Internship Report on Black Solder Fly Production at Hermetia, Baruth, March – August 2020

1 Background

In a quest to improve food and nutrition security in Malawi, Ich-Liebe Fisch, a project funded by the German Federal Ministry of Food and Agriculture, has been implementing activities aimed at promoting production and consumption of fish and fish products. The project which targeted the central region districts of Mchinji and Nkhotakota, has been implement by Malawian researchers headed by Professor Daud Kassam of the Lilongwe University of Agriculture And Natural Resources in partnership with researchers from two German institutions, Fraunhofer Research Institution for Marine Biotechnology and Cell Technology (EMB) and the Association for Marine Aquaculture (GMA) . Among the outcomes of the project, lack of good quality fish feed has been pin-pointed as one major challenging drowning the fish farming sector in Malawi. Fish feed in Malawi is expensive because it is mostly imported from neighboring Zambia and for the fact that fish meal which is also highly demanded in the poultry industry is used as the main source of protein. Alternatively soy bean has been used as a source of protein but high demand of it for other purposes makes fish feed production costly. The project therefore identified cheap and reliable source of protein that can be alternatively used as a key ingredient for fish feed production, the Black Solder Fly (BSF). Two Students were therefore given an opportunity to go to Germany and be trained in BSF production. The students Esther Nyirenda and Hassib Sainan were attached at Hermetia in Baruth from the 17th of March 2020 to the 31st of July 2020, a company that mass produce the BSF and it is owned by the Katz brothers, Heinrich and Peter.

2 Black Soldier fly Production

Black Solder Fly, Hermetia illucens (figure 1) has been successfully been used to produce animal and poultry feed due to its high nutritive value. What makes Hermetia Illucens a common friend is its ability to decompose organic matter into organic fertilizers there by reducing the cost of producing it. Black Soldier fly (BSF) is known to help in feed industry by reducing competition of feed between humans and animals. The competition is due to an increase in population growth and decrease in animal protein sources as they are getting depleted at an increasing rate. Looking for alternative sustainable means of animal protein

such as insects is ideal. There are a lot of ventures into BSF production by many companies in many countries such as Agri-Protein in South Africa, in Indonesia as well as in Germany by Katz a company known as Hermetia, Baruth. This report describes BSF cycle production at Hermetia, Baruth.

Figure 1: BSF adult fly

3 Daily Routine activities

At Hermetia Company in Baruth, work starts at 600 hours and ends at 1400 hours every day from Monday to Friday. Working during weekends is assigned to specific individuals. The day usually starts with a stand up meeting where the Manager gives tasks to each individual for that particular day. After the meeting members are then dispatched into their different tasks which may begin with a general cleaning of materials and equipment to be used on that particular day and then people go into more specific assigned tasks. At the end of the day, all the workers also engage in general cleaning activity where the tasks such as swiping, mopping and placing equipment into their right places are carried out.

4 Production Units at Hermetia in Baruth

Black Solder fly production at Hermetia can be divided into 4 sections. The fly house, incubation and pre-larvae rearing unit, bioreactor larvae rearing unit and BSF Pupae production unit.

4.1 Fly House Unit

4.1.1 Requirements

- Pupae incubation dark cage area
- Fly rearing light cage area
- Cages
- Water containers with a thick cloth
- Cardboards
- Pegs
- Spoons
- 2 personnel

4.1.2 Fly Rearing

Adult BSF can be obtained from the wild by preparing attractants which can be placed near pit latrines or waste dumping sites. At Hermetia in Baruth, there is already an existing colony that continues the cycle of broodstock.

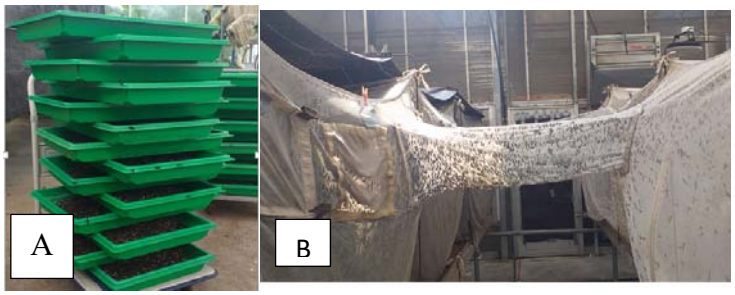

Figure 2: Pupae in trays A, light cage connected to dark cages B

The pupae hatches into flies after 1-3 days of placing the trays in the dark cages. A new cage is connected to the dark cage (figure 1B), but is placed at an open space in order to direct the flies into the new cage as the flies follow light. To increase the life span of the flies, containers filled with water and a cloth with good capillary put on top of the containers' lid are placed inside the cage (figure 2).

Figure 3: Water container placed inside the cage

4.1.3 Preparation of egg traps (card boards)

When egg traps are (reused) not new, they have to be cleaned using compressed air (figure 4A). The cleaned and new egg traps are weighed on a scale to record their weight, the weight is written on a paper sticker and pasted on each egg trap based on its weight (figure 4B). The egg traps with the weight written on them are taken to the fly house to be placed in the cages and on the corners for egg collection.

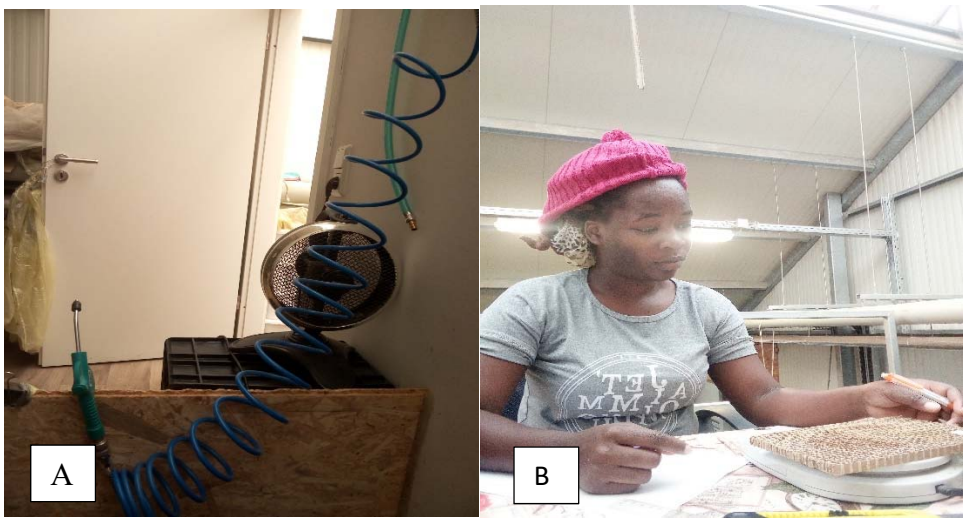

Figure 4: Air nozzle for cleaning card boards (A) and egg weighing (B)

This also serves as humidify for the cages since water gradually evaporates into the surrounding. When the cage is fully filled with the flies, it is moved to a new location where egg traps are placed on the corners and inside the cage (figure 5B). Egg collection may begin 24 hours after relocation.

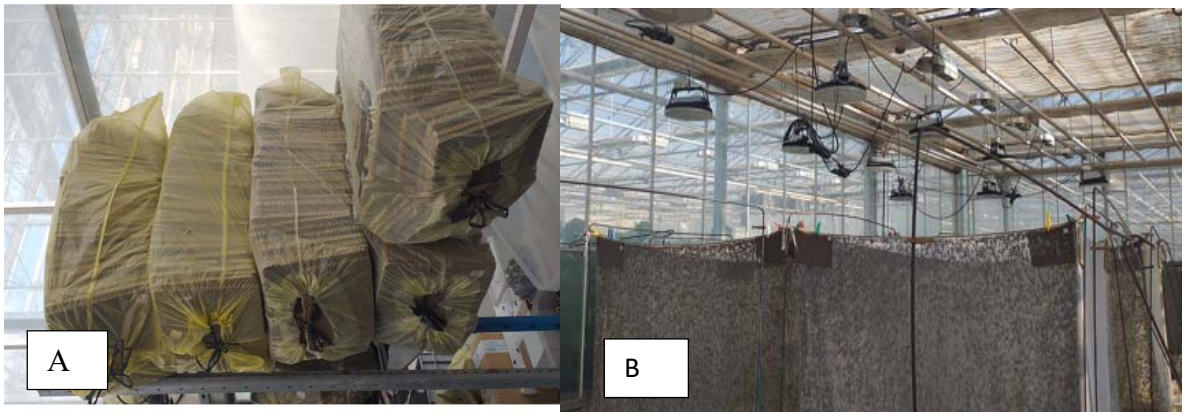

Figure 5: Card boards ready to be placed for egg collection A, fly rearing cages with card boards placed on the corners

Adult BSF will start mating when conditions in terms of light availability, space, temperature and humidity are favorable. It is crucial to provide sufficient ventilation in the fly house. Air humidity should be kept above 70% and temperatures within 25-30 degrees are suitable for the survival of the adult flies. After mating female BSF will lay eggs into the cardboards using their ovipositors.

4.1.4 Egg collection

H. illucens' eggs are collected from cardboards placed inside cages where adult flies are kept and on corners of the cages (figure 3B). The egg traps could be bamboo sticks, PVC cuttings, card boards, and any other locally made materials that provide space for oviposition of the eggs through black soldier fly's (BSF) ovipositor. Adult BSF can lay eggs up to an average of 500 and they are believed to lay eggs once in their life time. The eggs are tiny hence the need to use materials that will prevent the eggs from passing through. The cardboards used have holes with a diameter of 3 mm. However, the eggs are laid in batch and stick together preventing the eggs from passing through. At Hermetia, Baruth, card boards are used for egg collection. Small spatulas or plastic spoons are used to remove eggs that have been laid on the cage's surface as well as on the water containers.

It is recommended to collect the eggs in the morning during which most flies are not actively flying. Collecting the eggs when the flies are actively flying leads to flies escaping out of the cages which reduces number of broodstock.

4.2 Egg Incubation Pre-Larvae Rearing Unit

4.2.1 Requirements

- Weighing balance
- PVC rings
- Containers -5L
- Plastic shovels
- Measuring cylinder
- Feed
- 1 person

After eggs are collected from the cages, they are weighed (figure 6) to determine total egg production for a particular cage as well as particular day. It is also important to quantify the eggs to determine when a particular broodstock can be terminated. Termination of broodstock in cages is done when the amount of eggs starts to diminish, thus eggs can be collected 3 or 4 times before termination.

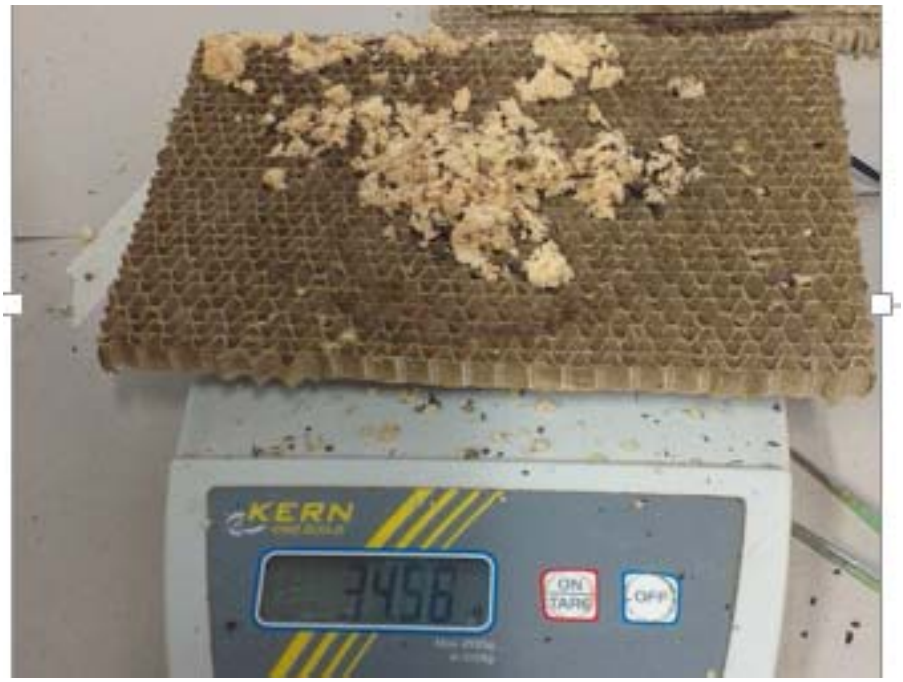

Figure 6: Weighing of card boards with eggs

Collected eggs should be free from debris that can lead to death of eggs and larvae. Eggs are incubated in small containers with temperatures between 25 and 30 ^{o}C. It is important to keep the incubators humid for Hermetia require a humidity of at least 70%. After the eggs are weighed, the eggs are incubated in white boxes with lids. In the boxes rings are used to hold the egg traps during incubation and also, leaves are placed at the bottom of the boxes to increase humidity (not mandatory). In each box about 20-23g of eggs are incubated for about 2-3 days.

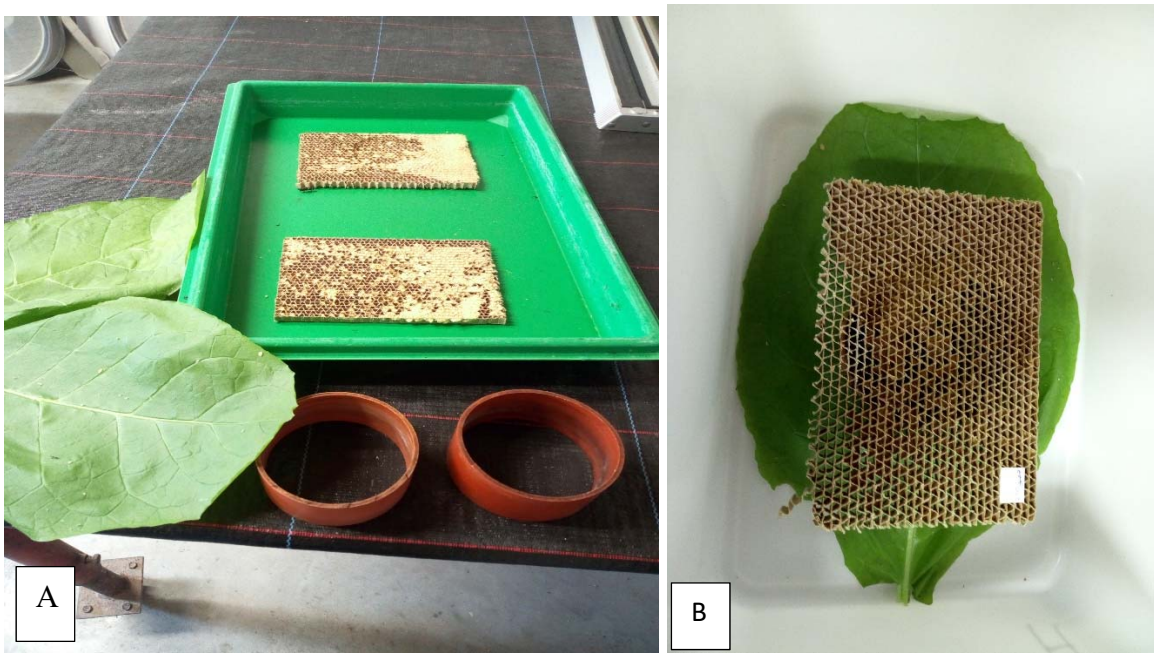

Figure 7: PVC rings, tobacco leaf and egg traps (A) and all placed in a white box (B)

At Hermetia in Baruth, a range of 21-23 grams of eggs are put in each incubation box and these are put together with the cardboards.

After the incubation period, white containers are transferred into nursing room where their contents, (hatched larvae) are transferred into a new container. One litre of feed mixture is added to each boxed that was stocked with 23 grams of BSF eggs. A little wheat or maize bran is spread on the surface of the container before transfer and on the surface of the contents after transfer. This is done to enhance the texture of the substrate and to control the water contents.

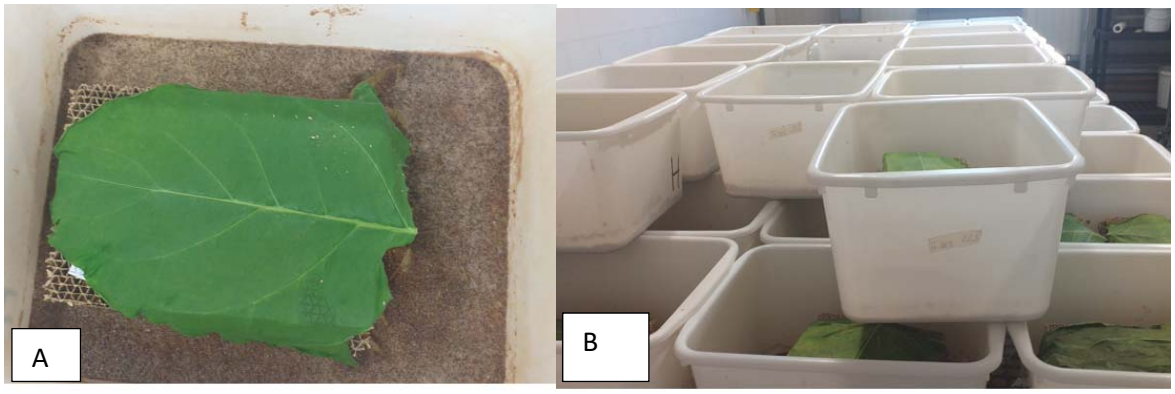

Figure 8: Larvae introduced to first feeding (A) and larvae in nursing containers during the first week (B)

The larvae in the first nursing containers are usually kept for a week before being given another feed. After this first week the cardboards and the rings are then removed. The rings are usually cleaned with slightly warm water (30-32 ^{o}C) to make sure that no larvae is taken with the rings (figure 9). This done carefully to avoid flooding the larvae in the container with too much water which would affect their mobility hence affecting their survival.

Figure 9: Removing cardboards and rings

4.2.2 Feed preparation

Feed for Hermetia larvae can be prepared from a variety of food stuffs ranging from organic wastes to industrial by products. Since Hermetia prefers warm temperature, feed preparation

should be done using warm water but at the same time not hot to kill the larvae. The feed can be prepared by thorough mixing the ingredients into warm water to form a watery mixture inform of porridge. The ingredients could be maize, wheat or bran, industrial by products and organic wastes. Tables 1 and 2 are the mineral and nutritive content of the two types of feed used at Hermetia.

Table 1: Sole Feed for pig fattening Type 2116

Inhalt	Content	%
Rohprotein	Raw protein	17.83
Rohfett	Raw fat	2.25
Rohfaser	Raw fibre	5.85
Rohasche	Raw ash	4.50
L-Lysin	L-Lysine	0.72
Methionin	Methionine	0.30
Calcium	Calcium	0.50
verd. Phosphor	digestible Phosphorus	0.25
Natrium	Sodium	0.11
Wassergehalt	Water content	12.00
Zusammensetzung	Composition/Ingredients	
Weizen	Wheat	
Malzkeime	Malt germs	
Rapsextraktionsschrot	Rape seed extraction grist	
Weizennachmehl	Wheat post-flour	
Gerste	Barley	
Mais	Corn	
Calciumcarbonat	Calcium carbonate	
Vitaminmischung	Vitamin mix	
Natriumchlorid	Sodium chloride	
ME (MJ/kg)	12.7	

Table 2: Sole Feed for pig fattening Type 2115

Inhalt	**Content**	**%**
Rohprotein	Raw protein	18.00
Rohfett	Raw fat	2.00
Rohfaser	Raw fibre	5.30
Rohasche	Raw ash	4.60
L-Lysin	L-Lysine	0.76
Methionin	Methionine	0.29
Calcium	Calcium	0.51
verd. Phosphor	digestible Phosphorus	0.25
Natrium	Sodium	0.13
Wassergehalt	Water content	12.00
Zusammensetzung	Composition/ Ingredients	
Triticale	Triticale	
Rapsextraktionsschrot	Rape seed extraction grist	
Weizennachmehl	Wheat post-flour	
Malzkeime	Malt germs	
Calciumcarbonat	Calcium carbonate	
Natriumchlorid	Sodium chloride	
ME (MJ/kg)	12.8	

4.2.3 Post-Larvae feeding

100 ml of food is measured in a “jug” and poured in an empty white container (with a label from the incubated container) in which an incubated container contents are emptied into and the ring is placed on the feed to hold the egg traps. A fresh tobacco leaf is placed on top to increase humidity for the neonates in the egg traps. It is very important to keep the nursing buckets moderately wet but not too dry.

After its introduction to the feed, there is need for daily monitoring to check if the substrate is still wet or not in order to give warm water to the larvae. After a week the egg traps and rings are removed and the white containers transferred into the incubation room for next feeding mostly from 1000ml to 3000ml feed given in days until sieving. The next feeding is done when the substrate dries up in the second week. It is also important to make sure that the rooms are well ventilated while keeping temperatures within the 25-30^{o}C range.

4.2.4 Larvae sieving, counting and measurement.

After second feeding of the larvae and the substrate is dried out, mostly in the third week some larvae are sieved in hand sieve for broodstock (big in size) and some in sieve machine for feed (mixed size). Firstly, when hand sieving (figure 10A) is done, 3 sieve trays are put on top of each other; the first tray being 1.2mm mesh size, seconded by a 0.7 then lastly a 0.2 mm mesh size diameter. This process separates the larvae based on size. Larvae in the 0.7mm mesh size are measured in a cylinder at 1ml in triplicates and counted in triplicates as well and their volume found based on an already existing chart of numbers of larvae against volume. The volume is measured in a volumetric flask and larvae emptied into small transparent holding containers of which each container is emptied into each black box and reared into pupae.

Sieving at this stage could also be done using a sieving machine (figure 10B). This is comprised of 4 compartments with sieves of varying sizes (3mm, 2mm, 0. 10 and 4 mm the bottom one). , The larvae from sieve machine are counted and are divided into the total amount of larvae required for that particular day. The volume is found and measured for each bio-reactor tray.

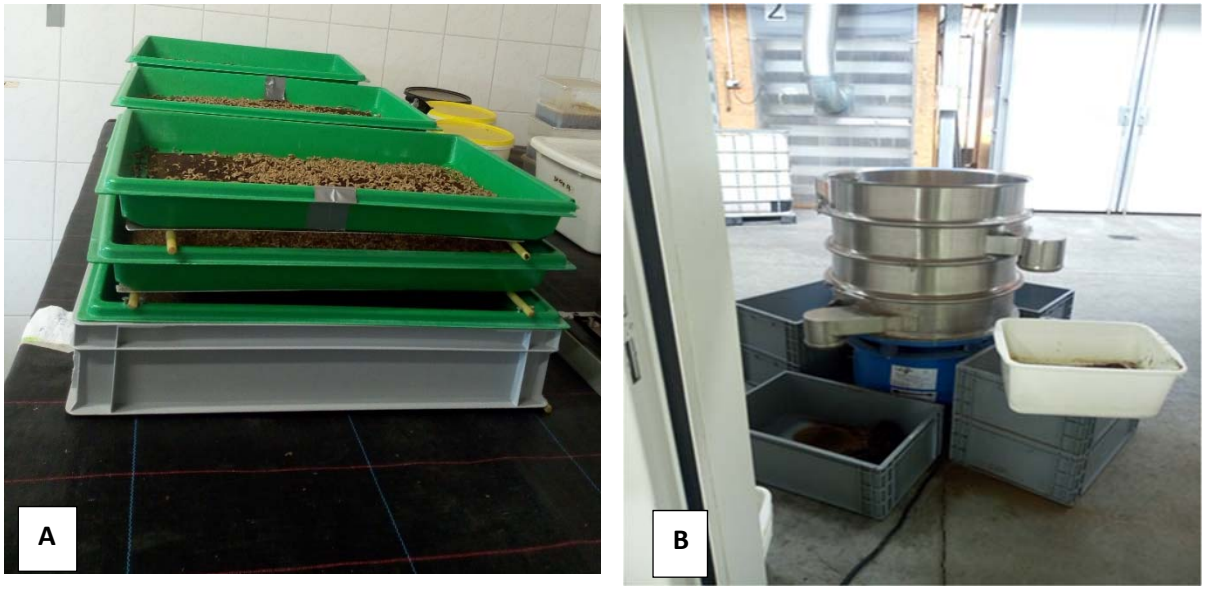

Figure 10: Hand sieve (A) and sieve machine (B)

4.3 Larvae Rearing in Bioreactors

4.3.1 Requirements

- Larvae rearing tables
- PVC Tanks1000L
- mixer
- Feed
- Metal shovels
- Drying trays
- Drying oven
- 1 person

The principle of rearing larvae in the bioreactors is the same to the one in the small containers. Here the quantities are several times higher and the environment in terms of temperature, humidity and air ventilation are well controlled. When conditions are not conducive the larvae either die or growth is compromised.

Figure 11: larvae rearing tables/trays with larvae feed ready for rearing.

A large number of larvae can be raised within a short period of time which is 14 days. At Hermetia large tables are filled with 300 liters feed and 400 000 and at times 200 000 larvae are raised. Air temperature varies between 30 to 35 ^{o}C and air humidity is substrate dependent but is kept around 60%. Too much humidity and higher temperatures will result into the larvae escaping out of the tables. Harvesting is done using sieving machines from which the feed remains are separated from the larvae. The larvae which are usually at pre-pupa stage (figure 12A) are harvested as they are reared for the purpose of feed and then are dried using a drying oven at constant temperature of above 80 ^{o}C (figure 12B). The trays intended for pupae production undergo similar process to the black boxes.

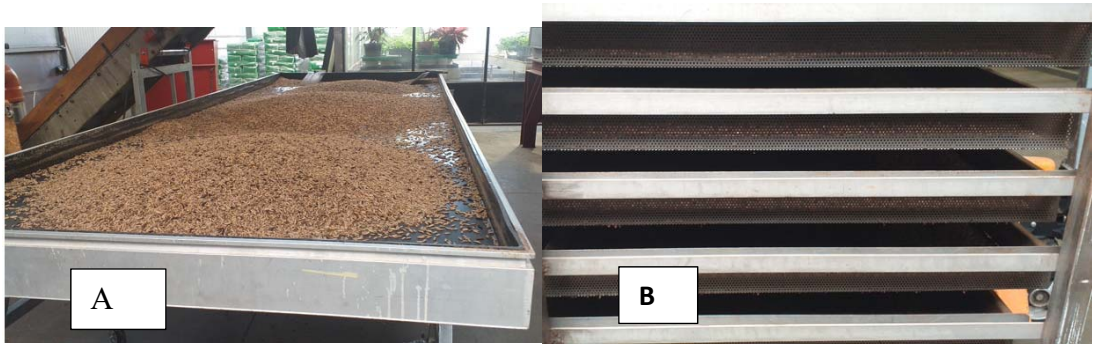

Figure 12: harvested larvae on harvesting table A, oven drying trays B.

4.4 Larvae Rearing in PVC boxes

4.4.1 Requirements

- PVC Boxes 20L
- Measuring cylinder
- Plastic shovel
- Mixer
- Feed
- Rotating and stationary sieve
- 1 person

Black boxes (figure 13) are used to rear larvae (6,500) into pupae. 5L feed is put in the black boxes before the larvae are introduced. The larvae are placed on top of the feed which provide a rough surface for the larvae not to crawl out using wheat bran (in the corners of the boxes). The larvae are raised up to 14 days by then almost all larvae are pupae. Feed (1L) is given once the substrate is dry as the larvae are still in feeding stage and need the feed for accumulation of fats for storage to be used in the time when they no longer feed and stopped when pupae stage is reached.

Figure 13. Stocking larvae in black boxes (A). Second feeding to the larvae in the black boxes (B)

4.4.2 Sieving

After the larvae has turned into almost pupae and substrate is dry, the pupae is sieved using a rotating sieve (figure 14) which consists of a 1mm sieve. This is done in order to separate the pupae from the substrate, and a fan is placed in front of the rotating sieve so that light debris are blown away from the pupae. After sieving larvae are transferred for pupation on pupation sieve.

Figure 14: Rotating sieve

4.4.3 Pupae Rearing

Pupae sieve trays (figure 15) separate complete pupated from non-complete ones. The pupae that are not stiff pass through and are placed in blue holding boxes. Those under complete pupation (rigid/stiff) stay on top of the sieve trays and are put in green plastic trays in quantities of 1.5 kilogram with a depth of 2 cm per try and transferred to fly house into dark cages.

Figure 15: Pupation sieve tray

Table 3: Summary of Production stages and their requirements.

Steps of production	Conditions						Feed		Time needed (days)
	Temp		Light		Humidity		composition	rate	
	min	Max	min	max	min	max			
Eggs	26	30			60	>60			2-4
Larvae	20	30			65	>60	Protein, carbohydrate, water etc	100mg\larva\day	4-14
Pupae	25	30	-	0	30	>60			1-3
Flies	25	30	3000	~	30	>60	water		5-15

Lessons

- The internship program has provided an opportunity to learn and understand the biology of BSF as well as the optimal environment factors suitable for mass production of BSF.
- The ability to modify the rearing set up, techniques and parameters that maximizes survival depending prevailing conditions in terms of weather and availability of requirements such as feed.
- The internship has also helped in attaining skills in observing the production trends, understand the challenges and attempt to look for various ways of improving the efficiency at every stage of production there by aiming at maximizing production.
- Working in a multicultural set up with people of different originalities and disciplines.
- Production of BSF can be achieved with locally and readily available resources in Malawi. Most of the requirements for production at each stage of the production process can be sourced within a farm compound.

Challenges

- The common challenge during the entire period was communication both at work place and outside. This provided an opportunity for the students to learn the German language. Today some basic communication terms has been learnt and understood.

- The Corona pandemic had brought some changes in people's everyday life but this did not affect the progress of the internship, only that there period of stay was unexpectedly extended. This provided even further opportunity to enhance our knowledge in BSF production.

Recommendation

- There a need to intensify training of technical staff and farmers in Malawi to boost the aquaculture industry for BSF has been deemed to be a good replacement of fish meal in manufacturing of feeds.
- After successfully establishing the pilot plant at the Lilongwe University of Agriculture and Natural Resources, there is a need for further research in BSF production in terms of optimal conditions as well as post-harvest technologies that will enhance efficient production and utilization of BSF.