

ON THE WEIGHT OF SOME OF THE DUCTLESS GLANDS OF THE NORWAY AND OF THE ALBINO RAT ACCORDING TO SEX AND VARIETY

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FIVE CHARTS

INTRODUCTION

In connection with another investigation, it was found that in the albino rat some of the ductless glands show a distinct sex difference in weight (Hatai '13): It was found later that a similar sex difference occurs in the Norway rat also. When, however, these two forms of rats are compared, the weights of the ductless glands are again in most instances characteristic for each form. In view of the fact that the albino rat is the domesticated variety of the Norway rat, the differences thus presented appear highly interesting and suggest a somewhat new line of investigation. It therefore seems worth while to note briefly the weight relations of these ductless glands in the two forms of rats, using the data which are available at the present moment.

The ductless glands with which we deal here are the suprarenals, hypophysis, thymus, thyroid, testes and ovaries. A part of the Norway records here used was obtained by Dr. C. M. Jackson while he was at the University of Missouri. He has kindly placed his entire data at my disposal and I take this opportunity to thank him for his courtesy in this matter. For the weights of the ductless glands in the albino rat, the reader is referred to my recent papers (Hatai '13, '14). The original individual data are deposited in The Wistar Institute of Anatomy in Philadelphia, where they may be consulted by anyone interested.

MATERIAL AND METHODS

1. *The suprarenal glands*

The weight relations between the body and the glands in both the Norway and albino rats are shown in table 1 and their graphic representation in chart 1.

a. *Albino rat.* As is shown in chart 1, for a given body weight the weight of the suprarenal glands of the male albino rat is less

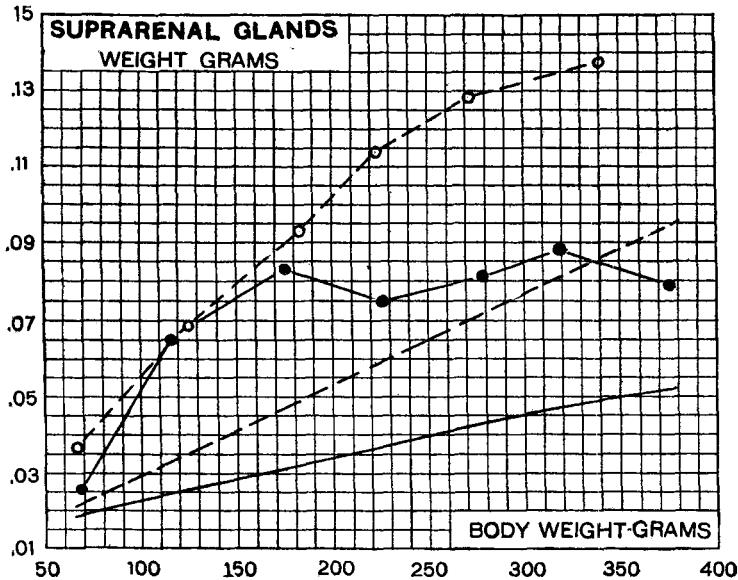


Chart 1 Showing the weight of the suprarenal glands in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat.

Males ● — ● Norway, observed ○ - - ○ Females
Males — Albino, calculated - - - Females

than that of the female. This sex difference becomes greater as the rat grows in weight. Furthermore, the difference appears at an early period of life; indeed it is already obvious at about 35 days of age, while sexual maturity is seldom attained in these rats before 60 to 90 days.

The sex difference in the weight of the suprarenals in the albino rat is thus not primarily connected with pregnancy in which con-

dition the female suprarenals are considered by some investigators (Biedl '13, and Vincent '12) to undergo hypertrophy.

b. Norway rat. As is shown in chart 1, the suprarenal glands of the Norway rat exhibit similar sex differences. Furthermore, the glands of the Norway rat are considerably heavier than those of the albino. We have not yet determined in the Norway rat the exact time of the appearance of the sex difference of this gland.

In table 1 we notice that the sex difference in the weight of the suprarenal glands is on the average 35 per cent in the Norway

TABLE 1

Showing the weights (grams) of the suprarenal glands in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat

SUPRARENAL GLANDS							
MALES				FEMALES			
Body weight	No.	Norway observed	Albino calc.	Albino calc.	Norway observed	No.	Body weight
69	1	0.026	0.018	0.021	0.037	4	67
117	4	0.065	0.025	0.035	0.069	3	126
175	5	0.083	0.031	0.049	0.093	6	183
226	17	0.075	0.037	0.059	0.109	15	224
278	15	0.081	0.042	0.070	0.128	10	272
319	10	0.088	0.047	0.086	0.137	5	340
375	1	0.079	0.052				
Avg. 223	53	0.071	0.036	0.053	0.096	43	202

and 47 per cent in the albino rat, both in favor of the females. However, owing to the deficiency of 21 grams in body weight of the female as compared with the male, some correction for the percentage differences just obtained, should be made.

By graphic interpolation from chart 1, we find that the weight of the female suprarenals in the Norway corresponding to 223 grams of body weight is nearly 0.109 gram. When this interpolated value for the female is compared with that observed for the male, we find a difference of 54 per cent in favor of the female rat. Similarly, we find a difference of 61 per cent in the albino rat in favor of the female.

TABLE 2

Showing the weights (grams) of the hypophysis in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat

HYPOPHYSIS							
MALES				FEMALES			
Body weight	No.	Norway observed	Albino calc.	Albino calc.	Norway observed	No.	Body weight
186	1	0.0065	0.0071	0.0123	0.0071	4	182
226	14	0.0071	0.0082	0.0157	0.0086	9	225
281	15	0.0085	0.0097	0.0195	0.0095	4	273
315	1	0.0100	0.0107				
Avg. 252	31	0.0080	0.0089	0.0158	0.0084	17	227

Concerning the differences between the Norway and albino rats in regard to the weight of the suprarenals, we find the following relations:

The suprarenals of the male Norway rat are heavier than those of the male albino rat by 97 per cent.

The suprarenals of the female Norway rat are heavier than those of the female albino rat by 80 per cent.

On the average, we obtain 89 per cent in favor of the Norway rat. We conclude therefore that the Norway rat, both sexes combined, possesses suprarenal glands which are nearly twice as heavy as those of its domesticated albino variety.

This difference in the weight of the suprarenals between the Norway rat and its albino variety has already been noted by Watson ('07) but he did not distinguish the sexes. Watson's observations were made on suprarenals which had been preserved in formalin.

The sex difference in the suprarenals is shown not only by their weight, but also often by their colors. For instance, in the albino rat the suprarenals of the male are a deep olive in color, while those of the female are much lighter. In the Norway rat, on the other hand, the color of the glands is ashy white in both sexes.

2. The hypophysis

The weight relation between the hypophysis and the body in both the Norway and albino rats is shown in table 2, and its graphic representation in chart 2.

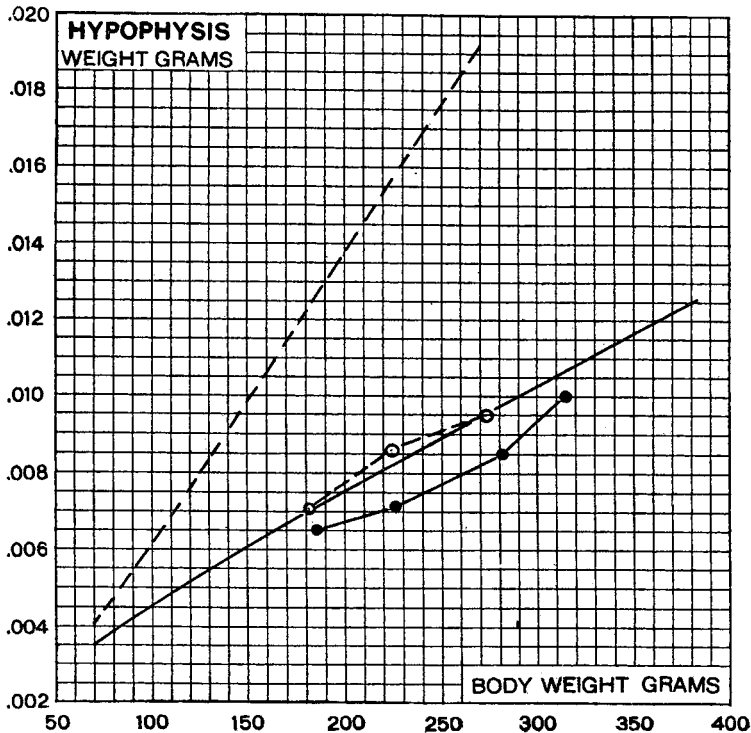


Chart 2 Showing the weight of the hypophysis in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat.

Males ● —● Norway, observed ○ --- ○ Females
Males ——— Albino, calculated - - - - Females

a. Albino rat. The sex difference in the weight of the hypophysis is more striking than in the case of the suprarenal glands, and indeed the difference, after a proper correction for the difference in body weight in the two sexes has been made, amounts to 97 per cent in favor of the female rat. The difference appears at about 30 to 40 days of age and thus is not primarily associated

with pregnancy in the female, during which condition the hypophysis is assumed to undergo hypertrophy.

b. Norway rat. Curiously, the sex difference in the weight of the hypophysis in the Norway rat is considerably smaller, and furthermore, the weight of the hypophysis in both sexes is smaller than in the corresponding albinos. The difference in the weight of the hypophysis in the Norway rat is found in the following way: From the graph for the female hypophysis in chart 2 we obtain a weight of about 0.0092 gram, corresponding to 252 grams of observed male body weight. When this value of the female hypophysis is contrasted with 0.008 gram for the observed male hypophysis (see table 2, average for male), the difference is 15 per cent in favor of the female rat.

Although the difference of 15 per cent is quite small when compared with that of 97 per cent, shown by the albino variety, nevertheless its reality is evident from the regularity and uniformity of the results shown in chart 2. It is interesting to note that the hypophysis of the Norway shows not only a small sex difference, but its absolute weight is considerably less than in the corresponding sexes of the albino rat. We obtain from table 2 the following relations:

The weight of the hypophysis of the male Norway is less than that of the male albino rat by 11 per cent.

The weight of the hypophysis of the female Norway is less than that of the female albino rat by 46 per cent.

We may note from the above relations that the smaller sex difference shown by the hypophysis in the Norway as contrasted with the albino, is especially due to the relatively smaller hypophysis of the Norway female. The sex difference is shown also in the general appearance of the hypophysis.

In both the Norway and albino rats the hypophysis of the female is much swollen, the upper surface is more convex and the color is a deeper pink than in that of the male. However, we do not find any characteristic appearance distinguishing this gland in the Norway from that in its albino variety.

3. *The thyroid gland*

The weight relation between the thyroid and the body is given in table 3, and its graphic representation in chart 3.

a. Albino rat. Unlike the suprarenals and hypophysis, the thyroid gland of the albino rat does not exhibit any difference distinguishing the sexes either in weight or in appearance. It must be admitted, however, that this failure to reveal a sex difference may be due either to its absence, or to the fact that the sex difference may be masked by the great variability of the thyroid. With our present data the variation in the weight of the thyroid in the albino rat according to sex is not ascertainable (Hatai '13).

TABLE 3

Showing the weights (grams) of the thyroid gland in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat

THYROID GLAND							
MALES				FEMALES			
Body weight	No.	Norway observed	Albino calc.	Albino calc.	Norway observed	No.	Body weight
69	1	0.015	0.014	0.015	0.014	3	73
117	4	0.022	0.021	0.022	0.025	2	122
174	4	0.029	0.029	0.030	0.034	6	183
226	17	0.033	0.035	0.035	0.028	15	224
278	15	0.031	0.042	0.041	0.042	10	272
319	10	0.050	0.046	0.049	0.078	3	342
375	1	0.046	0.053				
Avg. 223	52	0.032	0.034	0.032	0.037	39	203

b. Norway rat. In the Norway rat also the variation in the weight of the thyroid is considerable. Thus the slight excess shown in the weight of the female thyroid (table 3) is difficult to interpret. However, from the general trend of the graph, the difference here noted may be an incidental one. Further, it is an interesting fact that the weight of the Norway thyroid is practically identical with the weight of the albino thyroid.

Although I am unable to trace the authority for the statement, the thyroid gland in man is the only ductless gland which is

usually stated in the anatomical text books to exhibit a sex difference in weight. As we see, however, the thyroid gland of the rat not only fails to exhibit a sex difference, but fails also to respond to the changes of environment represented by domestication. If, therefore, our information concerning the human thyroid be correct, we have here an interesting difference in the comparative anatomy and physiology of this gland.

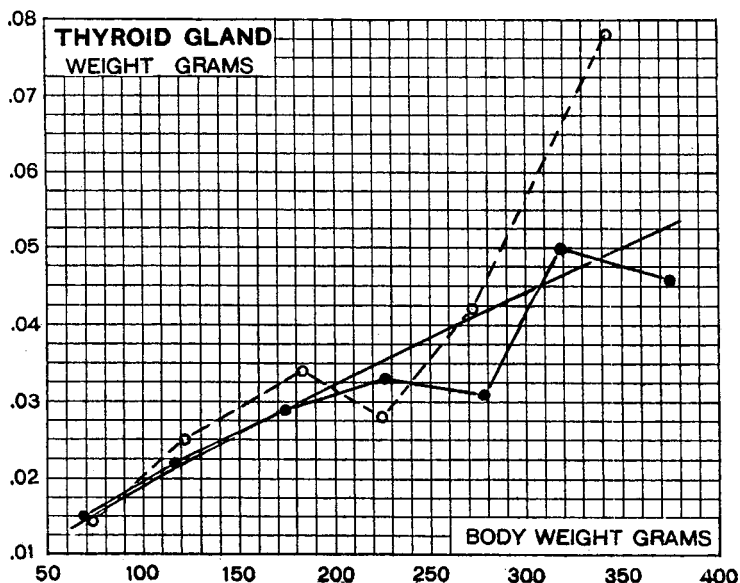


Chart 3 Showing the weight of the thyroid in the two sexes of the Norway compared with those in the albino rat.

Males ● — ● Norway, observed ○ --- ○ Females
Albino, calculated — Both sexes.

4. The thymus gland

The weight of the thymus gland is correlated with the age of the animal and is not evidently different according to sex (Hatai '14). Since our data for the Norway rat lack age records, no legitimate comparison between the Norway and albino thymus can be made. Consequently, the data on the weight of the thymus are excluded from the present paper.

5. The sex glands

The weight relation between the body and sex glands in both the Norway and albino rats is given in table 4, and its graphic representation in charts 4 and 5.

a. Testes of the Norway rat as compared with those of the albino rat.
The weight of the testes of the Norway rat is considerably greater

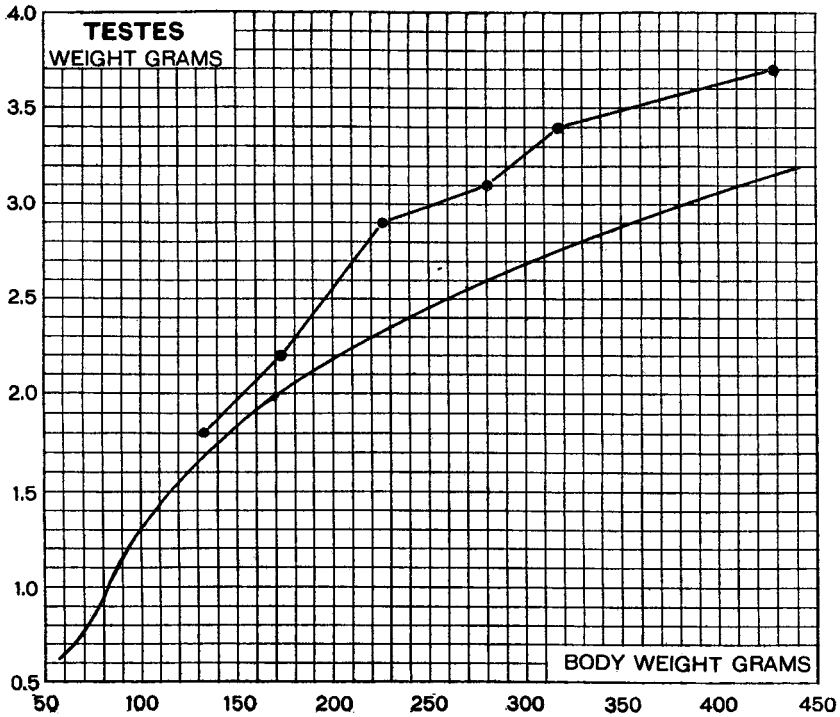


Chart 4 Showing the weight of the testes of the Norway rat compared with that of the albino rat.

Norway, observed ● — ● Albino, calculated —

for the same given body weight, than in the albino rat. The difference amounts to 21 per cent in favor of the Norway. I am unable to state at present whether this excess of 21 per cent is due to a uniform enlargement of all the structures of the testes, or whether it is due to the enlargement of some particular constituent. The histological investigation of this point will be of interest.

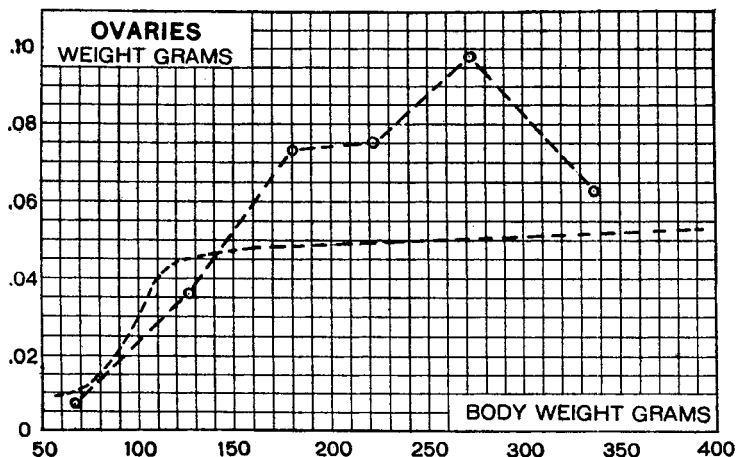


Chart 5 Showing the weight of the ovaries of the Norway compared with that of the albino rat.

Norway, observed ○ --- ○ Albino, calculated - - - -

b. Ovaries of the Norway rat as compared with those of the albino. For the same body weight, the ovaries in the Norway rat are considerably heavier than those in the albino. The difference amounts to 26 per cent in favor of the Norway. For the ovaries also we have no histological data as to the structures that are responsible for this excess in weight.

TABLE 4

Showing the weights (grams) of the sex glands—testes and ovaries—in the two sexes of the Norway compared with those in the corresponding sexes of the albino rat

SEX GLANDS							
MALES—TESTES				FEMALES—OVARIES			
Body weight	No.	Norway observed	Albino calc.	Albino calc.	Norway observed	No.	Body weight
				0.010	0.007	4	67
133	5	1.8	1.7	0.045	0.036	5	126
172	11	2.2	2.0	0.048	0.073	7	180
226	16	2.9	2.3	0.050	0.075	21	221
280	17	3.1	2.6	0.051	0.098	12	272
317	8	3.4	2.8	0.052	0.063	6	337
429	10	3.7	3.1				
Avg. 260	67	2.9	2.4	0.043	0.059	55	201

DISCUSSION

The preceding analysis shows that with the exception of the thyroid and the thymus, the weight of the ductless glands in the two forms of rats exhibits (1) a difference according to sex and (2) a difference according to zoological variety.

1. Difference according to sex

Although there are scattered statements concerning some of the ductless glands for man, I am not aware that the sex relations of these glands has been previously thus clearly shown. At the same time, even in recent studies of the glands, both in man and animals, the sexes are sometimes either combined or not given. Consequently, in the majority of cases, information with regard to the sex relations cannot be obtained. Whether or not the sex difference in these ductless glands is as marked in other animals as in the rat, remains to be determined.

Elliott and Tuckett's work ('06) suggests strongly the existence of a sex difference in the weight of the suprarenals in guinea-pigs, rabbits and cats. The amount of data given by these authors, however, is not sufficient for a critical test on this point. Recently Kolmer ('10) noted the structural difference in the suprarenals of guinea-pigs according to sex. It thus appears that so-called "hypertrophy of some of the ductless glands" in the females during pregnancy or during other special physiological conditions, must be received with reservation until data on the possible sex difference of the normal individuals have been obtained.

2. Difference according to zoological variety

This is another interesting relation quite worthy of further careful investigation. We have no data for animals other than rats showing the weight of the ductless glands in zoological varieties. Watson ('07) first noted that the suprarenals of the Norway rat are always heavier than those of the albino rat. The present investigation fully supports Watson's finding. Watson ('08) further noted that Norway rats under captivity lose in the

weight of the suprarenals as much as 28 per cent (computed from the absolute weight) within the first ten weeks. Unfortunately Watson did not record the sexes and consequently, since the weight of the adrenals show nearly 54 per cent normal difference according to sex, the reported reduction of 28 per cent cannot be accepted without reservation until it has been confirmed on rats of the same sex.

Elliott and Tuckett ('06) notice the weight variation in the suprarenals of different strains of guinea-pigs. It seems highly probable that investigations along this line might throw some light on the physiology of these interesting members of the endocrine system.

I shall not attempt at this time to interpret any of the differences observed according to either sex or variety; nevertheless, it may be stated in regard to the difference found between the two forms of rats that such differences have appeared to be the result of a response to the complex conditions represented by domestication. If it should appear that similar changes took place in other species under domestication, we would have an important instance of adaptation within the organism to the changes in the environment.

CONCLUSIONS

1. In both the Norway and albino rats the suprarenal glands of the males are considerably smaller than those of the females. When, however, these two forms of rats are compared, both sexes of the Norway rats have suprarenals considerably heavier than those of the like sexes of the albino.

2. A sex difference is noted in the weight of the hypophysis in both the Norway and albino rats. The male hypophysis is lighter than that of the female. However, when these two forms of rats are compared, the hypophysis of the Norway is found to be smaller than that of the albino rat; the greater difference being in the case of the female.

3. Neither in the Norway nor the albino rat is a sex difference found in the weight of the thyroid. Moreover, there is no weight

difference in the thyroid according to variety in these two forms of rats.

4. The sex glands (testes and ovaries), of the Norway rats, are heavier than those of the albino rats.

5. The differences found between the Norway and albino rats with respect to the weight of the ductless glands seem to be the result of a response to the complex conditions represented by domestication.

LITERATURE CITED

- BIEDL, A. 1913 *Innere Sekretion*. Second ed. Urban and Schwarzenberg, Berlin.
- ELLIOTT, T. R., and TUCKETT, I. 1906 Cortex and medulla in the suprarenal glands. *Jour. Physiol.*, vol. 34.
- HATAI, S. 1913 On the weight of the abdominal and thoracic viscera, the sex glands, ductless glands and eyeballs of the albino rat (*Mus norvegicus albinus*) according to body weight. *Am. Jour. Anat.*, vol. 15, no. 1.
- 1914 On the weight of the thymus gland of the albino rat (*Mus norvegicus albinus*) according to age. *Am. Jour. Anat.*, vol. 16, no. 2.
- 1915 The growth of organs in the albino rat as affected by gonadectomy. *Jour. Exp. Zool.*, vol. 18, no. 1.
- KOLMER, W. 1910 *Beziehungen von Nebennieren und Geschlechtsfunktion*. *Pflüger's Archiv f. d. ges. Physiol.*, Bd. 144.
- VINCENT, S. 1912 *Internal secretion and ductless glands*. Edward Arnold, London.
- WATSON, C. 1907 A note on the adrenal gland in the rat. *Jour. Physiol.*, vol. 35.
- 1908 The effect of captivity on the adrenal glands in wild rats. *Jour. Physiol.*, vol. 36.