

# THAT CUP IS FULL OF MAGGOTS: FEEDER INSECTS AT OMAHA'S HENRY DOORLY ZOO & AQUARIUM

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## INTRODUCTION

Crickets, mealworms, fruit flies and waxworms are standard zoo feeder insects. At Omaha's Henry Doorly Zoo & Aquarium, we have been working on providing more options to our carnivorous insects while helping to reduce the amount the zoo spends on feeder insects. We currently have flighted & wingless fruit flies (*Drosophila melanogaster*), crickets (*Acheta domestica*), house flies (*Musca domestica*), black soldier flies (*Hermetia illucens*), and waxmoths (*Galleria mellonella*) in culture. This paper will explain our husbandry of these feeder insects.

## METHODS

Currently, we have two different feeder rooms set up to accommodate different temperature requirements. The first is our cricket room which holds various sizes of crickets and the fruit fly cultures. It is kept at 24.4°C. The second is the fly room which holds house flies, black soldier flies, and wax moth cultures. It is kept at 28°C. Containers and enclosures used for the feeder insects are surplus items in our building. Use whatever is readily available to you. Similarly, the amounts of food or media used are relative to container size.

**House Flies *Musca domestica*;** House flies are primarily used as feeders for juvenile mantids, but are also shared with the reptile department for feeding frogs. They are readily available outdoors in the summer months, but an indoor culture provides a year-round, reliable source of flies.

**Housing:** Adults are kept in a 35.6 x 35.6 x 61 cm pop-up style rearing cage (Fig. 1). Larvae are kept in Magenta containers.

**Food:** Adults are offered 50% powdered milk and 50% granulated sugar in a dry mix. Larvae are fed a mix of 12.5% powdered milk, 12.5% sugar, 25% ground dog chow and 50% Carolina Biological Supply Instant House Fly Medium.

**Water:** A clear plastic cup with paper towel to prevent drowning for adults. Larvae obtain all of their water from the culture media so it should be kept moist.

Daily Routine Care: Check food and water levels. Check moisture and food in egg/larvae/pupation cups. Substrate should be moist, but too much water will drown larvae. Check for holes in adult cage. Check for newly emerged adults in pupation cups. Use excess fly population to feed mantids.

Twice weekly: Make a new egg/larvae cup by adding 1 scoop larvae substrate/food and 2 scoops water. Place a marble-sized meatball on top. Cover mixture with some wood chips to prevent larvae from drowning. Do not use cedar, redwood, or pine chips because they are toxic to larvae. Put egg/larvae cup into adult cage for a few days. Remove egg/larvae cup from adult cage and cover with a ventilated lid; this is now a pupation cup and adult flies will eclose within 2 weeks.

Catching: Cup method (for catching less than 10 flies): Open zipper only far enough to get a deli cup and your arm into the cage. Use the cup to trap flies against the side of the cage and slide the lid on.

Freezer method (for catching larger numbers): Remove all dishes from the cage. Place the entire cage into a chest freezer for no longer than 60 seconds. Remove from the freezer and shake the flies into a deli cup. Remember to reserve enough adults for continued breeding and replace all dishes.

Lifespan: 15- 30 days

Temperature: 26.7° - 31.7°C

**Black Soldier Flies *Hermetia illucens***; Soldier flies are a low maintenance, detritivore. The pupae are self-harvesting and the larvae will gladly eat your food waste. The adults are much larger than house flies. We feed them to mantids, tarantulas, assassins, birds, frogs, and many others. It is a native insect, so there is no concern if we release them outdoors.

Housing: Adults are kept in a 35.6 x 35.6 x 61 cm pop-up style rearing cage with an artificial plant suspended from the ceiling (Fig.3). Larvae are kept in an 18.9 L bucket with a vented lid and a tube that connects to a collection cup (Fig.4). There are many helpful tutorials online on how to construct a black soldier fly larvae bucket.

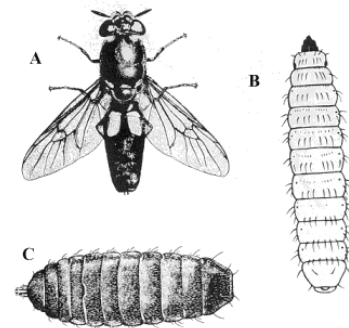
Food: Adults do not require food at this life stage. Larvae are offered food scraps and leftovers including: dog chow, orange & banana peels, rotten fruit & vegetables, and bird food.

Water: Provide a clear plastic cup with paper towel to prevent drowning for adults. Larvae get their moisture from food.

Daily Routine Care: Check food and water levels. Check for holes in cages. Use excess fly population to feed mantids or other carnivores.



Figure 1. Interior of house fly adult enclosure with water, food, and egg/larvae container



Black soldier fly. A, Adult female. B, Larva. C, Pupa.

Figure 2.

[http://ipm.ncsu.edu/AG369/notes/black\\_soldier\\_fly.html](http://ipm.ncsu.edu/AG369/notes/black_soldier_fly.html)

Adult flies practice lekking behaviors and need a plant to congregate on. Adult flies will lay clusters of eggs in the edges of corrugated cardboard near larval food sources, but not on the food. A rolled strip of cardboard placed above or near larval food with encourage egg-laying (Fig. 5).



Figure 3. Adult black soldier fly enclosure with lekking site, water, egg-laying cup, and pupation bin.



Figure 4. Black soldier fly larvae bucket with space at bottom for drainage and collection tube for pupating larvae to exit bucket. On the second photo, the collection is half full of puparium.

Weekly: Add a new egg/larvae cup under the egg laying site with dog chow, fruit waste, water, and wood shavings. Do not use cedar, redwood, or pine chips because they are toxic to larvae. Move contents of older larvae cup to the bigger larvae container. Drain accumulated fluid from the larvae bucket.

Catching: Cup method (for catching less than 10 flies): Open zipper only far enough to get a deli cup and your arm in the cage. Use the cup to trap flies against the side of the cage. Slide the lid on.

Freezer method (for catching larger numbers):  
Remove all dishes from the cage. Place the entire cage into a chest freezer for no longer than 60 seconds. Remove from the freezer and shake the flies into a deli cup. Remember to save enough adults for continued breeding and replace all dishes.

Lifespan: Eggs hatch in 4 days. The larval stage can be from 14 days to several weeks at room temperature. Adults are active for 5 – 8 days

Temperature: The optimal temperature for larvae is 35°C. The larval bin can be kept in a cooler room, but will become quite hot due to decomposition within the bin. The range for pupation is 25 - 30°C and preferred mating temperature is 27.8°C.

Humidity: 70% for larval development and 30 – 90% for mating



Figure 5. Clusters of eggs visible in the corrugations of the cardboard.

**Fruit Flies *Drosophila melanogaster***; Wild type, flighted fruit flies are used to feed mantid nymphs and other small predators that are stimulated by flying prey. The apterous (wingless) mutation is used to feed our tiger beetle larvae, spiderlings, scorplings, and other tiny arachnids. Housing: sturdy plastic container such as a deli cup with wood wool for perching and lid with foam stopper

Food & Culture Media: Carolina Biological Supply Formula 4-24® Instant Medium, Blue & yeast

Water: none

Daily Routine Care: Use excess fly population as feeders.

Females will lay around 200 eggs in the medium mixture. Maggots emerge from the eggs after 2 days and feed on the yeast. After 7-20 days the maggots climb up the sides of the housing container to dryer areas to pupate and transform into adult flies. Adult flies are ready to mate within 2 days and have a life expectancy of around 2 weeks.

Culturing: Use plastic deli containers as culture vessels for *Drosophila*. Add one scoop of dry Formula 4-24 to the container (scoop size will vary based on container size). Add one scoop of room temperature water to the container and swirl to mix. Use slightly less water than Formula 4-24 as it tends to get too wet otherwise. Add a sprinkle (0.3 ml) of yeast on top of mix. Add one baseball-sized ball of LOOSELY packed wood wool/excelsior. Add about 20 adult fruit flies from an existing culture. Close lid and wait 2-3 weeks before removing any flies.

**Catching:** Never remove all of the adult flies; a few should be left in the culture for breeders.

**Tapping (for wingless):** Tap the container lightly on a countertop. This will cause the flies to fall to the bottom of the container so they won't escape when you take the lid off. As long as you continue to tap the container every few seconds, the flies won't be able to escape. Simply remove the lid, tilt the container over a holding container and tap until the desired number of fruit flies fall out.

**Freezer method (for flighted):** Place the entire cup into the freezer for no longer than 60 seconds. Remove from the freezer and dump the flies into a new culture.

**Lifespan:** Adult: ~ 14 days, Culture: 6 weeks

**Temperature:** 18.3°-26.7°C. Minimum/Maximum Temps – 15°/29.4°C. Do not put the culture in direct sun. Optimum reproductive rate occurs at temps of around 26.7°C. The development of the flies is slower when the cultures are maintained at lower temperatures, while higher temperatures may promote male sterility, growth of bacteria and fungi, and mite infestation.

**Culture Care:** Do not remove any flies from the culture for the first 2 weeks. The culture is usable at about 3 weeks. It's important to maintain a reproductive population of flies. Keep at least 20 flies in the culture at all times and you'll ensure continuous reproduction. At the same time, don't allow too many flies to develop. Feed the fruit flies to your animals regularly.

Don't let any wild flies get into the wingless culture or they will breed with the wingless flies and you will end up with flighted flies.

The medium should look shiny and should not move when the container is tilted to the side.

**TOO DRY:** If the medium appears dry and cracks appear on the sides, add a small amount of water to the culture by spraying two or three times with a mister. Continue to add a few mists each day until the medium regains its proper moisture. Do not add more than a few mists each day, because the results aren't immediately apparent and because adding too much water at one time may drown the flies or give you a soupy medium.

**TOO WET:** If the culture is too soupy, add 5 ml of DRY culture media to absorb the water

**Cleaning:** Cultures should not be kept any longer than 6 weeks. After 6 weeks or when the culture media turns green, remove most of the adult flies and place the entire culture into the freezer. Once frozen, run the outside of the container under hot water and then pop the frozen contents out of the container into the trash. Use a knife to loosen material attached to the sides and lid of the cup. Soak the container, lid, and stopper sponge in a soapy bleach solution for 20 minutes to disinfect. Scrub with a sponge and rinse with clean water. Allow to air dry.

**Additional info:** Flighted fruit flies for new cultures should be transferred from mature cultures using the freezer method. Phorid flies are sometimes present in the flighted fruit fly cultures and can invade the wingless cultures too. They are larger than *Drosophila* and have bigger pupae. They fly in a zig-zag pattern.

**House Cricket *Acheta domesticus*;** Pinhead crickets are required for rearing tiger beetle larvae so we make our own. We consider them pinheads until they reach 10 days old. Then they are graduated to a larger size.

**Housing:** Pinhead crickets are kept in a plastic shoebox.

**Food:** Pinhead crickets are provided with Zeigler Cricket Diet

**Water:** A shallow dish with wet, folded paper towel or cricket quencher

**Breeding:** Add a shallow cup of coconut fiber to the adult cricket tub for egg-laying. Every other day, pour the coco-fiber with eggs into a Magenta container. Lightly mist the egg container and place the dated Magenta container in an incubator (if available). The time for the eggs to hatch at 30°C is about 10 days and about 26 days at room temperature (23.3°C). Once hatching begins, pour the contents of the Magenta container into a plastic shoebox. Provide food, water, and perching for new pinheads. Keep the shoebox in the incubator because there are more eggs to hatch.

**Greater Waxmoths (*Galleria mellonella*);** While most zoo crews keep their wax worms in the refrigerator, we allow ours to pupate. The fluttering wax moths are a favorite food for mantids. The wax worms produced by breeding our own are much more active than commercially produced wax worms. They produce silk and are skilled at climbing.

**Housing:** sturdy plastic container with ventilated lid (Note: they have been chewing through the plastic of the deli cup lids and we now use a heavier plastic mason jar style container with metal mesh ventilation in the lid)

**Food:** Adults do not require food. Larvae are fed bran mixed with honey and sheet of wax (Fig. 6).

**Water:** None required.

**Daily Routine Care:** Use excess population as feeders.

**Weekly:** Make a new breeding cup by adding ~236 ml bran and ~100 ml honey to a container.

Mix thoroughly until you have a sticky consistency, but not runny or dry. Add a piece of waxed bee foundation (or crumpled wax paper). The larvae will eventually strip it clean.

Add about 20 wax moths and put on a ventilated lid.

**Lifespan:** ideal conditions 6-7 weeks

**Temperature:** Ideal breeding temperature is 30°C

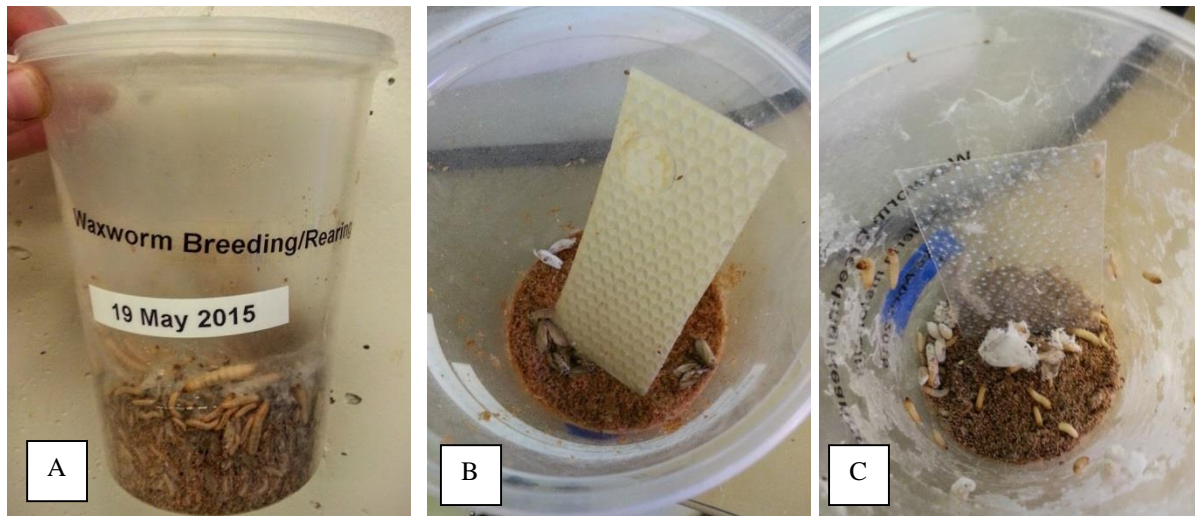


Figure 6. Wax moth Breeding/Rearing Cups. A) Larvae at 3 weeks old. B) Newly made cup with piece of waxed bee foundation. C) Larvae with their silk and wax stripped from foundation

## TROUBLESHOOTING

We have had problems with mites in our fruit fly and cricket cultures. These are reduced by carefully sorting flies into new cultures and keeping these cultures surrounded by a moat of soapy water. Phorid flies frequently invade the house fly cultures and are painstakingly removed by interns.

## **SUMMARY**

The addition of new feeder insects to our collection has improved the variety given to our carnivores and helped insure the constant availability of prey items. Surplus feeders are shared with other crews in the zoo and provide enrichment to birds, mammals, and herps. We have been able to reduce our dependence on feeders from outside sources. Our nutrition department approves of the new feeder insects and especially appreciates the money saved.

## **MATERIALS**

Carolina Biological Supply Formula 4-24® Instant Medium, Blue. <http://www.carolina.com/Hi-Cal-Ziegler-Monster-Cricket-Diet>. [http://www.monsterdiets.com/html/rc\\_hi\\_cal\\_cricket.htm](http://www.monsterdiets.com/html/rc_hi_cal_cricket.htm)  
Instant House Fly Medium., <http://www.carolina.com/>

Magenta GA-7 Plant Culture Box w/Lid (77 mm × 77 mm × 97 mm). [http://www.bio-world.com/productinfo/3\\_44\\_292/124429/Magenta%E2%84%A2-GA-Plant-Culture-Box-w-Lid.html](http://www.bio-world.com/productinfo/3_44_292/124429/Magenta%E2%84%A2-GA-Plant-Culture-Box-w-Lid.html)

Quincy Lab Model 12-140 Incubator. <http://www.quincylab.com/incubators.html>

Rearing & Observation Cage, 13.5 x 13.5 x 24", White, w/ Vinyl Window.

<https://www.bioquip.com/>

## **REFERENCES**

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How to Breed Waxworms. Retrieved from <http://www.wikihow.com/Breed-Waxworms>

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