000 pastoralists.

- The Centre set up a Geo-Information Unit within the Ministry of Livestock in Somaliland and commenced on training of local project staff. As a result, a satellite-derived map was produced, showing areas where the invasive plant *Prosopis juliflora* is most prevalent within agropastoral villages and rangelands.

  The Ministry of Livestock of Somaliland can use this map to identify areas where interventions to mitigate the expansion of this invasive species are more meaningful and effective.

Improving Somaliland milk value chain research partners:

Food and Agriculture Organization of the United Nations (FAO); Ministry of Livestock, Somaliland; Gollis University, Somaliland.

Profile:

DAN MASIGA, INTERIM LEADER OF THE HUMAN HEALTH AND ANIMAL HEALTH THEMES

Dr Dan Masiga is *icipe*'s Interim Head of Human and Animal Health Themes, overseeing the Centre's vision towards promoting the One Health concept. He is also Head of the *icipe* Molecular Biology, Bioinformatics, and Biostatistics Unit (MBBU).

Dr Masiga holds a BSc in biochemistry and zoology from the University of Nairobi, Kenya, an MSc in biochemistry and molecular biology from the University of London, UK, and a PhD in molecular parasitology from the University of Bristol, UK.

With initial research interest in trypanosomiasis, Dr Masiga worked at the Kenya Trypanosomiasis Research Institute (KETRI). He undertook postdoctoral training at the University of Glasgow, Scotland, UK, where he extended his interests to trypanosome genetics and genomics. In 1997, he was awarded a research grant by the International Foundation for Science (IFS), which enabled him to conduct groundbreaking research on African trypanosomes risk in small ruminants (e.g. cattle, sheep, and goats). As a result of this study, in 2011, Masiga was awarded the IFS-Danida Award for sub-Saharan Africa, which honours researchers who have made noteworthy achievements associated with research work supported fully or in part by IFS. Masiga was the first Kenyan to receive the award.

As leader of MBBU, he and his team provide molecular genetics tools (including DNA, RNA and protein analysis) across *icipe*'s research projects. The Unit also develops its own research; for instance, towards understanding the ecology of plant and animal diseases, and studies in the fields of population genetics, molecular diagnostics, genomics, and bioinformatics. In particular, MBBU's studies focus on malaria, trypanosomiasis, leishmaniasis, and arboviruses.

One of MBBU's major achievements is its contribution to the successful completion, in April 2014, of the mapping of the genome of the tsetse species *Glossina morsitans morsitans*. This milestone was achieved through a 10-year project led by the International Glossina Genome Initiative (IGGI), which brought together more than 150 researchers from nearly 100 institutions across the world. MBBU was instrumental in the description of the sensory

genes; which, in this and other tsetse species, are responsible for guiding interactions between the flies and their environment. It is anticipated that the knowledge on the genome of *G. morsitans morsitans* will contribute towards developing tools for the control of tsetse flies and the diseases they transmit. Key worldwide recognition for this research includes its publication in the prestigious journal *Science* (prominently featured on the cover page of the 25 April 2014 issue), and publication of several satellite papers in the *PLoS* family of journals.

The department has trained over 40 MSc and 15 PhD scholars, most of whom have moved on to become science leaders. On average, the Unit publishes 20 papers in respected peer-reviewed journals each year.

Dr Masiga hopes to use his experience with the aim of bringing more cohesion in the development of strategies to address disease challenges in people and animals.

PLANT
HEALTH THEME

The *icipe* Plant Health Theme aims to support agricultural production in Africa, towards improved food security, human and environmental health, and household and national economies. The Centre endeavours to achieve these goals through integrated pest management (IPM) options for pre- and postharvest pests, and for parasitic weeds. *icipe*'s IPM strategies and technologies eschew the use of the often-expensive and harmful pesticides; utilising instead, biological control, biopesticides, and habitat management strategies.

144,200
Farmers using *icipe*'s push–pull and fruit fly IPM technologies

117
Postgraduate students

76
Journal articles

Donors: Biotechnology and Biological Sciences Research Council, UK, through Rothamsted Research, UK; Biovision Foundation, Switzerland; Canadian Government through International Development Research Centre (IDRC) and Grand Challenges Canada (GCC); Humidtropics CGIAR Research Programme (CRP) led by IITA; UK Aid, UK Government; European Union; Federal Ministry for Economic Cooperation and Development (BMZ), Germany; Food and Agriculture Organization of the United Nations (FAO), Italy; International Atomic Energy Agency (IAEA), Austria; International Fund for Agricultural Development (IFAD), Italy; Liechtenstein Development Service (LED), Principality of Liechtenstein; McKnight Foundation, USA; National Commission for Science, Technology and Innovation (NACOSTI), Kenya; Russell IPM Ltd, UK; Swedish International Development Cooperation Agency (Sida); Swiss Agency for Development and Cooperation (SDC).

Fruit fly IPM

The *icipe* fruit fly integrated pest management (IPM) programme, which is funded by a range of development partners, aims to address the key constraints to fruit production, using a combination of complementary interventions consisting of spot application of food baits, male annihilation technique, application of biopesticides, releases of parasitoids, and use of the augmentorium for orchard sanitation and parasitoid conservation.

Activities in 2015

icipe continued to up-scale its IPM packages in Kenya, Tanzania, Mozambique, Botswana, Namibia, Zambia, Zimbabwe, and Uganda, while also introducing the technologies in Ethiopia for the first time.

2000 litres of Dudulure® produced and packaged in a pilot facility, and distributed to 1000 growers.

3 product commercialisation agreements signed with:

- Real IPM Limited for the commercialisation of various biopesticides.
- Kenya Biologics Limited for construction of a Dudulure® manufacturing facility.
- Russell IPM for the demonstration and commercialisation of Zonatrac, a male attract-and-kill system, and Ceranock, a female attract-and-kill system.

612 extension and quarantine officers, as well as mango growers trained on various aspects of fruit flies management, 44% of them females.

4623 fruit growers trained on monitoring and management of fruit flies in 2015 alone.

40 IPM learning sites set up in Kenya for fruit fly monitoring, using traps and analyses of fallen fruit.

Fruit fly IPM starter kits consisting of 680 litres of protein food bait, 3908 traps, 7816 ME cotton wicks, and 80 augmentoria distributed to fruit growers.

21,522 mango growers were using the *icipe* fruit fly IPM technologies at the end of 2015.

In preparation for the implementation of the fruit fly IPM in Ethiopia, an agreement has been signed with Hawassa University, Ethiopia.

56,200 wasp parasitoids of two fruit fly species, including 33,300 *Fopius arisanus* and 22,900 *Diachasmimorpha longicaudata* were released in Kenya. *Fopius arisanus* was also released in Burkina Faso and the Comoros to suppress *Bactrocera dorsalis*.

In a global first, *icipe* designed novel primers to identify endosymbionts in African fruit flies. Of particular interest was the discovery of *Spiroplasma* species that are entirely new to science in both native and exotic species.

Progress was made in the development of postharvest treatment of mangoes that meets the Probit-9 requirement, which is a measure of efficiency of postharvest disinfestation treatment required to ensure quarantine security to enable access of produce to export -sensitive markets.

Fruit fly IPM adoption and impact assessment studies

In 2015, several impact assessment studies were conducted on the *icipe* fruit fly IPM package.

Adoption of mango fruit fly IPM package: The study showed that 58.5% of mango growers in Embu County, Kenya, had adopted at least one component of the fruit fly IPM package. This suggests a high uptake of the technology since it was rolled out.

Socio-economic characteristics likely to influence intensity of adoption of the fruit fly IPM package include education of the household head, number of mature mango trees planted, record keeping skills, and farmer participation in IPM training at demonstration sites.

Economic impact of mango fruit fly IPM: The study was conducted in Embu and Meru counties in Kenya, and showed that the *icipe* IPM strategies have led to reductions in mango losses by 19–54% and expenditure on synthetic pesticides by 17–46%, leading to an increase in the income of mango growers by 22–48%.

An **impact assessment study based on expert opinion** revealed that IPM research and dissemination in Kenya can generate economic benefits (net present value) in the range of USD11.2–114.7 million and reduce the number of rural poor people living below the poverty line by 0.5–4.7% by 2026, assuming that the packages are implemented in 50% of the country's mango production regions.

Assessment of spillover benefits of mango fruit fly IPM on other crops (besides mango) that are attacked by the invasive fruit fly *Bactocera dorsalis* and other mango infesting tephritids showed an increase in returns from pawpaw and citrus.

The findings support investment in the development and dissemination of IPM technologies for suppression of mango fruit flies and participatory IPM strategies.

Ms Euphemiah Miroyo, an enumerator in the *icipe* Social Science and Impact Assessment Unit conducting a survey on the Centre's Fruit Fly IPM in a farmer's field in Kenya.

Towards developing citrus IPM

In 2015, *icipe* and partners launched the Strengthening Citrus Production Systems through the Introduction of IPM Measures for Pests and Diseases in Kenya and Tanzania (SCIPM) project, which is funded by the Federal Ministry for Economic Cooperation and Development (BMZ), Germany. Two of the most serious pests of citrus are the African citrus triozid (ACT) and the false codling moth (FCM). In addition to direct damage, ACT also transmits a devastating bacterium known as *Candidatus* Liberibacter africanus (CLaf), which is responsible for the citrus greening disease or huanglongbing (HLB).

> "The aim of SCIPM is to address the problem of insect pests and diseases constraining the production of citrus fruits in Kenya and Tanzania."
>
> *Dr Sunday Ekesi, Head, Plant Health Theme*

The SCIPM project was officially launched during a kick-off meeting held on 20 and 21 April 2015 at *icipe*, attended by over 20 participants, including all project partners. Participants reviewed and prioritised the project objectives and activities, and developed and assigned operational workplans, timelines and responsibilities for each activity.

Activities in 2015

- Studies by *icipe* and partners have indicated that ACT is more abundant at mid and high altitude regions in Kenya. FCM infestation is widespread across low, mid and high altitudes.

  Ongoing surveys in Kenya and Tanzania have yielded various populations of ACT and FCM, and the researchers are now conducting molecular analyses to establish their genetic diversity.

  The Centre has also established a vibrant colony of ACT on *Murraya koeinigii* seedlings to faciliatate bioecological studies. The Centre will also establish an FCM colony for similar studies.

- The researchers have collected plant samples from suspected symptomatic trees for molecular analysis, to ascertain HLB disease incidence and severity. DNA of leaf samples is being extracted and will be analysed to detect the presence of CLaf and/or CLas bacteria.

  The Centre also commenced studies in regard to ACT vector competency. Using earth observation tools, citrus production locales are being mapped alongside ongoing survey activities.

A researcher monitors an *icipe* food bait trap installed in a fruit orchard for catches of dead fruit flies.

- Preliminary assays on ACT have been conducted to facilitate more detailed studies on the pest's response to plant volatiles and establish any evidence of sex pheromone in the pest. Initial results indicate that the pest is attracted to citrus leaves.

- Results also indicate that FCM is susceptible to entomopathogenic fungi; thus, a dossier has been submitted to the Kenya Plant Health Inspectorate Service (KEPHIS) towards introducing and testing the biopesticide against FCM in Kenya.

- A viral based response of 12 improved cultivars of citrus to ACT and HLB is being evaluated.

- Activities on baseline data collection related to farmers' knowledge, attitudes and practices (KAP) have been initiated, as well as economic impact assessments of ACT, HLB and FCM on citrus production, and potential impact of IPM interventions.

- A training-the-trainer workshop attended by 11 project partners was organised in April 2015. The training included taxonomy and identification of ACT and greening disease, use and application of monitoring tools, and protocols for bioecological studies. Two sites in Kenya and Tanzania have been identified as potential citrus IPM learning sites.

Citrus greening disease symptoms include leaf mottling, as captured in this picture.

Fruit fly IPM research partners:

Center for Development Research (ZEF), University of Bonn, Germany; Texas A&M University, USA; Citrus Research International, South Africa; Kenya Plant Health Inspectorate Service (KEPHIS); Kenya Agricultural and Livestock Research Organisation (KALRO); University of Nairobi, Kenya; Ministry of Agriculture, Food Security & Cooperatives (MAFSC), Tanzania; Mikocheni Agricultural Research Institute, Tanzania; Real IPM Ltd, Kenya; Anglican Development Services (ADS), Kenya; Kenya Biologics Ltd; Ethiopian Institute of Agricultural Research (EIAR); Ministry of Agriculture, Livestock and Fisheries offices in Embu, Machakos and Meru, Kenya; farmer groups in target locations; mango growers in Kenya; Royal Museum for Central Africa, Tervuren, Belgium; Division of Plant Industry, Florida Department of Agriculture and Consumer Services, USA; Institute of Organic Chemistry and Biochemistry, Academy of Sciences of the Czech Republic; Sokoine University of Agriculture, Tanzania; Ministries of Agriculture of Botswana, Namibia, Zambia and Zimbabwe; Humidtropics CGIAR Research Programme (CRP) led by IITA; International Center for Tropical Agriculture (CIAT); International Potato Center (CIP); International Livestock Research Institute (ILRI); World Agroforestry Centre (ICRAF); Bioversity International; International Water Management Institute (IWMI); World Vegetable Center (AVRDC); Wageningen University, The Netherlands; Forum for Agricultural Research in Africa (FARA); University of Nairobi, Kenya; Moi University, Kenya; national agricultural research institutes (NARS); non-governmental organisations (NGO); private sector partners.

Vegetable IPM

There is need to increase vegetable yields, to improve nutritional security, household incomes, and national economies in Africa. However, a variety of factors constrain the production of vegetables. These include insect pests, which reduce yield by attacking crops or cause indirect losses by transmitting viral diseases. Some are quarantine pests, resulting in rejection of produce from Africa in export markets.

Thrips IPM project phase II concluded

Thrips (such as *Frankliniella occidentalis* and *Thrips tabaci),* and thrips-transmitted tospoviruses (such as *Iris yellow spot virus* and *Tomato spotted wilt virus*), cause losses ranging between 20–80% in vegetables. In 2015, *icipe* concluded phase II of a project funded by the Federal Ministry for Economic Cooperation and Development (BMZ), Germany and the African Union (AU), to develop and implement an IPM strategy for thrips and tospoviruses. Focus was on effective thrips monitoring, use of entomopathogenic fungi and/or botanicals, intercropping, host plant resistance, plant endophytes, and improved biopesticide application strategies.

> *icipe* has developed an IPM strategy for thrips and tospoviruses, and built the capacity of researchers, agricultural extension officers, and farmers to implement it.

Dr Sevgan Subramanian, Scientist, Plant Health Theme

Dr Johnson Nyasani explaining to farmers about some of the thrips management technologies developed by *icipe*.

Activities in 2015

- Focus was on scaling-up dissemination activities through large-scale field demonstrations in key vegetable production regions in Kenya, in leading farmers' fields, in partnership with Ministry of Agriculture extension officers. Locally-adapted biocontrol-compatible IPM technologies, for instance interplanting thrips-repellent crops, practising crop rotation and early planting to evade thrips outbreaks, seed treatments against early season pests, using *Metarhizium* biopesticide, conserving natural enemies, spot-spraying, and using agronets, were promoted.

- Demonstration fields served as learning sites, leading to capacity building of ToT trainers, 414 lead farmers, 57 extension officers, 7 research officers and 7 plant inspectors, on thrips and tospovirus management.

- A partnership with thrips semiochemical experts from Keele University was established, leading to the identification of a bean flower thrips aggregation pheromone with commercial potential.

- Improved strategies for application of biopesticides, (such as autodissemination and spot spray application) were developed, which have attracted the attention of private and public sector stakeholders.

- An end-of-project meeting involving partners, government ministries, national agricultural research institutes, and the private sector has led to potential new public–private partnerships that could, for instance, support the commercialisation of the autodissemination strategy and the bean flower thrips pheromone.

- *icipe has* developed capacity building for thrips research in the region.

African indigenous vegetables IPM

Although overlooked for many years, African indigenous vegetables (AIVs) present a significant opportunity for uplifting the continent's nutrition.

> *icipe* aims to contribute towards translating the renewed interest in AIVs into reality, by developing IPM strategies to address the constraints in their cultivation, primarily focusing on amaranth, leafy cowpea, and nightshades.
>
> *Dr Komi Fiaboe, Scientist, Plant Health Theme*

Activities in 2015

With funding from the Federal Ministry for Economic Cooperation and Development (BMZ), Germany, *icipe* conducted the following activities:

- Researchers selected the Centre's *Metarhizium anisopliae* entomopathogenic fungal isolate ICIPE 62 as the best biopesticide to incorporate into an IPM for AIVs based on laboratory, greenhouse and field trials.

- Field studies revealed that lepidopteran defoliators of amaranth are seasonal, with sporadic outbreaks. Because low field parasitism rates are recorded, and based on successful parasitoid colony rearing techniques developed at *icipe*, conservative and augmentative biological control are being included in an IPM package against these pests.

- Scientists discovered *a* new species of *Cotesia* that is efficient under laboratory conditions against leaf webbers and leafworms.

- A socio-economic study on farmers' knowledge, attitudes and practices in regard to IPM and other AIV production measures in Kenya identified pest and disease infestation as the most important challenge to the production and marketing of AIVs, contributing a considerable amount of pre- and postharvest losses.

- While past studies have shown minimal use of inputs in AIVs production, over 70% of the farmers interviewed in the *icipe* study reported that they use pesticides. This suggests the need to promote alternative pest and disease management strategies with minimal impact on human health and on the environment, such as IPM.

A young amaranth crop planted as part of *icipe*'s research on this indigenous vegetable.

Tomato cultivation is a key livelihood option for small-scale farmers in Africa.

Tuta absoluta IPM

Tuta absoluta is a harmful leafminer moth with a strong preference for tomato, but which also attacks other crops such as eggplant, pepper, potato, and nightshades.

> *icipe* and partners aim to develop, test and adapt an IPM strategy for *T. absoluta*, to increase tomato production and the incomes and nutrition of small- and medium-scale tomato growers in Tunisia, Sudan, Kenya, Republic of South Sudan, and Uganda.

Dr Samira Mohamed, Scientist, Plant Health Theme

Activities in 2015

With funding from the Federal Ministry for Economic Cooperation and Development (BMZ), Germany, *icipe* activities included:

- A survey, which showed that *T. absoluta* is spreading across sub-Saharan Africa. The researchers detected the pest in Uganda, and observed its heavy infestation on nightshade, *Solanum nigrum,* which is an important African indigenous vegetable in Kenya.
- An efficient larval parasitoid of the *Dolichogenidea* genus was identified in its aboriginal home Peru, and a colony initiated for further studies at the International Potato Centre in the country. Based on encouraging results of the performance of the parasitoid against *T. absoluta*, a dossier has been submitted to the Kenya Plant Health Inspectorate Service (KEPHIS) for its importation to Africa.
- Researchers found that two of the Centre's *Metarhizium anisopliae* isolates, ICIPE 18 and ICIPE 20, are pathogenic against *T. absoluta*. The baculovirus, *Tuab*GV granulovirus, originally isolated from *T. absoluta,* and the *Phop*GV-Huancayo showed high biological activity against *T. absoluta* with high stability 7 days post-treatment under laboratory conditions. The efficiency of five medicinal plants against *T. absoluta* is also being tested.
- *icipe* has identified a wild tomato, *Lycopersicon esculentum* var. *cerasiforme*, which is resistant to *T. absoluta* infestation.
- The Centre has trained 63 (51% female) extension and quarantine personnel in Sudan on *T. absoluta* monitoring, management, and taxonomy. Information on *T. absoluta* has also been disseminated to 170 farmers in the country.

Up-scaling DBM IPM

The diamondback moth (DBM), *Plutella xylostella* L., is a key pest of cabbage, kale and other cruciferous crops; and it can cause up to 100% yield loss.

Previously, *icipe* implemented an effective integrated pest management (IPM) strategy for controlling DBM in Kenya, Tanzania, Uganda, Ethiopia, and Cameroon. Following this success, and with funding from the International Fund for Agricultural Development (IFAD), *icipe* is scaling-up the IPM technologies to four countries: Mozambique, Malawi, Rwanda, and Zambia.

Management technologies include interplanting crucifers with DBM-repellent crops (such as onion and pepper), practising crop rotation, practising early planting to evade DBM population peak, removing crucifer vegetable stumps immediately after harvesting, using neem extracts or the naturally-occurring soil bacterium *Bacillus thuringiensis* (Bt), spot-spraying, and using biological control agents (releases and conservation of parasitoids, and conservation of ladybird beetles as a means of controlling aphids).

So far, the researchers have observed a reduction in pesticide spraying, and in general, better management of crucifer pests, even among resource-poor farmers.

Additionally, the Centre has made progress in convincing agro-dealers to market biocontrol-compatible IPM technologies such as Bt.

A thriving cabbage plot in Wundanyi, coastal Kenya, where *icipe* implemented its DBM integrated pest management strategies.

Vegetable IPM research partners:

University of Hannover, Germany; Martin Luther University of Halle-Wittenberg, Germany; Plant Research International, Wageningen University, The Netherlands; Kenya Agricultural and Livestock Research Institute (KALRO); Makerere University, Uganda; The World Vegetable Centre (AVRDC); Horticultural Research and Training Institute (HORTI-Tengeru), Tanzania; The University of Rwanda; Eduardo Mondlane University, Mozambique; Zambia Agriculture Research Institute (ZARI); Department of Agricultural Research Services (DARS), Malawi; The International Potato Center (CIP); Julius Kühn Institute Federal Research Institute for Cultivated Plants (JKI), Darmstadt, Germany; Higher Agronomic Institute of Chott-Meriem, Tunis, Tunisia; University of Sousse, Tunisia; Arid Regions Institute, Tunisia; Agricultural Research Corporation (ARC), Sudan; Ministry of Agriculture and Forestry, Government of South Sudan; Kenya Plant Health Inspectorate Service (KEPHIS); Ministry of Agriculture, Animal Industry and Fisheries, Uganda.

Push–pull IPM

The *icipe* push–pull technology

Push–pull is a platform technology developed over the past 20 years by *icipe* in collaboration with Rothamsted Research, United Kingdom, and partners in eastern Africa. This simple cropping strategy simultaneously addresses the five key constraints of cereal–livestock mixed production systems in Africa—insect pests (stemborers), the parasitic weed *Striga* (and other weeds), poor soil fertility, soil moisture management, and the need for high quality livestock feed.

Push–pull technology involves intercropping cereals with a pest repellent plant, such as *Desmodium*, which drives away or deters stemborers from the target food crop. An attractant trap plant, for instance, Napier grass (*Pennisetum purpureum*), is planted around the border of this intercrop, to attract and trap the pests. As a result, the food crop is protected from the pests. In addition, *Desmodium (D. uncinatum* or *D. intortum)* stimulates suicidal germination of *Striga* and inhibits its growth. Push–pull also has significant benefits for dairy farming, since desmodium and Napier grass are high quality animal fodder plants. *Desmodium* improves soil nitrogen, phosphorous, carbon, and biodiversity. It conserves soil moisture and adds organic matter, thus enhancing the soil's capacity to sequester carbon. Over the past five years, *icipe* and its partners have developed a climate-smart version of push–pull to extend its application to drier areas of the continent, and in relation to the increasingly dry and hot conditions associated with climate change. The climate-smart push–pull uses drought-tolerant repellent and trap crops, greenleaf desmodium (*Desmodium intortum*) and *Brachiaria* cv Mulato, as intercrop and border crops, respectively.

In recent years, *icipe* and partners have made a breakthrough in developing knowledge on the Napier stunt disease (NSD), which inhibits the growth of the grass or kills it altogether. In addition to being a key component of push–pull technology, Napier grass is an important crop, with over 80% of smallholder dairy systems relying on it as the main source of cattle fodder. *icipe* has identified two NSD-resistant grass varieties, Ouma2 and South Africa, which are now being disseminated to farmers.

In Africa's predominantly mixed crop–livestock farming systems, cereals, which include maize, sorghum, millet and rice, are the main staple and cash crops for millions of households.

In 2015, with support from a range of development partners (see cover of Plant Health Theme), *icipe*'s emphasis was on enhancing sustainable uptake of the push–pull technology. The Centre also intensified documentation, and monitoring and evaluation of gender inclusiveness in all aspects. In addition, the researchers continued laboratory and field based research, to augment the technology.

> *icipe*'s push–pull IPM simultaneously addresses the key constraints in the production of cereals in Africa, which include insect pests, notably stemborers, the parasitic weed *Striga,* and poor soil fertility.
>
> *Prof. Zeyaur Khan, Principal Scientist and Head, Push–Pull Programme*

Upscaling push–pull and its benefits in 2015

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Countries in Africa where push–pull is now being used:

In 2015, *icipe* and partners expanded the regional reach of push–pull, with the technology now being used by farmers in Kenya, Tanzania, Uganda, Ethiopia, Nigeria, Malawi, and Zambia.

122,650

Farmers using the push–pull technology by end of 2015:

New farmers (26,650) adopted push–pull, 62% of them female. Of the total push–pull users, 54,121 have adopted the climate-smart version. At least 10,000 farmers have adopted an integrated approach to NSD, including using NSD-resistant cultivars developed by *icipe*, known as Ouma2 and South Africa.

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New partnerships established with:

One Acre Fund; Plantwise, a CABI-led initiative; World Vision; Send a Cow; Project Concern International; African Conservation Tillage Network; Lilongwe University of Agriculture and Natural Resources; Total LandCare; Kasisi Agricultural Training Centre, Zambia; Seed Co Limited, Zimbabwe; East African Seed Company; Tigray Agricultural Research Institute; and Ministry of Agriculture, Ethiopia.

3186

Push–pull farmers have started new dairy enterprises

In addition to the direct benefits of the push–pull technology, farmers are benefiting from a range of economic initiatives being developed by *icipe* and partners around the technology. They include dairy cow and goat projects that have been initiated with support from Heifer International, Send a Cow and World Vision, with 3186 farmers involved.

Better availability of push–pull inputs

icipe and partners have intensified efforts to strengthen and improve access to push–pull inputs, including *Desmodium* seed, Napier, and *Brachiaria* planting materials. The key activities in this regard are presented below.

Partnerships with private sector seed producers: In 2015, *icipe* signed agreements with the East African Seed Company, Kenya, and SeedCo, Zimbabwe, to develop *Desmodium* and *Brachiaria* seed production and marketing systems.

A partnership agreement was signed with the **Ethiopian Institute of Agricultural Research** (EIAR) Seed Unit, for the production of desmodium seeds for Ethiopian farmers.

Contract farmers produced 2.4 tonnes of silverleaf desmodium seed, while those in Ethiopia produced 500 kilogrammes.

A **community-based system** has been instituted to multiply and commercialise the NSD-resistant grass identified by the Centre and partners, and alternative fodder grass.

Enhanced pathways to up-scale push–pull

In 2015, *icipe* and partners developed a range of dissemination pathways to create awareness, and increase the adoption and effectiveness of the push–pull technology, which are discussed below.

Use of drama has been introduced as a push–pull dissemination and uptake pathway. Videos and drama series produced by farmers will become part of the push–pull dissemination tools. Their effectiveness in transferring the technology, and contribution towards knowledge acquisition, retention and sustainable adoption will be assessed continously.

Use of comic books is being incorporated to create push–pull awareness among school children, as a way of reaching their parents. *icipe* is implementing this initiative in collaboration with government ministries and non-governmental organisations. In the pilot phase, 203 primary school pupils (107 males and 96 females) are being targeted.

Participation in **agricultural shows and demonstration fields** in schools has enabled the researchers to reach new farmers, and to provide them with the necessary skills to become involved in push–pull farming.

Farmer research networks (FRN) have been constituted with support from Heifer International, to enable push–pull farmers manage the Napier stunt disease (NSD) that has threatened the sustainability of the technology.

Various **training activities** were conducted, with the Centre reaching 23,850 (12,787 female and 11,063 male) farmers, collaborators and other stakeholders.

Key scientific findings

- **Plant signalling and communication:** *icipe* research revealed the superiority of the innate defence mechanism of maize landraces, the so-called 'smart maize', to stemborers in comparison to some commercial hybrid maize varieties. Stemborers damage the maize crop in their larval stage, triggering a defence reaction from the maize.

  The *icipe* study found that 'smart maize' is able to defend itself from the egg stage of stemborers before they hatch into larvae, pre-empting damage on the crop. This defence mechanism is induced in two ways. First, by a stress compound emitted by neighbouring smart maize plants. Second, if molasses grass is planted next to 'smart maize', it induces a similar defence reaction. These defence traits were absent in commercial hybrid varieties, probably having been lost during crop breeding.

- **Push–pull's role in reducing mycotoxins:** A study of farmer perceptions indicated that the push–pull technology reduces mycotoxin contamination of maize, as it decreases incidence and severity of ear rot diseases, and mycotoxin attack on maize grain. Mycotoxins are toxins produced by fungi that are associated with grains, and if ingested, have health impacts across Africa (they cause cancer, stunting, and death). The Centre is elucidating the mechanisms by which the technology delivers these benefits, to develop frameworks for exploitation of services rendered via cropping systems as components for management of ear rot of maize. Once confirmed, the role of push–pull in combating mycotoxins may be a major breakthrough.

- **Economic and poverty impact assessment** of biological control (parasitoids) of stemborers showed a 31% increase in maize productivity and 22% reduction in the number of poor people in selected maize growing regions in Kenya.

A Push–pull plot at the *icipe* Thomas Odhiambo Campus on the shores of Lake Victoria, western Kenya.

The push–pull field outside the Zentrum Paul Klee, an art museum in Berne, Switzerland. Photo: Biovision Foundation.

Publicity

- **International recognition of push–pull:** In August 2015, a thriving push–pull field in front of the Zentrum Paul Klee, an art museum in Berne, Switzerland, was part of the 'Culture and Agriculture' exhibition.

- **Push–pull featured by the Food and Agriculture Organization of the United Nations (FAO)** in its publication entitled *Save and Grow in Practice: Maize, Rice, Wheat—A Guide to Sustainable Cereal Production* (http://www.fao.org/3/a-i4009e.pdf). **Further, in October 2015, during the 70th meeting of the General Assembly of the United Nations**, the UN Secretary-General tabled a background document (posted on the UN website) on agricultural technology for development, which included *icipe*'s push–pull technology (http://www.un.org/ga/search/view_doc.asp?symbol=A/70/298). The Report examines the current status and trends of agricultural technologies.

  These FAO and UN reports mark an important milestone in the development of push–pull, and reinforce the commitment of *icipe* to develop comprehensive and holistic approaches to address food security.

- ***From Lab to Land—Women in 'Push–Pull' Agriculture*:** Published in 2015, *From Lab to Land—Women in 'Push–Pull' Agriculture* is a publication bringing together the voices of women scientists, agricultural extensionists, and farmers from across eastern Africa. Read more at: http://www.push-pull.net/women_in_push-pull.pdf

- An episode on an **international Science TV series** called 'The Mind of the Universe' was filmed by journalists from the Dutch Public Broadcasting Company, VPRO from 23–24 November 2015, featuring push–pull farmers in Ebukanga Village, Emuhaya District, Vihiga County in western Kenya.

Push–pull IPM research partners:

Agricultural Transformation Agency (ATA), Ethiopia; Bioversity International; Ethiopian Institute of Agricultural Research (EIAR); Forum for Agricultural Research in Africa (FARA); Heifer Project International – Kenya (HPI-K); Heifer Project International – Tanzania (HPI-T); Institute for Sustainable Development (ISD), Ethiopia; International Center for Tropical Agriculture (CIAT); International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); International Institute of Tropical Agriculture (IITA); International Livestock Research Institute (ILRI); Kenya Agricultural and Livestock Research Organization (KALRO); Lake Zone Agricultural Research and Development Institute (LZARDI), Tanzania; Maseno University, Kenya; Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Uganda; Ministry of Agriculture and Natural Resources, Ethiopia; Ministry of Agriculture, Food Security and Cooperatives, Tanzania; Ministry of Agriculture, Livestock and Fisheries Kenya, and county departments of agriculture; Agricultural Sector Development Support Programme (ASDSP), Kenya; National Crops Resources Research Institute, Uganda; Rothamsted Research, United Kingdom; Send-a-Cow; farmers' groups; Wageningen University, The Netherlands; WeRATE; World Agroforestry Centre (ICRAF); World Vegetable Centre (AVRDC).

Staple food crops IPM

Staple foods are those that are eaten regularly, sometimes daily, making up the dominant part of a population's diet, and supplying a major proportion of a people's energy needs. In Africa, the main staple foods in the average African diet are cereals, roots and tubers, and legumes. Small-scale farmers produce most staple crops in a household based subsistence economy, with their production constrained by a variety of factors, such as insect pests.

Maize lethal necrosis research

The recent outbreak and spread of maize lethal necrosis disease (MLND) has threatened food security in the eastern Africa region. MLND in Africa is caused by a co-infection by *Maize chlorotic mottle virus* (MCMV) and *Sugarcane mosaic virus* (SCMV). Corn thrips, *Frankliniella williamsi* Hood, and corn leaf aphid, *Rophalosiphum maidis* (Fitch), are known to vector MCMV and SCMV, respectively. However, information on the identity and distribution of potential vectors of MCMV and SCMV in eastern Africa, their host plants, and management strategies is lacking.

> *icipe* aims to fill knowledge gaps in regard to the maize lethal necrosis disease, by identifying potential vectors of viruses causing the disease and their host range, in order to develop sustainable vector management strategies.
>
> *Dr Subramanian Sevgan, Scientist, Plant Health Theme*

Activities in 2015

- The Centre made the first report on lethal necrosis infection on finger millet.
- *icipe* has identified six insect vectors of MCMV (*Carpophilus* sp., *F. williamsi*, *F. schultzei* [pale form], *Thrips tabaci*, *T. pusillus*, and a curculionid weevil), and one vector species of SCMV (*Rhopalosiphum maidis*).
- Protocols for rearing the identified vectors (*Frankliniella williamsi*, *F. schultzei* (pale form), *Thrips tabaci*) of MLN viruses have been established.

A finger millet field ravaged by lethal necrosis

- Distribution maps of potential vectors of MLN have been developed.

- Eight host plants of SCMV (*Digitaria abyssinica, D. velutina, Pennisetum clandestinum, Brachiaria brizantha, Saccharum officinarum, Sorghum bicolor, Eleusine coracana, Zea mays*) and nine hosts of MCMV (*Cyperus rotundus, D. abyssinica, P. clandestinum, D. velutina, B. brizantha, S. officinarum, P. purpureum, E. coracana, Z. mays*) have been identified.

- Preliminary results show that endophytes such as *Trichoderma harzianum* F3ST1, *T. harzianum icipe* 709, *T. asperellum* M2RT4, and *T. atroviride icipe* 710, when applied as seed treatment, induce resistance to the MLN viruses.

- Results indicate that disease symptom development is delayed in single infection of maize with SMCV or MCMV, compared with dual infection with SMCV and MCMV. These findings are important in enhancing plant breeding screening programme, since development of sustainable management strategies against MLN and its vectors requires incorporation of the vectors in plant screening programmes.

Impact assessment

From 1993 to 2008, *icipe* implemented a stemborers biological control programme in East and southern Africa. In 2015, *icipe* completed a study to assess the impact of the programme on food security and poverty, in Kenya, Mozambique, and Zambia, using the economic surplus approach. Findings indicate that the programme has contributed USD 1.4 billion to the economies of the three countries, with 84% of the benefit generated from maize production. The biological control of stemborers can help to lift about 47,400, 44,120, and 36,170 people per year out of poverty, in Kenya, Mozambique and Zambia, respectively.

Long-term Farming Systems Comparisons

Since 2007, *icipe* with the Research Institute of Organic Agriculture (FiBL) and partners, have been running trials on the contribution of organic agriculture to sustainable development.

The project consists of On-station Long-term Experiments (LTE) and Participatory On-farm Research (POR). Conventional and organic treatments are being implemented at two input levels in a 3-year, 6-season crop rotation with maize, beans, vegetables, and potatoes in two sites in Kenya. Research includes assessment of yield, fertility parameters, pests and diseases, socio-economic assessments, and awareness creation activities. In 2015, the project entered its third phase which will end in 2018.

Key findings

- For the 9th consecutive year, results from systems comparison studies have revealed that organic farming and conventional farming systems remain equal in terms of pest and disease damage, as well as yield.

- Since the 6th year of the project, profitability has been higher for organic systems whenever premium prices are applied.

Staple food crops IPM research partners:

International Institute of Tropical Agriculture (IITA); International Maize and Wheat Improvement Center (CIMMYT); Kenya Agricultural and Livestock Research Organization, Horticulture Research Institute (KALRO-HRI); Makerere University, Uganda; Plant & Food Research, New Zealand; Plant Research International, Wageningen University, The Netherlands; University of Nairobi, Kenya; Research Institute of Organic Agriculture (FiBL); Tropical Soil Biology and Fertility Institute of CIAT (TSBF-CIAT); Kenyatta University, Kenya; Kenya Institute of Organic Farming (KIOF); Kenya Organic Agriculture Network (KOAN); Embu University, Kenya; University of Hohenheim, Germany.

Postharvest research

Each year, significant volumes of food are lost after harvest in Africa. *icipe* is conducting analytical reviews of postharvest losses and postharvest innovations, with the aim of supporting decision makers to optimise their post-production policies and strategies along value chains, and towards designing improved structures for storing and drying grain.

Identification and evaluation of postharvest losses hotspots due to insect and rodent pests

This study established that the main storage problems that farmers face are insects, rodents, and moulds. The findings indicate that the lowland tropical zone is the main hotspot for storage losses to rodents. The dry-transitional zone has the lowest combined losses, while the moist mid-altitude zone has the highest total losses.

Storage of maize as both cobs and shelled grain, use of insecticides, and use of cats and rodent traps significantly decreases losses. Use of cribs, whether improved or traditional, prevalence of rodents, and the storage of maize during two seasons of the year contributes significantly to the increase of losses.

Assessment of postharvest losses in commercial and strategic grain reserve warehouses in Kenya

The main storage problems in warehouses according to a survey in six agroecological zones of Kenya are insects, rodents, moulds, spillage, and birds. Failure to follow set grain storage standards significantly increases losses due to moulds in private warehouses.

Evaluation of appropriateness of grain storage structures used by small-scale maize farmers and grain marketers

The Centre conducted a study in Nakuru County, a significant maize production region, to identify the storage innovations that farmers and traders use to mitigate storage losses, and the profitability of the different techniques.

The most feasible storage innovation for farmers is the metal silo, with a benefit–cost ratio (BCR) and net present value (NPV) of 4.4 and Kshs 44, respectively. For grain marketers, the most feasible technique is storage of threshed maize in a hired premises, which has a BCR of 1.3 and NPV of Kshs 2443, respectively.

Green gram is an important pulse crop in Africa, supplementing the protein needs of many communities. Poor storage, however, causes severe damage and losses of harvest.

icipe is conducting research on the maize weevil, *Sitophilus zeamais* (above), one of the most economically important postharvest pests of maize in Africa.

Studies on triple bag hermetic technology for postharvest storage of food grains

Hermetic or sealed storage, which places an airtight barrier between grains and the outside atmosphere, is one of the technologies being promoted by Purdue University, USA, as the lead partner, in collaboration with *icipe,* to farmers, as a way of stopping insects from damaging their stored grain. This technology is attractive because it uses no chemicals, is cost-effective, and has less destructive impact on the environment and human health. Comparative participatory storage trials demonstrated that hermetic triple-layer plastic bags prevent grain damage and losses caused by insects on maize in rural on-farm stores, and further prevent aflatoxin accumulation during multi-month storage, even under farmer conditions. The findings show that the triple bag hermetic storage technology is reliable and technically appropriate for mitigating storage losses, and could be disseminated.

Studies on acoustic early warning system for insect control in grain stores

The acoustic signals emitted by the last stage larval instars and adults of the larger grain borer, *Prostephanus truncatus* and the maize weevil, *Sitophilus zeamais* in stored maize were investigated under laboratory conditions. The counts of broadband and low-mid frequency impulses per burst, and the rates of broadband and low-mid frequency impulses in bursts, were found to be significantly different for adults than for fourth instar *S. zeamais* and either stage of *P. truncatus*. These findings can be useful in developing a single maize based acoustic sensor for the detection of cryptic insects, including *P. truncatus* and *S. zeamais*, in bulk storage warehouses. The findings also provide new insights into movement and feeding behaviours of these important pests. Studies under field conditions are ongoing to understand the acoustic characteristics of these and other stored product pests. *icipe*'s ultimate goal is to select specific sensors and develop an acoustic early detection tool for hidden insect infestations in stores and warehouses.

Ex-ante study on willingness to pay for acoustic device for early detection of insect infestations in government and private warehouses in Kenya

This ex-ante study was conducted to estimate the willingness-to-pay (WTP) by managers of government and private-owned grain stores in Kenya, for an acoustic technology, as an early warning system of insects in stores and warehouses. Results showed that the managers' WTP is much higher than the estimated price of the device. The WTP of government warehouse managers was found to be slightly higher than that of private facility managers.

Profile:

SUNDAY EKESI, LEADER OF THE PLANT HEALTH THEME

Dr Sunday Ekesi exemplifies *icipe*'s home grown scientific leadership talent. He is a former African Regional Postgraduate Programme in Insect Science (ARPPIS), PhD scholar (registered at the Ahmadu Bello University, Nigeria).

His doctoral research was instrumental in the development of a fungal-based biopesticide that has since been proven to be effective in the control of thrips, fruit flies, and mealybugs. The biopesticide, which now bears the trade names Campaign® or Met 69® is commercially registered in Ethiopia, Kenya, South Africa, Tanzania, and Mozambique, where it is being applied on > 21,000 ha of farmland by > 24,000 farmers annually.

Dr Ekesi undertook his postdoctoral training at *icipe*, helping to nurture the Centre's then emerging Fruit Fly integrated pest management (IPM) programme, alongside his own research interests in the development and commercialisation of biopesticides as alternatives to toxic chemical pesticides for the management of arthropod pests in agriculture. He was also a postdoctoral fellow at Rothamsted Research, UK, an opportunity that enabled him to enhance his understanding of the interaction between arthropod pests and their natural enemies.

Since 2005, Dr Ekesi has been Head of the *icipe* African Fruit Fly Programme (AFFP). Programme activities include: generating basic and taxonomic knowledge on fruit flies and their natural enemies; ecological research in regard to how the pests relate to their environment (especially in view of climate change), and their impact on ecosystem services; pest management through environmentally friendly options (such as biopesticides, baiting techniques, botanicals, orchard sanitation and classical biological control); dissemination of such strategies; and socio-economic impact assessments on their effectiveness.

In his further role as leader of the Plant Health Theme, Dr Ekesi oversees *icipe*'s goal of contributing towards enhancing agricultural production in Africa, with the overall aim of improving food and nutritional security, human and environmental health, as well as household and national economies. The Centre aims to achieve this

objective by generating fundamental scientific knowledge, and developing IPM strategies for pre- and postharvest pests and parasitic weeds using predators, parasitoids, microbials, and habitat management strategies. The Plant Health Theme also builds the capacity of scientists and key stakeholders, including small-scale farmers, extension agents, government ministries, national agricultural research institutions, and the private sector, towards sustainable agriculture.

Dr Ekesi serves in various advisory and consultancy panels for the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), and the World Bank. He is also involved in various regional programmes focusing on the control of fruit flies and several other important arthropod pests. He is a member of the International Fruit Fly Steering Committee (IFFSC) and member of the Editorial Board of *icipe*'s *International Journal of Tropical Insect Science*. He was recently elected as a Fellow of the African Academy of Sciences in recognition of his contribution to improving food and nutrition security in Africa.

Dr Ekesi is also the leader of *icipe*'s emerging Insects for Food, Feed and Other Uses Programme (INSEFF), where he is helping to develop a programme vision that encompasses research, and capacity building and institution building and R&D activities.

These assignments have instilled in Dr Ekesi extensive capacity in: (a) a broad understanding of the agricultural transformation agenda in Africa and globally; (b) knowledge of the science and technological needs of African agriculture; (c) research organisation and implementation; (d) scientific capacity building; and (e) knowledge transfer and network creation with stakeholders.

ENVIRONMENTAL HEALTH THEME

In Africa, population growth, poverty and climate change are adding pressure on habitats and biodiversity, leading to ecosystems that are less resilient, more vulnerable to shocks and disturbances, and less able to supply benefits to people and other organisms. *icipe*'s goal is to improve environmental health for better food security, health and incomes, especially for communities in marginalised and fragile regions. The Centre seeks to: (a) broaden the knowledge base on arthropods, their diversity and role in ecosystems; (b) contribute to conservation and sustainable use of biodiversity; and (c) define strategies for climate change mitigation and adaptation.

35,520
Community members directly involved in the *icipe* beneficial and commercial insects, and bioprospecting programmes

13
Postgraduate students

27
Journal articles

Donors: AIRD (French Inter-institution Agency for Research and Development); UK Aid (UK Government); Biovision Foundation for Ecological Development; European Union (EU); International Fund for Agricultural Development (IFAD); The MasterCard Foundation; Ministry for Foreign Affairs of Finland; SWITCH Africa Green; World Trade Organization (WTO) – Enhanced Integrated Framework (EIF).

Beneficial and commercial insects

The main focus of the *icipe* beneficial and commercial insects programme is the establishment of improved, science-led sericulture and apiculture enterprises, to enable communities engage in income earning activities that are sustainable and environmentally friendly, provide quick economic rewards, and improve food security.

Bee health research

> "Our goal is to establish an African bee breeding line with various advantageous traits, including resistance to specific pests such as *Varroa* mites."

Prof. Suresh Raina, Head, Beneficial and Commercial Insects

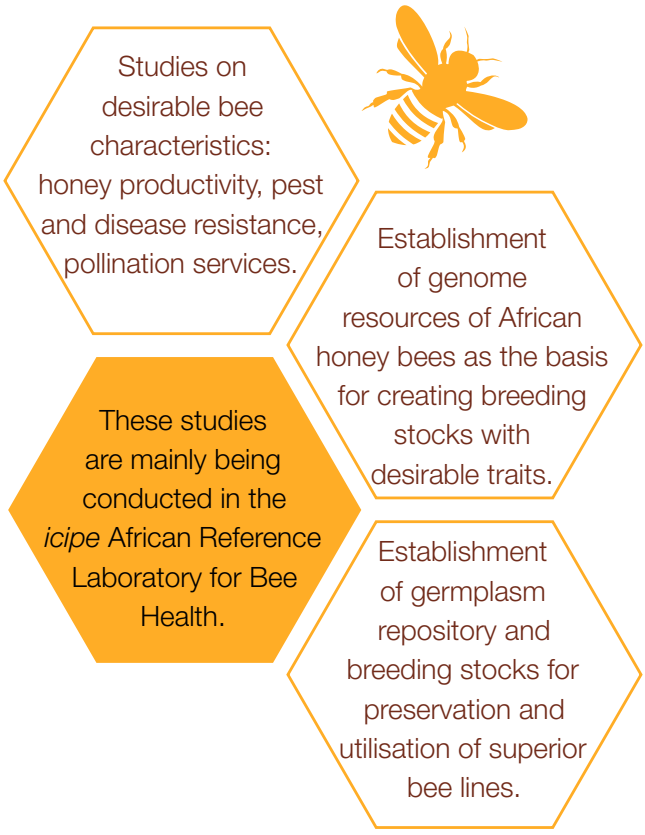
Accomplishments in 2015

- *icipe* developed methods for honey bee artificial insemination, to establish an African bee breeding line with various advantageous traits.

- The researchers initiated genetic selection and breeding of the African honey bee, *Apis mellifera scutellata,* with the aim of identifying a robust colony with resistance to specific pests such as *Varroa* mites, based on some of the attributes developed in European honey bees.

African honey bee, *Apis mellifera scutellata*

Ongoing activities



- *icipe* identified colonies of *A. m. scutellata* in Kenya's famous Karura Forest that have the desired characteristics.

  The researchers are conducting further studies on the bees to increase the expression of the desired traits in subsequent generations, with the ultimate aim of establishing robust and productive honey bee lines.

- *icipe* conducted a survey to collect information on the status of pests and diseases, and the bee health of five subspecies of *Apis mellifera.*

- In collaboration with Ruhr University Bochum, Germany, *icipe* started a study on the Meliponini (African stingless bees) resource usage and how they communicate when foraging.

Beekeeping in the island nations and regions

icipe has introduced improved beekeeping technologies and pollination services in four Indian Ocean island nations off the southeastern coast of Africa—Comoros, Madagascar, Mauritius (and Rodrigues), and Seychelles—and in Zanzibar, Tanzania on the eastern coast.

> "Our goal is to provide an alternative source of livelihood, increase crop yields and incomes, and enhance the ability to conserve biodiversity among communities targeted by the International Fund for Agricultural Development (IFAD) country programmes."

Dr Eliud Muli, Scientist, Beneficial and Commercial Insects

Accomplishments in 2015

- The Centre initiated studies in Zanzibar and Madagascar on the effect of climate change on the composition and behaviour of honey bees across altitudinal gradients (from low to higher altitude), and different temperature and rainfall zones.
- The researchers aim to establish, for example whether bees are migrating from low to high or vice versa, to determine the driving factors as well as the likely impact on honey production.
- Surveys on major pests and diseases of honey bees in the Island Nations have been initiated.

High quality honey produced in Africa through *icipe* projects.

Remote sensing and bee health

Researchers in the *icipe* Geo-Information Unit have developed a new remote sensing-based methodology to map flowering plants in Africa.

Using this methodology, which combines two hyperspectral mapping formulas, the researchers produced the world's first ever floral map.

The *icipe* results were published in two high impact, peer-reviewed journals, and were also prominently covered in local and international media.

icipe has demonstrated that it is possible to use remote sensing to map melliferous plants.

Floral maps are important for bee health and pollination effect assessments. Better understanding of floral diversity can support decision makers and beekeepers to discern the interaction between bee colonies and the floral environment, leading to optimised beekeeping.

Because flowering patterns are an important indicator of a range of factors (such as climate change and soil moisture), remote sensing of floral diversity could contribute towards the ultimate goal of enhancing food security in Africa.

> "We deployed a hyperspectral sensor on an aircraft, which enabled us to collect data on all flowering species over an area measuring 100 square kilometres in Mwingi County, Kenya, with an overall 83 percent mapping accuracy."

Dr Tobias Landmann, Head, Geo-Information Unit

Progress in silk farming

Silk farming is a new venture in Africa; therefore, *icipe*'s activities focus on establishing the basics of wild and mulberry silk farming in different agroecological regions. The Centre also undertakes research towards the development of various apiculture and sericulture products, on the basis of the quality regulations of the European Union, Organisation for Economic Co-operation and Development (OECD) and other trade agencies.

"Globally, silk is a premium product, resulting in a billion dollar trade. *icipe*'s goal is to create value chains that will enable communities across Africa to take advantage of the immense opportunities in silk farming."

Dr Everlyn Nguku, Scientist, Beneficial and Commercial Insects

Accomplishments in 2015

- *icipe* evaluated physical characteristics of the African moon moth, *Argema mimosae* cocoons, and outlined a procedure to extract viable silk fibre from them.

- The Centre commenced research to analyse plant volatiles responsible for parasitism on larval stages of the African wild silk moth, *Gonometa postica.*

- *icipe* introduced the eri silkmoth, *Samia cynthia ricini,* in Kenya. Scientists are now studying the development cycles of the moth, and the diseases and pests that affect it under local conditions.

  The Centre's goal is to make the species viable, so that communities can mass produce and use it to initiate income-generating activities.

Freshly harvested *Argema mimosae* cocoons.

The eri silkmoth, *Samia cynthia ricini.*

Beneficial and commercial insects research partners:

International Fund for Agricultural Development (IFAD) country programmes; ministries in charge of agriculture and livestock in implementing countries; Ministries of Agriculture and Irrigation, Industry and Trade; national agricultural research systems (NARS); farmers' and beekeepers' associations and community-based organisations in The Comoros, Mauritius, Madagascar, Seychelles, and Zanzibar, United Republic of Tanzania; farmers' and beekeepers' associations and community-based organisations in Yemen; farmers' and beekeepers' associations and community-based organisations in Ethiopia; Chora Botter Woreda (District) Agriculture and Rural Development Office; Chora Botter Woreda (District) Cooperative Agency; Kenya Organic Agriculture Network (KOAN); German Aerospace Center (DLR); University of Würzburg, Germany

Bioprospecting

The *icipe* Bioprospecting Programme undertakes research and development towards the following: discovery, development and commercialisation of products from biodiversity for pest, vector, and disease management; promotion of sustainable production; commercialisation and use of nature-based products through private–public–community partnerships; and capacity building of natural resource-dependent rural communities to sustainably produce pesticidal and medicinal plants and products for pest, vector and disease management.

SWITCH Africa Green case study

In 2015, the SWITCH Africa Green Programme selected the *icipe*-coordinated initiative on on-farm cultivation of insecticidal and medicinal plants by the community living adjacent to Kakamega forest, Kenya, as a case study, based on its success. The European Union has developed SWITCH Africa Green to support African countries in their transition to an inclusive green economy, and in promoting a shift to more sustainable consumption and production practices and patterns.

Involving 16 projects, the initiative is being implemented by the United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), and United Nations Office for Project Services (UNOPS), in Kenya, Uganda, Ghana, Burkina Faso, Mauritius, and South Africa. The *icipe* project is one of four chosen in Kenya.

Naturub® range of products.

Muliru community enterprise

Over the past two decades, *icipe* and partners have led a conservation effort of Kakamega Forest in western Kenya, world-famous for its unique biodiversity (including a variety of flora and fauna), while improving the livelihoods of the community living adjacent to it.

A major partner is the Muliru Farmers Conservation Group, which mobilises communities living adjacent to the forest to cultivate medicinal plants, among them *Ocimum kilimandscharicum*, an indigenous medicinal herb of the mint family known locally as 'mwonyi' that has been used traditionally to treat colds and flu, coughs, sore eyes, diarrhoea, abdominal pains, and measles.

Using the essential oils from these leaves, *icipe*, together with the University of Nairobi, have developed a commercially branded range of products known as Naturub®, which includes a balm and an ointment.

The Muliru community enterprise has the necessary capacity to contract other farmers adjacent to Kakamega forest, to manufacture Naturub® range of products and make them available in leading outlets across the country.

The Muliru community enterprise is now a commercially viable, profit-making venture, without any detriment to the Kakamega Forest.

Bioprospecting research partners:

Muliru Farmers Conservation Group (MFCG); Kamili Nature Brands Limited; United Nations Environment Programme (UNEP); United Nations Development Programme (UNDP); United Nations Office for Project Services (UNOPS).

Biosystematics

Through the *icipe* Biosystematics Unit, taxonomic research is interlinked with the Centre's mandate of conserving biodiversity. In 2015, the Centre and its partners discovered 16 previously undescribed wasp species in Africa. In naming the new species, the researchers have immortalised various sites and individuals in Africa and from across the world. The description of these species is important, as it contributes towards filling taxonomic gaps on wasps, which are significantly beneficial to humankind, specifically because of their ability to naturally control agricultural pests.


Anachrysis, female


Muhaka icipe, paratype


Alhajammyia Stuckenberg


Aphelopus severancei, male


Hermannomyia ukasi


Megastigmus sp. nov. 1, female

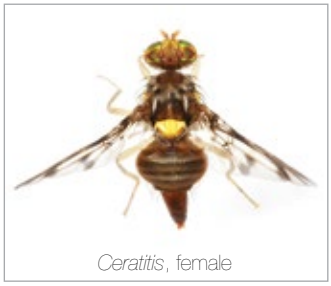

Anteon copelandi, female


Anteon alteri, female


Anteon shimbanum, female


Dinapsis, female


Hedychridium


Ceratitis, female


Embolemus burundensis


Cyphacolus copelandi, female


Megastigmus sp. nov. 6, male


Paramblynotus ruvubuensis

Biosystematics research partners:

National Museums of Kenya; US Department of Agriculture (USDA); Smithsonian National Museum of Natural History, USA; Royal Museum for Central Africa, Tervuren, Belgium; Tropical Entomology Research Center, Viterbo, Italy; University of Tuscia, Viterbo, Italy; Institut national de la recherche agronomique (INRA), France; Pennsylvania State University, USA; The Smithsonian Institution, USA.

Climate change and insects

The Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA) Project, funded by the Ministry for Foreign Affairs of Finland, was implemented between 2011 and 2015. CHIESA was a research and development initiative that was aimed at building climate change adaptation capacity and disseminating relevant strategies to researchers, extension officers, decision makers, and communities. CHIESA's main focus was on ecosystem services in the Eastern Afromontane Biodiversity Hotspot, specifically: Taita Hills (Kenya); Mount Kilimanjaro (Tanzania); and Jimma Highlands (Ethiopia). *icipe* was the implementing agency of CHIESA, coordinating activities within eight distinct work packages among four universities in Africa and Europe, and overseeing the participation of 22 stakeholder institutions.

CHIESA's concluding activities

In 2015, CHIESA partners moved towards the application of their research findings at community members' and policymakers' levels, through information exchange, capacity building, transfer of climate change adaptation technology, and installation of demonstration plots. This research will continue under the Adaptation for Ecosystem Resilience in Africa (AFERIA) Project, still funded by the Ministry for Foreign Affairs of Finland.

In Jimma Highlands, Ethiopia, 30 women were trained to establish nurseries of coffee berry disease (CBD)-resistant coffee plants, to improve their crops and generate additional income by selling seedlings.

In Taita Hills, Kenya, 12 drip irrigation kits were installed in small-scale farms and institutions, which now also serve as demonstration and learning sites for climate change adaptation technologies.

Policy briefs were prepared and distributed to policymakers and other stakeholders in Ethiopia, Kenya, and Tanzania.

Community-based climate change adaptation plans specific to the three CHIESA sites were developed through an inclusive process in regards to gender, community members with special needs, and local and national leaders.

Results dissemination seminars were held for policymakers, non-governmental organisations, and research organisations in the three countries.

A media training workshop attended by 16 journalists was held in Ethiopia, to enhance capacity to report on climate change.

Two seminars were held, in Ethiopia and Kenya, to improve the communities' knowledge on the environment and their possible contribution to climate change.

Activities to promote youth environmental education, leading to the planting of 560 indigenous tree saplings in schools in the three countries.

A new initiative known as the Adaptation for Ecosystem Resilience in Africa (AFERIA), which was developed through CHIESA, has been launched to disseminate and communicate research findings, insights and interactions of climate change and food security.

CHIESA project research partners:

University of Helsinki, Finland; University of York, United Kingdom; University of Dar es Salaam, Tanzania; Sokoine University of Agriculture, Tanzania.

Profile:

SURESH RAINA, LEADER OF THE ENVIRONMENTAL HEALTH THEME

Prof. Suresh Raina has 45 years experience in designing and implementing livelihood related programmes bringing together insects and the environment.

A native of Nagpur, India, growing up in the 1960s, he experienced first hand the struggles faced by farmers. His interest in contributing towards the creation of options that could improve community livelihoods was inspired by his father, whom he grew up helping in dairy and agricultural farming.

Prof. Raina earned an MSc in entomology and cytogenetics at Nagpur University, in 1971, obtaining a gold medal for being the top notcher. He then obtained a PhD in 1975, in insect neuroendocrinology from the same university, co-supervised by the Agriculture Canada Research Station, Saskatoon.

Through a fellowship from Rotary International, Illinois, USA, and the International Development Research Centre (IDRC), Canada, he undertook postdoctoral training between 1977 and 1980 at the Agriculture Canada Research Station, Saskatoon, where he developed a tissue culture laboratory and *in vivo* mass production of a protozoan parasite for the control of wheat grasshoppers in Canadian Prairies and in Bozeman, Montana, USA; and for a rice grasshopper species in Nagpur province.

He returned to Nagpur University with a grant from IDRC and the Universities Grant Commission (UGC), India, to establish a centre of sericulture and biological pest management. He was awarded a research professorship in 1988 by IDRC Canada, endorsed by Nagpur University. Through a United States Department of Agriculture (USDA) grant, he identified and introduced a biological control agent to eradicate citrus blackfly in orange orchards, an endeavour that won him a certificate of appreciation from USDA in 1990.

Prof. Raina joined *icipe* in June 1990 as a research scientist with a grant from the World Bank, to develop a biological control strategy for grasshoppers in the Sahel. Since 1994, he has overseen the initiation (with support from the International Fund for Agricultural Development – IFAD) and advancement of the *icipe* Commercial Insects Programme (CIP), which is aimed at improving the

livelihood of communities across Africa through science-led sericulture and modern apiculture enterprises. CIP collaborates with national and international research and development partners, and the private sector, to conduct research, demonstrations, capacity building, information dissemination, and commercialisation of products. In 2015, research activities revolved around the identification of honeybees, stingless bees and silkmoth lines with desirable traits. In the case of honeybees, characteristics include honey productivity, pest and disease resistance, and pollination services. In silkmoths, the desirable traits are disease resistance, increased cocoon weight, and quality silk yarn. Genome resources of diverse African honeybee and silkmoth races are also being established to provide the basis for developing breeding stocks with desirable traits. The Centre is also establishing a germplasm repository and breeding stocks for preserving and utilising the superior bees and silkmoths lines.

Prof. Raina also oversees the African Reference Laboratory for Bee Health, with a central reference laboratory in Kenya and satellite stations in Ethiopia, Burkina Faso, Cameroon, and Liberia, in a partnership between *icipe* and the African Union Inter-African Bureau for Animal Resources (AU-IBAR), and with financial support from the European Union (EU) and *icipe*'s core donors. The facility provides a focal point for cutting-edge research towards improved bee health and pollination services, with the ultimate aim of enhancing the livelihoods of beekeepers and farmers across Africa, through improved honey products and crop productivity.

As the leader of the *icipe* Environmental Health Theme, Prof. Raina coordinates the Centre's goals, which include: (a) broadening the knowledge base on arthropods, their diversity and role in ecosystems, to contribute to the conservation and sustainable utilisation of biodiversity; and (b) defining strategies for climate change mitigation and adaptation.

Prof. Raina has published over 100 peer-reviewed papers, five books, 10 proceedings and over 40 donors' reports. He is a consultant to several international agencies. He has supervised over 30 PhD students, 50 MSc scholars and 6 MPhil from India, Africa, Canada, and the UK. Cumulatively, he has contributed to the training of 45,000 farmer trainers, farmers, and national extension workers in 52 African countries and in the Near East and North Africa (NENA) region.

CAPACITY BUILDING AND INSTITUTIONAL DEVELOPMENT

Since its establishment, *icipe* has been committed to building the capacity of Africa's next generation of leaders in insect science, science and technology in agriculture, and health and environment, in support of sustainable development in the continent. *icipe*'s activities are conducted through: (a) postgraduate and postdoctoral level training; (b) strengthening of African R&D organisations and institutions, and (c) training to enable national agricultural and health research and extension systems to use the Centre's strategies and technologies. In all its capacity building activities, *icipe* is devoted to advancing scientific excellence and gender equity.

175 Postgraduate students

19 Postdoctoral fellows

75 Journal articles

48 Training courses and workshops

Donors: Aid for Africa, USA; Australian Centre for International Agricultural Research (ACIAR); DANIDA; German Academic Exchange Service (DAAD); German Federal Ministry for Economic Cooperation and Development (BMZ); Government of Kenya; International Development Research Centre (IDRC); Swiss Agency for Development and Cooperation (SDC); Swedish International Development Cooperation Agency (Sida); UK Aid (UK Government); National Institutes of Health (NIH), USA.

Postgraduate and postdoctoral training

icipe offers postgraduate training at masters and doctoral levels, through the **African Regional Postgraduate Programme in Insect Science (ARPPIS)** and the **Dissertation Research Internship Programme (DRIP)**. The **Postdoctoral Fellowship Programme** enables doctoral graduates to undertake research at the Centre, towards developing their research skills and careers, and also allows them to create collaborative research programmes with *icipe* scientists. These programmes not only build the capacity of individual scientists, but they also add new research capacity to *icipe*.

Achievements in 2015

175
postgraduate scholars were in various stages of their research training, among them 88 PhD fellows (44 ARPPIS and 44 DRIP PhD fellows), and 87 DRIP MSc fellows.

25
postgraduate scholars completed their studies: 17 PhD and 8 MSc students either graduated and/or defended their theses. Of note: 3 PhD students in the OviART project obtained PhD degrees from the prestigious London School of Hygiene & Tropical Medicine.

19
postdoctoral fellows were engaged in research at *icipe*, and **2 visiting postdoctoral fellows** were hosted at *icipe*.

43%
of all current postgraduate and postdoctoral fellows and 47% of PhD fellows are women. *icipe* remains committed to advancing excellence in science through gender equity.

Expanded DAAD scholarships programme: The German Academic Exchange Service (DAAD) increased its support for the ARPPIS PhD fellowship programme, enabling *icipe* to enhance country diversity and maintain gender diversity in the programme.

9
scholars from 9 African countries started their research programmes in 2015 under the expanded DAAD Postgraduate Scholarships Programme.

18
countries represented in the *icipe* postgraduate programmes: Benin, Cameroon, DR Congo, Eritrea, Ethiopia, Ghana, Ivory Coast, Kenya, Mozambique, Nigeria, Rwanda, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

52%
of the 143 peer-reviewed papers published by *icipe* in 2015 were co-authored by postgraduate and postdoctoral fellows (who were also first authors on 41% of the papers).

Key research findings in 2015

Xavier Cheseto (ARPPIS, PhD) identified the host marking pheromones used by three fruit fly species, results that could provide important leads in the management of these pests.

Mwanasiti Bendera (ARPPIS, PhD) demonstrated for the first time that cowpea volatiles play a key role in the mating behaviour of the legume pod borer *Maruca vitrata*, an insect pest that accounts for over 80% yield losses of cowpea.

Vincent Nyasembe (ARPPIS, PhD) published a study showing that an invasive weed, *Parthenium hysterophorus*, can increase malaria prevalence, due to its ability to support the survival of malaria vector, *Anopheles gambiae*.

Purity Kipanga (DRIP, MSc) showed that the enhanced sensitivity of nPCR-HRM highlights the limitations of malaria diagnostics in rural settings, which can give inaccurate estimates of malaria, and also lead to misadministration of anti-malarial drugs.

Two DRIP PhD scholars, **Manuela Herrera-Varela** and **Michael Okal** provided evidence of informed choices of egg-laying sites by gravid females of *Anopheles gambiae*, and isolated a major chemical determinant of this behaviour. This knowledge could help develop more efficient attract-and-kill mosquito traps.

Recent graduates: Where are they now?

Teresiah Njihia (DRIP, MSc, July 2015) is now enrolled in the ARPPIS PhD programme, where she is conducting research on the development of a potent mass-trapping tool using semiochemicals, for the management of antestia bugs in coffee.

Ryan Musumba Awori (DRIP, MSc, September 2015) is undertaking a PhD in infection and immunity through the University of Edinburgh, Scotland, UK.

– continued overleaf

Frank Chidawanyika (ARPPIS, PhD, March 2015) is a Research Scientist at the Agricultural Research Council-Plant Protection Research Institute (ARC-PPRI), Durban, South Africa, working on the biological control of invasive alien weeds.

Collins Odhiambo (ARPPIS, PhD, April 2015) who studied the dynamics of Bunyamwera virus circulation and transmission in Kenya, is continuing his career in medical research at KEMRI-Kisumu, researching the diagnosis and treatment of HIV.

Venansio Tumuhaise (ARPPIS, PhD, September 2015) is now employed by the National Agricultural Research Organization, Uganda, as an entomologist at the National Coffee Research Institute (NaCORI), where he is developing strategies to manage key pests of coffee in the country, especially the black coffee twig borer.

Daniel Mutyambai (ARPPIS, PhD, May 2015) has started a postdoctoral fellowship in the push–pull programme at the *icipe* Thomas Odhiambo Campus, Mbita.

Training courses

icipe's training courses cover a range of research and development activities, from basic research, technology development and validation, to community-based adoption of new technologies and approaches. In 2015, *icipe* conducted 48 training courses and workshops, and numerous farmer field days and trainings, for 26,482 participants, as shown in the table below.

Title of training (location, dates)	Number of participants	Nationalities of trainees
Animal Health		
Training for staff members of the Ministry of Agriculture and Rural Development (Asosa, Ethiopia), and National Tsetse and Trypanosomosis Investigation and Control Centre, Ethiopia (*icipe*, Nairobi and Mombasa; 15–25 March 2015)	6 men	1 (Ethiopia)
Local staff in Hargeisa, Somaliland trained on tick identification and control as part of the EU-funded Peri-Urban Milk Value Chain Project (Hargeisa, Somaliland; 14–15 April 2015)	14 (6 women, 8 men)	1 (Somaliland)
Extension staff and village elders trained in deployment and maintenance of targets, Quantitative Buffy Coat technique for examining parasites, testing for mastitis using California Mastitis Test (CMT) kits, milking hygiene and monthly entomological sampling using NZI traps (Hargeisa, Somaliland; 6–15 September 2015)	8 men	1 (Somaliland)
Integrated Biological Control Applied Research Programme (IBCARP) training on tsetse biology and ecology, and tsetse repellent technology (Shimba Hills, Kwale County, Kenya; 27 November–1 December 2015)	429 (142 women, 287 men)	1 (Kenya)
Human Health		
Stakeholder engagement training for the target malaria consortium staff (Uganda Virus Research Institute; 15–22 February 2015)	36 (11 women, 25 men)	6 (Burkina Faso, Italy, Kenya, Mali, UK, Uganda)
Plant Health		
FAO Group Training Course on Taxonomy, Detection, Management and Rearing of Fruit Flies and Parasitoids (*icipe*, Nairobi; 9 March–3 April 2015)	13 (6 women, 7 men)	10 (Botswana, Kenya, Lesotho, Malawi, Mauritius, Namibia, Seychelles, Tanzania, Zambia, Zimbabwe)
Fruit Fly Training of Trainers workshop, by invitation of the Ministry of Agriculture in Zanzibar (Agricultural Training Centre, Unguja, Zanzibar 13–14 April 2015)	23 (12 women, 11 men)	1 (Tanzania)
Purdue Improved Crop Storage Training of Trainers Workshop (Dar es Salaam, Tanzania; 10–22 May 2015)	253 (68 women, 185 men)	1 (Tanzania)
Training of Trainers Course on Fruit Fly Taxonomy, Monitoring and Management (Masii, Machakos, Kenya; 25–26 June 2015)	16 (5 women, 11 men)	1 (Kenya)

Title of training (location, dates)	Number of participants	Nationalities of trainees
Push–Pull Technology (PPT)		
Field days on awareness of PPT (January–December 2015)	7506 (4364 women, 3142 men)	4 (Ethiopia, Kenya, Uganda, Tanzania)
Individual farmers trained on PPT (January–December 2015)	16,975 (9680 women, 7295 men)	4 (Ethiopia, Kenya, Uganda, Tanzania)
Extension staff trained on PPT (January–December 2015)	46 (15 women, 31 men)	4 (Ethiopia, Kenya, Uganda, Tanzania)
Farmer teachers/peer farmers trained on PPT (January–December 2015)	97 (54 women, 43 men)	4 (Ethiopia, Kenya, Uganda, Tanzania)
School children learning from cartoon books (January–December 2015)	203 (96 girls, 107 boys)	2 (Kenya, Uganda)
Environmental Health		
Beekeeping Union training on honey and wax processing (Tolay, Ethiopia; 2–4 March 2015)	5 (2 women, 3 men)	1 (Ethiopia)
Honey bee pests management and control (PCA Church, Karura Forest, Nairobi, Kenya; 9–10 March 2015)	24 (15 women, 9 men)	1 (Kenya)
Setting of microscopes, incubators and inseminator, queen rearing and breeding (theory) (Manakara, Madagascar; 29 June–4 July 2015)	22 (1 woman, 21 men)	1 (Madagascar)
Honey quality control basics and post-harvest processes, pollination and greenhouse installation (*icipe*, Nairobi, Kenya; 28 September–2 October 2015)	3 men	1 (Ethiopia)
Training of Trainers Course for the IFAD-funded Alternative Livelihoods for Food and Income Security in Four Indian Ocean Island Nations and Zanzibar Project (*icipe*, Nairobi and Kakamega Forest Field Sites, Kenya; 4–14 August 2015)	16 (3 women, 13 men)	5 (Comoros, Madagascar, Mauritius, Seychelles, Tanzania)
Queen rearing and bee breeding (Koudougou, Burkina Faso; 9–13 August 2015)	15 (3 women, 12 men)	1 (Burkina Faso)
HPLC applications for honey quality control at the Ministry of Animal Resources, Veterinary Services Lab (Ouagadougou, Burkina Faso; 9–13 August 2015)	4 (2 women, 2 men)	1 (Burkina Faso)
Queen rearing and bee breeding (Ministry of Livestock, Yaounde, Cameroon; 14–19 August 2015)	65 men	1 (Cameroon)
HPLC applications for honey quality control at the Laboratoire National Veterinaire (LANAVET), Ministry of Agriculture (Yaounde, Cameroon; 14–19 August 2015)	16 (6 women, 10 men)	1 (Cameroon)
Queen rearing (Monrovia, Liberia; 20–27 August 2015)	85 men	1 (Liberia)
Training in honey quality control at the Fendell Campus Center, University of Liberia, National Livestock Bureau, Ministry of Agriculture (Monrovia, Liberia; 20–27 August 2015)	4 (1 woman, 3 men)	1 (Liberia)

Title of training (location, dates)	Number of participants	Nationalities of trainees
Beekeeping cooperative leaders' management training (Tolay, Ethiopia; 21–23 September 2015)	34 (3 women, 31 men)	1 (Ethiopia)
Bee health training of beekeepers (Mahe, Praslin and La Dique islands; October 2015)	44 (29 men and 15 women)	1 (Seychelles)
Bee health training (Ngazidja, Moheli and Anjouan islands, Comoros Islands; November 2015)	62 (14 women, 48 men)	1 (Comoros Islands)
Biosystematics Unit		
Training on insect taxonomy and identification (*icipe*, Nairobi; August–September 2015)	2 men	1 (South Africa)
Capacity Building and Institutional Development (CB&ID)		
Spatial Statistics with R training (co-organised by CHIESA and CB&ID) (*icipe*, Nairobi; 9–13 March 2015)	26 (6 women, 20 men)	7 (Benin, Cameroon, Democratic Republic of Congo, Ethiopia, Kenya, Nigeria, Togo)
Crawford Fund Communicating Research to Stakeholders Workshop, for staff of R&D institutions from across Africa (*icipe*, Nairobi; 16–20 March 2015)	23	
Science Writing Workshop (*icipe*, Nairobi; 20–15 July 2015)	30 (14 women, 16 men)	4 (Cameroon, Colombia, Ethiopia, Kenya)
Proposal Writing Workshop (*icipe*, Nairobi; 7–11 September 2015)	26 (10 women, 16 men)	7 (Cameroon, Eritrea, Ethiopia, Ghana, Kenya, Mozambique, Nigeria)
Thriving in a Research Career: An Introduction to the Toolkit for the Early Career Scientist (*icipe*, Nairobi; July 2015)	63 (30 women, 33 men)	8 (Cameroon, Colombia, Ethiopia, Ghana, Kenya, Nigeria, Oman, Tanzania)
ARPPIS/DRIP Introductory Training Courses – conducted by *icipe* research staff		
Health & Safety/Biorisk Awareness (*icipe*, Nairobi; 29–30 January and 15–17 December 2015)	25 (12 women, 13 men)	10 (Benin, Cameroon, Côte d'Ivoire, Ghana, Kenya, Nigeria, Sudan, Tanzania, Togo, Uganda)
Introduction to Information Literacy and e-Resources/e-Journals (*icipe*, Nairobi; 2 February and 16 November 2015)	23 (12 women, 11 men)	10 (Benin, Cameroon, Côte d'Ivoire, Ghana, Kenya, Nigeria, Sudan, Togo, Tanzania, Uganda)
Statistical Methods for Arthropod Research (*icipe*, Nairobi; 5–18 February 2015)	16 (10 women, 6 men)	4 (Cameroon, Kenya, Togo, Uganda)
Introduction to Modelling (*icipe*, Nairobi; 23–27 February 2015)	7 (5 women, 2 men)	4 (Cameroon, Kenya, Togo, Uganda)
Geographical Information Systems (GIS) and Remote Sensing (*icipe*, Nairobi; 16–20 March and 23–27 November 2015)	32 (15 women, 17 men)	12 (Benin, Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Nigeria, Togo, Sudan, Tanzania, Uganda, Zambia)

Title of training (location, dates)	Number of participants	Nationalities of trainees
Introduction to Behavioral and Chemical Ecology Course (*icipe*, Nairobi; 27–29 May 2015 and 9–11 December 2015)	36 (18 women, 18 men)	12 (Benin, Cameroon, Côte d'Ivoire, Germany, Ghana, Kenya, Nigeria, Sudan, Tanzania, Uganda, Zambia, Zimbabwe)
Insect Taxonomy, Identification and Photography (*icipe*, Nairobi; 8–19 June 2015 and 30 November– 8 December 2015)	27 (12 women, 15 men)	14 (Benin, Cameroon, Côte d'Ivoire, Ethiopia, Germany, Ghana, Kenya, Nigeria, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe)
Introduction to Molecular Biology and Bioinformatics (*icipe*, Nairobi; 3–5 June 2015 and 18–20 November 2015)	36 (18 women, 18 men)	11 (Benin, Cameroon, Côte d'Ivoire, Ghana, Kenya, Nigeria, Sudan, Tanzania, Togo, Uganda, Zambia)
Introduction to Biostatistics (*icipe*, Nairobi; 14 November 2015)	18 (7 women, 11 men)	10 (Benin, Cameroon, Côte d'Ivoire, Democratic Rep. of Congo, Ghana, Kenya, Nigeria, Sudan, Tanzania, Zambia)
Molecular Biology and Bioinformatics Unit		
Vector Biology Course (*icipe* Mbita; 20–25 April 2015)	25 (14 women, 11 men)	4 (Cameroon, Colombia, Kenya, Tanzania)
Hands-on Training on Mosquito Identification and Biology with THRiVE (*icipe*, Nairobi and Mbita; 15–21 June 2015)	4 (2 women, 2 men)	1 (Rwanda)
ML-EID Labs SP5 Confocal Microscope Training (*icipe*, Nairobi; 22–24 June 2015)	9 (3 women, 6 men)	2 (Kenya, Uganda)
Laboratory-based Sandfly Biology and Leishmaniasis Diagnostic Training (KEMRI, Nairobi; 28–30 July 2015)	16 (6 women, 10 men)	1 (Kenya)
Bioinformatics Approaches for Next Generation Sequencing Analysis Course (*icipe*, Nairobi, 30 November – 5 December 2015)	37 (17 women, 20 men)	8 (Benin, Ethiopia, Kenya, Nigeria, Rwanda, Tanzania, Sudan, Uganda)

Capacity Building and Institutional Development research partners:

Alexander von Humboldt Foundation (AvH); African Academy of Sciences (AAS); African Women in Agricultural Research and Development (AWARD); International Foundation for Science (IFS); Organization for Women in Science for the Developing World (OWSD); Training Health Researchers into Vocational Excellence (THRiVE); The World Academy of Sciences for the Advancement of Science in Developing Countries (TWAS); University of Nairobi; Jomo Kenyatta University of Agriculture and Technology; Kenyatta University; Egerton University; Mount Kenya University; Pan Africa University; Jaramogi Oginga University; Addis Ababa University; University of Ibadan; University of Pretoria; University of the Western Cape; University of Cape Coast; University of the Witwatersrand; North-West University; University of KwaZulu-Natal; University of Yaoundé I; University of Gezira; University of Dar es Salaam; Kwame Nkrumah University; University of Ghana; London School of Hygiene & Tropical Medicine; Wageningen University, The Netherlands; University of Bonn; University of Hannover; University of Hoheinheim; University of Würzburg; University of Constance; Humboldt State University.

INSECTS FOR FOOD AND FEED

Edible saturniid caterpillar

Globally, population growth, urbanisation, climate change, diminishing land and water resources, over- and under nutrition, and persistent poverty have created uncertainties and pressures on food and economic systems. Against this background, insects are being considered as alternative sources of food for human consumption and as feed additives for livestock. This is because insects are ubiquitous: they reproduce quickly, have high growth and feed conversion rates and a low environmental impact. Insects are also valuable sources of proteins, minerals and vitamins that are essential for human and livestock development.

Donors: Australian Centre for International Agricultural Research (ACIAR); International Development Research Centre (IDRC) through the Cultivate Africa's Future (CultiAF) programme; BMZ – German Federal Ministry for Economic Cooperation and Development through GIZ; DANIDA; Netherlands Organization for Scientific Research (NWO).

Insects for food and feed

Background

icipe began to consider insects for food and feed as a new strategic research opportunity in late 2013. In 2014, the Centre conducted background research, prepared proposals, and established linkages with national and international stakeholders, including donors, research institutions, and public and private sector institutions.

icipe compiled an inventory entitled 'African Edible Insects for Food and Feed: Inventory, Diversity, Commonalities and Contribution to Food Security', which was published in the first volume of the *Journal of Insects as Food and Feed*. The Centre also established the Insects for Food, Feed and Other Uses Programme (INSEFF), as the platform for its activities in this area.

icipe has also continued to extend knowledge on edible insects in Africa. In 2015, *icipe,* Jomo Kenyatta University of Agriculture and Technology, and United States Department of Agriculture/Agricultural Research Service (USDA/ARS), published a paper in *PLOS ONE* indicating that eating the meat of the desert locust could be good for your heart. The researchers show that the desert locust, known scientifically as *Schistocerca gregaria,* contains a rich composition of compounds known as sterols, which have cholesterol-lowering properties, thereby reducing the risk of heart disease. Sterols occur naturally in plants, animals, and fungi. The sterols from plants are called phytosterols and those from animals are known as zoosterols. Cholesterol is the most familiar type of animal sterol. Phytosterols and cholesterol have a common target of getting absorbed in the intestines. However, phytosterols have been shown to have a competitive advantage, as they are able to block the absorption of cholesterol. Although vegetables are the richest sources of phytosterols, insects have the potential to supply these useful compounds to people.

Locusts being reared at *icipe* as part of the Insects for Food and Feed research.

> *icipe* has defined a niche for itself in the global quest to advance the use of insects for food and feed. We are expanding our research in this area, while creating strategies to ensure that the promise of insects in nutritional security and economic improvement is realised.

Dr Sunday Ekesi, Team Leader, Insects for Food and Feed Programme

Crickets being reared at *icipe.*

GREEiNSECT: Mass-rearing insects for greener protein supply

Through the GREEiNSECT initiative, which is led by University of Copenhagen, Denmark, *icipe* is working with a consortium of public and private sector partners from Africa, Asia, Europe and USA, to investigate ways of mass-rearing insects in small, medium and large-scale industries. The overall aim is to integrate insects as a new, sustainable and inclusive component in addressing food, nutritional and feed security, and as part of the transition towards greener agriculture in Kenya.

Achievements in 2015

- Assessment of the diversity of gryllids (crickets) in Kenya has revealed the presence of the following species: *Acheta domesticus, Gryllus bimaculatus, G. mori, Diestrammena japonica, Teleogryllus* Chopard, *Brachytrupes membranaceus, Homeogryllus reticulatus*, *Gryllotalpa robusta,* and *Gymnogryllus miorus*. Mass rearing techniques for *A. domesticus* and *G. bimaculatus* are being optimised.

- Evaluation of oviposition devices for egg laying by *A. domesticus* has shown that the blue and green egg devices increase oviposition by 15–20% relative to the control.

- Evaluation of different substrates, including corn meal, wheat bran, pumpkin leaf powder, carrot meal, kale, fish meal and soya meal for mass rearing of *A. domesticus* revealed that wheat bran supplemented with kale enhances productivity of *A. domesticus*. The mean weekly production of adults per egg crate stands at 116.8 ± 22.4 adults with percentage adult emergence of 72%.

- Entomopathogens (including *Beauveria* spp., *Entomophthora* spp., *Metarhizium* spp., 'cricket paralysis virus', microsporidia, and nematodes) as well as mites that could potentially threaten cricket production, have been profiled.

- The GREEiNSECT project continues to raise awareness among regulatory authorities in Kenya and beyond on the role of insects as food and feed, and the need to develop and strengthen legislation and policy to regulate its application, with several workshops and meetings held with relevant bodies in 2015.

ILIPA: Improving livelihood by increasing livestock production in Africa

ILIPA is a collaborative project between *icipe* and Wageningen University, The Netherlands. The initiative aims to exploit the commercial potential of insects, mainly the black soldier fly, *Hermetia illucens*, in the production of affordable, high-quality protein for the poultry, pig and fish industries. To create an effective agribusiness model, the project partners will conduct research that will ensure high nutrition and microbial safety of the insect-based protein products. The research will also focus on creating awareness and identifying market opportunities for the technology. A participatory approach will be used, involving farmer groups, with particular focus on women and youth.

EntoNUTRI

In November 2015, the Federal Ministry for Economic Cooperation and Development (BMZ), Germany, approved funding towards a new project to develop insect-based products, to enhance food and nutritional security in sub-Saharan Africa.

Known as EntoNUTRI, the three-year project will be implemented by *icipe* in partnership with the Center for Development Research (ZEF), University of Bonn, Germany; Food Security Center, University of Hohenheim, Germany, and national agricultural research systems (NARS) partners from Kenya and Uganda.

The project partners will focus on four insects that are consumed by communities in Kenya and Uganda: crickets, grasshoppers, Zambezi emperor worm, and shea tree caterpillar.

They will also aim to develop viable insect rearing and harvesting techniques, assess the nutritional attributes of the insects (while taking into account the unique needs of women, girls and infants), identify the biosafety risks along the value chain, and build capacity for research on edible insects in the regions.

Considering the key roles already played by women in the edible insect sector, the research will endeavour to create low-input insect technologies to support their participation along the value chain.

Black soldier flies being reared by *icipe*, resting on maize.

INSFEED: Insect feed for poultry and fish production in sub-Saharan Africa

In many African countries, the poultry and fish industries are among the fastest growing agri-businesses. However, use of expensive inputs (such as fish and plants) as feed ingredients is threatening the survival of producers.

INSFEED, which is funded by the International Development Research Centre (IDRC) and the Australian Centre for International Agricultural Research (ACIAR), proposes to improve income generation, and food and nutritional security in Kenya and Uganda, by developing insect-based feeds for sustainable, safe and cost-effective poultry and fish production.

The project's major research thrusts include identifiying suitable insect species, assessing the potential market and nutritional attributes of the products, and developing and adapting cost-effective insect rearing, harvesting, and postharvest techniques for smallholder producers. It will also establish the risk factors associated with the insect-based feeds along the food chain and their mitigation strategies, as well as conduct research to inform policies for promoting safe, sustainable and cost-effective use of insects in the feed sector.

Accomplishments in 2015

- The researchers conducted a market demand analysis for the potential of insects as ingredients in animal feed that demonstrated the willingness and readiness of farmers to use insect-based feeds, provided that proper policy is put in place to support standards.
- They also demonstrated that in Kenya, in regard to poultry feed alone, the existing market for protein is above USD 45 million annually, providing a high potential for job creation and youth employment.

Insects for food and feed research partners:

University of Nairobi, Kenya; Sanergy Ltd., Kenya; Unga Feeds, Kenya; Lasting Solutions Ltd, Uganda: Makerere University, Uganda; National Livestock Resources Research Institute (NaLIRRI), Uganda; National Fisheries Resources Research Institute (NaFIRRI), Uganda; UgaChick, Uganda; Centre for Development Research (ZEF), University of Bonn, Germany; Food Security Center, University of Hohenheim Germany; Makerere University, Uganda; Uganda National Bureau of Standards; Kenya Bureau of Standards; Kenyatta University, Kenya; Egerton University, Kenya; Kenya Agricultural and Livestock Research Organisation (KALRO), Kenya; Solidaridad East and Central Africa, Kenya; Wageningen University, The Netherlands.

The desert locust, *Schistocerca gregaria*, contains a rich composition of compounds known as sterols, which in turn contain cholesterol-lowering properties, thereby reducing the risk of heart disease.

SOCIAL SCIENCE AND IMPACT ASSESSMENT UNIT

In R&D, social science is becoming more important than ever, to help researchers understand any barriers and conditions that could affect the adoption of a given strategy or technology. Similarly, impact assessment, i.e. the systematic analysis of significant livelihoods and environmental changes as a result of interventions, is becoming a priority. *icipe* has an emerging Social Science and Impact Assessment Unit that undertakes adoption, impact, gender and market analyses, to generate relevant evidence and knowledge, prioritise, and ensure the relevance and effectiveness of *icipe*'s research activities.

Donors: Australian Centre for International Agricultural Research (ACIAR) & International Development Research Centre (IDRC) through the CultiAF programme; Biovision Foundation for Ecological Development, Switzerland; UK Aid, UK Government; *icipe* core donors; European Union; German Federal Ministry of Economic Cooperation and Development (BMZ).

Social Science and Impact Assessment Unit

icipe has created a dedicated Social Science and Impact Assessment (SSIA) Unit to enhance this critical area of our research and to strengthen the work undertaken in this field within our research projects.

In 2015, the Unit conducted a number of research activities, provided technical backstopping across the Centre's research themes, and co-supervised postgraduate students.

The Unit also embarked on enhancing its capacity, by recruiting three new staff while at the same time continuing to enhance our social science capabilities embedded within our projects, with the appointment of additional gender and monitoring & evaluation specialists.

The key research agenda for *icipe*'s SSIA team is:

- Measuring adoption and impacts of technologies on economic, social, and environmental outcomes.
- Mainstreaming gender in the *icipe* technology development process, assessing gender issues in technology adoption and gender-differentiated impacts of the Centre's technologies on productivity and livelihoods.
- Conducting markets and value chains research to enhance farmers' competitiveness and capacities to adopt technologies.
- Capacity building of graduate students conducting research through application of advanced economics methods and tools.

Key achievements in 2015

8 household surveys conducted in Kenya and Ethiopia to understand enabling conditions and barriers to the adoption of *icipe* technologies, and their impacts on smallholder farmers' welfare. (*For more details see Human Health and Plant Health Themes chapters*).

4 impact papers published on: impacts of mango fruit flies on income, agrochemicals use and nutrition; returns and poverty reduction effects of *icipe*'s fruit fly IPM packages; impacts of bological control of stemborers on maize productivity and poverty; and technology combination adoption impact assessment on household and individual nutrition security and child stunting.

18 peer reviewed journal articles co-published with internal and external partners.

3 papers presented at the 29th Triennial Conference of the International Association of Agricultural Economists (IAAE), held in Italy in August 2015.

24 Postgraduate students (22 MSc and 2 PhD) aligned to *icipe* projects were undertaking studies related to social science and impact assessments in 2015.

> "Our goal is to support *icipe*'s efforts to develop and deliver technologies to end users by undertaking research activities to generate the relevant evidence and knowledge."

Dr Menale Kassie, Head, Social Science and Impact Assessment Unit

Annex 1: Internal *icipe* staff awards and recognitions

icipe staff awards

(i) *Outstanding Research Publication of the Year Award (ORPA)*
Recipient **-** *Dr Michael Okal et al.,* for their publication:
Lindh J.M., *Okal M.N.*, *Herrera-Varela M.*, Borg-Karlson A.-K., *Torto B.*, Lindsay S.W. and *Fillinger U.* (2015) Discovery of an oviposition attractant for gravid malaria vectors of the *Anopheles gambiae* species complex. *Malaria Journal* 14, 119. doi: 110.1186/s12936-12015-10636-12930.
New strategies are needed to manage malaria vector populations that resist insecticides and bite outdoors. This study describes a breakthrough in developing 'attract-and-kill' strategies targeting gravid females by identifying and evaluating an oviposition attractant for *Anopheles gambiae s.l*. In a world first, the team found that a naturally-occurring chemical attracts pregnant malaria-transmitting mosquitoes – a discovery that could boost malaria control efforts. The paper was rated by the journal as one of the top 10 (ranked 9th) papers of 2015.

(ii) Outstanding Professional Staff of the Year Award (OPSA)
Recipient **-** *Annah Njui:*
In recognition of the significant contributions that Annah has made over the years, during which time she has developed enduring relationships with donors, partners and staff alike. Her efforts ensure that *icipe* is viewed by the Centre's partners in the most positive manner, and that their needs are met in a timely and efficient way. She provides high quality relationship and contract management to *icipe* and its partners.

(iii) Outstanding Support Staff Contribution Award (OSSCA)
This year the panel felt that the contributions of two staff members were worthy of recognition:
Recipients **-** *Brian Mwashi and Syprine Amolo*

Brian Mwashi: In recognition of Brian's high level of professionalism and commitment to ensuring that *icipe* is always represented with a professional corporate image through his work on posters, banners, displays and the design of the Centre's new web site, among other things.

Syprine Amolo: In recognition of Syprine's efforts in leading the cleaning and gardening team at *icipe,* and in doing so supporting the transformation of the Duduville campus.

(iv) Outstanding Employee of the Year Award (OEYA)
Recipient **-** *Milcah Gitau:*
In recognition of Milcah's dedication to *icipe* and the support of the Centre's scientific activities through the supply of high quality insects that underpin a diverse range of research projects. The professionalism she shows in managing the *icipe* insect rearing facilities, including managing unpredictable demands, is appreciated by all those who rely on her services.

(v) Outstanding Team of the Year Award (OTYA)
This year the panel felt that the contributions of two teams of the Centre were worthy of recognition.
Recipients **-** *Plant Health Research Team and Facilities and Assets team*

Plant Health Team: In recognition of the Plant Health team's exceptional efforts and achievements in scientific publication, achieving stakeholder impact through the application of *icipe*-developed technologies, including public–private partnerships to commercialise a range of products, and in raising funds to carry out a diverse range of research.

Facilities and Assets Team: In recognition of the team's efforts and achievements in revitalising the Centre's infrastructure, including the oversight of the construction of new facilities (such as the bee health lab, student accommodation at Mbita, and the water harvesting facilities at both Mbita and Duduville). The team's achievements also include carrying out restoration projects in-house, including renovations of the Centre's Nguruman Research Field Station. The team's work has been of the highest quality while saving *icipe* considerable financial resources compared to outsourcing the projects.

(vi) Outstanding Partner-of-the-Year Award (OPYA)
Recipient - German Academic Exchange Service (DAAD)
The German Academic Exchange Service (DAAD) has been a consistent, major donor to *icipe*'s capacity building programme for the past 32 years, by providing PhD fellowships to students entering ARPPIS, *icipe*'s flagship capacity building programme.

The partnership between DAAD and *icipe* has provided young doctoral candidates, scientists, and academics, with the opportunity to carry out research and continue their education.

2015 *icipe* Governing Council Awards for Best Published Papers and Best Posters

In November 2015, the following scholars were awarded the 2015 *icipe* Governing Council Awards for publications and posters:

In the publications category the awardees were:
Winner: Xavier Cheseto for his paper 'Potential of the desert locust *Schistocerca gregaria* (Orthoptera: Acrididae) as an unconventional source of dietary and therapeutic sterols' published in *PLOS ONE.*

First Runner Up: Edith Chepkorir for her paper 'Vector competence of *Aedes aegypti* populations from Kilifi and Nairobi for dengue 2 virus and the influence of temperature' published in *Parasites & Vectors.*

Second Runner Up: Purity N. Kipanga for her paper 'High-resolution melting analysis reveals low *Plasmodium* parasitaemia infections among microscopically negative febrile patients in western Kenya' published in *Malaria Journal*.

In the poster category the awardees were:
Winner: Beatrice T. Nganso for her poster 'Aspects of the mechanisms of tolerance in *Apis mellifera scutellata* colonies to *Varroa destructor* mite in Kenya'.

First Runner Up: Nelly Ndungu for her poster '*Hypotrigona* bees (Hymenoptera: Meliponini): Morphology, behaviour, chemistry and genomics'.

Annex 2: External recognition of the Centre and its staff

Recognition of the Centre:

Science Fair Certificate of Participation: The certificate was awarded in recognition of the Centre's participation in the Science Fair during the Meetings of the Conferences of the Parties to the Basel, Rotterdam and Stockholm Conventions held in Geneva, Switzerland, 4 to 15 May 2015.

Certificate of Recognition: On 16th September 2015, *icipe* was awarded a Certificate of Recognition for its contribution towards the implementation of the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) on the occasion of PATTEC's 15th Anniversary.

Stockholm Convention Regional Centre for capacity building and the transfer of technology: The Centre was endorsed to continue operations as a Stockholm Convention Centre for a further 4 years (2016 to 2019) by the more than 160 countries that are members of the Stockholm Convention, following evaluation of the performance of the regional centres.

Recognition of staff:

Micky Mwamuye, an MSc scholar, was awarded the 'Emerging Research Talent Award' during the UNESCO–Merck Africa Research Summit 'MARS 2015' in Geneva (19–20 October).

Dr Benard Kulohoma, a Postdoctoral Fellow in the EID Lab was recognised as an exceptional researcher and trainer, and selected as the '2015 H3Africa-Harvard Fellow'. This fellowship is funded by H3ABioNet and supported by the H3ABioNet Harvard node. The appointment as a Visiting Researcher is for the period 25 January 2016 to 25 May 2016. He will be based at Harvard Faculty of Public Health (Harvard H3ABioNet Node).

He is also the winner of the 2015 award for 'Young Researcher' conferred during the UNESCO–Merck Africa Research Summit 'MARS 2015' in Geneva (19–20 October). This award comes with a 6-months' fellowship to gain professional experience in one of the Merck R&D hubs around the world.

Dr Daniel Masiga, Head of the Molecular Biology and Bioinformatics Unit (MBBU), was invited to participate in the Wellcome Trust Public Health and Tropical Medicine Interview Committee (PHATIC).

Dr Masiga, Acting Head of the Human and Animal Health Themes, was invited to the Cambridge–Africa Day in Cambridge on November 21, where he presented a paper entitled: 'Excellence in engaging with Africa: The example of THRiVE and the PhD programme at *icipe*'. SciDev.net interviewed him, and the interview was published in January 2016: http://www.scidev.net/global/communication/multimedia/culture-multitasking-threatens-african-research.html. The interview was titled: 'Culture of multitasking threatens African research'.

Dr Masiga also featured in the 2015 Annual Report of the International Foundation for Science (IFS) as a reviewer in the Animal Health Section.

Dr Charles Midega, a Senior Scientist in the Push–Pull Programme, Plant Health Theme, is the Cornell University, Ithaca, Distinguished Africanist Scholar.

In September 2015, Dr Midega, in his capacity as 'Distinguished Africanist Scholar' (awarded in September 2014), delivered various classroom and public lectures meant to stimulate discussion on agricultural research and development in Africa, challenges, opportunities, and future policy directions.

Dr David Tchouassi, a Postdoctoral Fellow in the Chemical Ecology Unit, was selected as a TWAS Young Affiliate. The prestigious affiliateship is for a period of five years, and was awarded by the World Academy of Sciences Regional Office for Sub-Saharan Africa (TWAS-ROSSA). Dr Tchouassi will be invited to participate in TWAS general meetings and conferences.

Dr Tchouassi received a Book Award entitled *One Health: The Human–Animal–Environment Interfaces in Infectious Diseases* edited by John S. Mackenzie, Martyn Jeggo, Peter Daszak, and Juergen A. Richt, as a Runner Up Winner for his poster at the 3rd International One Health Congress, from 15–18 March 2015, in Amsterdam, The Netherlands. His winning poster was entitled: 'Association of genetics of two key mosquito vectors of Rift Valley fever and changing outbreak patterns of the disease in Kenya'.

Prof. Zeyaur Khan, Principal Scientist, Push–Pull Programme, Plant Health Theme, was awarded the Royal Entomological Society, UK, Honorary Fellowship in June 2015, which is awarded to those who have given "eminent and distinguished service to Entomological Science and /or the Society".

In addition, Prof. Khan's presentation entitled: 'Exploiting plant behavior and chemical ecology for developing new crop protection strategies for Africa' was selected as one of the 20 Premier Presentations that was made at the Entomological Society of America's 2015 meeting in Minneapolis, Minnesota from 15–18 November 2015.

In April 2015, Prof. Khan was appointed an Adjunct Professor of Entomology at Cornell-Ithaca, with Dr Katja Poveda and Dr Andre Kessler as hosts.

Prof. Khan received the Louis Malassis International Scientific Prize for Outstanding Career in Agriculture in March 2015.

Dr Paul-Andre Calatayud, Visiting Scientist to 15th August 2015, Plant Health Theme, won the Prix Réaumur from the French Entomological Society, for his book *Interactions insects–plantes* (Insect–Plant Interactions), edited by Nicolas Sauvion, Paul-André Calatayud, Denis Thiéry and Frédéric Marion-Poll. Established in 1960, this prize is awarded to a book about biology written in French, with biology taken in its broadest sense. The award was presented at an official ceremony at the National Museum in Paris in March 2015.

Dr Baldwyn Torto, Head, Behavioural and Chemical Ecology Unit, was selected to serve as a member of the African Academy of Sciences (AAS) Commission on Sciences Education, one of four commissions that the AAS has established to build capacity and set the agenda for science in Africa. The others focus on women in science, Africa's science heritage, and Pan-African Science Olympiads.

The AAS has also selected him to serve on the jury for the award of the African Union (AU) Prizes.

Ms Prisca Oria, a student working in the SolarMal project, won a poster award at the Third Global Symposium on Health Systems Research in Cape Town, South Africa. Her poster was entitled 'Weaving together the technical, social and ecological perspectives in an innovative malaria control project'.

Dr Segenet Kelemu, Director General, *icipe*, was invited to serve on the National Science and Technology Council of the Republic of Rwanda.

The DG was celebrated in a commemorative calendar celebrating the 25th anniversary of the Organization for Women in Science for the Developing World (OWSD). The calendar recognises some of the senior members of OWSD from eastern and southern Africa who have made an immense contribution to gender, science and technology.

She is also being featured in an upcoming book on science and technology for Africa's development in a chapter devoted to highlighting the research, teaching, and leadership accomplishments of selected individuals who have contributed much to Africa.

The DG was invited to serve on international science award juries such as the L'Oreal–UNESCO Sub-Saharan Women in Science Award held in South Africa, and the Louis Malassis and Olam Prizes held in France, in 2015.

She was invited to speak on high profile science, food security and related gatherings, or to contribute to publications on important issues, at the Advancing Pest and Disease Modelling Conference held at the University of Florida, Gainesville, USA; Valagro Global Conference held in Italy; UNESCO's Science for Africa's Economic, Social and Technological Insurgence consultation held in Zimbabwe; the 2nd International Global Food Security Conference 2015

held at Cornell University, Ithaca, USA as International Scientific Committee member; and to contribute to a UNESCO special issue on 'Women and Biotechnology; Outlooks in Pesticide Management', among others.

In addition, the DG was invited to Expo Milano 2015 Women's forum to speak at the plenary session on women and food security. She was the only participant from Africa invited as a member of a high level panel on Science Week in Italy that TWAS and the Italian Government organised, where she presented and participated in a roundtable discussion at the Trieste Next 2015 Science week. The topic for the roundtable discussion was 'Ask Africa—Can Agribiotech Make the Difference?' An Italian journalist with international experience moderated the session, which involved two other speakers, Prof. Michele Morgante (University of Udine), and Prof. Alessandaro Vitale (National Research Council of Italy).

The DG made a presentation on *icipe* titled 'Out of Africa: Bioscience Innovations in Agriculture and Health' prior to the roundtable discussion. The event was given wide exposure in over thirty-one (31) print and electronic media platforms during the month of September. Considering that most of *icipe*'s current funding comes from Europe, this positive media coverage and fascination with *icipe* is valuable for the Centre. The strong partnership with TWAS is also critical on many fronts.

The DG (and *icipe*) was featured in an international science TV series called *The Mind of the Universe*, see http://themindoftheuniverse.nl/. She is one of only 30 individuals selected globally for this. *The Mind* is an ideological cross media project. It is the first open source TV series ever, providing the whole series for free to all countries in the world, to "spread knowledge". UNESCO is ambassador of *The Mind of the Universe*. Open University UK will create an international online learning experience to make all information available for everyone. The series is expected to air in 2017.

Dr Kelemu was elected a Fellow of The World Academy of Sciences (TWAS) at the 26th General Meeting of TWAS held in Vienna, Austria in recognition of her outstanding contribution to science and its promotion in the developing world.

Dr Lucy K. Murungi, a Postdoctoral Fellow in the Chemical Ecology Unit received a book award from African Women in Agricultural Research and Development (AWARD), for the best laboratory progress (February 2013–March 2015). She also received a grant from RUFORUM for research on soil-borne pathogens in smallholder greenhouse tomato production.

Dr Murungi was selected as an African Academy of Sciences Affiliate for the period 2016–2020. As an Affiliate, she will receive AAS assistance that will help her develop into a research leader in her respective field.

Ms Fiona Nelima Mumoki, a Research Assistant in the Molecular Biology and Bioinformatics Unit (MBBU), was named an AWARD Postgraduate Fellow for 2015, which is a prestigious fellowship for young African Women in Agricultural Research and Development awarded by the Organisation for Women in Science for the Developing World (OWSD). She commenced her PhD studies at the University of Pretoria, South Africa in March 2015.

Dr Sunday Ekesi, Head of the *icipe* Plant Health Theme, was elected a Fellow of the African Academy of Sciences in 2015. He is scheduled to attend the next General Assembly Meeting (21–24 June 2016) where he will receive his Certificate of Fellowship.

Prof. Clifford Mutero and his colleagues (Kramer R.A., Paul C., Lesser A., Miranda M.L., Mboera L.E.G., Kiptui R., Kabatereine N. and Ameneshewa B.), won the Best Overall Publication: Qualitative/Education/Health Systems Research, from the University of Pretoria Faculty of Health Sciences for their manuscript entitled: 'Factors influencing malaria control policy-making in Kenya, Uganda and Tanzania'.

Ms Edith Chepkorir, an ARPPIS PhD scholar supervised by Dr Rosemary Sang, received the L'Oréal–UNESCO for Women in Science Sub-Saharan Africa 2015 Award on 3rd December 2015 in South Africa worth EUR 5000, to support her PhD work.

Ms Matilda Gikonyo: Ms Gikonyo's presentation at the 2nd Africa International Biotechnology and Biomedical Conference, held in Nairobi, Kenya, Sep. 17th – 19th, 2015 was awarded the second runner-up award. Further Ms. Matilda also succeeded in gaining a PhD fellowship in the renowned Max Planck Institute for Chemical Ecology, Jena.

Dr George Obiero, who was a DAAD-supported ARPPIS scholar in *icipe* and currently lecturing at The Technical University of Kenya, has been awarded the Georg Forster Research Fellowship, becoming the first *icipe*-supported recipient of a fellowship from the Alexander von Humboldt Foundation. This will be tenable for 2 years at Max Planck Institute of Chemical Ecology, with Prof. Ewald Grosse-Wilde who works with Prof. Bill Hansson.

Dr Xavier Cheseto, a former ARPPIS Scholar and 2015 GC winner of the Publications Prize was informed of the successful selection of his application entitled: 'The enantioselective synthesis of plant-based semiochemical kairomones of tropical insect disease vectors' to the Rothamsted International Fellowship Scheme in March 2016. He has been offered the prestigious Rothamsted International Fellowship Award.

Dr Damaris Matoke, an *icipe* postdoctoral fellow and member of the Emerging Infectious Diseases (EID) Laboratory at *icipe*, was named the best biotechnology presenter, on her work on environmental determinants of sandfly and leishmaniasis distribution during a conference convened by the Kenya Medical Research Institute (KEMRI).

Dr Subramanian Sevgan (Plant Health Theme), was appointed as an Editorial Board Member for *SpringerPlus,* a peer reviewed open access journal. ■

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Hermannomyia ukasi

icipe

Annual Report 2015

icipe was established in 1970 in direct response to the need for alternative and environmentally friendly pest and vector management strategies. Headquartered in Nairobi, Kenya, *icipe* is mandated to conduct research and develop methods for pest control that are effective, selective, non-polluting, non-resistance inducing, and affordable to resource-limited rural and urban communities. *icipe*'s mandate further extends to the conservation and utilisation of Africa's rich insect biodiversity.

icipe focuses on sustainable development, including human health, as the basis for development, and the environment, as the foundation for sustainability. Working through a holistic and integrated approach through the 4H paradigm – Human, Animal, Plant and Environmental Health – *icipe* aims at improving the overall well-being of communities in tropical Africa by addressing the interlinked problems of poverty, poor health, low agricultural productivity and degradation of the environment.

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