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A NOVEL TRANSPORT SYSTEM FOR HELLBENDER SALAMANDERS (*CRYPTOBRANCHUS ALLEGANIENSIS*)

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Abstract.—**Populations of Eastern Hellbenders (*Cryptobranchus alleganiensis alleganiensis*) have declined considerably throughout their range. In Indiana, they are listed as state endangered and critically imperiled. Current conservation efforts include headstart programs, reintroductions, and captive breeding to bolster remaining populations. However, transporting Hellbenders into captivity, between facilities, or back to the wild can be potentially stressful or harmful to individuals. Hellbenders require cool, well-oxygenated water, and because of their conservation status, need to be handled with care. Insulated hauling trucks are effective at moving high densities of fish; however, they are inappropriate for Hellbender transport because they are designed to quickly drain fish through the bottom of the tank and are expensive. Herein we present a novel and affordable transport system to safely move Hellbenders, particularly over long distances. This method has been effective in transporting Hellbenders of multiple age classes over 1,513 km (940 mi) with 100% survival.**

Key Words.—amphibian; augmentation; captive-rearing; captivity; conservation; reintroduction; translocation technique; transportation

INTRODUCTION

Eastern Hellbenders (*Cryptobranchus alleganiensis alleganiensis*) have suffered dramatic population declines during recent decades because of habitat loss and destruction, pollution, disease, and human removal (Mayasich et al. 2003; Wheeler et al. 2003). In Indiana, Eastern Hellbenders are state-listed as endangered and are classified as critically imperiled (Mayasich et al. 2003). Conservation efforts are underway to preserve remaining populations by incorporating natural conditions (e.g., water current and rocky substrate) to captive rearing environments, expanding headstart facilities throughout the state, establishing a center for captive breeding, and translocating individuals to bolster wild populations (Burgmeier et al. 2016). Captive rearing and reintroduction efforts for Hellbenders have been successful; translocated individuals have been documented with annual survivorship as high as 70% when sufficient habitat is available at release sites (Bodinof et al. 2012). However, these activities require transporting individuals from the wild to captivity, between facilities, or to their release sites, which can complicate conservation efforts. If transportation procedures are not tailored towards the focal species, they can be stressful and potentially harmful for animals (Teixeira et al. 2007). Although Hellbender translocations have occurred, no information has been published about safely moving this species, particularly over long distances.

Previous translocations efforts have used plastic bins, drums, or bags to transport frogs and tadpoles (Adama, D.B., K. Lansley, and M.A. Beaucher. 2004. Northern Leopard Frog (*Rana pipiens*) recovery: captive rearing and reintroduction in southeast British Columbia, 2003. Report to the Columbia Basin Fish and Wildlife Compensation Program, Nelson, British Columbia, Canada. Available at http://www.sgrc.selkirk.ca/bioatlas/pdf/northern_leopard_frog.pdf. [Accessed 1 July 2016]; Daly et al. 2008; Muths et al. 2014); however, Hellbenders require cold, highly oxygenated water (Smith 1907). Fish also require temperature controlled and oxygenated water, but their transport systems are prohibitively expensive (e.g., $6,000–$140,000 USD, Aquaneering Inc., San Diego, California, USA; Marine Fabrication and Stainless Equipment, Duluth, Minnesota, USA) and are not designed for Hellbenders. Fish hauling trucks, for example, are designed to hold high densities of fish in the water column, which are forcefully removed through special tapping valves built into the bottom of collection tanks (Lekang 2007; Barry et al. 2015). This method would not be economically efficient for Hellbenders, which are usually transported at much lower densities. More importantly, it would be unsuitable because Hellbenders need to be handled individually to avoid injury and moved with care given their conservation status. Consequently, Hellbender transport can be financially and feasibly challenging as there is no system readily available. Herein, we present the design for an affordable and safe transport system tailored specifically for this species.

FIGURE 1. A rear view of the Hellbender (*Cryptobranchus alleganiensis*) transport system installed, secured, and ready for use. (Photographed by Brian Tornabene).

CONSTRUCTION OF TRANSPORT SYSTEM

We built our transport system to fit into the bed of a 2002 Chevy Silverado 2500 truck with a rear bed topper (2.5 × 1.6 m LW or 8.05 × 5.3 ft LW, which protects the system from wind and inclement weather) and can be installed or removed easily for short-term use (Fig. 1). We constructed two wooden cradles that fit over each of the wheel wells. We secured four 10.2 × 10.2 cm (4 × 4 in.) wooden corner posts with 5.1 × 10.2 cm (2 × 4 in.) support beams to hold a 1.1 × 0.5 m (42 × 20 in.) sheet of plywood. Each of the cradles supports a 113.6 L (120 quart) cooler and secured on the cradles with 5.1 × 5.1 cm (2 × 2 in.) padded supports (Appendix 1). The cradles elevate two animal-holding coolers 43 cm (17 in.) from the truck bed, which creates a gravitational flow system from cradled coolers down into a third, 113.6 L cooler placed on the bed between the two cradles. Water enters the third cooler, i.e., the water reservoir, where a water pump (Danner Supreme® 60 watt magnetic drive pump, Pentair, Cary, North Carolina, USA) pushes water out of the reservoir and through a chiller (Teco SeaChill Aquarium series, Pentair, Cary, North Carolina, USA). The chilled water enters into the cradled coolers to complete a closed, recirculating system: chiller to the two elevated and cradled coolers, down to the water reservoir, and then back into the chiller (Appendix 2). Water is moved through 1.9 cm (¾ in.) vinyl tubing from the chiller into coolers, but flows out through 3.2 cm (1¼ in.) vinyl tubing to the water reservoir to facilitate continuous movement. The inflow and outflow holes (3.8 cm bulkheads; 1 ½ in.) of the coolers have a PVC elbow and upward pointed pipe (3.2 cm diameter and 7.6 cm length; 1 ¼ in. and 3 in.) on the inside of the coolers so they can remain more than three-fourths full throughout travel (Fig. 2). These pipes have plastic drainage guards to prohibit the escape of Hellbenders. In addition, the truck bed is equipped with an electrical adaptor for AC power (up to 1,000 W) to the pump and chiller and is capable of operating when the truck is not running. Note that other truck and topper models can be used with appropriate changes to the height of and distance between cradles.

FIGURE 2. An interior view of a Hellbender (*Cryptobranchus alleganiensis*) holding cooler with plastic baffles, outflow PVC elbow and pipe, and attached drainage grate. (Photographed by Brian Tornabene).

USE OF TRANSPORT SYSTEM

This transport system is designed to maintain stable environmental conditions and reduce stimuli that can induce stress (Dickens et al. 2010). The chiller maintains cool, constant temperatures to prevent rapid fluctuations and can be set to match rearing conditions or destination temperatures to avoid shock (Lekang 2007). The rheostat on the chiller is accurate to ± 1° C (1° F) and the unit is capable of pulling water temperatures down about 15° C (27° F), which is ideal for maintaining water temperatures between 12.8 and 17.2° C (55 and 63° F) even during warm weather. Dissolved oxygen levels in the water reservoir are kept above 90% during transport by two battery-powered air stones (Schuette et al. 2014). The cradled coolers that house Hellbenders are equipped with horizontal plastic baffles; we constructed a rectangle out of 1.3 cm (½ in.) PVC pipe

TABLE 1. Materials, equipment, and associated price (USD), as of November 2015, for Hellbender (*Cryptobranchus alleganiensis*) transport system supplies. Most items were purchased from Pentair, an aquatic ecosystems and aquaculture source (pentairaes.com), and a local home improvement store.

Detailed description	Unit Price (USD$)	Quantity	Total (USD$)
10.2 × 10.2 × 243.8 cm (4 × 4 × 96 in.) wooden post	7.47	4	29.88
5.1 × 10.2 × 243.8 cm (2 × 4 × 96 in.) whitewood	2.42	4	9.68
5.1 × 5.1 × 243.8 cm (2 × 2 × 96 in.) pressure-treated	3.37	3	10.11
1.9 × 121.9 × 243.8 cm (¾ in. × 4 ft. × 8 ft.) plywood	31.57	2	63.14
113.6 L (120 quart) Igloo MaxCold cooler	81.99	3	245.97
1/5 HP Teco Chiller unit	764.00	1	764.00
Danner Mag Drive MD7 powerhead (water pump)	89.99	1	89.99
Xantrex high power converter	130.48	1	130.48
3.8 cm (1 ½ in.) slip-slip bulkheads	6.25	4	25.00
3.2 cm (1 ¼ in.) vinyl tubing (per 30.5 cm or ft.)	2.02	15	30.30
1.9 cm (¾ in.) vinyl tubing (per 30.5 cm or ft.)	1.60	25	40.00
3.8 cm (1 ½ in.) clear PVC	8.47	2	16.94
3.2 cm (1 ¼ in.) clear PVC	7.46	2	14.92
Male reducing adapter	1.74	2	3.48
3.2 cm (1 ¼ in.) female reducing adapter	5.72	2	11.44
2.5 cm to 1.9 cm (1 in. to ¾ in.) MNPT barb adapter	2.57	2	5.14
MNPT x barb adapter	2.75	1	2.75
Reducing male adapter: 3.2 cm to 2.5 cm (1 ¼ in. to 1 in.)	1.54	2	3.08
Reducer coupling, slip to slip, 3.8 cm to 3.2 cm (1 ½ in. to 1 ¼ in.)	1.29	2	2.58
2.5 cm (1 in.) MNPT coupling	0.79	2	1.58
FNPT x FNPT coupler	0.32	1	0.32
1.9 cm (¾ in.) barbed T for split	2.05	1	2.05
3.2 cm (1 ¼ in.) barbed T for split	4.18	1	4.18
Ratchet straps	20.99	1	20.99
			Total: $1,528.00

that has four horizontal PVC rungs, each has a slit to fit a baffle (10.2 × 33 cm; 4 × 13 in.; Fig. 2). These baffles rest just below the water surface to minimize internal water movement and sloshing (Swanson et al. 1996). Although not necessary for transport trips of less than a day, if the system was to house Hellbenders for longer durations (e.g., days) the addition of filter media in the water reservoir would be necessary to mitigate ammonia buildup.

We take additional precautions to ensure the safety of the transported Hellbenders by always dividing individuals between coolers by size and age. Cannibalism has been observed among Hellbenders in the wild, during transport in coolers, and when individuals differ by as little as 6 cm in total length (Groves and Williams 2014). Having two separate coolers in this system provides an opportunity to separate Hellbenders, reduce potential conflict, and permits the movement of more than one age class without the risk of cannibalism. We recommend adding Stress Coat to tanks, which is effective at reducing stress and healing damaged tissue of aquatic fauna (API Fish Care, Chalfont, Pennsylvania, USA). Lastly, we secure all parts of the transport system using multiple ratchet straps. The total cost of materials for this system is < $1,600 USD, which includes all building materials, coolers, chiller, water pump, and power inverter (Table 1).

This system may be limited in its year-round use, as it has not been tested in extreme temperatures. It is not designed to prevent freezing during subzero temperatures and may struggle to maintain cool temperatures in high-heat conditions, although bagged ice can be added to the reservoir for additional chilling capacity when ambient temperatures are high. Additionally, this system can be space-limited when moving older individuals. Based on optimal densities for Hellbenders in captivity, the number of individuals per cooler can vary from 37 juveniles (6–8 mo old), 11 subadults (2.5–4 y old), to one adult (7 y and older; Schuette et al. 2014). Despite these limitations, we believe this is an efficient and affordable technique for Hellbender transport. We have moved Hellbenders of multiple ages and for distances as great as 1,513 km (940 miles) with 100% survival (Table 2). This information can be useful for range-wide Hellbender conservation and can also be used in the transportation of other paedomorphic salamanders, such as amphiumas (*Amphiuma* spp.), mudpuppies (*Necturus* spp.), and sirens (*Siren* spp.).

TABLE 2. Details from trips when the Hellbender transport system was used, the distance travelled, and the number and age of individuals moved. These trips occurred during three seasons, with multiple age classes of Hellbenders (*Cryptobranchus alleganiensis*), and were absent of injury or mortality.

Date	From	To	Distance	Number: age
September 2011	Fort Worth Zoo, Fort Worth, Texas	Purdue University, West Lafayette, Indiana	1549.8 km (964 mi)	18:3
June 2012	Blue River, Indiana	Blue River, Indiana	Intra-river translocations 10–50 km (16–80 mi)	10:15+
June 2013	Purdue University, West Lafayette, Indiana	Blue River, Corydon, Indiana	331.5 km (206 mi)	20:4.5
March 2015	Purdue University, West Lafayette, Indiana	Fort Wayne Zoo, Fort Wayne, Indiana	201.2 km (125 mi)	19:3 1:4
April 2015	Purdue University, West Lafayette, Indiana	Mesker Park Zoo, Evansville, Indiana	331.5 km (206 mi)	19:3 1:4
May 2015	Purdue University, West Lafayette, Indiana	Columbian Park Zoo, Lafayette, Indiana	19.3 km (12 mi)	3:4
October 2015	Blue River, Corydon, Indiana	Purdue University, West Lafayette, Indiana	342.8 km (213 mi)	2:15+

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ERIN KENISON received her B.S. from Skidmore College and M.S. from Montana State University, USA. Her Master's work focused on the nonconsumptive effects of introduced trout on Long-toed Salamander (*Ambystoma macrodactylum*) morphology and life history. She also investigated the efficacy of added habitat structures to reduce nonconsumptive effects of predatory fish while maintaining recreational fishing. She is now pursuing her Ph.D. at Purdue University where she is working to improve the success of Hellbender reintroduction efforts through novel captive-rearing methods. Her work focuses on exposing natural stimuli to captive, juvenile Hellbenders to condition them to stressors they will experience post-reintroduction. She has always been interested in conservation and continually strives to apply her research toward the preservation of amphibian species. (Photographed by Ross Hinderer).

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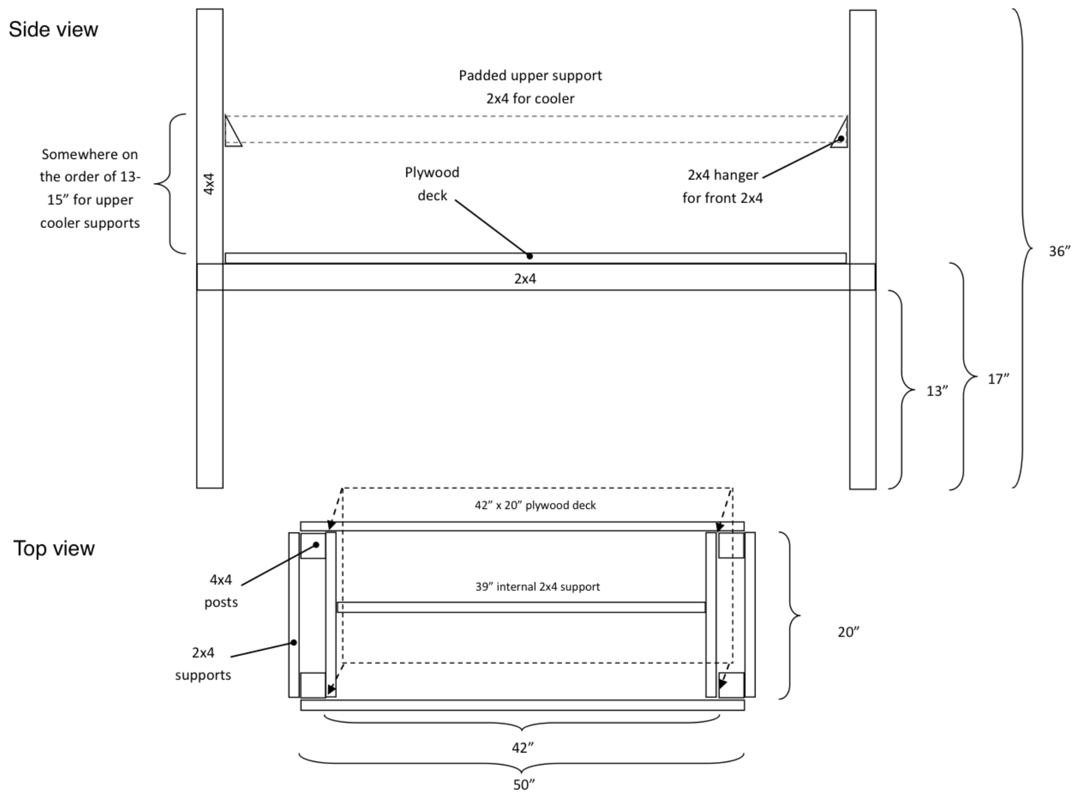
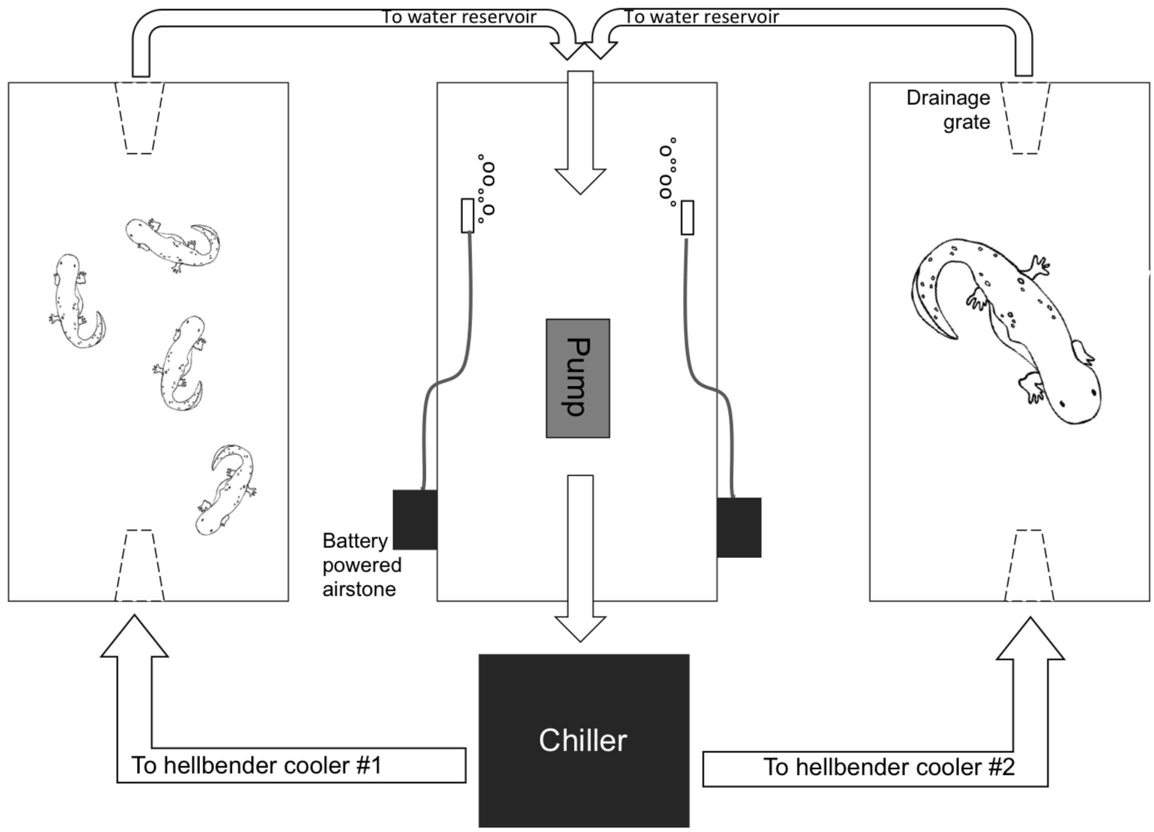


Appendix 1. Side and top view schematics for wooden cooler cradles with supplies and appropriate dimensions (see text for metric measurements) of a Hellbender (*Cryptobranchus alleganiensis*) transport system.



APPENDIX 2. An illustrated depiction of water movement through the Hellbender (*Cryptobranchus alleganiensis*) transport system and its working parts (1.3 × 1.5 m LW, 50 × 60 in. LW).