A novel approach to ornamental fish transportation for the aquarium hobbyist

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Received: April 2020 Accepted: July 2020

Abstract
Fish transportation methods for fish culture operations, public aquariums, biologists, and researchers often employ methods and use equipment which the average aquarium hobbyist does not have access to. Aquarium hobbyists typically transport fish via sealed plastic bags that are inflated with oxygen and shipped by next day mail service or as cargo on commercial airlines, however, the build-up of ammonia and carbon dioxide limit the duration that fish can be kept within these sealed bags to approximately 24 to 36 hours. This study outlines a novel technique for fish transportation suitable for the aquarium hobbyist. This protocol allowed for the successful transport of three fish and one marine invertebrate for 7 days, with minimal effects on water chemistry and stress. The use of a standardized transport procedure such as the method outlined in this study may help to reduce fish stressors; thereby, reducing short- and long-term morbidity and mortality associated with the transport of fish.

Keywords: Ammonia, Fish transport, Hobbyist, Stress, Water quality

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Introduction

The safe transportation of fish is influenced by many factors, including the duration of transport, temperature, water chemistry parameters, and the size and physical condition of the fish (Berka, 1986; Golombieski *et al*., 2003; Carneiro *et al*., 2009). A wide variety of methods for fish transportation have been described; however, these techniques typically involve the transportation of live fish for fish culture operations, public aquariums, biologists, and researchers (Norris *et al*., 1960; Hora and Pillay, 1962; Bardach *et al*., 1972; Harmon, 2009). The procedures employed by these commercial facilities are often useful for short term (< 36 hours) transportation, however, the methods often cannot be replicated by the average aquarium hobbyist.

The two most common methods for commercial fish transportation are divided into open and closed systems. Open systems are continuously aerated tanks housed within trucks for shipment over land (Norris *et al*., 1960; U.S. Fish and Wildlife Service, 1978; Johnson, 1979). Closed systems use two layers of polyethylene bags filled with water, inflated with oxygen, sealed and then transported by air. Fish destined for the pet trade normally travel long distances and are typically transported by the closed system method (Lim *et al*., 2003; Pramod *et al*., 2010). Aquarium hobbyists may use this method for fish transportation by shipping fish as cargo on a commercial airline or by next day shipping via a mail service. This method is expensive; however, most airlines will provide some form of guarantee for animals arriving alive. Ambient temperature, airline delays, and layovers may also impact the practicality of this transportation method. If packaged appropriately, most fish should be safe for approximately 24 to 36 hours depending on the fish’s condition prior to transport (Harrison, 2016).

The limitations of the closed system transportation methods include unstable water temperatures, the build-up of ammonia and carbon dioxide produced during transport, and the limited supply of dissolved oxygen (Gomes *et al*., 1999; Golombieski *et al*., 2003; Gomes *et al*., 2006a; Gomes *et al*., 2006b; Carneiro *et al*., 2009). For the average aquarium hobbyist, the open system methods for fish transportation are limited by the general non-availability or prohibitive capital required for equipment. Activities involved with both the open and closed systems, such as handling, confinement and exposure to sub-optimal water quality, have the potential to create physiological changes in the fish because of increased stress. Increased survival rates and the arrival of healthy fish are dependent on suitable transport protocols; therefore, the purpose of this study was to assess a novel method for fish transportation that the aquarium hobbyist can use.

Materials and methods

A non-breakable plastic container of two dimensions were used in this study. The first container was a 5-gallon (19

L) bucket that measured 11.91" diameter x 14.5" high. The second container measured 17" x 10-1/2" x 31 (L x W x H) (Fig. 1). Both containers used battery powered aerators for the duration of the study. A Topfin (PetSmart Co., Phoenix, AZ, 85027, U.S.A) aerator was used for the first container while a Mino-Mizer (HyPark Specialty Co., Chanhassen, MN, 55317, U.S.A) aerator was used on the second container. Carbon (BRS Premium ROX 0.8 carbon, Bulk Reef Supply, Golden Valley, MN, 55427, U.S.A) (0.5 cups) was added to a media bag and placed in both transport containers.

Figure 1: The two containers used in this study; container one (A), and container two (B). Both pictures depict the portable battery powered aerators used for the duration of the experiment. Not depicted in these photos are the media bags containing 0.5 cups of carbon which were used to assist with chemical filtration.

Two false clownfish (*Amphiprion ocellaris*), one Christmas wrasse (*Halichoeres claudia*), and one cleaner shrimp (*Lysmata amboinensis*) were used in this study. The first container held the two clownfish and cleaner shrimp. The second container contained the wrasse. Both containers were filled one third of the total volume with freshly made saltwater and 0.5 cups (64 grams) of sand from the display tank.

Prior to transportation, food was withheld for 2 days. Temperature (25.5°C) and salinity (1.025) in the transportation containers were matched to the display aquarium prior to moving the tank inhabitants. Partial water changes (30% of total volume) were performed every 48 hours. Water chemistry testing was performed every 24 hours, prior to water changes with an API Marine Saltwater Test Kit (Mars

Fishcare North America, Inc., Chalfont, PA, 18914, U.S.A). Salinity was measured using a Milwaukee MA887 Seawater Digital Refractometer (Milwaukee Instruments, Inc., Rocky Mount, NC, 27804, U.S.A). Animals were kept in their transport containers for a total of 7 days. Fish were assessed daily for signs of stress, which included observation of opercular rate, activity, and coloration.

Following the duration of this study, animals were drip acclimated and placed back into the display tank. Drip acclimation was performed by creating a siphon with airline tubing (0.09" diameter) and adding five drops per second of water from the display tank to the transport containers. After 1 hour, animals were moved into the display tank.

Results

Animals were transported a total of 595 kilometers by car, which lasted 5.5 hours. Ambient temperature during transport ranged from 21.1°C to 32.8°C, while the internal temperature of the car ranged from 22.8°C to 26.7°C. Water temperature ranged between 25.4°C to 26.0°C during transport. Animals were held indoors with an ambient temperature that ranged from 23.9°C to 25.6°C for the remaining duration of the study.

Water chemistry parameters and water temperature remained stable throughout the duration of this study (Table 1). Fish stress level, assessed by opercular rate, activity, and coloration was static compared to pre-transport assessment (Table 2).

Animals were monitored for signs of disease for one month following transport. All animals showed no signs of disease and displayed appropriate appetite and activity levels following transfer back into the display tank.

Table 1: Water chemistry parameters.

	pH $_1$	pH $_2$	Ammonia $_1$ (ppm)	Ammonia $_2$ (ppm)	Nitrite $_1$ (ppm)	Nitrite $_2$ (ppm)	Nitrate $_1$ (ppm)	Nitrate $_2$ (ppm)	Salinity $_1$	Salinity $_2$	Temp $_1$ (°C)	Temp $_2$ (°C)
Pre-transport	8.2		0		0		0		1.025		25.5	
Day 0	8.2	8.2	0	0	0	0	0	0	1.025	1.025	25.2	25.5
Day 1	8.2	8.2	0.25	0	0	0	0	0	1.025	1.025	25.1	25.5
Day 2	8.2	8.2	0	0	0	0	0	0	1.025	1.025	25.5	25.6
Day 3	8.2	8.2	0.25	0	0	0	0	0	1.026	1.025	25.8	25.7
Day 4	8.2	8.2	0	0	0	0	0	0	1.025	1.026	25.5	25.5
Day 5	8.2	8.2	0	0	0	0	0	0	1.025	1.025	25.4	25.6
Day 6	8.2	8.2	0	0	0	0	0	0	1.025	1.026	25.5	25.6
Day 7	8.2	8.2	0	0	0	0	0	0	1.025	1.025	25.7	25.5

Water chemistry parameters for container one and container two throughout the duration of this study. The subscripts ($_1$ or $_2$) corresponds to the respective transport container number. Pre-transport values were obtained from the display tank prior to transferring animals to the transport containers.

Table 2: Observational assessment.

	Opercular rate (pre minute)			**Activity**			**Coloration**		
	Clownfish 1	**Clownfish 2**	**Wrasse**	**Clownfish 1**	**Clownfish 2**	**Wrasse**	**Clownfish 1**	**Clownfish 2**	**Wrasse**
Pre-transport	80	78	110	BAR	BAR	BAR	WNL	WNL	WNL
Day 0	83	81	94	BAR	BAR	BAR	WNL	WNL	WNL
Day 1	71	79	93	BAR	BAR	BAR	WNL	WNL	WNL
Day 2	74	80	88	BAR	BAR	BAR	WNL	WNL	WNL
Day 3	75	71	109	BAR	BAR	BAR	WNL	WNL	WNL
Day 4	78	77	99	BAR	BAR	BAR	WNL	WNL	WNL
Day 5	73	81	97	BAR	BAR	BAR	WNL	WNL	WNL
Day 6	87	86	88	BAR	BAR	BAR	WNL	WNL	WNL
Day 7	80	89	104	BAR	BAR	BAR	WNL	WNL	WNL

Results of observational assessment for indicators of stress. Opercular rate was measured by counting operculum movements for one minute. Activity was graded as bright, alert, and responsive (BAR) if a fish was actively swimming normally or quiet, alert and responsive (QAR) if the fish was not actively swimming, but responsive when the transport container was approached. Coloration was subjectively assessed visually to see if there was any evidence of pallor or discoloration. If no evidence of pallor or discoloration was appreciated, the fish was determined to be within normal limits (WNL).

Discussion

Ornamental fish captured for the aquarium industry travel approximately 50 to 70 hours from the site of capture to their final destination for purchase (Bruckner, 2005; Sampaio and Freire, 2016). Aquarium hobbyists often use a similar method for transporting fish via sealed plastic bags that are inflated with oxygen and shipped by next day mail service or as cargo on a commercial airline (Lim *et al.*, 2003; Pramod *et al.*, 2010; Harrison, 2016). The build-up of ammonia and carbon dioxide limits the duration that fish can be kept within these sealed bags to approximately 24 to 36 hours if packaged appropriately.

The protocol for fish transportation established in this study allowed for the successful transport for three fish and one invertebrate for 7 days outside of an established aquarium with only minimal effects on water chemistry (Table 1) and stress level (Table 2). The methods used in this study provide hobbyists with an affordable alternative to shipping fish should they need to move their fish tank or transport fish to another location. Furthermore, this protocol can also be applied for fish transportation to a veterinary facility for further examination.

Stress in fish can be caused by biological, chemical, or physical conditions. Activities involved with transporting fish, such as handling, confinement and exposure to suboptimal water quality, have the potential to cause physiological changes in fish secondary to increased stress (Carmichael *et al.*, 1984; Davis and Parker, 1986; Maule *et al.*, 1988; Weirich and Tomasso 1991; Cech Jr. *et al.*, 1996; Brick and Cech, Jr. 2002). The impact of stress on the fish depends on the severity and duration of the stress, as well as the health of the fish (Noga, 2000). However, even a collection of mild stressors may act together to cause mortality (Carmichael *et al*., 2001). Stress also plays a role in increasing the susceptibility of fish to diseases (Winton, 2001). Many sources of stress during transport are unavoidable; however, the use of standardized transport procedures may help to reduce overall stress level (Table 2).

Although the focus of this study was marine species, a freshwater transport protocol has been performed three times by the authors using the same procedures outlined in this study. In the authors' experience, this method allowed for the successful transport of freshwater fish for seven days for two trips, and one day for one trip. In adapting this protocol to freshwater species, it is worthwhile to note that there are differences among marine and freshwater species, including osmoregulatory differences and sensitivity to certain water-quality parameters (Moyle and Cech, Jr., 1988; Harmon, 2009). Furthermore, optimal water-quality parameters may differ within or between species depending on life stage, health, and previous water conditions. Nonetheless, maintaining optimal water quality during transport is a pivotal component in reducing physiological stress regardless of the species being transported.

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