

THE RELATION OF THE GASTRO-INTESTINAL TRACT
AND CONTENTS TO THE BODY-WEIGHT
IN RABBITS.*

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In some experimental work on rabbits in this laboratory, in which the results were based on the body-weight, it has been found necessary to avoid the error introduced by the variation in the weight of intestinal, stomach, and bladder contents. In view of a possible wider interest in the data collected for our use, we report them in this paper.

Joseph¹ examined one hundred rabbits for the purpose of determining the proportion of body-weight which should be allowed for stomach and cecum contents when the dosage of various drugs is based on the weight of the animal. He gives figures for stomach and cecum contents of males and females, and for the stomach and cecum minus contents. The results given in this paper deal collectively with the contents of the stomach, small intestine, cecum, large intestine, and rectum, of both sexes; the figures also include the weights of the organs after the contents had been removed, in normal, castrated, and thyroidectomized animals. The data in the literature upon this subject are not sufficiently complete to meet all conditions nor to justify the formation of a rule which will cover all cases; hence it became necessary to determine the exact weights in each animal used. The error in body weight due to bladder contents may be obviated by applying digital pressure on the abdomen in the region of the bladder as soon as the animal is dead and the muscles are relaxed. This method was used in every case, and throughout the paper the weight after removal of urine is spoken of as gross body-weight. The problem of eliminating the error

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¹ Joseph, D. R., *Jour. Exper. Med.*, 1909, xi, 36.

introduced by inclusion of the stomach and intestinal contents is more difficult. The animal was weighed before and after the urine was expelled, and then the whole tract from the cardiac end of the stomach to the lower end of the rectum was removed, with as little of the mesentery as possible. The tract was then weighed with its contents. The removal of the latter was accomplished by first cutting the tract at the junction of its several parts; then the stomach was opened along its greater curvature and the material within was scraped away without the removal of any of the mucous membrane. The remaining parts were placed on a smooth board and by means of a small piece of sheet cork, which does not cut the tissue, the contents were forced out by pressure along the outside. This was continued until all the material was removed. The stomach and intestines, now minus their contents, were weighed collectively, and their weight was subtracted from that obtained before the removal of the contents, thus giving the content weight which when subtracted from the gross body-weight gave what we shall call the reduced body-weight. The method of clearing the intestines of their contents by allowing a current of water to pass through introduces a considerable error by the water that remains in the folds of the lining mucous membrane, while with the present method a comparatively small error is made. The animals were killed by coal gas when it happened to be most convenient, without respect to feeding time, and this undoubtedly accounts to some extent for the wide variation in the weight of gastro-intestinal contents.

Among the animals examined there were thirty-one castrated and thirty-three normal males, twenty-one spayed and thirty-one normal females, five thyroidectomized males, and six thyroidectomized females. In the tables the averages are arranged in ascending order with respect to the reduced body-weight. In column 1 of the first four tables the numbers indicate the limits between which the reduced body-weight varies.

In tables I to IV it will be observed that the absolute weights vary directly with the reduced body-weights, while the weights per kilo, as seen in columns 8 and 9, vary inversely with the reduced body-weight. In table V the averages of the twenty-one spayed females are compared with those of the thirty-one controls. It will be noted

that the reduced body-weight is slightly more in the spayed than in the normal animals and that the absolute weights vary even with this slight difference. In table VI where the averages of the thirty-three normal and thirty-one castrated males are compared, the absolute weights vary with the reduced body-weight without exception. In table VII where the averages of the whole group of sixty-four castrated and control males are compared with those of the whole group of fifty-two spayed and control females, it will be noted that the average of the gastro-intestinal tract plus the contents is slightly more in the males that have a lower average for reduced body-weight. This is due to the contents, as shown by column 6. The weight of the tract alone varies with the reduced body-weight.

In table VIII is given a comparison of the averages of the sixty-four normal animals, both males and females, with fifty-two operated males and females, and here again there is no exception to the rule that the variation in reduced body-weight, although small, is accompanied by a direct variation of the gross body-weight, weight of gastro-intestinal tract plus its contents, the same tract minus its contents, and the contents alone.

The same is true without exception in table IX, where the thyroidectomized males and females are compared.

In tables V to IX there is a constant apparent contradiction to tables I, II, III, and IV, in that the weights per kilo as shown in columns 8 and 9 vary directly with the reduced body-weight. The difference between the averages for the reduced body-weight is so small in tables V to IX that one would scarcely expect the same rule to hold without exception, and this is noted with few exceptions to be true when a comparison is made between groups with a wider variation in reduced body-weight (tables I to IV).

The variation between males and females (table VII) or between operated and control animals of either sex (tables V and VI) in cases of castration (table VIII) or thyroidectomy (table IX) is not sufficiently marked, it seems to me, to justify the conclusion that there is a constant difference due to sex or the experimental conditions here mentioned, in as far as the organs in question are concerned.

Table X, in which are included the averages for the eleven thyroid-

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ectomized and the sixty-four normal animals, shows a marked difference in that the absolute weights and the weights per kilo of the thyroidectomized group are much less than those of the normal group, especially when we notice that the reduced body-weight was considerably greater in the thyroidectomized animals. This is not due to thyroidectomy because the normal animals used as controls in the same experiment correspond closely. This variation between the two series seems too large to be explained on the basis of a normal

TABLE I.
Spayed Females.

| Reduced body-weight, in kilos. | No. of animals. | Gross body-weight, in kilos. | Weight of gastro-intestinal tract plus contents, in gm. | Weight of gastro-intestinal tract, in gm. | Weight of gastro-intestinal contents, in gm. | Reduced body-weight, in kilos. | Weight of gastro-intestinal tract, in gm. per kilo of reduced body-weight. | Weight of gastro-intestinal contents, in gm. per kilo of reduced body-weight. |
|--------------------------------|-----------------|------------------------------|---|---|--|--------------------------------|--|---|
| 0.787-1.684 | 6 | 1.529 | 334.0 | 105.0 | 229.0 | 1.300 | 81.0 | 177.0 |
| 1.778-1.976 | 4 | 2.114 | 354.0 | 123.0 | 231.0 | 1.883 | 65.0 | 122.0 |
| 2.018-2.471 | 6 | 2.584 | 422.0 | 145.0 | 277.0 | 2.307 | 62.0 | 120.0 |
| 2.554-2.861 | 5 | 3.035 | 437.0 | 163.0 | 274.0 | 2.761 | 59.0 | 99.0 |

TABLE II.
Normal Females.

| | | | | | | | | |
|-------------|----|-------|-------|-------|-------|-------|------|-------|
| 0.756-1.798 | 7 | 1.710 | 330.0 | 106.0 | 224.0 | 1.486 | 72.0 | 151.0 |
| 1.838-2.028 | 7 | 2.175 | 339.0 | 106.0 | 233.0 | 1.942 | 55.0 | 119.0 |
| 2.072-2.167 | 7 | 2.378 | 380.0 | 123.0 | 257.0 | 2.121 | 58.0 | 121.0 |
| 2.260-3.030 | 10 | 2.698 | 380.0 | 129.0 | 251.0 | 2.447 | 53.0 | 103.0 |

TABLE III.
Castrated Males.

| | | | | | | | | |
|-------------|----|-------|-------|-------|-------|-------|------|-------|
| 1.142-1.572 | 6 | 1.651 | 327.0 | 100.0 | 227.0 | 1.424 | 71.0 | 160.0 |
| 1.614-1.876 | 6 | 2.087 | 377.0 | 114.0 | 263.0 | 1.824 | 63.0 | 144.0 |
| 1.916-2.195 | 10 | 2.346 | 399.0 | 128.0 | 271.0 | 2.075 | 62.0 | 131.0 |
| 2.210-3.338 | 9 | 2.873 | 452.0 | 161.0 | 291.0 | 2.582 | 62.0 | 113.0 |

TABLE IV.
Normal Males.

| | | | | | | | | |
|-------------|----|-------|-------|-------|-------|-------|------|-------|
| 1.328-1.632 | 7 | 1.706 | 310.0 | 102.0 | 208.0 | 1.498 | 68.0 | 139.0 |
| 1.652-1.805 | 5 | 1.973 | 353.0 | 120.0 | 233.0 | 1.740 | 68.0 | 134.0 |
| 1.812-1.978 | 9 | 2.165 | 377.0 | 111.0 | 266.0 | 1.898 | 59.0 | 140.0 |
| 2.112-3.009 | 12 | 2.628 | 388.0 | 130.0 | 258.0 | 2.370 | 55.0 | 110.0 |

TABLE V.

| Group. | No. of animals. | Gross body-weight, in kilos. | Weight of gastro-intestinal tract plus contents, in gm. | Weight of gastro-intestinal tract, in gm. | Weight of gastro-intestinal contents, in gm. | Reduced body-weight, in kilos. | Weight of tract per kilo of reduced body-weight. | | Weight of contents per kilo of reduced body-weight. | |
|---------------------------|-----------------|------------------------------|---|---|--|--------------------------------|--|-----------|---|-----------|
| | | | | | | | In gm. | Per cent. | In gm. | Per cent. |
| Control females | 31 | 2.284 | 364.0 | 122.0 | 242.0 | 2.042 | 60.0 | 6.0 | 119.0 | 11.9 |
| Spayed females | 21 | 2.300 | 387.0 | 134.0 | 253.0 | 2.048 | 65.0 | 6.5 | 123.0 | 12.3 |

TABLE VI.

| | | | | | | | | | | |
|---------------------------|----|-------|-------|-------|-------|-------|------|-----|-------|------|
| Control males | 33 | 2.207 | 363.0 | 117.0 | 246.0 | 1.961 | 60.0 | 6.0 | 125.0 | 12.5 |
| Castrated males | 31 | 2.315 | 396.0 | 129.0 | 267.0 | 2.048 | 63.0 | 6.3 | 130.0 | 13.0 |

TABLE VII.

| | | | | | | | | | | |
|------------------------------------|----|-------|-------|-------|-------|-------|------|-----|-------|------|
| Castrated and control males . . . | 64 | 2.259 | 379.0 | 123.0 | 256.0 | 2.003 | 61.0 | 6.1 | 128.0 | 12.8 |
| Spayed and control females | 52 | 2.291 | 373.0 | 127.0 | 246.0 | 2.045 | 62.0 | 6.2 | 126.0 | 12.6 |

TABLE VIII.

| | | | | | | | | | | |
|-------------------------------------|----|-------|-------|-------|-------|-------|------|-----|-------|------|
| Control males and females | 64 | 2.244 | 364.0 | 120.0 | 244.0 | 2.000 | 60.0 | 6.0 | 122.0 | 12.2 |
| Operated males and females | 52 | 2.309 | 392.0 | 131.0 | 261.0 | 2.048 | 64.0 | 6.4 | 128.0 | 12.8 |

TABLE IX.

| | | | | | | | | | | |
|------------------------------------|---|-------|-------|-------|-------|-------|------|-----|-------|------|
| Thyroidectomized males | 5 | 2.098 | 270.0 | 90.0 | 180.0 | 1.918 | 47.0 | 4.7 | 95.0 | 9.5 |
| Thyroidectomized females | 6 | 2.424 | 338.0 | 108.0 | 230.0 | 2.194 | 50.0 | 5.0 | 105.0 | 10.5 |

TABLE X.

| | | | | | | | | | | |
|--|----|-------|-------|-------|-------|-------|------|-----|-------|------|
| Normal males and females | 64 | 2.244 | 364.0 | 120.0 | 244.0 | 2.000 | 60.0 | 6.0 | 122.0 | 12.2 |
| Thyroidectomized males and females | 11 | 2.276 | 307.0 | 100.0 | 207.0 | 2.069 | 49.0 | 4.9 | 102.0 | 10.2 |

variation. As an explanation, however, it appears reasonable that it may have been due to a difference in the food supplied. The thyroidectomized animals and their controls constituted a series which were killed in the spring after having been fed through the winter for the most part on grain, while the sixty-four normal animals with which they are compared in table X were killed in the fall after having been fed through the summer on grass and vegetables.

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Joseph concludes that for practical purposes 10 per cent. of the body-weight of a rabbit should be allowed for the stomach and cecum contents. It will be noted that this percentage agrees with the corresponding percentages in this paper as seen in column II, tables V to X, when it is kept in mind that in the present case the contents of the whole gastro-intestinal tract are included.

According to tables I to IV, which I believe is the more logical grouping, the smaller animals show a larger weight per kilo of the gastro-intestinal contents and gastro-intestinal tract than larger animals, which is also in accord with Joseph's results.