

On-Farm Transport of Ornamental Fish ¹

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Introduction

Any trauma and stress associated with handling and transport of fish will affect survival and overall quality of the fish (see *UF IFAS Circular 919 Stress-It's Role in Fish Disease*). Fish should be moved quickly and efficiently to minimize stress, the risk of disease outbreaks, and mortality. Important considerations for transporting fish include: 1) type of container, 2) transport vehicle, 3) aeration, 4)

type of water, and 5) additives for sedating the fish (Figure 1).

Typically, fish are harvested from a pond and placed into a transport container that is filled with water and covered with a lid (see *UF IFAS Fact Sheet FA-117 Harvesting Ornamental Fish from Ponds*). Some commonly used transport containers in Florida include: 1) polystyrene shipping boxes, 2) plastic boxes/tubs, 3) galvanized metal



Figure 1. Typical transport additives
Credits: Tina Crosby 2004



Figure 2. A transportation vehicle
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tubs, 4) wood/fiberglass boxes, and 5) 55-gallon plastic barrels. Following harvest, fish are transported to a holding facility (Figure 2). The facility is generally a building that has vats, tanks, or tubs where fish that are brought in from a pond are held until shipped to a buyer.

Transport Considerations

Many factors including dissolved oxygen levels, changes in temperature, and pH differences between transport and holding water should be considered when transporting fish. Poor water conditions can adversely affect the immune system of the fish, increase susceptibility to disease, and may lead to illness or death. Determine these differences before moving the fish, and, if necessary, make adjustments to the water. Then acclimate the fish. Acclimation is the process of slowly introducing the fish to different quality water to allow physiological adjustments to occur gradually over time.

Water Selection

One of the most important factors in moving fish from a pond to the holding facility is the source of water used in the transport container. Water taken directly from the pond, aerated well water, a half-pond / half-aerated well water mixture, or treated municipal water can be used to transport the harvested fish.

Many water quality parameters should be considered when handling fish, including pH, ammonia, nitrite, dissolved oxygen, temperature, total alkalinity, total hardness, and free carbon dioxide. Table 1 (modified from *UF IFAS Fact Sheet VM-147 Incorporating Pet Fish Into Your Small Animal Practice*) shows general desired water quality parameters for freshwater fish. However, different species of fish may have very different water quality requirements, so it is important to know the requirements for each species being transported to ensure its good husbandry and health.

Well water is usually low in dissolved oxygen and may have high concentrations of dissolved carbon dioxide (CO₂), dissolved hydrogen sulfide (H₂S), or dissolved iron. Vigorous aeration of well water in a mixing vat prior to use helps degas (drive off) dissolved carbon dioxide and hydrogen sulfide and increases the oxygen levels. Before using well water, it is best to test the water (pH, TAN, NO₂, DO, alkalinity, hardness, CO₂) to ensure good water quality.

Municipal water is generally treated with chlorine or chloramines for disinfection. Because these chemicals are highly toxic to fish, they must be removed from the water before use. Chlorine can be removed using sodium

Table 1. Water Quality parameter ranges for freshwater fish. Tolerance of parameters is species dependent.

Parameter	Good	Bad
Dissolved Oxygen (DO)	5-15 ppm	<5 or >25 ppm
Carbon Dioxide (CO ₂)	<5 ppm	>20 ppm
pH	6.5-9.5	<5 or >10
Total Ammonia Nitrogen (TAN)	0 ppm	>2 ppm @ pH>8
Unionized Ammonia (UIA)	0 ppm	>0.05 ppm = gill damage
Nitrite (NO ₂)	0 ppm	>0.5 ppm
Total Alkalinity (TA)	50-250 ppm	<50 or >250 ppm
Total Hardness (TH)	>20 ppm	0 ppm

thiosulfate (7.4 ppm sodium thiosulfate for each ppm of chlorine) or with vigorous aeration (Boyd 1990). Chloramine is a combination of chlorine and ammonia. Sodium thiosulfate and aeration does NOT remove chloramines. A commercial product must be used to remove chloramines.

Experiments conducted at the University of Florida Tropical Aquaculture Laboratory demonstrated that fish transported from a pond to a holding facility in aerated well water or a mixture of half pond and half aerated well water had improved behavior (i.e., showed less signs of stress) over time compared to transfer in pond water alone. Well water alone may be warmer or cooler than pond water depending on the season, and it usually lacks dissolved oxygen unless aerated. An advantage of using well water is that it is essentially pathogen-free, and with a bit of management, it can be properly adjusted for use in transporting fish. By contrast, pond water may contain phytoplankton, insects, crayfish, and many potential disease-causing organisms. The mixture of pond water and aerated well water allows the farmer to reduce problems associated with each.

Dissolved Oxygen Levels During Transport: The Limiting Factor

Dissolved oxygen concentrations in the transport container may change greatly during transport of fish. Water temperature, initial oxygen concentration, dirt and organics, quantity and size of fish, and length of time in the transport container all affect oxygen concentration. In most cases, the volume of water within the transport container is small relative to the mass of the fish. Loading too many fish into a container can cause increased physical damage (e.g., scale loss, fin damage) and lead to more rapid removal of oxygen. Loss of fish due to low dissolved oxygen during transport is common, but preventable.

A fish's metabolism increases with feeding and digestion, resulting in increase oxygen demand (Wedemeyer 1996). Therefore, withholding food 24-48 hours prior to transport significantly reduces oxygen consumption (Wedemeyer 1996).

Oxygen consumption is also higher when the fish are under increased stress. An increase in respiration and uptake of water following handling can lead to ion imbalance and result in mortalities days after the fish are transported (Wedemeyer 1996).

Higher water temperatures increase the rate of oxygen consumption as well (Wedemeyer 1996). Because warm water cannot hold as much dissolved oxygen as cool water, it is important to keep the transportation time to a minimum during warm weather.

When transporting large numbers of fish or when extended transportation times are involved, supplemental aeration or oxygenation should be used. Supplemental aeration can be provided using an air pump with air lines and air stones added to the transport water.

Bubbling pure oxygen into the water from a cylinder is another very useful method, but requires some experience. Care must be taken so that dissolved oxygen levels do not become supersaturated. Supersaturation is typically seen in well water (Boyd 1990) composed primarily of nitrogen gas, but it can occur when oxygen is dissolved into the water at a higher concentration than it can naturally hold, absorb, or retain. The amount of oxygen that water can hold is dependent on temperature, salinity, and pressure. It is easy to over-oxygenate or supersaturate the transport water if oxygen gas is added directly into the water, causing gas bubbles to form in the bloodstream of the fish, as well as in other tissues and organs (e.g., skin, eyes, fins, especially the gills), a condition known as gas bubble disease. Gas bubble disease, which is similar to the bends in human divers, is often fatal, but it can easily be avoided by the use of an oxygen flow meter and by taking frequent dissolved oxygen readings. Oxygen should be added so that a fine stream of bubbles barely breaks the surface of the water. The stream of bubbles should not be flowing as vigorously as air does when using an air pump. Supersaturation is not a problem when filling shipping bags with a high density of fish in a closed plastic bag. This is because oxygen gas is not forced into the water, but rather the bag is filled with oxygen. During transport, fish consume the finite amount of oxygen placed in the shipping bag.

Temperature

Fish are ectothermic, meaning they have a variable body temperature that fluctuates with the temperature of the surrounding environment. Different fish species have different optimal temperature ranges in which they will grow and flourish. Temperature affects respiration, feeding, and digestion. Sudden temperature changes stress the fish, suppress its immune system and can lead to disease and death.

Sunlight can quickly lead to increased transport water temperature, which affect other water chemistry (e.g., ammonia and dissolved oxygen). Additionally, high temperatures can directly cause stress to coolwater fish such as koi and goldfish. In cold weather, the temperature of transport water can drop significantly causing stress to warmwater fish (e.g., swordtails, gouramis, tetras). Thus, it is important to know the temperature tolerances of the species being grown and to compensate as needed.

During transport, temperature differences between transport water and holding facility water can vary greatly. Sudden changes in temperature can result in temperature shock syndrome in fish (Wedemeyer 1996). For this reason, fish must be acclimated (adjusted) to the water temperature in the holding facility.

ACCLIMATING FISH INTO HOLDING SYSTEMS

The process of acclimation involves placing the transport container in front of or in the holding tank, adding an airline, and gradually adding water from the holding tank into the transport container. The airline will help maintain an adequate dissolved oxygen levels and mixing the waters will prevent rapid temperature and pH changes. If the temperature difference is greater than 10°C, then ideally, acclimation should proceed slowly over a period of two or more hours (Wedemeyer 1996). However, more rapid acclimation may be tolerated by some species.

Effects of Carbon Dioxide and pH on Ammonia Toxicity

High levels of carbon dioxide lowers the affinity of oxygen to bind with hemoglobin in the blood of the fish (Wedemeyer 1996). In water, carbon dioxide forms carbonic acid (H_2CO_3). As the levels of carbon dioxide and carbonic acid increase, the pH of water decreases. Due to increases in CO_2 , pH often drops while fish are in transit. Levels of pH under 7 are considered acidic and over 7 are basic. Changes in pH shift in the ratio of unionized to ionized ammonia.

Ammonia is a metabolic waste product released primarily through the gills of fish. At high concentrations, ammonia can cause gill damage and stress (see *UF IFAS Fact Sheet FA-16 Ammonia*). As transport time or the number of fish in the transport container increase, the amount of total ammonia nitrogen (TAN) accumulates in the water. Total ammonia nitrogen is present in two forms: ionized ammonia (IA) and unionized ammonia (UIA). Unionized ammonia (NH_3) is much more toxic than ionized ammonia (NH_4^+). The portion of total ammonia that is present as toxic unionized ammonia (UIA) shifts with changes in temperature and pH of the water. As temperature and pH increase, the ammonia shifts to the more toxic form.

In transport water, carbonic acid produced by release of carbon dioxide lowers the pH of the water and shifts the ratio of toxic unionized ammonia to the less toxic ionized form. Figure 3 shows the shift between the unionized (toxic) and ionized (less toxic) forms of ammonia with change in pH, for a water sample at 75°F, with 1.0mg/L TAN.

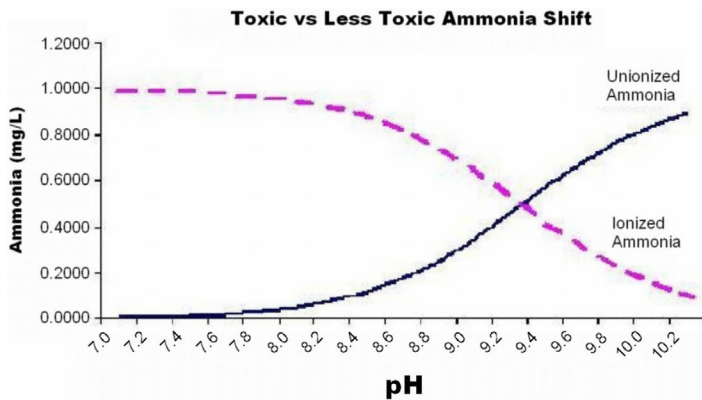


Figure 3. Example of pH-induced shifts between unionized (toxic) and ionized (less toxic) forms of ammonia. Credits: Tina Crosby 2004

Chemical Additives

Sedatives and salt are widely used in transport water to aid in alleviating stress and trauma to fish. Stress causes a rise in blood cortisol levels. Cortisol is a steroid hormone that causes physiological (e.g., increased heart rate, increased ventilation) and metabolic (i.e., energy) changes. The fish diverts energy to restore its physiological balance, which can lead to reduced immunity against disease. Sedatives slow down the metabolism of the fish which reduces respiration and ultimately helps the fish compensate for some fluctuations in water quality (e.g., low dissolved oxygen). Decreased respiration and activity lessens oxygen demand as well as the possibility of fish abrading themselves against the transport container and each other.

Table 2. Transport additives tested

Chemical	Intended Use	Dose Tested	Effect on Appearance and Behavior
Oxygen (gas)	Provide oxygen	Fine Bubbles	None
Salt	Aid osmoregulation	3 ppt	None
Acriflavine neutral	Antimicrobial	7 mg/L	Poor appearance and mortality
Methylene blue	Antimicrobial	2 mg/L	None
Clove Oil	Sedative	5 mg/L	None
MS-222	Sedative	20 mg/L	Improved initial appearance
Quinaldine	Sedative	2.5 mg/L	None

Salt reduces physiological stress by decreasing the osmotic gradient between the fish and the transport water (see *UF IFAS Fact Sheet VM-86 The Use of Salt in Aquaculture*), thus decreasing the amount of energy the fish must use for osmoregulation.

Additives can improve the quality of the shipped fish. Some farmers choose to treat fish with a prophylactic antimicrobial chemical during transport, while others wait until the fish have been acclimated to conditions in the holding facility (see *UF IFAS Fact Sheet FA-120 Preparation and Packaging of Ornamental Fish for Shipping*). Before using any chemical as a prophylactic treatment, a history of problems should be established. Using a chemical, especially an antibiotic, without a real need is wasteful, can result in increased bacterial resistance to antibiotics used, and can be detrimental to the fish.

On-farm transport trials were run at the University of Florida Tropical Aquaculture Laboratory to evaluate some commonly used additives. Fish were trapped in a pond and put into a polystyrene transport container with half pond water, half aerated well water. The boxes of fish were then transported by truck for four hours. Treatments tested were oxygenation with an oxygen bottle, salt (sodium chloride), acriflavine neutral, methylene blue, clove oil, tricaine methanesulfonate (MS-222), quinaldine and no treatment (control) (Table 2).

Upon arrival back at the facility, the fish were put into tanks with flow-through aerated well water, and held one week for observation. Using MS-222 improved the appearance (e.g., less ragged finnage, more normal coloration, minimal scale-loss) of the fish immediately following transportation from the pond; however, after one-week of being in the holding facility, the appearance of the fish was no better

than those that received no treatment. The behavior of the fish treated with MS-222 was no different than other treatments tested. All other treatments, except acriflavine neutral, had no beneficial or negative effect. The use of acriflavine neutral was found to have a negative affect on fish. Fish transported with acriflavine neutral looked worse (e.g., clamped fins, scale-loss, torn fins, etc.) than other fish and experienced greater mortalities than fish transported with no additive (i.e., control fish).

Depending upon length of time for transport, there may not be a significant benefit to use of a sedative or salt. Some of these treatments, however, may be useful for extended transportation and shipping of ornamental fish (see *UF IFAS Fact Sheet FA-120 Preparation and Packaging of Ornamental Fish for Shipping*).

Summary

Reducing the factors that contribute to stress in ornamental fish during transport from the grow-out pond to the holding facility lowers mortality and improves appearance. Optimal conditions can be achieved with careful planning and preparation prior to the move. Important considerations include: 1) transport container, 2) transport vehicle if needed, 3) type of water to be used in the transport container, 4) aeration, and 5) additives. Close attention should be given to various water quality parameters and their interactions. Transport time and fluctuations in water quality should be kept to a minimum. The level of dissolved oxygen and temperature are important and should always be a concern to the farmer. Fish should be slowly acclimated if there are significant differences in transport water and receiving water temperature [i.e., > 5.5°C (10°F)] (Petty et al. 2004). With experience and care, farmers can increase the quality and survival of fish going to market.

Recommended Reading

UF/IFAS Circular 919 *Stress - Its Role in Fish Disease*. <http://edis.ifas.ufl.edu/FA005>

UF/IFAS Fact Sheet FA-3 *Fish Handling and Transport*. <http://edis.ifas.ufl.edu/FA019>

UF/IFAS Fact Sheet FA-7 *Fish Fingerlings: Purchasing, Transporting, and Stocking*. <http://edis.ifas.ufl.edu/FA013>

UF/IFAS Fact Sheet FA-16 *Ammonia*. <http://edis.ifas.ufl.edu/FA031>

UF/IFAS Fact Sheet FA-117 *Harvesting Ornamental Fish From Ponds*. <http://edis.ifas.ufl.edu/FA117>

UF/IFAS Fact Sheet FA-118 *Grading Ornamental Fish*. <http://edis.ifas.ufl.edu/FA118>

UF/IFAS Fact Sheet FA-120 *Preparation of Ornamental Fish for Shipping*. <http://edis.ifas.ufl.edu/FA120>

UF/IFAS Fact Sheet VM-78 *Bath Treatment for Sick Fish*. <http://edis.ifas.ufl.edu/VM037>

UF/IFAS Fact Sheet VM-86 *Use of Salt in Aquaculture*. <http://edis.ifas.ufl.edu/VM007>

UF/IFAS Fact Sheet VM-147 *Incorporating Pet Fish Into Your Small Animal Practice*.

<http://edis.ifas.ufl.edu/VM108>

SRAC Publication No. 410 *Calculating Treatments for Ponds and Tanks*. <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/20/>

SRAC Publication No. 462 *Nitrite in Fish Ponds* <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/25/>

SRAC Publication No. 463 *Ammonia in Fish Ponds*. <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/25/>

SRAC Publication No. 464 *Interactions of pH, Carbon Dioxide, Alkalinity, and Hardness in Fish Ponds*. <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/25/>

SRAC Publication No. 468 *Carbon Dioxide in Fish Ponds*. <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/25/>

SRAC Publication No. 474 *The Role of Stress in Fish Disease*. <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/26/>

SRAC Publication No. 3900 *Anesthetics in Aquaculture*. <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/18/>

SRAC Publication No. 4601 *Measuring Dissolved Oxygen Concentration in Aquaculture*. <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/25/>

References and Further Reading

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Petty, B.D., and R.F. Floyd. 2004. Pet fish care and husbandry. *Veterinary Clinics Exotic Animal Practice* 7:397-419.

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