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M. F. MILLER, *Director*

The Weight and Thyrotropic Hormone Content of the Anterior Pituitary of Swine

H. D. ELIJAH AND C. W. TURNER

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The Weight and Thyrotropic Hormone Content of the Anterior Pituitary of Swine

H. D. ELIJAH* AND C. W. TURNER

Endocrine research conducted during the past few years has demonstrated that the hormones of the anterior lobe of the pituitary and the thyroid glands play important roles in the growth of domestic animals and their subsequent rate of fattening. When the pituitary is removed, irrespective of the age of the animal, growth quickly stops indicating the primary role of this endocrine gland in growth. However, when the thyroid is removed, especially in young animals, the rate of growth gradually subsides. In older animals increased fattening may mask the reduced rate of skeletal growth.

Since economic meat production depends upon rapid growth and fattening of cattle, hogs and sheep, it is important to gain a clearer understanding of the role of the hormones of the pituitary and thyroid in these processes. Some animals have the inherited ability to make rapid and efficient gains in weight, whereas others gain very slowly. It is suggested that the differences in the efficiency of these animals represents differences in the rates of secretion of the essential hormones. The slow gaining, inefficient animal may have inherited endocrine glands which are secreting insufficient or unbalanced amounts of the hormones which promote rapid growth.

If this theory is correct, it is of great practical importance to determine which hormones influence growth either directly or indirectly so that methods may be devised, if possible, to supplement deficiencies or by selection, to breed for the particular factors which are of greatest importance.

As a starting point in such research, it is interesting to note the presence in the anterior pituitary of a hormone, thyrotropin, which stimulates the growth and secretion of the thyroid gland. Thus if the amount of thyrotropic hormone in the pituitary is low, the thyroid glands of the animal are small, and the amount of hormone, **thyroxine**, which they secrete would be low. In such animals the growth rate would be expected to be low because it has been shown that in the absence of the thyroid gland growth soon stops. As increasing amounts of thyroxine are given to such animals, the rate of growth gradually increases.

*Formerly Instructor in Animal Husbandry, University of Missouri.

If the rate of growth is dependent upon an optimum amount of thyroxine being secreted by the thyroid, and the rate of secretion of thyroxine in turn is dependent upon the amount of thyrotropic hormone secreted by the pituitary, then the amount of thyrotropic hormone in the pituitaries of animals should be high both during the period of rapid growth and in animals making the more rapid growth, and lower in slow growing animals and after growth has been completed and fattening is taking place.

Preliminary work on experimental animals had shown that there was increasing concentration of the thyrotropic hormone in the pituitary of rats (Turner and Cupps, 1939) and rabbits (Bergman and Turner, 1941) during the period of rapid growth and a decreased concentration as they reached mature body weight. Further, it was observed that the female rats which grow more slowly and reach a lighter mature body weight had pituitaries containing less thyrotropic hormone than males. In contrast, in the rabbit, the two sexes grow at about the same rate and reach the same mature body weight; here the thyrotropic hormones of the two sexes were very similar.

At the Missouri Agricultural Experiment Station, three strains of Poland China hogs are being raised as part of the work of the Regional Swine Breeding Laboratory. These strains differ in their rates of growth and fattening and therefore offered ideal animals to study further the possible relation of the thyrotropic hormone secretion to the rate of growth. The object of the present bulletin is to report on the pituitary size and thyrotropic hormone content of these swine grouped according to age, weight, sex, growth rate and strain.

Description of the Animals Studied

The pituitaries included in this study were secured from Black Poland China hogs. Strain or line 2 was considered to be somewhat chunky in type, very easy feeders, early maturing, rapid gaining, but lacking in prolificacy. Line 3 was rather upstanding, active, leggy, and more extreme in type, slower gaining, slower maturing, and more prolific than line 2. Line 1 was intermediate in type and in most characters between lines 2 and 3. The line 1 hogs were of very desirable market type, fairly early maturing, medium rapid gaining, and average in prolificacy and vigor. (Fig. 1-2).

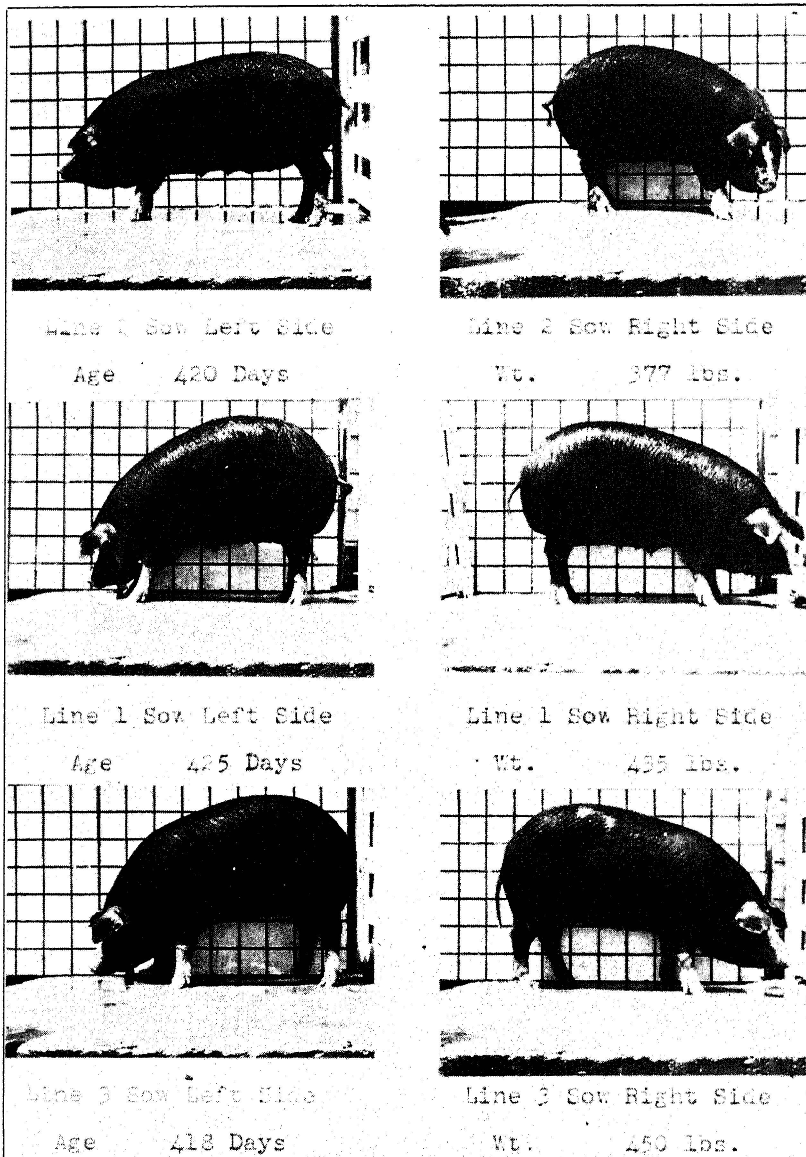

Fig. 1.—Two views of a representative sow of Lines 1, 2, and 3.

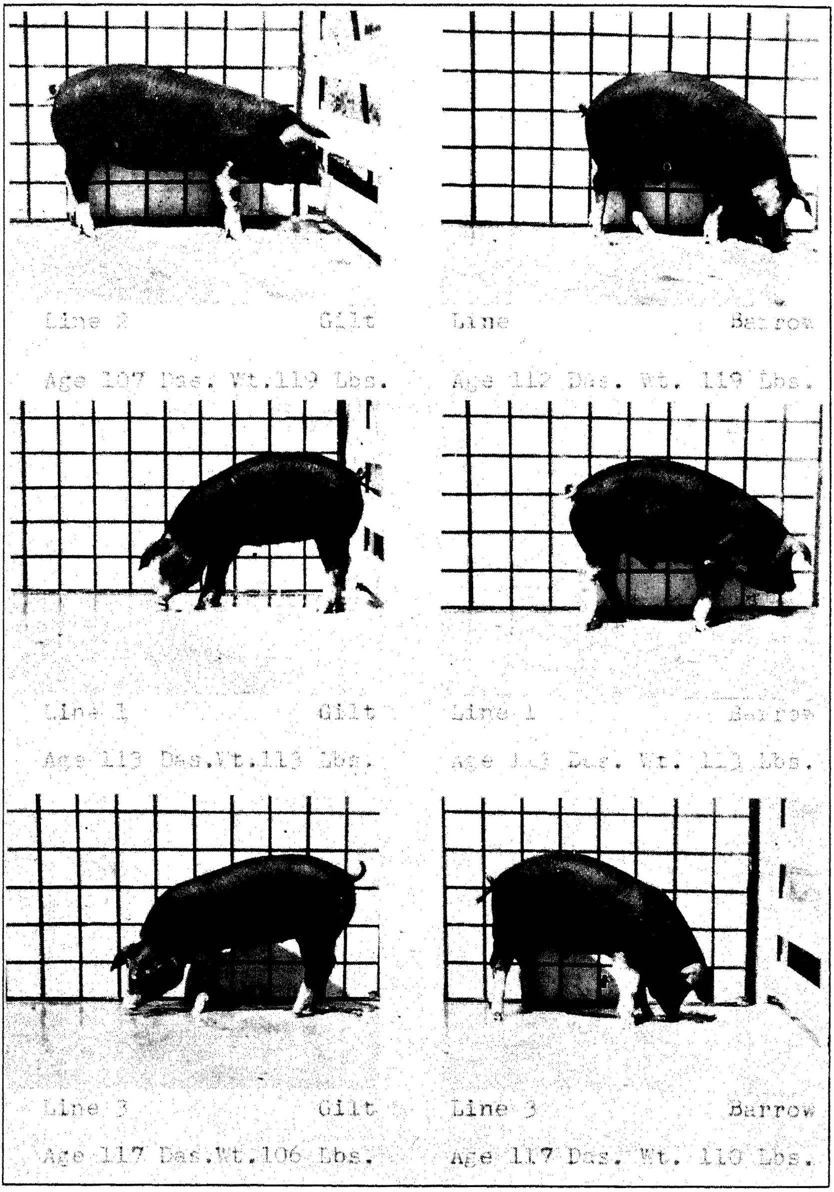

Fig. 2.—Showing the type and general conformation of representative Line 1, 2, and 3 hogs.

Collection of Swine Pituitaries

The pituitary glands from the animals described above were collected in a local slaughter house and at a large packing plant. Immediately following decapitation the top of the skull was sawed or cleaved open crosswise on a line ¼ to ½ inch behind the eyes. Upon removing the cerebrum, the optic chiasma was exposed.

The pituitary body of swine is located ventral to the brain in a depression in the base of the skull known as the sella turcica (Figs. 3-8). The sella turcica is situated in the sphenoid bone, in the mid line, about ½ inch from the posterior suture and immediately adjacent to the anterior suture. The pituitary body is oval in outline and flattened dorso-ventrally. The lobes vary considerably in size, weight, and shape. The anterior pituitary in a hog weighing 225 lbs. is approximately 11 mm. in length, 5 mm. in width, and 5 mm. in thickness (Fig. 4). The posterior lobe is approximately 12 mm. in length, 2 mm. in diameter at the stalk, and 1 mm. in diameter in the small region of the posterior lobe, to 4 mm. in diameter in the enlarged region of the posterior lobe. It is attached by a short, delicate tubular stalk (or infundibulum) to the tuber cinereum, situated between the optic chiasma in front and the pons behind. A fibrous capsule, derived from the dura mater, loosely encloses the pituitary. Cattle and horse pituitaries have a tough covering surrounding the gland except for an opening through which the stalk is attached to the tuber cinereum. The covering of the swine pituitary differs from that of the cattle and horse pituitary in that it merely lies underneath the pituitary and not completely around it. No cone of Wulzen was in evidence, as reported by Gilmore et al. (1941) and Lewis and Turner (1939), in many cattle pituitaries.

The swine pituitary is more or less suspended from the tuber cinereum by the cartilaginous diaphragm in the sella turcica. The swine pituitary is easily removed while the cattle pituitary must be carefully skinned or peeled out of the closely adhering cartilaginous membrane which is an extension of the dura mater.

The anterior lobe of the swine pituitary lies next to the cerebrum with the posterior lobe underneath as the mid-dorsal part of the gland (Figs. 10-11). The anterior end of the stalk is easily broken in dissecting the pituitary from the brain. The stalk is very short in the swine pituitary, the posterior lobe being attached almost directly to the brain.

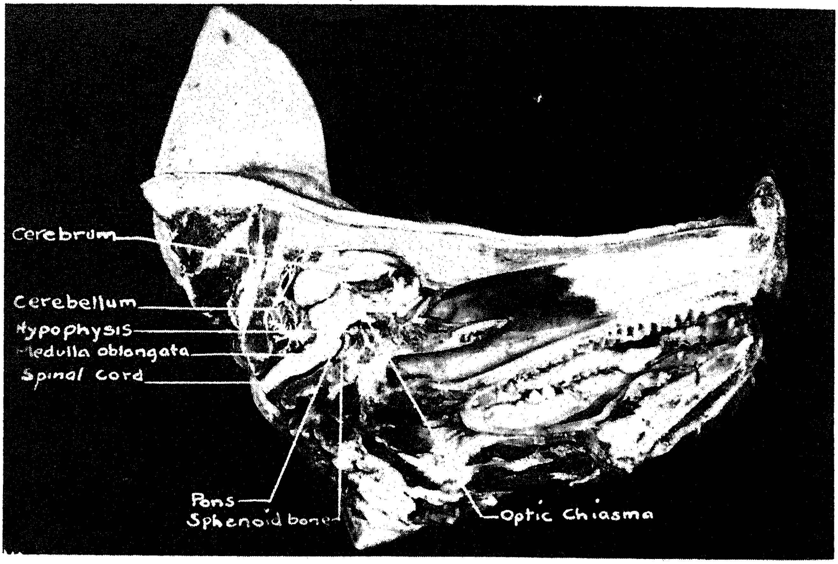

Fig. 3.—Median sagittal section of the head of a hog showing the position of the hypophysis or pituitary.

Fig. 4.—Enlarged view of Fig. 3 showing the brain and hypophysis or pituitary.

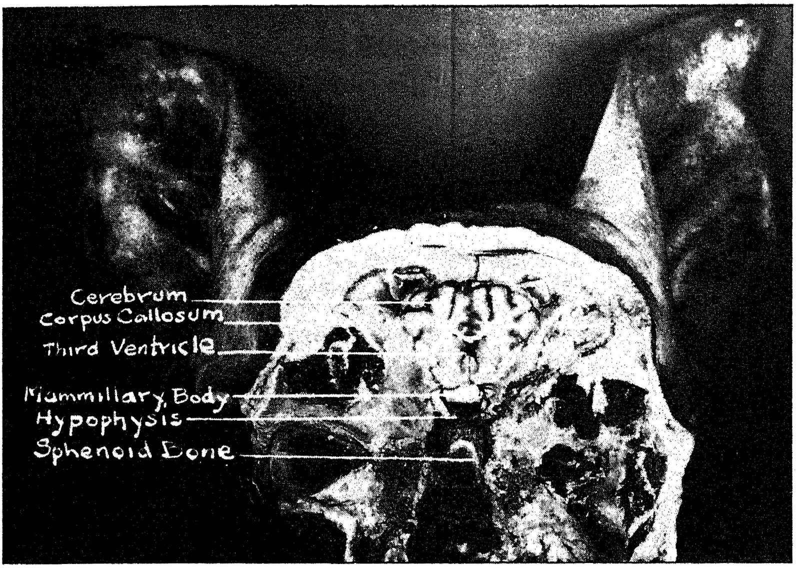

Fig. 5.—Transverse section of the head of a hog showing the position of the hypophysis or pituitary.

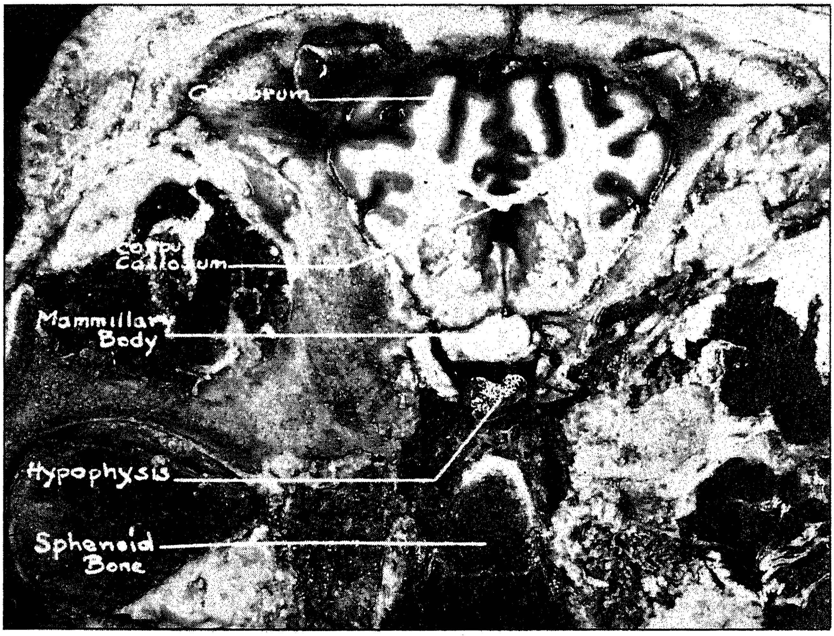

Fig. 6.—Enlarged view of Fig. 5 showing the brain and hypophysis.

Fig. 7.—Median sagittal section of the head of a hog with the brain removed (right view).

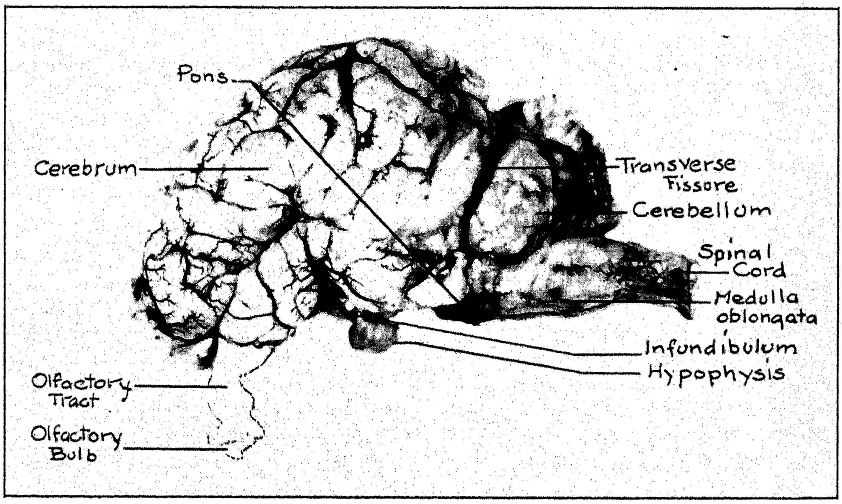

Fig. 8.—Brain of a hog hardened in 10% formalin. The hypophysis is shown attached to the brain by the infundibulum or stalk. (Left view).

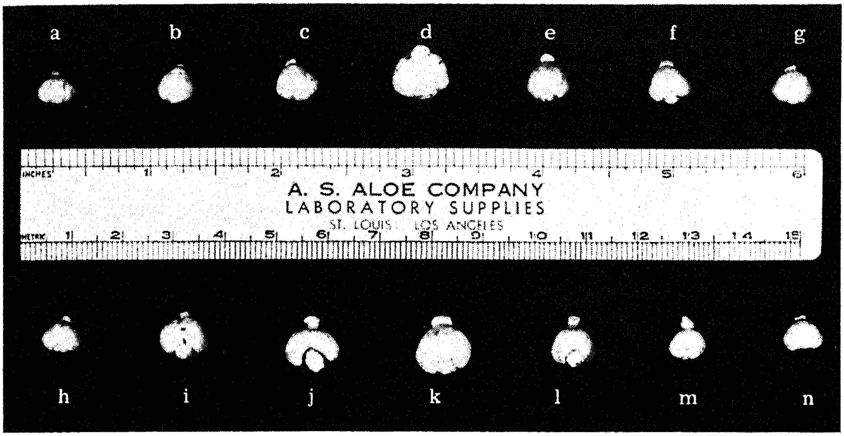

Fig. 9.—Showing variation in size and shape of swine pituitaries. Pituitaries a, g, h, m, and n were from hogs weighing about 175 pounds. Pituitaries b, c, e, f, i, j, and l are from 250-pound hogs. Pituitaries d and k are from 300-pound hogs.

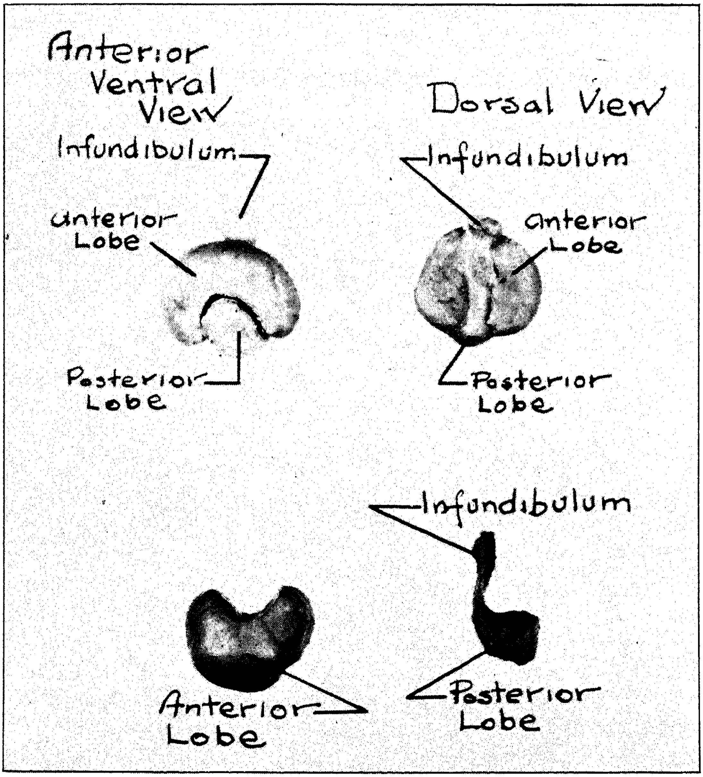

Fig. 10.—Views of hog pituitaries showing the gross relationship between the lobes.

Histology of the Swine Pituitary

Miller (1916) reported that the anterior and intermediate lobes were composed of two distinct cell types, the chromophobes and the chromophiles. While the chromophobes stain lightly by ordinary staining methods, the chromophiles stain deeply with acid stains. They form the greater part of the medulla of the anterior lobe. Because of varying degrees of activity they change greatly in appearance, although they are arranged in rather definite acini. The cortical portion of the anterior lobe and the intermediate lobe are continuous and are made up mostly of chromophobes, having no regular arrangement. Spindle-shaped supporting cells and colloidal vesicles also characterize the intermediate lobe. The pars nervosa or posterior lobe consisted mainly of tissue of fibroglia character with a small amount of white fibrous connective tissue.

Cleveland and Wolfe (1933), in reporting upon the cyclic histological variations in the anterior hypophysis, divided the anterior lobe into two lateral areas and a middle zone. In the anterior hypophysis three cell types were differentiated, two granular and one non-granular. The types were designated as type I, eosinophiles; type III or basophiles; and type IV or chromohobes. The anterior hypophysis of immature sows contained a high percentage of cells of type III, which are completely filled with granular material. The percentage of cells of type I was somewhat lower than was found in sexually mature animals.

In 1933 Nelson reported that the basophiles were first to arise from the chromophobic cells in the anterior lobe of the swine pituitary. They appeared in greatest numbers in the 70 to 100 mm. (crown-rump) embryo. This coincided with the stage at which Smith and Dortzbach (1929) first demonstrated the presence of growth-promoting hormone. Eosinophiles were present in the anterior lobe in numbers in the 160 to 170 mm. stage, which was approximately the same period in which Smith and Dortzbach obtained their initial positive responses for the gonad-stimulating hormone. Thus their work indicated a possible relationship between the basophiles and the growth-promoting hormone, and the eosinophiles and the gonad-stimulating principle.

Histological Technique

To show the gross relationship between the lobes, several pituitaries were fixed in Bouin's fluid immediately after collection, imbedded in paraffin, and stained with hematoxylin and eosin. The photographed sections (Figs. 11 and 12) show the intermediate, posterior, and anterior lobes. No cone of Wulzen was observed in these or in any of the swine pituitaries collected.

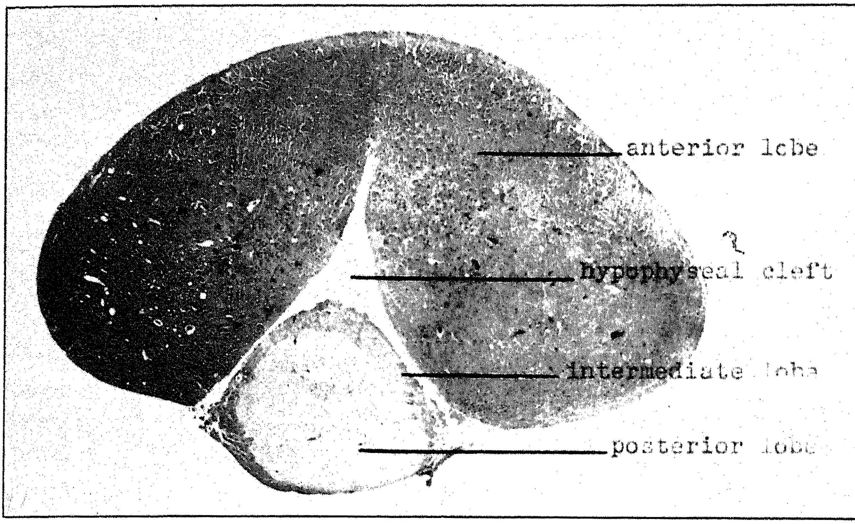

Fig. 11.—Vertical section through the pituitary of a 225-pound Poland China barrow showing the relative position of the lobes (x 11).

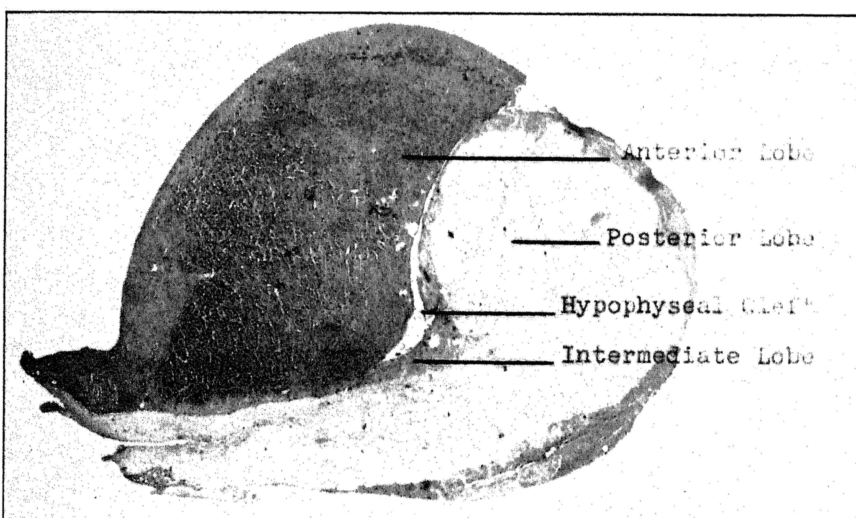

Fig. 12.—Median sagittal section through the pituitary of a 225-pound Poland China barrow showing the relative position of the lobes (x 11).

Laboratory Work Upon Swine Pituitary Glands

Within 24 hours after collection each pituitary was weighed on a chainomatic balance accurate to 0.1 mg. The posterior lobe was then separated from the anterior lobe and each lobe weight was recorded. The anterior lobes were again frozen until macerated. Each anterior lobe was macerated individually and suspended in distilled water. One ml. of water was added to 100 mgs. of tissue. The material was again frozen until assayed. Before injection another ml. of water was added to this stock solution. Therefore, 1 ml. of injected solution contained 50 mgs. of tissue. To provide sufficient material for an assay the groupings of pituitaries were made from hogs of similar sex, size, body weight, pituitary weight, strain, and other known data.

Assay Method

The details of the assay method of Bergman and Turner (1939), using day-old male White Leghorn chicks, were followed carefully. Each day-old male chick was injected subcutaneously daily for four days with 0.1 ml. of the solution, containing 5 mgs. of anterior pituitary material. Thus each chick received 0.4 ml. of a solution containing 20 mgs. of the anterior pituitary tissue. The baby chicks were weighed and sacrificed on the fifth day, their thyroids dissected with the aid of a binocular loupe, and immediately weighed on a balance accurate to 0.1 mg. Each chick was inspected at postmortem to assure that males only were used. The Bergman-Turner chick units of thyrotropic hormone were calculated for each group of pituitaries.

FACTORS AFFECTING PITUITARY SIZE

The collection of 192 swine pituitaries has provided considerable data on the total pituitary weight, anterior pituitary weight, and posterior pituitary weight in relation to age, weight, castration, and type in swine.

Influence of Age and Weight

The size and weight of the pituitary differ within the species, between individuals, and between individuals in different stages of development. The rather extensive work of Wittek (1913) with cattle showed an increase in pituitary weight with increasing body weight and age up to maximum, after which the pituitary weight and body weight both decreased. Reece and Turner (1937) compiled much of the available information on pituitary weights of different species. Lewis and Turner (1939) re-analyzed the Reece and Turner data to show the relation between pituitary weight and body weight. They concluded that pituitary size in proportion to body size decreases considerably as body weight increases. The recent studies of Gilmore, et al. (1941), Brody and Kibler (1941), Kibler, et al. (1942), and Mixner and Turner (1942) all indicate that the ratio of pituitary to body weight declines with increasing body weight during growth.

Experimental Results.—Pituitary weights of swine increase as the age and weight of the hog increases (Table 1). In the swine studied, the percentage of pituitary weight to total body weight is almost four times as great at birth as at 45 days. After the hogs weighed 27 pounds and were 45 days of age, the succeeding groups had a rather gradual decrease in the ratio of pituitary weight to body weight. The heaviest group studied, 751 pound hogs, had pituitaries that were 0.00025 per cent of their total body weight, while the 2.82 pound pigs at birth had pituitaries that were 0.00191 per cent of their body weight or 7.6 times as great as the larger hogs.

TABLE 1. A COMPARISON OF THE PITUITARY WEIGHTS IN SWINE BY AGE AND WEIGHT*

Number of Animals	Age days	Body Weight (lbs.)	Body Weight (gms.)	Pituitary Weight Total (mg.)	Pituitary Weight Anterior Lobe (mg.)	Pituitary Weight Posterior Lobe (mg.)	Pituitary Weight (gms.) / Body Weight (gms.) %
4	1	2.82	1,280	24.4	18.1	6.3	0.00191
6	45	27.00	12,247	61.8	39.2	22.6	0.00056
8	96	65.00	29,484	131.2	104.6	26.6	0.00044
8	108	74.00	33,566	135.1	99.2	35.9	0.00040
22	197	216.00	97,977	267.5	203.0	64.5	0.00027
25	248	245.00	111,132	413.0	286.0	127.0	0.00037
8	458	450.00	204,120	428.0	335.8	92.2	0.00021
4	520	530.00	240,408	651.6	539.6	112.0	0.00027
3	730**	751.00	340,653	864.5	708.2	156.3	0.00025

*This table includes Poland Chinas of both sexes and all types.
**Approximate age.

Influence of Sex

The limited work upon the effect of sex on pituitary size within different species of domestic and laboratory mammals would tend to leave some uncertainty. Wittek (1913) reported no difference in weight between the glands of male and female cattle until the age of 4 years. In cattle over 4 years of age the male glands were heavier. Reece and Turner (1937) found no constant difference in the weight of hypophyses from heifers and bulls, but glands from beef cows were 100 mgs. heavier on the average than glands from dairy cows.

Lewis and Turner (1939) used the proportion of pituitary weight to body weight in drawing their conclusions since the male usually weighs more than the female at the same age. They found the proportional pituitary weight of dairy bulls was the same as that of beef bulls under 500 pounds weight. Beef bull pituitaries were found to be heavier, proportionally, than those of beef heifers weighing 500 to 700 pounds live weight. They also found the bull proportional pituitary weight to be lower than the pregnant and nonpregnant dairy cow proportional pituitary weight. However, the bulls and dry dairy cows in the follicular stage of the estrus cycle had pituitaries that were about equal on a proportional body weight basis.

TABLE 2. A COMPARISON OF THE PROPORTIONAL WEIGHT INCREASE IN BODY AND PITUITARY FOR FEMALE SWINE

Number of Animals	Age days	Body Weight (lbs.)	Body Weight (gms.)	Pituitary Weight (mg.)	Proportion of Birth Weight to Developed Weight: Body	Pituitary
4	1	2.7	1,226	24.9	1: 1.0	1: 1.0
8	52	31.0	14,074	64.7	1: 11.5	1: 2.6
8	135	77.5	35,185	174.1	1: 28.7	1: 7.0
8	197	209.0	94,886	239.8	1: 77.4	1: 9.6
8	233	251.0	113,954	216.3	1: 93.0	1: 8.7
8	261	300.0	136,200	271.1	1:111.1	1:10.9
8	458	450.0	204,300	428.3	1:166.6	1:17.2
4	520	530.0	240,408	651.9	1:192.6	1:26.2
3	730*	751.0	340,950	864.5	1:278.1	1:34.7

*Approximate age.

Gilmore, et al. (1941) found 17 mature dairy cows to have proportionally heavier pituitaries than 4 mature dairy bulls.

Experimental Results.—In this study, gilts were found to have 28 per cent heavier pituitaries and 25 per cent heavier anterior lobes than the boar pig pituitaries (Table 3). The gilts had pitui-

TABLE 3. A COMPARISON OF THE PITUITARY WEIGHTS OF GILTS AND BOARS

Number of Animals	Sex	Age (days)	Body Weight (lbs.)	Body Weight (gms.)	Pituitary Weight (mgs.) Total	Anterior Lobe	Posterior Lobe	Pituitary Wt. Body Wt. (%)
8	Gilts	135	77.5	35,185	174.08	124.18	49.90	0.00049
4	Boars	107	74.5	33,823	135.10	99.20	35.90	0.00039
TABLE 4. A COMPARISON OF THE PITUITARY WEIGHTS OF BARROWS AND GILTS								
34	Barrows	193	224.0	101,696	271.00	204.00	67.00	0.00027
30	Gilts	230	247.0	112,138	298.00	219.00	79.00	0.00027
TABLE 5. A COMPARISON OF THE PITUITARY WEIGHTS OF SLOW AND RAPID GAINERS								
5	3 Boars 2 Gilts	108	27.6	12,530	61.82	29.56	22.38	0.00049
8	4 Boars 4 Gilts	107	74.5	33,823	135.10	99.20	35.90	0.00040

taries that were 0.00049 per cent of their total body weight as compared to 0.00039 per cent for the boar pigs.

Thus from these data it is concluded that in the hogs studied, gilts had heavier pituitaries than boar pigs of nearly the same age and weight. What was true on a pituitary weight basis was also true in regard to the ratio of pituitary weight to total body weight.

Influence of Castration

Wittek (1913) found an increase in pituitary size following castration in cattle when a comparison was made per unit weight of the dressed carcass. Reece and Turner (1937) found that 67 steers between the ages of 4 and 10 months had pituitaries that were 135 mgs. heavier, on the average, than pituitaries from 28 bulls of the same age. From 11 to 23 months of age the pituitary weights were nearly identical. Within the Hereford breed they found steer pituitaries to be slightly heavier than bull pituitaries. Lewis and Turner (1939) reported very little if any difference in the proportional pituitary weight due to castration in the male. The data obtained in this study would confirm the work of Reece and Turner (1937).

Experimental Results.—Thirty-four barrows had somewhat lighter weight pituitaries and anterior lobes than 30 gilts (Table 4). However, the barrows were somewhat lighter in body weight than the gilts. The ratios of body weight to pituitary weight in barrows and gilts were similar. Since gilts had heavier pituitary weights than boars of a comparable body weight, it was concluded that the pituitary weight of males was increased by castration. No castrate gilts were available in this study.

Comparing the Pituitary Weights of Slow and Rapid Gaining Pigs

Two small groups of similarly bred hogs were available whose gain in weight on the same feed and care had varied greatly. Group 1 was composed of 5 head, 3 boars and 2 gilts, that averaged 27.6 pounds at 108 days of age or a daily gain of 0.256 pounds, while group 2 contained 8 head, composed of 4 boars and 4 gilts, that weighed 74.5 pounds at 107 days or a daily gain of 0.696 pounds. The rapid gaining group had an average pituitary weight of 135.1 mgs. as compared to 61.82 mgs. for the slower gaining group (Table 5). The slow gaining group had pituitaries that were 0.00049 per cent of their body weight as compared to 0.00040 per cent for the rapid gaining group. The difference in the ratios of body weight to pituitary weight is due mainly to the very light body weight of the slow gaining group.

Influence of Type on Pituitary Weight

Very little data on the pituitary weights of domestic animals of various types are available. However, Reece and Turner (1937) found cows of beef type to have pituitaries weighing, on the average, 100 mgs. more than glands from dairy cows.

TABLE 6. A COMPARISON OF THE PITUITARY WEIGHTS OF GILTS AND BARROWS OF LINES 1, 2, AND 3

Number of Animals	Sex	Line	Age (days)	Body Weight (lbs.)	Body Weight (gms.)	Pituitary Weight (mgs.) Total	Anterior Lobe	Posterior Lobe	Pituitary Wt. Body Wt. (%)
4	Gilts	2	225	254	115,316	261.80	202.70	59.10	0.00023
8	Barrows	2	192	233	105,782	247.55	185.10	62.45	0.00024
8	Gilts	1	238	250	113,500	268.90	196.30	72.60	0.00024
8	Barrows	1	197	224	101,696	267.52	203.47	64.05	0.00026
4	Gilts	3	228	229	103,966	287.02	218.62	85.05	0.00028
8	Barrows	3	195	218	98,972	272.87	202.00	70.87	0.00028

The pituitary weights of hogs of three types previously discussed and illustrated in Figs. 1 and 2 are summarized in Table 6. Very little difference was noted between barrows and gilts of the same line. However, line 3 had somewhat heavier pituitaries, on a percentage of body weight basis, than line 1, and definitely heavier pituitaries on the same basis, than line 2. The fat content of the line 2 is higher than that of line 1 or line 3. This increases the body weight but not the muscular weight. Thus on the basis of the ratio of pituitary weight to lean meat weight, it would be expected that less difference between the lines would be shown.

FACTORS AFFECTING THE THYROTROPIC HORMONE CONTENT OF SWINE PITUITARIES

The Determined Thyrotropic Content in Anterior Pituitaries from Female Swine of Varying Ages

Anterior pituitaries from female swine weighing 31 pounds and 52 days of age contained 1.83 chick units per gland, or 44.05 units per gram of fresh anterior lobe tissue (Tables 7 and 8). As the female swine became older and heavier there is an increase in thyrotropic potency until the hogs weigh 251 pounds and are 233 days of age, at which time their anterior pituitaries contain 11.40 chick units per gland, or 74.45 chick units per gram of fresh anterior pituitary lobe tissue. Per unit weight of fresh anterior lobe tissue the pituitaries from the 251 pound females were 69 per cent more potent than those from the 31 pound females. After the

TABLE 7. A COMPARISON OF THE THYROTROPIC CONTENT OF THE ANTERIOR PITUITARY OF THE FEMALE SWINE ACCORDING TO AGE AND WEIGHT

Number of Animals	Age (days)	Body Weight (lbs.)	Body Weight (gms.)	Anterior Lobe Weight (gms.)	Chick Units per gm. Anterior Lobe	Chick Units per Anterior Lobe	Chick Units per 100 gms. Body Weight
8	52	31.0	14,062	41.56	44.05	1.83	0.0130
8	135	77.5	36,560	124.18	52.10	6.47	0.0177
8	197	209.0	94,802	182.65	56.35	10.29	0.0109
8	233	251.0	113,854	153.15	74.45	11.40	0.0100
8	261	300.0	136,080	220.00	70.25	15.46	0.0114
6	458	450.0	204,120	335.75	57.65	19.36	0.0095
4	436	520.0	235,872	539.60	33.50	18.09	0.0077

TABLE 8. ASSAY DATA FOR TABLE 7.

Number of Animals	Description	Body Weight (lbs.)	Number of Male Chicks Injected	Average Weight of Injected Chicks (gms.)	Average Weight of Injected Chick Thyroids* (mgs.)	Average Weight of Control Chick Thyroids (mgs.)	Thyroid Weight Difference (mgs.)	Chick Units in Amount Injected
8 Gilts	Nulliparae	31.0	20	52.3	5.25	3.51	1.74	0.88
8 Gilts	Nulliparae	77.5	14	53.6	5.61	3.74	1.87	1.04
8 Gilts	Nulliparae	209.0	46	54.6	6.55	4.05	2.50	1.13
8 Gilts	Nulliparae	251.0	54	50.8	7.45	4.05	3.40	1.49
8 Gilts	Nulliparae	300.0	26	55.1	6.43	3.64	2.79	1.41
6 Sows	Multiparae	450.0	25	52.4	5.86	3.51	2.35	1.15
4 Sows	Multiparae	530.0	26	53.3	5.13	3.91	1.22	0.67

* Each chick received 0.1 cc. of solution containing 5 mg. of pituitary daily for four days or a total of 20 mg.

female swine reached 300 pounds, the thyrotropic potency decreased somewhat, but much more in the 450 pound group and still more in the 520 pound group until they had only 76 per cent as much thyrotropic hormone per gram of fresh anterior pituitary tissue as the 31-pound pigs. Thus these data agree with the work of Turner and Cupps (1939) on rats, and with Bergman and Turner (1941) on rabbits in which they found a rise in the concentration of the thyrotropic factor during the period of rapid growth and a decline with old age and fattening. Therefore, it might appear that as the thyrotropic potency of the pituitary decreases, the rate of growth is reduced. Reece and Turner (1937) also found the thyrotropic concentration in the pituitary gland to increase in cattle until the animals were 4 to 10 months of age, after which it decreased.

On the basis of the units of thyrotropin per pituitary, it will be noted that there is a gradual increase in units with increasing pituitary weight. The units per 100 lbs. body weight was greater for the younger animals. In swine, however, it would seem that due to the great increase in weight from birth to maturity, the figure for the total content per gram of tissue is much more indicative of the relative thyrotropic hormone potency. However, it is true that the total hormone content may be a good indication of the output of the hormone from the pituitary at that time. High hormone content might indicate an inactive pituitary that was storing the hormone in its cells and not releasing it into the blood stream, while a low hormone content might indicate a pituitary that was actively secreting the hormone (Severinghaus, 1937). However, Reece and Turner (1937), Turner and Cupps (1939) and Bergman and Turner (1941) showed that a pituitary gland with a high thyrotropin content is usually present in animals that might be expected to be actively secreting and discharging large amounts of thyrotropin.

The Effect of Sex and Castration on the Thyrotropic Hormone Content of Swine Anterior Pituitaries

Reece and Turner (1937) found that pituitaries from bulls contained 115 per cent more thyrotropic hormone than glands from steers. Turner and Cupps (1940) presented data indicating that gonadectomy of both male and female rats produced a progressive decrease in the thyrotropin content of the pituitary up to 66 days. In this study the thyrotropin content of anterior pituitaries from 34 barrows (castrate males) averaging 224 pounds in weight and 193 days of age was compared with the thyrotropic hormone content of anterior lobes from 30 gilts (female) averaging 247 pounds in weight and 230 days in age (Tables 9 and 10). The gilts had 41 per cent

TABLE 9. A COMPARISON OF THE THYROTROPIC HORMONE CONTENT OF THE ANTERIOR PITUITARY OF BARROWS AND GILTS

Number of Animals	Sex	Age (days)	Body Weight (lbs.)	Average Daily Gain (lbs.)	Anterior Lobe Weight (mgs.)	Chick Units per gm. Anterior Lobe	Chick Units per Anterior Lobe	Chick Units per 100 lbs. Body Weight
34	Barrows	193	224	1.16	204.00	48.80	9.96	4.44
30	Gilts	230	247	1.07	219.00	69.15	15.14	6.13

TABLE 10. ASSAY DATA FOR TABLE

Number of Animals	Sex	Number of Male Chicks Injected	Average Weight of Chicks (gms.)	Ave. Wt. of Injected Chick Thyroids* (mgs.)	Ave. Wt. of Control Chick Thyroids (mgs.)	Thyroid Weight Difference (mgs.)	Chick Unit in Amount Injected
34	Barrows	38	53.25	5.46	3.68	1.78	0.98
30	Gilts	42	53.64	6.38	3.56	2.82	1.38

* Each chick received 0.1 cc. of solution containing 5 mg. of pituitary daily for four days, or a total of 20 mg.

more thyrotropic hormone per gram of fresh anterior pituitary tissue than the barrows. The gilts used in this comparison were somewhat older and heavier than the barrows and would have, according to Table 7, somewhat more thyrotropic hormone than they would have had at the same weight and age as the barrows. However, the great difference in concentration must be in a great part due to sex and castration and not to increased weight and age.

On the basis of the thyrotropin per gram of fresh anterior pituitary tissue, boars had 2.5 per cent more potent anterior lobes than gilts (Tables 11 and 12). Thus this work would indicate that pituitaries of boars and gilts at this stage of development have little difference in thyrotropic potency, while gilts have more potent lobes than barrows. The 74.5 pound boars had lobes more potent in thyrotropic hormone than the larger 224 pound barrows. Had boars been available that weighed near 224 pounds it might be expected that the difference in potency between barrows and boars would have been even greater. This would be true if the greater thyrotropic potency in the anterior lobes of boars came at or near the same time as in gilts, or near 250 pounds.

TABLE 11. A COMPARISON OF THE THYROTROPIC HORMONE CONTENT OF THE ANTERIOR PITUITARY OF GILTS AND BOARS

Number of Animals	Sex	Age (days)	Body Weight (lbs.)	Average Daily Gain (lbs.)	Anterior Lobe Weight (mgs.)	Chick Units per gm. Anterior Lobe	Chick Units per Anterior Lobe	Chick Units per 100 lbs. Body Weight
8	Gilts	135	77.5	0.574	124.18	52.10	6.47	8.35
4	Boars	107	74.5	0.696	99.2	53.40	5.30	7.11

TABLE 12. ASSAY DATA FOR TABLE

Number of Animals	Sex	Number of Male Chicks Injected	Average Weight of Chicks (gms.)	Ave. Wt. of Injected Chick Thyroids* (mgs.)	Ave. Wt. of Control Chick Thyroids (mgs.)	Thyroid Weight Difference (mgs.)	Chick Units in Amount Injected
8	Gilts	16	55.13	5.61	3.745	1.865	1.04
4	Boars	15	53.63	5.67	3.745	1.925	1.07

* Each chick received - .1 cc. of solution containing 5 mg. of pituitary daily for four days, or a total of 20 mg.

The Determined Thyrotropin Content in Anterior Pituitaries from Slow and Rapid Gaining Swine

Since investigators vary in their opinion concerning the role of the thyrotropic hormone in growth, the authors were interested to see if any difference existed in the thyrotropic hormone potency of anterior pituitaries from slow and rapid gaining swine. Five pigs, 3 boars and 2 gilts, averaging 27.6 pounds at 108 days of age, were used as the slow-gaining group. Eight pigs, 4 boars and 4 gilts, averaging 74.5 pounds at 107 days of age, were included in the more rapid gaining group (Tables 13 and 14). Both groups were purebred Poland Chinas that had like care, rations, and management. In the slow gaining group were 2 pigs that were litter mates to 3 pigs in the rapid gaining groups. The more rapid gaining lot had anterior pituitaries containing 27 per cent more thyrotropic hormone per gram of fresh anterior pituitary than the slow gaining lot. The difference was much greater in chick units per anterior lobe, the slow gaining lot having 1.66 chick units as compared to 5.30 chick units in the rapid gaining lot. This difference was exemplified by the increased weight of the anterior lobe in the rapid gaining lot, 99.2 mgs. as compared to 39.56 mgs in the slow gaining lot.

TABLE 13. A COMPARISON OF THE THYROTROPIC HORMONE CONTENT OF THE ANTERIOR PITUITARY OF SLOW AND RAPID GAINERS*

Number of Animals	Sex	Age (days)	Body Weight (lbs.)	Average Daily Gain (lbs.)	Anterior Lobe Weight (mgs.)	Chick Units per gm. Anterior Lobe	Chick Units per Anterior Lobe	Chick Units Per 100 lbs. Body Weight
5	3 Boars 2 Gilts	108	27.6	0.256	39.56	41.90	1.66	6.01
8	4 Boars 4 Gilts	107	74.5	0.696	99.20	53.45	5.30	7.12

* The hogs used in this comparison were bred, fed, and managed alike.

TABLE 14. ASSAY DATA FOR TABLE

Number of Animals	Sex	Number of Male Chicks Injected	Average Weight of Chicks (gms.)	Ave. Wt. of Injected Chick Thyroids* (mgs.)	Ave. Wt. of Control Chick Thyroids (mgs.)	Thyroid Weight Difference (mgs.)	Chick Units in Amount Injected
5	3 Boars 2 Gilts	20	52.25	5.15	3.64	1.51	0.84
8	4 Boars 4 Gilts	18	53.63	5.67	3.64	2.03	1.07

* Each chick received 0.1 cc. of solution containing 5 mg. of pituitary daily for four days, or a total of 20 mg.

The Determined Thyrotropic Content in Anterior Pituitaries from Gilts and Barrows of Different Types

Since the swine used in this study were of three distinct types: somewhat chunky (line 2), intermediate (line 1), and somewhat rangy and leggy (line 3), it was of interest to study the possible differences that might exist in the thyrotropic concentration in the anterior lobes among the different lines. Representative gilts and barrows of each type are shown in Fig. 2 and representative sows in Fig. 1. In each line the gilts had more potent anterior lobes than the barrows (Tables 15 and 16). The gilts and barrows in line 2 had respectively 1.8 per cent and 24 per cent more of the thyrotropic hormone per gram of fresh anterior lobe than the gilts and barrows of line 1. Likewise, line 1 gilts and barrows had 30 per cent and 27 per cent, respectively, more potent anterior lobes than line 3 gilts and barrows. Thus there was a definite positive correlation between the rapidity of growth in the lines and the thyrotropic hormone content. The more rapid gaining line 2 had more potent anterior lobes than the intermediate line 1 and the line 1 had more potent anterior lobes than the longer and taller, more slowly maturing line 3. However, the gilts had pituitaries containing more thyrotropic hormone than the barrows even though the barrows in each line were more rapid gainers than the gilts. This might partially be explained by the fact that gilts are somewhat earlier maturing than barrows.

TABLE 15. A COMPARISON OF THE THYROTROPIC HORMONE CONTENT OF THE ANTERIOR PITUITARY OF GILTS AND BARROWS OF LINES 1, 2, and 3

Number of Animals	Sex	Line	Age (days)	Body Weight (lbs.)	Average Daily Gain (lbs.)	Anterior Lobe Weight (mgs.)	Chick Units per gm. Anterior Lobe	Chick Units per Anterior Lobe	Chick Units per 100 lbs. Body Weight
4	Gilts	2	225	254	1.129	202.7	74.10	150.20	5.91
8	Barrows	2	192	233	1.213	185.1	55.50	102.73	4.41
8	Gilts	1	238	250	1.050	196.3	72.80	142.81	5.71
8	Barrows	1	197	224	1.136	203.47	44.80	91.15	4.07
4	Gilts	3	228	229	1.004	218.62	56.05	122.54	5.35
8	Barrows	3	195	218	1.117	202.0	35.25	61.11	2.80

TABLE 16. ASSAY DATA FOR TABLE

Number of Animals	Sex	Line	Number of Male Chicks Injected	Average Weight of Chicks (gms.)	Ave. Wt. of Injected Chick Thyroids* (mgs.)	Ave. Wt. of Control Chick Thyroids (mgs.)	Thyroid Weight Difference (mgs.)	Chick Units In Amount Injected
4	Gilts	2	18	51.63	6.600	3.640	2.96	1.48
8	Barrows	2	22	55.10	5.763	3.710	2.053	1.11
8	Gilts	1	40	51.61	6.545	3.640	2.905	1.46
8	Barrows	1	19	53.16	5.280	3.710	1.57	0.90
4	Gilts	3	21	54.63	5.790	3.640	2.15	1.12
8	Barrows	3	20	51.65	4.85	3.710	1.14	0.71

* Each chick received 0.1 cc. of solution containing 5 mg. of pituitary daily for four days, or a total of 20 mg.

The present work, indicating a relation between the thyrotropic hormone content of the pituitary (and presumably indicating a variation in the thyroxine secretion of the thyroid gland) and swine type, is of considerable scientific as well as practical interest. It may indicate one major cause of difference in live stock type as well as offering a scientific explanation for the differences in the rapidity of growth of farm animals. The line 2 hogs are the easier feeders, earlier maturers, and most rapid gainers up to a certain point. However, the line 3 hogs will make larger mature animals as shown in Fig. 1, where 3 representative sows are pictured. The line 2 sow was the lightest and the line 3 sow was the tallest, longest and heaviest of the group. Thus line 3 while being slower gainers and later maturing, will eventually make heavier, larger mature animals.

DISCUSSION

With the discovery of the pituitary thyrotropic hormone controlling, in part, the activity of the thyroid gland and thus indirectly the secretion of thyroxine, a marked advancement was made. The thyroid was observed to atrophy following hypophysectomy. Extracts of crude anterior pituitary tissue restored the normal thyroid cytology, and stimulated an increase in size and degree of activity. The development of an assay method for the thyrotropic hormone has made possible the purification of extracts containing the principle, and a study of factors influencing the thyrotropic hormone content of the pituitary.

The role of the thyrotropic hormone in growth is still under discussion. Since Horsley (1886) showed that hypophysectomized dogs would live, many workers have hypophysectomized young growing mammals and noted that growth ceased or the growth rate was greatly retarded, and that the metabolic rate was reduced. Hypophysectomized mammals likewise showed regression of the gonads and thyroids. Hammett (1923), Simpson (1924), Binswanger (1936), Todd et al. (1938), Salmon (1938), Reineke and Turner (1941) as well as many other workers have shown that thyroidectomy of young mammals reduced their body growth. If thyroid extracts were administered in correct amounts to thyroidectomized mammals, growth was increased to normal, while excessive amounts resulted in growth retardation (Hammett, 1924). Likewise, the administration of anterior pituitary extracts to mammals hypophysectomized while young, increased their growth, the amount of increase depending upon the dosage. Thus the pituitary and thyroids are essential to normal growth and development in young mammals.

The function of the hormone of the thyroid gland, thyroxine, is generally considered to be concerned with the regulation of general metabolism. When thyroid activity is low, body metabolism is low and a tendency to fatten results. An over-active thyroid results in increased oxidation in the body cells, increased heart beat, and a thin condition of the body due to the catabolic processes predominating over the anabolic processes.

Just how thyroxine may influence growth is still undecided. However, Althausen (1940) showed that thyroxine administration accelerated the intestional absorption of dextrose, while thyroidectomy slowed down the absorption rate. Thus the thyrotropic hormone may influence growth by stimulating the thyroid to secrete thyroxine, which speeds up absorption. It is also possible that the pituitary may be stimulated by thyroxine to a greater secretion of all its hormones, resulting in a more efficient utilization of food necessary for growth. Likewise, the increased heart rate due to thyroxine administration indicates that blood flows through the circulatory system at an accelerated rate. This would tend to speed up the body processes, resulting in more rapid growth if the amount injected is not so great that catabolism predominates over anabolism.

With these thoughts in mind, the authors have studied the thyrotropic content of swine anterior pituitaries grouped according to age, weight, sex, type, and gaining ability. The results of this study agree with those reported by Turner and Cupps (1939) in rats and Bergman and Turner (1941) in rabbits, in that the thyrotropic concentration in swine is greatest during the period of rapid growth and is lower before and after this period. Likewise, the pituitaries of more rapid gaining swine had a greater thyrotropic hormone potency than those of slower gaining swine. Castration of the male reduced the thyrotropic potency of their anterior pituitaries. Since the swine studied had more thyrotropic hormone in their anterior pituitaries during the period of rapid growth, and the rapid growing swine had more thyrotropic than the slower gainers, it might be assumed that one of the reasons for rapid growth in certain strains of swine is the secretion by their pituitaries of greater amounts of thyrotropic hormone than is secreted by the pituitaries of the slower gaining animals. These observations are further substantiated by the report of Koger, Hurst and Turner (1942) showing that thyroxine-injected mice repeatedly gained an average of 28 per cent more weight during a period of 5 weeks than did the controls.

SUMMARY AND CONCLUSIONS

A study of the anatomy of the swine pituitary, and its change in weight with age and body weight, with sex, strain, rate of growth, and castration, is reported. Included in the study were the pituitaries of 102 female and 90 male swine.

At birth, hogs have pituitaries weighing approximately 25 mgs., at 6 months 250 mgs., and at maturity 800 mgs. It was observed that the ratio of pituitary weight to body weight decreases with increasing body weight. Up until about 65 pounds body weight this decrease is rather rapid, after which the rate of decrease slows down.

In the hogs studied, gilts had heavier pituitaries than boar pigs, both on an absolute pituitary weight and ratio of pituitary weight to body weight basis. Gilts and barrows of the same age and weight had pituitaries of almost equal weight.

The longer, rangier type of hogs had heavier pituitaries, on the basis of the ratio of pituitary weight to body weight, than the shorter, thicker type hogs. However, the weight of pituitaries from hogs of the same sex, age, and body weight may vary greatly.

The thyrotropic hormone content of the anterior pituitaries of swine was determined according to age, weight, sex, strain, rate of growth, and castration. Weight increase in the thyroid of male baby chicks was used as the method of assay (Bergman-Turner method).

At 31 pounds (52 days of age) female swine had 44 chick units of thyrotropic hormone per gram of fresh anterior pituitary tissue, at 209 pounds (197 days of age) 56 chick units, at 300 pounds (261 days of age) 70 chick units, at 450 pounds (458 days of age) 57 chick units, and at 520 pounds (436 days of age) 33 chick units per gram of fresh anterior pituitary tissue.

Boar pigs and comparable gilts had about the same number of chick units of thyrotropic hormone per gram of anterior pituitary tissue. In every group studied gilts had more potent anterior lobes than barrows. Thus castration seemed to reduce the thyrotropic potency in the male anterior pituitary gland.

These data indicate that during the period of rapid growth in swine there is a definite rise in the concentration of the thyrotropic factor in the anterior pituitary. As the growth rate slowed down the thyrotropic potency decreased. Rapid gaining pigs of the same age, breeding, and environment as slow gaining pigs had anterior lobes containing 27 per cent more chick units of thyrotropic hormone per gram of fresh anterior pituitary tissue than the slow gaining group. Short, thick, rapid gaining swine had more chick units per gram of anterior lobe than the longer, rangier, slower gaining type of swine.

These data show a positive correlation between rapid growth and high thyrotropic hormone concentration in the anterior pituitary gland.

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