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# The Rise of the Black Soldier Fly: A Sustainable Protein Source for Poultry

**Dr. Ratna Supriya[1*], Dr. Vemula Sravathi[2], Dr. Katam Divya[3], Dr. Koppu Vasavi[4], Dr. Poloju Deepa[5], Dr. P. Bhagavan reddy[6], Dr. Palak Tripathi[7]**

[1, 2, 3, 7] Ph.D. scholar, college of veterinary science, Rajendra Nagar, Hyd

[4, 5, 6] Ph.D. scholar, Indian veterinary research institute, Bareilly, UP, India

## Introduction

As the global population continues to grow, the demand for food, especially animal protein, has surged. Poultry farming, in particular, plays a crucial role in meeting this demand. However, the conventional reliance on traditional protein sources like soybeans and fishmeal comes with its own set of environmental challenges. Black Soldier Fly (BSF), is a remarkable insect that has captured the attention of researchers and farmers worldwide as a sustainable alternative protein source for poultry and livestock.

## The Black Soldier Fly - A Marvelous Insect

The Black Soldier Fly (*Hermetia illucens*) may not be the most aesthetically pleasing insect, but its potential as a protein powerhouse cannot be ignored. Native to tropical and temperate regions, this species has been used for centuries as nature's garbage disposal. Their larvae are voracious eaters and have a unique ability to convert a wide range of organic waste into nutrient-rich protein, making them an excellent candidate for sustainable agriculture (Joosten et al., 2020).

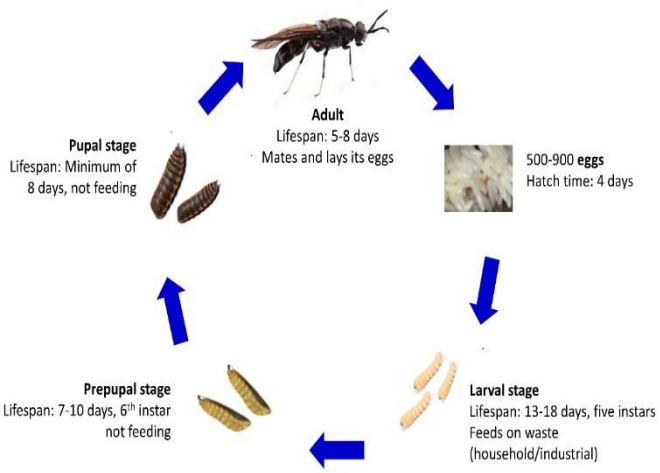


**Fig 1. The BSF life cycle**

The total life cycle of the fly lasts for



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approximately 5 to 6 weeks (Fig. 1). It starts with the oviposition of around 400 to 800 eggs, after which the female dies. After four days, the initial larva stage emerges, measuring a few millimeters in length and displaying a voracious appetite. They continue growing for 12 to 14 days when they are provided with suitable environmental conditions and with a good organic substrate. At the end of this period, the larva transitions into the pupa stage, which lasts for approximately 2 to 3 weeks, culminating in the emergence of a fly (Dortmans et al., 2017). During their brief one-week adult lifespan, female flies search for a mate, reproduce by laying eggs, and subsequently pass away. The 69 % of mating occurs 2 days after emergence, significantly affected by the light intensity (Tomberlin & Sheppard, 2002). Four days after the emergence, 70% of adult females had already laid their eggs.

**Nutritional composition of BSF larvae and its dynamics**

The substrate on which the larva is reared and the larval stadia can influence the composition of BSF larvae.

**Dry matter**

The fresh larvae's dry matter at harvest time is notably high, falling within the range of 30 to 35% (Spranghers et al., 2017).

**Protein**

The BSF larvae contain high levels of crude protein (> 33%) (Spranghers *et al*., 2017). Compared to a soybean meal of the same protein content (44%), the amino acid profiles are quite similar. Shumo *et al.* (2019a) reported that the amino acid profile of BSF larvae was superior to the FAO specifications of SBM and sunflower, with methionine levels also above the FAO standards for fishmeal. Defatting of BSF meal results in an increase in protein percentage, reaching up to 60%, along with a superior amino acid composition (Spranghers *et al*., 2017).

**Lipids**

Larvae are high in lipids, and their content depends largely on the quantity and types of lipids in the substrate. Liu et al. (2017) found a lipid content of 28% at 14 days, whilst Makkar et al. (2014) reported up to 36 % before the larvae become pre-pupae. While housefly meal exhibits a high level of unsaturated fatty acids (USFA) ranging from 60% to 70%, black soldier fly (BSF) meal contains significantly lower levels, ranging from 19% to 37% (Makkar et al., 2014). In contrast, BSF has a notable abundance of lauric acid, which is synthesized internally (Ewald et al., 2020), and it also contains low levels of cholesterol (Ramos-Bueno et al., 2016).

The high content of medium-chain fatty acids (MCFAs), especially lauric (C12:0) is of great importance in pigs and poultry. According to research, Lauric acid exhibits probiotic properties, particularly effective against Clostridium perfringens, while having minimal impact on Lactobacilli,



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thereby supporting a healthy microflora in the proximal small intestine (Spranghers et al., 2017). Additionally, Lauric acid has been reported to demonstrate its efficacy against enveloped viruses, other bacteria, and protozoa (Shumo et al., 2019).

**Fibre**

The NDF and ADF content of BSF larvae can be influenced by the NDF and ADF contents of the substrate on which they are reared. Shumo et al. (2019) reported values of 21%, 20%, and 29 % NDF for BSF larvae reared in chicken manure, kitchen waste, and spent grains, respectively. ADF values for larvae in the same substrates were 12.6%, 13%, and 15 %, respectively.

**Minerals**

The Calcium content is significantly influenced by the substrate's composition (Spranghers et al., 2017). On the other hand, the Phosphorus content remains relatively consistent, ranging from 0.6% to 1.5% DM (Makkar et al., 2014).

**Other components**

The presence of chitin, between 5% DM (Nafisah et al., 2019) and 8.5% DM (Spranghers et al., 2017), is of importance. Chitin has been attributed to some prebiotic effects. However, it is essential to be cautious of the anti-nutritional properties of BSF larvae, as even at low concentrations, they can negatively impact nutrient digestibility in animals (Nafisah et al., 2019; Spranghers et al., 2017). Moreover, the fermentation of larvae with chitinolytic bacteria like Bacillus subtilis has been shown to a reduction in chitin quality and content (Nafisah et al., 2019).

Shumo et al. (2019) reported the presence of five flavonoids in BSF larvae meal, with two of them, apigenin and kaempferol showing dependence on the substrate's concentration. Various factors contribute to modifications in the larvae's composition. Among these factors, the developmental stage and substrate composition play a significant role. Regarding vitamins, Shumo et al. (2019) found pro-vitamin D, alpha-tocopherol, and gamma-tocopherol, although in lower levels than reported.

**Environmental Sustainability**

One of the most significant advantages of using Black Soldier Fly larvae as an alternative protein source is its minimal environmental footprint. Traditional protein sources like soybeans and fishmeal require vast amounts of land, water, and energy resources. Conversely, BSF larvae thrive on organic waste, reducing the burden on landfills and mitigating environmental pollution, reducing the need for deforestation and minimizing greenhouse gas emissions, helping combat climate change (Siddiqui et al., 2022). Moreover, using BSF larvae as an alternative protein source can alleviate the pressure on overexploited marine ecosystems, as the demand for fishmeal decreases.



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**Nutritional Powerhouse**

The magic lies in the BSF larvae, which are voracious eaters capable of consuming a wide variety of organic waste, including kitchen scraps, agricultural residues, and food industry by-products. As they consume this organic waste, the larvae undergo rapid growth, accumulating high levels of protein and fat, making them an excellent source of nutrition. Black Soldier Fly larvae are packed with essential nutrients, making them an ideal substitute for conventional poultry feed. These tiny creatures are rich in protein, containing up to 50-70% protein on a dry matter basis, surpassing the protein content of soybeans and fishmeal (Lu et al., 2022). Additionally, they boast an optimal amino acid profile, including all the essential amino acids required for poultry growth and development. Bongiorno et al. (2022) reported that dietary supplementation of 10% live BSFL in the feed of broilers, did not impair the growth and slaughtering performance and the blood traits. As the live black soldier fly larvae (BSFL) supplementation increased, the weight of the immune organs (spleen and bursa of Fabricius) also increased.

**Improved Poultry Health**

Feeding poultry with Black Soldier Fly larvae has shown numerous health benefits. The larvae contain lauric acid, which has natural antimicrobial properties, leading to improved gut health in poultry, potentially reducing the risk of certain diseases, which can help reduce the need for antibiotics in poultry farming. Moreover, their diet of organic waste ensures that harmful contaminants found in some conventional feed sources are not transferred to the poultry.

**Promising Economic Opportunities**

The adoption of Black Soldier Fly larvae as a protein source opens up new economic opportunities. Rearing these insects requires minimal space, making it a viable option for small-scale farmers with limited resources. Moreover, the ability to convert low-cost organic waste into valuable feed reduces overall production costs, enhancing the profitability of poultry farming. With the increasing demand for sustainable and environmentally friendly food products, the market for insect-based protein is gaining momentum. Farmers can diversify their income streams by selling both live larvae for feed and processed larvae for value-added products, such as animal feed supplements and fish bait.

**A Delicious and Nutritious Poultry Diet**

Beyond sustainability and cost-effectiveness, the inclusion of Black Soldier Fly larvae in poultry diets has been shown to enhance the quality of poultry products. Studies suggest that poultry fed with BSF-based diets exhibit improved carcass traits, higher meat quality including increased



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tenderness and juiciness, and an overall reduction in cholesterol content, leading to higher consumer satisfaction. These improvements translate into healthier and more nutritious poultry products for consumers. Laying hens fed with Black Soldier Fly larvae-based diets have been found to lay eggs with higher omega-3 fatty acid content, making them more nutritious for consumers (Wang and Shelomi, 2017).

**Other uses of BSF Larvae**

**Animal Feed**: Black Soldier Fly larvae are used as a highly nutritious and sustainable protein source in animal feed, including poultry, fish and livestock diets.

**Lower Feed Costs**: Incorporating Black Soldier Fly larvae in poultry diets can lead to cost savings for farmers. The larvae can be reared on low-cost organic waste, reducing the overall feed ingredient expenditure.

**Pet Food:** The larvae are incorporated into pet food formulations, adding nutritional value and reducing the environmental impact associated with conventional meat sources.

**Waste Management**: Black Soldier Fly larvae play a crucial role in organic waste reduction by consuming food waste, agricultural residues, and organic by-products from various industries.

**Composting**: The excrement of Black Soldier Fly larvae, known as "frass," is rich in nutrients and serves as an excellent organic fertilizer for plants.

**Bioremediation**: BSF larvae can be utilized in bioremediation efforts to help break down organic pollutants in contaminated soil or water bodies.

**Medical Applications**: Some studies explore the potential of Black Soldier Fly larvae in wound healing, antimicrobial agents, and bioactive compounds for medical purposes.

**Industrial Applications**: Larvae are used in producing valuable compounds like bio-oils, chitin, and protein hydrolysates, which have applications in various industries, including pharmaceuticals and cosmetics.

**Research and Innovation**: The study of Black Soldier Fly larvae continues to fuel research and innovation in alternative protein sources, sustainable agriculture, and waste management solutions.

**Education and Awareness**: The use of BSF larvae in various applications promotes awareness of sustainable practices and encourages responsible consumption among consumers and industries.

**Insect Farming Industry:** The growing interest in insect farming, particularly Black Soldier Fly farming, has opened up new economic opportunities, creating jobs and entrepreneurial ventures in the insect-based product market.

**Conclusion**

The Black Soldier Fly has emerged as a sustainable and protein-rich alternative to traditional



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poultry feed sources. Its ability to upcycle organic waste, coupled with its nutritional benefits for poultry and environmental advantages, makes it a true eco-warrior in the quest for sustainable food production. Embracing Black Soldier Fly larvae as part of poultry diets can pave the way for a more efficient, cost-effective, and environmentally friendly approach to poultry farming while meeting the growing global demand for food. It's time for the poultry industry to spread its wings with the help of these ecological champions.

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