The Art of Live Food Culturing

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Introduction

As the title suggests, live food culturing does take some skill and time to properly master. Like any other art some people are going to be better at a particular talent and with time they become better. Having the "bug sense" is a skill that will help you excel at raising your own live food but like any art, it takes time to master and excel. This monograph is designed to help those who have an interest in raising their own live food cultures by providing information on a variety of food items. A majority of the information is from my first hand experience and also comes from researching other sources.

I would strongly encourage you to experiment with different methods and different types of food cultures. Many variables in the following information can be altered to work for you. Not every method is suitable for every person. Many institutions will not have appropriate space, conditions, and more importantly time to raise their own food.

The Nitty Gritty of Live Foods

With over 6000 different species of amphibians, there is no one diet that is universal across all taxa or within taxa. There are very few species of amphibians of which we know what exactly their diet entails. Information we do have on species often comes from a select few individuals that may have been collected together at the same location. This

would obviously exclude a large portion of the population from which we might gain additional diet information. Even within a single species, a diet can range depending on locality, the size of the animal, and its life stage.

For those prey items we are aware of, we have very little information on their diets and the nutritional value that they provide for predators, mainly due to a lack of research. Fortunately for the captive community, some amphibians aren't too picky about what they eat and we are able to provide them other options. At the same time there are many specialized amphibians that haven't been able to thrive yet in captivity due to limited options of food. This is one reason why I encourage you to experiment with new food items and methods. All it takes is one person to try something new and different to allow new specimens to be kept in captivity.

What Should I Do?

There are many factors one needs to consider when trying to figure out the age old question: To culture, or not to culture? The first question is "Is this worth my time?" If you live in the U.S. then you are fortunate enough to be able to click a mouse or dial a phone to get food and have it the next day. Culturing your own food items will take time out of your day and cannot be ignored.

How much of the food item do I need? Do I need 5000 individuals a week or just a dozen? Some food items are more prolific than others and may be worth investing more time in. It may also be easier to just order a few food items if you don't need a lot.

If I don't culture where will I get food? As mentioned previously, many food items are available from vendors. If you have a reliable source of food it may be more valuable to you to just purchase it. You must also plan ahead as some food items may be only available seasonally or deliveries might be delayed due to weather and other situations.

Another thing to ask yourself is will the animal eat it. This could be due to either the size of the food item or to its behavior. Crickets are often a main food item because of the large range of sizes available. There are some species that may prefer a worm like prey item that is wriggling as opposed to a 6 legged insect hopping in the enclosure. Also remember that many amphibians will eat something completely different in their larval stage versus their adult stage. A classic example is a tadpole which may be feed mainly on algae and will eventually become insectivorous as an adult and feed on insects.

Feeding out your Food

When feeding out food consider several things. The time at which you feed out is important and can easily be overlooked. If you have a nocturnal species then you should probably wait until the end of the day when the lights go out to feed it. If you were to feed right away in the morning the food item may either die before it is eaten, supplements could be inadvertently removed(will be discussed later), or may choose to make the predator a food item while it sleeps.

Many amphibians are cued to feed due to the movement of the prey item. There are some species which will eat prekilled food or can be trained to eat prekilled food but in general they require live food. While it might seem obvious to you, I have been surprised by people who can't figure out why their frog won't eat the freeze dried mealworms they bought.

Making sure the animal is actually eating is also important. Many people will just throw a handful of crickets in an enclosure and not see if everybody is eating or how much they are eating. There are several things you can do you make sure your animals is eating.

One option is hand feeding each individual. While time consuming this is the most reliable method to see who is and isn't eating. Another way is to take frequent weights of individuals. This involves accurate record keeping but can prove invaluable. Some species, such as glass frogs (Centrolenidae), have transparent skin and the digestive tract and food items in it can easily be seen.

How you will feed the food out should also be looked at. One method mentioned earlier is simply putting the food item in the cage. This is the easiest method to feed animals and requires the least amount of time. Unfortunately there is no way to ensure the animals are getting their food and if they are getting food with supplements. Placing food items in an escape prove container is another way to feed. With this method the animal comes to the container and eats right from it. This prevents food from running around the enclosure and allows you to count how many food items are eaten.

The Third Source

There is a third source of food items that is often overlooked. This third source is the nature itself. It is probably the most enjoyable method because it involves you getting outside and catching insects. This method will allow you to collect a large diversity of food items which is very important. While it is fun, you must also consider that many insects are contaminated with things such as pesticides, herbicides, fertilizers, and no telling what else. A bad batch of bugs can quickly downsize your collection so do this with extreme caution.

There are several methods to collect your own food. One is simply take a butterfly net into a field and swing it through the grass and then see what you get. You can also hand pick from under rocks and logs or wherever you might find food. One way to attract insects is to set up a white sheet and place a light on it. Bugs should quickly be attracted to this at night. There are also commercially available traps that use this same concept.

Another method is pitfall traps. These are simply a can or bucket buried to the rim. The concept is that a bug will walk and fall into the bucket and allow you to collect it. It is important to realize that more than just insects can fall into these and that if left unchecked for days may result in the unintended death of other animals.

One easy way to collect nutritious insects is by trapping termites, a commonly available and nutritious food source in many areas of the world. Roll moist, pesticide-free corrugated cardboard and place into a two foot (0.6m) long piece of PVC pipe with a cap on one end. Drill some holes into the lower half of the pipe. Bury the open half of the pipe into the ground. After a week or two, periodically check the trap for termites. If occupied, shake the open pipe end into a bucket to collect termites. Animals that particularly relish termites include natural ant consumers such as microhylid, dendrobatid, and mantella frogs (Pramuk 2008).

Vitamin and Mineral Supplementation

There are two main forms of supplementing your animal's diet. The first form is by dusting or powdering the food item. This basically is putting a scoop of powder in with your food and shaking them up. The powder coats the food item and the animal eats it. One disadvantage to using this method is that the powder can easily come off. If the food isn't eaten immediately it can be cleaned off or washed off by misting.

The second method of supplementing food is by gut loading. You feed the food item (typically crickets) a special diet to increase its nutritional value. This is typically done

for 48 hours prior to when you will be feeding out the prey. It is important to note that this should be the only food available to the insect because it is typically not their preferred food. After all, who would prefer a salad over cake? Most gut loading diets are designed for the nutritional needs of the predator and not the prey. Due to this, growth and reproduction of crickets is typically diminished. They also have a greater need for water because most gut loading diets are high in calcium.

I am by no means qualified to tell you what supplements your animals need. Consult your veterinarian for more information and to figure out what supplementation will work best for you and your animals. More information can be found in the Nutrition monograph.

IMPORTANT CONSIDERATIONS

1. Culturing food takes time and space.
2. Cleanliness is very very very very important.
3. Stick to a tight schedule
4. Experiment and have fun culturing food.

How to Culture

House Cricket (Acheta domesticus)

These are your basic pet shop cricket. They are light brown in color and have an adult size averaging from 18-23mm. Eggs are usually about 2mm and the nymphs are similar is size. Females are distinguished from males by the ovipositor which is used to lay eggs in the substrate. Males also will be the ones making all the noise. The time required to incubate eggs is related to the temperature. According to Friederich, at 20°C (68°F) it takes about 21 days to hatch out while at 30°-33°C development takes 9-10 days (2004). During the average 12 week life of an adult female, she can lays 200-300 eggs. It is recommended that crickets are kept at a temperature of 80°-85°F (Pramuk 2008).

Humidity is a very important aspect that must be looked at. Adults survive better at a lower humidity and will quickly die if maintained at a high humidity. Pinheads on the other hand will quickly perish if kept at a low humidity. I have found it best to leave any crickets past their 3rd or 4th molt without a lid. I keep our freshly hatched pinhead covered with a few holes drilled in the plastic lid to allow for some ventilation. Many times the humidity from their hatching substrate provides enough moisture but I will sometime LIGHTLY mist their enclosure. Do not allow any condensation of water to occur with these little ones because they will all manage to pile onto one drop of water and drown themselves. It will happen.

Crickets can be housed in a large variety of enclosures. At the Toledo Zoo we house out crickets in white wash tubs. It is important to realize that they can climb many different types of surfaces so we put a band of clear packaging tape around the top to the tubs to prevent escapes. You can also use a band of petroleum jelly but this can become very messy very quick. Other housing options include large plastic containers or aquariums. It is important to provide a large surface area for them and not to over crowd the crickets. Provide additional surface area in the form of cardboard egg crating stacked in the container.

Pinheads should be housed in smaller enclosures such as a 5 gallon aquarium. If using an aquarium make sure to remove the top inch of silicone from the corners to prevent them from crawling out and escaping. I like to use wadded up paper toweling to provide surface area for them to crawl on.

There are several substrates that can be used. For out larger crickets we use corncob bedding because it absorbs moisture well, is cheap, and is easy to clean. For small sized crickets such as pinheads, I recommend using either newspaper or paper toweling. This can be removed and changed very quickly and is easy to separate from the small insects.

We replace and clean enclosures once a week. It is very useful to have extra containers on hand so you can have a clean one setup to quickly transfer crickets from their old enclosure. Pinheads should be cleaned more frequently because they are the most sensitive to an unhealthy enclosure and will quickly die. You may find that you end up with a large mixture of dead, molted exoskeletons, waste food, and live pinheads and wonder how to separate them. I have found an easy solution.

1. I simply take an empty aquarium/container and invert a short deli cup in it.
2. Place a lid or flat surface on top of the cup.
3. Pour you cricket hodgepodge on top and wait.
4. After several minutes the live pinheads will have walked off and you will be left with waste material on the lid.

Water is an important aspect that cannot be overlooked. While it seems like it should be simple, it's not. It is essential for keeping them alive, but it also is their quickest form of death. For adults sized crickets we use poultry waterers. This seems to work fine with large crickets but is not very good with smaller sizes. For smaller sizes we use the cricket gels made by Flukers. Only give pinheads a few chunks of gel because as mentioned previously they will all pile on and die. We have also used folded up wet paper towels place on a deli cup lid. We then invert a test tube of water that plugged with cotton or a sponge. This keeps the paper towel moist. This method works well but can quickly drown a tank of crickets if the water seeps out to quickly. The paper towel will also become dirty quickly. Another source of moisture is by vegetable and fruit matter. This works well but might cause issues if you are on a strict gut loading diet.

Breeding crickets is very easy. I simply mix one expanded brick of coconut fiber and mix with a 32oz cup of fine sand. The sand helps aerate the soil and prevent it from becoming too solid. I then place about 1 inch of this substrate into a small salad container or sandwich box sized container and place in with the adult crickets for about 24 hours. Remove the container the next day and place a lid over it with a few tiny holes. Write the date on the container to keep them in order and then place on a shelf. If you do this everyday then you should have a new supply of pinheads hatching daily. Simply set up the hatching containers in a new aquarium with food and water and cover with a lid. I like to stack the pinhead eggs containers by separating them with a piece of white egg crate. This allows them to be stacked while still allowing the pinheads to crawl out. I also like to put a moist paper towel on top of each egg container to provide moisture.

Feeding your crickets depends on what your institutions goals are. If you want a strict gut loading diet then you should only feed them this and not offer them other food options. If you are less concerned about gut loading then there are many food choices. Many people use fresh fruits and vegetables. Here is a list of common things I have found that people use: lettuce, carrots, sweet potatoes, apples, oranges, dog foods, cat foods, and flake fish food. It is important that all food it replaced and cleaned daily. Make sure to consult your veterinarian before developing a food to see if it is appropriate.

To harvest crickets from their container simply shake off the cardboard egg crating into a container. I have found it is much easier if you shake the cardboard into a much larger container than a deli cup. You can then simply pour them into the cup. To harvest pinheads remove the wadded up paper toweling and also shake into a container and separate as previously mentioned.

Fruit Flies (*Drosophila sp.*)

There are 2 main species that are bread for food; *D. melanogaster* and *D. hydei*. The first is the smaller of the two species maxing out at a whopping 2.5mm while the second is about 3.5mm.

Female *D. melanogaster* mate within 24 hours of hatching from their pupae and lay their first eggs about 3 days later. In a period of 16 days a female can lay 300-350 eggs which in 1-2 days after being laid hatch out and then pupate 5-7 days later. After 4-6 days they hatch out and start the cycle again. Under ideal conditions the life span of *D. hydei* is 8-10 weeks.

The life cycle of *D. hydei* is takes about twice as long. The females lay eggs after about 11-13 days which then hatch 2 days later and are maggots for about 2 weeks and are then pupae for about a week and a half. A female is capable of laying about 22 eggs per day for 6 weeks. They have about a 10 week life span.

As you can see, the generation times for fruit flies are very short. As a result, desirable traits can easily be bred for. Fortunately traits such as small or malformed wings have been bred for and both of the species can be purchased in the flightless form. If any of your cultures have individuals that can fly you should discard them to prevent from breeding them further and possibly causing all of your future flies to become flighted.

Keeping fruit flies is fairly simple but takes a little tweaking at first. They can easily be kept in 32oz plastic deli cups. They do need ventilation so you can either buy lids with a cloth top, cut a hole in the lid and push on top of a coffee filter, or cut a hole in the top and plug with a piece of foam. They can also be bred in canning jars with a coffee filter screwed on under the rim.

There are many different types of mediums to use. You can either use your own or purchase it from place such as Carolina Supply Company or Ed's Fly Meat. There is no single recipe for fruit fly medium so do some research and try something. Everybody says theirs is the best, so try a few different types to see what works best for you. The medium is usually mixed one part water with one part medium by volume. Some people like to mix their water with half white vinegar to help make it slightly acidic which is supposed to help increase productivity. Many mediumss contain a mold inhibitor. If your cultures get a mold outbreak quickly disposed of them and do not use those flies for starting new cultures. Add a pinch of bakers or brewer's yeast to provide food for the flies and maggots.

Once the medium is setup it is beneficial to add extra surface are for the flies to crawl on. This can be done by adding folded up pieces of cardboard, folded paper plates, pieces of wax paper, or excelsior which is should be a wood such as aspen.

Add about 50-100 flies to the culture. Some sources recommend a large number of flies initially to eat any molds that might be on the surface to prevent a mold outbreak. After about a week remove the flies so the maggots will have enough food and start new cultures with these or feed them out. If you notice the maggots are crawling up the sides this is often an indication that they are out of food and should be fed again with yeast.

Place the cultures in a warm area out of direct sunlight. Some references say that a light cycle is beneficial to their reproduction. It is also important that they aren't placed directly in air currents or in areas that are very dry because the cultures will quickly dry out.

To harvest fruit flies you can simply tip the cup at about a 45 degree angle upside down and gently tap it above another container. Note the word gently. If you tap them too violently you will also knock out everything in the cup. If you are going to be dusting your flies I would recommend putting the powder in the receiving container and shake the flies as you go. This will help keep them from crawling out so you don't have to juggle containers. If the cultures seem dry you may get a lot of media flakes and pupae that will fall out. It is your choice if you wish to try to harvest from them. One option is to set the cups in a larger container and allow the flies to crawl to the top and the tap them out.

Maggots can also be harvested as food. Simply take a scoop of maggot infested medium and place it on a Petri dish and place in the enclosure. Old/retired cultures can also be placed in cultures to allow any remaining flies or pupae to be fed out. I have actually taken old medium and put it on a lid and put in my personal enclosures at home so the frogs can pick out any last maggots or flies.

House Flies (Musca domestica.)

The house fly is often seen as a pest but, this annoying insect is a nice addition to any amphibian menu. These flies only get about 1cm long. Males are distinguished from females in that their eyes are closer together and the underside of the abdomen is grey color instead of a yellowish color. The maggots feed by consuming proteins that have been broken down by their saliva. The length of time they are maggots depends on the temperature, the quality of food and the quantity of food. Once they pupate out, the flies become mature after several days. Eggs are laid and they hatch about 2 days later and then pupate generally a week and a half later. After a week of being pupae they then hatch out as flies. Females can lay between 800-1500 eggs (Freiderich). The life cycle is completed the quickest at a temperature of about 29°-32°C (85°-90°F) (SpiderPharm2008).

In order to breed flies, they require a rich source of protein. This often involves meat which quickly becomes rancid and is then followed by a putrid smell. Due to this it is often not worth the time or effort to breed these insects. If you are interested visit the SpiderPharm care sheet to see how to breed them. Their method doesn't use meat but rather uses dog food.

Rather than breeding house flies they can easily be purchased and don't cost very much. They can be fed out as maggots or can be separated out and hatched into flies. In order to morph them out you simply remove maggots from the substrate they are in and place them in a deli cup with a lid. Make sure there are a couple small holes in the lid to allow for air circulation. After a couple days most should turn into pupae and will shortly become flies.

To feed out flies we have found a couple of tricks to be useful. The first is count out a certain amount of pupae and place them in a test tube with a sponge in the end to allow the air to exchange. When they morph out simply remove the sponge and place the test tube in the enclosure. If you decide to morph the flies out in a deli cup you can easily put them to sleep my pumping carbon dioxide into the container. You can also slow them down by placing them in the refrigerator or freezer; just don't forget they are in there.

Wax Worms (Galleria mellonella)

The name wax worm is derived from their parasitic life style. These worms are actually caterpillars of the wax moth and are not worms. They are parasites of beehives are often despised by bee keepers. The adult moths typically have a wingspan of 30-35mm and a body length of 13mm. Females can lay up to 150 eggs per clutch and over their life span can lay up to 800 eggs total. Eggs aren't much larger than 1 mm and hatch after about a week in tiny caterpillars. After 3 to 4 weeks the larvae grow and form pupae which then hatch 2 weeks later into moths. Most moths mate immediately and lay eggs 4-5 days later. When found in beehives a moth typically lives 6 weeks however in captivity they rarely outlive 3 weeks. This is probably due to the ideal conditions provided by the bees (Frank).

Wax worms are fairly easy to propagate in captivity. It is important to have a container that can't be chewed through such as wood and that it is escape proof because escapees can cause issues. Escaped larvae/moths can wreak havoc on books and other materials that can easily be chewed on so a tight fitting lid is important. One possible option is a gallon plastic or glass jar with a coffee filter screwed on for the lid.

Since these insects do live in beehives they typically do best in temperatures ranging from 27°-28°C (80°-83°F) and should remain in a dark place. Food can be offered in several forms. If you happen to know a beekeeper who can supply you with bees wax this can be used. It is recommended that if you do this you should freeze the wax for several days prior to using it to kill of any parasites that might be waiting. There are also several recipes that can be used. Many differ by a few ingredients but in general all are based from dry instant cereal, oatmeal, honey, and glycerin. The following recipe is fairly general and can be altered to fit your needs.

> Blend up 16oz of dry cereal and 16oz of dry oatmeal in a blender. Mix this with 32oz of honey and 4oz of glycerin. The end result should be a dry, crumbly dough that is somewhat sticky (Pramuk 2008).

Place 2-3 inches of food in the container and add the larvae to it. Add several pieces of corrugated cardboard for egg deposition sites for the moths. Larvae may also crawl into these crevices to pupate out. A couple sources suggest using crumpled up wax paper to provide both wax and sites for the larvae and adults to do what they do.

Both the larvae and the adults can be fed out. It is important to note that wax worms are very high in lipid content and should only be fed out sparingly to prevent issues with your animals. Consult your veterinarian to figure out what is appropriate.

Meal Worms (Tenebrio molitor)

Mealworms are the larval form of the mealworm beetle which is a black beetle that is usually about 15mm long. A female will lay eggs that are just over 1mm long in a substrate which hatch out into golden colored larvae. After close to a dozen molts, the larvae reach their maximum size which is about 2.5cm and will then form a pupae that will sit for just over a week. A single female can lay 160 eggs during her 3 month life as a beetle.

Keeping mealworms is a fairly simple thing to do. The container would be smooth sided plastic to prevent them from crawling out or chewing through. If they can climb the sides you can still contain them by placing a band of clear packaging tape around the top ledge. Don't use a lid so any moisture in the container can quickly evaporate out. They can also be kept for extended periods of time in the refrigerator in deli cups with lids. If you choose to go this route don't offer them fresh foods.

The substrate typically is their food which is usually a dry powder/grainy mixture. They should not be housed in humid or moist conditions. I use the gut loading diet that we use for out crickets as mealworm substrate. Friederich has two different recipes that he suggests and has had fairly good success with both (2004).

Mixture A	Mixture B
250g wheat flour	250g wheat flour
250g oats	250g oats
100g hen mash	100g soy meal
350g wheat bran	70g corn meal

30g yeast
300g wheat bran

When two groups of mealworms were fed on these diets, he found that Mixture B grew mealworms 2 weeks faster and grew them to a larger size. Other substrates that have been suggested are ground up rice, crackers, bread crumbs, and wheat bran. Whichever substrate you use should be ground up fine enough so it can be separated from the worms by a sifter. While they don't require a water source it is beneficial to offer them fresh foods such as slices of apple, carrots, sweet potatoes and greens. These foods should be removed as soon as they begin to spoil to prevent problems with mold. I generally offer fresh food about every other day.

The substrate should be replace as it becomes broken down and as feces accumulates. There are a couple ways to tell when you should change the substrate. The first way is it becomes dark and very powdery. Another way is that it becomes very dusty and may cause problems with anybody that has allergy issues. I also recommend removing exoskeletons once a week to prevent them from becoming part of the substrate. Many times the sheds will be worked to the top and can just be skimmed off or blown off. Another way to remove exoskeletons is by sifting out the worms and the sheds and placing them on a tray. You can then gently blow out any sheds. I would recommend doing this outside or in a well ventilated room to prevent breathing in any particles.

Breeding mealworms is also a simple process but it does take some time to work with them. The first thing you need is beetle. If you can get these from a supplier that is great but you can also make your own form your mealworms. You will have to remove any pupae that you can find from your mealworm container and separate them into their own container for hatching out. If you keep pupae with the larvae, they will chew on the pupae and kill them. Once the pupae hatch you will have your beetles.

Keep your breeders in a dark area that is at a temperature of 27°-28°C (80-83°F). This seems to be the optimal temperature for reproduction. I set up our beetles in a plastic shoe box with a paper towel on the bottom. They will lay their eggs on this and it helps prevent them from laying on the container which makes them hard to remove without damaging them. I then put a layer of substrate on top of the paper towel for them to eat. This will also serve as the substrate for the new mealworms that will be hatching out. Once a week I set up the beetles in a new container and pour their old substrate into another container with the paper towel to raise up the larvae. It is important to keep a strict schedule to keep different sizes separate. If you are successful at this then you will have a large range of sizes to choose from for food.

You will end up with some dead larvae mixed in with your live larvae. One simple way to separate them is to sift them out and then place a slice of sweet potato or apple in with them. A majority of the live ones will pile onto the food and you can simply remove them. This is also very effective with separating your beetles. Another method to separate them is to place them on a tray and place a bright light above them. They prefer darkness so you will crawl off away from the light leaving you with the dead worms.

Many times you may find that you don't need thousands and thousands of mealworms and it isn't worth your time breeding your own. One suggestion I found is that if you don't need more than 100g of larvae per week then you are better off purchasing them.

To feed mealworms out it is usually easiest to place them in a smooth side dish and allow the animal to come to them. If broadcast into an enclosure they will quickly burrow

down and won't be eaten. Wright suggests slitting the exoskeletons of the larvae to allow for better digestion (2001).

Superworms/ King Mealworms (*Zophobas morio*)

These are very similar in appearance to mealworms but are much larger. The large black beetles are typically 3-4cm long. Males are identified by a head that is 4.5-5mm wide while females are typically 3.5-4mm wide. These beetles can cause an allergic reaction in people when they release a milky, white chemical known as quinone. The beetles mate 2 weeks after hatching from pupae and then lay eggs about a week later. Eggs are typically about 1.3mm long and incubate for a week to a week and a half. At temperatures around 27°C (80°F), development to pupae take 6-8 weeks and they reach a size of 3-4 cm. If separated they will then turn into pupae and remain in this state for another 2 weeks. At their preferred temperature and humidity, adult beetles can live up to a year and produce 1500 eggs.

Keep superworms in a smooth sided plastic container. If they can climb the side put a band of packaging tape around the top. For substrates, Freiderich suggests using equal parts of peat moss and saw dust (2004). I personally use our cricket gut loading diet and have found this to be sufficient. As mentioned previously they prefer temperatures around 27°C (80°F) so this can be done by storing them in a warm room or placing a heat mat under them. Depending on the demand you have for superworms, they can still be bred and raised under normal room temperature conditions just with slower results.

They prefer a humidity level of about 60%. This can be obtained by misting their container daily and making sure the substrate remains lightly moist.

Superworms feed primarily on plant matter. They can be fed a variety of food such as apples, carrots, sweet potatoes, and greens. I prefer to cut the food into thin slices rather than chunks because they will usually dry out before they become mushy and moldy. Replace the food frequently to prevent any issues.

To breed superworms, I set up the beetles just like described in the mealworm section. I also like to put a piece of cardboard egg crating with the adults for increased surface area. They will sometimes lay their eggs on this so look it over carefully. If there are eggs I will put it in the new rearing container until they hatch.

In order to get the larvae to turn into pupae you must separate them individually. You can do this by placing the larvae in empty film canisters or tackle storage boxes with multiple compartments. Make sure there is a tiny vent hole in the lids to prevents stagnant air and death.

You can feed them out the same way you feed out mealworms. Again, you might want to consider slicing the exoskeleton to aid in digestion. Some sources also recommend crushing the head of the superworms to prevent them from doing internal damage to the predator.

White worms (*Enchytraeus albidus*) and Grindal Worms (*E. buchholzi*)

White worms have a length of about 2-3cm while grindal worms are about .5-1cm long. These are a good small food item to have on hand especially for some amphibian larvae. Both of these species prefer dark conditions. White worms do best at about 18°C while the grindal worms do best at a temperature range of 18°-24°C (64°-75°).

They can be housed in plastic deli cups or plastic shoe boxes but should have a tight fitting lid with a few small air holes to allow for some air circulation. White worms can

be raised in a substrate of soil mixed with peat moss and sand and should be moist but not wet. Grindal worms prefer pure peat moss mixed with sand to help break up and aerate the soil.

White worms can be raise on a diet of moistened oats mixed with a little sugar and margarine. Make sure the consistency is paste like and isn't very water. There are a couple ways to feed this out. For the first way you need to make a small indentation in the substrate and scoop some of the food into it. Don't over feed. It is better to add more later than make a mess. For the second feeding method you can put a piece of glass or plastic in the enclosure and place the food on it. The worms will then crawl onto it and you can scoop them off for feeding out. Grindal worms can be fed a diet of dry oats sprinkled on the surface or flake fish food. They can also be harvested in the same manner as the white worms.

Springtails (Collembola spp.)

These tiny insects are a very easy and important food item to culture. Ranging in sizes from 0.2-9mm they are a very prolific insect. For those of you unfamiliar with springtails their name says it all. They have a paired appendage called a furcula tucked under a body part called the tenaculum. When a quick getaway is in need the furcula is pulled on and pops out catapulting the insect through the air. Springtails are also unique in that they have a specialized organ called the ventral tube. With several uses including righting ability, holding onto surfaces and intake of water, it also is used for cleaning and oiling. The oil makes these minute insects hydrophobic, which means they float on water.

There are many ways to set up springtails. You can set them up in individual deli cups or in containers such as plastic shoe boxes. These are then filled with a wide variety of substrates. Substrates include but are not limited to peat moss, forest soils, coconut pith, plaster, and charcoal. It is recommended that leaves are mixed in with substrates when possible to add extra nutrition and to help break up the soil. Substrates are to be moist but not wet. Pieces of cork bark can then be placed on the surface. This will help in the future to feed out because they will infest the pieces and they can be rotated in and out of an enclosure for feeding out.

Springtails typically do best when kept at room temperature and the extremes should be avoided. They can survive extreme temperatures but they will not thrive at them.

Feeding is a simple and quick task. They will eat a large variety of foods including vegetable matter, yeast, and flake fish food. Food should be offered sparingly. Overfeeding will cause molding and can help lead to an infestation of mites that will diminish a thriving colony.

If given proper food and conditions, springtails will breed and will provide you with a good source of food. To feed them out to animals there are several different techniques that can be used. The first is simply taking a scoop or even dumping a deli cup full of the pith or whatever substrate you used into the enclosure. If you use charcoal as a substrate you can simply flood the container so the water is above the charcoal. Due to their hydrophobic trait you can easily suck them off the surface with a syringe and then pour them into the enclosure. You can also scoop them up with a fry net or another fine meshed fish net. Having a drain in your charcoal container that is plugged with a rubber stopper will allow you to employ this method. Another method is blowing them out. When you blow across the top them they will all jump so you can simply tilt the container in an enclosure and blow them into it.

Roaches

The following information on roaches comes from Pramuk 2008. Roaches can be easily cultured in a well-secured aquarium by placing a layer of newspaper on the bottom and providing cork bark pieces for increased surface area. The roaches are fed a diet of vegetables and fruits, and although they are relatively slow to reproduce they provide a nice alternative to crickets. While conventional feeder insects such as domestic crickets and mealworms are readily available to amphibian keepers, there are other insects that can be easily cultivated and can offer an important supplement to a quality and varied amphibian diet. Three species are currently propagated in large numbers as food items:

Lobster Roach (*Nauphoeta cinerea*)

Probably the most commonly-bred of the feeder roach species. Adults are comparable in size to large crickets (23–26 mm), although they have a greater *meat* to exoskeleton ratio than adult crickets. Adults of both sexes are winged, but flightless. Lobster roaches can easily climb glass, so measures to keep them contained should be employed. A 1-2 inch wide band of petroleum jelly or a product called Bug Stop[1] will work perfectly well. This species is a very prolific breeder with a short time between generations. A newly hatched nymph can reach breeding age within three months. Adult females produce clutches of 20–30 nymphs at 30–60 day intervals. The female produces an ootheca (egg case); however, she pulls it back into her body for incubation. Individual roaches can live for 12–24 months.

Discoid Roach (Blaberus discoidalis)

The discoid roach is also easily propagated. The adults (35-45 mm) are ideal for larger species of amphibians, but the nymphs are useful for smaller and medium-sized species. Both sexes are winged, but flightless, and they cannot scale smooth surfaces like glass. This species is not as prolific as the smaller lobster roach and colonies can take some become established; however, once they are established they can be quite prolific. Breeding age is reached within 4–5 months and the life span is 12–18 months. Young are born live, remain hidden under the mother for several hours or days, and then disperse.

Orange-Headed Roach (*Eublaberus prosticus*)

This is a larger species (38–48 mm) that is a prolific breeder. Sexual maturity occurs between 3-5 months. These roaches can live up to 24 months. Due to aggression, house these insects in as large an enclosure as possible. If not provided with adequate space, moisture, and high-protein food, orange-headed roaches become cannibalistic, biting the wings of other adults and eating freshly-shed adults or nymphs. Ensure that plenty of water is available at all times in the form of chopped fruits or vegetables. These roaches are winged, but flightless and incapable of climbing glass or smooth surfaces.

Depending on the production needs, colonies may be established in containers ranging from 10-gallon aquariums to plastic containers (30 gallons or larger). Cardboard egg-crates may be stacked in multiple layers for furnishings. No substrate is necessary, and in fact may make collection more difficult. The roaches will make refugia out of the multiple layers of egg-crate.

Temperatures should be kept at 80–90 F (27-32 C). All three roach species discussed can handle temperatures lower than this, however reproduction declines dramatically at temperatures lower than 80 F (27 C), or may cease completely.

Finely ground premium dry dog food or crushed high-quality tropical fish flakes should be offered at all times in a shallow dish. This part of the diet should be kept dry at all times to prevent potentially harmful mold growth. As a source of moisture and vitamins, a variety of chopped vegetables should be offered at least three times per week. Remove unconsumed vegetables after 24 hours to prevent mold in the colony.

Smaller roach colonies should be cleaned weekly, and more frequently for larger ones. Due to their usually dry fecal pellets, sweeping out the enclosure is often sufficient, although disinfecting the container should be undertaken every 1–3 months depending on the number of roaches in a colony. Egg-crates should also be replaced as they become coated in feces (Pramuk 2008).

References

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