

Rearing Mealworms

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1. Introduction

This booklet is a manual to set-up and run a small-scale mealworm 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 have to comply with your local legislation regarding farming, processing and selling insects for food and feed. This manual was created as part of the Social Bugs project (Erasmus+ KA220-VET program)

2. What is a Mealworm?

Mealworms (*Tenebrio molitor*) undergo complete metamorphosis, which includes four distinct life stages: egg, larva, pupa, and adult beetle. The life cycle of *Tenebrio molitor* begins when the adult female beetle lays eggs. Each female can lay 12-14 eggs/day for several weeks after which the number of eggs starts to decrease. These eggs hatch into larvae (mealworms) after approximately a week, depending on environmental conditions. The larval stage is the longest and most active feeding phase. During this time, the mealworm undergoes 9 to 20 molts, gradually increasing in size with each instar. Fully grown larvae can reach a weight of 120–180 mg and a length of up to 2.5–3.0 cm. Once the larva reaches its final instar, it enters the pupal stage, during which it does not feed or move, after which the adult beetle emerges. Adult beetles are typically 1.5–2.5 cm long and weigh around 100–150 mg. They are initially white but darken to a reddish-brown or black color within a few days.

An illustration of the life cycle of *T. molitor* is shown in Figure 1.

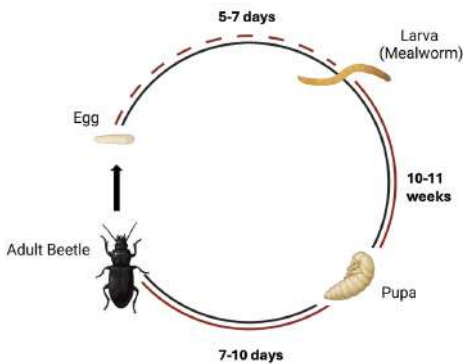


Figure 1: Life cycle of *T. molitor*. Dashed red line illustrates number of days (5-7) for the egg to hatch. Red line illustrates number of days from newly hatched mealworms to adulthood. Figure made in Biorender.com.

3. Why rear Mealworms?

Mealworms (*Tenebrio molitor*) are a popular choice for insect farming due to their ease of rearing and the relatively low initial investment required to start production. They produce minimal odor and are completely silent, making them particularly well-suited for urban farming environments. Compared to crickets, mealworms require less space and exhibit higher survivability rates. Unlike black soldier flies (BSF), mealworms do not require specialized fly cages for reproduction, simplifying the farming setup. Importantly, mealworms—like crickets but unlike BSF—are approved in the EU for both human consumption and use in feed including petfeed, offering broad market opportunities across food and feed sectors.

4. What do you need?

4.1 Infrastructure

4.1.1 Rearing room

Mealworms are cold blooded animals and therefore the climate conditions within the rearing room will have a huge impact on the growth of the animals. It is recommended to rear at 27 °C. Nevertheless, they are sturdy animals and can survive a broad range of climate conditions. They especially tolerate colder temperatures, as low as 12 °C (e.g. at night). This will not cause any mortality but will reduce the growth rate of the larvae. Care should be taken to avoid temperatures above 33 °C as this will cause the animals to die rapidly. It is recommended to keep the relative humidity of the air at 60 – 70 %. A very low humidity may cause the eggs to desiccate and too high will promote the growth of moulds and mites (see section 6). Light is not needed for the animals as they prefer the dark. A ventilation system should be present to introduce fresh air. This is needed as the larvae will produce large volumes of carbon dioxide which is harmful to human health in high concentrations.

In a small-scale farm these environmental conditions can be met in a well insulated room (more is better), preferably including an insulated ceiling and floor. This can be a second-hand container or climate rooms from other industries such as bakeries commonly made from insulated sandwich panels. The room can be fitted with a dual-purpose air-conditioning unit (heating and cooling) combined with a (de)humidifier. Air exchange can be done via a simple ventilator (e.g. those used in bathrooms). An additional fan in the room is recommended to evenly distribute the air inside the room, especially in higher rooms as hot air rises creating a temperature gradient in the production. Light, either artificial or via windows, is not needed for the animals, but is useful for the people working in

the farm. Finally, the room should be easy to clean with a minimal number of gaps and crevices.


One of the benefits of the mealworm is that all life stages of this insect can be kept in the same room without affecting each other. On a larger scale it is recommended to rear in multiple rooms to minimize the spreading of diseases and have the option to empty and clean rooms.



4.1.2. 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:

<p>Rearing crates</p>	<p>These are the corner stone of the farm as they are the home for all the animals. It is recommended to use plastic 60 x 40 cm crates. This is a durable material and compatible with EU standard shipping sizes (Euronorm).</p> 
<p>Sieves</p>	<p>2 mm square mesh for harvesting larvae 0.5 mm square mesh for sieving frass and separate beetles</p>

	<p>A bar-sieve with a width of 3.5 mm for harvesting pupae</p> 
<p>Masks</p>	<p>An FFP3 mask, preferably full face.</p> 
<p>Barrels or similar</p>	<p>To store (wet) feed</p>

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.

<p>Scales</p>	<p>One or more scales are useful to weigh feed (e.g. kitchen scale) and larvae (e.g. jewellery scale)</p> 
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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.


Egg laying sieve

This will vastly improve your reproduction efficiency as it prevents cannibalism (see later)


Dead beetle separator

Needed when the reproduction is scaling up and can be build using basic tools and materials.



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. Many different configurations exist and it is recommended to try them before buying.



4.3 Substrate

Because mealworms do not only eat their feed, but also live inside it, it is called the substrate. It consists of two parts, a dry feed and a wet feed. It is important to know the origin of the substrate to ensure they are free of insecticides. Procuring organic substrate is preferable, but may be more expensive than the non-organic alternative.

4.3.1 Dry Feed

The most standard practice is to feed mealworms (both larvae and beetles) wheat bran although they may survive a range of dry agricultural/grain industry by-products. It is important to note that smaller particles, generally, result in a faster growth of the larvae. Furthermore, smaller particles make it easier to have a clean harvest through sieving (see 6.1).



Figure 2: *Wheat bran, a good source of dry feed for mealworms*

4.3.2 Wet Feed

The main purpose of the wet feed is to provide the animals with water, and they are not very picky about the origin. Good results have been obtained with carrots, tomatoes, cucumber leaves, chicory etc. Chopping up the carrots (or other goods) and a good and even distribution throughout the crate is needed for efficient growth. Specifically, this means that, especially for young larvae, the wet feed should not be more than 10 cm apart from each other.

To reduce the workload, it is possible to spray water directly into the crates. However, this will result in slower growth and should be done with great care as it can easily result in an explosive growth of moulds and mites.

BOX 1

Most wet feed can be fermented easily by shredding or chopping up the feed and placing it in an airtight container or barrel for at least one week. An airlock has to be added to ensure any gasses produced in the first days can be vented but no oxygen can reach the fermented product. If done well, the fermented product should remain good for several months. Hence, a large batch can be made at once reducing the daily labor. However, it is very important to keep in mind that once opened the content will spoil in a few days.

The equipment can be made or purchased from specialty stores such as for beer brewing.

5. The rearing process

When starting a mealworm farm, it is important to determine if you want to rear the whole cycle (from egg to egg) or want focus on a specific part of the cycle (e.g. fattening the larvae; section 5.1).

The whole cycle is described below, but keep in mind that the development times are based on a temperature of 27°C and a humidity between 60 and 70% and mealworms fed with wheat bran. Due to local changes in climate and feed (quality) these may be different in your farm. Therefore, it is always important to respond to the needs of the insects and visually check their growth and health. Dead mealworm larvae, if not consumed by others, turn black and are easily observed. It is however not normal to see more than a handful in a crate in good condition. Unfortunately, recognizing healthy vs suboptimal/sick mealworms is based on experience that is acquired through actual rearing cycles as they grow slower and are less active.

5.1 Egg to larvae

Fresh mealworm eggs will hatch in 7-8 days. The young larvae are very small (0.45 mg) and can be left undisturbed in the leftover parental diet (see 5.4) for 2 weeks. Thereafter, the larvae should receive wet feed at least three times a week, boosting their growth. It is important not to give too much to avoid rotting or moulds growing on the wet feed. As a guide you can use 3 x 60 g of wet feed per week if the reproduction set-up is as described below, but visually check if this is ok for your system. At week 4, when the reproduction went well, it will get crowded in the crates and it is time to redistribute the larvae. The redistribution should be done as accurately as possible as this will influence the stability and efficiency of the rest of the rearing process (see below).



Figure 3: One week old larvae, miniature version of the older larvae

For **production** purposes, the larvae can be placed with 20.000 in a crate. They should be fed in total 4.2 kg of wheat bran minus the weight you add at the start. As wheat bran is dry and does not spoil, it can all be given in a single serving. Yet, because wheat bran can be very voluminous (up to 5 litre/kg) this may not be possible depending on the height of the crate as the feed should remain 2 cm from the edge of the crate (to prevent escapees). The larvae should be ready to harvest in 8 to 9 weeks (see section 5) when they weigh around 100 mg/larvae.

It is advised that larvae destined for reproduction are placed in crates at a lower density of only 5000 larvae/crate and with 2 kg substrate per crate. In contrast to the production larvae, these larvae should always have some substrate left. This will ensure that the larvae grow bigger and result in healthy pupae and beetles.

For both production and reproduction, the larvae should receive a wet feed source

at least three times a week to ensure good growth. Especially near the end it is important to visually check if the wet feed is provided in the optimal quantity. This means that the wet feed should be just fully consumed before the next feeding round. Because the moisture content and spoilage rate of wet feed can vary greatly—and because water can evaporate at different speeds—it is difficult to set precise feeding guidelines. Instead, feed amounts should be assessed visually. As a general starting point, offer approximately one handful (50–60 g) during the first week, and gradually increase this by about one handful each week, reaching roughly 300 g by the end of the rearing period.



Figure 4: *Single mealworm, close-up and group*

BOX 2: Counting and dosing mealworms

Counting mealworms 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 correctly. The following steps can be followed:

- 1) Combine all crates of the same batch (e.g. all four-week-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 for production (20k) and reproduction (5k).

5.2 Larvae to pupae

Mealworm larvae will start to pupate when they are about 10 weeks old. However, the larvae are cannibalistic and may feed on the immobile pupae. To avoid pupae failure due to cannibalism it is important to separate mealworms and pupae when the mealworms start to pupate. Fortunately, the mealworms are slightly more narrow and more mobile than the pupae. We can use this feature to sieve off the pupae with a bar sieve or fish grader (mesh size 3.5 mm, although the mesh size may depend on the population). The slightly larger pupae will remain on the sieve, while the mealworms and substrate fall through the sieve.



Figure 5: *Fragile and immobile pupae*

Mealworms do not pupate all at once, so this procedure will need to be repeated once a week for 3 to 4 weeks. Continue to provide dry and wet feed in limited portions. Fully grown larvae need some feed but much less than in the growing phase. It can take up to 4 weeks for most mealworms to pupate.



IMPORTANT: Mealworm pupae are very fragile and should be handled very carefully. Damaging the pupae, even slightly, will often result in the death of the animal.

5.3 Pupae to beetle

The collected pupae can be placed in the same type of crate and conditions as the larvae but no more than a single layer of pupae (approx. 400 gr) with a small amount of dry substrate. The latter serves as both a cushion and initial feed for the new beetles. Fresh pupae will eclose into beetles after about a week, but the first beetles may already occur much sooner given that not all collected pupae are fresh.

When the first beetles are observed, it is advised to also provide a limited amount of wet feed. Two weeks after the harvesting of the pupae it is time to collect the beetles. Any pupae that have not turned into a beetle after 14 days will not eclose anymore.



Figure 6: Hatching beetle, freshly hatched white beetle a 2-day old brown beetle and fully mature black beetle

5.4 Beetle to egg

Beetles are not ready to mate and produce eggs at day one and may take up to a week to start reproducing. They can continue to reproduce well for 11 weeks if maintained in good conditions and fed well with dry and wet feed. During that time, female beetles will lay up to 12 eggs/day but it will decrease when they get older.

A reproduction crate is constructed in the following way:

- First, a layer of feed is provided (about 1 cm) consisting of fine particles in a standard 60 x 40 cm crate.
- Secondly, an oviposition mesh is inserted and an equal amount of feed is placed on top.
- Finally, 250 grams of beetles are placed on the oviposition mesh (picture). Although the oviposition mesh is not strictly mandatory, it is highly recommended. This will prohibit the beetles of eating the already laid eggs. This is not trivial as they can easily eat up to 75% of the eggs.



Care should be taken that the beetles always have access to dry and wet feed. Especially, even a brief lack of wet feed will reduce the lifespan and egg laying capacity of the beetles dramatically.

After one week the mesh and beetles can be removed. The total number of eggs laid should be between 40.000 and 50.000 although higher numbers are possible (theoretically up to 80.000)! The crate, with the eggs and substrate, can now be left alone for 2 weeks as described in 5.1. The beetles of the different crates are all combined and the dead beetles are removed. To remove the dead beetles, we take advantage of the fact that healthy beetles will hold on to a mesh or paper while dead beetles do not. On a small scale, this can be done with paper towel and let them crawl on it. In a larger farm, a beetle separator becomes useful. This is a conveyor belt made of a mesh that is turning on an angle ensuring only living beetles reach the top.

The living and healthy beetles can now be replenished with the fresh beetles (5.3) at a rate of 25% (1 kg of beetles should consist of 750 g of old beetles and 250 g of new beetles). Of course, if the mortality was higher than 25%, more new beetles should be added. This ratio will ensure that the total population will remain

young and vigorous ensuring optimal egg production*. Dead adult beetles can be removed with the waste. In a small-scale farm, there are not enough dead beetles to have an economic value.

*During start-up this replacement is either impossible or unwanted as we want to scale-up as fast as possible. Therefore, each beetle, even older ones, has value and should be retained.

6. Achieving the products

6.1 Larvae

Mealworm larvae are the main product (not the beetles) and are harvested around 9 weeks after the eggs have hatched depending on the local conditions. Preferably, all the substrate and wet feed is consumed ensuring minimal loss of feed. The mealworms are easily harvested using a 2 mm sieve, either by hand or mechanically. It is very important to wear a proper FFP3 mask at this stage, as sieving produces a lot of dust and inhaling this should be avoided (see below). In some cases, mealworms are left in an empty crate for 24h to empty their digestive tract.

After sieving, you have two fractions: the mealworms and what is called frass (6.2). The mealworm fraction should be clean at this stage, but it is possible that some of the exoskeleton skins are still present with the mealworms after sieving but they can be blown away ensuring a pure product. Because an individual mealworm should weigh around 100 mg, the total harvest per crate should be around 2kg. The larvae can be sold live or killed by placing them in the freezer at -20°C or submerging them in boiling water.

6.2 Frass

The frass fraction (a combination of insect manure, leftover substrate and insect parts) is everything that fell through the sieve and is the second product produced on a mealworm farm. Unless you sieved earlier in the process, it will surpass the quantity of mealworms in both weight and volume as they may produce 1.5 to 2 kg of frass for each kg of mealworms. This fraction should be dry (no more wet feed) and is therefore a stable product in ambient conditions. If the frass is used within the EU, it is mandatory that the frass is heat treated to a core temperature of 70°C for a minimum of 1 hour by an accredited processor. Depending on the local legislation this can be done in an oven, biogas facility and/or composting facility.

BOX 3: Product composition

Mealworm

The composition of the mealworm is very dependent on the substrate they fed on during the production phase. But in general, when dried, half their body weight consists of protein and one third is fat. It is mainly the protein part that is very appealing for both human food (e.g. protein bars) and animal feed. It is worth noting that using mealworms for animal feed offers very diverse options: from feeding live mealworms to reptiles and birds to processing them into cat- or dogfood to feeding them to livestock such as chicken and fish.

Main analysis	Unit	Avg	Min	Max
Dry matter (DM)	% as fed	42.2	37.1	57.6
Crude protein	% DM	52.8	47.2	60.3
Ether extract	% DM	36.1	31.1	43.1
Ash	% DM	3.1	1.9	4.5

Frass

Similar to the larvae, the frass depends on the substrate and rearing conditions. When the larvae are reared correctly, 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: 4.5-1.5-1.9) at about half of what is in houseplant fertilizer or a quarter of what is used in professional agriculture and varies 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

One of the main problems in a farm is the possibility that one becomes allergic to mealworms. This is mainly related to the production of fine dust during feeding and sieving. Therefore, it is very important to wear proper face masks (ffp3), especially when sieving. The latter is preferably done in a separate room with a separate ventilation (see photo). An allergic reaction can be identified by itching skin and eyes, headaches and in a later stage (severe) shortness of breath. Currently we cannot predict who or when a person will become allergic. However, it is known that people that already are allergic to house dust mite are more at risk.



Figure 7: Full face mask and suit as protection during sieving at harvest to protect against dust and allergens.

Tip: Try to avoid making dust by vacuuming instead of sweeping

7.2 Diseases

Mealworms can, just as every living organism, get sick (viral, bacterial, fungal, etc.). Currently little is known about the different diseases and even less about the treatment. Therefore, the best course of action is to remove and disinfect all affected crates and, when possible, disinfect the entire room using a locally legal disinfectant. The latter can, sometimes, be done by the combination of a pressure washer and a foam lance if the electricity is fully sealed (or absent). Diseases can be either recognized by a change in behaviour and feeding rate (although this requires a lot of experience) or by an increase in dead (black) mealworms at a later stage. Diseases are more prevalent at higher humidities. Therefore, reducing the humidity is always a good action when there is doubt. Fortunately, there are no known cases of diseases that transfer from mealworms to humans.

7.2 Infestations

At a mealworm 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 (e.g. wheat bran) 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. Be aware that, in some countries, defensive measures against certain pests are mandatory.

Meal moths

Meal moths are the most widespread infestation at a mealworm farm as their optimal conditions are identical to the mealworms but they grow faster. It is a group of several species, and unfortunately it is possible to have more than one species simultaneously in the facility. They are all small moths (20-25 mm) that lay eggs in substrate. The emerging larvae will, in general, not harm the mealworms but munch on the same substrate of the mealworms and thereby compete with the larvae. Furthermore, they will produce a silk layer on the surface of the crates which will make the harvesting of the mealworm larvae much more difficult.

Once they are in your facility, they are very difficult to get rid of. It is possible to use sticky traps (similar to those used for flies) in combination with vacuuming the adult moths on a daily basis. Furthermore, the reproduction crates should be sieved regularly to remove the silk layer (and the meal moth larvae within). Finally, releasing the parasitic wasp *Habrobracon hebetor* could help to control the numbers as they infect the larvae of several meal moth species.



Figure 8: (Indian)meal moth, a common pest species in mealworm rearing

Flour mites

These very small arachnids are pale white and only 0.4 mm long. They will feed on stored products but may also infest mealworms. They can explode in numbers when the ventilation is too low (or broken) in combination with a high humidity (> 70%). At high numbers they can spoil the feed. They also cause allergic reactions. Fortunately, they are easy to eradicate by increasing the ventilation and decreasing the ambient humidity.

Fungus

Fungal infections of the dry feed are possible, but in general they are a sign that the dry feed is improperly stored (humidity too high) or too much wet feed is provided during the rearing of the larvae. It is therefore easily controlled by reducing the amount of wet feed that is provided or use wet feed that is less prone to microbial degradation.

Rodents

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



Figure 9: Mice can infest the substrate (or feed storage) and eat your mealworms.

Bibliography

Wageningen Livestock Research, T. V., Claeys, J., Haenen, O.L.M., van Loon, J.J.A., & Spranghers, T. (Eds.). (01 Sep. 2025). The basics of edible insect rearing. Leiden, The Netherlands: Wageningen Academic.
<https://doi.org/10.3920/978-90-8686-902-2>

International Platform of Insects for Food and Feed. (2021). Guide on good hygiene practices for European Union producers of insects as food and feed.
<https://ipiff.org/good-hygiene-practices/>



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