The Role of Black Soldier Fly Larvae in Conserving Biodiversity

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Introduction

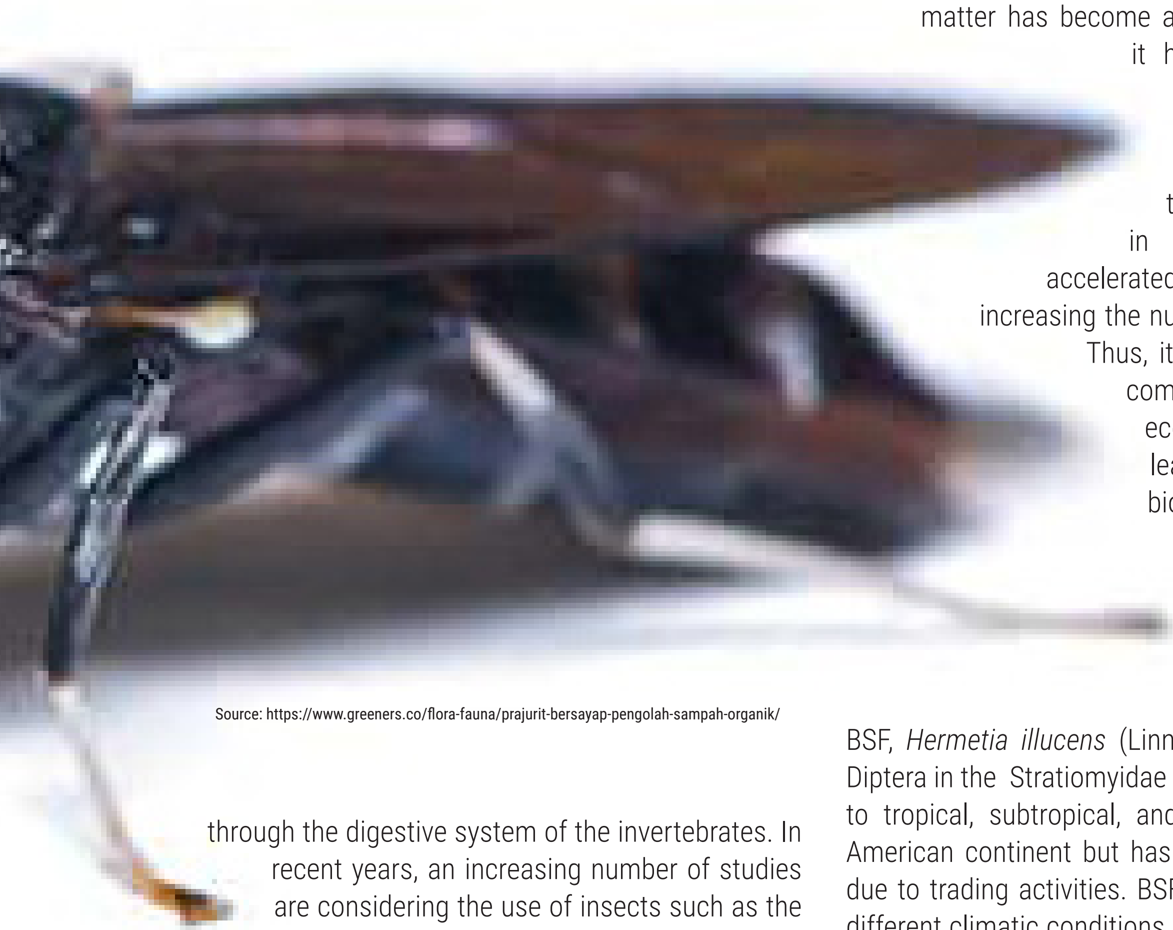
Conserving biodiversity can be accomplished through programs that involve public policies, communities, and ecosystems. Biodiversity keeps ecosystems in balance so they can continue to function and regulate themselves. It maintains our existence in innumerable ways by supplying us with food, fuel, shelter, and medications. One such activity that protects and maintains the diversity of the declining ecosystem is composting. In such natural technology, a wide range of fungi, bacteria, and other invertebrates including insects convert the available nutrients from the organic matter to develop and reproduce. Insects, such as flies, beetles, termites, ants, and other arthropods, all make substantial contributions to the transformation of organic matter into valuable materials.

Composting is the process of enhancing the nutrient content produced by the breakdown of organic materials. The process involves decomposing organic material into a humus-like substance, known as compost. Generally, composting heaps require a constant supply of organic materials from the surrounding environment. The air and moisture around the composting areas are greatly responsible for the conversion of organic matter. Compounds formed throughout the various phases of decomposition attract a wide range of invertebrates whose life cycles are completed inside the compost. This activity protects and maintains the diversity of decaying ecosystems, resulting in the preservation of specific types of biodiversity in the environment. Hence, it was deemed necessary to educate the public about the variety of organisms that can be found inside it.

Decomposers

A decomposer is an organism that feeds on and decomposes dead plant or animal matter, releasing organic nutrients into the ecosystem. It is commonly classified as a bacterium, fungus, or invertebrate. Many yeasts, bacteria, and fungi contribute to the production of enzymes that degrade the cellulose, lignin, and tannins in waste. Pre-treatment by the microbial activity or the presence of lactic acid bacteria helps to improve digestibility and utilization of the nutrients in the organic substrate by the invertebrate animals [1]. The important groups of arthropods involved in the processes of decomposition of plants and animal remains belong to several taxonomies. They are responsible for eliminating dead organic matter and releasing nutrients into the soil. Mesofauna includes mites (Acari), springtails (Collembola), and small insects with sizes ranging from 100 to 200 mm. The larger size of the organisms is called macrofauna, which includes earthworms (Oligochaeta), beetles (Scarabaeidae, Geotrupidae or Silphidae), Diptera larvae (Muscidae, Sarcophagidae, Scatophagidae, Stratiomyidae or Calliphoridae), centipedes (Diplopoda), millipedes (Myriapoda) and woodlice (Isopoda) [2].

Decomposition is a natural biological process that reduces the organic materials while composting occurs under a controlled environmental condition. The natural decomposition process is time-consuming, has potential microbial contamination, produces offensive odours, and may contain insufficient nutrient content. The controlling process in composting differentiates from decomposition by requiring certain conditions such as the feed substrates, temperature, humidity, and acidity for the organisms to survive. Composting can be achieved through the enzymatic degradation of organic materials as they pass



Source: https://www.greeners.co/flora-fauna/prajurit-bersayap-pengolah-sampah-organik/

through the digestive system of the invertebrates. In recent years, an increasing number of studies are considering the use of insects such as the beetle, cricket, mealworm, and various flies' larvae in waste management or particularly, composting [3]. Among these species, the Black Soldier Fly (BSF) larvae have become popular worldwide due to their ability to degrade a various range of organic matter [4].

The BSF larvae

The prominently labelled insect decomposer, BSF larvae, was discovered through composting; living in natural ecosystems with plentiful organic matter. They are not only reproducing but also contribute to the composting process in their unique way. Many decomposer insects were found but this species was a companion that completed its entire life cycle in the compost. Since the composting matter has become a miniature ecosystem, then it has also become essential and deemed necessary to educate the people and for them to understand the role of these larvae in biodiversity. This species accelerated the process while also increasing the nutrient value of the compost. Thus, it is important to remind the community about this detritus ecosystem, which ultimately leads to environmental and biodiversity conservation.

BSF larvae decompose various organic waste and convert them into the non-polluted, high nutrient residue. BSF, *Hermetia illucens* (Linnaeus) belongs to the order Diptera in the Stratiomyidae family. This species is native to tropical, subtropical, and temperate regions of the American continent but has been distributed worldwide due to trading activities. BSF is uncommonly tolerant to different climatic conditions apart from its preference for tropical and subtropical regions. There are five stages in BSF life cycle, which include adult, egg, larva, pre-pupa, and pupa (Figure 1). The larval stage is further divided into phases known as an instar. The life cycle of BSF from egg to adult stage is estimated to be completed within 44 days. However, this length of time depends on the types of organic matter and conditions of the present environment.

BSF larvae start to feed on a discovered organic source once it hatches from the eggs. The larvae are about 27 mm in length and 6 mm in width (Figure 2). They are pale white and have a small black head containing their mouthparts.

Figure 1. Life stages of BSF (Photo by Hadura Abu Hasan).

The Role of Black Soldier Fly Larvae

The moisture level of the feed which is optimum for larvae feeding ranges from 60% to 90% while temperatures that are optimum for the development of this species range from 27°C to 33°C. During this stage, lower temperatures are most likely favoured due to the heat generated by the wriggling movements of the larvae as they consume organic matter. BSF larvae release enzymes to liquefy organic substrate to ensure that it is digestible prior to consumption.

BSF larvae are extremely efficient digesters of organic waste. They combine organic and inorganic molecules and redeposit them as frass, a powdery form of faeces. Observed in the compost, the larval stage of this species contributed to composting. The continual tunnelling of larvae transports microorganisms and air throughout the compost, while their excrement enhanced the nutrient content. This larvae species feed on leftover vegetable matter, and the fragmentation of this organic matter allows greater surface area for bacteria to interact with it. In addition, adult flies never come close to human habitation and therefore never created any nuisance. Together with bacteria in the compost, BSF larvae can be considered useful decomposers in the natural world.

Figure 2. Decomposer, BSF larvae
(Photo by Hadura Abu Hasan)

Pre-pupae leave the organic substrate and search for a dry location for shelter. The pre-pupae stage requires approximately seven days to develop into the pupae stage. Time spent in the migration phase for each pre-pupae varies but it showed to be dependent on the pre-pupae ability to find an ideal pupation site. The pupae are dormant and turn into darker coloration. They are inactive and can survive without food sources. The pupation period might take two to three weeks, depending on the temperature and humidity.

The appearance of an adult BSF is like a wasp, black, and about 15 to 20 mm in length. It has one pair of wings and

Figure 3. Adult BSF, *Hermetia illucens*
(Photo by Hadura Abu Hasan)

three pairs of legs (Figure 3). The terminal part of the legs is white. Adult BSF does not feed as they are surviving on the body fat obtained during the larval stage and die when these fat reserves are depleted. The adults of BSF do not pose any pest-like behaviour and only live for a few days or a week [5].

An aerial mating process happens in adult and female BSF oviposit on a suitable organic matter. The mating process takes place two days after the emergence of the adult BSF while oviposition occurs two days after the fertilization of eggs. The instinct of female adult BSF to lay their fertilized egg near the organic source is trusted to be due to the detection of volatile chemicals from rotting wastes. Eighty percent or more egg hatching rates are achieved at an egg-laying site with a constant temperature of 27°C and an ambient relative humidity of 60% or more [6]. Female BSF prefers areas with an abundance of organic substance to lay eggs, whilst males prefer sunny spots with a lot of vegetation (Figure 4).

Figure 4. Black Soldier Flies resting on the plant
(Photo by Hadura Abu Hasan)

Composting by BSF larvae

One of the primary causes of insect declines worldwide is habitat loss. A diverse landscape with open grasslands, shrubby areas, and forestland can encourage a diverse insect community because these different areas provide a variety of native foraging and nesting resources. Many strategies for supporting insect communities have already been devised, and these steps can also benefit pollinators and non-pollinating insects by creating ideal habitat. Insects benefit from composting because it provides them with a place to live. Because BSF larvae feed on mostly biodegradable materials in the ecosystem, they are more efficient than many other ways of composting. The larvae are photophobic, they typically hide from view. Pre-pupae harvest themselves and instantly reside under the rocks, sand, or any organic matter for protection. This behaviour makes it simple to create a clean compost site free from visible larvae.

The BSF larvae can consume organic waste double their body weight daily and efficiently convert this organic feed into valuable biomass containing high protein and lipid content. This makes them an ideal animal feed for poultry, livestock, and fish. As they prepare to pupate, they search for drier substrates until they mature as flies. This characteristic is advantageous because the mature larvae can easily be collected as they migrate out of their initial feeding substrate. The black soldier fly larvae can be introduced into a heap composting cage unit using the simple composting method. Food scraps, dry leaves, or animal manures can be used as the main components of the composting process. Composting cages constructed of wire mesh can be installed in the desired locations to keep animals out of the composting materials (Figure 5). The size of the cages is determined based on the amount of waste generated from the targeted areas. For instance, due to the large amount of green waste generated on a university campus, a larger scale composting plant is required. The unit can also be covered by a roof to protect it from rain. The collected rainwater may then be utilized to water the compost and moisten the substrate for BSF larvae development. Compost material produced can be further tested for nutrient content and quality. Enrichment of the compost nutrient is significant to generate interest in the composted product. The BSF larvae produce frass that is unpolluted, odourless, and most importantly, that provides nutrients for the plants.

Figure 5. Composting by the community
(Photo by free image Pixabay)

Community participation

Various composting methods can be implemented during the early phase of the community projects. A small-scale cage composting can be set up at selected locations such as schools, universities, animal facilities, or residential areas in urban, suburban, and rural areas. Community participation at the neighbourhood or regional level results in several benefits, including increased social involvement and empowerment, improved local soils, enhanced food security, and increased local career opportunities. The composting knowledge and skills using BSF larvae among the local workforce can be passed on to subsequent generations. The innovations in composting techniques using BSF larvae are required to produce quality compost and can be conveniently practiced by the communities. To generate economic activities from BSF composting, cooperation among the relevant stakeholders, including the government, private agencies, industry, and the community promises a good economic prospective.

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Author Profile

Dr Hadura Abu Hasan is a senior lecturer in Medical Entomology at the School of Biological Sciences and a fellow at Vector Control Research Unit (VCRU), Universiti Sains Malaysia. She obtained her PhD from Liverpool School of Tropical Medicine, United Kingdom in 2015. Her research background is in mosquito behaviour and vector control. She is actively involved in vector control research projects, especially on mosquitoes and other non-biting flies. Her current project on Black Soldier Fly (BSF) which was initiated in 2017, focuses on transferring the knowledge of biology, behaviour, and production of this species to the community. She has extensive experience in rearing and mass production of black soldier flies, houseflies, and mosquitoes in laboratory settings. She conducted mass rearing of insects for various scientific research such as waste management, biological control, and the production of animal feed. She conducted several knowledge transfers programs on the importance of insects especially the black soldier flies, that involve the exchange of creative and innovative ideas, research findings, skills, and experiential education between universities, research organizations, industries, government agencies, and the community.