

Cold Water Koi Keeping Coming out of Winter

Richard E. Carlson

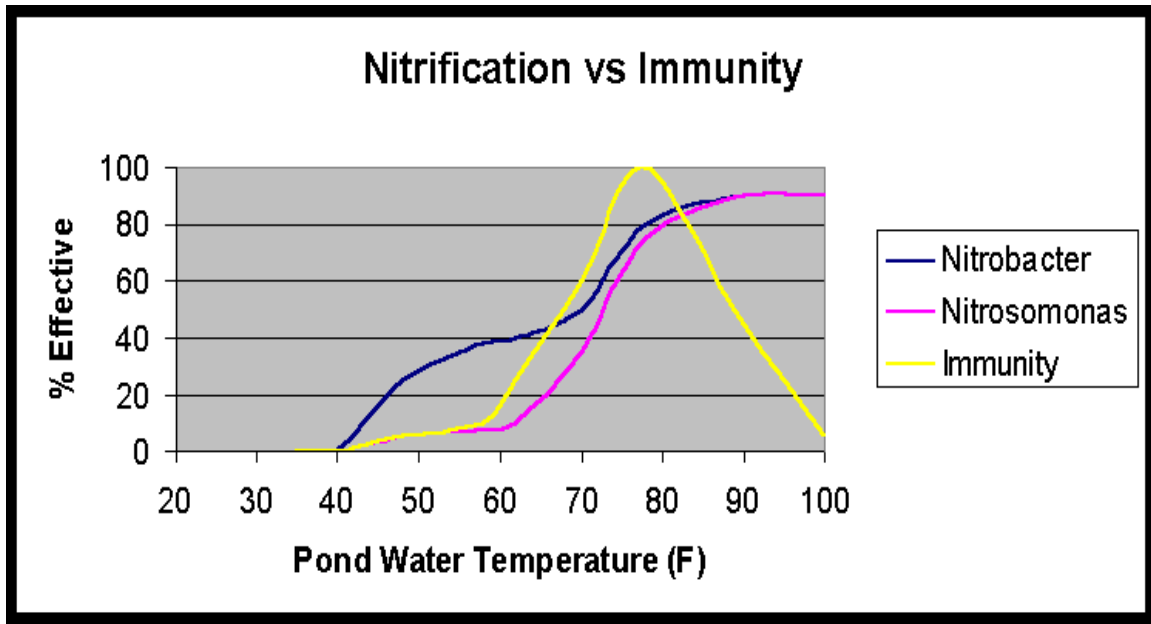
The purpose of this section is to introduce the KHA to the effects of water temperature on the ecology of the pond and physiology of the fish. It is important to understand the dynamics of the pond as the seasons change and as the conditions in and around the pond change. For the purposes of this section, we will focus on the approaching spring season.

This course will teach the KHA how cold water and changing water temperatures affect the health of koi and also the ecology of the pond as they emerge from winter.

As spring approaches in those climes that endure winter, we need to consider what is happening in our ponds as the water warms and the fish become more active. First, let's look at water temperatures, portrayed as the "*Magic Numbers*" and we will start from colder and work our way to warmer water.

Let's start from a point where our fish are in torpor and the water temps are just beginning to rise. We also need to realize that there is an appreciable amount of ammonia in the water (primarily from respiration) but the fish have been protected by the cold water which makes ammonia far less toxic.

Consider the chart below. Here the effects of pond water temperature are shown against the activity levels of the nitrifying bacteria (nitrosomonas and nitrobacter). Most are aware that of the debate revolving around other nitrifying bacteria and so for the purposes of this course, we will focus on nitrosomonas and nitrobacter only. The KHA can use the same rationale as presented here on other bacteria types. Also note the range where the koi's immune system is most effective. The increased activity of the nitrifying bacteria increases the quality of the water as harmful ammonia and nitrites are removed from the water. This increase in water quality then supports the koi's ability to build and maintain its immune system. The immune system will be discussed later. It looks like Mother Nature knew what she was doing when she developed this part of the ecosystem.



Working from colder to warmer, we see that the first appreciable biological filtration activity starts somewhere in the low 40's F. Typically, the pond will register some level of ammonia and quite possibly nitrites as well, although nitrite levels are not expected. So, in most cases and with the presence of ammonia, the first biological activity will start with the nitrosomonas bacteria converting ammonia to nitrites. Nitrite conversion to nitrates will follow. The bio-filtration filter will mature as the colonies of bacteria increase and establish themselves in the filter and pond's natural bio-mass.

At 45 deg F. (7.5 deg C) the fish start to come out of torpor and become more active and alert. Actually, while in torpor they are alert to their surroundings but lack the need to move around as Nature's metabolic clock slows them down.

At 50 degrees F (10 deg C), we start to consider feeding our fish. It is at this temperature that the koi's metabolism begins to increase and so does his appetite. As we approach winter, we reduce feeding and also may switch to a lower protein food because of the reduced metabolism at this temperature. For spring we do the exact inverse by offering limited amounts of food and a food with a lower protein content. Lower protein foods offer a better digestibility as well as lower ammonia production. Reduced feedings are important at this time as the fish's nutritional requirements are still fairly low and overfeeding may result in poor reduction of the food in the gut and possibly intestinal problems. The thing to remember is not how much they will eat, but how much they really need. And with a reduced metabolism, the need for food is reduced as well.

Our next magic number is 55 deg F (13 deg C). At this temperature, the koi's immune system begins to hold its own. Feeding becomes more important as does ensuring stressors, especially from poor water quality, are reduced. With added feeding and increased movement, ammonia production increases and becomes more toxic to the fish. And as the chart above illustrates, the nitrification processes are just not up to speed yet.

This is a good time to talk about cold water, ammonia and nitrites.

Cold Water Ammonia and Nitrites

We have mentioned how cold water reduces the toxicity of ammonia. In fact, the fish are still producing ammonia through respiration and waste from what little food they are eating; therefore it is a good practice to monitor ammonia and nitrite levels over the winter months and into spring. So, let's look a little deeper at the effects of ammonia and nitrite on our fish during the cold-water months.

First ammonia: in numerous articles and publications, we have read that ammonia is much more toxic in high pH (alkaline) water and since this is true, we must always balance our ammonia readings with the pH readings of the water to get a better picture of the extent of the effect on our fish. However, it is also very important to point out that water temperature has a profound effect on the toxicity of ammonia as well. In order to understand the effect of water temperature and pH on the toxicity of ammonia, let's take a look at how we need to interpret ammonia testing.

Most commercial kits for ammonia testing provide readings for what is called Total Ammonia Nitrogen or TAN. If you read the labels and instructions on your test kit, chances are you will see where the manufacturer uses the term "NH₃/NH₄" as the "ammonia" the test kit is capable of reading. The term "NH₃/NH₄" is Total Ammonia Nitrogen. So, let's take apart this "Total Ammonia Nitrogen" and see what we are actually dealing with.

Ammonia in water occurs in two different forms: **Ionized Ammonia** which is represented as NH₄ and **Unionized Ammonia (UIA)** which we see as NH₃. The combination of NH₄ and NH₃ are what is termed **Total Ammonia Nitrogen (TAN)**. The average ponder's test kit cannot differentiate between NH₄ and NH₃ readings and so the TAN number is provided. But it is the Unionized Ammonia (NH₃) that is the only ammonia form that is toxic to fish. And it is **both** water temperature and pH levels that will determine which form of ammonia is predominant in the water at any given time.

The toxicity of UIA begins at levels as low as 0.05 mg/l and so determining the UIA level from inside a TAN reading can be a valuable exercise for pond keepers. UIA levels of 2.0 mg/l are the levels where fish begin to die off quickly. As stated, both water temperature and pH levels impact the toxicity of UIA and so when TAN tests are performed, it is important to read to both the water temperature and pH levels as well in order to complete the picture. Below are a couple of examples that illustrate the effects of water temperature and pH on TAN readings:

In Table 1 below, the first example shows a TAN reading of 0.5mg/l from the ammonia test kit. The water temperature is 50 degrees Fahrenheit and the pH 8.0. The first reaction to getting a positive ammonia reading is that the ammonia level is unacceptable and water changes, chemical treatments, or other measures are necessary to bring the ammonia

under control. But a closer look at the actual situation shows that the UIA, the toxic form of ammonia, is 0.0091 mg/l and in fact under the 0.05 mg/l "undesirable" level and thus does not pose much of a threat.

TAN	Water	Water	Factor *	UIA (NH3)
Level (mg/l)	Temp (F)	pH		Levels (mg/l)
0.5	50	7	0.0018	0.0009
0.5	72	7	0.0046	0.0023
0.5	86	7	0.008	0.004
0.5	50	8	0.0182	0.0091
0.5	72	8	0.0438	0.0219
0.5	86	8	0.0743	0.03715
0.5	50	8.6	0.0688	0.0344
0.5	72	8.6	0.1541	0.07705
0.5	86	8.6	0.2422	0.1211

Table 1

* The "FACTOR" column of the chart provides conversion factors available from a number of sources, including the University of Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences.

In reviewing the contents of **Table 1**, it is easy to see the correlation between water temperature and pH and the toxicity of UIA. For instance, compare the UIA level for a pH of 7 and a water temperature of 86 (.004 mg/l) and the UIA level for a pH of 8.6 and a water temperature of 86 (0.1211 mg/l). The effect of increased pH at a constant water temperature and constant TAN reading yield dramatic differences in UIA levels, with the increased pH resulting in greater toxicity of the UIA. This is the basis of the argument that higher pH readings make ammonia levels more toxic.

Next, compare the UIA level for a water temperature of 50 deg F. at a pH reading of 8 (0.0091 mg/l) and the UIA level for a water temperature of 86 deg F also at a pH of 8 (.03715). Here it is easy to see the impact of water temperature on UIA levels with constant pH and TAN readings with the cooler water offering more protection against UIA toxicity.

Now nitrites: unlike ammonia, which has an immediate toxic effect on fish, nitrite problems are caused by a prolonged exposure to nitrites over a period of time. Nitrites destroy hemoglobin which basically eliminates O₂ levels in the blood causing "brown blood syndrome" with eventual death to the fish through extreme O₂ deprivation. So, it takes some time for koi to accumulate enough nitrites to cause serious problems. How much time? That depends on a number of critical factors including nitrite levels in the water, the chloride levels of pond water, and the metabolism of the fish. In colder water (50 deg F and under) we know that the fish's metabolism slows significantly and one of the results is that his respiration will be less. This results in a decreased opportunity to take up nitrites from the water. However, lethal levels of nitrites can still be accumulated over time if the nitrite problem is not addressed.

For most ponders facing nitrite levels during cold water periods, salt is the best treatment as salt levels of only .1% will inhibit the uptake of nitrites and prevent brown-blood syndrome. And salt levels of .1% can be maintained for indefinite periods of time without a risk to the fish or concern for developing salt resistant parasites.

There is good news and bad news about nitrites. First, the bad news... it is deadly to our fish if left unchecked. The good news is that it is easy to protect our fish with low salt levels and the presence of nitrites means the biological filtration system is beginning to kick in. Most experienced ponders who understand the nitrogen cycle do not even test for ammonia in a mature system and will use the nitrite test to determine any water quality problems caused by bad filtration.

It is important to point the affect of salinity levels on water temperature. We know from physics that fresh water under standard pressure and within bounds of natural salinity levels (.02 to .1%) reaches maximum density at about 39 deg F. Ostensibly this means that a pond of proper depth and volume for a particular area of the country will not achieve water temperatures below 39 deg F at depth. We also know from physics that if we increase the salinity levels of the water, we lower the temperature at which water reaches its maximum density. This is why ice cream is made with salt and why salt water does not freeze at 32 deg F like fresh water. As temperate fish, koi will withstand water temperature down to 35 deg F before being affected by hypothermia and given this thin line of maximum water density (39 deg F) to the lower limit of 35 deg F, we can see that allowing an elevated salinity level (>.1%) has the potential to cause serious problems with the fish's well-being. This fact needs to be considered when applying salt in cold water conditions whether to prevent nitrite poisoning or parasite control.

Parasites, Bacteria, and Cold Water.

Next we need to discuss the pond's micro- and macro-organisms, more notably known as the parasites and the bacteria. Here we will differentiate between the nitrifying bacteria discussed above and the pathogenic bacteria that cause disease in our fish. Most parasites are basically warm-water creatures and as the water temperature increases into the high 40's and low 50's F, the common micro- and macro-parasites have the ability to appear. Did all of the parasites die off in winter?? I am not sure we know this to be fact.

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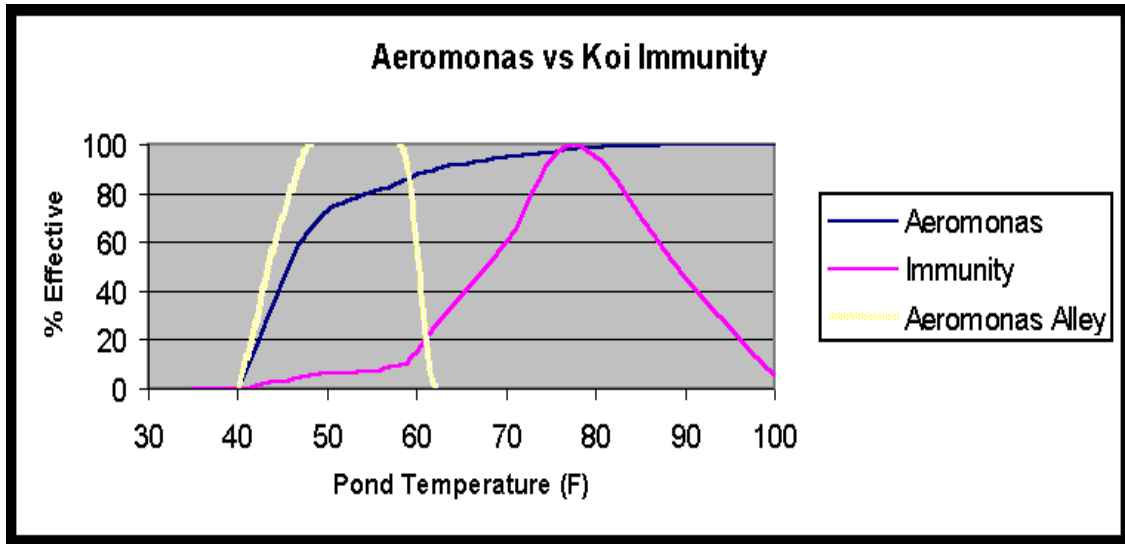
Therefore, it is always a good idea to do a .3% (3000 ppm) salt or, if you are an advanced ponder - a 2PPM potassium permanganate treatment, to your pond at about 60 degrees in an effort to reduce or kill off the emerging parasite colonies. The PP treatment will not only help eliminate parasites, but also provide a nice level of organics removal to clean up the water. Salt at higher levels is not tolerated well by some plants.

The lone exception to parasitic cold-water intolerance is costia. Costia, which is formally named *ichthyobodo necator* and not to be confused with common "ich", is one of the smallest ectoparasites (lives on the outside) and is especially active in water down to about 38 degrees F. This is what makes it so dangerous to our fish during cold-water times. As the fish's immune system and metabolic processes are reduced due to decreasing temperatures, costia parasites are still active and have the potential to cause significant damage through normal parasite attacks (cold water ulcers) and increased stress on the fish. The good news is that costia can be managed through salt and/or potassium permanganate treatments.

But the real problem we face as koi keepers is how to reduce the effects of aeromonas and pseudomonas bacteria on our fish during those times when the immune system is still strengthening. Aeromonas (and I will lump pseudomonas bacteria into this discussion as well) are the pathogenic bacteria that are the primary cause of ulcer disease, fin rot, and mouth rot. There is significant truth to the statement that aeromonas bacteria are ever-present in our ponds and they really only get to affect our fish when the fish become stressed or lack the ability to fight them off. Think of it this way: - cold germs are ever-present in our surroundings and we become significantly more susceptible to catching a cold when our resistance is low, such as when we are cold or tired. Dr. Richard Strange's course on Bacteriology provides an excellent discussion on the cycle for bacterial infections.

Much is made of the control and even the elimination of aeromonas in our ponds. And while aeromonas are the primary cause of bacterial disease in our fish, their presence in the pond is essential. The primary role of aeromonas in the pond is to begin the breakdown of fish feces by eating away the slime coat on the feces; their favorite food. While such treatments as in-water antibiotics, KoiZyme, and potassium permanganate will reduce or even eliminate aeromonas on a short term basis, a healthy level of aeromonas is required in the pond to balance the ecology of the pond correctly.

Consider the chart below. The activity levels of aeromonas and the koi's immune system are compared. Note that aeromonas becomes active at about 42 degrees (F) and remain active well above 90 degrees (F). Now notice the koi immune system activity. The fish only begin to have the ability to fight off infection at about 45 degrees (F) or so and by that time, the aeromonas are off and running at greater than 60 percent lead!



But the real problem area we need to consider is that portion of time/temperature that we call “Aeromonas Alley,” where the net effect of the aeromonas activity is so great and the koi’s immune system so weak that the potential for real trouble exists. Aeromonas Alley is the pond water temperature range between 40 degrees (F) and 62 degrees (F) and this represents the time where our fish are in most danger from aeromonas infections. While there is significant debate as to whether Aeromonas Alley really exists, the facts surrounding the activity of parasites, bacteria, and the koi’s immune system are irrefutable. Call it what you will, but all experienced koi keepers know that this is the single most dangerous time for koi health-related problems.

To counteract the potential for disaster, especially while temperatures are in Aeromonas Alley, ponders can take a number of steps to reduce aeromonas loads, including the following:

1. Reduce the amount of organics in the pond with a thorough cleaning of the pond bottom and filters. Remember that pathogenic bacteria thrive in high organic environments.
2. If possible, treat the pond with therapeutic potassium permanganate treatments. PP removes the organic load through oxidation and also kills off significant, if not all, bacteria in the pond. A therapeutic dose of PP is 2PPM for 4-8 hours)
3. Add salt to your pond at a dose rate of no less than .2 % (that is two pounds per 100 gallons) and keep it there for at least two weeks. Then reduce the salt level to about .08 to .1% through water changes and salt at that level for the remainder of the season. This will reduce the parasite load as well provide much needed chloride levels into the water. Do not use PP with salt levels over .1%.
4. Reduce feeding of the fish. The primary food source of aeromonas bacteria is fish feces. Actually, the slime coat on the feces. Reduced feeding causes less feces and so less food source for the aeromonas.

5. Not all chems and meds work well in cold water and some are dangerous. Of particular note is formalin. Formalin should only be used in water temperatures above 60 deg F. At lower temperatures, formalin is more toxic to fish and will easily push a stressed fish over the edge.

There are a number of other tricks for protecting your koi such as feeding them immune system enhancing food, but the one that seems to work well is the use of Koizyme. It is rare that I will specifically recommend any one product, but this is one product that every koi owner should use. Koizyme is a natural enzyme developed to help eliminate aeromonas bacteria by out-competing them for their primary food source. In effect, the presence of Koizyme starves out the aeromonas and reduces their numbers. Having said all of that, I only recommend Koizyme use in the early spring and late fall when the pond needs the most help. During the warmer months, the pond's ecology will handle the aeromonas load nicely assuming the pond is kept clean and the fish stress free. Aeromonas are necessary in our pond and in their beneficial role, help establish the natural balance of the pond.

Water Quality

It is probably safe to say that most pond owners have ignored their water quality over the winter months but now it is critical to start working to get the water right. Obviously the goal here is to take away yet one more major stressor on the fish. Here are some tips for managing the pond water's health coming out of winter:

1. Water change.... there is never a bad time for a water change. Do it NOW... even if it is a small one. All pond water tends to go stale, even over winter and even with the melting snow and ice, so change your water. Add dechlorinators as needed.
2. Check KH levels. NOW!!! The pond is still "living" and activities such as fish respiration, waste elimination (nitrification) and photosynthesis are producing CO₂, which is neutralized by the carbonates in the water. The net result is a reduction in the carbonates that could cause a pH swing or a pH crash. This happens more than we realize and a number of fish deaths that are attributed to cold water and in fact, from pH problems. Many folks, me included... now have green water from the increased production of algae as the weather and water warms and more sunlight is hitting the pond. The increase in algae means an increase in photosynthesis and this means more CO₂ which means that the carbonates are being eaten up at a faster rate. Without carbonates to balance the acid load from CO₂, the pH will swing first, then drop like a rock with the result being dead fish. Remember to warm your pond water to room temps prior to testing and if needed, start adding baking soda to get your KH levels to the 100 or so mark.
3. Salt for parasites. If you are convinced that your water temps will not drop back into the 30's, add salt to your pond (up to .3%) to help control parasites. While some parasites may not be affected by salt, there are still some that are and any reduction in numbers is good.

4. Until your water hits 55 deg F or so, don't even concern yourself with ammonia and nitrite readings as the biofilter bugs aren't awake until then. Concentrate on KH and pH readings first. Ammonia is far less toxic at cooler water temps and nitrite is most likely not even present yet. As your filters start to kick in and you start to read nitrites, add salt to .15% to protect the fish until the nitrites levels are gone.

As mentioned, a number of fish deaths are attributed to the effects of cold water initially but once we look closer at the problem, we very often see that water quality, and in particular pH swings or pH crashes have driven the fish into a high stress condition.

When investigating fish deaths in a cold water/spring situation, do not overlook water quality as more often than not, this is the cause of fish deaths in cold water and early spring conditions.

Cold Water Bloating

One of the more common problems we see in cold water and rapid temperature change settings is a bloating of the fish, including bulging eyes and raised scales. Normally these symptoms are associated with *dropsy*, the clinical presentation of fluid accumulation in the body cavity. With dropsy, it is usually a bacterial or viral infection or a parasitic attack on one of the internal organs that causes the fish's body to react with increased body fluid production. However, there is another cause of bloating that will offer the same symptoms but is a much less sinister problem. As was mentioned earlier, the metabolism of the fish slows considerably as the water temperature decreases and one of the results of this process is an adverse effect on the osmotic regulation system. Once the osmotic regulation system gets out of balance, the fish loses an effective way to regulate its body fluids and the result is a retention of excessive body fluids. Thus we get classic bloating. I have found this common in ponds where there is a fluctuation of water temperatures in the colder ranges (35 to 50 deg F) or that temperature range where the fish is moving in and out of torpor.

The treatment for this type of bloating is fairly simple, however the procedures for maintaining the fish post-treatment can get tricky. A bloated fish needs to be removed to a separate tank with water the **same** temperature as the pond's water. It is best to use pond water for this treatment not only for its temperature but also to reduce stress on the fish. I use a 100 gallon Rubbermaid trough as the q-tank. The q-tank is placed in the garage (unheated) and fitted with a small pump, a 300 W heater, and a grow-light on a timer (with on-off the same as the sunset-sunrise). I then wrap the tank with R19 house insulation and put a cover on the tank (but not sealed). Let the water warm slowly with the heater and at the same time, bring the salt levels up to .3%. The water temperature you finally achieve will of course depend on many factors but anything above 52 degrees and holding steady is good. The combination of warmer water and increased salt levels should jump-start the osmotic regulation system.

I have seen bloating reduce within 48 hours and the fish start responding to the warmer environment by looking for food. If the fish does not respond within 48 hours and a

noticeable reduction in bloating is not realized, up the salt level to .4%. You can repeat this every 48 hours up to .6% without significantly stressing the fish.

The drawback to this regimen is what to do now with a warm fish and a cold pond. This is a tough call and must be considered before removing a fish for treatment under these conditions. Obviously the fish would be reasonably content to stay in the warm tank but this may not be convenient. So, what you need to do is reverse the procedures for getting the fish to this point by reducing the water temperatures slowly until they equate to the pond's temperature. More than likely you had to change the water in the q-tank and so it is a good idea to now use pond water to replace any tank water lost to water changes. Also reduce the temperature settings on the heater. If you are lucky you can catch a warm spell where the pond's temperatures may have risen a few degrees. If not, once the tank temperatures and the pond's temperatures are within 5 degrees of each other, it is time to return the fish to the pond.

Cold Water Fungus

One of the most common ailments we see in our ponds during spring warm-up is the cold water fungus saprolegnia. Saprolegnia (or sap) is a freshwater fungus which simply means it lives in fresh water environments and needs water to grow and reproduce. Sap can also be found in brackish water and moist soil. It is often referred to as a "cold water" fungus as it flourishes in colder water, but it lives well in a wide range of water temperatures extending from 37 deg F to 91 deg F (3 to 31 deg C).

In the water, sap looks like fluffy cotton; however, out of the water it appears to be a matted mess of slime. Sap starts out either white or grey in color. The grey appearance also may indicate the presence of bacteria growing with sap's structure. Over a short period of time, sap may turn brown or green as organic particles in the water (such as algae) adhere to the filaments. Note the picture below. This is a classic presentation of sap that has invaded a bacterial infection of the dorsal fin area of a koi. The green color is actually embedded algae particles within the sap's filaments.



(Courtesy of Dr. Jim Phillips)

By appearance, sap can be easily confused with epistylus, a freshwater parasite that presents as a white cottony substance growing on the skin of the fish. Epistylus does not gather organic particles and will remain white. Confirmation of Epistylus versus sap should be done with a microscope.

Typically we think of sap as a “secondary” invader. This means that something else has violated the integrity of the fish’s skin allowing bacteria to enter and provide direct tissue access for the sap hyphae to embed themselves. In treating sap, it is imperative to treat BOTH the sap and the underlying primary cause. This will be discussed in more detail in the treatment section below.

However, sap can also be a primary invader under the right conditions and this is where it gets the reputation as a “cold water” fungus. We all know that cold water conditions, including dramatic temperature changes, cause great stress on the fish and suppress the fish’s natural immune system. As stated above, sap flourishes in colder water by producing and releasing increased zoospore counts into the water. The combination of stress, suppressed immune systems, and increased spore counts give sap the ability to cause major problems in colder water. Sap infections are commonly the cause of “winter kill.”

The following is a list of conditions that support the spread of sap:

- **Overcrowding** – *stress* and too many organics in too little water
- **Handling** – *stress* and removal of the mucous coat on the fish
- **Epidermal integrity** – open wounds that provide direct access to tissue

- **Parasites and pathogens** – parasites cause wounds that allow pathogens (like bacteria) to enter the tissue thus giving sap a chance to take hold and *stress*
- **Pollution** – *stress* and reduced water quality
- **Spawning** – *stress* and physical damage
- **Water quality** – *stress* and reduced physiological conditions
- **Water temperature changes** – *stress*.

Obviously the underlying theme in the above list is “*stress*” and this is the one thing that we need to guard against *first and foremost* to keep our fish healthy. In healthy conditions, our fish have some natural protection against sap with the mucous layer being the most effective first line of defense. The mucous layer or slime coat provides the ability to reject a sap attack by sloughing off a layer of mucous and sending the sap with it. The mucous coat also provides a natural fungicide at the cell-level. So you can see that improper handling or any activity that reduces the mucous coat offers an increased opportunity for sap to take hold.

The best “cure” for sap is prevention. As mentioned, sap is present in every pond and has its place in the order of life in the pond’s ecology. It really only becomes a problem when something has gone wrong with the fish and/or the pond or a condition such as cold water suppresses the fish’s immune system. Some of the steps we can take to reduce sap’s effectiveness include:

1. **Providing a stress-free environment (which starts with excellent water quality)**
2. **The active reduction of organics in the pond (good mechanical filtration and a balanced ecology). This also will reduce natural aeromonas bacteria counts**
3. **The quick removal of dead and dying fish and excess food**
4. **Proper handling (which starts with as little handling as possible)**
5. **Elimination of parasites**
6. **Increased water flow during warmer conditions**

But no matter how hard we try, and especially for those ponds located in areas subject to cold water situations and/or rapid water temperature changes, sap is always a possibility. **Except as noted above, there are no reasonable preventive measures, including the use of anti-fungal products as they just do not work effectively against sap.** Therefore, we must be prepared to diagnose and treat sap as soon as we see it and here are some treatment recommendations:

1. **Malachite Green (MG):** Hands down, this is the best treatment for all fungal problems, including sap. MG baths and dips work_ exceptionally well and one treatment will usually solve the problem (assuming any contributing causes are corrected as well). There are certain cautions that go with using MG, such as use only in cooler, well aerated water, so read the label carefully for instructions and precautions. MG is not recommended as a pond-wide treatment for sap as the concentration levels needed to kill off sap are too high for a pond-wide treatment to be effective. Such products as ProForm C, a Malachite Green-formalin

combination can help reduce the incidence of sap and parasites in the water, but because the sap hyphae may be deeply embedded, the stronger dip or bath method is recommended. **Caution: Malachite green is carcinogenic and has been banned for use on food fish. Use MG with great care.**

2. **Salt:** This is a distant “second best” treatment to MG. Salt in the 0.6 to 1.0% range for 30 minutes or less can help eliminate sap. The caution with this approach is that the higher the salt level, the more stress the fish will endure so check carefully on the stability of your fish prior to performing a high-level salt bath.
3. **Formalin:** Formalin is mentioned as a treatment for sap however, generally speaking, formalin is ineffective against most molds and fungi. Like MG and salt, formalin comes with its own precautions, including limiting its use in warm water, where low oxygen situations may develop. Handle formalin with care, its toxicity is well known. Diluted versions of formalin products, such ProForm C offer a nice one-two punch where MG takes out the sap and formalin gets the parasites. It is not recommended to use formalin against open wounds because of the harmful effect of formalin on exposed tissue and cell structures. Formalin is also more toxic to fish in cold water.
4. **Potassium Permanganate:** In the right hands, PP is one of the better treatments for sap. PP treatments at 4PPM (4g/1000 litres) will eliminate most of the sap but for deeply embedded sap hyphae, further surface treatments using a PP paste may be required. **The down side of PP, of course, is the inherent danger of using it at all. It is not recommended for those inexperienced with its use.**

Treating a sap-affected fish requires that the wound site be tended completely. As mentioned, sap is generally a secondary invader; this means something else went wrong to allow the sap to take hold, like a parasite attack or another wound that opened the tissue. So, when treating a sap-affected fish, first eliminate the sap from the surface of the fish and then treat the actual wound site, which is most likely starting to look like an ulcer. For the latter, Tri-Cide Neo, iodine, PP paste and/or Debride topical ointment are good choices. Depending on the extent of the underlying wound, injectable medications may be required and the assistance of a veterinarian sought. If you suspect that cold water has allowed sap to become a primary invader, attention to the surface tissue of the affected fish is still required as the sap hyphae penetrates the tissue and can allow bacteria to enter the wound site.

Conclusion

From this course, the KHA should be able to discuss the following:

1. The effects of water temperature changes on the health of the koi and the pond's ecology.
2. Techniques for treating the fish and the pond for parasite and bacteria control.
3. How to manage the pond and fish as they emerge from winter into spring.