THE BEGINNER'S BUCKET

A Word About Water

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Photographs by the author.

Fish need water. But there's more to good fishkeeping than just adding water. More precisely, fish need water that's to their liking, and, more important, they need it to be clean.

Water—especially aquarium water—isn't simply water. It's analogous to a soup, containing salts, or minerals, and chemical susbstances released by the fish.

Water's chemical abbreviation, H_2O, stands for "two parts hydrogen, one part oxygen." In high school chemistry classes, the simplest illustrations depict water as three spheres. The largest sphere, oxygen, is in the middle, and two slightly smaller spheres, each one a hydrogen ion, are stuck to each side of the large oxygen in the middle, with the whole structure looking like an upside-down Mickey Mouse head.

A home aquarium contains countless such water molecules, along with some free-floating hydrogen ions, as well as another molecule called the hydroxide ion. The hydroxide ion is just a simple combination of hydrogen and oxygen. (If you took our Mickey Mouse-head water molecule and lopped off one of the hydrogen "ears" you'd be left with a hydroxide ion.)

Tests and Measures

Keeping fish successfully depends on a rough accounting of how many free hydrogen molecules versus free hydroxide molecules a given volume of water contains. This rough accounting is typically obtained by measuring pH, which stands for *pondus hydrogenii*—the proportion of hydrogen ions. Water with low pH has proporitonately more hydrogen ions than hydroxide ions; water with proportionately few hydrogen ions and a lot of hydroxide ions has a high pH.

In nature, fish inhabit various bodies of water with different pH. You can buy commercial kits or strips to measure pH. These may be test strips that change color, or small vials that you fill with tank water and to which you add a few drops of a chemical reagent. The water will then change color, depending on the pH, and you compare the color to a chart to get an approximation of the pH. You can also buy more sensitive (and more expensive) meters to measure pH.

A comparatively low pH—say, in the low 6s, is said to be acidic, whereas a high pH is referred to as alkaline. The scale for measuring pH increases by a power of 10 for each increment. For example, a reading of 8 is ten times more alkaline than a ph of 7, and a reading of 9 is 100 times more alkaline than a reading of 7.

A sudden shift in pH, say from 6 to 7, means a ten-fold reduction in hydrogen ions, which could shock fish or even kill them. A large water change might also result in a large pH swing, which could shock the fish. For this reason, frequent small water changes are often better than infrequent large ones.

The pH for most aquariums falls within a fairly narrow range, say from the low 6s for acidic water species like *Enneacanthus* sunfish, to the high 7s for coastal species like sailfin mollies or mummichog.

The pH level is usually linked with another water measure called hardness. Hardness refers to the amounts of dissolved minerals and salts in the water. A high concentration of salts and minerals results in hard water, and a low concentration results in soft water. Most commonly, hard water contains dissolved salts of calcium, magnesium and iron. Soft water lacks these salts.

Blackwater habitats are typically soft. In contrast, water from streams that run over limestone or other mineral deposits tend to be hard. Similarly, coastal habitats, because of the influx of seawater, which is high in dissolved minerals, also tend to be hard.

I suspect that calcium is the most important mineral for coastal species. I know fishkeepers who've kept sailfin mollies and mummichogs in water with high calcium levels with no ill effects.

There are two kinds of test kits for measuring water hardness. One, a test for general hardness, measures all of the dissolved salts in a sample. Carbonate hardness, or dKH, measures just the levels of dissolved calcium.

Many native species aren't too fussy with regards to pH and water hardness. If you avoid extremes, most *Lepomis* sunfishes (Fig. 1), catfishes, darters, sculpins, and minnows will do well.

Blackbanded sunfish, in my experience, tend to get sick in water with even moderate hardness levels. Similarly, the sailfin mollies I've kept tend to sicken and die if I don't supply a little marine salt to their water—usually just a half to a full teaspoon per gallon. Commercial sea salt mixtures also contain other minerals, such as calcium, that may be important to the health of brackish water species.

Another measure of water properties you may hear of is water conductivity. Conductivity refers to how easily an electric current will travel through a water sample. Water of high conductivity contains a high proportion of mineral salts, which promotes the passage of electricity. Water of low conductivity contains few such salts.

Keep it Clean

Another factor influencing fish health is how clean the water is. Changing water at regular intervals—10-20%, monthly or even weekly—is essential for keeping fish healthy. Good filtration and thriving aquarium plants can also help to keep fish healthy.

Regular water changes are always important, but probably even more important if you're keeping fish in water that's not chemically suited for them. If a fish is stressed, for example, by a pH and a hardness level that's not to its liking, then dirty water will stress the fish even more. Stress may lead to disease which can kill the fish.

In keeping water clean, it helps to understand a phenomenon known as the nitrogen cycle. After eating, fish produce waste. The principal component of this waste, and the one most hazardous to fish health, is ammonia. The ammonia molecule consists of nitrogen bound to four hydrogen molecules. Depending on the pH, the compound exists in either one of two forms. At a pH above 7.0, ammonia, represented as NH_4+, is the preponderant form. Below 7.0, the molecule

Fig. 1.
Lepomis species, like this longear sunfish (*L. megalotis*), aren't too fussy with water conditions and do well except in extremes of hardness or pH.

loses a hydrogen ion, and is known as ammonium, or NH_3+. Of the two forms, ammonia is the most toxic, so if you keep fish in an aquarium with a high pH, you'll need to be particularly vigilant with water changes.

Between water changes, there are a couple of tricks you can rely on to keep ammonia and ammonium levels down.

The Nitrogen Cycle

Although ammonia is poisonous to fish, other organisms need the compound and actually feed on it to survive. Among these, nitrosomonas bacteria were said to feed on ammonia, but now different species are thought to be involved. During their feeding process, these one-celled microbes chemically convert ammonia to another chemical, nitrite, or NO_2. Nitrites are slightly less poisonous than ammonia, but are still pretty toxic to fish. Luckily, another kind of bacteria convert nitrite into a much less toxic form, nitrate, or NO_3. Nitrate is toxic only at high levels, and by doing regular water changes you can keep nitrate levels low.

Both types of bacteria eventually take up residence in the gravel of healthy aquariums. For the most part, these helpful bacteria carry out most of their work within the filter. Corner box filters typically pass water through a filter sponge, which the bacteria colonize. Similarly, the bacteria will colonize the individual sand particles in a sand filter, or other types of filtration media.

The bacteria need oxygen to survive. When the media becomes clogged with detritus, it cuts down the flow of water, depriving the bacteria of essential oxygen and cutting down on their ability to keep the water clean. When this happens, you'll need to clean the sponge by squeezing it out in old tank water or dechlorinated tap water. In addition to killing fish, the chlorine in tap water will also kill denitrifying bacteria.

For my aquariums, I usually rely on outside box filters, which pass the water through a sponge inside the filter. I also fit the filter intake with another sponge, to capture small particles before they get to the main filter sponge. This keeps the main sponge cleaner for longer, which means that I don't have to clean the sponge (and disturb the bacteria) as often as I'd have to otherwise.

Along with denitrifying bacteria, aquarium plants also help to keep water clean. Green plants will take up ammonium as well as nitrate.

Although I keep native fishes, I don't focus solely on native plants. I've tried several plants, and focus on what does well for me. My tanks contain, and in some cases are overwhelmed by, an odd gathering of *Valisneria americana* (Fig. 2), *Cryptocoryne wendtii*, Java fern, Java moss, *Anacharis*, hornwort, and *Bacopa*.

Floating plants are more efficient at processing nitrogen wastes than submerged plants. All green plants need carbon dioxide to process, but carbon dioxide is more abundant in air than it is in water. The leaves of floating plants capture more carbon dioxide from the air at the water's surface than submerged plants can obtain from the water. For this reason, floating plants can process greater quantities of nitrogen compounds than submerged plants can.

Regarding floating plants, I've had good luck with frogbit in my acid water tanks, and wisteria in my hard water tanks. Since I occasionally buy plants at aquarium club auctions, I also have duckweed in several of my tanks, which came in as contaminants on the plants I bought. I don't care for duckweed, as it rapidy multiplies and covers the surface of my tanks, cutting off light to the plants and fish below (Fig. 3). Still, it's a consolation to know that, before I remove it, the duckweed has probably taken a lot of nitrogen wastes out of the water.

Along with taking up ammonia and nitrates, plants may also absorb other minerals from the water. For example, other hobbyists have told me that *Valisneria* will remove calcium carbonate from the water, separating the compound into calcium, and carbon dioxide, which they use to fuel photosynthesis. If you keep fish that like carbonate hardness with *Valisneria*, it's a good idea to test for carbonate hardness periodically, and replace the calcium if you need to.

With each water change, I'll dissolve a half teaspoon or so of garden limestone in a gallon of hot water and add it to the molly tank. I think the added carbonate hardness benefits the fish and promotes the growth of the plants I keep. The lime solution makes the water cloudy for a day or two, but it clears up eventually.

Fig. 2.
Submerged plants like this *Valisneria americana* help keep water clean by removing ammonium and nitrates. *Valisneria* is also reputed to remove carbonate hardness from the water.

Fig. 3.
Floating plants like duckweed are better able to process nitrogenous wastes than submerged plants. This is because floating plants can extract carbon dioxide from the air, where it is more plentiful than in water.

If plants don't grow and thrive in your aquariums, you're probably better off without them. Plants that are dying and decaying will also release ammonia into the water, adding to the wastes produced by the fish. In this case, it's probably

Fig. 4.
The author collects rainwater in a 50-gallon tub below the downspout of his rain gutters.

better to rely solely on the denitrifying bacteria and water changes to keep the tank clean.

Coming Up with Clean Water

But even if you've got healthy, thriving plants and good bacterial filtration, you'll still need to do water changes. Not only will you need to prevent the nitrates from building up, you may also need to remove substances that the fish produce. Many fishkeepers believe that young fish produce substances that inhibit the growth of other small fish in the tank. If you raise fry, like I do, you'll want to change the water to get rid of such growth-inhibiting compounds. I've heard of angelfish breeders who do 50-80% daily water changes to promote maximum growth among their charges.

Most home aquarists probably rely on tapwater for water changes. If your water comes from a municipal supply, it probably contains chlorine to inhibit the growth of disease-causing organisms. It may also include chloramines. You can remove chlorine with a commercial dechlorinator that you can buy at an aquarium store. Chlorine will also evaporate out of tap water if you let it sit for a day. Chloramine, however, is much more stable than chlorine. If your tap water contains chloramines, you'll probably need to add a commercial formulation to remove it before adding it to your tank.

The Python™ hose is probably the most convenient means for carrying out a water change. One end fits to the tap, the other end consists of a suction tube through which you can remove water and clean trapped detritus from the gravel. When you're ready to refill, adjust the water temperature and twist the valve to send the water back into the tank.

While tap water is a convenient option, it may not always contain what your fish need. When I change the water in my molly tanks, I dissolve some commercial marine salt in a gallon jug, and pour the salt mixture into the tank as I'm refilling it. The mix provides the sodium and other marine minerals that mollies need. In my experience, sailfin mollies do best with one-half to one teaspoon per gallon of aquarium water.

I also keep blackwater fish that don't do well in moderately hard water. To meet their needs, I collect rainwater in a 50-

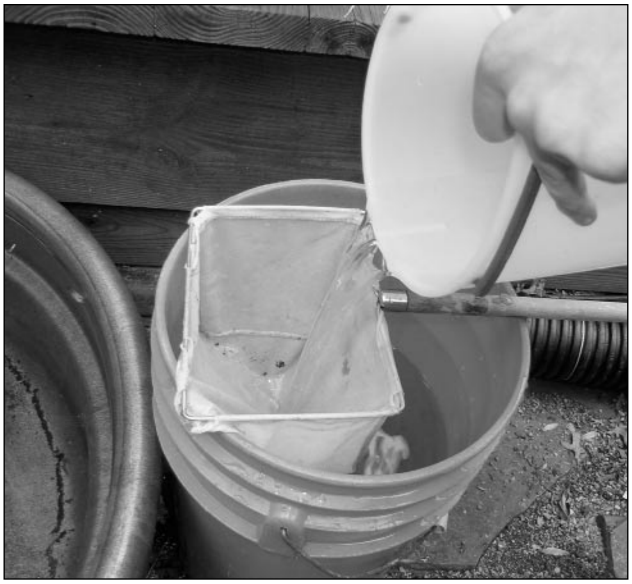

Fig. 5.
The author filters out dead leaves and large particles by pouring rain water through a fine-mesh net.

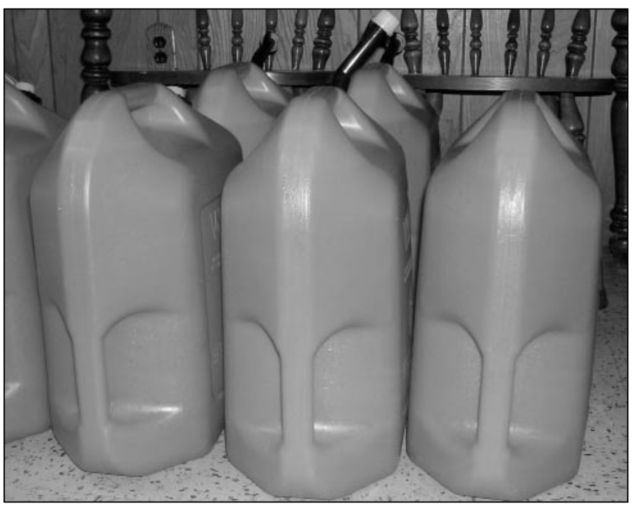

Fig. 6.
The author stores rainwater in six-gallon containers in preparation for a dry day.

gallon tub that I keep below the downspout from the rain gutters on my house (Fig. 4). Rainwater is usually soft and acidic, containing few dissolved minerals. I pour the water through a fine-mesh net to remove the larger particles (Fig. 5), store it in containers (Fig. 6), and keep it on hand for water changes.

Some aquarists have told me they're afraid to use rain water, as it may contain hazardous chemicals—especially if collected near a large city. I live in a major metropolitan area, but, so far, I haven't had any problems with it.

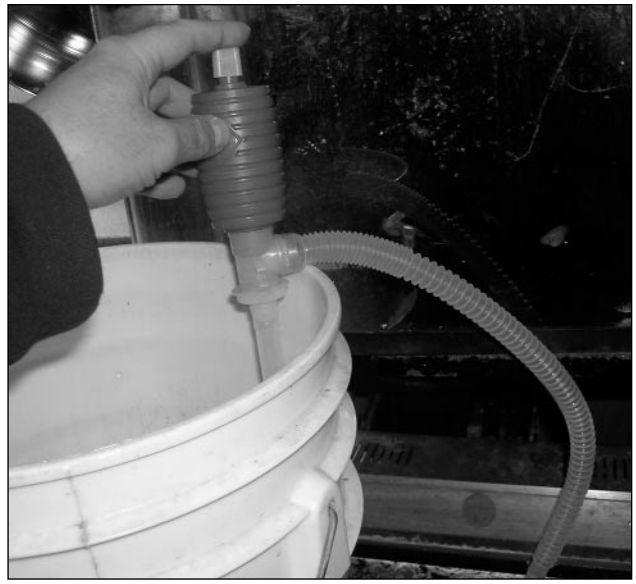

Fig. 7.
A bulb syphon comes in handy for doing water changes and filling water storage containers.

Other aquarists produce soft water by passing their tap water through a reverse osmosis (or RO) unit. This is a device that passes water through a fine membrane, which traps the mineral salts. The resultant water is often so pure that most fish and plants can't survive in it and the aquarist needs to add a few minerals back to it before adding it to a tank.

Along with the Python™ hose, I have a simple bulb siphon (Fig. 7) that I bought at a hardware store. It's convenient for the frequent small water changes I carry out on the numerous small two gallon window sill aquariums I keep.

In this article, I've described a water maintenance system that works for me. I hope it's provided you with some ideas for maintaining your own fish. If you progress in the aquarium hobby, you'll no doubt work out a system that works best for you.