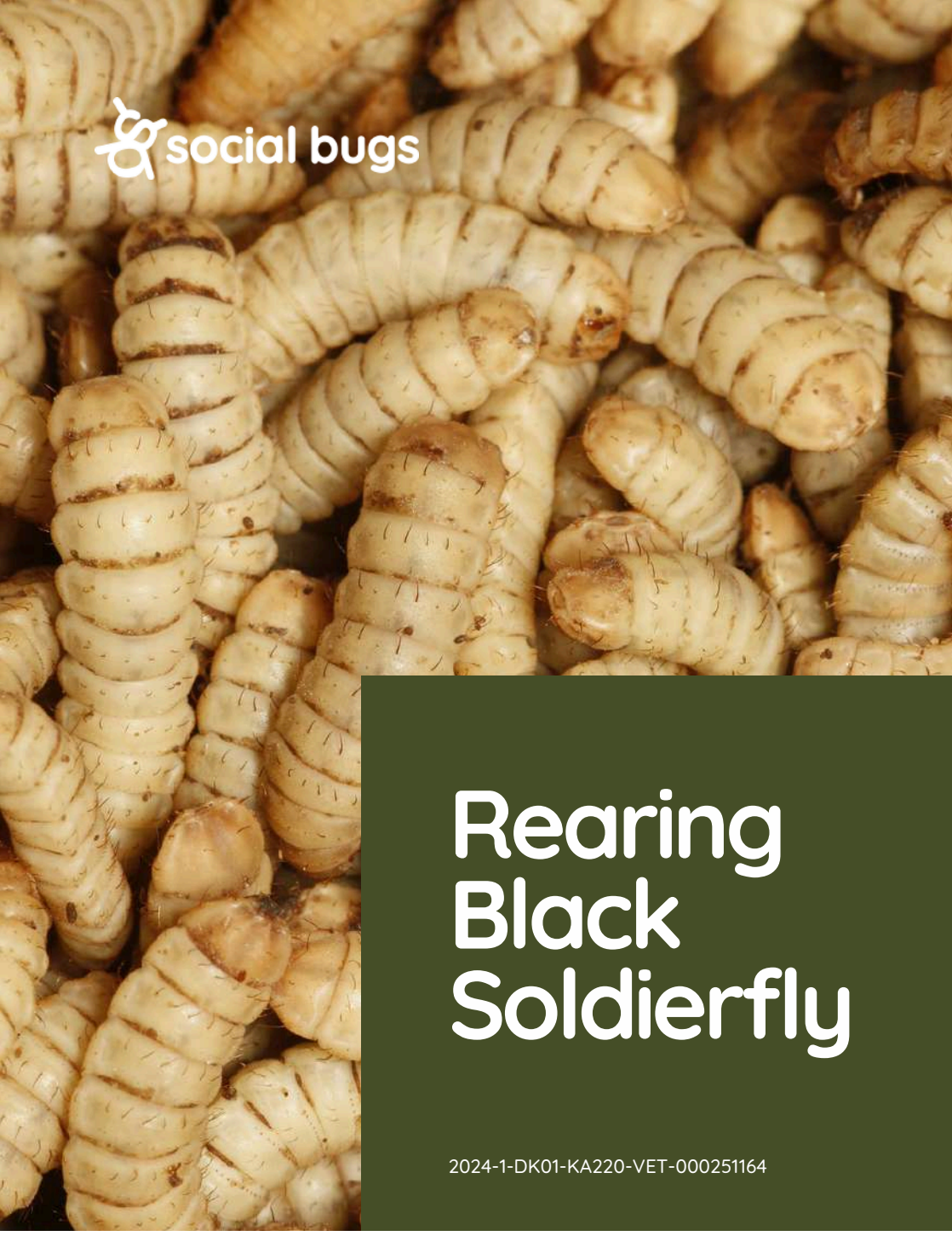

social bugs

Rearing Black Soldierfly

2024-1-DK01-KA220-VET-000251164

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1. Introduction

This booklet is a manual to set-up and run a small-scale black soldierfly farm. It is based on a combination of scientific evidence and a decade of experience by the authors running a small farm. Please be aware that you must comply with your local legislation regarding farming, processing and selling insects for feed. The protocol is published as part of the Social Bugs project, co-funded by the European Union (Erasmus+ ID 2024-1-DK01-KA220-VET-000251164).

2. What is a black soldierfly?

Black soldier flies (*Hermetia illucens*) undergo complete metamorphosis, consisting of five distinct life stages: egg, larva, prepupa, pupa, and the adult fly. The life cycle begins when the adult female lays a single cluster of 400 to 800 eggs in dry crevices near (decaying) organic matter. These eggs hatch within 3 to 4 days, depending on environmental conditions. As with other insects, the larval stage is the most active feeding phase and typically lasts 12 to 14 days under optimal conditions. During this time, the larvae rapidly increase in size, reaching a weight of up to 200 mg. Once fully grown, the larvae enter the prepupal stage, during which they stop feeding and migrate away from the food source to pupate.
The pupal stage lasts about one week, after which the adult fly emerges. Adult BSF are black flies measuring about 1.5–2.0 cm in length. Unlike many other flies, adult BSF can survive without food and live only for about 5 to 8 days, during which their sole purpose is to reproduce. In general, a female fly will lay her eggs around day 4.

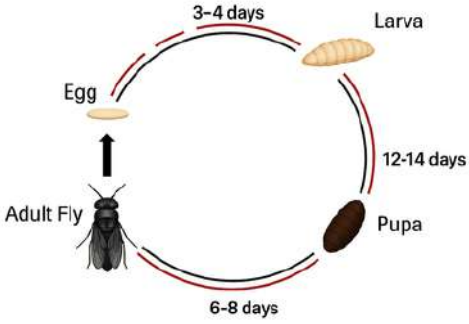

Figure 1: *BSF Lifecycle, dashed red line illustrates number of days (3-4) for the egg to hatch. Red line illustrates number of days from newly hatched neonates to adulthood stage. Figure made in Biorender.com.*

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3. Why rear BSF?

Black soldier flies (*Hermetia illucens*) are, worldwide, the most farmed insect species due to their exceptional efficiency in converting organic waste into high-quality protein and fat. The larvae grow rapidly and can be harvested in just 10–14 days, resulting in a high-throughput production system. Much more than mealworms or crickets, BSF larvae can thrive on a wide variety of low-value organic waste streams, this may significantly reduce feed costs and contribute to circular economy models. BSF are currently not approved for human consumption in the EU, they are widely accepted for use in animal feed, aquaculture, and pet food. Finally, as a downside, they do require a specialized setup for reproduction compared to mealworms and crickets.

4. What do you need?

4.1. Infrastructure

Rearing black soldier flies will require three rooms even in a small-scale set-up as the adult phase and larvae phase should be separated from each other and from the other operations. Ideally, all spaces should be easy to clean, well-sealed, and free of unnecessary crevices to maintain hygiene and efficiency.

4.1.1. Rearing room

Black soldier fly larvae (*Hermetia illucens*) are cold-blooded organisms, meaning their growth and development are highly influenced by environmental conditions. The recommended rearing temperature is 27°c with a relative humidity between 60–70%. The larvae do not require light and even prefer a dark environment. Adequate ventilation is essential, as the larvae generate substantial amounts of carbon dioxide, ammonia and heat. A basic ventilation system, combined with fans for air circulation, helps maintain a stable and safe environment for both insects and workers.

In small-scale operations, these conditions can be achieved in a well-insulated room or repurposed container, ideally constructed from insulated sandwich panels. Climate control can be managed using a dual-function air-conditioning unit and a (de)humidifier. Air exchange can be handled using simple ventilators to ensure fresh airflow and prevent gas buildup.

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4.1.2. Reproduction room

Adult black soldier flies require slightly different environmental conditions than the larvae. They thrive at a temperature of around 30°C and a high relative humidity of approximately 80%. Unlike the larvae, adult flies need bright white light to initiate mating behavior. Natural sunlight can be used if the rearing space has access to a window. However, sunlight may be inconsistent depending on your location and weather conditions. In such cases, artificial lighting should be provided. If the light intensity or spectrum is insufficient, the flies may not mate, and as a result, no fertile eggs will be laid (see section on reproduction).

Additionally, the rearing room should be free of strong or unpleasant odors, as female flies are sensitive to smell and may refuse to lay eggs in unsuitable environments. For this reason, it is mandatory to keep larvae and adults in separate rooms to avoid odor interference and ensure successful egg-laying.

4.1.3. Work room

Besides the rearing room there is a need for a general place to prepare the substrate (see below), clean the crates, harvest insects, etc. This should not be done inside the rearing room. Optionally, but highly recommended, is a separate room for sieving (see further) as the production of fine dust particles should be contained as much as possible (see section 6).

4.2. Equipment

In its most basic form, one does not need much to set-up a farm. In addition to the rearing and work room, the following is recommended:

Rearing crates	These are the corner stone of the farm as they are the home for the larvae. It is recommended to use plastic 60 x 40 cm crates. This is a durable material and compatible with EU standard shipping sizes (Euronorm). 

Fly cages	These can be simple pop-up cages
Light	If the sun is unavailable, 6000K white LED light
Egg collector	Can be made out of cardboard, wood or plastic
Sieves	2 or 3 mm square mesh for harvesting larvae 
Masks	An FFP3 mask and ammonia mask 
Barrels or similar	To store (wet) feed

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There are however a lot of other items that are useful in the farm to reduce the workload and improve efficiency, depending on the scale of the farm.

Scale(s)	One or more scales are useful to weigh feed (e.g. kitchen scale) and larvae (e.g. jewelry scale)
Transport equipment	Some equipment to move all the crates. This can be a trolley or more convenient, although more expensive, individual dollies.  
Shredder	Depending on the substrate, a shredder may be mandatory to chop up the insect feed. 

(Wine)cooler	A colder storage space (15-20°C) to store pupae or larvae
High pressure cleaner	A high-pressure cleaner can be very useful for cleaning rooms and equipment. 
Mechanical sieve	From a certain scale a mechanical sieve will be a must have, to reduce the workload and improve efficiency. 

4.3. Substrate

Black soldier flies go through several life stages, and their feeding requirements differ significantly between them. The adult flies do not need any feed—they only require access to clean water. In contrast, the larvae are voracious feeders and require a well-prepared substrate to grow efficiently. Since the larvae live and feed within the same material, this feed is referred to as the substrate.

BSF larvae can grow on a wide variety of organic materials, but there are a few important guidelines to follow:

- The substrate must be moist, ideally containing around 70% water. However, this can vary slightly depending on the feedstock. It's important to avoid standing water or puddles, which will lead to larvae escaping or drowning.
- The feed should be finely ground or soft, as larvae do not have teeth and cannot chew. Proper texture ensures they can access nutrients efficiently.
- Always check the origin of the substrate to ensure it is free from insecticides. Using substrates from an organic farm is preferable for safety and quality, though it may be more expensive than conventional alternatives.

Figure 2: *Feed at aprox. 70% moisture.*

5. The rearing process

When starting a black soldier fly (BSF) farm, one of the first decisions to make is whether you want to manage the entire life cycle—from egg to egg—or focus on a specific stage, such as larval fattening.

The full cycle is outlined below, but keep in mind that the development times mentioned are based on ideal conditions: a temperature of 27°C and humidity between 60–70% for the larvae. In practice, these values may vary depending on your local climate and the quality of your feedstock. That's why it's essential to observe your insects closely and adjust conditions based on their behavior and growth. Unfortunately, recognizing the difference between healthy and underperforming larvae is something that comes with hands-on experience. The

more time you spend rearing, the better you'll get at spotting what your population needs.

5.1. Egg to neonate

Fresh black soldier fly (BSF) eggs should be placed in a clean, empty container or bucket that is tightly sealed with fine mesh. This container should be kept in the fly room, where the temperature is around 30°C and humidity is high. The eggs typically hatch within 3–4 days.

Newly hatched larvae (called neonates) are extremely small—about 0.02 mg each, or roughly 48,000 larvae per gram—which is why a tight seal is essential to prevent escape. These neonates can survive for up to 24 hours without food, but after that, they must be transferred to a suitable substrate to avoid starvation.

For the first five days, you can prepare a starter substrate using the following 1 kg mixture:

- 200 g wheat bran
- 100 g cornflour
- 700 ml water

This mix provides the right balance of nutrients, structure and moisture for early larval development.

You can add 1 gram of fresh (<24h old) larvae per kilogram of substrate, with a maximum of 5 kg of substrate per 60 × 40 cm crate. To avoid co-rearing of fruit flies and houseflies, these boxes are best kept in a cage similar to the fly cage ensuring that no oviposition of these pests can occur.

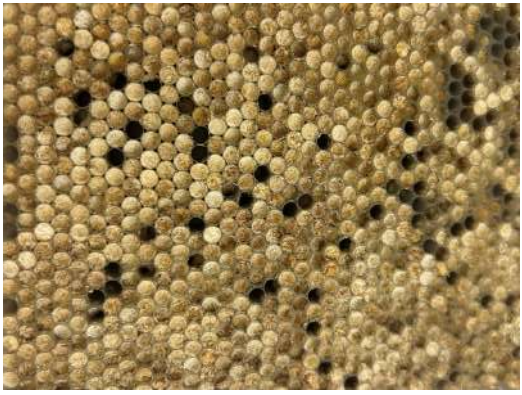

Figure 3: *BSF egg packages*

5.2. Larvae fattening

After the first five days, BSF larvae should be redistributed into multiple crates as they begin to run out of feed and space. Before doing this, it's important to estimate the number of surviving larvae (see redistribution box). A good estimate helps optimize feed efficiency and prevents overcrowding.

If the larvae are intended for reproduction, they should be given a high-quality diet such as chicken feed, which is rich in protein, carbohydrates, and easy to digest. Well-fed larvae grow into larger, healthier flies that produce more eggs. A typical mix for this purpose includes 3.3 kg of chicken feed and 6.7 liters of water, supporting 10,000 larvae per 10 kg of moist feed. It's important to ensure the chicken feed is free of larvicides, which are sometimes present in commercial products in certain regions.

For larvae raised for production, higher densities are acceptable—up to 20,000 larvae per crate (see box X). The higher density will result in smaller larvae, yet they will use the provided feed more efficiently. While chicken feed can be used, it's usually not cost-effective at scale. Instead, cheaper and locally available feedstocks should be explored. This feed has to be moist (in general ±70% water) with a minimum protein content of 10% (preferably 15%) and twice the amount in carbohydrates (1-2 ratio). Finally, it is important to note that a high content of liquid oil is detrimental for the larvae. In most cases, the substrate can be added in one batch to reduce labor. However, if the feed spoils quickly, feeding in smaller rounds may be more effective. These crates can be placed in the rearing room without any additional protection as healthy larvae will outcompete any fruit- or housefly infestation.

As larvae grow, their activity generates heat, and crate temperatures can reach up to 40°C. The heat produced by the larvae also helps evaporate excess moisture from the substrate. As a result, the substrate gradually changes from a wet, mashed potato-like texture to a drier, soil-like consistency. This drying effect makes the final frass easier to sieve and handle. However, if temperatures exceed 50°C, it's a sign that bacterial activity is outpacing larval feeding, which means the system is more comparable to composting rather than insect rearing. This can be avoided by using more larvae or feeding in smaller batches.

BOX 3: Counting BSF

Counting BSF is an important task as knowing how many larvae you have gives you information how your production is doing, information on how many are needed in each box and the survival. Yet, it needs to be done right. The following steps can be followed:

1)Combine all crates of the same batch (e.g. all five-day-old larvae) and weigh the total amount
2)Gently mix all larvae by pouring them from one crate in another five times
3)Take three samples while pouring, a tablespoon is enough in most cases.
4)Weigh the individual samples
5)Spread the sample on a table and count the larvae in each sample
6)Calculate the number of individuals per gram of substrate and multiply this with the total amount.
7)Take the average of the three samples.
8)Use this value to redistribute the larvae.

Figure 4 & 5: *BSF larvae at harvest stage*

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5.3. Larvae to pupae

BSF larvae go through a unique transformation stage not seen in many other insects. Before becoming pupae, they first turn into prepupae. These black, non-feeding prepupae look very different from the whitish larvae. Their only goal at this stage is to find a suitable place to pupate. At this point, the crates become more vulnerable to escapes, especially if the substrate is too wet.

When most of the larvae have reached the prepupal stage, the contents of the reproduction crates should be sieved using a 2 or 3 mm mesh, depending on the size of the larvae. It's important to sieve quickly and avoid letting the larvae sit still on the mesh, as they will try to burrow and may get stuck.
Once separated, the prepupae can be placed in an empty crate. After about 4 to 5 days, they will transform into immobile pupae. These crates should be placed inside a cage to prevent early-emerging flies from escaping into the facility.

The pupal stage lasts around 7 to 9 days. However, this process can be slowed down by storing the pupae at cooler temperatures—about 18°C for one week or 15°C for up to two weeks. Do not store them in a regular refrigerator (4–6°C), as this is too cold and will kill them.



Figures 6, 7 & 8: *Single mobile prepupae, batch of prepupae & immobile pupae*

5.4. Pupae to fly

The collected pupae can be placed in the fly cage at a density of maximum 20 pupae/dm³ of fly space. For example, this corresponds to 6500 pupae in a pup-up cage of 60*60*90cm (see box: fly cage). If the previous stages went well, the flies should emerge fairly simultaneous (48-72h). It is recommended to keep the cages in the dark or with a dim light for those first 2 or 3 days and only provide sunlight or 'mating' light after most flies have emerged.

Figure 9: *Adult black soldierfly*

5.5. Fly to egg

Flies will mate two days after eclosion and when enough light is available (sun or artificial). If the flies were kept in the dark for 2 or 3 days, this means that they will start mating within the hour after the light is turned on. After another two days the females will lay all her eggs in a single clutch. It is important to lure the female to a specific location for egg laying to ensure an efficient collection. Females are attracted to a smell of decaying matter. To make this lure, a simple mixture of frass, dead flies and hot or boiling water can be used. Besides the smell, they want to lay eggs in small crevices (2mm). For that you can use cardboard (not reusable), a stack of wooden sticks or a honeycomb plastic sheet.

BOX 2: Fly cage

The cage should be made of mesh ensuring enough ventilation. Typically, a good start is to use 6*60*90 cm pop-up cages for insect rearing, but larger cages work as well. Inside the cage we have three objects: the first is the pupae crate where the clean pupae are placed to emerge. The second is a water source that will ensure proper hydration of the flies. Finally, the oviposition site composed of a lure and a place to deposit eggs.

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Figures 10 & 11: *flycage and inside flycage*

Figure 12: *watersource with rocks to avoid drowning*

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6. Achieving the products

6.1. Larvae

BSF larvae are harvested around 12-14 days after the eggs have hatched. As always this may vary depending on the local conditions. Preferably, all the substrate is consumed and it should be dry enough to sieve. If this is the case, the larvae are easily harvested using a 2 mm sieve, either by hand or mechanically. If the substrate is too wet, changes have to be made to the diet (e.g. lower the initial moisture content) or larvae density (higher will result in more drying) as harvesting the larvae will be impossible or very time consuming. Depending on the feed it is advised to wear a specific mask to block ammonia as sieving the larvae may release large amounts.

After sieving you have two fractions, the larvae and what is called frass (6.2 (a combination of insect manure, leftover substrate and insect parts). The BSF larvae should be fairly clean at this stage but washing them may be needed depending on the market.

6.2. Frass

The frass fraction is everything that fell through the sieve and is the second product produced on a BSF farm. It may surpass the quantity of larvae in both weight and volume as they may produce 1.5 to 2 kg of frass for each kg. This fraction should be dry enough for sieving but is not a stable product and will compost if piled high. If the frass is used within the EU, the frass does need to be heat treated (70°C core temperature for 1 hour by an accredited processor). This may reduce the moisture content of the frass to make it more stable.

Figure 13: *dry frass after rearing*

BOX 3: Product composition

BSF

The composition of the BSF is very dependent on the substrate they fed on during the production phase. But in general, and dried, half their body weight consists of protein and one third is fat. It is mainly the protein part that is very appealing as animal feed. It is worth noting that the animal feed part can be very diverse from live feeding to reptiles and birds to processed into cat or dog food up to chicken and fish feed.

Main analysis	Unit	Avg	Min	Max
Dry matter (DM)	% as fed	32	21	41
Crude protein	% DM	43	31	60
Ether extract	% DM	34	22	58
Ash	% DM	11	4	23

Frass

Similar to the larvae, the frass depends on the substrate and rearing conditions. When the larvae are reared well, the moisture content should be below 10% which makes it a very stable product and suitable for pelletizing. The fertilizer value is in general limited (NPK: 3-1.3-2) less then half of what is in houseplant fertilizer or a quarter of what is used in professional agriculture and variable depending on the rearing conditions. However, in contrast to those fertilizers, there is growing evidence that frass boosts the plant health and resistance to pest species.

7. Problems and challenges

7.1. Allergies and poisoning

In contrast to many other species for food and feed, becoming allergic to BSF is unlikely. This is probably correlated with the fact that much less dust is produced as they live in a moist feed. However, also in contrast, they do produce ammonia during the fattening stage and the concentration can quickly increase to uncomfortable or even dangerous levels (if the ventilation is poor). Fortunately, there are specific masks on the market to filter out the ammonia and this can be necessary for harvesting the larvae.

7.2. Diseases

Only few instances of diseased BSF larvae are known and this indicates two things. Firstly, BSF larvae are hardy animals and this probably stems from the fact that they naturally live in decaying material. Secondly, they are not totally immune to diseases. If a disease is suspected, currently not a lot can be done and the crate(s) should be removed and disinfected as soon as possible.

7.3. Infestations

At a BSF farm we create the optimal conditions to rear these little insects, however they are also perfect conditions for other animals we do not want to rear. These can either be directly harmful to the insect, reduce the amount of available feed or just be very annoying. Some of the more prevalent infestations are described below. To avoid infestations, it is important to ensure that any incoming product is clean, or at least as clean as possible. Secondly, it is important to avoid 'natural influx', for example via windows or open doors without a mesh screen in front.

Fruit and house fly

Other flies are the main issue in a BSF farm, and most commonly those are house flies or fruit flies. They are most likely to infest the young BSF larvae, that is also the reason why they should be kept in a cage or more secure area. The larger larvae, if healthy, will outcompete any other fly.

Figure 14: *the housefly is a common infestation in BSF farms*

Rodents

Mice and rats can be an issue as they may eat the substrate or worse eat the larvae itself as a protein rich snack. Once inside the farm they can rapidly reproduce. Depending on the scale use traps or contact an expert to eradicate them properly.

Figure 15: *Mice can eat the substrate (in storage) or larvae.*

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