194

Pulsed Gastric Lavage: An Efficient Method of Removing the Stomach Contents of Live Fish

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ABSTRACT: Laboratory and field tests of an improved water flushing method for removing stomach contents of live fish were conducted on largemouth bass *(Micropterus salmoides)* and grass pickerel *(Esox americanus vermiculatus)* and compared with the suction pump, stomach flush, and induced regurgitation methods. Pulsed gastric lagave was not injurious to the fish and, of the methods tested, it enabled procurement of the most accurate samples through the entire range of predator sizes and types of prey foods.

Reported alternatives to killing fish to obtain samples for dietary analysis include installation of chronic fistulas in the digestive tract (Krayukhin 1962), inspection by gastroscopes (Dubets 1954), removal by flushing the digestive tract (Baker and Fraser 1976), removal by stomach lavage (White 1930; Seaburg 1957; Voinarovich 1958), removal by stomach suction (Robertson 1945), and removal by induced regurgitation (Jernejcic 1969). Most of these methods have disadvantages that limit their usefulness. The influence of chronic fistulas on digestion rate has yet to be documented, and it is doubtful if such a method would be applicable to field studies. Gastroscopes are inadequate for detailed analysis of the entire stomach contents. Flushing the digestive tract may bias the sample toward slowly digested items retained in the intestines and is unsuitable for species with stomach constrictions and long or coiled intestines. Suction pumps and emetics are usually unreliable and difficult to use.

Gastric lavage is the oldest and most widely used technique for obtaining the stomach contents of live fish; it appears to be a non-injurious method that is fast and easy to use and that removes all types and sizes of natural food. This paper describes an improved method of pulsed gastric lavage and compares it with the induced regurgitation (Jernejcic 1969), suction pump (Robertson 1945), and stomach flush (Seaburg 1957) methods for efficiency in removing the stomach contents of grass pickerel (*Esox americanus vermiculatus)* and largemouth bass *(Micropterus salmoides)*.

Pulsed Gastric Lavage Compared with Other Stomach Sampling Methods

Description of Pulsed Gastric Lavage

The stomach flushing device consists of a hypodermic needle and polyethylene tube, coupled to a water pump by a variable pressure valve. The size of the needles and tubes was adjusted to the size of the fish: For pickerel 50-100 mm and bass 50-75 mm in total length (all fish measurements given here are of total length), a polyethylene tube, 2.5 cm long, (1.44 mm ID, 1.58 mm OD) was fitted to a 2.5-cm, 19-gauge hypodermic needle; for pickerel 100-175 mm long, the same length of tubing (1.78 mm ID, 2.79 mm OD) was fitted with a 2.5-cm, 15-gauge hypodermic needle; for pickerel longer than 175 mm and for all bass except the smallest ones, the polyethylene tubing (2.16 mm ID, 3.25 mm OD) was 5.0 cm long and was coupled with a 5.0-cm, 13-gauge hypodermic needle. The variable pressure water pump was a compressed air sprayer of about 10-liter capacity, with a Luer-lock mechanism welded to the valve outlet so that the various sizes of tubes and hypodermic needles could be interchanged.

Pulsed gastric lavage with this equipment was used in the present work (Fig. 1). The fish is anesthetized and placed horizontally in a fine-mesh net and the polyethylene tube is inserted through the open mouth until it reaches the end of the stomach. The adjustable valve is then opened and closed to allow pulses of water under pressure to pass into the stomach, forcing the flushing water and stomach contents through the esophagus and into the net. The stomach contents are then removed with forceps. After the fish has been removed, the net is reexamined for portions of stomach contents that might have been overlooked.

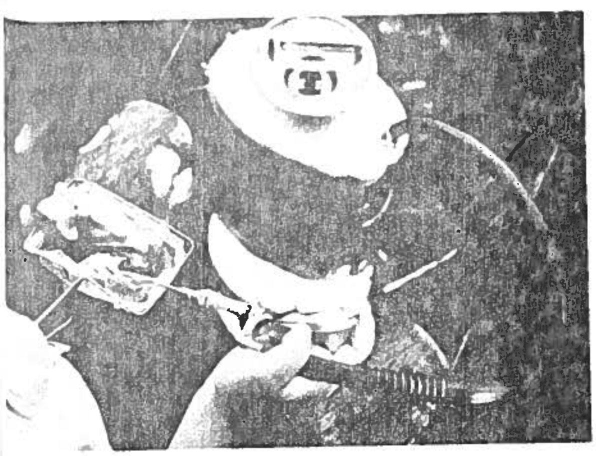
Although this paper reports only on the application of the pulsed lavage technique to bass and pickerel 50-350 mm long, I have used this technique on larger and smaller fish of many species. For fish shorter than 50 mm, a small polyethylene tube (1.44 mm ID, 1.58 mm OD) coupled by a 19-gauge hypodermic needle to a 10-cc syringe was used. The method involves holding the fish head up in a small net, inserting the tube into the stomach, and flushing the stomach contents into the mouth. For fish longer than 350 mm, a larger polyethylene tube (15 mm ID, 22 mm OD) coupled by a gun-type garden hose sprayer to a 2.2 × 10⁶ e cm $^{-2}$ water pump was most efficient. The fish is ed head down on a slanting V-shaped measuring board the stomach contents are flushed into the mouth or in- net attached to the end of the measuring board.

n performing comparative tests, the regurgitation nejcic 1969), suction pump (Robertson 1945), and mach flushing (Seaburg 1957) methods were duplicated ept for a few minor alterations. I used 2 mg of antimony assium tartrate per milliliter of water instead of the g/ml used by Jernejcic, and injected it into the stomach ough the esophagus until the solution began to appear in mouth. In tests with the suction pump and stomach h, the largest glass tube that could be inserted into the mach was used.

ficiency of Methods

Postmortem examination of 43 grass pickerel (50-300 mm g) and 41 largemouth bass (50-450 mm) were used to test completeness of the flushing method described here. ce pulsed gastric lavage proved to be nearly 100% effec- , it was used as a check on the efficiency of the other thods: the specified test method was used, followed by sed gastric lavage. Gastric lavage, the suction pump, d the stomach flush were applied for 5 min or until the mp water was clear. For the regurgitation method, test h were not examined until 15 min after the emetic had en administered.

Data from postmortem stomach examinations of 43 grass kerel and 41 largemouth bass (Table 1), on which pulsed stric lavage had been performed, indicate nearly 100% iciency. All stomachs examined were completely emptied flushing, except for that of a 311-mm largemouth ss; although more than 50 small bullheads *(Ictalurus* sp.) d been removed from this fish, one had remained with its



g. 1. Apparatus and technique for removing the stomach con- nts of a bass (125 mm long) by the pulsed gastric lavage method escribed in the text.

spines imbedded in the stomach wall. Pulsed gastric lavage was the most effective method for removing stomach contents, followed in decreasing order of effectiveness by the stomach flush, the suction pump, and the tartar emetic (Table 1). The table also indicates that these methods, particularly the tartar emetic, were significantly more successful in removing the stomach contents from bass than from pickerel (Chi-square test, $P<0.01$).

The suction pump and stomach flush were ineffective for removing stomach contents of pickerel shorter than 125 mm, the regurgitation method was partly effective for the smaller fish (50-125 mm long), and pulsed gastric lavage was effective for all sizes tested (Table 1). Except for the ineffectiveness of the suction pump and stomach sampler for the smallest sizes, all methods tested were about equally effective over the range of pickerel sizes tested.

Data on the relation between percentage removal and total length are not presented for bass because of the small number of fish used (87 fish, divided by four treatments, in length ranges of 50-450 mm). However, it was clear from these data that the suction pump and stomach flush were much more effective in removing the stomach contents of small bass than of small pickerel, presumably because of the larger mouth and esophagus of the bass.

Regardless of the percentage of the stomach capacity taken up by the contained food, pulsed gastric lavage, stomach flush, and regurgitation methods were about equally successful for grass pickerel (Table 1). However, the greater the percentage of the stomach capacity taken up by prey, the less effective was the suction pump. Since 66% of the bass stomachs were less than one-third full, comparison of the effectiveness of various methods in removing the stomach contents of bass with different degrees of stomach fullness is not presented.

For both bass and pickerel, pulsed gastric lavage and the stomach flush removed about equal amounts of invertebrates, soft-rayed fish, and spiny-rayed fish (Table 1), but the suction pump and regurgitation methods were much more effective in removing invertebrates than fish (Chi-square test, $P<0.05$). With the regurgitation method it was difficult to remove most types of prey from the stomachs, whereas with pulsed gastric lavage all types of prey were removed without difficulty. With the suction pump or stomach flush methods, it was almost impossible to remove whole crayfish and sunfish *(Lepomis* sp.), and difficult to remove darters *(Etheostoma* sp.), golden shiners *(Notemigonus crysoleucas),* largemouth bass, and bullheads *(Ictalurus* sp.).

Thus the nature and shape of the stomach and contents had a marked effect on the efficiency of the sampling methods and may therefore account for the difference between my results and those reported by Seaburg (1957) and Jernejcic (1969), though in the latter case postmortem examination of the five bass tested by Jernejcic might have shown that the stomach contents had not been completely regurgitated. On the other hand, the results of the present study were very similar to those reported by Robertson

(1945) for various species of trout feeding on small invertebrates.

Convenience of Sampling Methods

Of the four methods used for removing the stomach contents of live fish, the tartar emetic was the least convenient, requiring a separate container for each predator, and at least 15 min per fish. Since the time for regurgitation ranged from a few minutes to several hours, and since the emetic may affect digestion, stomach samples obtained by this method are not reliable for determining the time of ingestion and digestion rate. In contrast, removal of the stomach contents with the suction pump and stomach flush required only 1 to 2 min from the time the fish was placed in anesthetic. However, both these techniques were difficult for one person to use on bass or pickerel longer than 250 mm. Pulsed gastric lavage was faster and easier to use, requiring less than 1 min per pickerel and less than 0.5 min per bass.

Survival of Fish after Sampling

In fall 1974, 100 grass pickerel were captured, measured, tagged, and randomly divided into five groups of 20 each. Stomach contents of the pickerel in four of these groups were removed either by gastric lavage or by one of the other three methods. Pickerel in the fifth group were released with their stomach contents intact as a control group. All pickerel were then randomly released into three study ponds, and observed for 1 month. The same general experimental procedure was followed in the study of the survival of 41 largemouth bass.

Of the four methods tested, pulsed gastric lavage caused the least mortality. Of the fish subjected to pulsed gastric lavage, 90% survived 1 month compared with 65% of the

Table 1. Percentage success in removal of the complete contents of the stomachs of grass pickerel and largemouth bass, by four methods, under the conditions stipulated (number of stomachs shown in parentheses).

Conditions and items	Method: Pulsed gastric lavage	Stomach flush	Suction pump	Regurgitation (tartar emetic)
Species examined				
Grass pickerel	100 (43)	50 (46)	41 (46)	12 (49)
Largemouth bass	98 (41)	60 (15)	67 (15)	69 (16)
Stomachs of grass pickerel filled to different percentages of capacity				
0-33	100 (11)	53 (17)	59 (17)	21 (14)
34-67	100 (18)	53 (17)	47 (19)	8 (13)
68-100	100 (14)	46 (13)	30 (10)	18 (22)
Grass pickerel of different lengths (mm)				
51-100	100 (12)	0 (10)	0 (4)	17 (6)
101-150	100 (11)	64 (11)	48 (21)	14 (14)
151-200	100 (13)	56 (12)	50 (14)	25 (12)
201-250	100 (3)	67 (6)	50 (4)	10 (10)
251-300	100 (4)	72 (7)	33 (3)	14 (7)
Specific prey animals of wild grass pickerel and largemouth bass				
Grass pickerel				
Invertebrates	100 (11)	60 (10)	67 (12)	33 (9)
Soft-rayed fish	100 (9)	63 (24)	38 (16)	15 (27)
Spiny-rayed fish	100 (23)	59 (22)	38 (16)	10 (21)
Largemouth bass				
Invertebrates	100 (11)	50 (8)	100 (3)	50 (6)
Soft-rayed fish	100 (9)	77 (9)	50 (8)	17 (6)
Spiny-rayed fish	95 (21)	25 (4)	67 (9)	71 (7)

fish subjected to the suction pump, 60% of those subjected to the stomach flush, 50% of those given the tartar emetic, and 85% of the controls. Mortality of pickerel given the emetic was significantly higher than that of the control fish or those subjected to pulsed gastric lavage (Chi-square test, $P<0.05$).

Three dead grass pickerel were found 24 h after the removal of their stomach contents. The stomach contents of two fish had been removed by the stomach flush and one by the suction pump; all three fish had tears at the juncture of the stomach and esophagus. Also, some of the grass pickerel that had been given the tartar emetic were lying on the bottom and were lethargic.

In contrast to the grass pickerel, nearly all bass survived 1 month after removal of the stomach contents by any of the four methods tested. Although the results for bass were similar to those reported by Jernejcic (1969), the results for pickerel differed significantly. However, Prys-Jones et al. (1974) also found the effectiveness of tartar emetic varied considerably from species to species, and that failure to regurgitate appeared to increase mortality.

Delays in Resumption of Feeding

Tests were conducted to determine whether the type of stomach contents removed affected the length of time between feedings. Pumpkinseeds *(Lepomis gibbosus)*, yellow perch *(Perca flavescens)*, golden shiners, and banded killifish *(Fundulus diaphanus)* were removed from the stomachs of largemouth bass (125 mm long) and grass pickerel (125 and 175 mm long), and the intervals between the removal of the stomach contents and the capture of a different type of prey (fathead minnow, *Pimephales promelas)* were recorded. The interval between feedings of the control group of fish was 1 day; the interval between removal of stomach contents and resumption of feeding was also 1 day for all other groups of fish except those given the tartar emetic, which did not resume feeding for more than 5 days. This difference was significant (Mann-Whitney U test, $P<0.001$).

Tests were conducted to determine whether removal of various prey species from the stomachs of pickerel and bass affected frequency of feeding. If the stomach contents were completely removed and did not become lodged in the esophagus, the length of time between feedings did not differ from that of the controls. However, most pickerel and bass that ate pumpkinseeds did not feed again within 48 h if the prey was lodged in the esophagus and forceps were required to remove it. Autopsies of these fish frequently showed tears or punctures of the stomach lining. Removing yellow perch with forceps apparently was less damaging than removing pumkinseeds, since most bass and pickerel fed again within 24 h. All pickerel from which golden shiners and banded killifish were removed with forceps fed within 24 h. Forceps were not required to remove banded killifish or golden shiners from bass.

Forceps removal of spiny-rayed fish (particularly those with a deep body) from the stomach apparently adversely affected feeding frequency. The percentage of grass pickerel on which forceps were needed to help remove stomach contents was directly related to the technique used: pulsed gastric lavage, 3%; stomach flush, 20%; suction pump, 27%; and tartar emetic, 43%.

Conclusion

When keeping the predator alive after removal of the stomach contents has significant advantages, the convenience, reliability, and efficiency inherent in postmortem stomach examinations need not be unduly compromised. The results of the present study indicate that pulsed gastric lavage is superior to the other three methods of obtaining stomach contents of live fish and is almost as effective, easy to use, and nonselective as postmortem stomach examination.

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