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Assessment of diet in two cyprinids using a modified stomach-flushing technique

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Abstract. A modified flushing technique was used to sample the anterior gut contents of the stomachless cyprinids, the tench, *Tinca tinca* (L.), and grass carp, *Ctenopharyngodon idella* Val., in the laboratory and the field. The method was developed to provide quantitative estimates by measuring optimum penetration of a catheter into the gut of tench from their fork length. Possible implications for the sampling of gut contents of other cyprinids are discussed.

Introduction

The examination of food from fish stomachs usually necessitates killing the fish. However, this may be unacceptable when dealing with valuable species or large individuals which may have a low abundance in the population being studied. Therefore, various methods have been devised to facilitate the removal of stomach contents without killing the fish. The techniques used have been variously modified depending on gut structure and feeding behaviour of the particular species. The stomach-flushing technique is normally used on carnivorous fish with a well-defined stomach and all devices used are based on similar principles: injection of water by means of a pump or bulb, through a tube (Seaburg 1957; Gaudin *et al.* 1981; Georges & Gaudin 1984), a pipette (Strange & Kennedy 1981) or a needle (Meehan & Miller 1978) combined with back flushing by suction, gravity or external pressure on the abdomen. Baker & Fraser (1976) injected water through the anus and flushed it through the mouth, but they found this successful only with small fish whose gastrointestinal length did not exceed their body length. Hyslop (1980) and O'Farrell & McCarthy (1983) have reviewed these methods.

The flushing technique has not been applied quantitatively to cyprinids, stomachless fish without pyloric constrictions, which possess pharyngeal teeth, although Giles (1980) has used a qualitative technique on roach, *Rutilus rutilus* (L.). In the present study a modified technique was devised and used successfully on an omnivorous species, tench, *Tinca tinca* (L.), in both a laboratory and field environment. The method was extended to the grass carp, *Ctenopharyngodon idella* Val., to examine the application of the technique on a qualitative basis for this herbivorous species.

Materials and methods

Tench (>18 cm) were anaesthetized and laid horizontally on a specially designed wooden board at an inclined level of 30° with the head facing downwards. A stiff catheter with a blunt

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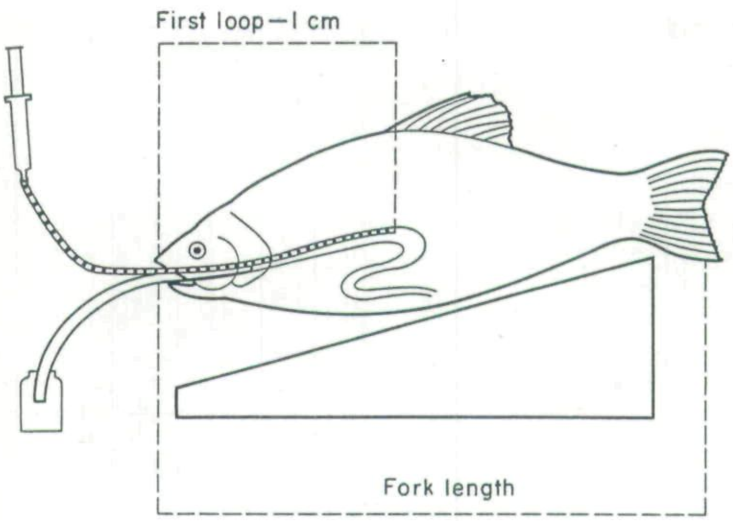

Figure 1. Diagram of stomach-flushing technique as used on tench.

end was inserted into the gut through the mouth as far as the 1st loop of the intestine. A large transparent, slightly elastic, tube was then inserted between the pads of the pharyngeal teeth. Water from a 60-ml syringe attached to the catheter was injected under pressure using the syringe plunger to flush the contents of the anterior bulb of the gut (hereafter referred to as the stomach) via the tube, into a jar by gravity (Fig. 1). Small movements of the tube up and down were used to prevent any clogging of the flushed material within the tube. The procedure was complete when the flushing water became clear. The combination of tubes and catheters used in relation to fish size are shown in Table 1. To quantify the method for use as a field technique the relationship between the distance of the snout of the fish to the 1st loop of the gut minus 1 cm and the fork length of the fish was established. This distance reflects the length of the catheter needed for insertion with the subtraction of 1 cm made to avoid any damage to the intestinal wall of the loop and reducing the possibility of recovering any

Table 1. Size relationship between tench and stomach sampler

Fish length	Tube*	Catheter
20–25	Small	Cat 3FG or 4FG
26–30	Small/medium	Cat 4FG or dog 6FG
30–35	Medium	Dog 6FG
36–40	Large	Dog 6FG

* Diameter of tubes (mm):

	Internal	External
Small	4·0	5·0
Medium	4·5	7·0
Large	6·0	9·0

material from beyond the loop. Seventeen tench ranging between 18 and 40 cm were killed, dissected and the two measurements were made *in situ*.

The effectiveness of the technique was evaluated by offering maggots (dipteran larvae), chironomids, *Asellus aquaticus* (isopod) and wetted groundbait (a finely ground, bread-based, fish attractant used by anglers) as food items. Maggots simulated bulky prey and ground bait detrital material frequently encountered in tench stomachs from the wild (Petridis 1986). The volume of ground bait recovered from stomachs was not measured but was incorporated as a diet item to duplicate any interference effect detrital material may have had on the recovery of animal diet components in the field diet (Petridis 1986). Six fish from each of two size groups (20–29 cm and 30–40 cm) were starved for 24 h, fed on these items for 45 min and then anaesthetized individually in a small tank prior to flushing. Items not consumed were removed from the fish tanks with a hand-net and counted. The outflow openings of the two tanks were covered by fine net to prevent prey escape. The flushing time of each of six large tench combined with the anaesthetization time took 7·5–10 min and involved two operators. Total and prey species efficiency was estimated by the formula

$$E = \frac{n \times 100}{N}$$

n = number of prey items recovered and N = number of prey items ingested.

To assess the influence of digestion on the flushing efficiency, six tench of 30–40 cm, separated into two groups of three, were fed on the same food items (maggots, *Asellus*, chironomids) in equal proportions and flushed after 45 min and 100 min (see Table 2).

Table 2. Efficiency of stomach-flushing technique in relation to food type and period of digestion

Time after feeding (min)	Fish size (cm)	*Asellus*		Maggots		Chironomids		Overall efficiency (%)
		n ingested	Flushing efficiency (%)	*n* ingested	Flushing efficiency (%)	*n* ingested	Flushing efficiency (%)	
45	30–40	20	75·0	29	89·6	107	86·0	85·3
45	20–29	2	100·0	21	76·2	73	93·1	89·6
45	30–40	31	77·4	15	66·7	58	86·2	80·8
100	30–40	8	25·0	9	100·0	30	63·3	63·8

See text for further details.

Potential effects on condition factor ($K = W/L_3 \times 100$) where W = weight of fish in g and L = fork length in cm were examined by weighing flushed and unflushed fish of both size ranges retained in four 227-l tanks with continuous water flow at 19°C held over a 4-week period. Weights and lengths were taken after anaesthetization with MS222 at the beginning and end of each week following 24 h prior starvation. The flushed fish were subjected to this once, before the start of the experiment. Fish were fed in excess in two meals daily. Any unconsumed maggots were removed every other day before the addition of new maggots.

In the field, two experimentally separated stations were established in the Lancaster Canal (National Grid Reference SD 520854 to SD 526849) and the condition of large tench (>35 cm) subjected to monthly stomach flushing for diet examination (Petridis 1986) was monitored from May to October.

Twenty large grass carp (>40 cm) coexisting with tench at the same field sites were also flushed periodically from May to July. The technique used was identical to that for tench except that the penetration distance into the intestine of the catheter was not calibrated.

Results

A polynomial regression equation $Y = 8{\cdot}36 + 1{\cdot}95 \times 10^{-4} X^3$ ($R^2 = 0{\cdot}936$, $N = 17$, $P < 0{\cdot}001$) gave the best fit between tench stomach length minus 1 cm and fish fork length relationship. The catheter was graduated to facilitate catheter insertion proportionately equivalent to the length of the fish.

The total efficiency of the technique ranged from 85·3% for the large fish (>30 cm) to 89·6% for the medium fish (20–29 cm in length) (Table 2). The efficiency for *Asellus* (75%) was lowest in the large group because the pharyngeal teeth masticated the animal making the counting of individual prey items impossible except by the recognition of their abdomen (Gledhill, Sutcliffe & Williams 1976). The efficiency for *Asellus* in the medium group cannot be reliably compared due to the small number investigated. The technique was less effective with maggots in the medium-sized fish, because they are bulky and either cannot pass through the tube or are pushed further along the intestine by the catheter. Wounds around the pharyngeal area occurred in two fish but no mortality was observed during 1 month after treatment.

The effectiveness of the technique 45 and 100 min after feeding is shown in Table 2. The efficiency for *Asellus* (77·4%) and chironomids (86·2%) for fish flushed after 45 min is very similar to that of the large fish of the previous experiment. Only maggots were not flushed very effectively, bringing the total efficiency to 80·8%; the efficiency for *Asellus* and chironomids for fish flushed after 100 min was much lower compared to that of fish flushed after 45 min although the efficiency for maggots was 100%.

Analysis of variance was used to test the condition factor between flushed and unflushed (control) fish at the end of each week. No significant differences were found between any week.

In the Lancaster Canal, at the two experimental sites, an increase in the condition of tench with time was evident throughout the feeding season (May–October), except for a sharp drop due to spawning in July.

The mortality of the flushed fish was nil in the laboratory and only one was found dead in the field, but this was associated with electrofishing effects rather than with the flushing technique.

Grass carp stomach contents were difficult to flush successfully; plant material, mainly *Elodea nutallii* Michx. fragments, *Lemna minor* L. and filamentous algae, clogged the mouth of the tube and movements of the tube up and down were needed to unblock it. Because of these difficulties in the field only qualitative stomach flushing was attempted on grass carp with no laboratory back-up to quantify the technique.

Discussion

The flushing device allowed the quantitative estimation of the diet of tench with high efficiency (85·3% for 30–40-cm-length fish and 89·6% for 20–29-cm fish). It was less efficient with partly digested large animals (maggots) and more effective with the same items when well digested. This feature was similarly reported by Giles (1980). For these types of food when the time of digestion increases the digestive fluids dissolve the whole prey, leaving the cuticle intact, which, being lighter, is flushed back easily, thereby improving the total efficiency. Regurgitation during anaesthesia, escape of flushed material outside the tube and loss of prey pushed further into the intestine by the catheter were the main problems reducing the effectiveness of the technique. The pharyngeal teeth of cyprinids, particularly those of large individuals, were found to be the major obstacle to the insertion of the flushing tube. The degree of anaesthetization affected the movements of the pharyngeal teeth, and deeper anaesthesia facilitated an easier passage of the catheter and tube through the pharyngeal area, greatly reducing any potential for damage.

The condition of tench throughout the season was unaffected by the technique, and a similar conclusion was reported for salmonids in field trials by Strange & Kennedy (1981), Giles (1980) and O'Farrell & McCarthy (1983). However, Meehan & Miller (1978) noted a depression in the condition of wild fish, although they ascribed it to changing the food of the animals from wild prey to commercial pellets. These authors and Neveu & Thibault (1977) reported that the effectiveness of their technique decreased with increased fish length.

The present flushing technique, modified from that of Giles (1980), is promising for carnivorous, omnivorous and detritivorous cyprinids, but due allowance must be made for the length of the time taken to complete the sampling when only two operators participate. Implementation of the method on cyprinid species requires quantification of the intestinal division, particularly the positioning of the catheter in relation to the 1st loop of the intestine and the length of the fish. However, quantitive data can be obtained by inserting the catheter to an approximate position and this considerably increases the speed of application.

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References

Baker A. W. & Fraser D. F. (1976) A method of securing the gut contents of small live fish. *Transactions of the American Fisheries Society* **105,** 520–2.

Gaudin P., Martin E. & Gaillere L. (1981) Le tubage gastrique chez les poissons: mise au point d'un equipment et test chez le chabot *Cottus gobio* L. *Bulletin Francais de Pisciculture* **282,** 8–15.

Georges P. J. P. & Gaudin P. (1984) Gastric tubing in fishes: experimentation in juvenile trout. (English summary). *Archiv für Hydrobiologie* **101,** 453–60.

Giles N. (1980) A stomach sampler for use on live fish. *Journal of Fish Biology* **16,** 441–4.

Gledhill T., Sutcliffe D. W. & Williams W. D. (1976) *A key to British freshwater crustacea: Malacostraca.* FBA Scientific Publications No. 32.

Hyslop E. J. (1980) Stomach content analysis – a review of methods and their application. *Journal of Fish Biology* **17**, 411–29.

Meehan W. R. & Miller R. A. (1978) Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. *Journal of the Fisheries Research Board of Canada* **35**, 1359–63.

Neveu A. & Thibault M. (1977) Feeding behaviour of a wild population of fario trout (*Salmo trutta* L.) in the Lissuraga, a stream in Pyrenees Atlanticues. (English summary). *Annales d'Hydrobiologie* **8**, 111–28.

O'Farrell M. M. & McCarthy T. K. (1983) An evaluation of stomach flushing as a fishery technique. *Proceedings of the 3rd British Freshwater Fisheries Conference*, pp. 59–70.

Petridis D. (1986) *Some ecological aspects of tench*, Tinca tinca *L. and its isopod prey*, Asellus aquaticus *(L.) in habitats influenced by grass carp*, Ctenopharyngodon idella *Val.* PhD Thesis, University of Liverpool.

Seaburg K. G. (1957) A stomach sampler for live fish. *Progressive Fish-Culturist* **19**, 137–9.

Strange C. D. & Kennedy G. J. A. (1981) Stomach flushing of salmonids: a simple and effective technique for the removal of the stomach contents. *Fisheries Management* **12**, 9–15.