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A Gastric Lavage Technique for Characterizing Diets of Sturgeons

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Abstract.—Sacrificing sturgeons for diet analyses is not a feasible option because many sturgeon species are protected by laws or management plans that prohibit direct taking. Consequently, basic food habits data are limited for many populations of Atlantic sturgeon *Acipenser oxyrinchus* and shortnose sturgeon *A. brevirostrum*. A safe and effective method for removing stomach contents from live sturgeons is needed to address this data gap. I describe a method for safely flushing stomach contents from live sturgeons that addresses problems previously encountered with gastric lavage on these fishes. The system was used during the summer of 1996 to obtain stomach contents from shortnose sturgeon and juvenile Atlantic sturgeon in the Hudson River estuary. Identifiable prey items were retrieved from 91% (21 of 23) of juvenile Atlantic sturgeon and 81% (39 of 48) of shortnose sturgeon. More research is needed to test the efficiency of this procedure for removing prey items from sturgeons.

Despite the endangered status of shortnose sturgeon *Acipenser brevirostrum* and the commercial value and associated concern about declining stocks of Atlantic sturgeon *A. oxyrinchus*, many aspects of the life history of these species are unstudied. Food habits information is needed to improve the understanding of sturgeon life history and habitat requirements. Basic diet data are limited or unavailable, partly due to the absence of a safe and efficient method for removing stomach contents from live fish. To date, most diet studies on sturgeons have involved sacrificing fish and examining stomach contents of carcasses (Atlantic sturgeon: Vladykov and Greeley 1963; Johnson et al. 1997; Gulf sturgeon *A. o. desotoi*: Huff 1975; Mason and Clugston 1993; lake sturgeon *A. fulvescens*: Choudhury et al. 1996; pallid sturgeon *Scaphirhynchus albus* and shovelnose sturgeon *S. platorynchus*: Carlson et al. 1985; shortnose sturgeon: Dadswell 1979; white sturgeon *A. transmontanus*: Sprague et al. 1993). Although sacrificing fish ensures researchers that all food items contained in the stomach have been examined, destroying fish for this research purpose is a serious drawback. Many sturgeons are protected by laws (e.g., Endangered Species Act) or fishery management plans that prohibit or restrict killing fish for research.

Due to the constraints on obtaining specimens and the need to avoid sacrificing sturgeons for study purposes, a new, harmless method is needed to study food habits of sturgeon species. Mason and Clugston (1993) used emetics to induce regurgitation from live Gulf sturgeon but were unable to retrieve any food items. Subsequent internal investigation revealed that ingested prey remained trapped in the intestinal tract. Gastric lavage, or stomach flushing, has been used by other researchers to remove food items from the stomachs of live fish (e.g., see Seaburg 1957; Meehan and Miller 1978). The method, which involves pumping water through a tube into a fish's stomach to induce regurgitation, is considered to be a highly effective and efficient technique (Hyslop 1980; Bowen 1983; Hartleb and Moring 1995). Hyslop (1980) noted that stomach flushing can be difficult to use on small fish and recommended flushing the stomachs of smaller fish with a syringe (as used by Meehan and Miller 1978) to control and minimize water pressure. Sprague et al. (1993) used a gastric lavage device (i.e., aquarium tubing attached to a syringe: M. Parsley, U.S. Geological Survey, personal communication) to remove stomach contents from juvenile white sturgeon in the Columbia River but rejected the technique because of a 33% mortality rate (4 of 12 fish) in 1 week of sampling. Sprague et al. (1993) concluded that high water pressures associated with stomach flushing harmed juvenile white sturgeon by rupturing swim bladders and causing other internal injuries.

This report describes a gastric lavage method for safely flushing stomach contents from live sturgeons. The method was modeled after techniques used on other fish species (Meehan and Miller 1978; Hartleb and Moring 1995) but was modified

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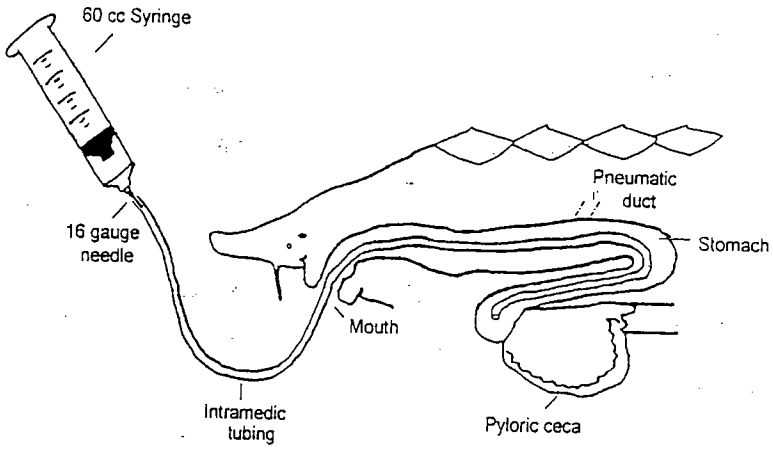

FIGURE 1.—The components of the gastric lavage method and an illustration of tube placement within a sturgeon's digestive track.

to address problems encountered during previous use of gastric lavage on other sturgeon species. I used the method during the summer of 1996 to obtain stomach contents from shortnose sturgeon and juvenile Atlantic sturgeon (hereinafter referred to as sturgeon) in the Hudson River estuary.

Methods

Sampling occurred between June and September 1996 within a 146-km section of the Hudson River estuary between Nyack and Hudson, New York. Sturgeon were captured in anchored gill nets set during slack tide for an average of 40 min. Captured sturgeon were held in live cars alongside a research vessel prior to stomach sampling.

I measured the fork and total lengths (FL and TL, respectively) of each sturgeon to the nearest mm. Each fish was anesthetized in a 45-L holding tub containing tricaine methanesulfonate (MS-222; 100 mg/L) buffered with sodium bicarbonate (100 mg/L). The tub was filled with 20 L of water and 30 mL of the MS-222 solution was added. Typically, sturgeon became sedate (i.e., immobile or devoid of muscle movement when handled) after approximately 4 min. Once sedated, I placed the sturgeon dorsally on a Plexiglas holding rack and inserted an intramedic polyethylene tube (1.57-mm inner diameter, 2.08-mm outer diameter; Fisher Scientific) slowly down the sturgeon's esophagus. The tubing was attached to a 60-cm^3 syringe with a 16-gauge hypodermic needle (Figure 1). This tubing was small enough to allow for the passage of ingested food items back up the digestive track between the tubing and the walls of the track. The flexibility of the intramedic tubing allowed me to guide the tubing toward the stomach and away from the pneumatic duct. Once positioned safely, I pushed the tubing slowly further down the alimentary canal until I could feel the tube with my hand on the ventral surface of the fish. I then slowly injected water from the syringe into the stomach causing the sturgeon to expel food items through the mouth and across the gills. Depending on stomach fullness and the size of the fish, more than one syringe of water might have been needed to flush food items from the stomach. Regurgitated food items were washed with water down the holding rack onto a standard sieve with 0.5-mm mesh openings. After lavaging, sturgeon were placed in a second "recovery" tub equipped with an air stone. The fish were monitored and then returned to the river once they became active and were able to remain upright for several minutes. The water in the recovery tub was emptied through the sieve to collect any additional food items that were expelled in the tub. All food items were preserved in 95% ethanol.

Before using this lavage technique on wild sturgeon, I tested the method on five hatchery-reared Atlantic sturgeon (mean FL, 413 mm; range, 382–434 mm) in the laboratory. The fish were fed manufactured food pellets and pieces of salmon several hours before the experiment. I did not test the efficiency of this method for retrieving all material ingested by the laboratory fish because the purpose

of the experimental trials was to test the safety and not the efficiency of this method.

Results

The gastric lavage technique was successful in removing the partially digested pellets and salmon from all five Atlantic sturgeon tested in the laboratory. All of these sturgeon recovered after lavaging and continue to feed and grow in the laboratory.

Between June and September 1996 I used the gastric lavage method in the field on 48 shortnose sturgeon and 23 Atlantic sturgeon. The FLs of shortnose sturgeon sampled ranged from 533 to 937 mm (mean = 732 mm). Atlantic sturgeon FLs ranged from 484 to 1,150 mm (mean = 718 mm). Two shortnose sturgeon (FL < 500 mm) and all Atlantic sturgeon (FL < 1,500 mm) were juveniles. No injuries or deaths were observed during any aspect of capture, handling, stomach flushing, or recovery. Identifiable prey items were recovered from 81% (39 of 48) of the shortnose sturgeon and 91% (21 of 23) of the Atlantic sturgeon. Ten invertebrate taxa were counted in the Atlantic sturgeon samples, and 24 invertebrate taxa were identified in the shortnose sturgeon samples. Major prey items retrieved from shortnose sturgeon included both soft-bodied invertebrates (e.g., amphipods *Gammarus*, chironomids [Chironomidae], and isopods *Cyathura polita*) and shelled organisms (e.g., zebra mussels *Dreissena polymorpha* and snails [Hydrobiidae]). Polychaetes (Spionidae), isopods, and amphipods (Oedicerotidae) constituted the primary food obtained from Atlantic sturgeon. This assortment of food items is consistent with previously reported prey species of shortnose sturgeon (Dadswell 1979; Carlson and Simpson 1987) and Atlantic sturgeon (Vladykov and Greeley 1963).

Discussion

Stomach flushing is considered a highly effective method for removing prey from fish stomachs (Meehan and Miller 1978; Hyslop 1980; Bowen 1983; Hartleb and Moring 1995). However, stomach flushing can be harmful to sturgeons because of the configuration of their digestive system. Sturgeon intestinal tracts are relatively narrow and follow a z-shaped path from the oral cavity to the first cavity of the stomach. In addition, sturgeons possess a physostomous swim bladder, the entrance to which lies at the end of the esophagus, just before the first bend in the digestive tract (Buddington and Christofferson 1985). These physical characteristics require the use of small-diameter, flexible tubing that can be easily guided past the pneumatic duct and down the alimentary canal to the forestomach, thereby avoiding the possibility of rupturing the swim bladder with either the tubing or excessive amounts of water. My method proved to be safe on a small sample of captive Atlantic sturgeon and effective at recovering food items from a large majority of the field-collected specimens.

Sprague et al. (1993) reported ruptured swim bladders, bleeding from the vent, and relatively high mortality (33% of white sturgeon sampled) when they used stomach flushing to remove stomach contents from juvenile white sturgeon in the Columbia River. There are two key differences between the method used by Sprague et al. (1993) and the one I describe that best explain the relative success and presumed safety of my technique. Sprague et al. (1993) used aquarium tubing and did not anesthetize fish before performing gastric lavage. Intramedic tubing is more ductile and smaller in diameter than aquarium tubing, thus allowing better maneuverability down the digestive track and limiting water pressure inside fish. Although sturgeon tend to be docile fish and generally easy to handle, the anesthetic was helpful in relaxing the densely muscular region of the alimentary canal, sometimes referred to as the gizzard, and further facilitated manipulation of the intramedic tubing.

With any approach to stomach sampling, there are limitations to the usefulness of the data. Some food groups (e.g., soft-bodied organisms) may already be digested before sampling takes place. This is also a problem when fish are sacrificed to examine gut contents. Fish may also regurgitate some food between the time they are captured and when they are sampled for prey items (Bowen 1983; Johnson et al. 1997). Therefore, not all prey items ingested can be identified. Some other limitations associated with the method described above include the length of time for processing individual fish and the uncertainty of determining how much water is needed to completely flush the stomach. An average of 20 min per fish was needed from the time fish were placed in the anesthetizing tub to when they could be released. Stomach flushing was considered complete once food items were no longer passing out of the sturgeon's mouth or opercula and only the water being pumped into the stomach continued to be expelled orally or anally. Occasionally a sturgeon with what seemed to be an empty stomach was encountered. This conclu-

sion was based on the inability to retrieve food items from the fish after several syringes of water had been injected into the gut. A determination of when to cease flushing the stomach was qualitative, which raises the possibility that I might have failed to recover ingested food items from some fish, particularly larger ones. A detailed quantitative assessment of this procedure by using captive fish may enable researchers to more accurately determine the amount of water that must be injected for adequate sampling and would provide better consistency to this method. A rigorous study of captive sturgeon could be used to better assess the percentage and diversity of food items potentially recoverable from sturgeon when using this procedure.

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