

## FLUKER'S MEALWORM BIOLOGY Guide

### DIRECTION BOOKLET (copyrighted)

#### INTRODUCTION:

The yellow mealworm, *Tenebrio molitor*, probably originated in the mountainous regions of Iran and Northern India and migrated into Europe during biblical times. It was introduced into the United States around the time of the Revolutionary War. In the early 1800's the mealworm was already being raised as a food for pets, especially birds, and over the years millions of mealworms have escaped into the environment. It is a grain and stored product pest in the northern states, but it has not taken hold in the South. The mealworm does better in cooler climates.

Fluker Labs Mealworm Biology information provides an easy and interesting way for students to observe the life cycle of insects with complete metamorphosis. Specially designed breeding and rearing conditions at Fluker Farms combined with a specially formulated diet ensures the delivery of healthy and long-lived mealworms. Mealworms belong to the Order Coleoptera or beetles; the larvae of the adult beetle are called mealworms. Students will enjoy being able to find and identify all stages of development, observe the rate of growth of the larval stage, observe the mating of the adult beetles, and oviposition (egg laying). The external anatomy of larval, pupal and adult stages are completely illustrated and labeled, allowing students to quickly learn the different parts of the insect in the different stages of development.

In terms of the number of different species, the Coleoptera, or beetles, is the largest Order in the entire animal kingdom. The heavily armored exoskeleton, much like a knight in armor, is one reason for the success of these insects. Beetles belong to the group of insects in which the larval stage does not resemble the adult stage, and therefore they require a pupal stage in order to metamorphose from the larval stage into the adult stage. This is called indirect development or complete metamorphosis.

#### 1. MATERIALS FOR CONDUCTING THE MEALWORM EXPERIMENT:

1. One 13 inch long, 8 inch deep, and 10-inch high clear plastic terrarium with vented lid
2. One jar Fluker's Mealworm Bedding
3. One jar Fluker's Cricket Quencher
4. One cup Fluker's live mealworms
5. One container insect pins

## 2. SETTING UP THE TERRARIUM AND ESTABLISHING REARING CONDITIONS.

- A. Place Fluker Labs mealworm feed in bottom of rearing terrarium (approximately 2 inches deep).
- B. Dump live mealworms into terrarium on top of food.
- C. Place a few (5-6) pieces of quencher on top of the food. Make sure the quencher is not clumped together; space out around the terrarium.
- D. Cover terrarium and place in proper area (see heading 3).

## 3. ESTABLISHING PROPER REARING CONDITIONS.

- A. Temperature is the most critical environmental factor. The ideal temperature for mealworms is approximately 75-82 F. At this temperature, mealworm growth will be optimal. If more heat is needed to reach this temperature, a Fluker Labs Under Tank Heater can be used to raise the temperature. Mealworms have a long life cycle and can take up to 3 months to go through a complete cycle.
- B. Proper moisture is a major factor in the life cycle of the mealworm. Fluker's Cricket Quencher provides an excellent source of moisture. However, care must be taken to avoid using excessive amounts of moist material in the environment. Only add Fluker's Cricket Quencher or other forms of moisture when worms or beetles are actively feeding. When the worms are in the pupation stage, do not add quencher. Carrots, potatoes, or other vegetables can be used as an additional source of food and moisture.
- C. Light cycles are not important for the development of mealworms. In fact, mealworms do not like light. Never place the terrarium in direct sunlight and if possible, find a dark area to place the terrarium.

## 4. GROWTH AND DEVELOPMENT OF THE MEALWORM

Mealworms have indirect development, which means that the larvae do not resemble the adults. This type of development is termed complete metamorphosis. There are always four stages of development: egg, larva, pupa and adult. Only the adults have wings and can reproduce. In this species, all stages are active both during the day and at night.

- A. Egg. The eggs are oval in shape, and milky white in color with a slight shine. They are found

singly or in clumps mixed in the rearing medium. The eggs are small, about 1.8 x 0.7 mm. The incubation time at 80°F is about 7 days.

- B. Larval stage. The egg hatches into the first instar larva, which after feeding molts into the second instar larva. First and second instar larvae are very small and difficult to see without a magnifying glass. At each molt, the old skin (cuticle) is shed and a new and larger cuticle is formed. The first instar larva molts into the second instar. The larvae eat and grow in each larval instar to the limit their armored cuticle permits, then they must molt again in order to grow. Immediately after a molt the larva is soft and white, but within a few hours the cuticle becomes hard and assumes its normal yellow and black color. The number of larval instars varies from about 8-12, depending on temperature and available food. Higher temperature means fewer molts and faster development. The duration of the larval stage is from a few weeks (high temperature) to several months (room temperature). A full-grown last instar larva is about 30 mm long and about 4 mm in diameter.
- B. Pupal stage: The full grown, last larval instar molts into a pupa, which looks somewhat like the adult. Note the wing pads and the adult-like legs and antennae. The pupa is quite vulnerable, it cannot move about, and it does not feed. If rearing conditions are poor, the larvae or the adults will eat the immobile pupae. If cannibalism is noted, add more moist material (quencher, potatoes, etc.). During the pupal stage, the internal organs of the larvae are digested and the adult internal organs develop. The pupa is dark yellow grading into dark brown or black, and about 25 mm long by 7 mm in width. The duration of the pupal stage is about 6 days at 80°F.
- C. Adult stage: Mealworms in nature emerge as pupae and the adults emerge in the spring. Indoors at room temperatures the adults emerge from the pupae throughout the year. The adult males and females can only be distinguished by examination of the genitalia (see below under External Anatomy). The adult males live an average of about two months, the females about 3 months. Mating of the beetles starts within a few days after emergence and is repeated at intervals throughout the life of the beetles, probably 2 or 3 times in their lifetime. Semen is transferred directly through copulation. The females generally start laying eggs 8-10 days after pupal emergence at 80°F and females will lay their eggs singly or in small batches at intervals of 2 to 8 days. As mealworms consume feed, fresh feed can be added to the terrarium.

## 5. BEHAVIOR OF LIVING MEALWORMS

- A. Remove a larva from the terrarium and place it on a hard flat surface and note how poorly it moves about. It has very short legs and a worm like body, and is therefore adapted to

burrow through a medium such as grains or meal and not for crawling on flat surfaces. Drop the larva back into the bedding and watch how quickly it burrows into the bedding and disappears. The main goal of the larval stage is to feed and grow as rapidly as possible. Larvae are basically eating machines. It is typical of burrowing animals that many sensory organs are poorly developed, and in the case of the mealworm, the larva has very small eyes and reduced antennae (feelers).

- B. Remove a pupa from the terrarium. A pupa will normally lie motionless in the medium (food) and cannot move about or walk. However, the pupa will strongly wriggle if you pick it up with your fingers. Try it! This thrashing about is the only defense the helpless pupa has against predators. If food is in short supply or in poor condition, both the larvae and adults will kill and eat pupae. The main goal of the pupa is to make the transformation (metamorphose) from a larva to an adult.
- C. Notice that the adult beetles are mostly walking about on the surface of the food and seldom burrow. Remove an adult from the terrarium; hold it with your fingers so that it cannot run away. Note that the mouthparts of the adult are small. The adults have large well-developed legs with claws on the ends. Release the beetle and allow it to walk about on your hand and climb up your fingers. The senses are well developed, as seen in the large black compound eyes on the sides of the head and the large antennae. The main goal of the adult is to disperse (find new habitats) and to reproduce. Characteristic of all insects, the adult mealworm (beetle) does not grow any larger and therefore does not molt. If you observe a culture of mealworms long enough, you will eventually observe a pair copulating. Describe the mating process. With any luck you may observe the females depositing eggs with their short tubular ovipositor.

## 6. EXTERNAL ANATOMY

To study the external anatomy, remove a larva, pupa and adult from the terrarium and place them in about 10 ml of 50% isopropyl alcohol (rubbing alcohol). The head bears the paired mouthparts and antennae. The thorax always consists of three segments: the prothorax, the mesothorax and the meta-thorax. Each thoracic segment in all stages bears a pair of walking legs. The abdomen consists of 9 segments in the larva and pupa, only 6 (some fusion occurs) in the adult stage. Only adults have wings. In beetles the first pair of wings is modified into hard covers to protect the more delicate second pair of wings.

- A. Larva: The most striking thing about the larva is their worm-like appearance. The reduced legs and sensory organs (eyes and antennae) are typical of burrowing animals. The digestive tract and fat deposits take up almost all of the space inside the body. Basically larvae eat, get fat, and grow through a series of molts. You will need a magnifying glass to clearly see the relatively small mouthparts, which are adapted to feed on finely ground material. Note the paired spiracles on the ventral-lateral surface of the mesothorax and on

the first 8 abdominal segments. Lay the larva on its back (dorsal-surface). The spiracles are actually located on the ventral edge of the lateral plates, but because the lateral plate curves under the body, the spiracles are best seen in a ventral view. The spiracles are the openings into their respiratory system. The spiracles can be opened and closed to control the flow of air into and out of the respiratory system. On which segment is the anus located?

B. Pupa: The most striking thing about the pupa is its resemblance to an alien, as seen in a horror-movie. Though wing buds and legs are present, they are nonfunctional. Therefore the pupa cannot walk or fly. There is no functional mouth or anus, because they do not feed. Internally the larval tissue is being digested in the young pupa (very mushy) and in the older pupa adult organs grow and develop.

C. Adult: The most striking thing about adults is their similarity to a knight in armor. The entire body is covered with hard plates, with distinct joints between each plate. When viewed from the top (dorsal) the abdomen is not visible, because it is covered with the hard wing covers. The wing covers are the modified first pair of wings (mesothoracic wings). The second pair of wings (metathoracic wings) are non-functional. They are membranous and transparent and are neatly folded under the wing covers. Lift one of the wing covers and pull the second wing out, unfold it and spread it out. Note the large surface area of the wing.

The sensory organs, comprised of the eyes and antennae, are large. The black compound eyes extend from the dorsal surface of the head around the sides and onto the bottom surface. With a magnifying glass you can see the hundreds of individual facets of the compound eye. The mouthparts are small for an insect of this size. The legs are large and powerful, and the beetles can rapidly run and climb. Each leg has a pair of curved claws at the end, allowing the beetle to rapidly climb rough surfaces. They cannot climb a smooth surface.

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