# THE RELATIVE GROWTH OF THE THYROID GLAND IN THE BOVINE FETUS[1]

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The nature of thyroid iodine in the postnatal state is fairly well understood. At least 90 per cent of it is organic and almost all of this can be accounted for by two fractions: thyroxine-like and diiodotyrosine-like iodine.[3] These two compounds do not exist in the free state in the gland but are combined there with other amino acids to form the characteristic thyroid protein, thyroglobulin.

The nature of the iodine in the fetal organism has not been clearly established. To obtain such information, a study of various iodine fractions of the bovine fetal thyroid was undertaken. Data on that phase of the study will be presented in the following paper. The material acquired during these experiments also provided an opportunity for studying the growth of the gland in relation to body weight, body length, and age of the bovine fetus from 62 days to term (278–285 days depending upon breed). The present paper is concerned with this phase of the study.

## EXPERIMENTAL

Intact uteri of pregnant beef were collected randomly at abattoirs at the time of slaughter. The embryos and fetuses were weighed and measured immediately after the umbical cord was tied off at the fetal level. The thyroids were then removed, freed of extraneous connective tissue and fat, and weighed. A small portion was fixed in Bouin's solution for histological examination.

The fetuses were coellcted from random herds. Breeding or stock histories were not available. The present series comprises a total of 121 bovine fetuses obtained from dams chiefly of the Hereford breed (97 specimens). Four fetuses were obtained from Guernsey, 15 from Holstein, and five from Jersey breeds. Since the slopes of curves relating thyroid weight to body weight did not differ for the two sexes, no distinction was made between male and female fetuses.

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[3] Monoiodotyrosine has recently been found in the thyroid gland by Fink *et al.* (1948) and by Taurog *et al.* (1949).

## RESULTS

In order to determine fetal ages, we employed the data of Winters *et al.* (1942) who measured body dimensions of fetal calves of known ages. In the present study, the age of each fetus was taken as the average of ages derived from the following four measurements: body weight, crown-rump (C.R.) length, chest circumference, and abdominal circumference. These were determined by methods previously described (Nichols, 1944).

The ages of the fetuses ranged from 62 days to term. In table 1, they have been grouped with respect to arbitrarily selected age ranges and the body measurements have been recorded for each range.

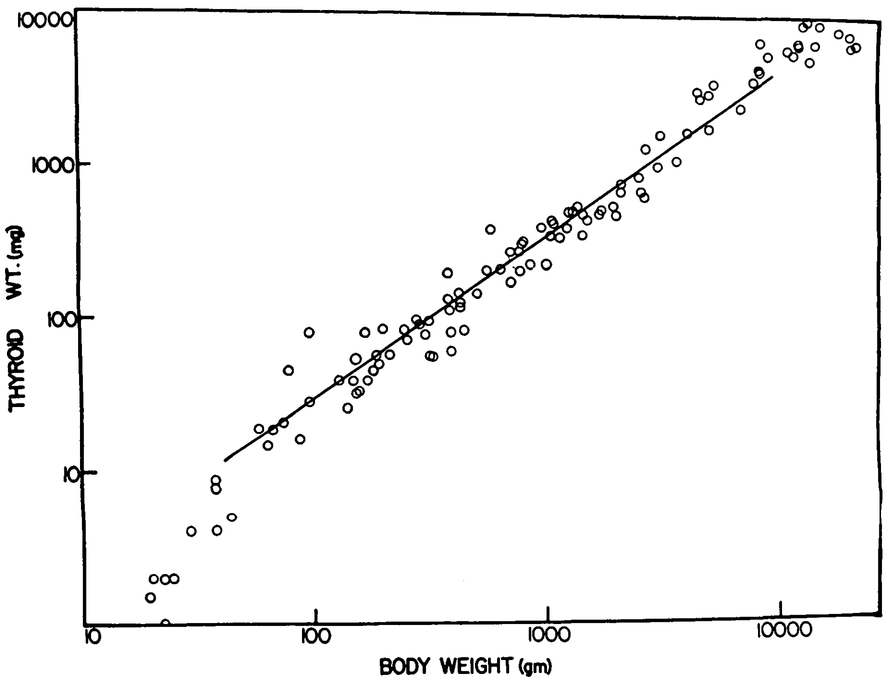


FIG. 1. Double-logarithmic plot of fetal thyroid weight against body weight.

When thyroid weights were plotted on a double logarithmic grid against total body weight (fig. 1), C. R. length (fig. 2), and calculated age (fig. 3), straight-line curves were obtained.

The data shown in figs. 1–3 were therefore fitted to the simple allometry equation of Huxley (1932):

$$y = bx^k \tag{1}$$

where $y$ = thyroid weight expressed in mg.

$x$ = body weight expressed in gm. (fig. 1), or C.R. length in mm. (fig. 2), or age in days (fig. 3).

TABLE 1. THYROID WEIGHTS AND BODY DIMENSIONS OF FETAL CALVES FROM 62 DAYS TO TERM

| Calculated age | No. of fetuses | Body weight | | C.R. length | | Chest circum. | | Abdom. circum. | | Thyroid weight | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Range | Mean | Range | Mean | Range | Mean | Range | Mean | Range | Mean |
| days | | gm. | gm. | mm. | mm. | mm. | mm. | mm. | mm. | mg. | mg. |
| 62–70 | 9 | 18–34 | 27 | 73– 96 | 85 | 51– 75 | 66 | 61– 80 | 70 | 1–9 | 4 |
| 75–85 | 10 | 42–150 | 84 | 104–153 | 127 | 87–120 | 99 | 82–122 | 100 | 5–45 | 25 |
| 87–95 | 14 | 96–235 | 168 | 151–185 | 165 | 115–133 | 123 | 115–149 | 129 | 24– 82 | 53 |
| 98–105 | 16 | 240–433 | 350 | 178–222 | 203 | 142–168 | 154 | 144–174 | 161 | 57–183 | 90 |
| 106–120 | 15 | 433–860 | 639 | 215–273 | 245 | 167–208 | 189 | 175–214 | 183 | 117–348 | 200 |
| 125–135 | 11 | $0.98 \cdot 10^3$–$1.50 \cdot 10^3$ | $1.21 \cdot 10^3$ | 295–334 | 312 | 214–253 | 233 | 227–265 | 252 | 202–471 | 350 |
| 136–150 | 9 | $1.52 \cdot 10^3$–$3.13 \cdot 10^3$ | $1.94 \cdot 10^3$ | 325–418 | 353 | 243–352 | 276 | 270–354 | 295 | $0.32 \cdot 10^3$–$1.37 \cdot 10^3$ | 542 |
| 152–160 | 9 | $2.10 \cdot 10^3$–$3.82 \cdot 10^3$ | $2.76 \cdot 10^3$ | 382–462 | 408 | 280–331 | 301 | 282–342 | 320 | $0.42 \cdot 10^3$–$1.10 \cdot 10^3$ | 709 |
| 163–175 | 7 | $4.34 \cdot 10^3$–$5.60 \cdot 10^3$ | $4.95 \cdot 10^3$ | 445–590 | 511 | 349–435 | 381 | 367–453 | 394 | $1.13 \cdot 10^3$–$2.74 \cdot 10^3$ | $2.01 \cdot 10^3$ |
| 190–210 | 9 | $7.25 \cdot 10^3$–$13.0 \cdot 10^3$ | $9.83 \cdot 10^3$ | 573–703 | 622 | 408–508 | 461 | 428–564 | 486 | $2.85 \cdot 10^3$–$6.69 \cdot 10^3$ | $4.01 \cdot 10^3$ |
| 213–228 | 5 | $12.5 \cdot 10^3$–$15.7 \cdot 10^3$ | $14.5 \cdot 10^3$ | 700–735 | 710 | 535–562 | 548 | 532–597 | 575 | $3.91 \cdot 10^3$–$6.95 \cdot 10^3$ | $5.40 \cdot 10^3$ |
| 240–260 | 7 | $19.9 \cdot 10^3$–$32.5 \cdot 10^3$ | $24.7 \cdot 10^3$ | 790–855 | 838 | 617–676 | 650 | 645–705 | 673 | $4.59 \cdot 10^3$–$11.4 \cdot 10^3$ | $6.54 \cdot 10^3$ |

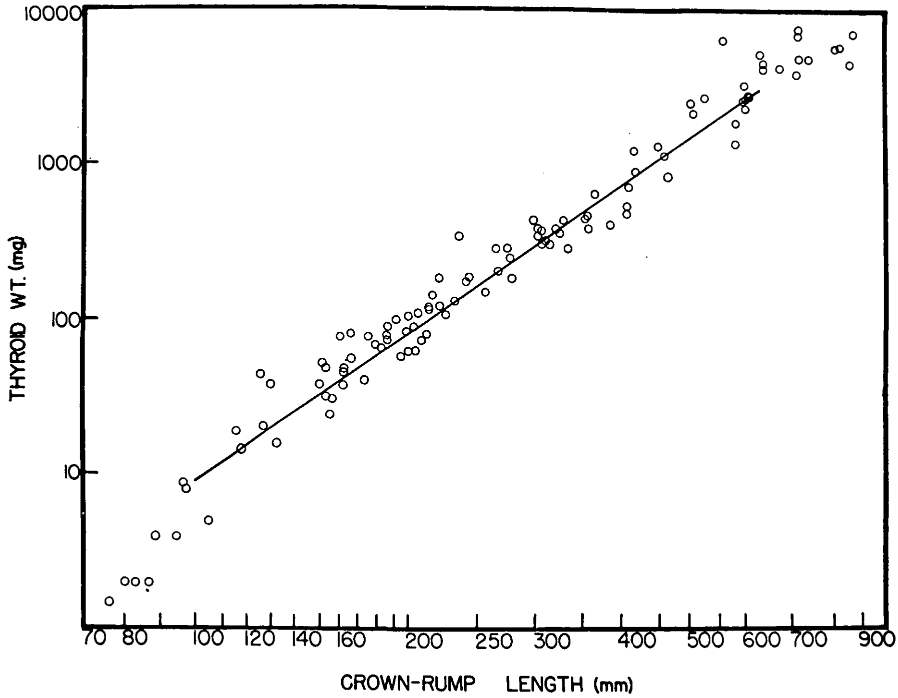


FIG. 2. Double-logarithmic plot of fetal thyroid weight against crown-rump length.

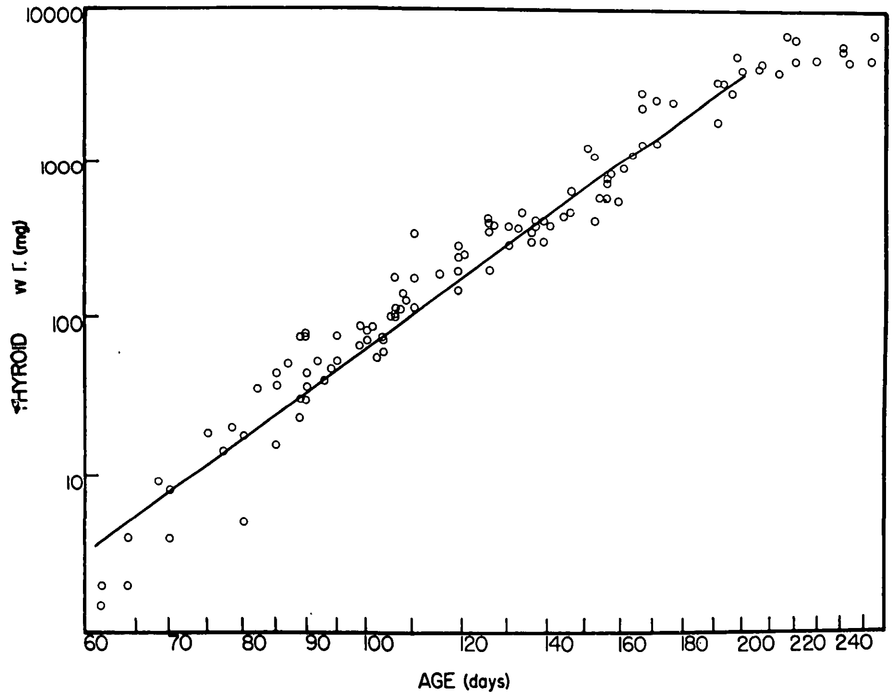


FIG. 3. Double-logarithmic plot of fetal thyroid weight against calculated age.

$b$ (the initial growth index of Reeve and Huxley, 1945)
= a constant that indicates the value of $y$ when $x$ is 1, i.e., a scale factor.
$k$ = the allometric growth constant.

*Relation to Body Weight*

In the case of fig. 1, equation (1) becomes

$$y = 0.25x^{1.0} \tag{2}$$

Equation (2) is valid from approximately 40 to 10,000 gm. body weight and from 11 to 3000 mg. thyroid weight.

The relative growth constant of the fetal thyroid with respect to body weight is 1.0. This indicates that during prenatal life, thyroid weight is almost directly proportional to body weight.

It is of interest to note that our value for $k$, namely 1.0, which is based on 121 measurements, is in good agreement with values reported earlier by Abeloos (1946) for calf fetuses (0.95), and by Schultze and Turner (1945) for fetal goat thyroids (0.98). Brody and Kibler (1941), furthermore, found a value of 0.924 for the relation of thyroid weight to body weight in a large variety of mature mammals.

*Relation to Body Length*

The expression for the curve shown in fig. 2 (thyroid weight plotted against C.R. length) is

$$y = (4.6 \cdot 10^{-6})x^{3.4} \tag{3}$$

The validity of this formula extends from 100 to 600 mm. C.R. length and from 10 to 4000 mg. thyroid weight.

*Relation to Age*

The curve representing thyroid growth in relation to age is shown in fig. 3. The following formula was found to fit the observed data:

$$y = (2.3 \cdot 10^{-11})x^{6.2} \tag{4}$$

This formula holds from 60 to 200 days of age with a corresponding thyroid weight range of from 2.7 to 4800 mg. Beyond 200 days of age there was considerable spread in the data.

The manner in which the values for the constants $k$ and $b$ were derived is shown below for fig. 3.

Let $x_1 = 60$ days and $x_2 = 200$ days; then $y_1$ (thyroid weight) = 2.7 mg. and $y_2 = 4800$ mg.
Therefore,

$$k = \frac{\log_{10} y_2 - \log_{10} y_1}{\log_{10} x_2 - \log_{10} x_1}$$

$$= \frac{\log_{10} 4800 - \log_{10} 2.7}{\log_{10} 200 - \log_{10} 60}$$

$$= 6.2.$$

The value for $b$ was calculated from the expression $\log b = \log y_0 - k \log x_0$, where $y_0$ (organ weight) and $x_0$ (age in days) are values on the plot of thyroid weight against age from approximately 62 to 200 days. For example, at 200 days:

$$\begin{aligned} \log_{10} b &= \log_{10} y_0 - k \log_{10} x_0 \\ &= \log_{10} 4800 - 6.2 \log_{10} 200 \\ &= 2.3 \times 10^{-11} \end{aligned}$$

*Percentage Growth Rate*

The percentage growth rate of an organ can be obtained from the expression

$$\frac{d \text{ (organ weight)}/d \text{ (age)}}{\text{organ weight}}.$$

Employing the above notation, this expression becomes

$$\frac{dy/dx}{y}.$$

If the absolute rate of growth of the thyroid gland is $dy/dx$, then

$$\begin{aligned} \frac{d}{dx}(y) &= \frac{d}{dx}(bx^k) \\ &= bkx^{k-1} \\ &= bx^k(kx^{-1}). \end{aligned}$$

Therefore

$$\frac{dy}{dx} = y\frac{k}{x}$$

and

$$\frac{dy/dx}{y} = \frac{k}{x}$$

For example, in the calf at the age of 75 days, $[(dy/dx)/y] = (k/x) = (6.2/75) = 0.083$. Therefore, the rate of growth of the fetal calf thyroid at 75 days is 8.3 per cent per day, i.e., per cent of its weight at this age.

Fig. 4 shows that the percentage growth rate declines steadily with increasing age. Thus, at 60 days, the percentage growth rate (instantaneous relative growth rate×100) is 10.2 per cent per day; at 220 days, approximately 2.8 per cent per day. Such a decline has also been demonstrated by Lowrey (1911) for the fetal pig thyroid and by Fenger (1913) for the fetal calf thyroid. The curve in fig. 4

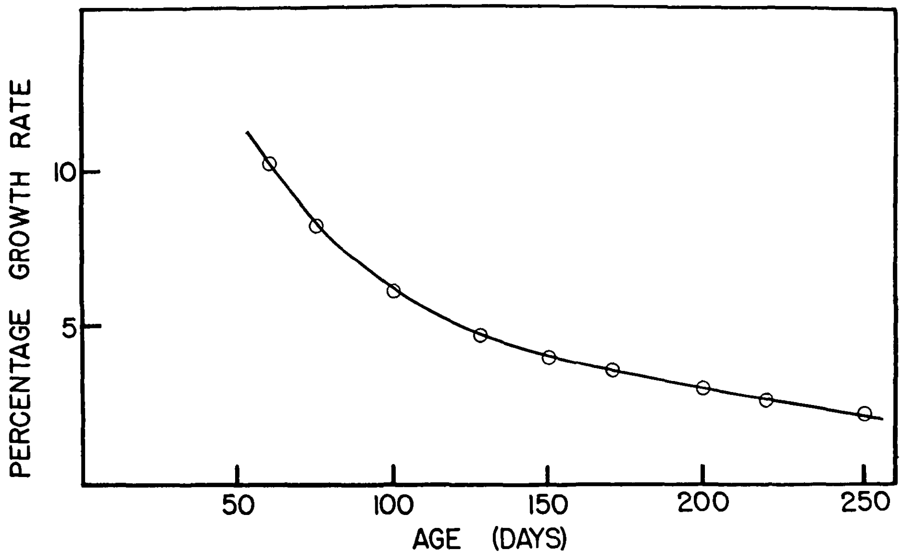


FIG. 4. Plot of percentage growth rate of the fetal thyroid against age.

resembles that obtained by Brody (1941) for the percentage growth of the thyroid in the postnatal state.

## SUMMARY

The growth of the thyroid gland, in relation to body weight, body length, and age, in the bovine fetus from 62 days to term was investigated. Fetal age was calculated from the following four parameters: body weight, crown-rump length, chest circumference, and abdominal circumference.

The simple allometry equation $y = bx^k$ was found to fit the data for the growth of the thyroid in relation to body weight, body length, and age. The relative growth constant ($k$) for thyroid weight against body weight was found to be 1.0. This indicates that thyroid weight in the fetus is nearly directly proportional to body weight within the limits of the empirical formula.

Percentage growth rates were calculated and found to decrease with increasing age.

## ACKNOWLEDGMENT

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