North American Journal of Fisheries Management 26:587–591, 2006
American Fisheries Society 2006
DOI: 10.1577/M05-090.1

[Management Brief]

Evaluation of a Gastric Lavage Method on Juvenile Pallid Sturgeon

Greg A. Wanner*

U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office, 420 South Garfield Avenue, Suite 400, Pierre, South Dakota 57501, USA

Abstract.—Because of the endangered status and limited knowledge of the early life history of the pallid sturgeon *Scaphirhynchus albus*, I tested the safety and efficiency of a nonlethal method for investigating the food habits of age-2 juvenile pallid sturgeon. Pallid sturgeon were fed a mixture of live prey items, including earthworms *Lumbricus terrestris*, red worms *Alloloborpha calliginosa*, meal worms *Tenebrio molitor*, and wax worms *Galleria mellonella*. Gastric lavage was performed on two test groups; a third group did not undergo gastric lavage but was held as a control ($N = 30$ fish per group). Over a 60-d test period, no mortality was observed. No significant differences were detected in relative condition and growth in length between the two lavaged groups and the control group over the 60-d test period. The efficiency of the gastric lavage procedure was tested on 29 age-2 juveniles, and food items were recovered from 100% of the fish with food in their stomachs. The average recovery rate for all food items combined was 74.9% by number and 73.7% by weight. Gastric lavage was determined to be a safe method for recovering food items from juvenile pallid sturgeon. More research is needed to test the efficiency of the method in recovering natural prey in the field.

The pallid sturgeon *Scaphirhynchus albus* was listed as a federally endangered species in 1990 (Dryer and Sandvol 1993). A long-lived species, pallid sturgeon males reach sexual maturity at ages 5–7 and females begin egg development at ages 9–12 and first spawn at age 15 (Keenlyne and Jenkins 1993). The early life history of the pallid sturgeon is not completely understood. The lack of information primarily results from the species' low abundance, which is attributable to the absence of recruitment in the Missouri River above Gavins Point Dam for more than 40 years since the closure of six Missouri River main-stem dams (Keenlyne and Jenkins 1993). Currently, no information is available on the food habits of juvenile pallid sturgeon.

Most studies on food habits have involved sacrificing large numbers of fish, including the pallid sturgeon and shovelnose sturgeon *S. platorynchus* (Carlson et al. 1985), Atlantic sturgeon *Acipenser oxyrinchus* (Johnson et al. 1997), lake sturgeon *A. fulvescens* (Choudhury et al. 1996), Gulf sturgeon *A. oxyrinchus desotoi* (Mason and Clugston 1993), and white sturgeon *A. transmontanus* (Sprague et al. 1993). Given the current endangered status of most sturgeon species, a safe method of studying food habits is needed.

Gastric lavage, or stomach flushing, is an effective and efficient method used to safely remove food items without sacrificing the fish (Meehan and Miller 1978). Gastric lavage involves inserting a tube down the esophagus into the stomach where water is flushed to induce regurgitation. Gastric lavage has been used in studies of food habits of various sturgeon species; the technique's success and the subsequent mortality rates have been variable. While performing gastric lavage on juvenile white sturgeon, Sprague et al. (1993) found that water injected at too high pressure could rupture the swim bladder, causing mortality. Brosse et al. (2002) evaluated gastric lavage methods on adult Siberian sturgeon *A. baeri* (fork lengths [FLs], 780–1,050 mm) and recovered food items with no mortality; however, they found a significant difference in weight change between the fish that had undergone gastric lavage and the control fish (no lavage) after 60 d. Haley (1998) found no mortality from the use of a gastric lavage technique on shortnose sturgeon *A. brevirostrum* (mean FL, 732 mm; range, 533–937 mm) and juvenile Atlantic sturgeon (mean FL, 718 mm; range, 484–1,150 mm). Although there was no mortality, the fish were anesthetized in tricaine methanesulfonate (MS-222), which allowed the muscular region of the alimentary canal to relax (Haley 1998). Food items from shovelnose sturgeon have been recovered with ease by gastric lavage without mortality or the use of anesthesia (D. A. Shuman, University of Nebraska–Lincoln, School of Natural Resource Sciences, personal communication). The objectives of this study were to evaluate the safety (in terms of mortality and growth) of using gastric lavage to remove food items from the stomachs of juvenile pallid sturgeon and to evaluate the technique's efficiency in recovering food items from juveniles.

Methods

The safety and efficiency of the gastric lavage technique were tested at the Bozeman Fish Technology

* E-mail: greg_wanner@fws.gov

Received June 1, 2005; accepted January 23, 2006
Published online July 24, 2006

Center (U.S. Fish and Wildlife Service [USFWS]) in Bozeman, Montana, from February to April 2003. The tests were performed on hatchery-reared, age-2 juvenile pallid sturgeon (mean FL, 408 mm, range, 179–515 mm; mean weight, 215 g, range, 80–480 g). The pallid sturgeon were not fed for a period of 4 d, after which they were fed a mixture of different types of live prey, including earthworms *Lumbricus terristris*, red worms *Alloloborpha calliginosa*, meal worms *Tenebrio molitor*, and wax worms *Galleria mellonella*. Two test groups (lavage groups 1 and 2) underwent gastric lavage, and a third test group was the control ($N = 30$ in each group). The control group was measured for length and weight, fed, and maintained at similar temperatures (22–23°C) over the same period of time as the fish that underwent gastric lavage. A fourth group ($N = 29$; mean FL, 407 mm, range, 179–490 mm; mean weight, 219 g, range, 135–350 g) underwent gastric lavage and then was sacrificed to allow evaluation of food removal efficiency.

I used a gastric lavage method similar to the method described by Foster (1977) but also included the use of a pressurized reservoir (Light et al. 1983; Brosse et al. 2002). A pressurized air tank can provide a continuous supply of water during the gastric lavage process. The lavage apparatus was a 5.5-L, hand-pumped, pressurized garden sprayer tank fitted with a 3.18-mm (outside diameter) polyethylene tube. The gastric lavage experiment began 30 min after feeding. Holding the pallid sturgeon dorsal side down at about a 45° angle, I slowly inserted the polyethylene tube through the esophagus as far as the first stomach loop and then lightly pulsed water into the stomach to dislodge food items while slowly withdrawing the tube from the stomach and esophagus. After the stomach filled with water, I lightly massaged the ventral surface of the fish to facilitate regurgitation. A 500-μm-mesh sieve was used to collect any items flushed from the stomach. This process was repeated until regurgitation ceased, which I assumed to indicate an empty stomach. The procedure, which was timed with a stopwatch, lasted approximately 2–3 min for each fish, during which time the gills were periodically hosed with freshwater.

All pallid sturgeon were measured and weighed at the start of the experiment and at 30 and 60 d after performing gastric lavage. Differences in mean length were examined among the two test groups that underwent gastric lavage and the control group at 0, 30, and 60 d by using a one-way analysis of variance (ANOVA) with a least-squares means (LSM) multiple range test (SAS 1988).

Condition indices among the two test groups and the control group were compared by using the relative condition factor (Anderson and Neumann 1996) because mean weights among the groups were nearly significantly different at the start of the experiment. Relative condition factor (Kn) was calculated as W/W', where W is the weight of the individual and W' is the length-specific mean weight predicted by a weight–length equation calculated for that population. Keenlyne and Evenson (1993) provided a weight–length regression ($\log_{10}W' = -6.378 + 3.357 \log_{10}\text{FL}$; $r^2 = 0.974$) for 214 pallid sturgeon collected throughout the species' range. The FL of the fish ranged from 468 to 1,600 mm, which abutted the upper end of the length range of juvenile pallid sturgeon in this experiment. Differences in mean Kn were examined among groups throughout the test period by using a one-way ANOVA with a LSM multiple range test (SAS 1988). Examination of the differences in mean FL and mean Kn over the test period allowed me to determine whether the lavaged fish resumed feeding and grew.

Gastric lavage efficiency was tested on a fourth group of 29 age-2 juvenile pallid sturgeon. After a fish underwent gastric lavage and after regurgitation was presumed to have ceased, the food items collected on the 500-μm-mesh sieve were identified and weighed. The pallid sturgeon were then sacrificed to allow examination of any remaining food items in the stomach. Any remaining food items were also identified and weighed. Efficiency was calculated as the percent by number and weight of food items recovered from a juvenile pallid sturgeon by gastric lavage, in comparison with the total number and weight of all food items in the stomach.

Results

Safety of the Method

Throughout the 60-d test period, no mortality was observed in lavage groups 1 and 2 or in the control group. Throughout the test period, the mean FL of the control group was between that of the lavage groups 1 and 2 (Figure 1). Mean FL differed significantly among the groups at 30 and 60 d (Table 1). However, the LSM multiple range test revealed that mean FL differences were significant only between lavage groups 1 and 2, whereas the control group remained intermediate between these two groups.

Because mean weights among groups were nearly significantly different at the start of the experiment ($F = 2.86$, df $= 2$, $P = 0.0629$), I compared mean Kn between groups. Throughout the test period, the mean Kn of the control group was also intermediate between those of lavage groups 1 and 2 (Figure 2). No significant differences were found in mean Kn among groups at 0 or 30 d (Table 1). Significant differences in mean Kn were found at 60 d. However, the LSM

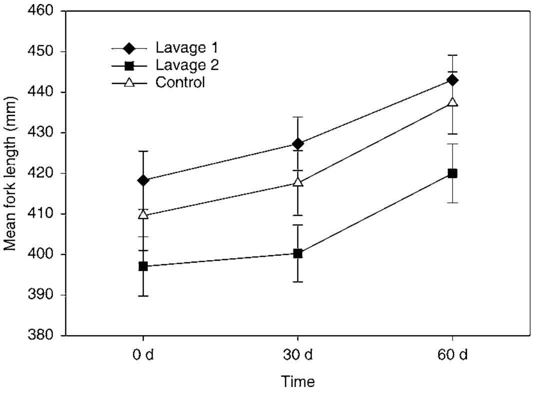

FIGURE 1.—Mean (±SE) fork length of age-2 juvenile pallid sturgeon in two test groups (lavage 1 and 2) 0, 30, and 60 d after gastric lavage and in a third group (control) that did not undergo gastric lavage ($N = 30$ per group).

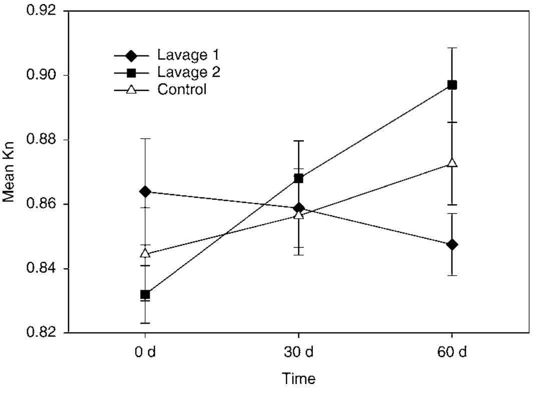

FIGURE 2.—Mean (±SE) relative condition (Kn) of age-2 juvenile pallid sturgeon in two test groups (lavage 1 and 2) 0, 30, and 60 d after gastric lavage and in a third group (control) that did not undergo gastric lavage ($N = 30$ per group).

multiple range test revealed that mean Kn differences were significant only between the two lavaged groups.

Efficiency of the Method

Food items were recovered from all juvenile pallid sturgeon that had food items in their stomachs when the gastric lavage procedure began ($N = 25$). Twelve of the twenty-five juveniles had a 100% food recovery rate. The average food recovery rate for all food items was 74.9% by number and 73.7% by weight. The recovery rate varied among food types. Meal worms, the only food item with a hard exoskeleton, had lower recovery rates by number and weight than all other food items (Table 2).

Discussion

Because of the endangered status and limited knowledge of the early life history of the pallid sturgeon, I investigated the safety and efficiency of gastric lavage for this species. Gastric lavage is considered a safe and effective method for removing food items from fish stomachs (Meehan and Miller 1978; Hyslop 1980; Hartleb and Moring 1995; Haley 1998; Brosse et al. 2002). No pallid sturgeon mortality was observed over the 60-d test period; this was similar to gastric lavage findings for other sturgeons (Haley 1998; Brosse et al. 2002). Haley (1998) attributed the success and presumed safety of the technique to the use of flexible intramedic tubing and anesthesia with MS-222. The Pallid Sturgeon Recovery Team has prohibited the use of MS-222 on pallid sturgeon, however, because of the potential for detrimental effects, including mortality (S. Krentz, Pallid Sturgeon Recovery Team Leader, USFWS, personal communication), so I tested a gastric lavage technique without anesthesia. The results of the length and Kn analysis of the juvenile pallid sturgeon tests in this study indicate that the gastric lavage procedure did not cause undue stress, and feeding was observed to resume soon after handling. The use of a pressurized tank with a constant supply of water and the avoidance of anesthesia helped limit handling time

TABLE 1.—Summary of results from the one-way analysis of variance test of the mean length and mean relative condition factor (Kn) among two test groups that had undergone gastric lavage and a control group of age-2 juvenile pallid sturgeon over a 60-d period.

Time period	df	*F*	*P*
Mean length			
0 d	2	1.921	0.153
30 d	2	3.585	0.032
60 d	2	2.900	0.060
Mean Kn			
0 d	2	1.380	0.257
30 d	2	0.260	0.775
60 d	2	4.730	0.011

TABLE 2.—Efficiency of gastric lavage in recovering food items, expressed as percent composition by number and by weight, from age-2 juvenile pallid sturgeon fed various prey taxa in the laboratory.

Food item	Number of juvenile pallid sturgeon	Number of food items recovered	% By number (SE)	% By weight (SE)
Meal worms	14	9	50.0 (12.8)	49.4 (12.9)
Earthworms	11	13	86.4 (9.7)	86.7 (9.6)
Red worms	21	43	85.4 (6.0)	82.9 (6.7)
Wax worms	4	3	75.0 (25.0)	75.0 (25.0)
Total	25	68	74.9 (5.5)	73.7 (5.7)

to 2–3 min/fish compared with 20 min/fish in the study by Haley (1998).

To further investigate the safety of the gastric lavage experiment, the Bozeman Fish Health Center (USFWS) sacrificed five of the juvenile pallid sturgeon that had undergone gastric lavage after the 60-d test period and examined the digestive tracts. No digestive tract damage was observed, and gross examinations of the swim bladder revealed no water. However, four of the five pallid sturgeon had inflated swim bladders. Histological examination of the swim bladder tissues was inconclusive in determining whether any changes were the result of the gastric lavage procedure (Staton 2003). Similar anomalies that have caused unexplained mortalities have been observed in largemouth bass *Micropterus salmoides* (Hakala and Johnson 2004).

Extreme caution is advised for the use of gastric lavage in juvenile pallid sturgeon, because the small, 3.18-mm tubing could easily puncture the swim bladder if excessive pressure is used to insert the tube down the esophagus. In some cases, the alimentary canal was constricted during insertion of the tube and injection of water into the stomach. Care was taken to reduce the amount of water injected into the stomach, which allowed time for the fish to relax and begin regurgitation. Brosse et al. (2002) inserted a large-diameter tube (12 mm) into the digestive tract of an adult Siberian sturgeon, followed by a smaller-diameter tube (6 mm) within the larger tube to prevent puncturing the swim bladder and allow food items to flush out during injection of water. Haley (1998) used an intramedic polyethylene tube with a 2.08-mm outside diameter; this may have allowed food items to flush out more easily with less constriction of the alimentary canal. Further studies are needed to determine the appropriate tube sizes for various sizes of pallid sturgeon.

Food items were recovered from 100% of the juvenile pallid sturgeon that had food items in their stomach. Food items were recovered up to 2 h after fish were fed. Meal worms, which have hardened exoskeletons, were recovered at a much lower rate than the soft-bodied earthworms, red worms, and wax worms were. Constriction of the alimentary canal may have prevented the regurgitation of the hardened meal worms. Brosse et al. (2002) also found variations in the recovery rate of prey items, where only 50% of the vermiform prey and 75% of larger prey (fish and shrimp) were recovered. Brosse et al. (2002) also found that the recovery rate of food items decreased after 2 h postingestion, indicating the technique will most likely recover only the most recently ingested food items. Further investigations are needed on the recovery rate of different prey items in the wild. Without knowledge of recovery rates, the gastric lavage technique may provide only a qualitative determination of food habits (Haley 1998).

The results of this experiment demonstrated the relative safety and effectiveness of the gastric lavage tests performed. In both the mean FL and Kn analyses, results for the control group were intermediate between those for the two lavage groups, demonstrating that the gastric lavage procedure did not stress the pallid sturgeon because they resumed feeding soon after the experiment. Although juvenile pallid sturgeon may be more accustomed to being handled in the hatchery, fisheries managers should feel confident in the safety of this gastric lavage technique in collecting qualitative food habit data for juvenile pallid sturgeon in the field. My experiment also demonstrated that this technique has a differential recovery rate for different food items. More research is needed to evaluate the effectiveness of this gastric lavage technique for recovering prey items from juvenile pallid sturgeon in the field.

Acknowledgments

I thank the USFWS for funding and Wayne Stancill for supporting the project. David Willis and Robert Klumb provided advice and reviewed earlier versions of the manuscript. Dane Shuman provided training in the gastric lavage method, and Robert Klumb assisted with the experiment. I thank Ron Zitzow and Matt Toner of the Bozeman Fish Technology Center for providing the pallid sturgeon and for assistance throughout the project.

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