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National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email:japr@napri.gov.ng Url:journals.napri.gov.ng

HOUSE FLY (*MUSCA DOMESTICA*) LARVAE AS PROTEIN SOURCE FOR LIVESTOCK PRODUCTION – A REVIEW

[*]Gadzama, I. U. and Amodu, J. T.
[*]*National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria.*
**Corresponding Author's Email: iugadzama@napri.gov.ng; Phone: 09055569839*

ABSTRACT

One of the Sustainable Development Goals (SDGs) of the United Nations is to achieve food security and improved nutrition. To be successful in feeding the rapidly growing human population, we need innovative changes in food production. Increasing demand for food (particularly meat and eggs) has led to an urgent need for new, safe supplies of protein from sustainable sources for inclusion in animal feeds. Globally, livestock production relies heavily on plant and animal protein supplements especially soybean meal and fish meal. But the availability of these protein supplements for use in animal nutrition in Nigeria and other parts of the world is limited due to their uses in human diets. The use of insects as animal feed is increasingly promoted as a replacement for other less sustainable animal protein sources such as fish meal. Among insects, fly larvae are particularly promising, because they can be produced cheaply and rapidly on organic waste material and thereby convert low value waste into a high value product. Housefly (*Musca domestica*) larvae have the potential as a sustainable future protein source for diets of production animals like poultry, fish and pigs. Therefore, mass production of house fly larvae must be encouraged as this will offer solution to the high cost of protein feed in the diets of production animals.

Key words: House fly, Larvae, Sustainable Protein, livestock

INTRODUCTION

Globally, livestock production rely heavily on plant and animal protein supplements such as fish meal and soybean meal which have become scarce and expensive in livestock feeds regime (Khusro *et al*., 2012). The impact will continually to be felt most especially in the sub-saharan Africa (SSA) where fish and poultry contribute about 61% of the human protein intake (Kenis *et al*., 2018). In Nigeria for instance, as one of the countries in SSA with the highest chicken meat production, the price of fish meal had almost doubled in the last decade. This is due to mainly the fact that most of the protein ingredients such as fishmeal are imported while locally available alternatives like soya bean and groundnut also serve as food for humans (Makinde, 2015). Recently, an alternative to fish meal and soybean meal in diets of animal production has attracted immense attention among researchers and nutritionists (Ruhnke *et al*., 2018).

However, insects are increasingly proposed as a component of feed for production animals such as poultry and fish, as a replacement for conventional protein sources that are becoming increasingly expensive and considered unsustainable (van Huis *et al*., 2013; Makkar *et al*., 2014; Kenis *et al*., 2018). Ogunji *et al*. (2006) stressed that insects in various developmental stages have been used to feed fish and farm animals. Among insects, fly larvae are particularly promising because they contain a high amount of animal protein (Kenis *et al*., 2018), that can be produced rapidly and at low costs on organic wastes (van Huis 2013) and thereby convert low value waste into a high

value animal feed (Kenis *et al*., 2018) and have lower ecological footprint (Pastor *et al*., 2015).

Housefly (*Musca domestica*) larvae have the potential as a sustainable future protein source for diets of production animals like poultry, fish and pigs. Many studies have reported on the evaluation of fly larvae meal as a complete or partial replacement of other protein sources such as groundnut meal (Adeniji, 2007), fishmeal (Ogunji *et al.*, 2006; Agunbiade *et al*., 2007) and soya bean oil cake meal (Hwangbo *et al*., 2009). However, considerable variation in the nutrient composition of house fly larvae was reported in literatures (Ogunji *et al.*, 2006; Ukanwoko and Olalekan, 2015; van Huis *et al*., 2013; Pastor *et al*., 2015; Kenis *et al*., 2018). The variation may not be unconnected with the type of fly attractant and substrate used during the production process (Ukanwoko and Olalekan, 2015) and processing, drying or storage methods used. Therefore, this paper reviewed the different production systems of housefly larvae as a sustainable future protein source for diets of production animals.

Production of Housefly (*Musca domestica*) Larvae

In Africa, housefly larvae is commonly used by farmers as poultry feed but there are few publications on rearing techniques (Koné *et al*., 2017; Kenis *et al*., 2018). There are two systems of housefly larvae production. Firstly, the larval production that relies on natural oviposition (i.e. substrates are exposed and females are naturally attracted to lay eggs); this technique is suitable for small production systems (e.g. on farm), in tropical regions where housefly are available in the whole year. Secondly, adults can be reared in cages or confined rooms to produce eggs that are then inoculated in a substrate suitable for larval development. This system is most appropriate for industrial scale production, but individual farmers also use it, particularly in China (Nyakeri *et al*., 2017; Koné *et al*., 2017; Kenis *et al*., 2018).

Housefly Larvae Production Based on Natural Oviposition

The technique of obtaining larvae from substrates exposed to naturally-occurring flies is mainly known from sub-saharan Africa, and particularly West Africa, where house flies are available in abundance all year round. Several studies assessed the suitability of housefly larvae as animal feed in West Africa have obtained larvae by freely exposing various attractive substrates (Ogunji *et al.*, 2006; Ukanwoko and Olalekan, 2015; van Huis *et al*., 2013; Pastor *et al*., 2015; Kenis *et al*., 2018). However, very little was known on the actual use of housefly larvae on livestock farms until Pomalégni *et al*. (2017) that show that nearly 6% of the indigenous poultry farmers in West Africa produce housefly larvae for their poultry (Koné *et al*., 2017; Kenis *et al*., 2018). Housefly larvae are produced by exposing substrates, usually organic wastes, in containers around farms to attract naturally occurring flies. Larvae are extracted from the substrate 3 – 5 days later using sieves, and then given directly to the poultry. In West Africa, farmers use at least 28 substrates to produce larvae, the most commonly being soy and maize bran, as well as pig and chicken manure (Pomalégni *et al*., 2017).

Farmers using housefly larvae as a source of protein tende to have a higher income from poultry farming and a larger flock than those that do not use housefly larvae (Kenis *et al*., 2018). Pomalégni *et al*. (2017) suggested that farmers can use suitable substrates that are available free, or affordable in their community. Koné *et al*. (2017) described a system set up in Mali as part of the PROteINSECT project and tested over a period of 2 years with different substrates. In summary, about 10 kg of dry substrates were placed in cement beds of about 1 m2 under a roof and moistened, for the first day, naturally occurring flies were allowed to oviposit on the substrate. At the end of the day, the substrates were covered with ventilated plastic sheets and left for 2 days. On the fourth day, larvae were separated from the substrate using colanders that

allowed the larvae to leave the substrate by themselves. The larvae were then left in containers for one night for purging of gut contents before being fed alive to animals or dried in the sun or in a solar dryer. The rearing residues were sold as compost (Koné *et al*., 2017). Authors revealed that humidity in the substrates is essential for larval growth, but substrates that are too wet will also be detrimental for the growth and survival of larvae (Kenis *et al*., 2018).

Additionally, it was recommended that the depth of the substrate should not be more than 10 cm to avoid anoxia. The best substrates were chicken manure, alone or with ruminant blood, and sheep manure with ruminant blood (Kenis *et al*., 2018). The system produced on average 124 – 144 g of fresh larvae per kg of dry substrate in 3 days, but with high variations between and within seasons (Bouafou *et al*., 2006). In the rainy season, a maximum of 427 g per kg of dry substrate were obtained. Nevertheless, experiments have shown that flies also oviposit (albeit at a lower rate) on substrates that are placed on shelves (Koné *et al*., 2017; Kenis *et al*., 2018). In such systems, rearing substrates have to be attractive for adults and suitable for larval development. Both animal and vegetable wastes can be used, but not all wastes are suitable. The protein content in the substrate undoubtedly plays an important role, as well as volatiles present in the substrates (Tang *et al*., 2016).

Poultry and pig manure are suitable when used alone, but ruminant manures are productive only when animal protein such as blood or animal offal are added (Koné *et al*., 2017). Blood and animal offal can also improve larval yields on otherwise poor vegetal substrates such as decaying fruits and vegetables (Bouafou *et al*., 2006). Aniebo *et al*. (2008) tested a mixture of cow and goat blood from a Nigerian abattoir with wheat bran, rice dust and saw dust. Mixtures of 25 kg blood and 5 kg wheat bran produced an average of 7.16 kg of fresh housefly larvae. It was calculated that the abattoir could potentially produce 2 tons of housefly larvae per day. Abattoirs can also provide rumen contents, which is also a suitable substrate for housefly production (Kenis *et al*., 2018), performing particularly well when mixed with cereal bran (Koné *et al*., 2017). In another study, Ukanwoko and Olalekan (2015) reported raw egg as the best fly attractant.

Housefly Larvae Production from Adult Rearing

The systems based on adult rearing use basically the same substrates as those used in natural oviposition, in most cases, a substrate that is suitable for larval development will also attract female flies for oviposition. In most systems outside West Africa, housefly larvae are produced by rearing adults in confinement to obtain eggs that are placed directly in suitable substrates (Kenis *et al*., 2018). House flies are maintained in very high densities under controlled environments (temperature, humidity and light), in rearing rooms or cages of various sizes (e.g. from 25,000 flies in 0.7 m^3 in Čičková *et al*. (2013) to 4.8 million flies in 48 m^3 in Wang *et al*. (2013). Adults are fed with a mixture of carbohydrates (usually sugar), proteins (usually milk powder, sometimes yeast) and water. Eggs are laid on various oviposition devices filled with attractants, e.g. pig manure (Čičková *et al*., 2013) or fermented wheat bran (Cortes Ortiz *et al*., 2016). Egg production may also depend on how the oviposition devices are placed. Flies are fed with a mixture of sugar and dry milk, butadding a hen's egg in the feed strongly enhanced oviposition in Ghana (Charlton *et al*., 2015).

The oviposition substrate consisted of fermented wheat bran in China whereas chicken manure, brewery waste or a mixture of both were used in Ghana (Koné *et al*., 2017). The oviposition substrate can be packed in bags made with pleated fabric to facilitate egg laying and egg collection. However, in China, to prevent eggs from drying out, eggs were laid by females directly in the substrate, and freshly hatched larvae in the oviposition substrate, rather than eggs, were moved to the larval rearing substrate

(Wang *et al*., 2013). Rearing adult flies for egg production also implies that healthy and strong adults have to be produced. Adult fecundity and longevity depends on the conditions experienced in the larval stages and, so, rearing the larvae in the best conditions will ensure that females are capable of producing large amounts of eggs (Pastor *et al*,. 2015). Hence, it is important to keep the larvae for adult production in a nutritious substrate until pupation (Cortes Ortiz *et al*., 2016; Kenis *et al*., 2018).

Extraction of Larvae and Pupae

In small systems where the larvae are fed live to poultry birds or fishes, the separation of larvae from rearing substrates can be easily achieved using various sieving systems (Koné *et al*., 2017; Pomalégni *et al*., 2017). When placed on a sieve in the sunlight, larvae tend to leave the substrate and crawl through the sieve. However, the type of sieve needed depends on the substrate used. With pig manure, mature larvae are simply collected with a broom and a shovel before being fed to chickens (Charlton *et al*., 2015). In other systems, larvae are extracted from the chicken manure by lowering the oxygen concentration, which forces the larvae to leave the rearing containers (Cortes Ortiz *et al*., 2016).

Čičková *et al*. (2013) developed a behavioural method to extract larvae from processed pig manure. In a dark room, a cover was placed over larval rearing trays that were then placed in larger collection trays. After 24 h of separation, 74% of the larvae had egressed from the manure into the collection tray, probably because of the lack of oxygen and accumulation of noxious metabolic products. An advantage of the system compared with sieves was that egressed larvae were free of any manure particles and purged of gut contents. In general, larvae should be purged for at least 12 h before being given to po ultry birdsor dried to minimize the amount of substrate that are eaten by the animals or to maximise the purity of dry larvae (Koné *et al*., 2017; Kenis *et al*., 2018).

Killing and Drying

When larvae are not fed directly after extraction or purging, they have to be killed and dried for preservation. Dried housefly larvae can be stored in a sealed container for several months or even years (Pastor *et al*., 2015). Various types of ovens and other drying methods can be used but the easiest ones, such as gas or electric ovens or microwaves (Wang *et al*., 2013), are usually costly and energy-demanding. In warm climates, housefly larvae can be dried in the direct sun on a metal sheet within a day (Koné *et al*., 2017). In the rainy season, however, the larvae should be first killed and dried a few minutes on a cooker (Kenis *et al*., 2018).

CONCLUSION

Rearing, processing and use of housefly larvae as feed in the diets of production animals is still at experimentation level in sub-saharan Africa. More research are needed on the technical and economic feasibility of using housefly larvae, as the current cost of feeds (fishmeal, soya bean meal, groundnut cake) too high for most African fish and poultry farmers.

REFERENCES

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.

Aniebo, A.O., Wekhe, S.N., Erondu, E.S., Owen, O.J., Ngodigha, E.N. and Isirimah, N.O. (2008). Sustainable commercial maggot production (maggotry) for animal and aqua feeds in Rivers State, South Nigeria. *International Journal of Biotechnology and Biochemistry*, 4:197 – 205.

Bouafou, K.G.M., Kouame, K.G., Amoikon, E.K. and Offoumou, A.M. (2006). Potentiels pour la production d'asticots sur des sous-produits en Côte d'Ivoire. *Tropicultura*, 24:157 – 161.

Charlton, A.J., Dickinson, M., Wakefield, M.E., Fitches, E., Kenis, M., Han, R., Zhu, F., Kone, N., Grant, M., Devic, E., Bruggeman, G., Prior, R. and Smith, R. (2015). Exploring the chemical safety of fly larvae as a source of protein for animal feed. *Journal of Insects for Food and Feed*, 1:7 – 16.

Čičková, H., Kozánek, M. and Takác, P. (2013). Improvements of survival of the house fly (*Musca domestica* L.) larvae under mass rearing conditions. *Bulletin of Entomological Research*, 103:119 – 125.

Cortes Ortiz, J.A., Ruiz, A.T., Morales-Ramos, J.A., Thomas, M., Rojas, M.G., Tomberlin, J.K., Yi, L., Han, R., Giroud, L. and Jullien, R.L. (2016) Chapter 6. Insect mass production technologies in Dossey AT, Morales-Ramos JA, Guadalupe Rojas M (eds) Insects as sustainable food ingredients. *Academic*, San Diego, pp: 153 – 201.

Hwangbo, J., Hong, E.C., Jang, A., Kang, H.K., Oh, J.S., Kim, B.W., Park, B.S. (2009). Utilization of house fly-maggots, a feed supplement in the production of broiler chickens. *Journal of Environmental Biology*, 30(4): 609 – 614.

Kenis, M., Bouwassi, B., Boafo, H., Devic, E., Han, R., Koko, G., Koné, N., Maciel-Vergara, G., Pomalegni, S.C.B., Roffeis, M., Wakefield, M., Zhu, F. and Fitches, E. (2018). Small-Scale Fly Larvae Production for Animal Feed. Halloran, et al. (eds.), *Edible insects in Sustainable Food Systems*, https://doi.org/10.1007/978-3-319-74011-9_15

Khusro, M., Andrew, N.R. and Nicholas, A. (2012). Insects as poultry feed: a scoping study for poultry production systems in Autralia. *World's Poultry Science Journal*, 68: 435 – 446.

Koné, N.G., Sylla, M., Nacambo, S. and Kenis, M. (2017). Production of house fly larvae for animal feed through natural oviposition. *Journal of Insects Food and Feed*, 3:187 – 192

Makinde, O. J. (2015). Maggot Meal: A Sustainable Protein Source for Livestock Production-A Review. *Advances in Life Science and Technology*, 31:35 – 42.

Makkar, H.P.S., Tran, G. and Heuzé, A.P. (2014). State-of-the-art on use of insects as animal feed. *Animal Feed Science and Technology*, 197:1 – 33.

Nyakeri, E.M., Ogola, H.J., Ayieko, M.A. and Amimo, F.A. (2017). An open system for farming black soldier fly larvae as source of proteins for smallscale poultry and fish production. *Journal of Insects for Food and Feed*, 3:51 – 56.

Ogunji, J.O., Kloas, W., Wirth, M., Schulz, C. and Rennert, B. (2006). Housefly Maggot Meal (Magmeal): An Emerging Substitute of Fishmeal in Tilapia Diets. *Conference on International Agricultural Research for Development*, Deutscher Tropentag, October 11-13, http://www.tropentag.de/2006/abstracts/full/76.pdf.

Pastor, B., Velasquez, Y., Gobbi, P. and Rojo, S. (2015). Conversion of organic wastes into fly larval biomass: bottlenecks and challenges. *Journal of Insects as Food and Feed*, 1: 179 – 193.

Pomalégni, S.C.B., Gbemavo, D.S.J.C., Kpadé, C.P., Kenis, M., and Mensah, G.A. (2017). Traditionnal use of fly larvae by small poultry farmers in Benin. *Journal of Insects for Food and Feed*, 3:187 – 192.

Ruhnke, I., Normant, C., Campbell, D.L.M., Iqbal, Z., Lee, C., Hinch, G.N. and Roberts, J. (2018). Impact of on-range choice feeding with black soldier fly larvae (*Hermetia*

illucens) on flock performance, egg quality, and range use of free-range laying hens. *Animal Nutrition*, https://doi.org/10.1016/j.aninu.2018.03.005

Tang, R., Zhang, F., Koné, N.G., Chen, J.H., Zhu, F., Han, R.C., Lei, C.L., Kenis, M., Huang, L.Q. and Wang, C.Z. (2016). Identification and testing of oviposition attractant chemical compounds for *Musca domestica*. *Science Repository*, 6:33017

Ukanwoko, A.I. and Olalekan, O. A. (2015). Effects of Source and Time of Harvest on the Proximate Composition of Maggot (*Musca Domestica*) Larva Meal. *International Journal of Livestock Research*, 5(7): 01 – 07.

Van Huis, A., Van Itterbeeck, J. and Klunder, H. (2013). Edible Insects: Future Prospects for Food and Feed Security, FAO Forestry Paper no. 171. Rome: FAO.