

SEPTEMBER, 1942

RESEARCH BULLETIN 349

UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

M. F. Miller, Director

GROWTH AND DEVELOPMENT

With Special Reference to Domestic Animals

LIV. Age Changes in Size, Energy Metabolism and Cardio-Respiratory Activities of Thyroidectomized Cattle

SAMUEL BRODY AND R. F. FRANKENBACH

(Publication Authorized August 31, 1942)



COLUMBIA, MISSOURI

FOREWORD

The special investigation on growth and development is a cooperative enterprise in which the departments of Animal Husbandry, Dairy Husbandry, Agricultural Chemistry, and Poultry Husbandry have each contributed a substantial part. The parts for the investigation in the beginning were inaugurated by a committee including A. C. Ragsdale, E. A. Trowbridge, H. L. Kempster, A. G. Hogan, and F. B. Mumford. Samuel Brody served as Chairman of this committee and has been chiefly responsible for the execution of the plans, interpretation of results and the preparation of the publications resulting from this enterprise.

M. F. MILLER

Director Agricultural Experiment Station

ABSTRACT AND SUMMARY

A comparison is presented of the relative growth and development, metabolism and cardio-respiratory activities, general appearance and behavior of a thyroidectomized Jersey heifer with that of a normal Jersey heifer.

At age 40 months, the thyroidectomized animal was about half normal weight, metabolism per unit surface area about 40% below normal, completely undeveloped sexually. Feeding iodized milk protein ("thyrolactin") following age 40 months, stimulated growth and sexual development.

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INTRODUCTION

It is generally known that the thyroids have an important function in life processes. Thus thyroid removal prevents tadpoles from changing into frogs¹ and prevents pre-adolescent mammals from developing into normal sexed animals, indeed arrests their development almost completely.² Thyroid removal depresses egg production in chickens³ and milk production in cows.⁴ Thyroidectomy depresses heat production (metabolism) by about 40%;⁵ the metabolic rate is, therefore, employed as a diagnostic index of the level of thyroid activity.⁶

Relatively normal animals may be slightly hyper- or hypo-thyroid. If hypo-thyroid, thyroid administration in very small doses increases the rates of growth,⁷ milk production,⁸ and other processes.

It is evident that thyroid administration can accelerate a productive process in an animal only when the degree of hypo-thyroidism is sufficient to become a limiting factor in the process. If the level of thyroid activity is not the limiting factor, thyroid administration may depress the rate of the process by undue acceleration of catabolic processes at the expense of the anabolic processes, or at any rate, decrease the efficiency of the process by increased maintenance cost.

¹Allen, B. M., *Science*, 44, 755, 1916.

²See, for example, Simpson, S., *Quart. J. Exp. Physiol.* 6, 119, 1913, and 14, 161 and 185, 1924; also *Am. J. Physiol.* 80, 735, 1927.

³Winchester, C. F., *Mo. Agric. Exp. Sta. Res. Bul.* 315, 1940.

⁴Graham, W. R., Jr., *J. Nut.* 7, 407, 1934.

⁵Magnus-Levy, A., *Berlin. Klin. Wochensch.* 32, 650, 1895.

⁶Du Bois, E. G., *Basal Metabolism in Health and Disease*. Philadelphia, 1927.

⁷See, for example, Robertson, T. B., *Austral. J. Exp. Biol. & Med.* 5, 69, 1928. Wilkins, L. et al., *J. Clin. Endocrinol.* 1, 3 and 518, 1941; also *J. Am. Med. Assn.*, 114, 2382, 1940. Koger, M., Hurst, V., and Turner, C. W., *Endocrinology*, 31, 237, 1942.

⁸Graham, W. R., Jr., *Bioc. J.* 28, 1368, 1934. Herman, H. A., Graham, W. R., Jr., and Turner, C. W., *Missouri Agric. Exp. Sta. Res. Bul.* 275, 1938. Ralston, N. P., et al., *Id. Res. Bul.* 317, 1940.

Since thyroid activity is measured by the metabolic rate (oxygen-consumption rate) one wonders whether it may not be possible to diagnose the state of thyroid function of cattle when they are still young, by measuring the metabolism of calves; thus predicting future performance is so far as the thyroid function affects it.

Such prediction of future lactational performance of calves would have to be based on the correlation of metabolic rate in calves with later lactational performance, a rather tedious research. As a preliminary approach to such a research, observations were made on the effect of thyroid removal on the behavior of cattle, especially on metabolic rate. The purpose of this bulletin is to report the results.

RESULTS

Survival.—Of six Jersey calves thyroidectomized at various ages, only the one thyroidectomized at the latest age, 54 days (Jersey T5, born July 28, 1938, thyroidectomized September 19, 1938), survived and is the subject of this report. The other five, thyroidectomized earlier, died at ages ranging from three weeks to five months following thyroidectomy. They shed much of their hair and in some cases shed patches of hide. The immediate causes of death were colds, pneumonia, and bloat.

Growth in Body Weight.—The photograph, Fig. 1, of the thyroidectomized heifer (taken along side the normal control) at age 40 months, shows in a general way how thyroidectomy retards growth and development. The timing of the growth retardation is shown in Fig. 2. The growth rate began to decline following the first month after thyroidectomy. Between ages 8 and 18 months the weight gains were 100 pounds for the thyroidectomized animal and 250 pounds for the control. Practically no weight gain was made between 18 and 40 months in the thyroidectomized animal, whereas the control increased from 700 pounds at 18 months to over 1000 pounds at 40 months.

It appears that under the given condition thyroidectomy reduces mature body weight by over 50%.

General Appearance.—The general appearance of the thyroidectomized animals at age 40 months, shown in Fig. 1, may be supplemented with the following notes: weight, 480 pounds (contrasted to the normal Jersey of 1100 pounds); height at withers, 41.6 inches (contrasted to that of the normal, 50 inches); heart girth, 55.1 inches (contrasted to 62 inches in the normal); width of hips, 14.4 inches (contrasted to 20.4 inches in the

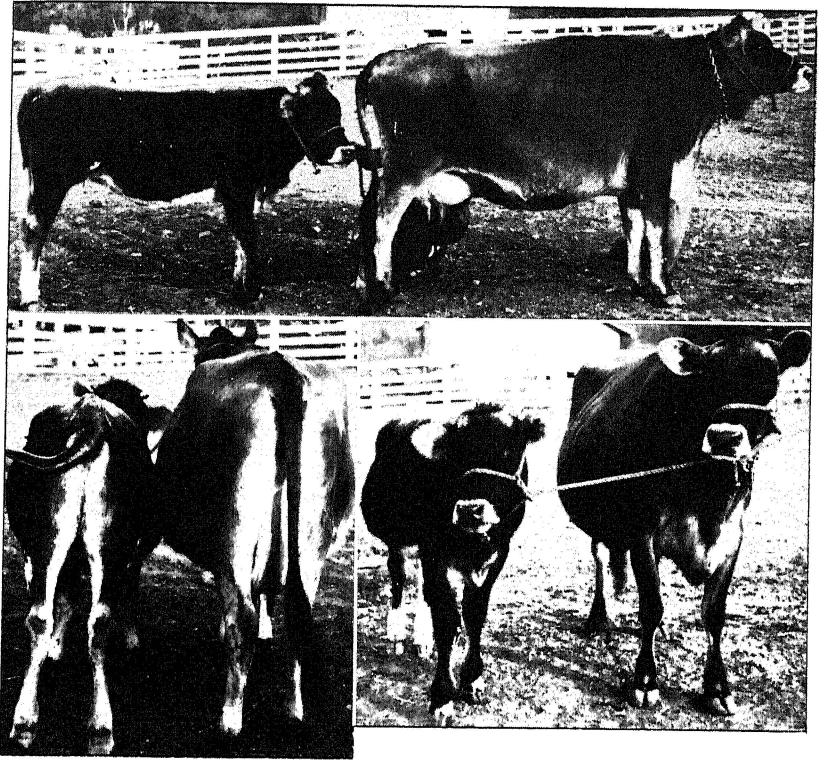


Fig. 1.—Photographs of the thyroidectomized heifer (left) and control of the same age, in various positions.

normal); distance of shoulder to ischium, 49.6 inches (contrasted to 60 inches in the normal); skin, dry and scaly; hair, short and rough (it is the original baby-calf hair, as she did not follow the custom of normal heifers of shedding the hair in the spring); joints, stiff and large bony growth formed about the ankles; characteristic cretin (large) pouch; extremely disk-faced, due to disproportionate retardation of growth of the muzzle and jaw bones; practically hornless; has never exhibited signs of heat.

The characteristic dryness and dullness of the hair and the constipation appeared about a month after thyroidectomy and preceded the growth and metabolism retardation.

As might be expected from her low metabolic rate (Fig. 3), T5 was particularly sensitive to cold during the winter, and her joints stiffened so that she could hardly walk. Administration

of thyroxine and housing in a warm room promptly "cured" her stiff joints. The stiffness reappeared on cessation of thyroid treatment.

The following are weight comparisons at several ages, supplementing Fig. 2 (thyroidectomized at 54 days of age):

TABLE 1. COMPARISON OF WEIGHTS OF THYROID ECTOMIZED AND CONTROL HEIFERS

Age	Thyroidectomized	Control
	Jersey	Jersey
	<u>pounds</u>	<u>pounds</u>
Birth	72	70
6 months	240	243
1 year	375	450
1 1/2 years	443	600
2 years	450	735
3 years	470	860
3 1/2 years (Dec. 2, 1941)	480	900

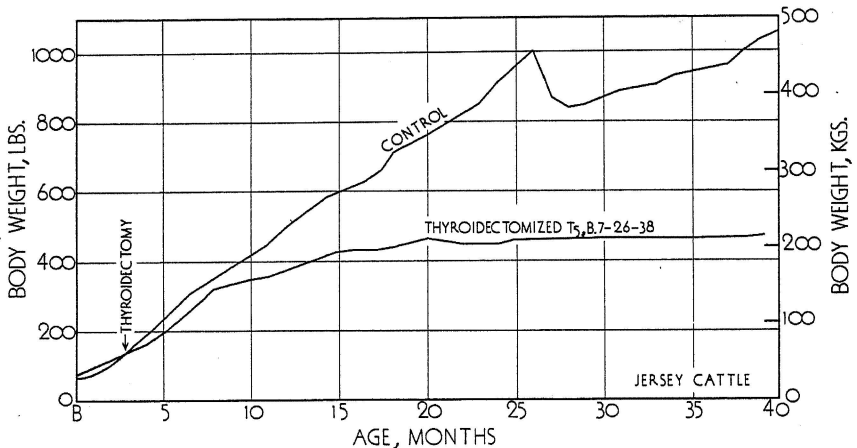


Fig. 2.—Comparison of age curves of growth of thyroidectomized and normal Jersey heifers.

Resting Heat Production.—The decline in resting metabolism following thyroidectomy, shown in Fig. 3, along side that of the control animal, is as spectacular as the decline in growth.

Beginning with a resting metabolism of about 1600 Cal./sq. meter/day at age two months, the metabolism in the normal

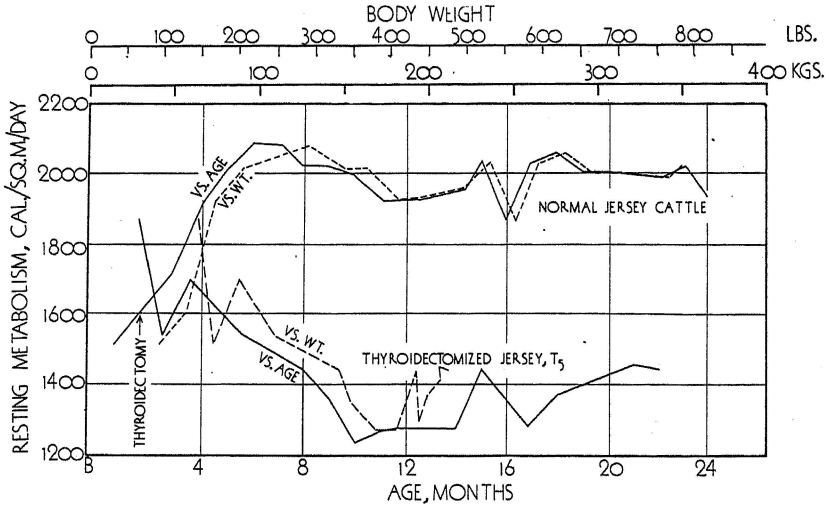


Fig. 3.—Comparison of age and weight curves of resting energy metabolism, Cal./sq. meter/day of thyroidectomized and normal Jersey heifers.

heifer increased to about 2000 Cal./sq. meter/day at the age of eight months, at which level it remained to the age of twenty-four months (when pregnancy complicated the picture in the normal control), while that of the thyroidectomized animal decreased to about 1300 or 1400 Cal./sq. meter/day at the age of eight months, at which level it remained to age forty months. Fig. 4 shows the age changes in the total metabolism of the animal.

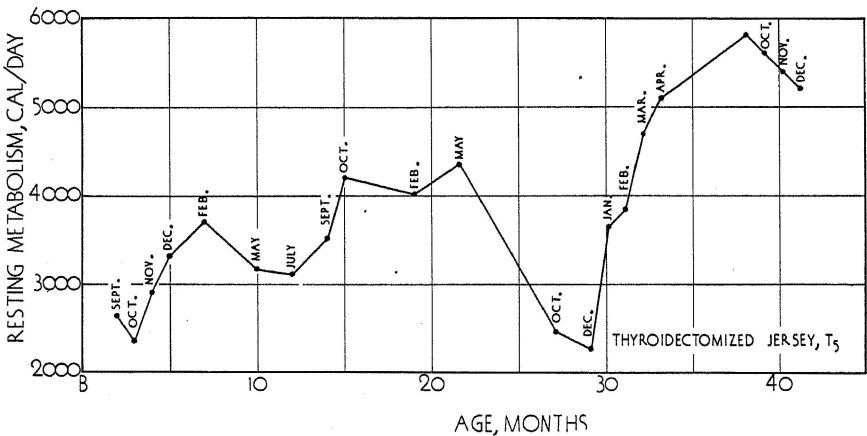


Fig. 4.—Total resting metabolism of the thyroidectomized heifer as function of age and of season.

Heat Increment of Feeding.—It is generally known that feeding is associated with an extra heat production, the so-called specific dynamic action, SDA. There is considerable literature¹ concerning the influence of thyroid activity on SDA. Fig. 5 compares the slopes of the decline of heat production following feeding in the thyroidectomized animal, T5, and in an older normal cow measured at the same time. The data plotted on

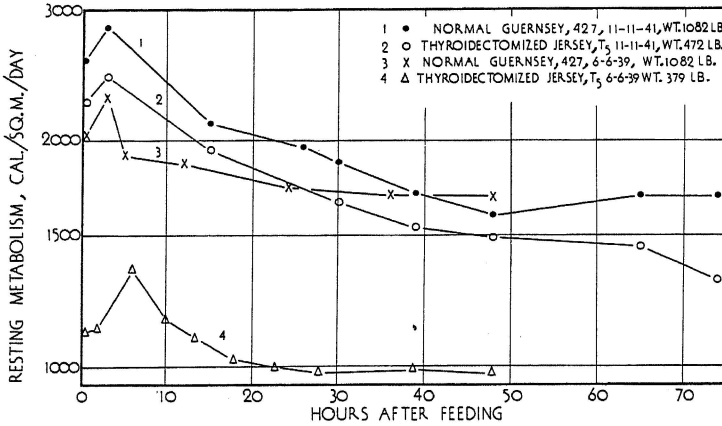


Fig. 5.—Comparison of the time curves of the heat increments of feeding in the thyroidectomized and normal cattle.

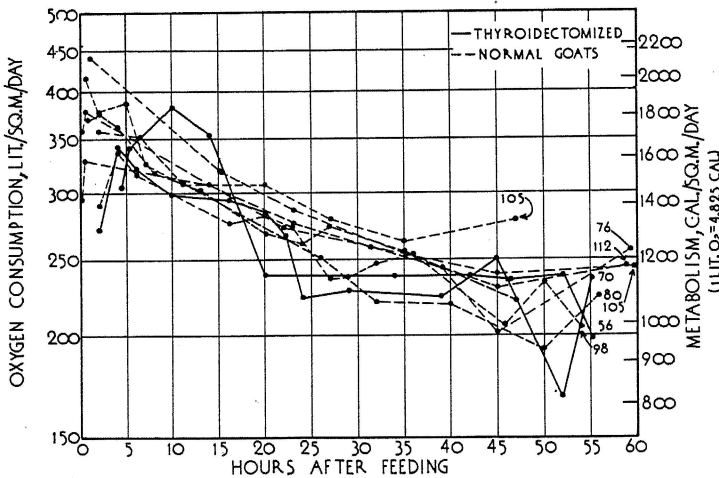


Fig. 6.—Comparison of the time curves of the heat increments of feeding in thyroidectomized and normal goats.

¹For review of literature see Brody, S., Ann. Rev. Biochem., 3, 303, 1934.

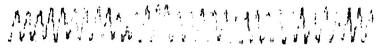
an arithlog grid, indicate that what differences there are in position of the curves are due to differences in size of the animals and, therefore, to differences in the amounts of feed consumed. There does not appear to be any basic difference in the pattern of the SDA time curves of normal and thyroidectomized cattle. This conclusion is substantiated by similar data on thyroidectomized and normal goats in Fig. 6.

NORMAL JERSEY

THYROIDECTOMIZED JERSEY



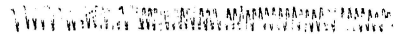
5 MONTHS, 220LBS.#4



5 MONTHS, 197LBS.# 4



10 MONTHS, 420LBS.#8



10 MONTHS, 352LBS.#8



8MONTHS, 350LBS.#8



15 MONTHS, 597LBS.#8



15 MONTHS, 429LBS.#8



11 MONTHS, 433LBS.#8



20 MONTHS, 763LBS.#8



20 MONTHS, 460LBS.#8



12 MONTHS, 468LBS.#8

Fig. 7.—Respiration rate and volume of normal and thyroidectomized heifers at given ages and live weights.

Cardio-respiratory Activities.—The volume and shape of the respiration curve, shown in Fig. 7, indicate, as might be expected, that both respiration volume and frequency are less in the thyroidectomized animal.

Table 2 shows that the ventilation rate (volume of air inhaled per minute) is less in the thyroidectomized animal, paralleling the oxygen consumption (metabolism). The percentage oxygen removed from the inhaled air is, within the limits of error, the same in thyroidectomized and normal animals.

Table 2 shows that the pulse rate per square meter surface area in the thyroidectomized animal is somewhat lower than in the control. However, surface area is not a proper reference base for pulse rate. We have no good reference base for pulse rate for animals differing in size.

The Influence of Iodized Protein on the Thyroidectomized Animal.—On December 2, 1941, T5 was started on a “thyrolactin”¹ (iodized-milk protein) feeding experiment.² Her metabolic rate was increased, by proper dosage, to 2250 Cal./sq. meter/day within a week, and kept at this level thereafter.

TABLE 3. THE INFLUENCE OF “THYROLACTIN” FEEDING ON SEVERAL MEASUREMENTS OF T5

	Dec. 2	Feb. 21	April 14	May 23
Weight	480 lbs.	452 lbs.	497 lbs.	526 lbs.
Height at withers	41 in.	41 in.	44 in.	45 in.
Heart girth	54 in.	54 in.	55 in.	57 in.
Width of hips	14.4 in.	14.6 in.	15.2 in.	15.6 in.
Horns (tip to tip)	9.6 in.	10.6 in.	11.6 in.	12.2 in.

The appearance of T5 is now (June 1) quite changed. The hair coat is no longer rough and coarse. She appears more feminine. There has been considerable development of mammary gland and horn. She has gained 46 lbs. since December 2, and has increased in body length and weight. Before feeding the “thyrolactin” she had never been in heat, but has exhibited heat twice since then.

¹Heathman, W. W., and Turner, C. W., *J. Dairy Sc.*, 23, 534, 1940.
Reineke, E. P., Williamson, M. B., and Turner, C. W., *J. Biol. Chem.* 143, 285, 1942.

²This feeding was done under the direction of Dr. E. P. Reineke.