# What Is in the Stomach Is Not the Proportion Eaten but the Proportion Weighted by Resistance to Digestion

— with half-lives of **0.5** hours for soft-bodied prey, **2.0** for small fish, **6.0** for crustaceans and **24.0** for bones and otoliths, bones and otoliths make up **88.8503** % of the stomach after **24** hours — the separator is whether the half-lives of the prey are equal — [Paper 657]

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September 2026

*— From thinking to syncing. —*

**Abstract**

**What a fish eats is often inferred by opening its stomach and examining the contents. But digestion goes on in the stomach: soft prey vanish quickly, while hard parts such as bones and otoliths remain long.How far the proportions in the stomach drift from the proportions eaten is counted from the half-life of each prey.No new theorem or law is claimed. First, even eaten in equal amounts at once, the proportions in the stomach shift over time——eating the four at 25 % each, after 4 hours soft-bodied prey were 0.2201 % and bones and otoliths 50.1981 %, and after 24 hours 0.0000 % and 88.8503 %** (Section 2). **Second, and this is the core.Eaten continuously, the proportions in the stomach are proportional to the half-lives——eating the four continuously at the same rate, the stomach held soft-bodied prey 1.5385 %, small fish 6.1538 %, crustaceans 18.4615 % and bones and otoliths 73.8462 %, exactly the ratio of half-lives 0.5 : 2 : 6 : 24. Integrating over the time of eating agreed within $10^{-6}$** (Section 3). **Third, what digests easily can be found for a shorter time——the time to fall to 1 % of the initial amount was 3.3219 hours for soft-bodied prey and 159.4525 hours for bones and otoliths, a ratio of 48.0000** (Section 4). **Fourth, the separator is whether the half-lives of the prey are equal——if equal, the stomach contents equal the proportions eaten. If not, then only when feeding is continuous does dividing the stomach proportions by the half-lives recover the proportions eaten. After a single meal, they cannot be recovered without knowing when it was eaten** (Section 5). **Keywords**: stomach content analysis, digestion rate, half-life, diet, residence time.

Scope of this paper (scope note): No new theorem or law is claimed——that differences in digestion rate among prey bias the results of stomach content analysis is known (Hyslop 1980 and others).This is an example——half-lives of 0.5, 2.0, 6.0 and 24.0 hours are set as an example. Real digestion rates move with water temperature, prey size and fish species.Digestion is taken to proceed exponentially——the part passed from stomach to intestine and the stage at which partly digested prey can no longer be identified are not separated.Relation to earlier papers: Paper 364 showed that even with everyone equally able, selecting only the top makes the mean appear 1.52 standard deviations higher ——here only what survives digestion is seen in the stomach.Paper 576 showed that widening a water main lengthens the time the water spends in it, so the water grows older——here too, what stays longer is seen more.What is added is listing how the proportions change over time after a single meal, confirming by closed form and integration that the proportions under continuous feeding are proportional to the half-lives, counting the difference in the time each can be found, and placing the separator on the equality of half-lives.

## 1. Notation and the Question

Setting: when an amount $m_i$ of prey $i$ is eaten, what remains in the stomach falls with half-life $h_i$, to $m_i 2^{-t/h_i}$ after time $t$.If prey $i$ is eaten continuously at a constant rate $r_i$, the amount held in the stomach is

$$Q_i = \int_0^\infty r_i \, 2^{-t/h_i} \, dt = \frac{r_i h_i}{\ln 2}$$

proportional to the product of the eating rate and the half-life.The premised half-lives are 0.5 hours for soft-bodied prey, 2.0 for small fish, 6.0 for crustaceans and 24.0 for bones and otoliths.

Question: how far do the proportions in the stomach drift from the proportions eaten, and what sets that?

## 2. A Single Meal

Computation 2.1: with the four eaten in equal amounts at once, the proportions in the stomach were derived over time.

| elapsed | soft-bodied | small fish | crustaceans | bones and otoliths |
|---|---|---|---|---|
| 0 h | 25.0000 % | 25.0000 % | 25.0000 % | 25.0000 % |
| 2 h | 2.7173 % | 21.7384 % | 34.5076 % | 41.0367 % |
| 4 h | 0.2201 % | 14.0864 % | 35.4954 % | 50.1981 % |
| 8 h | 0.0012 % | 4.9878 % | 31.6703 % | 63.3407 % |
| 24 h | 0.0000 % | 0.0434 % | 11.1063 % | 88.8503 % |

**Observation 2.2**

even eaten in equal amounts, the stomach shifts over time toward what digests slowly.Opened after 24 hours, the stomach makes this fish look as if it ate almost nothing but bones and otoliths. Soft-bodied prey fall to 2.7173 % in 2 hours and have nearly vanished after 8——the proportions in the stomach give a different answer depending on when it is opened.

## 3. Continuous Feeding

Computation 3.1: with the four eaten continuously at the same rate, the closed form gave stomach proportions of 1.5385 % soft-bodied prey, 6.1538 % small fish, 18.4615 % crustaceans and 73.8462 % bones and otoliths.Integrating numerically over the time of eating agreed with these values within $10^{-6}$.With one meal each hour, the proportions were 2.7188 %, 6.9620 %, 18.6903 % and 71.6288 %.

**Observation 3.2**

this is the core: under continuous feeding, the proportions in the stomach are proportional to the half-lives.The amount held in the stomach is the eating rate times the time the prey stays there. Eaten at the same rate, a prey that stays four times longer is seen four times more——the stomach contents are the proportions eaten multiplied by resistance to digestion.When the interval between meals approaches the half-life of soft-bodied prey, the remains of each meal stand out, and the proportion shifts slightly back toward soft-bodied prey (2.7188 % with hourly meals).

## 4. The Time for Which Prey Can Be Found

**Computation 4.1**: **the time to fall to 1 % of the initial amount was 3.3219 hours for soft-bodied prey, 13.2877 for small fish, 39.8631 for crustaceans and 159.4525 for bones and otoliths. The ratio of bones and otoliths to soft-bodied prey was 48.0000.**

> **Observation 4.2**
>
> **what digests easily loses its evidence first.That soft-bodied prey were eaten can be told for only 3.3219 hours after the meal, while bones and otoliths remain for 159.4525 hours——not finding something in the stomach does not mean it was not eaten.**

## 5. The Separator

> **Observation 5.1**
>
> **the separator is whether the half-lives of the prey are equal.If equal, the proportions in the stomach equal the proportions eaten. If not, then only under continuous feeding does dividing the stomach proportions by the half-lives return every prey to 25.0000 %. After a single meal, the divisor is not fixed unless one knows how many hours have passed since eating——to go back from stomach contents to what was eaten requires separate information, the rate of digestion.**

> **Observation 5.2**
>
> **beside Paper 364 and Paper 576.Paper 364 showed that even with everyone equally able, choosing only the top makes the mean look higher. Here, only what survives digestion is seen in the stomach. Paper 576 showed that when the time spent in a pipe grows, the water grows older——here too, what stays longer is seen more, and the proportions are weighted by time.**

**Observation 5.3**

**what is not said.Real digestion rates, differences with water temperature and passage out of the stomach are not treated. The half-lives are an example——what is shown is what separates the proportions in the stomach from the proportions eaten.**

## 6. Roll Call and Closing

1. **bones and otoliths 50.1981 % after 4 hours** (Computation 2.1): **the shift begins.**
2. **88.8503 % after 24 hours** (Computation 2.1): **looks like bones alone.**
3. **the answer depends on when it is opened** (Observation 2.2): **a single meal.**
4. **73.8462 % under continuous feeding** (Computation 3.1): **proportional to half-life.**
5. **agrees with the integral within $10^{-6}$** (Computation 3.1): **checking the closed form.**
6. **proportion eaten times resistance to digestion** (Observation 3.2): **the core.**
7. **soft-bodied prey gone from view in 3.3219 hours** (Computation 4.1): **evidence lost first.**
8. **ratio of times found 48.0000** (Computation 4.1): **bones and otoliths over soft-bodied.**
9. **dividing by half-life recovers it** (Observation 5.1): **only under continuous feeding.**
10. **whether half-lives are equal** (Observation 5.1): **the separator; Paper 364 and Paper 576.**

**Closing**: **What is in the stomach is not the proportion eaten.Even with the four eaten in equal amounts, bones and otoliths made up 88.8503 % of the stomach after 24 hours, and under continuous feeding the proportions were proportional to the half-lives, with bones and otoliths at 73.8462 %.The evidence of soft-bodied prey vanished in 3.3219 hours, while bones and otoliths remained for 159.4525 hours——stomach contents are the proportions eaten multiplied by resistance to digestion.The separator is whether the half-lives of the prey are equal.Placed among the earlier papers——as with the selection of Paper 364, only what survives digestion is seen.To be honest——the half-lives are an example, and real digestion rates are not entered.**

## References


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