FLYgene

Sustainable and efficient insect production for livestock feed through selective breeding

Stakeholders' workshop report in WP1

Deliverable under Milestone 1 (M1)

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UDENRIGSMINISTERIET
Ministry of Foreign Affairs of Denmark

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1. Introduction

1.1. Background of the report

The FLYgene project was launched in April 2022 to address the research gap in insect genetics and breeding thereby enabling the implementation of selective breeding for black soldier fly (BSF) in Kenya and Uganda. The project is implemented by Aarhus University, center for Quantitative Genetics and Genomics (AU-QGG), in collaboration with Makerere University (MAK), University of Copenhagen (UCPH), University of Nairobi (UoN), Jomo Kenyatta University of Agriculture and Technology (JKUAT), International Center of Insect Physiology and Ecology (ICIPE), InsectiPro ltd, and Marula Proteen ltd.

The implementation of selective breeding programs involves engaging various stakeholders, such as producers and consumers, service providers, and regulators, and taking their preferences into account when setting up the breeding programs. The success of the FLYgene project depends on the active participation of all stakeholders in the insect-for-feed value chain. To achieve this, the FLYgene project organized stakeholder workshops in Kampala, Uganda on November 22, 2022 and in Nairobi, Kenya on November 28, 2022. The main goals of these workshops included:

- Provide general overview of the FLYgene project;
- Jointly assess major challenges and opportunities in the insect-for-feed value chain as a step to identifying and prioritizing economically important BSF traits in smallholder and commercial BSF production systems of Kenya and Uganda;
- Raise awareness among stakeholders on the benefits of using genetically improved BSF strains for improved livestock feed availability;
- Stimulate linkage between the various stakeholders and actors.

1.2. Scope and methods

The workshops were held in each target country of the FLYgene project at a national level, with the goal of identifying specific constraints, breeding preferences, and stakeholder dynamics within each country. Participants represented a diverse group of stakeholders along the insect-for-feed value chain, including small-scale Black Soldier Fly (BSF) producers, commercial BSF companies, waste management companies, livestock feed processors, government agencies such as regulatory bodies and extension agents, and private extension workers and researchers (see Figure 1). The workshops included a

combination of plenary and breakout group discussion sessions (see Appendix 1 for the programs of the workshops in Kampala and Kenya). The workshops began with opening remarks by the country coordinators/work package PIs of the FLYgene project, followed by speeches from deans of participating universities, the head of unit at ICIPE, and a representative from the Danish International Development Agency (DANIDA). The project coordinator, Goutam Sahana, then gave an overview of the FLYgene project and a presentation on insect for food and feed research at Makerere University and ICIPE was provided. Participants were divided into three groups, each with a diverse representation of stakeholders, to discuss challenges in the insect-for-feed value chain, potential solutions, and the role of selective breeding and genetic improvement in the growing insect-for-feed sector. Each group selected a chairperson and presenter to lead the discussion based on pre-prepared talking points (see Appendix 2). The results reported in this document are limited to the situation in the target countries (Kenya and Uganda) and the scope of the data generated during the discussion and plenary sessions of the national workshops in these countries.

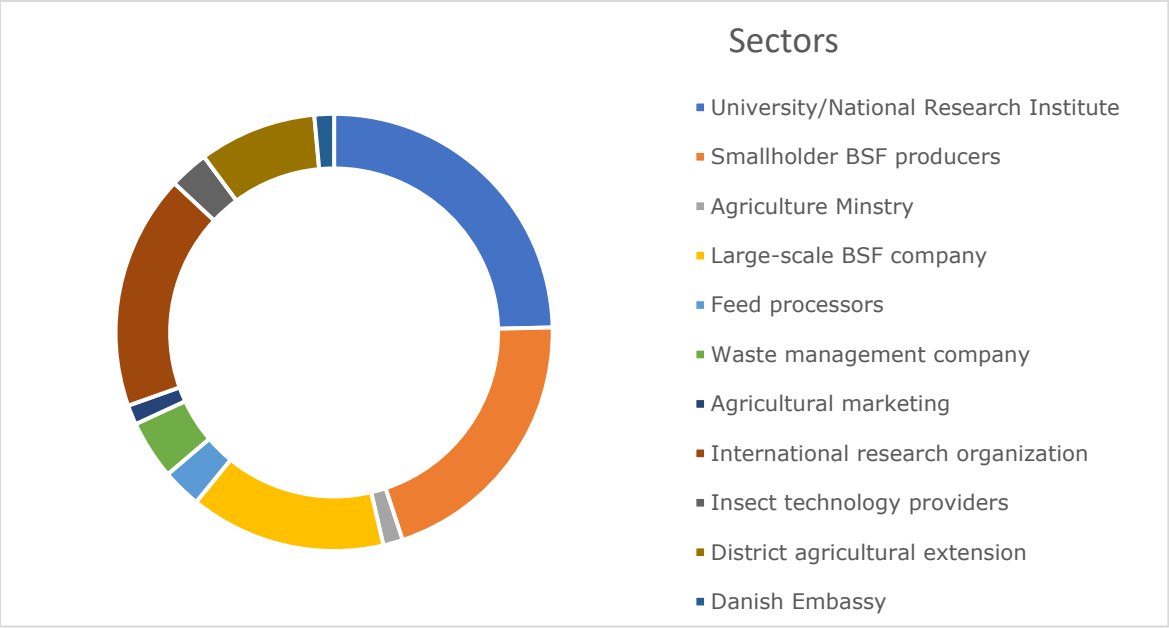


Figure 1. Sectors represented in the two national workshops combined (Nairobi and Kampala).

2. Major challenges in the insect-for-feed value chain

During the initial breakout discussion sessions, the focus was on identifying the main obstacles in the insect-for-feed value chain as perceived by different stakeholders and actors. While the specific challenges suggested and discussed varied depending on the sectors within the value chain (BSF producers, feed processors, extension services, etc.), they can be broadly categorized into: inadequate access to knowledge on BSF rearing, inadequate waste management systems, limited access to start-up financing, unfavorable climatic conditions for BSF rearing, ambiguous regulations, and inadequate collaboration among BSF producers and other stakeholders. In particular, the following problems were brought up and discussed from the perspective of:

BSF producers

i. Climate Factors. Adverse weather conditions, specifically low temperatures during the cold season, have a significant impact on the growth and reproduction of BSF. This presents a particular challenge for small-scale producers as climate-controlled facilities are too costly. Producers reported low egg production and hatchability during the cold seasons, resulting in colony collapse.
ii. Obtaining BSF Feed (substrate). Securing a consistent supply of organic waste for BSF feed is a major challenge for farmers. This category addressed issues such as a lack of organized waste management systems, limited knowledge on how to process low-quality feed to improve its nutritional content, and poor performance of BSF on fibrous feed materials. Participants emphasized the need for a steady supply of organic waste to sustain BSF production, but noted that there is intense competition for organic waste among BSF farmers and other organic waste users. The distance between BSF facilities and the source of organic waste was also identified as a problem, as transporting organic waste to facilities located far from its source in cities, towns and commercial hubs is expensive. Some suggested that instead of transporting waste, it would be more efficient to transfer 5-day-old larvae to the source of organic waste as the waste is bulky and difficult to move. Additionally, it was reported that lowland areas in Kenya, which have the best climate for BSF rearing, have limited access to organic waste streams. This is because most agricultural activity in the country is still dependent on rain and concentrated in mid- to highland areas, where the cold season may not be suitable for BSF rearing.

iii. Access to technical know-how, training, and understanding in BSF rearing and post-processing is limited. Most farmers that venture into BSF farming lack the necessary training to operate and maintain a BSF facility, resulting in colony collapse. Furthermore, some are unaware of waste segregation methods for quality f eeds and products associated with BSF rearing, such as frass fertilizer.
iv. Parasite and disease. Some farmers reported mite infestation in their colony which had a negative effect on the BSF colony.
v. Finances. Many farmers, primarily the young farmers face financial challenges in setting up and running a BSF facility.
vi. Lack of business models and financial advice that give farmers a clear picture of the economic sense and break even following after BSF rearing.
vii. High cost of post-processing. The post-processing is costly as it requires equipment such as dryers and sterilizers which most farmers cannot afford.
viii. Capturing the wild BSF. Capturing the wild BSF was reported as a challenge for farmers who depended on the wild to boost the genetic diversity of their captive colony.
ix. Mechanization. For farmers hoping to significantly increase their production, mechanization was a huge challenge due to the high cost of equipment.
x. The foul smell around the rearing areas resulting from the waste has deterred individuals from engaging in BSF farming since it is deemed filthy.
xi. Colony collapse. Colony collapses due to one or more of the aforementioned technical challenges has been reported as one of the major causes of farmers abandoning BSF production. Some of the participating farmers reported collapse of their own colony at some point or another and that they had to source a new colony from other farmers. However, some of their cohorts who received training and initial stocks with them abandoned the production when they faced similar colony collapse.

Waste management companies

i. Improper handling of organic waste. In some cases, the organic waste is not managed correctly at its source, leading to contamination with hazardous chemicals and pathogens, which can negatively impact BSF production.
ii. Standardizing nutritional value of organic waste. There is a lot of variability in organic waste and given its nature, there is no ideal way of standardizing the substrate as BSF feed to maintain uniform nutritional quality.
iii. Regulation. The regulations set for handling organic waste are strict. Obtaining the licenses is also an uphill task with financial implications.

Feed Processors:

i. Lack of access to equipment needed for efficient processing of BSF products
ii. Lack of access to technical know-how on proper BSF product processing information e.g., appropriate temperature, storage conditions, etc.
iii. High demand but very low supply of BSF product: Feed processors noted that the BSF industry in both Kenya and Uganda only contributes a small part of the overall protein required for animal feed so far. There is a substantial demand that has yet to be satisfied. Another issue in this category is that even the limited supply is not consistent, and feed processors report significant fluctuations in the availability of BSF meal throughout the seasons.
iv. There is no standard documentation for using the BSF feed. Inadequate data prevents processors from determining how much BSF to include in their commercial feed.

Extension Agents

i. Huge demand for advisors: There is lack of a specialists with enough information available to guide the BSF farmers, which are far too many for the number of extension workers and distributed in distant places.
ii. Lack of manuals and training. In Uganda, it was reported that there is a weak link between universities that develop information and extension agents who communicate it to smallholder farmers. It was also claimed that the extension agents' capacity to offer effective advice to their clients (smallholder BSF farmers) was hampered by a lack of standard manuals and other support.

Researchers

i. Farmers dropping out. Of the farmers that received training and initial stock supply by ICIPE, a significant number have dropped out of the practice. It was noted that its a challenge to keep track of which of the recipients of training and initial stock are continuing their farming and which ones dropped out for further engagement.
ii. "Secrecy" in the industry (lack of collaboration among established commercial farms). Research necessitates communication with stakeholders and a shared understanding of issues. Researchers reported

that there is a significant level of secrecy within the BSF industry, particularly among larger companies, which hinders cooperation and causes individuals to try and independently "reinvent" solutions for every problem.

3. New opportunities in the BSF value chain

3.1. Increasing awareness on importance of the sector

Although insect production for livestock feed has the potential to establish a circular bioeconomy, mitigate the effects of climate change, create jobs, and improve livestock productivity, the sector has not yet received adequate recognition or support from the general public or relevant institutions. However, participants noted that this is starting to change as more research and development efforts are directed towards the sector.

Organizations such as ICIPE are working to increase awareness among policymakers and regulators of the many benefits of using insects for feed, food, and other purposes. In this regard, ICIPE is collaborating with the African Union to create regulations and policy frameworks that guide the insect-based food and feed production sector across Africa.

3.2. Specialized BSF production systems

BSF farming is a relatively new field in agriculture around the world, and there are many opportunities for optimization at different levels of the production chain. Currently, BSF production worldwide has largely followed a generalized system in which each producer or company handles a wide range of activities in the production process, from collecting inputs (waste) to processing the final product (BSF protein and oil). During the stakeholder workshop, it was suggested that this generalized system may hinder progress in different parts of the BSF production chain, and there may be a need for specialized production in the future. In this model, producers or companies would focus on a specific aspect of the production process, for example, substrate processing, breeding (egg production), larvae production, post-production processing, etc. similar to other livestock production systems such as poultry.

During the experience sharing session at the workshop held in Kampala, at least two participants mentioned that their respective companies are moving towards specialization in egg production, with a business model that relies on other BSF producers who purchase the eggs and rear the larvae. It was suggested that such specializations in the future might promote collaborations, as producers specializing in different aspects of the production chain would be complementary to each other rather than competitive.

3.3. Huge demand for BSF products including organic fertilizers

Participants from the user side of BSF production (feed processors) and researchers highlighted the significant gap in protein for livestock feed that the BSF sector has the potential to fill, providing a huge opportunity for growth in the sector. BSF producers also reported increasing demand for other BSF products, particularly frass, which is used as an organic waste fertilizer.

During the workshop, it was widely reported that the financial benefit from selling frass is almost the same or even higher than the return from BSF protein and fat, which may be due to the increasing prices of chemical fertilizers and growing evidence of the wide range of benefits of BSF frass as an organic fertilizer.

While these developments present opportunities for the BSF industry, they may also have implications for the selective breeding operations that the FLYgene project aims to carry out. It was suggested that this could be addressed in the future by developing separate BSF strains, one for efficiency in feed production, and another for high-quality waste fertilizer production.

4. The importance of selective breeding in BSF production

4.1. Stakeholders' awareness

An important aspect of the discussion during the breakout session was evaluating the awareness of different stakeholders on the significance of genetic improvement in agriculture. A majority of the stakeholders were familiar with selective breeding, although primarily in other livestock and poultry species. BSF producers had high expectations for genetic improvement in addressing some of the challenges they have experienced and reported at the workshop. Many farmers were optimistic that selective breeding could significantly improve production, fertility, and resilience traits in their colonies and reduce the risk of colony collapse. Some farmers were also aware of the potential effects of inbreeding accumulation over generations.

4.2. Prioritized traits for improvement

The discussions on the role of genetic improvement in BSF production were further refined by examining the candidate traits that stakeholders believed were priorities for genetic improvement. These traits were discussed not only from the perspective of BSF farmers but also from the perspective of other stakeholders, such as feed processors, who may have different priorities. A long list of traits was suggested as priorities by different stakeholders, including smallholder and industry-scale BSF producers, as well as livestock feed processors. However, the two most important traits suggested by almost all breakout groups in both countries were: 1) thermo-plasticity, specifically, the ability of the adult colony to survive and reproduce under low temperatures, and 2) survival and productivity under a wide range of low-quality substrates. Smallholder producers who reported colony collapse during cold seasons, agreed that the ability to survive and lay viable eggs in low temperatures was critical. Providing climate control (heating systems) is unaffordable in the smallholder production system, and hence selection for this trait is deemed a priority. The major characteristic of the BSF production system is the lack of consistency in the composition and quality of organic waste available. Farmers reported huge variations in productivity even with minor changes in substrate composition and quality, so the ability to degrade and survive on a wide range of low-quality substrates is an important BSF attribute consistently suggested for genetic improvement. The suggestion to target this trait included selection for feed conversion ability, growth, and body weight under a specific type of organic waste. The nutritional quality of the BSF product was also

suggested and discussed as a key trait, deemed necessary by all major stakeholders, particularly large BSF companies and livestock feed processors. The complete list of traits suggested for improvement is as follows:

i. Adaptation to variable temperature conditions. BSF farmers look for a resilient colony that will not be affected by temperature fluctuations. More specifically, farmers are interested in the ability of the adult fly to survive and reproduce at lower temperatures during the cold season without the need for heating. Along with this category, the hatchability of eggs under such low temperature conditions was mentioned.

ii. Ability to degrade and grow under a wide range of low-quality substrates. These characteristics were highly prioritized by most farmers (smallholders and medium- to large-sized companies alike). To achieve those several traits need to be improved, including the ability to degrade low quality feeds, especially with high fiber content, feed conversion efficiency, and growth-related traits.

iii. Hatchability of eggs. Farmers frequently stated that they would like to see up to 90% of all laid eggs hatch. It was suggested as one of the priority traits to improve through genetic selection.

iv. Resistance to pests and diseases. A colony that is resistant to pests (mites) and diseases.

v. Longevity of the adult fly. An adult fly that has a longer lifespan and hopefully one with high fecundity.

vi. Protein to fat ration. High protein content relative to fat was suggested as an important trait to consider for improvement. This trait was mostly suggested by the medium- to large-scale BSF producers and the livestock feed processing companies. Although not raised by the majority, a few participants also suggested detailed protein composition as a target for genetic improvement.

vii. Size uniformity. Larvae tend to vary in size despite being fed on the same substrate. From the point of view of production and harvest, farmers would like to have uniformly sized larvae from the same batch at the time of harvest. This is also important to prevent larvae to turn pupae at the time of harvesting.

5. Stakeholders' linkage and platform

The main goal of the stakeholder workshops was to evaluate the current level of collaboration between stakeholders and discuss ways to improve it. Attendees were asked to identify any missing sectors that should be included in future workshops. Financial institutions, specifically those focused on microfinance, were identified as important stakeholders to engage with. The lack of access to finance was identified as a significant challenge for the BSF farming sector in Kenya and Uganda, leading participants to suggest engaging with donors and financial institutions in future workshops.

It was acknowledged that the current level of collaboration among stakeholders was weak. Many participants stated that it was their first time participating in a forum that brought together various sectors in the value chain. There were different suggestions for platforms in the future, including:

i. Cooperatives:
Most attendees in both countries suggested the formation of cooperatives as a solution. It was emphasized that cooperatives can assist in organizing consultation meetings, sharing ideas, and influencing policy making. There were two different perspectives on the structure of these cooperatives: some proposed creating cooperatives based on specific sectors, such as a BSF producers cooperative, to facilitate connections across sectors, while others suggested a unified cooperative that brings together all major sectors involved in BSF production.

ii. Regular stakeholder workshops to encourage collaboration and communication:
Regardless of the specific structure of the cooperatives proposed, it was agreed that holding annual conferences or meetings would be essential in promoting future collaboration. These conferences could be organized by the cooperatives once they are established.

iii. Using digital tools and platforms to facilitate communication and collaboration among stakeholders:
It was noted that there have been some attempts to form social media groups, specifically a WhatsApp group, but they were reported as disorganized, exclusive, and lacking specific goals. Therefore, it was emphasized that a well-organized WhatsApp group is needed for efficient information exchange.

iv. TIMPs (Technology Innovation Management Practices)
It was noted that some stakeholders are already in the process of developing platforms to promote consistent cooperation and communication among BSF value chain

stakeholders. One such effort is the TIMPs initiative, which was discussed by a participant from the Nairobi meeting who is involved in its development. They provided an overview of the objectives and plans of the TIMPs initiative.

6. Conclusion and way forward

The FLYgene stakeholder workshops organized in Nairobi and Kampala have successfully achieved the overarching objectives of familiarizing the various stakeholders with the project plans for the coming years, raising awareness about the benefits of genetic improvement to address some of the emerging major challenges the industry is facing, and stimulating linkage among the various stakeholders.

The major challenges as seen from the perspective of the different sectors involved in the insect-for-feed value chain have been identified, and genetic improvement was suggested as a powerful means to tackle some of these challenges. Furthermore, BSF traits have been identified and prioritized as targets for implementing the selection programs in the FLYgene project.

The workshops concluded that the current linkages among the various stakeholders in the insect-for-feed value chain are weak, and the need for platforms to bring these stakeholders together was stressed. Additional sectors, such as the microfinance institution, were suggested for inclusion in future engagements. It is suggested that cooperatives of BSF producers or BSF associations in general bring together all stakeholders.

The following points were highlighted as the way forward:

- A follow-up large-scale survey will be implemented in at least 3 agro-ecological zones in each target country to validate the stated trait preferences and prioritize among them for future economic weight derivations. Once trait preferences are validated and traits are prioritized, all phenotyping and breeding program development activities in the project will focus on these priority BSF traits;

- The FlyGene project will create regular feedback mechanisms where research progress is periodically shared to stakeholders and feedbacks received for future considerations;

- Additional partnerships will be included in the FlyGene project to bring in organizations and enterprises which showed keen interest during the workshops.

These includes the Kenya Agricultural and Livestock Research Organization (KALRO) and Regan Organics ltd (Kenya);

- Inputs from the stakeholder workshops regarding stakeholders' cooperation will be incorporated into ongoing initiatives by some partners to create stakeholder platforms which might gradually evolve into cooperatives;

- The FLYgene project will continue to engage the various stakeholders throughout the project implementation period. Accordingly, a regional workshop for stakeholders from different countries in sub-Saharan Africa is planned for the end of 2023.

Appendix

Appendix 1: Programs of the workshops

	FlyGene PROJECT INCEPTION & STAKEHOLDER WORKSHOP; MONDAY 28th NOVEMBER 2022; ICIPE DUDUVILLE CAMPUS, KASARANI, NAIROBI, KENYA			
	Description	**Time**	**Presenter**	**Moderator**
	Arrival and guest registration	8.00 am - 9.00 am	Carolyne Akal & Cynthia Opany	Dr. Fathiya Khamis (*icipe*)
	Introduction of participants	9.10 am - 9.20 am	All	
	Welcoming address by *icipe*	9.20 am - 9.30 am	Dr. Thomas Dudois, Head of Plant Health Theme	
	Remarks from the Dean Faculty of Veterinary Medicine, University of Nairobi	9.30 am – 9.40 am	Prof. John Demesi Mande	
	Remarks from the Dean, School of Biomedical Sciences, JKUAT.	9.40 am – 9.50 am	Prof. Johnson Kang'ethe Kinyua	
	Overview of *icipe* & Road map of insects for food and feed in Africa – setting the scene for FlyGene project	9.50 am – 10.20 am	Dr. Peter James Egonyu, Scientist, Insects for Food, Feed and Other Uses program (*icipe*)	
	GROUP PHOTOGRAH & TEA BREAK AND PRESS BRIEFING	**10.20 am - 10.30 am**	All	
	FLYGene Project overview	10.30 – 11.00 am	Prof. Goutam Sahana	Prof. Grum Gebreyesus
	Experience sharing from stakeholder representative: Success stories and challenges	11.00 – 12.00 am	Selected insect farmers	
	Break-out sessions into three groups	12.00 – 13.30 am	All	
	LUNCH	**1.30 pm - 2.00 pm**	All	
	Continued break-out sessions into three groups	2.00 pm - 3.00 pm	All	Dr. Catherine
	Brief presentations from each group & discussions	**3.00 pm - 4.00 pm**	Group Representatives	
	Closing remarks	4.00 pm– 4.30 pm	Dr. Segenet Kelemu (DG and CEO; ICIPE)	
			Prof. Mogens Sandø Lund (Center leader; AU-QGG)	
			Dr. Rawlynce Cheruiyot Bett (country coordinator for Kenya; FlyGene project)	
			Dr Fathiya Khamis (WP PI, FlyGene project)	
			Asst. Professor Grum Gebreyesus (co-coordinator; FlyGene project)	
	EVENING TEA/NETWORKING AND DEPARTURE	**4.30 pm**	All	

Appendix 1: Programs of the workshops

FLYGENE INCEPTION MEETING, MAKERERE, 22ND NOVEMBER, 2022		
ACTIVITY	**TIME**	**RESPONSIBLE/PRESENTER**
Arrival and registration	8:00 – 9:00	Dr. Ndagire/Robert
Self-introductions	9:00 – 9:15	All
Welcoming remarks	9:15 – 9:20	Prof. Nakimbugwe
Remarks from the Head Dept. Food Technology & Nutrition (DFTN)	9:20 – 9:30	Prof. Mukisa
Remarks from the Dean, School of Food Technology, Nutrition & Bio-engineering (SFTNB)	9:30 – 9:40	Dr. Atukwase
Remarks from the Principal, College of Agricultural & Environmental Sciences (CAES)	9:40 – 9:50	Prof. Nabanoga
Commissioner Entomology, Ministry of Agriculture, Animal Industry & Fisheries (MAAIF)	9:50 – 10:00	Mr. Gidudu Masaba
DANIDA representative	10:00 – 10:10	DANIDA Representative
Project over view	10:10 – 10:30	Dr. Goutam Sahana
Tea Break	10:30 – 11:00	All
BSF rearing and processing research, training and outreach at MAK	11:00 – 11:30	Dr. Ssepuuya
BSF Farmer experiences	11:30 – 12:00	Selected Farmers
Discussions & Reflections	12:00 – 13:00	All
Lunch Break		
Break-out sessions	14:00 – 15:00	All/ moderated by Prof. Grum Gebreyesus
Presentations & discussions	15:00 – 16:00	Group Representatives
Closing Remarks	16:00 – 16:30	Prof. Nakimbugwe
Evening Tea & Departure	16:30	All

Appendix 2. Breakout discussion points

1) Can you tell your activities/experiences/exposures within the BSF value chain?
   This could be as part of:
   - *BSF farmers/breeders*
   - *Feed processors*
   - *Input suppliers*
   - *Extension Agents*
   - *Policy makers*
   - *Regulatory agencies*
   - *Consumers/consumer associations*
   - *Other (kindly list the other stakeholders in the group)*

2) As a stakeholder in the insect-for-feed value chain, what do you think are the most important challenges facing the sector now.

3) How do you think these challenges can be addressed?
4) What do you think are the most important BSF qualities/traits that should be genetically improved?

5) What are the linkages between the different stakeholders in the BSF value chain?
   · Leading questions
   - *Have you had any meetings with stakeholders in the last 12 months?*
   - *Would you prefer/like to have a platform that links the stakeholders together?*
   - *What stakeholders would you prefer to join/be part of this platform?*
   - *What kind of platform do you think can work for this BSF value chain?*

Optional (according to time availability)

- kindly suggest or recommend the names and contacts of people involved in BSF activities in your area that didn't attend this workshop yet crucial to the project's success

Appendix 3. Pictures

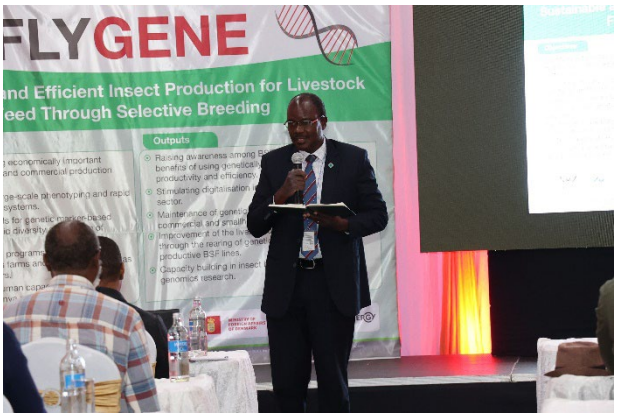
Participants on the workshop in Makerere, Uganda

Participants on the workshop in ICIPE, Kenya

Welcoming remarks Makerere, Uganda

Welcoming remarks, ICIPE, Kenya

Opening remarks, Danish Embassy, Uganda



Opening remarks, UoN, Kenya

Opening remarks, Makerere, Uganda

Opening remarks, JKUAT, Kenya

Introducing the FlyGene project

Introducing the FlyGene project

Experience sharing sessions, Uganda

Experience sharing sessions, Kenya

Experience sharing sessions, Uganda

Experience sharing sessions, Kenya

Group discussion sessions, Uganda

Group discussion sessions, Kenya

Group discussion sessions, Uganda

Group discussion sessions, Kenya

Group discussion sessions, Uganda

Group discussion sessions, Kenya

Discussion groups report to plenary (Uganda)

Discussion groups report to plenary (Kenya)

Discussion groups report to plenary (Uganda)

Discussion groups report to plenary (Kenya)

Closing remarks (Uganda)

Closing remarks (Kenya)

Closing remarks (Uganda)

Closing remarks (Kenya)

Closing remarks (Uganda)

Closing remarks (Kenya)