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Black Soldier Fly Larvae Meal in Fish Culture

Jeyaprakashsabari S.[1] and Aanand S.[2]
[1]P.G. Scholar and [2]Assistant Professor and Head, Erode Bhavanisagar Centre for Sustainable Aquaculture, TNJFU, Bhavanisagar, Erode, Tamil Nadu

SUMMARY

Fish meal is the chief protein source in most of the aquafeed industry. However, in recent days the demand for fish meal has increased, dragging price in the market. Hence, researchers and feed formulators have been looking for alternative protein ingredients to replace fish meal in aquafeed. Among the various plant and animal protein sources, insect meal is one promising source of protein for feed. Black soldier fly larvae meal is one important animal protein source that can replace the fish meal up to 50% in the aquafeed without causing any adverse effect on the fishes.

INTRODUCTION

India is the second-largest fish-producing country in the world. The feed sector plays a dominant role in the growth of the aquaculture industry. The world production of farmed fish rose to 73.8 million tons in 2014, from 1.6 million tons in 1960 (FAO, 2016). The sustainability of aquaculture depends on cost-effective feed, which constitutes 60% of the total operating cost. Fish meal is a significant component in every aqua feed because of diverse reasons: high protein content, excellent amino acid profile, good digestibility, and palatability (Daniel et al., 2018). However, increasing demand and unstable production of fish meals lead to increased prices in the market, raising the cost of production. Fish meal replacement, either partial or total, with less expensive and protein-rich animal or plant sources in the aquafeed, is expected to reduce production costs. Insect meal is one promising animal protein source that can be utilized in aquafeed. Insects being the largest group of organisms in the ecosystem, there is no scarcity in availability. In recent years, with constant exploration, the use of insect resources has developed into an industry.

Black soldier fly insect larvae

Insect Meal as a Protein Ingredient:

Currently, insects are considered a new protein source for animal feed (Premalatha et al., 2011). The global insect diversity is expected to be 80 million; however, only about 1 million of them are known to mankind (Erwin, 2004). More than 58% of the known global biodiversity are insects, of which approximately only 20% of insects have been named and described (Foottit and Adler, 2009). In using insects as a food source for feeding fishes, the natural feeding habits of cultivable fish species need to be considered (Bell et al., 1994). Insects have different feeding habits and can be fed by-products such as slaughterhouses, restaurant surpluses, cereal remnants, etc. Insects can be reared under controlled conditions to optimize the nutritive value (Sealey et al., 2011). Some insect species can be grown organically to reduce environmental contamination and transform waste into high protein feed that could replace fish meal in aquafeed. Thus, from an ecological point of view, insect cultures are sustainable and can be done in warehouses, which do not require larger areas and water when compared with crops. In addition, culturing insects also scores low on carbon footprint while recycling waste (Blonk et al., 2008).

Insects are efficient food converters since they do not need any energy to maintain a high body temperature (Nijdam et al., 2012). While considering insect meal as a feed ingredient in aquaculture, all the insect species cannot be used as a feed ingredient. Only a few insect species can be produced on a large scale depending on their protein, amino acid profile, fat, mineral, and raw material availability. The most familiar insects are Black Soldier Fly (*Hermetia illucens*), Housefly (*Musca domestica*) (MD), and Yellow Mealworm (*Tenebrio molitor*) (Laura et al., 2018). Among these three, black soldier fly larvae is a valuable protein ingredient for use in aquafeed for commercial exploitation.

Black Soldier Fly Larvae:

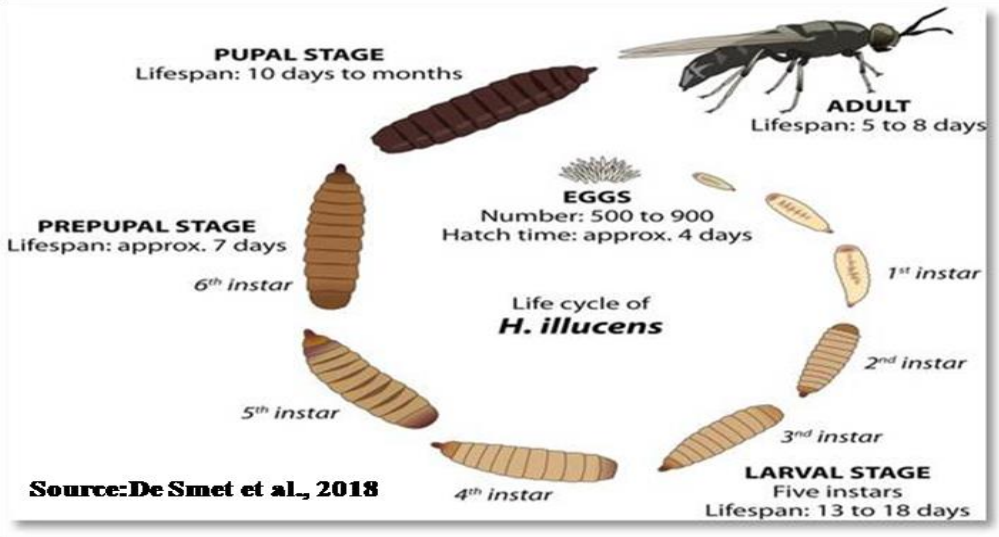
Black soldier fly (*Hermetia illucens*) is native to the Neotropical realm, but in recent decades has spread across all continents, becoming virtually cosmopolitan.

Adult Black soldier fly

The adults of *H. illucens* are 16 millimeters long with a black body, with blue to green metallic reflections on the thorax, occasionally with a red-ended abdomen. The second abdominal tergite has translucent areas. They have a broad head, well-developed eyes, and antennae that are twice the length of the head. The legs are black with whitish tarsi. The wings are membranous and folded horizontally on the abdomen, and overlapped while resting.

Life Cycle:

An adult female of *H. illucens* lays between 206 and 639 eggs at a time. The eggs are deposited in crevices or surfaces above or adjacent to decaying matter such as manure or compost.



Black soldier fly life cycle

The eggs hatch into larvae within 3-4 days. Freshly emerged larvae are 1 millimeter long and weigh about 0.1 grams. They can reach a length of 25 millimeters and 0.22-gram weight by the end of the larval stage. The larvae can adapt to diets with different nutrient content, and it grows for 18 to 36 days, depending on the food substrate available and temperature. The pre-pupal stage lasts up to seven days. The pupal stage lasts for 1 to 2 weeks. Adults live for 47 to 73 days when provided with water and sugar in captivity or nectar in the wild.

The Nutritional Profile of Black Soldier Fly:

Black soldier fly larvae contain 42.1% crude protein, and the defatted black soldier fly larvae contain 56.9% crude protein (Makkar et al., 2014), comparable to that of soybean meal and slightly less than fish meal. The processing and extraction of a lipid fraction from black soldier fly larvae generate protein meals with lipid content from 3.4 to 38.6% of DM. The black soldier fly larvae have a better amino acid profile than soybean meal; hence, a better substitute for fish meal (Tran et al., 2015). However, the oil must be extracted from the black soldier fly larval biomass before processing (Stamer, 2015). They are rich in ash, calcium, and phosphorus, with a nutritional peak at the pupal stage. Maximum shelf life is achieved at 10 to 16 °C (50 to 60 °F), while at room temperature, they can be kept for several weeks.

Black Soldier Fly as a Feed:

Black soldier fly larvae have been approved to be used as feed in aquaculture in the EU. The harvested pupae and pre-pupae are fed to poultry, fish, pigs, lizards, turtles, and even dogs. They are a promising fish meal substitute in diets for turbot, rainbow trout, Jian carp, Pacific white shrimp, and Atlantic salmon. Juvenile Jian carps *(Cyprinus carpio var. Jian)* show good growth, carcass composition, antioxidant enzyme activities, and digestive enzyme activities when fed with defatted black soldier fly larvae meal up to 50% of fish meal in their diet (Senlin et al., 2017). However, 75% replacement causes adverse effects such as dietary stress and intestinal histopathological damage on the fishes. Juvenile Japanese seabass (*Lateolabrax japonicus)* also showed good growth performance, good intestinal antioxidant activity, and better immune response to 64% defatted black soldier fly larvae meal as a replacement of fish meal (Guoxia et al., 2019). Fish meal and fish oil in rainbow trout (*Oncorhynchus mykiss*) diet can be replaced up to 50% black soldier fly pupae reared on dairy cattle manure and trout offal to promote good growth (Wendy et al., 2011). Atlantic salmon *(Salmo salar)* also showed a good growth response when fed with black soldier fly larvae meal. They exhibited good feed utilization, nutrient digestibility, and the sensory qualities of the fillets when the fish meal was replaced partially or totally with black soldier fly larvae meal in their diet (Ikram et al., 2018). Similarly, 50% replacement of fish meal with black soldier fly larvae meal in the diet of tilapia *(Oreochromis niloticus)* showed positive effects without causing adverse effects on growth and feed utilization parameters (Muin et al., 2017). Although no significant differences in crude protein content among fishes fed with different levels, i.e., 20%, 30%, 40% & 50% of black soldier fly larvae meal were observed, fish provided with 50% inclusion level showed a significant increase in crude protein content compared to other treatments. Black soldier fly larvae meal can also be used for the ornamental fish culture, especially for guppy *(Poecilia reticulate),* wherein it can replace fish meal up to 25-50% (Sanjaya et al., 2020). Besides fin fishes black soldier fly larvae meal are also having a positive impact on shellfishes, particularly in the pacific white shrimp species *(Litopenaeus vannamei),* with good weight gain, specific growth rate, and food conversion a less than 25% replacement of FM in diet (Vaun et al., 2017). And in pacific white shrimp (*Litopenaeus vannamei),* 95% maximum whole-body protein and lipid content could be achieved when black soldier fly meal level was restricted to less than 29% and 15%, respectively.

CONCLUSION

Black soldier fly larvae meal is a protein-rich feed ingredient that can replace the fish meal in aquafeed. As the demand and price for the fish meal increase in the market, it is essential to look for an alternative protein feedstuff used as a substitute for the fish meal. Black soldier fly larvae as a feed have been found efficient for both ornamental fish and food fish. From the various studies conducted, it can be concluded that the black soldier fly larvae meal can effectively replace fish meal up to 50% in the fish feed without having any adverse effect on

the fish body. Thus, the use of black soldier fly larvae meal as an alternative source of protein can reduce the production cost in the aquaculture industry without reducing fish's quality.

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