

Mucus – the slime that binds

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C. 2020

The mucus produced by the fish's epidermal cells gives them their characteristic slimy feel. Mucus is produced by three specialized cells: goblet cells, sacciform cells, and club cells. Goblet cells are the most abundant and produce mucus granules containing glycoproteins. The sacciform cells mix their exudate with that of the goblet cells, and the club cells mainly secrete proteinaceous compounds. This viscous colloid is collectively known as "mucus" and is the primary defense the fish has against many external pathogens; trematodes, protozoans and bacteria. This mucus contains antimicrobial peptides (AMPs) and lysozymes that provide some of this immunity, as well as the physical barrier the sticky mucus provides itself. As the mucus is continually sloughed off, it carries with it pathogens trying to attack the fish. The mucus layer also assists the fish in osmoregulation; balancing their hydration level with that of the water they are swimming in. There is also some evidence that the mucus coating of fish develops its own "microbiome", with bacteria that enhance this protection.

Mucus covers all external surfaces of the fish; skin, fins, eyes gills and oral cavity. Indeed, think of a fish as a doughnut, with their alimentary canal as the "hole", even their intestines produce mucus. Some fish such as Mandarin dragonets possess a thick mucus coat, while others, such as pygmy angelfish, have a much thinner coat and feel almost "dry" to the touch. In all cases, physical handling of the fish can remove mucus, leaving the fish more prone to infection. If the handling actually damages the epidermis, the chance for infection is even greater.

Skin mucus is normally invisible, but under certain stressful conditions (often caused by water quality issues, parasites or bacteria) the fish's mucus production ramps up and the mucus coating thickens and becomes more visible. This can be especially notable over the fish's eyes, or on dark portions of the skin. This can lead the aquarist to make the false assumption that it is only the eyes, or dark portions of the skin that are affected, when actually, it is just more visible in these areas.



Thickened mucus on the trailing edge of the pectoral fin on a fire clownfish. This resolved with no treatment needed.

Idiopathic mucus plugs/cones: Fish sometimes develop excess mucus that excretes from the producing skin cells and rather than spreading out along the body, rises up as a cone or a plug. These presumable develop from some sort of skin irritation. If you do a skin scrape on them, all you see is mucus. They do show up on dark colored fish more often, probably because the contrast makes them easier to see. The cause(s) for this is unknown. In some cases, they just go away, in other cases, the fish dies - but in those cases, it is probable that there was a secondary issue. There may be some correlation between copper sulfate use, or a reaction to a previous skin infection. There is also some strong correlation between this issue and the species of fish; surgeonfish, tetras and Anabantids are all known to develop this. Many people misdiagnose these mucus plugs as *Cryptocaryon* or *Lymphocystis*, but the plug or cone shape to the mucus is diagnostic to some degree.

Thickened mucus coat: This can result from water quality issues or parasitic infections. If the fish's respiration rate is elevated, the mucus on the gill lamellae may also be thickened, and disrupting normal gas exchange. *Brooklynella hostilis* is well-known in causing thickened skin lesions that resemble excess mucus production. Even late-stage *Cryptocaryon* and *Amyloodinium* infections can cause opaque mucus layers on the skin of fish. Elevated ammonia levels in water can cause this, as well as possibly other toxins. There may also be a viral component in some cases, but that hasn't been fully proven.

Cloudy eyes: In some cases, a milky/cloudiness to a fish's eyes is just a more visible symptom of generalized mucus production that is also on the fish's skin, just not as visible as it is on the eyes. In other cases, it is thickened mucus solely on the eyes, due to a bacterial infection, or the presence of *Neobenedenia* flukes.



A *Sebastes* rockfish with bilateral retrobulbar exophthalmia; it healed with no treatment after a few months.

Excess mucus in fish feces: this will present as white or light colored, stringy fecal material that often hangs from the fish's anus for a longer than normal period. There are a number of different causes for

this, some benign, others very serious. Without access to a microscope, there is little that can be done to diagnose this issue effectively.

Idiopathic mucus feces: this fancy term is just to describe white mucoid bulky feces of no serious consequence, but of an unknown cause. Some suspicion is that this can be caused by changes in diet or diets high in fats.

Starvation: Fish that have no food moving through their bowels may excrete white mucoid feces with little bulk to them. The primary diagnostic for this issue is evident in that the fish won't been seen to be eating. Resolving the anorexia is of course the prime focus to resolve this issue.

Bacterial infection: internal bacterial infections can cause stringy feces as well. While some of these may resolve on their own, medicated foods containing a broad spectrum, gram negative oral antibiotic may be required.

Metazoan infections: multicellular worms are often blamed for mucoid feces, but in reality, they are almost never the root cause for this, and really, can only be diagnosed through looking for their ova in fecal samples. Fish can harbor tapeworms and nematodes without producing mucoid feces.

Protozoan infection: *Hexamita* and related diplomonad flagellate protozoans very frequently cause white stringy feces, especially in newly acquired clownfish. Metronidazole is the most frequent treatment for this issue. It can be dosed orally at 25 mg per kg of fish body weight, or 5 g in a kg of food. However, it is a very bitter medication, and some fish will refuse to feed on food containing it. It can be dosed in the water at 25 mg/l, but this is more effective in treating marine fishes, as freshwater fish do not "drink" aquarium water.

Coccidia: These microscopic, spore-forming, single-celled parasites are common diseases in dogs and cats. In fish, they cause epithelial necrosis of the gut, enteritis and the copious production of mucus (Noga 2010). These cannot be diagnosed without microscopic examination, and there is no well researched cure for this in fishes, although Toltrazuril has been tested.

Constipation: This malady is often given as a cause for stringy feces, but it is not as common as one would think. When it is seen, the feces are usually dark, not light in color. Often touted as a "cure for constipation", many aquarists add Epsom salts (magnesium sulfate) to the aquarium's water – do not do this in marine aquariums, its use is primarily as a tonic/dip for freshwater fish. Seawater formulas already contain between 7 and 19 grams of magnesium sulfate per gallon (depending on the recipe). NSW magnesium level is around 1200 ppm and sulfur is around 840 ppm. Some benefit might be seen using it as a dip in additional concentrations, but adding a small amount to a marine aquarium itself has no benefit. Epsom salts do have some possible benefit when mixed into the food as a 3% by weight adjunct. Another commonly heard remedy for constipation is; "feed fresh peas". This is an effective cure for fancy goldfish and Malawi cichlids that develop constipation and bloating. Again, overextrapolation has marine aquarists trying to feed peas to carnivorous fish, etc. The best method to enhance gut motility in fish is to feed frozen adult brine shrimp – not as a permanent diet, just long enough to get the constipation resolved.

Artificial slime coatings have been sold for decades, ever since Novaqua appeared on the market in the mid 1970's. The "slime coatings" in these products are usually combined with sodium thiosulfate to remove chlorine, EDTA to bind with heavy metals, and some buffers for pH control. These products should never be used as a treatment for acute disease issues in aquariums. They can be overdosed, possibly clogging a fish's gills to some degree. One study showed that a 50-ppm dose of raw Aloe vera caused >80% mortality in Tilapia after 72 hours (Taiwo et-al, 2005). Some of these products also contain

phosphate which can be problematic for low nutrient reef aquariums. There is little to no direct evidence that the Aloe vera and other polysaccharides reduce stress in fish. It seems implausible that a small amount of polysaccharides added to aquarium water can preferentially coat the skin of fish, offering artificial protection as the fish's natural slime coat does. In fact, while one study indicates that Aloe vera in water can enhance the activity of leukocytes in freshwater fish, the mechanism by which the Aloe reached the fish's blood was not explained (Zanuzzo et-al, 2012). Indeed, in marine fish, the oral route would be the most likely, yet another study indicates that oral Aloe vera actually had an adverse effect on the antioxidant defense system on Rainbow trout (Golestan et-al, 2015). It seems prudent then, to use these products only to treat tap water in order to make it safer for fish.

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