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SHORT NOTE

A comparison of gastrointestinal transit time in ten species of mammal

BY E. T. CLEMENS AND C. E. STEVENS

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(Revised MS. received 10 December 1979)

The efficiency of digestion and absorption is dependent upon the rate at which digesta moves through the gastrointestinal tract. The following report describes the gastrointestinal transit for digesta markers given to ten species of mammals fed the same diet.

METHODS AND MATERIALS

Three animals of each species were fed a commercial, pelleted hay–grain diet (12.5% fibre) and preconditioned to the diet before beginning the experiment. Each animal was fed for a 1 h period twice daily at 12 h intervals, with continuous access to drinking water.

Movement of fluid digesta was determined with water soluble marker, polyethylene glycol (PEG). Particulate markers consisted of radio-opaque polyethylene tubing cut in lengths of 2, 10 and 20 mm. Markers were administered immediately after the morning meal via a tube and syringe into the stomach of each animal except the ox and llama. Markers were administered, via a rumen fistula, into the abomasum of the ox and via a fistula in the first compartment of the llama's stomach into the most aboral compartment. All faeces were collected at 12 h intervals for 10 days. The faeces were analysed for PEG (Hydén, 1956) and particulate markers were recovered by washing the faeces through a 1 mm² screen.

RESULTS

Table 1 gives the mean transit time for each digesta marker. Results for species were arranged according to the rate of fluid transit. Particulate markers demonstrated varying rates of transit such that several species transported smaller particles (2 mm in length) more rapidly than fluids. In all species except the opossum, raccoon and dog larger particles (10 and 20 mm) were selectively retained within the gut for prolonged periods of time. More than 50% of the longest particles were still within the tract of the llama, ox and pony 10 days after administration. The transit time for 15% and 85% of the digesta marker to pass into the faeces is also presented in Table 1.

Table 2 gives the approximate length of various segments of the gastrointestinal tract for each species. The information in no way indicates the degree of complexity of the digestive tracts due to gastric folds, intestinal flexures or sacculations, nor the volume capacity. The data represent the axil-length from beginning to end of each segment. The reader is referred to various texts for structural characteristics (Habel, 1975; Stevens, 1977).

DISCUSSION

Movement of digesta may be regulated via structural and physiological characteristics of the digestive tract. Its movement is further influenced by physical, as well as nutritional, characteristics of the diet (Hogan & Weston, 1969; Hintz et al. 1971). Retention of digesta generally occurs within the stomach and/or hindgut, while passing rapidly through the small intestine. Prolonged retention can aid the digestive process by providing adequate time for host and microbial enzymatic degradation of the ingested materials, as well as enhancing absorption time.

Animals with a simplified digestive tract exhibit rapid transit of both fluids and particulate material (Clemens & Stevens, 1979; Banta et al. 1979). The stomach is the primary site of retention with relatively rapid flow through the small and large intestines. Species with a simple stomach and short, non-sacculated, non-voluminous colon (i.e. the opossum, raccoon and dog) displayed no selective retention according to the size of particles.
Complexity of the hindgut varies considerably among species, as does the degree of digesta retention. The sacculated caecum of the rabbit selectively retained fluids (Pickard & Stevens, 1972), while the colon of the pony selectively retained larger particles (Argenzio, Southworth & Stevens, 1974). Swine also possess a complex sacculated hindgut; however, the particulate markers of all sizes appeared to pass through the caecum and colon at similar rates (Clemens, Stevens & Southworth, 1975). The extended transit time of 20 mm particles in the pig (Table 1) was due to a selective retention of these particles within the stomach (Clemens et al. 1975).

The extended retention of markers in the forestomach compartments of the llama and ox was by-passed by administering markers into the most aboral stomach compartments, thus rendering the information more comparable to that on other mammals presented. The ox demonstrated extended retention of fluids and particles, as well as selective retention of the larger size particles. However, retention time of fluid and all but the largest particles was less than half that observed in the pony. The llama demonstrated more rapid transit of fluids and smaller particles than either the ox or pony, but retained larger particles for an extended period of time. Closer examination of one llama indicated that the majority of the 10 and 20 mm particles were retained within the most aboral compartment of the stomach.

Mean transit time, while representing an effective way of presenting comparative information, can be misleading for two reasons; the single value ($T_A$) in no way (1) indicates how the bulk of material moved through the gastrointestinal tract, or (2) considers the structure, volume or length of the digestive tract. An example of the difference between mean transit time and bulk movement can be seen by comparing the information in Table 1. Mean transit time for fluid marker in the guinea pig and llama was identical (40 h). However, the 15 to 85% interval (i.e. when 70% of the marker passed through the tract) for the llama was 34 h compared with 60 h for the guinea pig.

In many mammals with a simple stomach, gastric emptying and small intestinal transit of fluid and 2 mm particles occurred within 4 to 8 h after feeding (Clemens et al. 1975; Clemens, 1978; Banta et al. 1979). Based upon this assumption and simply using the combined length of caecum, and colon, rectum, calculations were made with regard to transit of the markers through the hindgut for each species (Table 2). It is interesting to note that the rate of marker movement was reasonably constant (2–5 cm/h) for most species. Three exceptions were noted. The pig, llama and ox demon-

<table>
<thead>
<tr>
<th>Species</th>
<th>Recovery</th>
<th>Fluid marker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opossum (Didelphis virginiana)</td>
<td>10</td>
<td>85%</td>
</tr>
<tr>
<td>Raccoon (Procyon lotor)</td>
<td>11</td>
<td>85%</td>
</tr>
<tr>
<td>Pig (Sus scrofa)</td>
<td>20</td>
<td>85%</td>
</tr>
<tr>
<td>Dog (Canis familiaris)</td>
<td>20</td>
<td>85%</td>
</tr>
<tr>
<td>Rabbit (Oryctolagus cuniculus)</td>
<td>20</td>
<td>85%</td>
</tr>
<tr>
<td>Guinea pig (Capra hircus)</td>
<td>40</td>
<td>85%</td>
</tr>
<tr>
<td>Llama* (Lama guanicoe)</td>
<td>40</td>
<td>85%</td>
</tr>
<tr>
<td>* Markers were administered into the most aboral compartment of the ox and llama stomach. The data on the llama actually consists of measurements from two lamas and one guanaco (Lama guanicoe).</td>
<td>40</td>
<td>85%</td>
</tr>
</tbody>
</table>

Table 1: Gastrointestinal transit time (h) for 50%, 15% and 85% of each digesta marker to be recovered in the fecal excretion.
Table 2. Length of gut segments (cm) and mean distance (cm) each marker travelled along the caecum, colon and rectum per hour, assuming either 4 or 8 hours for gastric emptying and small intestinal transit time

<table>
<thead>
<tr>
<th>Species</th>
<th>Segment of tract</th>
<th>Assuming 4 h</th>
<th>Assuming 8 h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stomach*</td>
<td>Small intestine</td>
<td>Cæcum</td>
</tr>
<tr>
<td>Opossum (Didelphis virginiana)</td>
<td>5</td>
<td>54</td>
<td>4</td>
</tr>
<tr>
<td>Raccoon (Procyon lotor)</td>
<td>6</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>Pig (Sus scrofa)</td>
<td>28</td>
<td>1416</td>
<td>17</td>
</tr>
<tr>
<td>Rat (Rattus norvegicus)</td>
<td>3</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>Dog (Canis familiaris)</td>
<td>14</td>
<td>248</td>
<td>8</td>
</tr>
<tr>
<td>Rabbit (Oryctolagus cuniculus)</td>
<td>13</td>
<td>151</td>
<td>44</td>
</tr>
<tr>
<td>Guinea pig (Cavia porcellus)</td>
<td>5</td>
<td>97</td>
<td>9</td>
</tr>
<tr>
<td>Llama (Lama peruana)</td>
<td>88</td>
<td>1044</td>
<td>20</td>
</tr>
<tr>
<td>Ox† (Bos taurus)</td>
<td>20</td>
<td>1250</td>
<td>25</td>
</tr>
<tr>
<td>Pony (Equus caballus)</td>
<td></td>
<td>722</td>
<td>51</td>
</tr>
</tbody>
</table>

* Distance through the greatest axial length of stomach (most aboral compartment of the llama and ox stomach).
† No caecum.
‡ Measurements derived from Habel (1975). All other values were determined by direct measurements.

Stratified a transit of both fluid and particle markers 5-15 times more rapid than that of other species. Transit of markers through the caecum and colon of the rabbit was slightly faster than many species, but considerably slower than that observed in the pig, llama and ox.

REFERENCES


