The Axolotl Newsletter

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Printed copies of back issues 1-27 of the Newsletter are available. Single issues cost $1.50. Unless individual numbers are requested, issues 1-9 and 11-14 are sent reduced in size and bound together. The set containing issues 1-9 costs $10, and the set containing issues 10-14 costs $5. Contents are listed on our Web site. Indices for numbers 1-15 are in issue 15 and for numbers 16-20 in issue 20. Issue 25 contains indices for issues 21-25. Beginning with issue 26, the Newsletter is available free online at the Axolotl Colony Web site.

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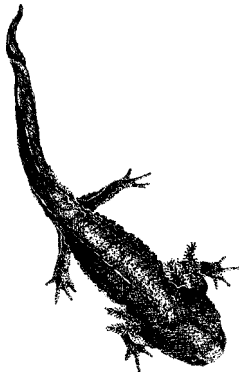

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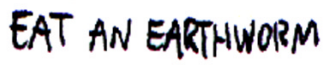

Axolotl artwork by Peter Van Eeten, Melbourne, Australia

Axolotl Colony News

Grant Renewal! The National Science Foundation grant that, along with user fees, supports the Axolotl Colony was renewed this year for three years. We want to thank all our users and others who have put in a good word for us and supported our efforts over the years.

New Staff Member. We have added an assistant curator to the colony staff. Her name is Meg Newberry, and she will be working closely with Sandi and Susan to improve animal stocks and deliver better service to you, the user. Meg has her B.S. degree in biology from IU, and she has experience as an animal caretaker and laboratory assistant. Her help is especially appreciated because, since May, Susan has been working in the colony only halftime.

International Shipments. As some of you know, we now use a freight forwarder, Phil Thomas & Son International Co., to assist us with international shipments. This company acts as our agent in Chicago (the port of export) and makes sure that all of our packages get inspected and go out with the proper paperwork and on time. Although the additional fee (usually about $60) makes the material more expensive for the user, we have been saved a world of trouble with lost packages, unstamped paperwork, and delayed delivery that made international shipments so frustrating before for everyone concerned.

Services. In addition to supplying live axolotl material, remember that we are able to provide other research services as well, including early embryo injection (dyes, mRNA) and fixing and freezing of staged embryos. Charges for these services are by the hour, plus the usual charge for the embryos. For more information, contact the Axolotl Colony.

Food for Urodela

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Worms

Most salamanders are crazy about worms. There are several species of worms around, however, and not all of them are equally appreciated by our salamanders.

Worms that live on animal-waste products are best avoided since—through their feeding—they can contain toxic products. Some salamanders such as *Pachytriton* and *Paramesotriton* species will refuse to eat them. They will first smell them, eventually take a first bite, and then spit them out again. When buying worms in pet stores, you will probably get tropical compost worms. These are accepted by some species, but not by all. The trouble with them is that when attacked they will excrete a milky secretion, which is not appreciated by all of our tailed friends.

There also exist a lot of insect-eating salamanders, such as the Plethodontidae, and worms normally don't fit into their diet. Examples are the mid-American tree salamanders of the genera *Bolitoglossina* or *Oedipus*. Other little salamanders have such a narrow mouth that worms simply don't fit in them (for example, *Plethodon cinereus*). One of the major points (for any food resource) is to choose the size of the prey in relation to that of the predator. The general idea is that the salamander eats the worm and not that the worm strangles the salamander.

Worms are rich in calcium and thus important for growth. Feeding juvenile axolotls solely on earthworms resulted in 15-cm long axolotls in one year, a length they failed to reach when I fed them solely with bloodworms. On the same feeding schedule, young *Hynobius dunni* doubled their size in only two months. Urodeles that readily accept worms include species belonging to *Salamandra*, *Ambystoma*, *Pseudotriton*, *Gyrinnophylus*, *Cynops*, *Paramesotriton*, *Neurergus*, *Necturus*, and *Taricha*.

Slugs

When gardening among my hosta, fern, and bamboo, I'm always happy to discover that I have a garden that's very rich in slugs. My wife—who is an enthusiastic plant lover—doesn't share this sentiment with the same

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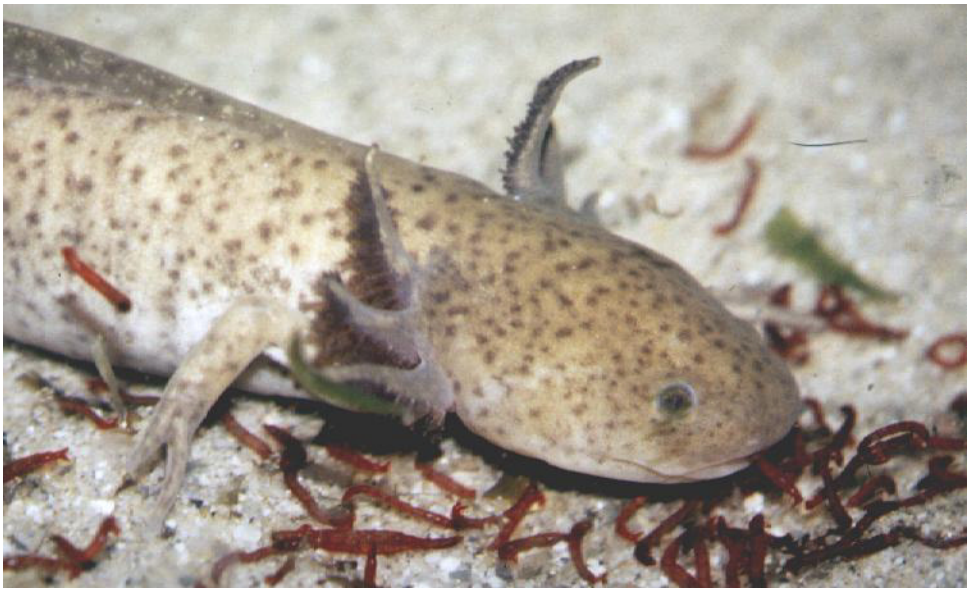
Northwestern salamander *(Ambystoma gracile)* enjoying an earthworm meal.



Axolotl *(Ambystoma mexicanum)* and bloodworms. ©Henk Wallays

enthusiasm, however. The slugs congregate in the shadowy damp places of the garden, underneath stones and, especially, wood or plastic. I offer them to most of my Amercan mole salamanders, who chase them with much appetite. Remarkably enough, they are left unharmed by most of the *Hynobius* species. *Ambystoma maculatum* and *A. macrodactylum*, especially, are true slug chasers. In older literature (Lacerta, Holland) we also read a story that tries to link fertility with feeding with slugs.

Tip. An easy way to catch slugs is to put a sheet of newspaper for a few minutes into a dish with beer, and then put the beer-soaked paper outside in a shady place underneath some stones. It's common knowledge that slugs are attracted by beer. You can harvest them each morning.

Aphids

In the middle of the summer, when the usual food resources were getting scarce, I once took an aphid-infested leaf from a rosebush and placed it in the raising tank of my juvenile *Cynops pyroghaster*. After two days, the quite starved *Cynops* showed off a nicely filled belly again. However, if you plan on feeding aphids, take care to cut only branches of trees or shrubs that you are sure have not been treated with insecticide.

Enchytraeids

These little white worms are quite easy to breed and keep at room temperature (20 °C). Whereas *Daphnia* are the main source of food for aquatic young, enchytraeids have an important place in the feeding of terrestrial juveniles. I culture my enchytraeids in plastic pots filled with composted soil, on top of which I lay a piece of newspaper (to create a layer of darkness and humidity). The ground is quite moist, but not swampy. When I need worms, I mix a large spoonful of rolled oats into the soil. At a temperature of about 17°C, it takes about a week to have large masses of little white worms ready to offer to your precious young. The worms can also be offered to aquatic-stage larvae, since they tend to move around quite a while (hours) and thus attract the attention of the larvae. Rearing enchytraeids with the usual milk and cheese method yields worms that contain much fat, which, when offered frequently, are said to cause liver trouble. I offer enchytraeids especially to young *Ambystoma*, *Cynops*, *Neurergus*, and *Hynobius*.

Tip. If you want to start a fresh culture, here's a tip for catching them. Find a convenient compost heap and put in a slice of bread in a damp place by the heap. Leave it there for two days, then dig it up: normally, you will find lots of enchytraeids underneath the bread.

Bloodworms

Whereas earthworms are the main dish for the terrestrial adults, bloodworms play an important role in the diet of larvae and aquatic animals. In Belgium, we have three sorts of mosquito larvae: translucent white, black, and red. The red form is most suitable: they move more and have a striking coloration, making them easy for larvae or adults to discover them. Especially at night, you will be able to see them dancing around through the pursuing salamanders. They can be purchased at a local fish store

Problems

Egg penetration. I've already observed bloodworms that penetrated the outer layers of eggs. Whether they are actually damaging the egg or not, I've not yet been able to verify.

Planaria. While feeding with bloodworms, one also imports eggs of other, more harmful things into the tank. One of them might be planaria. This little grey flatworm, recognizable by its triangle-shaped head, has an insatiable appetite for salamander eggs. They avoid direct light and start crawling around only during twilight, when they leave their hideouts (underneath a stone or leaf) and climb on the sides of the tank. While breeding *Neurergus strauchii* in 1996 and 1997, I lost well over 80% of the total egg package because of planaria. They intrude through the different jelly layers in order the reach the egg, on which they feed. One ends up having eggs that look like they have imploded; the eggs shrink day by day. If this sounds familiar, start checking the underside of the stones. So far I have not found a method for eliminating only the planaria from the tank, without harming the other inhabitants. Raising the salt level in the tank seems to work well, but the mortal limit of planaria will also harm the urodela, which are not too keen on brackish water, either. A simple solution is to clean the entire tank by hand. Another practical solution is to move the salamanders to another tank and put little fish in the planaria-filled tank. Some cold-water fish will eventually eat them (sticklebacks do).

When temperatures start to rise suddenly during the springtime, most bloodworms in nature will metamorphose and become mosquitos. In this short period, which most unfortunately always seems to coincide with the reproductive period of the salamanders, bloodworms will not be available in the shops (unless they carry imported material).

Tips for raising juveniles

Terrestrial juveniles can easily be fed with bloodworms, too. Take a piece of wet paper towel and put some bloodworms on it. The wet substrate will keep them alive a long time, and the wriggling red worms on the white substrate are sure to attract the attention of

©Henk Wallays

Planaria

the young hunting salamanders. After feeding, you simply take away the paper towel, so you don't get the urodarium dirty. I have successfully used this technique in raising *Cynops*, *Paramesotriton*, and *Triturus* species.

Cyclops

It's best to avoid feeding larvae these little crustaceans, since they will attack the larvae. High densities of *Cyclops* can result in the death of the larvae and negate most of your efforts in raising the species.

Artemia

Most people who have formerly kept tropical fishes know about this food resource. The eggs are for sale in the tropical fish stores and can, through an easy process, be hatched and raised in salt-enriched water. The orange brine shrimp can then be offered, and, despite being released in freshwater, they tend to stay alive for awhile. Just as with *Daphnia*, these shrimp seem to contribute a lot to the red coloration of the belly of firebellied newts.

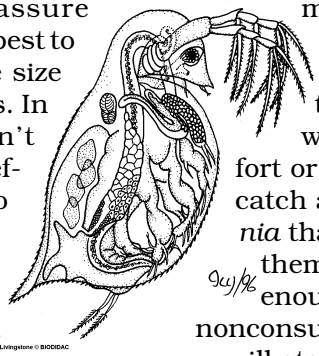
Problems

Separating the shrimp from the remaining eggshells is quite important. After feeding some *Pleurodeles waltl* larvae with *Artemia*, the larvae suddenly started developing gas bellies and floating around the water's surface, and finally dying off. After a search with a microscope, remains of eggshells were found in the intestines, blocking them off.

Daphnia

Feeding larvae of Asian firebellied newts *(Cynops, Paramesotriton)* frequently with *Daphnia* will enhance the red belly coloration. We frequently notice captive-bred species with orange bellies; feeding them with *Daphnia* just might make a difference. Adult newts are willing predators on *Daphnia*, too. Currently, it looks as if feeding *Daphnia* to *Neurergus strauchii* might—surprisingly—be troublesome. Further observations and investigations are, however, necessary to confirm this.

Tips. For the raising of salamander larvae, *Daphnia* and their young play an important role in the early phase: they are the main source of food for most captive-bred species. One should choose their size in relation to the size of the larvae to be fed. This can be done by sifting them through some fine *Daphnia* nets, which are available in various sizes. To assure maximum uptake, it's best to offer *Daphnia* the size of the larvae's eyes. In this way, larvae don't waste unnecessary effort or energy trying to catch and swallow *Daphnia* that are too large for them. When there's enough lighting, nonconsumed *Daphnia* will stay alive in the tank, offering the advantage that they clean up the water while feeding. On the other hand, food stays available, and when the *Daphnia* reproduce, you end up having young *Daphnia* in your tank year round.



Livingstone©Biodidac

Where. *Daphnia* can be purchased in some tropical pet shops. During the summer months, they can be massively available in stagnant water containing much plant debris or animal waste, sometimes in such densities that the water appears reddish. A small duck pond (in a park) is a handy source. You'll also be surprised how many *Daphnia* you will find if, during the winter, you net through waterweeds in a well-filled garden pond (even under ice).

Mysis (Freshwater Shrimp)

In some brackish water, it's possible to find *Mysis*. This creature looks like a little shrimp and can be eaten by various aquatic salamanders. I have, however, not yet worked with this food resource. It's also not an easy task to bring home captured *Mysis* alive.

Fruitflies and Their Larvae

In most terrarium pet shops, you can buy the well-known pots with fruitfly maggots. They are, perhaps, more commonly used by frog keepers, but they also have a value for the urodela keeper. Some plethodonts are mainly insect eaters. For little species such as *Plethodon cinereus*, they are good-sized prey, which in no time will be discovered and captured by means of a sticky tongue. Land-phase juvenile salamanders will accept both flies and larvae. The maggots, however, are delivered in a smelly paste, which is better not spread around the raising tank. Offering them

in a small pot, on the other hand, carries the risk that your juveniles will fall into this swamp and drown. For this reason, I herewith quote a nice, clean, and practical solution, which was originally worked out by Henri Janssens, Brugge, Belgium.

Take a piece of a plastic electric tubing and seal off one of the ends. Fill the tube halfway to two-thirds full with the jelly and maggots. Cover the other end with a fine mosquito netting. Place the tube in the rearing tank with the end with netting somewhat higher then the sealed end. When the maggots want to spin their cocoon for their metamorphosis, they will search for a dry spot and start climbing out the open end—where after a while the young salamanders will know to find them.

Waxmoths and Larvae

Waxmoths are very nutritious and fairly easy to breed and keep. There are various ways of raising them; one is to make your own mixture, and another consists of keeping them on used wax combs, which you might obtain from someone who keeps bees as a hobby. However, in this last case, it's better not to pronounce the name of this little insect in their hearing. One escaping waxmoth might mean the end of their hobby.

Tadpoles

Tadpoles are frequently predated on by newts in nature, so it must not be a shock to see this food item on the list. I have personally observed predation by adult *Alpestris* on frog eggs. The newts started crawling over the egg mass and picked out just the eggs. After the festival, only an empty transparent jelly remained. Species like *Pachytriton* and *Paramesotriton* just love tadpoles and will chase them around in the tank. However, be aware that most European frog and toad tadpoles are protected by law. So you will need to breed the frogs if you want to offer this type of food.

Fish

Some of the larger neotenic species, such as *Andrias*, neotenic Ambystomids, and *Necturus* (to name a few), will also eat live fish. This feeding behavior has given mudpuppies and other species a very negative name to sports fishermen. The overall damage mudpuppies can do to salamander populations has been quite exaggerated, however. But anyway, you can readily offer little fish to these species.

Buffaloworms

You can purchase these little mealworm-like animals in some pet shops as food for exotic birds. They are tinier in size than mealworms, and I have offered them to various sorts of terrestrial urodela such as *Ambystoma*, Plethdontidae, and even *Hynobius*. Especially when raising juveniles of *Hynobius*, *Ambystoma opacum*, and *Macrodactylum*, such a food resource comes in handy. As in the case of mealworms, one should not feed solely these little worms, since they are rich in fat and are said to cause liver troubles.

Problems

Don't feed buffaloworms in polystyrene foam (for example, Styrofoam or Tempex) boxes: they will eat their way through, making little 'ventilation holes.' The danger with this is that they get eaten on the way by the salamanders, who at the same time devour the Tempex. This can lead to constipation and eventual death of the juveniles.

Beef heart

Beef heart can be purchased at a butcher shop or at the meat counter of a grocery store. It might not look or smell appealing, but it is a powerful food resource for salamanders. Some salamanders used for lab research are mainly fed on this. For the larger species, it's sufficient to cut the meat into little strips and move it in front of the animals. Most of them will react to the movement and snap at it (e.g., *Ambystoma gracile)*. For aquatic urodela, I cut the meat in pieces and stir it thoroughly until it becomes a paste. Then I take an ice-cube tray from the freezer and divide the meat into little portions and freeze it. From one beef heart you can get a lot of food. Fifteen minutes before you want to start feeding you can pick out one of the cubes and let it thaw (or put it in the microwave briefly), then divide it among the different tanks. The scent of blood will spread through the water and most of the newts react to it quite soon. Streamside salamanders, especially, are very successful in locating the prey and can react quite aggressively. I have successfully tried out this food resource with *Pachytriton*, *Paramesotriton*, *Neurergus* (*strauchi* and *crocatus*), *Cynops*,

axolotls, *Triturus*, and *Pleurodeles*, and even aquatic Gymnophiona such as *Typhlonectes compressicauda*. In Oregon (USA), we even barehandedly caught neotenic Dicamptodons this way. After a short adaptation period—to recognize and appreciate the food—most salamanders readily ate this food resource, which might just make the difference during the periods of the year when other supplies are unavailable (early spring and midsummer).

Problems

Water pollution. Leftover pieces of beef heart should be removed from the tank, since they pollute the water. This problem can be avoided by the introduction of meat-eating red water snails. In contrast with the other snails—who mainly devour plants—this red form prefers flesh. But, on the other hand, they might also eat some of the salamander eggs (e.g., *Cynops* and *Neurergus*). If you offer beef heart frequently, water changes should be performed on a regular basis, too.

Housefly maggots. This food resource still meets with much discussion; some people talk about the danger of perforated stomachs or intestines, other people just praise it. I will not take in a position in the debate, but can only confirm that, over the years, I have raised quite a lot of salamanders *(Hynobius, Neurergus, Ambystoma, Triturus, Pachytriton, Cynops)* on this easy and cheaply available resource without encountering troubles. Only the *Paramesotriton* are not too crazy about it.

Tip. From a urodela meeting in the Netherlands, I have the following practical tip from Edo Van Uchelen for actually raising your own maggots "a la carte." The advantage of the procedure is that you can raise them to any size you need, even very handy little ones (which are generally not available in pet shops).

Take some cat or dog food out of a can and put it outside in a sunny place. Be sure to keep the food wet when placed in the sun, and when you have dogs or cats in the environment, pay attention that they don't run off with all your efforts for dinner. On account of the odor, it's recommended that you place this somewhere outside. If all goes well, the flies will soon show interest and lay their eggs. After some days, you will get a not-very-good-smelling, moving jelly of crawling larvae and half-eaten meat. You can dip out the necessary portion of larvae daily by putting them in a little *Daphnia* net. By washing off the remains of the jelly under water (to prevent fungi from flourishing) you will get pure food for juveniles that you can safely release in the raising tank.

Water Sow Bugs

In standing water with much plant waste, especially, you'll find a lot of these crustaceans. In my garden, I keep a large plastic container (100 liter) filled with waterweeds and swamp plants. In the fall and winter these plants die off and pollute the water. An explosive culture of sow bugs follows as a reaction during the late winter and early spring. I offer these especially to my *Neurergus* species to enrich their diet. If they are small enough, they will also be consumed by the larvae.

Pill bugs, Rolypolys, Sow Bugs

These crustaceans can be found under pieces of rotten wood in humid and shady places. During the winter, I have even found a large aggregation pressed together between the roots of still-living trees. During other seasons, you'll probably find them in your own garden under stones and in moist wood, from which they are easy to remove. I feed them mainly to my land-dwelling species and even to land-phase *Triturus*. Since most of my tanks are configured in a natural way (with pieces of wood and ferns) and have at least five hours of lighting, the nonconsumed animals stay around and even reproduce in the urodariums, thus offering a large variety in size. This is very practical if you have young to raise. Refreshing with newly captured animals from time to time may be necessary.

Hyalella Azteca

Another good friend suggested to me a second unusual food resource: the American species *Hyalella azteca*. Some streamside salamanders young such as *Neurergus* and *Salamandra* larvae consume large amounts of these crustaceans under natural conditions.

These little crustaceans are much smaller then their European counterpart, *Gammarus*, which is not suited for keeping at room temperatures. Furthermore, transportation of *Gammarus* is not that easy either because they need much oxygen. In the USA and Canada, *Hyallela* is a much-used lab animal

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Typhlonectes compressicauda and shrimp.

for testing water quality. They are found in standing or gently flowing waters, where they live as sediment burrowers feeding on plant debris. Under favorable conditions, they can be present quite massively and are a good healthy nutrient for fish and salamanders. Adults measure from 6 to 8 mm.

Concerning Captive Maintenance

The optimal temperature is around 23°C, which, together with a 16-hour light cycle, will result in a large reproduction. Temperatures higher then 33°C are lethal. As food, you can offer them fish flakes, trout pellets, and even maple leaves.

I recommend that you give the animals a substrate in which they can hide. A piece of cotton or nylon nets are suggested in the literature, but some more natural substrate such as pebbles might work as well.

Finally, in water, salamanders act like little predators who will hunt down anything that is moving and soft enough to ingest, including their own larvae. Some (*Ambystoma*) salamanders are even the top predators in fishless waters. Aside from the above mentioned food resources, there are certainly many other prey that might be useful. This list is only meant to be a first practical step, mainly based on my personal experiences. As we encounter and use other sources, I hope to extend this list. If anyone else has other useful ideas and tips, feel free to inform me.

Raising Metamorphosed Juveniles

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When just metamorphosed, young salamanders undergo some quite dramatic changes:

Breathing. Breathing doesn't happen through the gills anymore, but through the skin and lungs. Their skin starts to change and dries out into a rougher, sometimes granulated, land-phase skin.

Weight. They no longer get help from the water pressure to carry the weight of their body. Their tiny legs are not used to such pressure, so moving takes up much effort.

Food. Most of the food they are accustomed to eat in the water will probably no longer be available on land, and they'll need to discover what to catch.

No wonder that for the first few days, freshly metamorphosed juveniles lie still and passively undergo these dramatic changes. It's only after a few days that they will start settling in to their new environment and begin to forage about.

Outside Enclosures

From a friend, I learned a nice trick for raising land-phase juveniles outside in the garden. It's not something extraordinary and difficult, but really quite simple. How is it done?

Use a large and deep (at least 60 cm) plastic box or dustbin, and turn it upside down. Cut a hole in the bottom of the box, but be sure to leave overhanging sides of about 5 cm or more. Then dig a hole in your garden somewhere in a shaded place (for instance, underneath a tree or shrub) and put the box in it, top down. After filling up the sides of the hole around the box again, you will have just created an escape-proof hole. For the first 10 cm of soil inside the box, I use leaf compost that I get from a wood or park. This normally contains little bugs and slugs. The rest of the box is filled with rotten wood, moss, and wood again up to 10 cm from the top. After this is

©Henk Wallays

An outdoor enclosure.

Indoor Terrarium

all installed, you can release your young salamanders into it and let them grow up. I've tried this trick with *Salamandra*, *Ambystoma*, *Triturus,* and *Cynops* species, and it worked real well in all cases.

Remarks

1. Take care that the ground is hard around the box, so that burrowing salamanders don't dig themselves out. Otherwise, you will need to set the box first on some iron fence or grating. It's important that the bottom be in contact with the soil, so earthworms can get in.

2. Go at least as deep as 60 cm if you want to keep your animals year round and frost free. This will also prevent moles from coming into the box to feast on what you've tried to raise so carefully. So if you can, avoid this drama.

3. It's important that direct sunlight doesn't shine right down into the box, since this would make temperatures rise pretty high, especially during summer weather. The shade will also help maintain enough humidity for both salamanders and prey.

Indoor Raising

Before you install your tank, you might consider posing to yourself the following question: What do young salamanders really need to develop well? Here so far are the answers that I have come up with: food, a hiding place, dry and wet places, and a good temperature. The latter, however, is something that will depend on the kind of species you are taking care of; young *Echinotriton/Tylototriton* and *Cynops ensicauda* for instance will not adore colder temperatures (less then 12°C), whereas species from other genera, such as *Notophthalmus*, *Salamandrella*, and *Onychodactylus,* will tolerate much lower temperatures, but will suffer from higher temperatures. For adult species, the preferred temperature might even differ depending on the elevation where they came from. So I'll leave finding the exact temperature to your experience with just this note: a "safe" temperature lies somewhere between 12 and 20 °C. If you're not sure about temperature, it's mostly better to err on the low side than on the high side.

Cynops / Paramesotriton / Triturus / Salamandra / Tylotriton

I have experimented with little raising "urodariums" that I install in the following way.

Soil and Food

As soil I use forest litter, which can be gotten from a forest or park. This compost-like soil contains many little insects, slugs, sow bugs, and worms. It even carries eggs of some little insects that will hatch and provide your youngsters with a rich variety of live food. Of course, I supplement this food and add mosquito larvae, little worms, and other little things that I can lay my hands on. Another important thing about this way of raising is that the young have to hunt for their prey and more or less carry out their 'normal' lifecycle. When do I refresh this soil? Well, after a while the soil will start to compost and will emit a thin smell of chloride. Then it's time to change it and replace with new soil. I also tend to add some composted peat that I buy in a garden shop. It consists of cut-up sphagnum, which is often used for flowering plants and fern cultures since it is light and holds humidity well. It also has another very interesting capacity: it's so acid that it will prevent development of some harmful bacterial infections in your young salamanders.

Tip. Write on your raising tanks how many little salamanders are inside, because when you refresh the soil, you really want to be sure you have taken all the animals out!

WET and DRY places
AKA the skin problem

My raising tanks are entirely closed off with a plastic plate; some have holes for air, others don't. In them I place a little plastic bowl with a sponge in it. In Belgium, they sell a kind of sponge with one rough side for cleaning cooking pans. It has a hard scrubbing surface, which I use as follows: the sponge is put in the plastic bowl, which gets filled with water up to 1 or 2 mm above the sponge level. With so little water there's no real possibility that your animals will drown, and they will be able to take up moisture when needed. Also, and certainly important for young, quick-growing salamanders, they need a place to change their skin, so they can use the rough surface to wriggle it off. The air humidity will get high from the evaporation of the water in the bowl. If during repeated observations, you find your youngsters congregated on the water or in the cool wet place just beneath the bowl, then you might consider keeping the tank a little more humid.

Hiding Places

In nature, young salamanders often metamorphose in large numbers. They are particularly vulnerable at that time and preyed upon by many predators, including rodents, large bugs, adult salamanders, and birds. At the time of metamorphosis, young fire salamanders, for instance, do not yet have the ability to produce the milky poisonous skin secretion and are thus quite vulnerable. Finding a shelter in which to hide and undergo metamorphosis is thus a priority. In captivity, the predators won't be there, as we know, but the little salamanders of course don't, so why not help them feel comfortable and put in some flat pieces of wood or stones for them. Put in some little things to create a dungeon-like shelter. By day, they will congregate under their shelter and only come out during the twilight hours to hunt for prey. I use wood, since it serves several goals at the same time: it's food for some of the little bugs and worms; it's rough, so it helps the young salamanders molt; and it soaks up humidity well.

Hynobius

Young *Hynobius* need to have an extremely wet environment. I use the following "paludarium" setup (a terrarium with both water and land area) to raise several pond-type *Hynobius*; in all of the cases where I used this approach, I never lost a single *Hynobius* juvenile.

Soil

The soil of the rearing tank consists of gravel and/or sand. On top of this, I add about one cm of water. When not on the land area, the animals are thus immersed, and, at the same time, there's little chance they will drown.

Land Area

Pieces of broken pottery and large flat stones can make up the foundations of the land area.[1] The idea is to create numerous

open places in between these stones as hiding places. From my lawn, I pick up moss polsters (spaghnum-like), which I use to blend in with and entirely cover the stones. In fact, it now looks as if you have created an emerald green island. Through the capillarity function of the stones, the water will reach even the highest stones, which will help the moss suck up the necessary water. On top of the moss and stones, you can eventually lay pieces of wood and plants. The whole terrarium is closed off entirely by a glass plate, making the air humidity very high. At night, when the temperature drops, you will see condensation on the glass. At the same time, by making the tank escape proof, the glass plate will also prevent your losing animals. *Hynobius* are the most likely to escape. If you want to make it all look natural, add a plant on top of the "mountain." A little plant that goes real well in such a setup is *Ficus repens*. Just take the plant out of the pot, wash the dirt off its roots, and put the roots in the water while laying the leaves on the land.[2]

Depending on the size of your setup, you'll finally end up with a rich variety of hiding places with a large variation in humidity and temperature.

Remarks

1. For my land area, I use large special insulating bricks made out of lava. They have the advantage that they are perforated with 1.5 cm holes for insulating purposes. These holes always prove to hold numerous young, especially around water level.

2. When introducing plants from flower shops, be aware that most of the soil contains fertilizer. When the fertilizer comes into contact with the water, it can pollute it to such a high degree that it will affect the development of eggs and (eventually) larvae. I always wash the soil off entirely, thus avoiding this trouble.

Food

Most of the time, *Hynobius* don't really move around a lot, but in the fall and spring, when

Hynobius tokyoensis juvenile

temperatures are between 12° and 16°, they are active and thus consume energy, so they'll need additional food. For this reason, freshly metamorphosed *Hynobius* young (metamorphosis starts around fall) develop a good appetite and should be provided plenty of food. If this need is not respected, they will start to supplement their diet with their younger brothers or sisters!! Since *Hynobius* are rare species in the hobby, we might try avoiding this state of affairs. *Hynobius* juveniles are not too difficult when it comes to food: anything that fits in their mouth and that's not too hard will get inside. I've fed them on buffalo worms, fly maggots, bloodworms, and, of course, the main dish—earthworms. Curiously enough, introduced slugs wandered around the tank for days. When raising young *tokyoensis* in 1997, I offered two medium-sized earthworms to each animal every two days. The animals doubled their size in just over a month! In this way, my one-year-old young were able to attain the length of three-year-old wild-captured animals (study by Kusano). So, don't neglect food. If you have put plants and wood on top of the island part, introduced buffalo worms will stay around, as will earthworms, even though they could escape.

Neurergus

The Eurasian salamander genus *Neurergus* includes very colorful species, which, through the efforts of some German herpetologists, have found their way into salamander husbandry. Not that many people keep these precious yellow diamonds, and I'm quite pleased to be keeping both *strauchii* and *crocatus*. In large contrast to their beauty stands the fragility of the animals, however. Evolutionarily, they diverged from the genus *Triturus* some 40 million years ago and adapted themselves to flowing-water conditions. I have been lucky enough to breed *strauchii* for three consecutive years; this last year I even obtained a fall and spring reproduction from my only couple. Because of the rarity of the genus and the scarce reports on its reproduction, I will describe both the approaches I used for raising juvenile *strauchii.*

Wet Approach

Following the guidelines of the original keeper of my animals (which are already F-4), I kept my *strauchii* in the following setup: the soil consists of gravel, above which is a little layer

Neurergus crocatus

Neurergus strauchii male

of water (from 2 to 5 cm deep). An island of stones takes up a third of the tank. Some of the stones are placed so that they lean down into the water with another one hanging over the top (like an umbrella). Some moss (*Fontinalis* sp.) will at the same time purify the water and prevent the crawling animals from drowning. Young *strauchii* tend to drown even in shallow water. *Ficus repens* on top of the stones both creates extra shelter—necessary to offer the juveniles peace of mind—and gives your setup an appealing look. The tank is sealed off entirely; the environment is very wet. Since *Neurergus* are found in lime-rich environments, I introduce some sand consisting of crushed shell into the water. Any pet shop should have this sand, which is most often used in canary cages. The crushed shells make the water hard. In this setup, my limited captive-bred *strauchii* of '97 and '98 grew up quite well.

After reading some reports and discussing the matter with other keepers at the annual Urodela meeting in Gersfeld, Germany, recently, I was told that both adults and juveniles in fact did better in dry air, and that I might wish consider not closing off the tank. Since I had frequently found the juveniles congregated in the driest parts of the tank with only rare visits to the water to feed, I decided to try it out.

Dry Approach

Fill a 60 by 40 cm tank with a mixture of washed gravel and shell sand, adding only about 5 mm of water, just enough to cover the gravel and keep the humidity high in the lower part of the tank. Fill the whole tank with the insulating bricks in between which carpets of moss can be "woven." In a way this setup is the same as for *Hynobius*, but less humid. Again place a *Ficus repens* on top of this emerald green island. The tank is not entirely sealed off. Instead, the covering lid has an opening in the middle for fresh (dry) air. This difference causes the tanks to have a very dry upper level (with the heating of the

TL lamps) and a moisture-saturated level in the bottom. Two animals from the 1999 breeding (out of 24 juveniles) were first introduced to this "dry approach."

Comparison

During August '99 I compared the animals in the "dry" tank (group A) with those in the "wet" tank (group B). Both the A animals were larger than any animals in group B. They even surpassed in length the offspring from the 1998 breeding that were one year older. During my repeated observations, they have always been found in the dry top layers with nicely filled bellies. In both setups they always seem to hide in the holes of the bricks.

Food

Food offered consisted of buffalo worms, (little) fly maggots, bloodworms (offered both on land and in the water), little earthworms, millipedes, and slugs. All of these "happily" disappeared. These species are not as aggressive when feeding as other newts. Whereas *Cynops* and *Triturus,* for instance, snap at each other (to preserve discovered prey for themselves), this rarely occurs with either of my *Neurergus* species.

Personal Note

The general idea of this article is to give some suggestions for raising young terrestrial salamanders. It is restricted to my own captive-breeding experiences, with the addition of some literature studies and personal communications with other urodele keepers. With time and experience, new techniques might be added/discovered. Despite all efforts spent raising young *Paramesotriton,* for instance, it still seems to be a troublesome experience: especially the terrestrial phase is very critical, and most commonly offspring are decimated during this period. Although one Belgian specialist in the field has succeeded with third generation reproduction of *hongkongensi*, the raising of juvenile *caudopunctatus* and *chinensis* is still not optimized or even known. More observations and experiments on soil pH, temperature, and food could reveal worthwhile ways for enhancing the success ratio. But such data are very scarce, at least at this moment. There's still much interesting work to do. Constructive comments on these topics are always welcomed.

Practical Axolotl

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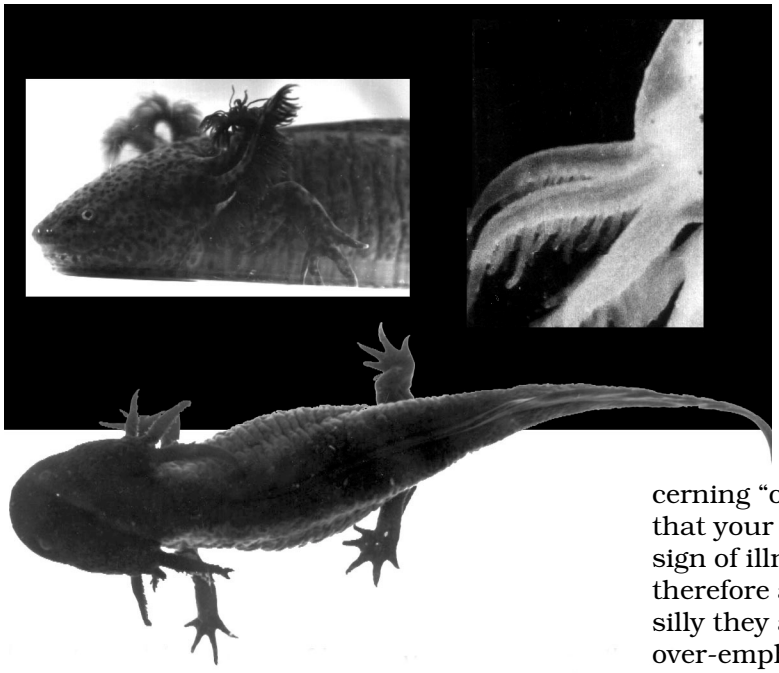
I have received hundreds of calls and emails over the years from researchers, teachers, and pet owners who want to know "Is my axolotl sick?" or "What should I do?" or "Can I give it something?" Sometimes their animals are not eating, sometimes their axolotls are floating, sometimes the axolotls just don't seem quite right. When this happens, people want to *do* something that helps. And it is very tough for people to go out and find someone or some book that has much to say about salamander medicine, let alone axolotl medicine! I am afraid that even I haven't always been much help over the years, since my experience with what can be done for a colony of 600 adults has very little to do with what the average axolotl owner with only a few animals in the lab or at home can do. I catch myself saying, "Well, in that situation, with those symptoms, we usually give antibiotics." "How?" "Well, we inject . . ."



The top pictures are of healthy gills and healthy gill posture. The lower picture shows raggedy gills with many missing filaments and twisted branches.

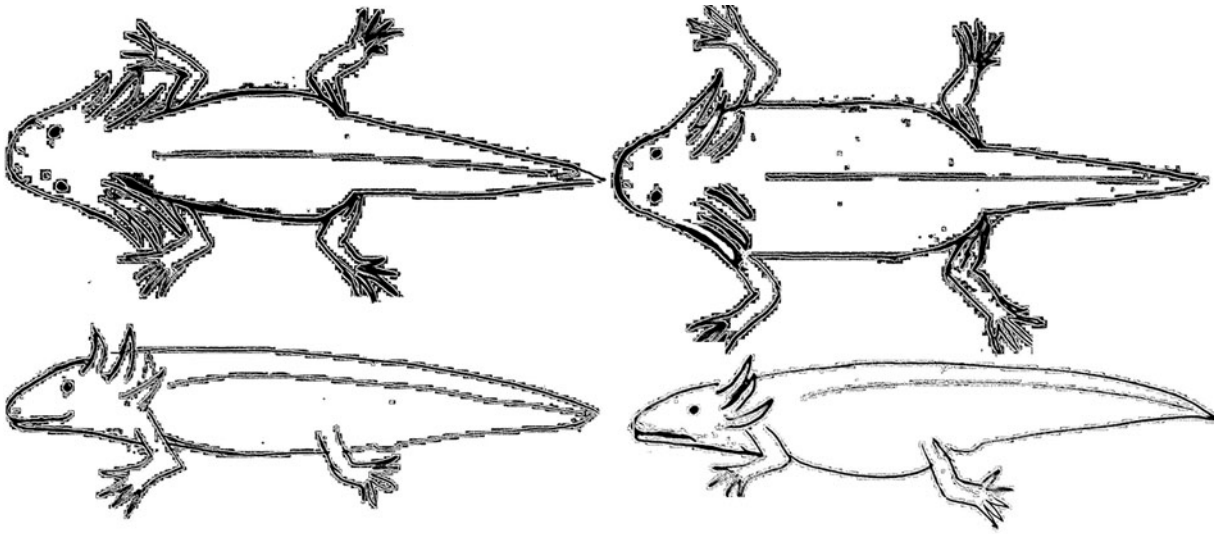
Alerted to the need for more practical advice by an increasing volume of email and calls, I decided to write this article. I will describe signs of illness in axolotls, tell what to do immediately and how to go about selecting a treatment, and mention a few treatments from a local pet store that I have tried and know are safe.

Signs of Illness

The easiest way to tell if an axolotl is sick is by noting changes in its eating habits. If the animal is stressed because of infection or water quality, it will probably stop eating or reduce the quantity it consumes before other symptoms become obvious. On the other hand, if you think your animal is ill, yet it is still eating, then you can probably safely assume that it must not be too sick and that you have caught the problem early.

Floating or "tilting" in the water can be a sign of systemic problems. This behavior is different than the axolotls' "hangout" posture, in which they appear to be suspended midtank. *Hangout* is normal axolotl behavior. When floating is a symptom of illness, the axolotl looks a bit hunched, sometimes with its back or tail out of the water at the surface. It seems sprawled out. Often it looks like it is leaning on one side. These signs can be an indication that there is some infection either effecting the animal's equilibrium or producing extra gas.

Poor gill condition is an early sign of poor water quality, but it can also be an early sign of stress on the inside. Continuously pale gills (more obvious on white and albino axolotls), overgrown gills, and limp gill posture can all be signs of infection. There may be times when your animal's gills are pale, but a few hours later you note that they are nice and pink or red again. This is normal. Concerning "overgrown gills": please don't think that your animal's beautiful healthy gills are a sign of illness! Gills that are overgrown (and therefore a sign of possible trouble) look sort of silly they are so large, like a caricature that over-emphasizes key features. We think animals with overgrown gills are compensating for other internal problems. Overgrown gills don't happen overnight, but if you don't look at your animal very often it may seem that way!



Poor skin condition is usually a sign of more advanced illness, unless you are talking about damage from dirty water or chemicals. Skin that has a grayish cast (on dark animals), blisters or open sores, or pale white patches, or skin that is too red (in the case of whites or albinos) or too yellow or white (again, in the case of whites and albinos), can simply mean that you have a parasite you need to get rid of, or it can mean that you are seeing signs of advanced systemic infection.

If the shape of your axolotl's body is your first clue that something is wrong, then there is a good chance that it is too late. Bloating of the abdomen or tissues is a sign of fairly advanced illness. Please don't confuse a well-rounded female filled with eggs with a bloated, sick animal. Bloating makes the animal look sort of like a balloon with legs. The skin feels tight when touched, and the balloon-effect is apparent on the underside as well as side to side. Swelling is most obvious in the limbs and neck area, where the tissue will look puffy.

If you find blood in your axolotl's water, don't panic. It could just be a simple injury. If the axolotl is housed with other axolotls and a gill gets nipped, the gills will sometimes bleed and bleed, but ultimately be OK. However, some parasites can cause localized bleeding. And there are some internal infections that make the skin more fragile and susceptible to injury and to parasites and bacteria in the environment.

You will notice most of these symptoms only if you have a very good idea what your axolotl looks like when it is healthy. For example, you can't tell if an albino is too yellow unless you know how yellow it was in the first place; you can't tell if it is eating well if you don't watch it eat every once in a while when it is healthy.

Practical Refrigeration

Now, what to do with the diagnosis of a problem? As soon as you decide that there is definitely a problem, or even if you suspect one, put the animal in the refrigerator and get it cooled down. Cooling the animal slows the animal's metabolism and the progress of the infection. Cooling the animal helps the animal get better, but we aren't sure why. We know from experience that refrigeration has saved animals that would have otherwise died. It could just be because it lowers the level of stress that the animal is experiencing. It could be because there is more oxygen dissolved in the water. It could be because it creates conditions unfavorable to the bacteria in the axolotl's environment. Whatever the reason may be, cooling the animal is the best and easiest way to give your axolotl a chance.

Here at the Axolotl Colony, refrigeration for every axolotl illness and injury is a very practical solution because we have a refrigerator

dedicated to axolotls and their embryos. However, since this article is dealing with practical solutions for the reader, I want to talk about practical ways of refrigerating your axolotls so that those of you who are squeamish about putting your animal in the fridge may give it a try. Find a plastic bowl or bucket with a lid. For adult axolotls, one-gallon (about 4 L) ice cream buckets work very well, as do large margarine containers. Remember that the cooling will slow down the animal's metabolism, so having lots of space isn't all that necessary.

Fill the bowl with 1.5-2 L of water (approximately 0.5 gallon), put the sick animal in and put the lid on. When we were kids, we were all told not to put the lid on tightly or to punch holes in the lids of containers holding the various poor critters we caught and stuck in jars. But it will be OK for your axolotl to not have holes. You wouldn't want to stick your animal in the fridge, then totally forget about it, of course, but remember that (1) when cooled, the axolotl needs less oxygen because its metabolism is slowed, and (2) when it is cold, more oxygen is dissolved in the water. So if you take the axolotl out every few days to change the water and feed it, there should be plenty of oxygen for the animal. In this way, if you are squeamish about salamanders in the fridge you don't have to worry about amphibian water being splashed on your food. If you really feel a need to put holes in the lid, just cut some slits or a small hole with a knife in the center of the lid to minimize escaping splashes.

After refrigerating the axolotl, you may want to watch it for a few days to see how it does before proceeding to other treatments. You may suddenly find rocks in its bowl, for example, and voila! There's your problem. If you are sure it is something more serious, then pack up and head to the pet store to browse through the available treatments.

Practical Pet Store

Your choice of a treatment will depend on your diagnosis of the illness: systemic infection or localized infection or injury. Shopping for medications for aquatic animals can be quite a trial—I discovered this when doing the research for this article! Here are some tips on buying safe treatments for your axolotl.

First, never buy something that doesn't list the ingredients very clearly. I was shocked at how many products don't have ingredients listed. I also found this problem when doing searches for medications on the Internet. The same medicines were there, but I could not read the package in the picture, and the vendors most often didn't volunteer this information on their sites. If you know exactly what you are looking for, the Internet can be a convenient source, but it is definitely not good for browsing and choosing the right treatment. The most helpful site I found is Noah's Pets (http://www.noahspets.com), where they list what chemicals are used for what bacteria/fungi/parasites and then what medicines contain those chemicals.

A second tip when shopping for treatments for axolotls is to avoid treatments containing any of the following:

copper
other heavy metals in long-term treatments
acriflavin, if you are treating white animals
tetracycline or related antibiotics
(for instance, doxycycline or oxytetracycline).

Effective treatments for axolotl disease might contain

nitrofuran derivatives
(Nitrofurazone, Furazolidone)
naladixic acid
formalin
sulfa drugs
(sulfamethazine, sulfathiazole, sulfacetamide)
sodium chloride or other salts

I tested lines of medications from Aquarium Pharmaceuticals and Jungle because they seemed the most basic of all that was available at the stores where I shopped. Nala-Gram, E.M. Tablets, Triple Sulfa, Furan-2, and Fungus Eliminator tested safe at one, two, and sometimes three times the dose listed on the package. I tested double and triple doses because the doses listed on the packages were often well below the recommended dose for amphibians for these medications (See Table 2 for comparison). These medicines are all designed to go right into your aquarium, so multiplying the dosage might disturb the balance in your aquarium. Or, if you have fish in your tank, it might not be good for them. It is a better idea, when treating an axolotl, to remove it from the aquarium into a bowl by itself. The catch here is that the available medications are all premeasured for 5- or 10-gallon volumes (about 19 or 38 L, respectively), and you only

Table 1. Recommended Doses

Drug	Dose	Regimen
Naladixic acid	10 mg/L[1]	Bath
	24mg/L[2]	Dip for 24 hours every other day
Nitrofurazone (in Furan-2)	10-20 mg/L	bath, change daily
Sodium Chloride	2 g/L	Housing water
	4-6 g/L	Bath for 1 week
	35 g/L(1)	dip 10 min
Artificial sea water	35.8 g/L[3]	Dip 10 minutes, every other day for 3 doses
Formalin 10%	1.5 ml/L(1)	dip 10 min every 48 hrs
Sulfamethazine (in Triple-Sulfa)	1 g/L	bath, change daily
Gentamicin (or Amikacin)	10 mg/L*	dip, 1 hr/day
Enrofloxacin	10 mg/L*	dip, 1 hr/day

1. Modified from *Kirk's Current Therapy XI Small Animal Practice* (1) R.W. Kirk and J.D. Banagura, Eds. W.B. Saunders Co. ,1992
2. Dr. Heather Eisthen, Michigan State University, Web page on the treatment of "red leg" (*Aeromonas* infection) in axolotls (http://www.msu.edu/user/eisthen/lab/methods/animalcare/redleg)
3. Dr. Heather Eisthen, Michigan State University, Web page on the treatment of *Columnaris* infection in axolotls (http://www.msu.edu/user/eisthen/lab/methods/animalcare/columnaris)
* Gentamicin and enrofloxacin (Baytril) are effective against *Pseudomonas*, a common pathogen. They are not available except through a veterinarian. I know that the doses listed are safe from our experience with them in the Axolotl Colony.

need about 1/2 gallon (about 2 L) of water in the bowl. There are a few ways to handle this:

1. Find a large container in which to make the medicated water in the volume specified on the package, then fill the bowl from this larger container each day until the treatment is finished.

2) Make a concentrated stock solution by adding the dose to 1 quart (this makes a 20X solution) or 1 liter of water. For example, if the medicine is packaged for a 5-gallon volume, add 3 fluid ounces of stock solution to the 2 quarts of water in the bowl (don't forget to treat the water for ammonia and chloramine also!). If the medicine is packaged for a 10-gallon volume, you need to add 1.5 fluid ounces of stock to the bowl. If you are working in liters, add either 100 ml to 1.9 L or 50 ml to 1.95 L water in the bowl. Keep in mind that these calculations are designed to achieve the recommended dose for fish, which is safe for axolotls, but not necessarily therapeutic.

3) If you decide to increase the dose, you can modify the above by adding more tablets or capsules to your treatment water or by using more of the stock and less fresh water.

For those of you who want to do the math, Table 1 shows some doses that have been recommended for axolotls.

All of these products contain antibiotics or antimicrobials. They may be effective for localized skin infections at the dose on the package, so if you are worried about skin infections as a result of irritation or injury, try that dose as a safety precaution to prevent infection. Say you walk up to your tank one day and you notice suddenly that your animal has dropped all of its gill filaments, the gills are limp, and the animal looks stressed. This probably means there is a water problem. The problem could be chemical contamination, the proliferation of bacteria or parasites, or too warm a temperature. Correcting the water problem is a must, of course, but you should protect your animal from opportunistic bacteria that might attack its damaged skin. Refrigerate the axolotl, select one of the treatments listed above, or another with similar content, and use it for a week, maybe in conjunction with a water conditioner such as Novaqua or StressCoat, which are designed to reinforce the natural slime coats of aquatic animals. Then give the axolotl nice clean water until you have determined the cause of the initial problem and corrected it. I would follow this same procedure for an injured animal.

Adding salt to the water is an excellent thing to do for animals with skin problems. You can use any of the commercial aquarium-salt products, sea salt, or even just non-iodized table salt. One to two teaspoons (5 to 10 cc) of salt in a gallon (about 4 L) of water will help to keep bacterial levels low, and

axolotls can live in this slightly salty water indefinitely. For serious skin problems, a strong salt-water dip is one of the best and safest things you can do (see Table 1).

To treat for systemic infection, you will need to increase the listed dose for most of the pet-store medications (see Table 2). If you notice that your animal has stopped eating, is floating or tilted in the water, has limp gills with no apparent damage, or other symptoms of illness, separate the animal from other axolotls, refrigerate it, and treat it with an antibiotic. Salt can also be added to reduce the titer of bacteria in the sick animal's water. This way its body can concentrate on healing inside. If you need help coming up with the right dose, please email me (sjborlan@indiana.edu), and I can help you figure it out.

Another chemical that I haven't mentioned yet is Mercurochrome. We use Mercurochrome routinely at the Axolotl Colony for skin problems or injuries. If an animal develops skin sores, or it has been injured by a tank mate, I isolate the animal and give it a few drops of Mercurochrome tincture. It is hard to recommend this to people, because it isn't readily available, and people often confuse "methiolate" with Mercurochrome. You do NOT want to give your axolotl methiolate!

Mercurochrome can be purchased from Sigma online. A small quantity will go a long way. Add a few crystals to a small bottle and fill it with water. Use an eyedropper to add some of this tincture to your axolotl's water, stirring between drops. The water should turn a peach color. You can make the solution stronger, but you should then limit the length of time in the solution to 2 or 3 days. Mercurochrome can be used in combination with salt. For serious infections, follow with an antibiotic treatment or, for parasites, a chemical such as formalin, which is also available at pet stores.

Practically the End

I think that it is important to recognize that there are all kinds of disease-causing bacteria and parasites in the axolotl's environment at all times. As long as the axolotl is healthy, it can fight off these bacteria and not be overwhelmed by the parasites. However, even minor stress can eventually bring down the animal's immune system. If your tank is a little too warm, for instance, or it has low levels of chlorine, or ammonia occasionally builds up to dangerous levels, the axolotl(s) may not be killed right away, but opportunistic bacteria may take hold. The axolotl may not be able to fight off the disease while still under stress. Please remember that preventing disease in axolotls is easier than curing it.

It is also important to realize that one illness may cause a different illness. If you are treating an axolotl for systemic infection, you still need to give it clean water and watch for skin problems. Or, if the axolotl has had parasite problems, they may have led to a systemic infection.

And, remember, it all takes time! Your axolotl won't be frolicking around the tank in a day. It may take weeks to get back to normal. The resumption of normal eating will be your sign. Good luck. Write to me if you have any questions.

Table 2. Package-Recommended Doses

Brand Name	Drug	Dose on Package	Recommended Dose
Triple-Sulfa	Sulfa Drugs: sulfamethazine	4.3 mg/L	1 g/L
Nala-Gram	Naladixic Acid	5.3 mg/L	10 mg/L(1)
Fungus Eliminator	Nitrofurazone Furazolidone Sodium chloride	Specific mg not listed	
Furan - 2	Nitrofurazone	1.6 mg/L	10-20 mg/L
Dr. Wellfish's Aquarium Salt	Sea salt	Tonic Dose 1.3 g/L	4-6 g/L

Instructions for Contributors

Contributions pertaining to axolotls or other urodeles or more generally to amphibians are welcome. All of the following categories are encouraged:

short reviews
research notes
technical comments
material requests or material available
announcements
inquiries for information
colony descriptions or directories
disease control notes

Authors are encouraged to submit line drawings, diagrams, or photographs to accompany the text.

The Axolotl Newsletter is an informal, non-peer reviewed, online publication. Contributions should be written in a style appropriate to both the nature of the material and the character of the Newsletter. The contribution need not be based on new research, but may be a distillation of previously published work.

There is no predetermined length, but please inquire before submitting a manuscript longer than 15 pages (250 words/page). Manuscripts are not cut to fit space.

Copyediting will be minimal. Ordinarily, only typographical and spelling errors and grammatical mistakes will be corrected. More extensive editing (e.g., for correct English) will be done if the author gives permission.

Manuscripts should be submitted on disk or as an email attachment. Both PC and Macintosh disks are accepted.

Any computer-produced graphics should be sent as separate files (TIFF, JPEG, GIF, or other standard format). Please indicate the type of file by an appropriate extension or other means.

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