136

A Method for Securing the Gut Contents of Small, Live Fish

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ABSTRACT

A technique for securing the gut contents of small, live fish consists of injecting water from a hypodermic syringe through the alimentary tract by means of a short tube that is inserted into the intestine at the anus. The gut contents are flushed out through the mouth. Experiments on killifishes, *Fundulus* spp., indicate a nearly 100% efficiency in emptying the gut and no detrimental effects from multiple injections. The technique does not work equally well for all species of small fishes.

Studies of the food habits of fish usually require large samples of fish. Recognizing the need to minimize disruption of small populations, several authors have devised and reported methods of securing stomach contents without killing the fish. These include flushing the stomach with water (White 1930; Robertson 1945; Seaburg 1957; Voinarovich 1958), drawing the contents out by suction (Kuthalingam 1961), examination by gastroscope (Dubets 1954) and induced vomiting by means of chemical emetics (Markus 1932; Jernejcic 1969).

In a recent study of the feeding habits of three species of killifish, *Fundulus diaphanus*, *F. heteroclitus*, and *F. majalis*, we found that the contents of the entire alimentary tract could be obtained efficiently by a simple pumping procedure. It is the purpose of this paper to describe the procedure and to provide information concerning its efficiency and general applicability.

METHODS

The pumping apparatus consists of a short plastic tube attached to a hypodermic syringe. The tubular insulation of ordinary radio wire (the copper wires are easily pulled from short sections) works well, and is available in various thicknesses.

The stomach contents of *Fundulus* of 20 mm to 150 mm in standard length can be effectively flushed using a tube with an outside diameter of 1.5 mm and length of 40 mm. The tube is pushed over the blunted end of a 20-gauge hypodermic needle, and the needle is attached to a small (1–3 ml) syringe filled with water. The free end of the plastic tube is tapered slightly by shaving it with a razor blade. The pumping procedure consists of carefully inserting the tube into the intestine and slowly injecting water, which has the effect of forcing the contents of the entire digestive tract out via the mouth. For very small *Fundulus*, simply pressing the tube against the opening of the anus was sufficient to cause water to be injected and the contents flushed. There was no damage to stomach contents obtained in this manner.

The length and thickness of the tube and the size of the syringe will vary with size and species. For small (standard length less than 25 mm) blacknose dace, *Rhinichthys atratulus*, and creek chub, *Semotilus atromaculatus*, it was necessary to insert the tube into the intestine, and for these individuals it was necessary to use a tube of smaller outside diameter (0.75 mm). Small, one-ml, disposable 40-unit insulin syringes were used in place of the larger 1–3 ml syringe.

The efficiency of the procedure and the possible ill effects of multiple pumpings were evaluated. Twenty mummichogs, *Fundulus heteroclitus*, varying in standard length from 40 mm to 60 mm, were assigned by means of a table of random numbers to twenty, 3.8-liter glass jars. The jars were equally divided into an experimental and control group. We deter-

136

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TABLE 1.—*Results of the pumping experiments performed on* Fundulus heteroclitus. *Experiments were performed on alternate days for 14 days. A =* Drosophila melanogaster *eaten in the 20-minute feeding period, maximum number = 15. P = number of flies pumped.*

Fish number	A	P	A	P	A	P	A	P	A	P	A	P	A	P
						Experimental								
1	1	1	7	7	10	10	5	5	12	12	15	15	15	15
2	15	15	13	13	15	15	15	15	15	15	15	15	15	15
3	15	15	12	12	13	13	10	10	15	15	15	15	15	15
4	12	12	15	15	12	12	13	13	15	15	15	15	14	14
5	12	[a]	13	13	14	14	15	15	15	15	15	15	15	15
6	13	13	14	13	15	15	8	8	15	15	14	14	15	15
7	13	13	15	15	13	13	10	10	12	12	15	13	13	13
8	9	9	15	15	15	15	13	13	13	13	15	15	15	15
9	15	15	15	15	15	15	15	15	15	15	15	15	15	15
10	14	14	4	4	14	14	15	15	15	15	15	15	15	15
						Control								
11	15		13		15		15		15		15		15	
12	14		15		15		15		15		15		15	
13	15		14		12		10		15		15		15	
14	14		15		14		11		15		15		14	
15	12		12		15		11		15		14		15	
16	13		14		15		15		15		15		15	
17	5		14		15		15		15		15		15	
18	14		15		15		13		15		15		15	
19	11		5		15		14		12		14		14	
20	15		15		15		15		15		15		15	

[a] Fish accidentally killed during pumping. It was replaced by another.

mined that most fish could easily consume 15 fruit flies within a 20-minute period. Therefore, after a seven-day acclimation period in the jars, each fish was fed 15 fruit flies, *Drosophila melanogaster*, on alternate days for a period of 14 days. We recorded the number of flies eaten by all of the fish after 20 minutes of feeding, and then immediately flushed the stomach contents of the experimental group. The flushed flies were counted and then refed to the fish. It was assumed that by refeeding the experimental fish, the hunger levels of the experimental and control groups would remain the same. The water in all of the jars was changed once a week.

RESULTS

In only two of the 70 pumpings of the experimental group (2.9%) did we fail to recover 100% of the flies that were fed (Table 1).

The mean number of flies ingested at each 20-minute feeding period over the two-week time course increased gradually for both the experimentals (11.9 to 14.7) and the controls (12.8 to 14.8) indicating that the pumping was not having detrimental effects on the feeding. The number of flies taken by each of the experimental and control fish on the last day of pumping did not differ significantly as tested by the Mann-Whitney U test (two-tailed, $P < 0.001$), again indicating that no detrimental effects had occurred. There was no delayed mortality.

Other Species

The general applicability of the technique was tested on several other species of small fish. It was successful on 24 out of 26 *Semotilus atromaculatus* (17 mm to 107 mm standard length), and 8 out of 10 *Rhinichthys atratulus* (35 mm to 60 mm standard length). Species which we could not successfully inject (failure rate greater than 50%) were the white sucker, *Catostomus commersoni*; rosyface shiner, *Notropis rubellus*; brown bullhead, *Ictalurus nebulosus*; yellow perch, *Perca flavenscens*; smallmouth bass, *Micropterus dolomieui*; and goldfish, *Carassius auratus*.

DISCUSSION

The species which we could not successfully inject, due to a blockage in the intestine, usually had either distinct stomachs with constrictions at both ends and/or long and coiled intestines. For these, the pressure needed to force water through the alimentary tract usually exceeded the retaining strength of the intestinal walls. The alimentary tract of *Fundulus heteroclitus* is about equal to the length

of the body and is not coiled (Babkin and Bowie 1928).

Because of the great variability in the partitioning and length of the digestive tracts of different species of fish, it is not possible to predict which species will be amenable to the pumping technique unless the alimentary tract morphology is known. For those that can be pumped, the simplicity and efficiency of the pumping method make it a valuable tool for collecting the digestive tract contents of small, live fish.

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