

**ON-FARM LOW-COST INSECTARIUM FOR SMALL SCALE
PRODUCTION OF BLACK SOLDIER FLY LARVAE**

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**DEPARTMENT OF ANIMAL SCIENCE
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BENIN CITY**

JANUARY, 2023

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**A PROJECT SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE,
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CERTIFICATION

This is to certify that this project work was carried out by Isaac Onimisi ONIMOWO with Matriculation Number AGR1600237 of the Department of Animal Science, Faculty of Agriculture, University of Benin-City, Nigeria.

DR. G.I.O. ODAFE-SHALOME
PROJECT SUPERVISOR

DATE

PROF. J.A. IMASUEN
HEAD OF DEPARTMENT

DATE

DEDICATION

This work is dedicated to God Almighty, to my loving parents Mr. and Mrs. Onimowo, and my Project Supervisor Dr. G.I.O. Odafe-Shalome for their immeasurable support throughout this project work.

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To my entire course mate, I love you all, and to you Favour Omigie, one with a loving personality, thanks a million and keep resting in God's blossom till we meet again. And to Peb, I wanna say a big thank you for your support and generosity, God bless you all.

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ABSTRACT

An insectarium was designed and constructed for the production of Black soldier fly larvae, to be used as resource for insect protein. The larvae of the Black soldier fly (*Hermetia illucen*) family was grown on three different substrates- poultry dung, kitchen waste and brewers dry grain. The venture made possible the conversion of wastes into a valuable biomass (BSFL) rich in protein and fat. Harvesting was performed after 30 days of setting up the insectarium. The yield obtained was appreciable. Among the three treatments, kitchen waste, BDG, Poultry droppings, kitchen waste gave the highest yield. The production system thus serves the dual purpose of providing a nutrient-rich resource as well as a source of waste transformation and reduction.

CHAPTER ONE

INTRODUCTION

1.0 INTRODUCTION

The production of sufficient protein from livestock, poultry, and fish represents a serious challenge for both the present and the future. The reason is because of the growing world population of humans and livestock, especially, in the developing countries. The high rate of increase in world population has made advances in agricultural technology imperative. Dairy, poultry, meat and fish are the main sources of animal proteins, lipids and vitamins which are essential ingredients for human nourishment. It is therefore critical that the animals and fishes be properly reared with complete diets formulated by the combination of essential nutrients in the right proportions (AIFP, 2014).

In developing nations like Nigeria, the cost of commercial livestock farming and fish feeds have become very expensive (Ayinla, 2008; Sogbesan *et al.*, 2015) accounting for over 60% of the recurrent overhead costs of livestock farming and about 70% of a fish farming venture (Sogbesan *et al.*, 2015). This is due mainly to the fact that most of the protein ingredients such as fishmeal are imported while locally available alternatives like soya beans and groundnut also serve as food for humans. Several attempts have been made to find inexpensive and relatively abundant nutrient-rich substrates to partially or, even completely, replace these expensive components. Maggots and other non-conventional insects like winged termites, earthworms and

garden snails have been explored to check their nutrient contents, relative abundance, use and conversion into processed meals, incorporation into formulated diets and subsequent development of technique(s) for on-farm mass production (Ugwumba and Ugwumba, 2013). The short life cycle of maggots- the larval stage of flies of the order Diptera (Houseflies- *Musca domestica*) and their production in large biomass (quantity) from materials regarded as waste make them a viable option to explore.

1.1 Justification

Maggot meal has been reported to be a possible alternative to the expensive protein sources (Ogunji *et al.*, 2008). Calvert *et al.* (2010) suggested the use of maggots as a replacement source of some key ingredients in feeds and this was further corroborated by Teotia and Miller (2014). It has good nutritional value, cheaper and less tedious to produce than other animal protein sources. It is also produced from wastes, which otherwise would constitute environmental nuisance. The production system thus serves the dual purpose of providing a nutrient-rich resource as well as a source of waste transformation and reduction. The reported crude protein values range from 43 to 64% (Hwangbo *et al.*, 2009; Odesanya *et al.*, 2011). However, the production system is yet to be commercialized (Teguia and Beynen, 2015) probably because its utility and value as feed ingredients have not been elucidated and so far previous researches on maggots as poultry feed (Dankwa *et al.*, 2012) and fish (Ebenso and Udo, 2003; Madu and Ufodike, 2013) were only done under experimental conditions.

1.2. Objectives of the Study

1. Therefore, this study aimed to examine the possibility of producing BSF larvae on small scale farms;
2. to produce quantitatively the BSF larvae and process for farm use;
3. to determine the cost implication of erecting an Insectarium and managing the structure for continuous production of BSFL;
4. determine the prospects and the potentials of maggot meal as suitable protein source in livestock feed.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Housefly (*Musca domestica*)

The house fly (*Musca domestica*, Linnaeus, 1758; Diptera) is widely known as a pest and a key vector of diseases both larvae (maggots) and adult flies. Housefly maggots can grow on a wide range of decaying organic wastes, including animal manure and feed (Hogsette and Farkas, 2010). The maggots are a potential supply of aquaculture feeds for more than 50% crude proteins (in dry weight) which are higher than those in soybean, meat and bone scrap (Akpodiete *et al.*, 1997) and a promising source of limiting amino acids, such as lysine, methionine and phenylalanine (Hou *et al.*, 2007). Additionally, maggots contain a variety of biologically active substances, including antimicrobial peptides, lectins and chitins (Fu *et al.*, 2009; Hou *et al.*, 2007). It was observed that maggot proteins may stimulate the animal appetite when itdding to animal feed (Zhu *et al.*, 2012). Nutritional value of housefly larvae and pupae reared in manure were similar to that of fish meal or animal proteins (Hou *et al.*, 2007). Recently, chitosan from maggots was even used in cosmetics and medicines (Ai *et al.*, 2008; Jing *et al.*, 2007).

2.2 Life Cycle

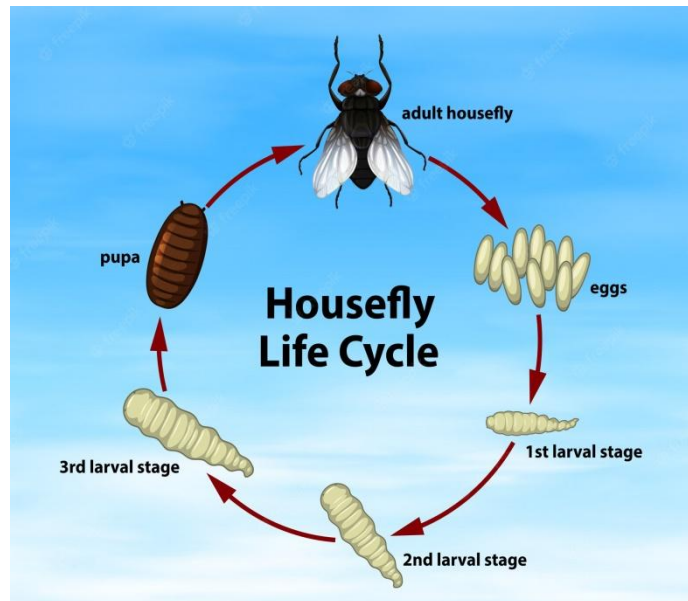


Figure 2.1: Housefly Life Cycle



Figure 2.2: Maggot Meal

2.3 Nutrient Composition of Maggot Meal

There is a considerable variation in nutrient composition of maggot meal reported in literature. This variation may not be unconnected with the type of fly attractant and substrate used during production process (Fasakin *et al.*, 2013), processing, drying or storage methods used but studies have shown that maggot meal can be a good source of animal protein in fish and poultry diets. The reported crude protein varied from as high as 64% (Hwangbo *et al.*, 2009) to as low as 39.16% (Atteh and Ologbenla, 2013).

Aniebo *et al.* (2008) reported that the proximate analysis showed that maggot meal from substrate mixture of cattle blood and wheat bran harvested on day 3 contained 47.1% crude protein, 25.3% fat, 7.5% crude fiber and 6.25% ash at dry matter level of 92.7%. Also, range of 40-58% crude protein, 21-28% fat, 5-8% crude fiber and 0.56-1.4% ash have been documented for maggot meal (Ajayi, 2008) whereas Olele (2011) showed that maggots have 44.5% crude protein, 10% ash and 24% lipid. Zheng *et al.* (2010) reported on the nutritional values of maggot meal processed with different methods, the authors observed that the moisture level of fresh maggot averaged 74.8% while dry maggot averaged 7.5%. They further reported that crude protein in biomass of fresh larvae and dry larvae ranged from 10.4-18.5% and 55.3-61.2% respectively. These values were relatively higher than those observed in other studies (Odesanya *et al.*, 2011). Proximate analysis of maggot meal in a study by Odesanya *et al.* (2011) indicated $86.0 \pm 0.47\%$ moisture content, $10.03 \pm 0.44\%$ ash

content, $5.89 \pm 0.05\%$ CF, 48.0 CP, $31.76 \pm 0.02\%$ crude fat, 3755 ± 190 kcal/kg energy. Fatty acids profile showed lauric acid, palmitic acid, oleic acid and stearic acid to be 69.92%, 2.09%, 15.25% and 12.75%, respectively. Adesulu and Mustapha (2010) reported that the levels of some essential amino acids including cystine, histidine, phenylalanine, tryptophan and tyrosine in maggot meal is higher than in fish meal and soy bean meal. Maggot meal is rich also in phosphorus, trace elements and B complex vitamins (Teotia and Miller, 2013). In addition, Zheng *et al.* (2010) reported that essential amino acids (THR, VAL, LEU, PHE, MET and LYS) accounted for around 48.5% of the total amino acids, while higher percentages of GLU, ASP, and HIS were also found.

Maggot meal is of high biological value. According to Akpodiete and Ologhobo (2009), maggot meal contains the ten essential amino acids and this is comparable to fish meal (Fetuga, 2007), thus, it has high nutritive value. The percentage of crude protein of 39.55%, lipid 12.5-21% and crude fiber 5.8-8.2% were reported by Ogunji *et al.* (2008). Ogunji *et al.* (2008) reported that the biological value of maggot meal was equivalent to that of whole fish meal and that the larvae contained no anti-nutritional or toxic factors sometimes found in alternative protein sources of vegetable origin. Fasakin *et al.* (2013) reported that crude protein content of maggot meals ranged between 43.3% and 46.7% in full –fat sun dried and hydrolyzed /defatted oven dried maggot meals respectively. Thus similar crude protein and lipid

values were obtained in processing methods involving sun drying and oven drying either hydrolyzed or defatted maggot meals (Fasakin *et al*, 2013).

Table 2.3.1: Nutrient composition of maggot meal

Nutrients %	A	B	C
Dry matter	92.7	94.78	91.34
Crude protein	47.1	63.99	39.16
Crude fibre	7.5	-	8.25
Ash content	6.25	5.16	6.15
Ether extract	25.3	24.31	20.76

A – Aniebo *et al.* (2008); B – Hwangbo *et al.* (2009); C – Atteh and Ologbenla (2013)

Table 2.3.2: Amino acid composition of maggot meal

Nutrient %	A	B	C
Essential amino acids			
Valine	3.61	3.40	2.92
Isoleucine	3.06	3.50	1.46
Leucine	6.35	5.30	5.22
Lysine	6.04	5.20	5.22
Phenylalanine	3.96	4.20	3.57
Methionine	2.28	2.60	2.34
Tryptophan	-	-	3.17
Histidine	3.09	2.60	1.98
Arginine	5.80	4.20	3.63
Threonine	2.03	3.40	2.27
Non – essential amino acids			
Aspartic acid	8.25	8.50	2.21
Serine	3.23	3.20	5.63
Glutamic acid	15.30	10.80	5.71
Proline	2.85	3.10	1.58
Glycine	4.11	3.90	3.27
Alanine	2.86	4.20	4.85
Cystine	0.52	0.40	0.42
Protein (% DM)	47.10	63.10	63.99

A – Aniebo *et al.* (2008); B – Hwangbo *et al.* (2009); C – Atteh and

Ologbenla (2013)

2.4 Utilisation of Maggot Meal in Poultry Diets

The search for alternative and sustainable proteins is an issue of major importance that needs viable solutions in the short term, making maggot meal an increasingly attractive feed option for poultry. Insects are natural food sources for poultry. Chickens, for example, can be found picking worms and larvae from the topsoil and litter where they walk. Maggot meal has been included in broiler diets as a replacement for conventional protein sources, notably fish meal. Most trials indicate that partial or even total replacement of fish meal is possible, though the optimal inclusion rate is generally lower than 10%. Higher rates have resulted in lower intake and performance, perhaps due to a decrease in palatability, as the darker colour of the meal may be less appealing to chickens (Atteh and Ologbenla, 2013; Bamgbose, 2009). The research conducted by Adeniji (2007) indicated that maggot meal could replace 75% and 100% of groundnut oilcake meal in the diets of broilers without adverse effect on dry matter intake. Also, Atteh and Ologbenla (2013) replaced fish meal with maggot meal in a 0-5 week old broilers and reported that maggot meal could replace up to 33% fish meal without adverse effect on intake and weight gain. At higher levels however, lower feed intake was reported. In order to increase the palatability of maggot meal, Bamgbose (2009) suggested that maggot meal should be supplemented with methionine. Also, positive results have been reported on the effect of maggot meal on growth performance and carcass characteristics of broilers. For instance, Hwangbo *et al.* (2009) investigated the effect of maggot meal

supplementation on performance of broilers. The authors formulated diets to contain 0% (control), 5%, 10%, 15%, 20% maggot meal respectively and these diets were formulated to be isoenergetic and isonitrogenous with similar lysine and methionine inclusion levels. Broilers receiving diets with maggot meal supplementation at 10 and 15% respectively had significantly higher ($P<0.05$) weight gains than the broilers receiving no maggot meal.

The feed conversion ratio was also significantly lower ($P<0.05$) in all the diets supplemented with maggot meal when compared to the control. Hwangbo *et al.* (2009) attributed the differences in weight gain and high crude protein digestibility to the essential amino acid profile of the maggot meal. These differences can also be attributed the fact that the control diet had high levels of maize gluten meal (8%) that could have caused the lower performance (Afshar and Moslehi, 2010). These results differ from the findings of Awoniyi *et al.* (2013), Adeniji (2007) and Tegua *et al.* (2002) who found no significant effect ($P>0.05$) of maggot meal supplementation on weight gain and feed conversion ratio (FCR). Awoniyi *et al.* (2013) replaced fish meal with maggot meal at levels of 25, 50, 75 and 100% respectively with no significant effect on feed intake ($P>0.05$). The effect of maggot meal supplementation is more visible after three weeks of age and this may be due to the difference in which adults and young broiler chickens utilize the maggot meal protein (Awoniyi *et al.*, 2013). Furthermore, Tegua *et al.* (2002) studied the effect of maggot meal supplementation in broiler nutrition and its effect on performance and

carcass characteristics in the starter, grower and finisher phases. The species of maggot used was not reported though. All the treatment diets were formulated to have similar nutritional values, but the control diet contained no maggot meal. Results showed that there was no significant effect ($P>0.05$) regarding weight gain when 10% of the fish meal was replaced with maggot meal as compared to the control group in the starter phase. This may be attributed to the lower crude protein concentration (22.65%) as compared to the other treatment diets in the starter phase. When 5% and 15% of the fish meal was replaced with maggot meal in the starter phase the weight gain was higher and this effect was found to be significantly better ($P<0.05$). During the finisher phase, Tegui *et al.* (2002) replaced 50% and 100% of the fish meal with maggot meal respectively.

These authors found that there was no significant effect ($P>0.05$) on weight gain when 50% of the fish meal was replaced with maggot meal when compared to the control diet. The weight gain was significantly better ($P<0.05$) when 100% of the fish meal was replaced with maggot meal when compared to the control diet. The overall inclusion levels of maggot meal were, however, very low and ranging between 0.23% and 2%. In a similar study, Okah and Onwujiariri (2012) investigated the effect of replacing fish meal with maggot meal on 0- 35day old broilers. Diets were formulated such that maggot meal replaced fish meal at 0, 20, 30, 40 and 50%. The authors reported that maggot meal could replace 50% fish meal with higher performance and economic returns. They also reported that the 25% maggot meal

diet yielded better live weights, feed intake and daily gain when compared to the 25% fish meal diet in the growth phase. Furthermore, Cadag *et al.* (2011) compared maggot meal with fish meal, meat and bone meal and soybean meal in a 0-21 day broilers, they reported that maggot meal could be included at up to 10% in the diet with no adverse effect on intake, body weight, feed conversion and palatability. The effect of maggot meal on egg production by laying birds has been extensively investigated by several authors with positive results. In a 7-month layer feeding trial, maggot meal replaced meat and bone meal and the results indicated that maggot meal increased egg yield and hatchability (Ernst *et al.*, 2014). Similarly, In 50-week laying hens, maggot meal replaced 50% of fish meal protein (5% diet as fed) without adverse effects on egg production and shell strength. However, 100% replacement was deleterious to hen-day production (Agunbiade *et al.*, 2007). Akpodiete *et al.* (2014) investigated the replacement values of maggot meal for fish meal in diet of laying chickens and concluded that maggot meal can nutritionally and productively replace fish meal in layer diet without adverse consequences on performance and egg quality characteristics. The authors also found that egg yolk cholesterol and calcium concentration significantly ($P<0.05$) declined with increased inclusion of maggot meal in laying chickens' diet, suggesting that the use of maggot meal in poultry diets may reduce cholesterol intake through consumption of eggs. The effect of maggot meal on carcass characteristics of broiler chickens was reported by Teguaia *et al.* (2002). They observed that broilers fed maggot meal diets had carcass quality that

are similar to the control, the liver and gizzard increased in size, but no signs of toxicity were observed. Indeed, none of the numerous studies on maggots as animal feed has revealed any health problems (Sheppard and Newton, 2009). Also, Awoniyi *et al.* (2013) observed that maggot meal supplementation had no significant influence on dressing percentage and breast muscle weights and this agrees with the findings of Teguia *et al.* (2002), but differs from the findings of Hwangbo *et al.* (2009). This contradictory report could also be attributed to the trial design where Hwangbo *et al.* (2009) had 30 replicates per treatment in relation to the six replicates of Awoniyi *et al.* (2013) and the four replicates of Teguia *et al.* (2012).

2.5 Utilisation of Maggot Meal in Rabbit Diets

Utilization of maggot meal in rabbit diets has not been extensively investigated. Duwa *et al.* (2014) reported that there was a significant ($P < 0.05$) difference in the dry matter intake (DMI) of rabbits. The dry matter intake increased with increasing levels of maggot meal across dietary treatments, with rabbits fed 37.5% and 50% maggot meal having the highest values and those on the control, 12.5 and 25% maggot meal the least. This result is similar to the finding of Abubakar *et al.* (2006) who reported that there were significant differences ($P < 0.05$) in dry matter intake of weaner rabbits fed varying levels of plant protein sources in diets. Duwa *et al.* (2014) reported that there were no significant differences ($P > 0.05$) in the weight of rabbits. They attributed the insignificant difference to the intake of energy and protein which were well above maintenance requirements.

2.6 Utilisation of Maggot Meal in Pig Diets

Information on the use of maggot meal for pig feeding is scarce but the few literatures that available showed that maggot meal is not detrimental to the performance and health status of pigs. For instance, Adeniji (2008) reported that early weaned pigs could tolerate up to 10% of a 3:1 mixture of dried rumen contents and maggot meal in the diet without any adverse effect on performance. Similarly, Viroje and Malin (2012) fed weaned pigs with 10% maggot meal and reported no negative effect on body weight gain and feed conversion efficiency. Also, Bayandina *et al.* (1980) fed sows and their offspring a diet containing processed housefly maggots and reported no adverse effect on piglet performance, health and organoleptic properties or on the sows' physiology and breeding performance.

2.7 Utilisation of Maggot Meal in Fish Diets

There have been numerous experiments on the use of maggots in the diets of African catfish, mostly *Clarias gariepinus*. The results are generally positive though the inclusion of maggot meal should be limited to 25-30% as performance tends to decrease when higher inclusion rates are used. For instance, Ebenso and Udo (2013) fed Nile tilapia fish a 4:1 mixture of wheat bran and live maggots; they reported that the maggot-fed fish had a better growth performance, specific growth rate, feed conversion ratio and survival than fish fed wheat bran alone. Similarly, Sogbesan *et al.* (2006) replaced 0-100% fish meal (0-30% diet) with maggot meal in the diet of *Heterobranchus longifilis* (f) x *Clarias gariepinus* (m) and reported that best growth

performance was obtained at 25% replacement (7.5% inclusion). They however observed that 100% replacement (30%) is economically viable.

In another experiments by Ogunji *et al.* (2007), Ogunji *et al.* (2008) and Ogunji *et al.* (2008), maggot meal was included at 15 to 68% in the diet, replacing fish meal. The best performance and survival was obtained at 25% maggot meal in the diet. Maggot meal was found beneficial to fish growth and performance with no adverse or stress effect on the haematology and homeostasis was observed. However, the authors suggested that adequate sources of n-6 and n-3 fatty acids should be included in the diet to enhance the optimal fatty acid profile.

The superiority of maggot meal inclusion in fish feed over other animal byproducts was also reported by Adewolu *et al.* (2010) who fed *Clarias gariepinus* fingerlings with 4:3:2 mixture of feather meal, chicken offal meal and maggot meal replacing 0-100% fish meal and reported that maggot meal could replace 50% fish meal (30% diet as fed) without adverse effect on weight gain, specific growth rate, feed conversion ratio, and protein efficiency ratio. They however reported poor performance at 75 and 100% substitution. In another study, Ossey *et al.* (2012) compared the performance of *Heterobranchus longifilis* fed diets containing soybean meal, cattle brain meal and maggot meal included at 80%. The authors reported that Maggot meal gave better performance than soybean meal and lower performance than cattle brains. However, maggot meal was much less expensive than the latter feed. A research on inclusion of differently processed maggot meal was carried out

by Fasakin *et al.* (2013). The authors evaluated the growth performance of *Clarias gariepinus* fed diet containing defatted, sun-dried and oven-dried maggot meal replacing fish meal. They reported that fish fed 27% defatted oven-dried maggot meal (27% in the diet) had similar growth performance and survival than fish fed 25% fish meal.

Fashina-Bombata and Balogun (2011) and Ajani *et al.* (2014) showed that the nutritive value of maggot meal compared favourably with that of fish meal. They concluded that maggot meal can replace up to 100% of fish meal in the diets of Nile tilapia (*O. niloticus*).

CHAPTER THREE

MATERIALS AND METHODS

3.1. Location of Study

The experiment was carried out in the main campus farm project unit of the University of Benin, Edo State. It lies between Latitude 6°S and 30°N of the equator and longitude 5.4°W and 6°E of the Greenwich meridian with a temperature of 27.6°C . Benin City is a low lying plain covered with porous sand that rises gently to the North East. Its soils are derived from sand stones and shales and are of very recent deposits and highly susceptible to leaching and hence lose their fertility very fast. The topography denotes a flat platform of about 80m above sea level. Its sandy plain is marked with rivers generally running towards the southeast. There are a few hills to the eastern part of the city and the lands are drained by the rivers: Osse, Orhiomwon and Ikpoba. The climate condition is marked with wet and dry seasons, with a rainfall pattern that varies from 1500 mm – 2000 mm per annum. The wet season occurs between April and October with a break in August. The dry season ranges from November to April with a cold harmattan spell from December to January. The temperature averages about 25°C in the rainy season and about 28°C in the dry season. The climate is humid tropical. The soil is red, very deep, well drained and mainly sandy loam, sandy, clay and loamy sand.

3.2. Construction and Management of Insectarium

All materials used in this experiment were locally sourced. The insectarium was protected with fine wire netting that are screwed on the frames from outside. Cleaning of the insectarium was done daily. Construction of the insectarium was carried out on the 22nd of January to 19th of March 2022. The materials used were:-

- Palm frond __ for roofing to prevent excessive wetting and sunlight, also to give the insectarium a shade.
- 7 bamboo stick mounted on each side {diagonally} to serve as support with a rope tied by each side.
- Motor Tyre - 9 tyres of 15/65 size were used. it functioned as the collecting chamber for the larvae to prevent digested waste from the chamber, to protect from predators, it served as the experimental block for each treatment.
- Bowl - it was used for collecting the harvested larvae.
- Sieve - used to separate impurities from the larvae during the harvesting process.
- Water - this was used to keep the larvae collecting chamber moist to promote growth and proper development of the larvae.

3.3. Dimensions of Insectarium

- Dimension ___ 15ft x 13ft
- Circumference of pit ___ 29inches
- Depth of pit ___ 20inches
- Height of insectarium ___ 6ft

3.4. Substrates Used as Growth/Production Media

T1R1-3__Poultry dung {100%}

T2R1-3__Kitchen waste {100%} which constitute different food residues e.g. plantain peels, rice, beans, onions, spaghetti, potatoes and lots more residues.

T3R1__Brewers dry grain {100%}

T3R2__Poultry dung cum Brewers dry grain {50:50}

T3R3__Kitchen waste cum Brewers dry grain {50:50}

3.5. Other Parameters- Wire gauze:

The wire gauze made of stainless steel, ranges from 12m-100mm in Size, wire diameter 2mm to 16mm. Thus it functioned to cover the pit and to allow BSF to access the substrate.

3.6. Experimental Design

Three treatments were adopted for the study and they included;

Treatment 1: poultry droppings

Treatment 2: kitchen waste

Treatment 3: brewers dry grain

Nine (9) pits were dug on the ground to create chambers for the deposition of the substrates, under the roof of the Insectarium. The three pits represented the replicates for each treatment.

The openings of the pits were protected by wire mesh (mesh of 3.5 x 1.5 cm) to allow the flies access the substrates as well as to allow emergent insects to leave the pit.

The substrates were sourced from different locations. Kitchen waste was sourced from municipal household, restaurants and fruits and vegetable market. Poultry waste was collected from the poultry unit of the farm project. Brewers dry grain was supplied from the feed store in the Farm project.

The following parameters were studied;

- i. Period of production
- ii. Yield
- iii. Growth rate and size
- iv. Temperature and
- v. pH



Plate 3.1: Construction of the insectarium with locally sourced materials



Plate 3.2: Showing the 3 different treatments used



Plate 3.3: T1R1-3



Plate 3.4: TR2R1-3



Plate 3.5: T3R1-3



Plate 3.6: Kitchen Waste



Plate 3.7: Poultry Dung



Plate 3.8: Brewers Dry Grain

CHAPTER FOUR

RESULTS

4.1. Maggot Reproduction

The Life cycle of the maggot of BSF is shown in Fig 4.1. The Black Soldier Fly undergoes a complete life cycle comprising of four live stages: egg/embryo, larva, pupa/imago and adult (Li *et al.*, 2011). Eggs hatch into larvae within 3-4 days of being laid (Diclaro and Kaufman, 2009). Under the right conditions of food, relative humidity and temperature, larvae mature into prepupa in about two weeks. Pre-pupa, given the right conditions take two weeks to change into pupa in a process called pupation and characterized by development of an embryo within the puparium (casing), stiffness of the body, followed by immobility. Prepupae change into pupa when they find a dry medium to burrow in. In the dry medium, pupa go into a sleeping mode for a duration of at least two weeks during which time, the embryo further develops within their exoskeletal casing. When fully developed, the casing breaks up at the tip to release an adult fly in a process called emergence (Sheppard *et al.*, 2002). Freshly emerged adult flies have undeveloped, folded wings which gradually unfold within 2-3 hours and also have slightly larger, softer and greenish coloured bodies compared to one day old adults. Adults have a lifespan of 5-12 days during which time they mate and lay eggs (Diclaro and Kaufman, 2009). Eggs are laid in masses of 500-1200 eggs depending on the fertility level of the female, which in turn is dependent on the diet and rearing conditions at the larval stage (Tomberlin

et al., 2005). The lifecycle of a Black Soldier Fly from egg to adult is estimated to last about 40-43 days under optimum rearing conditions but under unsuitable rearing conditions, the period can stretch up to six months (Popa and Green, 2012). The longest part of the lifecycle is spent at the larval and pupal stages (Figure 1) (Popa and Green, 2012). In addition, the larval stage determines and influences the longevity of other stages and the productivity of the adult stage (Holmes *et al.*, 2012). It is the most vital stage to humans in relation to its economic significance (Mutafela, 2015).

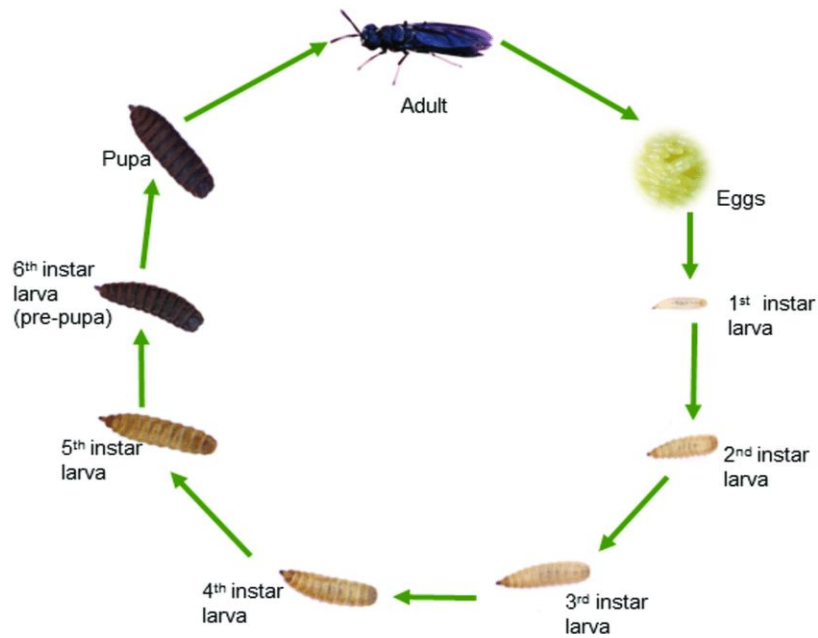


Figure 4.1: Life cycle of the black soldier fly *Hermetia illucens*. Sizes of different developmental stages depicted are not proportional



Plate 4.1: BSF Larvae from Poultry Dung



Plate 4.2: BSF Larvae from Kitchen Waste



Plate 4.3. BSF Larvae from Kitchen Waste Cum Brewers Dry Grain



Plate 4.4: BSF Larvae from Poultry Dung Cum Brewers Dry Grain

4.2 Harvesting of BSF larvae

Harvesting of the larvae from the chambers was performed at the end of 30 days after feeding the chambers with the substrates. The eggs were hatched into larvae five days prior to harvesting (5th of March, 2022 and harvested 19th of March).

The harvesting method used was floating method, we poured the harvested larvae into a bowl filled with water and waited for some minute, immobile larvae were securely fixed beneath the water while mobile larvae floated, so we disposed the mobile larvae and properly harvested the immobile larvae. This was done with a sieve and the harvester wore a glove while carrying out this process, after that we packaged the larvae in plastic cans for preservation and further research.

4.3 Yield of BSF Larvae by different Substrates/Treatment

T1R1-3__Poultry dung {100%}

Poultry dung was collected from the layer pen in the university farm project. The dung was usually deposited on the floor at the bottom of battery cages housing the layers. The dung was collected by scooping with spade, after 24hrs of dropping from under the cage. The dung is scooped into trays and wheel barrow; and then transported from there. It was transferred to the insectarium. A quantity that filled a container of about 2.5 L volumes was measured and delivered into the collecting chamber.

- T1R1 Yield in weight ___ 59.39g
- T1R2 Yield in weight ___ 56.09g
- T1R3 Yield in weight ___ 39.87g

T2R1-3 __Kitchen waste {100%}

Kitchen waste was made up of different food residues and remnants freshly collected and dumped into the waste bin of university catering services where waste are dumped and collected daily on a regular basis. The composition included plantain peels, rice, beans, onions, spaghetti, potatoes, cabbage, carrots and lots more residues.

- T2R1 Yield in weight ___ 63.09g
- T2R2 Yield in weight ___ 113.46g
- T2R3 Yield in weight ___ 108.79g

T3R1 _____BDG {100%}

This was supplied from the feed store by the university farm project; it was collected with the use of a spade, tray and wheel barrow. It was then transferred to the insectarium, a quantity that filled a container of about 2.5L volume was measured and delivered into the collecting chamber.

- Average Yield in weight ___ 0.00g (Nil)

T3R2 __Poultry dung cum BDG {50:50}

It was collected from the layer pen and the feed store by the university farm project; it was collected with the use of a spade, tray and wheel barrow. It was then transferred to the insectarium, a quantity that filled a container of about 1.25L capacity each was measured and delivered into the collecting chamber.

- Average Yield in weight ___28.68g

T3R3 __Kitchen waste cum BDG {50:50}

It was obtained from waste bin of university catering services where waste are dumped and collected on a regular basis while brewers dry grain was obtained from the feed store of university farm project; they were collected with the use of a spade, tray, wheel barrow and trash bag {for the kitchen waste}. It was then transferred to the insectarium, a quantity that filled a container of about 1.25L capacity each was measured and delivered into the collecting chamber.

- Average Yield in weight ___53 50g

CHAPTER FIVE

DISCUSSION

5.1 Features of Insectarium

The insectarium is a building with a significant wind surface area. Its design took into account anti-seismic standards, as well as the capacity to withstand strong winds, after a lighter construction, roof frame in bamboo covered by fine mesh net of 0.5 mm). The insectarium occupies an area of 800 (40 × 20) m² with an average height of 3.2 m, thereby giving a volume of about 2560 m³. It was built on the ground of the Uniben farm project, so it rests on soil. The insectarium comprises a wide central corridor and narrow peripheral and transversal corridors giving access to all sides of building.

5.2. Economic Importance of BSF

Maggot meal has been reported to be a possible alternative to the expensive protein sources (Ogunji *et al.*, 2008). Calvert *et al.* (2010) suggested the use of maggots as a replacement source of some key ingredients in feeds and this was further corroborated by Teotia and Miller (2014). It has good nutritional value, cheaper and less tedious to produce than other animal protein sources. It is also produced from wastes, which otherwise would constitute environmental nuisance. The production system thus serves the dual purpose of providing a nutrient-rich resource as well as a source of waste transformation and reduction. The reported crude protein values range from 43 to 64% (Hwangbo *et al.*, 2009; Odesanya *et al.*, 2011). However, the

production system is yet to be commercialized (Tegua and Beynen, 2015) probably because its utility and value as feed ingredients have not been elucidated and so far previous researches on maggots as poultry feed (Dankwa *et al.*, 2012) and fish (Ebenso and Udo, 2003; Madu and Ufodike, 2013) were only done under experimental conditions.

With a growing world population and increasingly demanding consumers, the production of sufficient protein from livestock, poultry, and fish represents a serious challenge for the future especially, in the developing countries. Maggot, the larvae of the domestic fly (*Musca domestica*) family has ability to grow on a large range of substrates and this can make them useful to turn wastes into a valuable biomass rich in protein and fat. Studies have shown that maggot meal has a great benefit as a potential protein source in poultry nutrition and its use as fish and crustaceans feed in pond farming has been studied extensively since the late 2000s.

Therefore, mass production of maggot meal must be encouraged as this will offer solution to the high cost of protein feed in fish and livestock production.

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CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

In this study insectarium of the production of BSF larvae was built with materials that were readily available and at minimum cost. The design was simple and located on a small space within the farm project. Thus it was possible to monitor the production of the BSF larva until harvest. Black soldier fly larvae (*Hermetia illucens*) (BSFL) are a promising protein source for the feed industry. They can be used to convert organic waste into valuable biomass, and due to their chemical composition, they are a valuable ingredient for several industrial sectors. To use BSFL as a feed ingredient, their chemical safety must be guaranteed. The composition of their rearing substrate is one of the crucial factors for safety, since it might introduce safety risks by bioaccumulation of various inorganic/organic compounds (e.g. toxic metals, mycotoxins, pesticides, etc.) in BSFL.

6.2. Recommendation

I recommend the construction of insectarium in the farm is possible. It is a cost effective means of producing alternative or supplementary protein source for the production of protein efficient feed particularly for poultry, we recommend that small scale and large scale should exploit the possibility of converting their poultry dung into BSF larvae as a means of environmental management, sanitation and producing quality alternative feeding stuffs from the waste which implies; indirect recycling of waste into productive and economic use i.e. waste to wealth.

REFERENCES

- Adeniji, A.A. (2007). Effect of replacing groundnut cake with maggot meal in the diet of broilers. *International Journal of Poultry Science*, 6(11): 822-825.
- Adesulu, E.A. and Mustapha, A.K. (2010). Use of housefly maggots as a fishmeal replaces in tilapia culture: A recent vogue in Nigeria. In: K. Ftzimmons and J.C. Filho (Ed.). Proceedings of the Fifth International Symposium on Tilapia Aquaculture. 3–7 September, Rio de Janeiro: 138–143.
- Adewolu, M.A., Ikenweiwe, N.B. and Mulero, S.M. (2010). Evaluation of an animal protein mixture as a replacement for fishmeal in practical diets for fingerlings of *Clarias gariepinus* (Burchell, 1822). *Israeli Journal of Aquaculture*, 62 (4): 237-244
- Afshar, M. and Moslehi, H. (2010). Investigation in the effect of using wheat gluten meal on broiler performance. Agricultural Ministry. Tehran, Iran. 12.
- Agunbiade, J.A., Adeyemi, O.A., Ashiru. O.M., Awojobi H.A., Taiwo. A.A., Oke. D.B. and Adekunmisi A.A. (2007). Replacement of fish meal with maggot meal in cassava-based layers' diets. *Journal of Poultry Science*, 44(3): 278-282.
- AIFP, (2014). Farming Nigeria's waters: newsletter of the Aquaculture and Inland fisheries Project (AIFP) of the Special Programme for Food Security. Technical Note No. 5, April, 2004.
- Ajani E.K, Nwanna L.C and Musa B.O. (2014). Replacement of fishmeal with maggot meal in the diets of Nile tilapia, *Oreochromis niloticus*. *World Aquaculture*, 35(1): 52-54.
- Ajayi O.O. (2008). Evaluation of full fat/ defatted maggot meal in the nutrition of African catfish, *Clarias gariepinus*. M.Sc. thesis. Akure Nigeria: Federal University of Technology.
- Akpodiete O.J. and Ologhobo A.D. (2009). Biochemical evaluation of Maggot (larvae) meal on the growth and sexual maturity of replacement pullets. *Tropical Journal of Animal Science*, 1 (2):45-51.
- Akpodiete, O.J, Ologhobo, A.D. and Onifade, A.A. (2014). Maggot meal as a substitute for fish meal in laying chicken diet. *Ghana Journal of Agriculture Science*, 31: 137-142.

- Aniebo, A.O., Erondue, E.S. and Owen, O.J. (2008). Proximate composition of housefly larvae (*Musca domestica*) meal generated from mixture of cattle blood and wheat bran. *Lives. Res. Rural Dev.* 20 (12)
- Atteh J.O. and Ologbenla F.D. (2013). *Nigerian Journal of Animal Production*, 20:44-49.
- Awoniyi, T.A.M., Aletor, V.A. and Aina, J.M. (2013). Performance of broiler chicken fed on maggot meal in place fishmeal. *Int'l Journal of Poultry Science*, 2 (40): 271-274.
- Ayinla O.A. (2008). Nutritive and Reproductive performance of *Clarias gariepinus*. Unpublished Ph.D thesis, University of Ibadan. Nigeria. 433.
- Bamgbose A.M. (2009). Utilization of maggot meal in Cockerel diets. *Indian Journal of Animal Science*, 69(12):1056-1058.
- Bayandina, G.V., Nkiru, T.O. and Inkina Z. G. (2010). Effect of prolonged use of housefly larvae in the diets of sows and their offsprings, on the fattening and meat quality of the young pigs. *Nutritional Abstract Rev.*, 52:355.
- Cadag, M.T., Lopez, P.L. and Mania, R.P. (2011). Production and Evaluation of maggot meal from common housefly (*Musca domestica*) as animal feed. *Philippine Journal of Veterinary Animal Science*. 7(1):40-41.
- Calvert, C.C., Martins, R.D. and Eby, H.J. (2010). Housefly pupae as food for poultry. *Journal of Economic Entomology*, 62 (1): 939
- Dankwa, D., Nelson, F.S., Oddoye, E.O.K. and Duncan, J.L. (2012). Housefly larva as a feed supplement for rural poultry. *Ghana Journal of Agricultural Science*, 35:185-187.
- Ebenso I.E. and Udo M.T. (2013). Effect of live maggot on growth of the Nile perch, *Oreochromis niloticus* (Cichlidae) in south Eastern Nigeria. *Global Journal of Agricultural Science*. 2(2):72-73.
- Ernst L., Vagapov R., Posdeeva E., Zhemchuzhima A. and Zvereva E. (2014). A high-protein feed from poultry manure. *Ptitsevodstve*, 1:30.
- Fasakin, E.A., Balogun, A.M. and Ajayi, O.O. (2013). Evaluation of full-fat and defatted maggot meals in the feeding of Clariid catfish *Clarias gariepinus* fingerlings. *Aquacult. Res.* 34, 733 – 738.

- Fashina-Bombata, H.A. and Balogun O. (2011). The effect of partial or total replacement of fish meal with maggot meal in the diet of tilapia (*Oreochromis niloticus*) fry. *J. Prospects Sci.*, 1: 178–181.
- Fetuga B.I. (2007). Animal production in Nigeria and feed supplies. *Nigeria Journal of Animal Production*, 418-421.
- Hwangbo, J., Hong, E.C. Jang, A., Kang, H.K., Kim, B.W. and Park, B.S. (2009). Utilization of house fly-maggots, a feed supplement in the production of broiler chickens. *Journal of Environmental Biology*, 30: 609–614.
- Koo, S.I., Currin, T.A., Johnson, M.G., King, E.W. and Turk, D.E. (2010). The nutritional value and microbial content of dry face fly pupae (*Musca autumnalis* (De Geer) when fed to chicks. *Poultry Science*, 59: 2514- 2518.
- Madu C.T. and Ufodike E.B.C. (2013). Growth and survival of catfish (*Clarias anguillaris*) juveniles fed tilapia and maggot as unconventional diets. *Journal of Aquaculture*, 18(1):47-51.
- Odesanya B.O., Ajayi S.O., Agbaogun B.K.O and Okuneye B. (2011). Comparative Evaluation of Nutritive Value of Maggots. *International Journal of Science and Engin. Resource*, 2(11).
- Ogunji J.O., Kloas W., Wirth M., Neumann N. and Pietsch C. (2008). Effect of housefly maggot meal (magma) diet on the performance, concentration of plasma glucose, cortisol and blood characteristics of *Oreochromis niloticus* fingerlings. *Journal of Physiology and Animal Nutrition*. 92(4): 511-518.
- Ogunji, J.O., Kloas W., Wirth, M., Schulz, C. and Rennert, B. (2008). Housefly maggot meal (Magma) as a protein source for *Oreochromis niloticus* (Linn.). *Asian Fisheries Science*, 21(3): 319-331.
- Ogunji, J.O., Toor, R.A.S., Schulz, C. and Kloas, W. (2008). Growth performance, nutrient utilization of Nile Tilapia *Oreochromis niloticus* fed Housefly maggot meal (Magma) diets. *Turkish Journal of Fisheries and Aquaculture Science.*, 8: 141-147.
- Okah, U. and Onwujiariri, E. B. (2012). Performance of finisher broiler chickens fed maggot meal as a replacement for fish meal. *Journal of Agricultural and Technology*, 8(2): 471-477.
- Olele, N.F. (2011). Comparative study on the use of natural and artificial based feeds for the culture of *Clarias gariepinus* Fingerlings. Asian Research Publishing Network. *Journal of Agricultural and Biological Science*, 6: 9-13.

- Ossey Y. B., Koumi A. R., Koffi K. M., Atse B. C. and Kouame L. P. (2012). Use of soybean, bovine brain and maggot as sources of dietary protein in larval *Heterobranchus longifilis* (Valenciennes, 1840). *Journal of Animal and Plant Science*, 15 (1): 2099-2108
- Poluektova L.S, Chaplinskaya K.N, Dement'eva T.A, Kozlova L.S. and Ganenkova N.M. (2014). Effect of adding into the diet of pigs a meal from house-fly larvae on metabolism, development, and meat quality of the pigs. *Nauchnye Trudy Novosibirskogo Sel'skokhozyaistvennogo Instituta*. 128: 24-27.
- Rocas, R.C. (2013). Improved utilization of poultry manure in broilers through maggot (*Musca domestica*) production. Thesis, University of the Philippines at Los Banos, College, Laguna.
- Sheppard, C. and Newton, L. (2009). Insect digestion of manure. *In* Lorimor J. (2002). Manure management white paper written for the National Center for manure and animal waste management. 23.
- Sogbesan, O.A., Ajuonu, N.D., Ugwumba, A.A.A. and Madu, C.T. (2015). Cost benefits of maggotmeal as supplemented feed in the diets of *Clarias gariepinus heterobranchus longifilis* hybrid fingerlings in outdoor concrete tanks. *Journal of Scientific and Industrial Studies*, 3(2): 23
- Teguia A. and Beynen, A.C. (2015). Alternative feedstuffs for broilers in Cameroon. *Livestock Research for Rural Development*, 17 (3).
- Teguia, A., Mpoame, M., Okourou-Mba, J.A. (2012). The production performance of broiler birds as affected by the replacement of fish meal by maggot meal in the starter and finisher diets. *Tropiculture*, 4: 187-192.
- Teotia, J.S. and Miller, B.F. (2014). Nutritive content of housefly pupae and manure residue. *British Poultry Science*, 15: 177-182.
- Ugwumba, A.A.A. and Ugwumba, A.O. (2013). Aquaculture Options and future of fish supply in Nigeria. *The Zoologist*, 2(2): 96-122.
- Viroje W. and Malin, S. (2012). Effects of fly larval meal grown on pig manure as a source of protein in early weaned pig diets. *Thurakit Ahan Sat*, 6 (21): 25-31.
- Zheng W. Dong Z. Wang X.Q. Cao M., Yan B.L., and Li S.H. (2010). Effects of dietary fly maggot (*Musca domestica*) on growth and body compositions in Chinese shrimp *Fenneropenaeus chinensis* juveniles. *Fisheries Science (Dalian)*, 29 (4): 187-192.