Beginning with Killies

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Forward

This series of articles was originally prepared for the BKA Killi-news. In preparation for publication here, it was reread and as per usual, I found bits of text I did not like, or thought something was not just quite right (or totally wrong) and needed to be fixed. In some places I have included additional information. My first points are these: don't take what I write too seriously; and test the information in this article for yourself. In biology, there are no hard and fast rules or guides that will work in every situation. That is all part of the beauty of life, the appreciation of which is what killifish keeping is about.

I have only included references for contentious issues, disputing current lore; or where something specific was required to substantiate my suppositions. My ideas and observations are indicated as such, otherwise the content can be assumed to be second hand.

No doubt, the next time I reread this text I will make further modifications. Perhaps the next information addition will stem from observations you contribute.

Happy killifish keeping!

Part I

What you need to get started

Obviously a fish tank.

Your choice of tank will determine what fish you will keep. Big tanks are good for big fish, and small tanks adequate for small fish (although small fish do much better in big tanks). Most killifish are reasonably small (about 5 cm) and a tank of about 40 L is acceptable to begin with. Such a tank will provide a comfortable home for a trio or small group of fish.

Your fish tank must have a tight fitting lid with no gaps nearly big enough for a killifish to fit through. This is very important as killifish have a wicked tendency to jump through narrow gaps, land on the floor and die. Such victims are almost always very rare and/or costly to replace.

Decoration need not be extravagant with plastic model castles and neon colored plastic plants. Keep the tank simple. For many species you may have to start collecting eggs, and the more spawning substrates there are the more difficult it will become to find the eggs.

I like a tank with a stand of Java fern and/or some Java moss. I'm particularly fond of tying the *Anubias* and/or Java moss to pieces of drift wood or stone. The fish are less likely to spawn against it, and it is easily removed from the tank if need be. It also looks very attractive. Some floating plants in the form of hornwort, *Elodea* or *Riccia* is also a good idea. This may provide cover for fry that hatch out in the parent tank. The substrate can be left as plain glass but a thin layer of fine sand, peat or gravel looks better. Some people dispute the need for lighting but I find that fish seem more comfortable and relaxed in a well lit tank.

A good filter is not mandatory. If the tank is lightly stocked partial water changes maybe all the filtration you need. That said, having a sponge or box filter in the tank does not hurt the fish. Strong aeration is not needed, just enough to keep the filter ticking over. An under-gravel filter would be fine, as would be a small external (provided it cannot suck up the fish). I prefer to allow the plants to do all the filtration, as they are very capable of clearing the water of ammonia/ammonium and other pollutants. (See Diana Walstad's 1999 book: *The ecology of the planted aquarium*, Echinodorus Publishing).

Water changes are essential to maintain good growth and health of the fish. For many fish, this is an essential trigger for spawning.

Do not worry too much about pH and hardness. The pH can be prevented from dropping too low with water changes, and fiddling with it if it is too high only creates problems for you and your fish. The fish can rapidly adapt to changes of pH, but try to keep the hardness stable. Constant hard water is better than fluctuating hard/soft water. This can cause serious damage to the fish's gills. Such damage is generally fatal to fry.

Most killifish are quite adaptable in respect to water

Most can tolerate temperatures between 19 and 26° C. Do not expect most to breed at 19° C and some may not like it as high as 26° C. I aim for 24° C for most of my fish tanks. When changing water it is again important that temperature difference not be too large. While adult fish may not suffer much from such abuse, young fish and fry can be killed.

As regards feeding, a varied diet is best. Most commonly available killifish will take flake and granulate food (such as sold by Tim Addis at http://www.killifish.f9.co.uk/killifish/killifish%20website/index.htm). (A similar product of equal proficiency is available via South Africa's Dirk Bellstedt, based at the University of Stellenbosch's Biochemistry Department.) Supplemental feeding with live or frozen foods (mosquito larvae, bloodworm, white/grindal worms etc. . .) is a good idea. *Daphnia* is a firm favorite for most fish and serves as an excellent healthy treat.

Remember the more fish, the more you feed, the more water changes you need to do!

This is a very general layout of the basic needs of killifish. In the next part I will discuss some reliable beginners fish and the subtleties of their care.

Part II
Some good beginners fish

Once you have a fish tank you will need fish!

There are many killifish suitable for the beginner. Most do not require much more effort to maintain than other types of fish. You need to feed them correctly, change the water and so on. What follows are a small selection of fish I would give to a beginner to experiment with and gain experience.

Fundulopanchax gardneri

This is one of the most splendid killifish there is. It is colorful, active, not fussy about its food, breeds willingly and can tolerate a wide range of water conditions.

Males reach about 7 cm and can be a bit belligerent towards one another. They are not seriously aggressive but can nip and tear each other's fins. Males can often harass the females but I have never had fatalities.

They can be setup in a tank described in Part 1 without any worries. You will not need to collect eggs as the parents (normally) will not molest their fry. Very quickly the tank will be full of fry if you take good care of the parents. The fry are also very easy to raise. They will take the same food as the parents.

Aphyosemion striatum

Some people would recommend *Aphyosemion australe* to a beginner but there are some poor quality strains that produce fish that will resist breeding efforts regardless how well you treat them. *Aphyosemion striatum* is a guaranteed breeder and like *Fp. gardneri* it (normally) will not molest its fry.

They are very colorful with flanks of neon blue-green and crimson red. They are active fish that are not shy. These fish prefer not to be kept too warm. They prefer to be kept at about 24° C, but do not seem to suffer at 26° C. They can be a bit more picky in diet, but soon come round to a high quality flake food. The most important thing to remember is to keep the tank covered as *A. striatum* like to jump!

Epiplatys dageti

This is one of those popular fish that every now and then floods the market and then vanishes for a time before again flooding the market. It breeds very easily. So easy it is prone to neglect. A pair will quickly fill a tank with fry.

The young fish are brightly colored with contrasting black/blue-green bars. This contrast fades in adults while the fins remain a lovely yellow with blue edging. The throat of the *monroviae* subspecies is orange to red. They are active fish that cruise around beneath the surface of the tank. They do no pass up anything resembling food.

They tolerate a wide range of temperatures but do best at 24° C and above.

The most important thing with this fish is to keep the fry ticking over. Old fish loose fertility and after a time cease to produce eggs. Unless you have young fish available you will loose the strain. Young pairs seems to produce more females than males, and older pairs seem to produce more males than females—at least when comparing broods between myself and a nearby friend using the same quality water.

Simpsonichthys whitei

This is what is termed an annual killifish. It will lay its eggs into the substrate (in fish tanks we use peat), the water will evaporate or drain away and the eggs will incubate over the course of several weeks until the rains come, the pool floods and then they will hatch and begin a new generation.

While the previous three species came from Africa this is a South American fish (Brazil). It reaches 10 cm in size if fed well and given adequate water changes. It is chocolate brown with a myriad of blue-gold spots decorating its flanks and fins.

Males will spar, but not generally cause serious injury. Females are plain and inoffensive. Males will entice the female to the spawning receptacle wherein both will dive into the peat and spawn. Once every week or two the peat is collected, dried and stored till the incubation time has elapsed.

On hatching, the fry are large and enjoy copious feedings of baby brine shrimp. They will do equally well on crushed flake or powdered foods. The adults are equally unfussy about what they eat. They fare well on a diet of *Spirulina* flake.

Nothobranchius foerschi

This is another annual killifish, this time from East Africa (Tanzania). This fish sports a yellow body with blue iridescent scales decorating its flanks. The caudal fin is scarlet red, and the anal and dorsal fins yellow with narrow red streaks. The males can reach about 5 cm in total length. Females are smaller and plain olive in color.

This fish is peaceful and undemanding to care for. It will take flake and temperatures down to as low as 16° C and still spawn. It is sensitive to velvet disease. Velvet can be warded off with the addition of 1 teaspoon of salt per 4 liters of water. This need not be added if an extra special effort is taken to keep the tank clean.

These fish are spawned over peat and the damp peat incubated until the eggs are ready to hatch (eyed-up). The fry are smaller than those of *Simp. whitei*, and will need feedings of newly hatched baby brine shrimp. Growth is rapid.

These are the beginners fish, fish chosen to get your started. Once you are done with *Fp. gardneri* you can try something more challenging such as *Fp. spoorenbergi*. *A. australe* or *Chromaphyosemion bitaeniatum* are a good next steps up from *striatum*, which is already more challenging than *Fp. gardneri* (if but only because of its acrobatic skills). There are many *Epiplatys* species, but *dageti* was chosen because it teaches one that while a fish may be “easy” to care for and breed, effort is required to keep the colony ticking over. *Simp. whitei* and *N. foerschi* are two of the most undemanding annual killifish. There are many many more and few are fundamentally more difficult to care for. In truth most killifish are suitable for the beginner.

All the species mentioned above are in South Africa, distributed among the handful of killifish keepers scattered across the country. If the fish you desire cannot be obtained locally there are resources available via the American (AKA) and British Killifish Associations (BKA) which are easily located using Google. Another option is http://www.aquabid.com.

Not much attention has been paid to collecting and incubating eggs nor caring for the fry. This will be the topics of the next three Parts.

Part III
Non-annual egg collection

I cannot think of any killifish that needs extra special encouragement to spawn. Most are very eager spawners once their needs are met. The only snag is finding their eggs, incubating their eggs and raising the fry.

For non-annual killifish three basic methods are used to breed killifish. Each method has its pros and cons; and may not be suitable for each and every species.

The permanent setup

In this method you place a pair or small group into a spacious well planted tank (i.e. wall to wall Java moss with some surface plants). You feed this group a varied diet including baby brine shrimp. After some time young fish will appear out from among the plants. You may be lucky to see fry scooting in and out among the surface plants.

These young fish can be caught out or left to grow and mature with the parents. Leaving the young fish with the parents is risky as most juveniles will prey on their younger brethren. In general the fish that grow up with their parents are stronger, healthier fish. A self sustaining colony can be established of many different aged fish.

This method has worked well for me in respect to *Chromaphyosemion poliaki*. Two pair I begun with rapidly reproduced (in a small tank) to produce many young fish of various ages. After a while production stopped. As the numbers of the group decreased, new fry began to appear. Similar success was had with *Epiplatys dageti* and *Fundulopanchax gardneri*.

This method works well with many of the *cameronense* type fish of the genus *Aphyosemion*. Another good candidate is *Pseudoepiplatys annulatus*. I have heard reports of success using this method for most of the *Aphyosemion*, *Chromaphyosemion*, *Diapteron*, *Fundulopanchax* and *Rivulus* species. In many cases this only works if the colony is begun with a single pair. Bill Shenefelt (AKA) supplies such useful data at: http://shene.killi.net/Articles/shenebreedingfish.htm.

The temporary spawning setup method

In this method you select a pair or small group and set them up to spawn in a tank. You fill the tank with plants (Java moss) or include a thin layer of gravel or peat for a spawning substrate; allow the fish to spawn and then remove them after a week. Then you patiently wait for the fry to emerge.

It often helps separating the genders for a while before putting them together to spawn. This way the females can be bursting with eggs.

This method is often very effective in breeding fish such as *Aphyosemion australe* and *Fundulopanchax gardneri*. Weeks spawns exceeding 200 fry are not unheard of. This method works well for “switch spawners” such as *Fundulopanchax* and *Raddaella* (the *Aphyosemion batesii*-group).

For strict plant spawners such as *Epiplatys dageti*, the plants can simply be moved to a new tank and fish left where they are.

The hands on approach

In the two previous methods you never touched an egg and probably never saw any either. Sometimes you want to know if the fish are spawning and if the eggs are fertile. For this purpose you need to construct an artificial spawning structure for the fish to lay their eggs on. We call the structure a *spawning mop* (and it literally looks like a little mop).

Acrylic yawn is best. Obtain a book (Herbert Axelrod’s *Community Aquariums* works well with its dimensions of $23 \times 13 \times 1.5$ cm but his *Breeding Aquarium Fishes* may be more informative) and wrap the yawn around it about 50 to 100 times. Tie one end with another piece of yawn and cut the other end so you have the threads of yawn tied together in the middle. Fold the threads so that the tied part (the top) is opposite to the loose ends (the bottom). Now take another thread and tie all the threads together about 2 cm from the top. Tie the threads together again about 1 cm lower than the second tying. Now you can attach the flotation device: a cork or piece of styrofoam. Take a piece of thread, attach it to the top of the mop and tie it to the cork etc. . . Or, you can just toss in the mop as it will sink to the bottom of the tank where some fish will spawn in it all the same.

Before using the mop, boil it with some bicarbonate of soda to get rid of the excess dye. This may not be necessary with today’s color-fast dyes, but it is better to be paranoid than sorry. Boiling also forces out the air between the fibers enabling it to sink.

When choosing the color of the yarn you are going to use, get two colors rather then one. I have observed that a combination of dark and light threads yields the best results for me. Dark blue or green yarn in combination with tan or cream yarn works well.

Picking eggs is straight forward. Remove the mop (being careful not to remove any fish), give it a firm squeeze to shed any water and leave it to drip dry for about

10 to 15 minutes. While this is happening wash your hands and make sure to rinse them free of soap.

Begin to examine the mop strand by strand. The eggs are plainly visible to a keen eye. Gently pick up the egg with your fingers. Some species prefer to spawn near the top of the mop (sometimes on the flotation device!) while others will spawn near the bottom. Many like to spawn near the knots in the mop wherever they may be.

These eggs can be placed in shallow trays or tubs. I like to put the eggs on top of Java moss or in to shallow peat slurry and then float the small tray in the spawning tank to supply fresh clean water of the same source and avoid any temperature fluctuations. The addition of some methylene blue to stain dead eggs (for easy recognition and removal) as well as increase oxygen supply is helpful.

The rate of egg development will depend on temperature and the genetics of the fish. Fry that hatch in the tray can be removed with a spoon or other scooping device. The fry can be moved to another tub, of same water quality and temperature, for feeding and initial rearing.

The primary benefit of this method is that you can amass many eggs and so get many fry in a very short period of time. You do however require much more space and equipment.

Mops can also be used for the **temporary spawning setup** method, whereby the mops with eggs are simply moved to a new tank or tub for hatching. The benefit of this is that you never handle and risk damaging the eggs.

So you have eggs, what now? That will be covered in Part 5. In Part 4 we will look at spawning annual killifish so you will have even more eggs to experiment with by the time Part 5 is published.

Part IV

Annual killifish egg collection

Very few annual killifish need to be spawned over an entire substrate of peat. The majority are happy with a tub of peat.

Nothobranchius and *Fundulosoma* are satisfied with a shallow layer of peat in which to spawn. 1 to 2 cm is all that may be needed for adequate reproduction.

Many of the South American annuals (SAAs) need deeper spawning vessels. Large SAAs like *Gnatholebias zonatus* are spawned in coke bottles filled with peat to a depth equal to the length of the fish. This is because while *Nothos* prefer to plough through the peat, many SAAs prefer to dive into it (disappearing completely).

Spawning tubs

For most peat ploughers, a shallow tub filled with peat (and pebbles to weigh it down) will do. I like to use shallow (4 to 5 cm) but wide (15 cm) tubs with an entrance hole of about 12 cm. These tubs are excellent for training new fish to spawn. Fish unaccustomed to spawning in tubs will often not recognize it as a spawning site and will then spawn all over the tank. Once the fish accept the tub and the dark peat as the spawning site, then the shallow training tub can be replaced with a smaller tub with smaller entrance whole so less peat will be strewn over the tank as they spawn.

This spawning tub should be positioned away from the area where the fish are fed. One of the main advantages of using the spawning tub over a complete peat substrate is that the tub and peat can be kept free of decaying food.

Deep jars and soda bottles weighted with pebbles work well for peat divers. For small SAAs such as *Austrolebias nigripinnis*, 5 cm of peat is adequate and the fish can be spawned in as small a jar as 6 cm wide and 7 cm deep. For larger SAAs such as *Simpsonichthys whitei* a jar of at least 12 to 15 cm deep is needed with a peat depth of about 5 to 8 cm. The fish will of course, while spawning, fling most of the peat out of the jar... The eggs sink faster than the peat, so when the peat is down to about half the length of the fish it is a good idea to harvest it.

For monsters such as *Megalebias wolterstorffi* it may be best to use a goldfish bowl full of peat. Some breeders do not use bowls or jars at all but rather condition the genders separately and then put them together to spawn in a tank or bucket over a deep layer of peat. This works as well for difficult to spawn SAAs and *Nothos*, especially so if they are aggressive towards the duller sex.

Preparing peat

There is much debate as to what peat is best. The author prefers Canadian peat moss over all other brands, but most other brands would probably suffice. Avoid peat with added fertilizer, peat with a composition of mainly sticks, and palm peat fibre which isn't peat at all and will rot both in the tank and the incubation packet. Fine peat moss or long fibre peat is by far the best.

This peat must be prepared by boiling. The peat can either be boiled in glass jars in the microwave or simply put into a bucket and boiling water poured over it. The important thing is to repeat this several times and preferably with some alkali (such as baking soda, lime or slaked lime) to draw out as much acid as possible from the peat.

The eggs of many annuals are sensitive to the peat acids and can perish in the peat from acid burns. The peat can also cause the pH in fish tanks with soft water to plummet to as low as pH 4 over night! Some German breeders add some alkaline clay to the peat to obtain good spawns off some acid sensitive SAAs.

The prepared peat can be rinsed clean of dust in a fine mesh net and then stored in plastic bags for later use after having the water squeezed from it. Storing it in the bottom of the fridge is a good idea (if you can convince your family).

Collecting peat and eggs

To use the peat, take the spawning tub and add several spoonfuls till you have about half the required depth in squeezed dry peat. Add water from the tank you wish to spawn the fish in to the tub and allow the peat to settle. It will now be about twice as deep as it was before. Gently pick up the tub and slowly sink it into the tank so as not to spray peat all over the tank. This creates a terrible mess.

A friend sinks the spawning tub along with a saucer on top to keep the peat from spreading all over the tank.

With luck the fish will instantly see this as the site to spawn and will get to work. Peat strewn all around the tub is a good sign that the fish are spawning where they are supposed to.

After one or two weeks you can retrieve the spawning tub and wash the contents into a fine mesh net using tank water. Give this a gentle squeeze (not suggested for large eggs in course peat). Empty the contents of the net onto newspaper to dry. Some breeders simply leave the peat exposed while others wrap the peat ball in newspaper for drying. Paper toweling would also work well but be expensive.

Allow the peat to dry till it looks wet and is moist to the touch, but you have to squeeze hard to get any water from it. If water is still seeping from the peat it is too wet for all but a few *Fundulopanchax* and SAA species. The peat has to crumble freely.

Once the peat has dried to an acceptable state it must be emptied into a plastic bag or tub and sealed away with the name of the species, its strain/population code and collection date clearly written onto it. The peat is then stored away in a location with temperature between 20 and 26° C. It is a good idea to examine the peat before storage to see if there are any eggs in the peat. *Notho* eggs are plainly visible as little amber balls in the peat. SAA and *Fundulopanchax* eggs tend to be dark and/or adhere to the peat making them hard to see. With patience and practice they can also be seen with not too much difficulty.

Long lists of incubation times exist for a myriad of species under many conditions but these are only ever partly accurate under the conditions they were determined. The best course of action is to routinely examine the peat to check on the development of the eggs. When the eggs have eyed-up you can begin to think about wetting the eggs.

It is important to note, that various experiments have shown that eggs of *Nothos* will develop to a hatching state in less than 4 weeks, if incubated at or above 26° C. Do not think that because reference A says that the eggs of *Notho* B will take 4–6 months to develop, this will be the case under your breeding conditions. It certainly is not the case in Singapore where *N. rachovii* eye-up in 4–6 weeks rather than months.

What do eyed-up eggs look like? That will be discussed in Part 5.

Part V

Egg and fry care

Eggs are no less fragile than new born babies. If you let them get too cold or warm, damage them in any way, or allow them to become infected they will perish. Biological development is a stringently regulated process where small disturbances to homeostasis can have large negative repercussions. This part of the series will focus on providing an environment suitable for egg and fry development.

Caring for eggs

The eggs of many non-annuals do not tolerate massive changes in temperature nor poor water quality. Many do not tolerate being handled as they are fragile and sensitive to mechanical damage.

Obtaining viable eggs is the first step towards getting healthy fry. This was described in Parts 3 & 4.

The eggs of some fish are sensitive to water chemistry. I have heard it alleged, several times by several different people, that the big *Fundulopanchax* and some *Aphyosemion* do not produce viable eggs in hard water. The chemistry whereby eggs harden to prevent bacteria penetrating them involves the element calcium. High calcium levels in the water can cause the egg to harden too fast, before the sperm can fertilize it. So this piece of lore seems quite reasonable.

On the other hand, eggs that are not adapted for soft water devoid of calcium may harden too slow or not at all, allowing bacteria and fungus to penetrate the eggs and kill them.

These is some other plausible explanations relating fish fertility to water parameters in addition to those above. One is that big fish produce more waste, and ammonia is as (if not more) toxic to eggs as it is to fish. Also, with more waste there is more bacteria that can damage eggs. Big fish also need more oxygen in the water to produce viable sperm or eggs. Water quality cannot be overlooked.

Water parameters are important for many fish breeding attempts. Those beginner fish mentioned in Part 2 are generally resistant to the above problems, hence their ease and popularity in the hobby.

The addition of tea has been proposed to solve many problems with fish infertility and non-viable eggs. This is hardly surprising. Tea is a hodgepodge of tannins, humic acids and polyphenol compounds with anti-bacterial/fungal and anti-oxidant properties. The tea from the Sea Almond *Terminalia catappa* has long been used in SE Asia fishkeeping to prevent disease and increase the survivability of spawns. Oak leaves have also been used with success. Peat also contains such afore mentioned compounds, and the success of Joergen Scheel and his contemporaries may be that they employed a substrate of peat in all their tanks.

Temperature cannot be ignored. For non-annuals the eggs are best kept at the temperature they were spawned. My friends and I only had success in spawning *Epiplatys bifasciatus* when the eggs were left to develop in a small floating dish in the parent's tank.

Dead eggs are best removed from the incubation container. These eggs will become a food source for bacteria and fungus that may damage healthy eggs. These dead eggs will also pollute the water in respect to ammonia and nitrite (never mind bacterial toxins).

Dead eggs can be spotted with the aid of some methylene blue that will dye the inside of dead eggs but only the outside of healthy eggs. If too strong a dose is used, the difference will not be evident. The water should be just slightly tinted by the dye. The late Ed Warner used 5 drops (≈ 0.33 mL) of methylene blue (presumably a 5% solution) per 4 liters. (Ed's excellent book, *Success with Killifish*, is still available from his wife, Ruth, at http://www.geocities.com/killiesbyruth.)

The efficacy of dyes at killing bacteria and fungus at doses where it will not harm eggs is largely speculative. Methylene blue has been shown to act as an oxygen carrier in solution and may be of added benefit in this respect as there is bountiful evidence that eggs are very sensitive to oxygen deprivation.

Annual eggs are not as sensitive to temperature as non-annual eggs. Changes in temperature do seem to hasten development and as the old proverb goes "haste makes waste." In diapause the eggs are very robust, but once development begins they are as sensitive as non-annual eggs and losses can be large. This is speculated to be the reason for massive egg losses in shipping annual eggs over vast distances and differences in climate.

Hatching eggs

Non-annual eggs will normally hatch by themselves. On some occasions they may need some help.

Eggs are ready to hatch not when you can see eyes but when you can see a gold or blue ring around the eyes. This is termed “eyed-up”. Eyed-up eggs have a limited shelf life. As the fry sits in the egg waiting to hatch, it is slowly burning away its fuel reserves. Once this reserve is used up it will have to burn its own tissues for fuel. At this point the fry may not have enough energy reserves to break free of the egg and if it does it will normally die from exhaustion or be deficient in some way (e.g. a belly-slider). Scheel (in his 1975 book *Rivulins of the Old World*) reports that keeping the eggs in the dark will reduce the activity of the fry inside the eggs and may extend the shelf life of the eyed-up annual and non-annual fish eggs.

I prefer to wet only a portion of any packet of peat at any one time. In this way, the risk of wetting immature eggs can be spread. This is also a useful way to discover the ideal hatching window for the respective fish under the conditions you employ.

Fry that need help can be stimulated to hatch by increasing the oxygen or carbon dioxide concentration in the water. Manual agitation also works. Some authors claim the addition of some peat extract/tea to work wonders, not only in stimulating hatching but curing belly-sliders. This could be because the peat compounds bind to calcium and magnesium in solution, and so lower the osmotic potential of the water, allowing more water to rush into the egg and break the chorion, enabling the fry to hatch out. Another idea, is to put the eggs into a glass jar and sink it into a deep tank to increase the pressure in the jar’s water that will force hatch the eggs.

It is not suggested that one force hatch annual eggs unless they are water incubated (or suspected to be long overdue). Annual eggs will hatch when they are good and ready. It is important however, to have a high oxygen content in the water to prevent belly-sliding. Cool water ($\approx$4–10° C) is important for many South American annuals, and seems to benefit African annuals too. This may simply be because cool water holds more oxygen.

Shallow trays are best used for hatching eggs. Once the fry have hatched they are best removed from the peat filled hatching tray and put into a new tray with water of the same parameters where feeding can begin. This is so that the peat can be redried—free of polluting fish food—and rewet later on (about four weeks).

Non-annual fry can be handled in the same way. Fry should never be fed in the tray they were hatched in if it can at all be prevented. Decaying food will reduce the survival odds for the remaining eggs and quite likely kill the fry.

Care of fry

Fry need clean water and good food. Fry are also very sensitive to water changes in respect to temperature and hardness. Osmotic or temperature shock can kill.

Good foods for newly hatched fry are infusoria (Java moss is teaming with it), microworms, fresh baby brine shrimp (bbs) and various commercial dry or paste aquaculture microfoods (such as supplied by Tim Addis and Co.). The notion that newly hatched fry will not eat dried food is not always true. My newly hatched *Aphyosemion punctatum* fry accepted freshly ground Tetra Bits and *Spirulina* flake as a first food, and grew well on this.

As fry grow and mature their diet needs to change. Infusoria is no longer adequate for two week old *N. foerschi*. These fish grow fast and need bigger and richer food. Fresh bbs, cyclops, *Daphnia* and various dried foods work well for young fish. Finely chopped frozen bloodworm is excellent for two week old *Nothos* if they are large enough to take it.

The fry need to be fed regularly and hence their tanks/tubs/trays need to be cleaned and the water changed regularly. This is very important. Sloppy maintenance is the leading cause of such disasters as *Flexibacter columnaris* (the normal cause of sliminess of the skin, finrot, clamped fins, shimmying, mouth fungus etc. . .) and velvet outbreaks. Under such stressful conditions any cure is likely to be ineffective. Keeping some plants (such as Java moss) in the fry tank can help keep the levels of ammonia and other pollutants low.

Stocking density is also important. Fry compete with each other for food. To make sure each fry has enough food, the fry generally need to be slightly over fed. This means the more fish the more waste. With severe overcrowding a daily 50% water change may not be enough. For this reason it is best keeping fry in small numbers. 10–20 fry per 2 L tub for the first week is generally a good standard. As they grow the numbers will need to be thinned. One 2 L tub is good for two 15 to 20 mm fry with a 25% water change per day. Most *Nothos* can reach this size in only 2 weeks with heavy feeding.

Water quality and nutrition are very important in keeping fish healthy and obtaining the best growth. The topics of health and disease will be the focus of the next installments in the series.

Part VI
Nutrition and Health

At sea, malnourished sailors developed scurvy, got ill and died. Captain Cook's answer to the problem was limes, but our fish do not seem to enjoy citrus fruits.

This and the next part will deal with the issues of fish health. Health and disease cannot be separated from nutrition and basic care practices. This part will deal with nutrition and some simple dos and don'ts to keep your fish healthy. The next part will address what to do in the face of the worst case scenario.

The good food guide

Fish need a diet high in fats/oils and protein. In conjunction they also need vitamins like B, C, E etc... This is best obtained by feeding the fish a rich and varied diet.

In old literature it is stated that live foods are far superior to dry foods. This is not the case today where dry foods are every bit as good if not better. Scheel, himself pointed this out in his 1975 book. Because of intense aquaculture research, today's dried foods are rich in protein, fats/oils and vitamins. Fish can thrive on these menus their entire lives.

Clean live and frozen foods are still very good and make a good treat and may be essential in catering to the needs of certain species (such as *Diapteron* that seem to do best on *Cyclops* and other small crustaceans). Many live/frozen foods, such as bloodworm, have very high protein contents making them excellent for conditioning breeders. White mosquito larvae are also excellent for this purpose. Experiments performed by myself with *Aplocheilus lineatus* suggested white mosquito larvae boosted egg production by as much as 1.6$\times$ compared to bloodworm or varied diet (of bloodworm, black and white mosquito larvae) and 3.9$\times$ compared to a standard high quality flake food.

Some foods are richer in certain kinds of fats and oils. *Cyclops* is one such food. Mach Fukada has observed that by feeding his fish *Cyclops* and/or *Daphnia* enriched with algae, rectified the phenomenon of panic attacks in his fry that would often lead to massive casualties.*Cyclops* and *Spirulina* algae are two foods rich in the good-fats (highly unsaturated fatty acids) needed for proper nerve activity, and are now considered vitamins in the aquaculture industry, essential for proper growth and health.

(Another reason put forward for panic attacks is heavy metal poisoning. Lead and copper are particular problems in this regard. Lead weights can contaminate small tubs and tanks if the tank turns acidic. Lead concentrations need not be high to cause fatalities. Copper is a problem that comes with very new and very old pipes. Heavy metal toxicity is reduced by using harder water. A vitamin B_6 deficiency is also plausible.)

Spirulina is a God-send for the fishkeeper. It has a very favorable nutritional profile being rich in vitamin B, C, E etc... It is also rich in essential amino acids. *Spirulina* flake should be fed to all fish that will take it. As for fussy fish, there are ways of dealing with them.

Many home cultured foods such as microworms, grindals, whiteworms and crickets (even earthworms) will feed on *Spirulina*. These organisms can be easily gut-loaded and fed to fish. These organisms will also feast on crushed peanuts (another good-fat, protein and vitamin rich food). Brine shrimp (from the age of 48 hours) can also be fed on *Spirulina* powder and their nutritional profile can be enhanced tremendously in this way. Fresh brine shrimp nauplii are an excellent food in their own right for young fry. The good-fat profile of microworms can be enhanced by the simple addition of some olive oil to the culture container.

Brine shrimp nauplii are easily hatched from eggs bought at petstores and the like. You will need a salt solution (I like to use sea salt sold for marine tanks) of about 20–25 g/L (where 1 teaspoon of salt is about 4.5 g). The salt water can then be poured into shallow trays and a small amount of brine shrimp eggs sprinkled over it. The eggs will hatch and the nauplii will mass in the brightest lit corner where they can be sucked up with a glass or plastic pipette or syringe. Another method is to put the salt water in inverted soda bottles to which an air line is added so the water is bubbled up from the bottom to the top. The eggs are added to this and when the nauplii are to be harvested the air is stopped and the shrimp siphoned out from the bottom of the bottle.

In both instances the shrimp eggs will take about 36 hours to hatch. Soaking the eggs in some fresh water before adding to the salt water seems to accelerate the hatch time and result in a better separation of the nauplii and egg casings.

I have found fresh sea water (36 g/L) to give the best overall results.

Prevention is better than cure

It is important to understand that in feeding your fish the high protein diet they need, there will also be a lot of ammonia waste produced, meaning you have to maintain good water quality as well as supply good food. Over-feeding brine shrimp nauplii goes hand in hand with velvet out-breaks in fry tubs. Well fed fish living in a clean tank will be far less susceptible to attacks by bacteria and parasites. A couple of snails or other scavengers are very useful for cleaning up after your killifish.

Quarantine is a very good idea if you want to avoid having sick fish. Many diseases are able to piggy-back into your setup via other fish. The most dangerous is *Glugea*, which is very costly to eradicate. This parasite spreads easily via contaminated tanks, peat, buckets, nets etc... It lies dormant for many weeks before striking, and by that time can be spread throughout your fishroom forcing you to cull all your fish and sterilize your tanks. Its main prey is *Nothobranchius*, but seems to be able to infect most fish (without exhibiting the fatal symptoms associated with annual killifish).

Keeping new arrivals separate from the rest of your stock for a time (as much as one generation) is an example of the very best of ideas. Having a dedicated tank and equipment is essential to this task.

Likewise, try to keep established tanks as independent from others as possible by always sterilizing nets and equipment between use in other tanks. Nets are easily sterilized of most freshwater pathogens by dipping in a saturated salt solution. Letting equipment soak in bleach, Condi's Crystals (potassium permangemate) or a saturated salt solution is a valuable protocol to implement in your fishroom. Though, this may reduce the life-expectancy of your fish nets.

Sometimes, despite our best efforts fish will get ill. Sometimes the reasons are not obvious and the next course of action is obscure. How should you respond? What is handy to have around in case of emergency? These are the topics of the next Part.

Part VII

Disease and Treatment: when microorganisms attack

When your fish are under attack by bacteria or parasites do not reach for antibiotics. Unless you want to corrupt your local pharmacist and get the good stuff you are wasting your time with pet store antibiotics (such as Nitrofurazone which most aquarium bacteria are already resistant too).

The first order of business is to quarantine the offending tank so whatever it is does not spread. Then, do a water change. A good size water change may be all that is needed to rectify the problem.

It is very difficult diagnosing fish diseases without a microscope and a good textbook. Most take the form of clamped fins, listlessness, slimy skin or cottony like growth. Some diseases, like white spot, are more or less obvious. Velvet is more subtle but with indirect light you can see the gold haze on the fish's body and fins. Most ailments can be treated with a small selection of chemicals. These are the following:

- Malachite green
- Acriflavine
- MelaFix
- Metronidazole
- Methylene blue
- Table salt (NaCl)

Malachite green is effective against bacteria, protozoans and fungus at a concentration of 0.05–0.15 mg/L. (See http://aquascienceresearch.com/APInfo/DrugDose.htm for a list of recommended doses of various compounds for fish-tanks.) Many species of fish (particularly catfish) are very sensitive to this compound. Malachite green should NEVER come into contact with galvanized metal or zinc lest you wish to kill your fish through zinc poisoning. Begin with a low dose, and then increase the dose if need be.

Acriflavine is a powerful antibacterial agent. It can be safely used for most species at a concentration of 5–10 mg/L. Water changes are essential. This compound will inhibit or kill most bacteria, meaning your filters will be offline for a time. Acriflavine is listed as an irritant on some material safety and data sheets and will interfere with DNA—it is a potential mutagen best handled carefully! Eggs and fry are best not exposed to it. Acriflavine works well against *Flexibacter columnaris*, velvet and *Costias*.

Both acriflavine and malachite green are effective against white spot.

MelaFix is a product of the Tea Tree plant of Australia. It works very well against bacteria. It also seems to be without side effects if used as per the manufacturer's instructions.

Metronidazole (also known as Flagyl) is a marvelous drug. It is effective against bacteria, fungi, yeast and protozoans like white spot. It will cure hole-in-the-head and other flagellate infections (characterized by the fish not eating and wasting away). It is also free of side effects (except if you are a pregnant woman, so keep it away from eggs and fry). The dosage is 5 mg/L, with the dose repeated twice interspersed by three days with a 50% water change on the third day (so you have a 9 day treatment composed of 3 dosings, beginning with dosage and ending with a water change). For more aggressive infections (such as bloat) the dosing can be changed to 5 mg/L per day for three days with a 30% water change between dosing.

Methylene blue is of little use in treating fish diseases other than white spot, but has the benefit of being an oxygen carrier and so aiding in fish respiration. It is also an antidote to nitrite poisoning (as is table salt). The dosage of methylene blue should be between 3 and 5 mg/L. Methylene blue can also inhibit the growth of some species of bacteria (such as in your filter) and will harm some plants (such as *Ceratophyllum*).

Table salt (NaCl) is very useful in many respects, but first we have to handle some physiology. Freshwater fish retain a salt concentration (these salts are termed electrolytes) within their bodies that is much higher than the surrounding water. The physiological salt concentration is 9 g/L. According to Keith Hand of Australia (who wrote the very informative article *The biological management of salt in fish* for the Journal of the National Australian Killifish Association, vol. 3 no. 4 and vol. 4 no. 1), almost 80% of this salt is sodium chloride. As consequence fish are constantly being flooded by water diffusing into them from the outside, seeking to dilute the salt. This is osmosis. (Osmosis the movement of *water* from a low solute concentration to a high solute concentration.) At the same time, they are also leaching salts into the environment by diffusion across the gills or skin lesions. As consequence, fish kidneys work very hard excreting water and storing salts as part of the process of osmoregulation to balance electrolyte levels.

Raising the concentration of salts in the surrounding water will reduce the osmotic stress allowing the kidneys to relax. But too much sodium is a bad thing. For the nerves and muscles to work they have to maintain a low sodium concentration inside their cells and a higher concentration in the blood and plasma. Too much sodium in the water (which will lead to too much sodium in their body fluid) will cause the fish to die. This is particularly problematic in soft water fish that are not adapted to deal with high salt concentrations. This problem is easily remedied by adding some other salts such as potassium, calcium and magnesium to the water to compensate for the increase in sodium. The goal is for the fish to keep the electrolytes in balance internally so it can better fight infection and stress less.

This is a difficult task if your kidneys are failing because of a bacterial or viral infection. The addition of some salt to the water (1 to 3 teaspoons per 4 L where one teaspoon is about 4.5 g) will ease the burden on the kidneys by allowing the external salt concentrations to approach physiological levels. This allows the fish to better regulate its salt balance so its tissues (read immune system) can function properly.

Salt baths are also helpful (3–6 teaspoons per 4 L). A 20 minute salt bath will knock velvet and white spot, and most other ectoparasites right off the fish. The high salt concentration will dehydrate the small ectoparasites killing them. Most killifish are able to resist this for a short time. Again, some soft water fish will not tolerate this!

Salt baths are also recommended for dropsy by some koi keepers.

While not a disease, *Hydra* are a nuisance we can live without as killifish keepers. Formalin has been suggested as a means to kill it (just a few drops per day to a tank), but this stuff is so very dangerous no one should be using it. A sprinkling of flubendazole over the water surface has been reported to work. Copper coins or pipes left in the tank water also seems to work, but caution must be taken with some species which may be sensitive to copper in the water.

If you have healthy fish then they will certainly breed. And once you have a lot of healthy young fish you may think about trading them with other fishkeepers. This is the topic of the next part of Beginning with Killies.

Part VIII

The Trade

There are many things to be careful of when you buy or receive fish or eggs. Likewise there are many other things you have to worry about when sending fish or eggs.

I am going to assume there are only two reliable ways to come by killifish: hobbyist exchanges (at auctions) or post. The same procedures can be followed in either instance. (Yes, a killifish or two may appear at the local petstore but this is a rare event.)

Trading fish

Fish should be shipped double bagged, 1 fish per bag, and placed in a box with some form of insulation to prevent large rapid temperature changes. The fish should have been starved one or two days before shipping. This is especially important if the fish have to travel in the bag for an extended period.

The fish should be packed in the bag with clean water—preferably fresh water of the same water parameters and free of chlorine etc... The goal is to have as little waste build up in the bag and starting at zero helps tremendously.

The addition of some ammonia/nitrite adsorbent (such as sold for Hagen Aquaclear filters) is a good idea. Some methylene blue added to the water (to just tint it blue) can aid in oxygen exchange between the fish and water.

The ratio of air to water should be 1:4 in the case of the usual polyethylene bags. These bags can exchange oxygen and carbon dioxide between the contents of the bag and outside world. They can also pass ammonia. Fish can stand international shipping of 2–3 weeks in ordinary polyethylene bags. Kordan breathing bags are also made of polyethylene but due to some mysterious manufacturing process they are more efficient when it comes to gaseous exchange. There is no need to include any air inside breathing bags. Including air does not hurt however—although there is some deflation. With a plastic frame inside the bag, they could be used to ship labyrinth fish without concern.

On receiving fish, open the bag and pour the contents into a bucket or tub. Dispense with most of the water and add water from the intended tank to the bucket or tub in small volumes. A drip system works well in this regard. **Remember:** killifish jump!

After several rounds of dilution net the fish out and put them into the tank. Do not put the water you received with the fish in the tank as well. This will reduce the risk of spreading infections.

Routinely monitor the fish to see how they are doing.

Care should be taken when adding hard (KH) alkaline water to soft acidic water. Enough ammonia may have built up as ammonium in the bag to harm or kill the fish, when the hard alkaline water is added, that will see the harmless ammonium revert to harmful ammonia. Scheel showed that fish can tolerate a 50% change in water hardness. When moving from soft to hard water, a fast 50% dilution could spare the fish some hurt. Scheel also showed that pH was not really important at all when moving fish from tank to tank.

Trading eggs

Eggs should be shipped in insulated containers. Rapid temperature changes can kill eggs of both the annual and non-annual persuasion.

Non-annual eggs can be shipped in damp peat or on spawning mops/poly-filter material with the excess water squeezed out. Shipping in a normal fish bag is fine. Some people have great success shipping the eggs in little camera film containers with some anti-biotic. . . In my experience this has always yielded the worst results. It only takes one bad egg to kill the rest. The success of this approach depends largely on the skill of the sender.

The peat method works well with many fish species, where it can extend incubation by as much as 100%. *Aphyosemion australe* eggs take about 14 to 21 days to develop in water. In peat they can endure for 6 weeks!

On receiving such peat, check for eggs and then wet it (even if you do not see any eggs) with tank water and wait. Keep changing water for at least 6 weeks. Thereafter you can dispose of the peat. In one instance, I was sent eggs of *Aphyosemion elberti* Diang in peat. They spent 2 weeks in the post, and then took another 3 to 4 weeks to hatch out. Normal incubation is 2–3 weeks.

A simple change of water can induce eggs to hatch that normally would not. Force hatching and fry care were dealt with in Part 5.

Shipping eggs on damp mops (without ever touching the eggs!) is the best course of action for species with sensitive eggs.

For annual eggs the peat should be received in a “fluffy” state. Peat that is compressed hard into a corner or flattened out in the packet is not a good sign. Undue mechanical pressure can kill eggs. Also, without any free air in the bag, pressure changes in transit can cause eggs to burst or collapse.

Finding lots of brine shrimp cysts in the peat is also bad news. This could imply the fish were very young when spawning (and so maybe not fully fertile or not producing many eggs) and certainly indicates there is a lot of biological waste in the peat with the eggs. If the peat is overly wet this could mean most of the eggs have been burnt to death by ammonia or destroyed by bacteria. On delivery, point this out to the person who sent the peat. . . Check for good eggs and if any, move them to fresh peat.

Annual eggs should also be shipped insulated from sudden temperature changes. A simple homemade box (able to fit in an padded envelop) or layers of paper or bubble-wrap is sufficient in most cases.

Annual eggs shipped through the post tend to develop abnormally. Eggs that would normally take six months to develop can arrive eyed-up after only three weeks total incubation. Peat should be inspected on arrival and any eyed-up eggs hatched. Monitor the rest of the eggs regularly (at least once per month). Such abnormally developed eggs may require force hatching.

If the eggs arrived with a label that can be pried from the packet, stick it to the tub used to house the fry. This is very helpful when one has a massive collection of fry tubs. Post-it notes are enormously helpful in this regard.

A special note is that *Glugea* can be spread via peat and so special care must be taken with new peat killi imports.

Bookkeeping

On arrival of fish or eggs, make a record from whom the fish/eggs came from and what was received. This information can come in very handy when you want to try find a particular fish again, or should you forget just what strain or population you had received. Knowing the pedigree of your fish can also be helpful in selecting mates to out cross your line to and improve genetic diversity. In some respects, knowing the pedigree of your fish is more useful than knowing the strain or collection code which can be easily corrupted or confused along the way.

Keeping strains and populations separate is important for two reasons: 1) hybridizing can dilute good genes built up over the course of several generations in the aquarium; and 2) that hybridizing strains or populations can produce progeny with incompatible genetics.

This latter reason is very important. Many of the strains/populations of *Fundulopanchax gardneri*/*nigerianus* or *Chromaphyosemion* yield sterile progeny. Worse yet, in some instances such sterility may only be manifest several generations after the cross. Had such a cross occurred and the progeny distributed as a pure line such genetic incompatibility could end up contaminating an entire strain and doom it to extinction in the hobby.

While intrinsically there should be nothing wrong with crossing two strains from the same location, but of different collection dates, there is the problem that the newer collection may be harboring some genes that could be of detriment to the fitness of the old established strain or vice versa. If you wish to make the cross to "liven-up" an old strain this is even more silly as you would be introducing accumulated bad genes from the old strain into the new.

This may not be a problem if proper selective breeding is performed, but many of us do not keep records (essential to any breeding program); and/or do not have the time nor space for a proper selective breeding project (because several lines will need to be established and tested for fitness).

Enforcing sound selective breeding principles is always the way to go in animal breeding. Do not select by pictures in books or magazines (unless you want to do something fancy as with guppies), but rather select based on overall fitness (disease resistance and fertility) and form.

This concludes the series of articles on getting started. There is a lot more information out there, but to discuss it all would entail the production of a mighty tome—and much of the information to fill it is not in my possession. With the advent of the internet, vast stores of information are available to the hobbyist. All he or she need do is enter the correct search criteria into http://www.google.com.

About the Author

Tyrone Genade has a M.Sc. from the University of Stellebosch's Department of Biochemistry for research into steroid biochemistry. Thereafter, he went to Italy where he did contract research on the annual fish *Nothobranchius furzeri* at the Institute for Neuroscience based in the Pisa CNR. The purpose of the research was to develop the fish as a model organism for aging research. Protocols developed by Mr. Genade and the rest of the Italy team were able to increase the average lifespan of the fish by more than 25% using a compound commonly found in red wine. Mr. Genade has been keeping fish for more than 20 years. 10 of which have been devoted to killifish. He is currently starting a Ph.D. project at UCT's Division of Cellular Biology using *N. furzeri* in aging/developmental biology research.