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# Growth patterns of Chianina bull from 6 to 24 months fed two different diets. 2. Tissues

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**Abstract**

Sixty-nine Chianina young bulls were fed two unifeed diets to ad libitum intake from six months of age (H and L diet, 0.94 and 0.76 UFV/kg DM respectively), and were serially slaughtered at nine two-month intervals from 8 to 24 months of age. A further eight calves were slaughtered at six months as an initial reference. Sides were anatomically dissected into total muscle (TSM), fat (TSF), bone (TSB) and other tissues (TSOT). Statistical analysis used the allometric equation, and variation in the growth coefficients was tested by the log–log relationship of the second or third degree. Overall, relative to cold side weight (CSW), TSM and TSOT were nearly in isauxesis ($b = 0.97$ and 1.05 respectively), TSF had late development ($b = 1.55$) and TSB was in bradiauxesis ($b = 0.79$). The allometric coefficient of TSM was lower (0.95 versus 0.99) and that of TSF was higher (1.68 versus 1.41), in H diet bulls than in L diet bulls. In relation to TSB weight, the allometric coefficient of TSM (for H and L bulls) and of TSF (only for H bulls) varied along the developmental range and the TSM growth rate did not differ between diets. The average growth coefficient of TSM and TSF relative to TSB peaked at about 18 months. The multiple relationships of the average daily gain of tissues relative to BW and to daily weight gain (DWG) showed that lean gain varied linearly with BW and DWG, while fat and bone gain were sensitive to an interaction between BW and DWG.

*Keywords:* Young bull; Chianina; Diet; Growth pattern; Carcass composition

## 1. Introduction

In meat animals the composition of the carcass largely determines commercial value, but as animals grow the relative proportions of tissues in the carcass (mainly bone, muscle and fat) vary. To identify the optimal time (age or weight) for slaughter, therefore, it is useful to know the patterns of relative growth of the major tissues in meat animals. Studies on dairy and beef cattle (Robelin et al., 1974; Andersen, 1975; Robelin et al., 1977; Berg et al., 1978; Fortin et al., 1981; Andersen et al., 1984; Shahin and Berg, 1985) have shown that tissue allometric growth is sensitive to a number of factors, mainly breed, plan

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of nutrition, sex and the duration of the experimental period. As far as the last factor is concerned, the initial or end point and the duration of the test period studied influence the pattern of relative growth that emerges: a range that is too short cannot give a clear picture of the development pattern of muscle, fat and bone (Andersen, 1975) while a longer range made it possible to describe multiphasic growth and enabled Walstra (1980) for example to detect such growth in pigs. Moreover Geay and Robelin (1979) and Toelle et al. (1986) reported significant genotype $x$ nutrition interaction for body composition characteristics. Therefore previous results on precocious breeds (Friesian or Red Danish) characterized by weak potential of muscular growth, or on British and French beef breeds, cannot be entirely applied to an Italian beef breed such as Chianina, well-known for its high growth potential, large size and late development.

Moreover, for the grower-finisher system it is very important to know the patterns of daily weight gain of carcass, lean, fat and bone at various moments of body development in relation to the weight growth rate. Andersen (1975) in Red Danish bull calves reported a non-linear pattern for daily gain of carcass and tissues in relation to live weight and feeding level. Toelle et al. (1986) and Korver et al. (1987) found that levels of lean and fat gain were different among breeds or breed groups and that for some of these there was a significant interaction between daily body weight gain and body weight. Similar information has so far been lacking for the Chianina breed.

An experiment on the serial slaughter of Chianina young bulls, over a fairly long growth period which included puberty, was carried out employing two different nutritive planes. The general aim of the project was to provide information about the development of organs, tissues and body regions of the Chianina breed, and to determine the optimum age or weight for end-use in relation to the nutritive plane employed.

The objective of present work, which follows a number of previous papers (Giorgetti et al., 1995; Giorgetti et al., 1996), was to examine the allometric growth of the major tissues from 6 to 24 months of age in Chianina young bulls fed two different diets and to evaluate average daily tissue growth in relation to body weight and average daily weight gain.

## 2. Material and methods

### 2.1. Experimental design and animals

The basic design of the entire experiment, in vita performances and the developmental pattern of organs and carcass were described in previous papers (Giorgetti et al., 1995; Giorgetti et al., 1996). Briefly, at six months of age, 72 Chianina young bulls were randomly assigned to nine slaughter ages (8, 10, 12, 14, 16, 18, 20, 22, 24 months) and to two diets to ad libitum intake (an H diet, 0.94 UFV/kg DM; and an L diet, 0.76 UFV/kg DM). A further eight calves were slaughtered at six months to determine the initial body characteristics. These calves had been randomly assigned to one of the two diets in equal numbers. At the beginning of the trial on all animals, the live weight and some external body measurements were recorded (Giorgetti et al., 1995). During the experimental period two bulls on the H diet (20 month slaughter point) and one bull on the L diet (22 months) had to be slaughtered in advance; all data relating to these animals were removed from the analyses.

After 8 days of storage at 2°C the right side of the slaughtered animals was weighed (cold side weight-CSW), trimmed of cavity fat (parietal fat of the thoracic, abdominal and pelvic cavities including kidney knob and channel fat) and jointed into eleven anatomical regions (Giorgetti et al., 1996). Joints were dissected into muscle, fat, bone and 'other tissue'. The following definitions and abbreviations were used: *Total side muscle* (TSM); *Total side bone* (TSB); *Total side fat* (TSF) as the sum of subcutaneous, intermuscular and cavity fat; *Total side other tissue* (TSOT), mainly tendons, blood vessels, fascia and ligaments.

For each of the bulls serially slaughtered from 8 to 24 months, the daily gains of carcass and tissues (TSM, TSB and TSF) were estimated from the beginning of the trial. The daily gains were then calculated using the individual weight data determined at slaughter, the corresponding weight estimates recorded at the start of the trial, and the length of the growth period, following the basic principles of the comparative slaughter method employed in studies on body retention (Lofgreen and Garrett, 1968; Thomson and Cammell, 1979). The equations used to estimate initial body composition (carcass and tissue percentages) were obtained from the eight calves slaughtered at six months, using the anatomical composition, BW, age and body measurements of these animals.

### 2.2. Statistical analyses

To examine the developmental growth pattern, the allometric function $Y = a^{*} X^{b}$ (Huxley, 1932) was used. Data were transformed logarithmically ($\log_{10}$) and analysed with the following model (Harvey, 1990):

$$\log Y_{ij} = A + D_i + b_i * \log X_{ij} + e_{ij}, \quad (1)$$

where $A$ is the intercept, $D_i$ is the effect of the $i$th diet and $X_{ij}$ is CSW or TSB for the $j$th animal. Individual diet group regression coefficients were reported in cases where regressions were not homogeneous ($P < 0.05$). The common regression coefficient is shown in all cases. This regression coefficient is referred to as the allometric coefficient and is defined as the ratio of the relative growth rate of $Y$ to the relative growth rate of $X$ $(dY/Y)/(dX/X) = b$.

In Eq. (1), the allometric coefficient remains constant and can indicate the average growth rate during the whole period. Because of the long developmental range, significant ($P < 0.05$) improvement for a second or third degree equation was probed, and in these cases, the allometric coefficient varied with $X$ (Giorgetti et al., 1996) according to the following functions:

$$(dY/Y)/(dX/X) = b + 2c * \log X$$

for the second degree

$$(dY/Y)/(dX/X) = b + 2c * \log X + 3d * (\log X)^2$$

for the third degree,

where $c$ and $d$ are, respectively, the regression coefficients of the second and third degree in the primitive equation. Besides the allometric coefficient obtained from Eq. (1), therefore, the instantaneous growth coefficients with their standard errors at initial, average and final values of the independent variable were estimated as suggested by Geri et al. (1986).

The body composition (carcass and tissue percentages) of the eight calves slaughtered at six months was related to BW, age and body measurements using a stepwise multiple regression procedure (SAS, 1988) to select the significant ($P < 0.1$) independent variables.

Daily carcass and tissue gain estimates in the bulls slaughtered from 8 to 24 months were related to body weight (BW) and to daily weight gain (DWG) using the same stepwise procedure. Because of the long developmental period, the interaction and the second degree of the independent variables were tested by using the following general model:

$$Y = a + b_1 * X_1 + b_2 * X_2 + c_1 * (X_1)^2 + c_2 * (X_2)^2 + d * (X_1 * X_2),$$

where $Y$ = daily gain of carcass or tissues from six months to slaughter (8–24 months); $a$ = intercept; $X_1$ = BW at slaughter; $X_2$ = DWG from six months to slaughter.

The first degree independent variables were forced into the model irrespective of their significance level while the second degree and the interactive components were left in the model only when they were significant ($P < 0.1$). The diet effect was not considered because diet-linked variability was assumed to have been absorbed by the different individual growth rates. The G3D procedure of SAS (1988) was employed to plot the graph of the response surfaces.

## 3. Results and discussion

Table 1 shows the allometric relationships of total tissue weight relative to CSW for the two feeding

Table 1
Average allometric coefficients of total side tissue weight in relation to cold side weight (CSW) and estimated means (g)

| | Allometric coefficient (± s.e.) | | | Means [a] | | $R^2$ |
|---|---|---|---|---|---|---|
| | common | H diet | L diet | H diet | L diet | |
| TSM | 0.97 ± 0.007 | 0.95 | 0.99 | 111960 [b] | 115130 [b] | 0.99 |
| TSB | 0.79 ± 0.016 | | | 27040 | 27510 | 0.97 |
| TSOT | 1.05 ± 0.041 | | | 4760 | 5010 | 0.90 |
| TSF | 1.55 ± 0.046 | 1.68 | 1.41 | 19222 [b] | 16070 [b] | 0.95 |

[a] Estimated at an average CSW, kg 164, along the slope of intraclass regression.
[b] $P < 0.05$.

treatments. The shared allometric coefficients indicate that the TSB grew more slowly ($b < 1$) than the carcass, TSM and TSOT were nearly in isauxesis, and TSF exhibited late development. This pattern agrees with the classical growth model of tissues (Hammond, 1932) and generally confirms the results

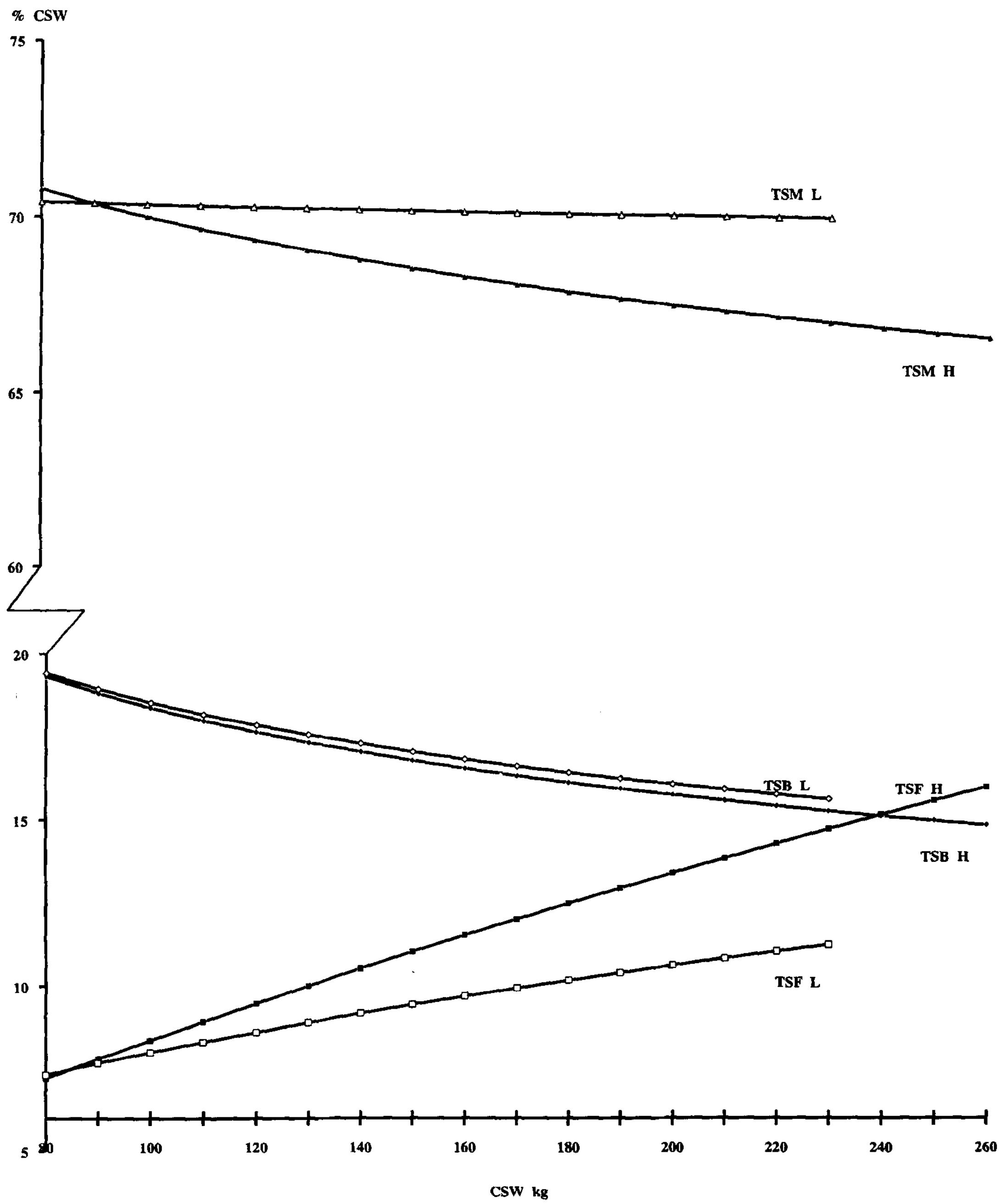


Fig. 1. Evolution of incidence of tissues (% CSW) at increasing CSW (obtained by transformation of the original data fitted from the allometric equations) TSM H $= 0.101 * \text{CSW}^{0.949}$, TSF H $= -4.486 * \text{CSW}^{1.682}$, TSB H $= 0.373 * \text{CSW}^{0.778}$, TSM L $= -0.125 * \text{CSW}^{0.994}$, TSF L $= -3.151 * \text{CSW}^{1.411}$, TSB L $= 0.289 * \text{CSW}^{0.796}$.

obtained on bulls from various breeds (Robelin et al., 1974; Andersen, 1975; Robelin et al., 1977; Berg et al., 1978; Fortin et al., 1981; Shahin and Berg, 1985; Martinsson and Olsson, 1993). Comparison among the absolute values of allometric coefficients, on the contrary, must be made with some caution since they are affected by differing experimental conditions (mainly feeding plane, age at the start and end of the trial, and duration of developmental range). Nevertheless, in comparison with these results, dairy breed bulls (Robelin et al., 1974; Martinsson and Olsson, 1993) exhibited higher growth coefficients for fat and lower coefficients for bone and lean; Hereford and Beef Synthetic (Shahin and Berg, 1985) had slower growth of muscle and bone; Double Muscled (Shahin and Berg, 1985) and Limousin bulls (Robelin et al., 1977) presented more favourable relative growth of lean and bone. In an extensive study on the progeny of eight sire breeds (including Chianina) and two dam breeds, Berg et al. (1978) found allometric coefficients for muscle, fat and bone identical to those here reported, although they were restricted to a more limited period of growth (from 300 kg to 15 months of age).

The relative growth of the tissues was well described by the linear allometric equation (the second degree of the log–log relationship never attained significance: $P > 0.05$) and indicated that the allometric coefficient did not vary as the CSW increased, despite the long developmental period. Only Robelin et al. (1977), among the above-mentioned authors, tested the significance of a second degree allometric relationship. They found that the carcass fat of Limousine bulls increased its relative growth rate from 9 to 19 months.

Diet influenced tissue growth. The allometric coefficient of TSM was lower, and that of TSF higher in H than in L diet bulls, while no differences were detected in TSB and TSOT. This means that at an average CSW of 164 kg, H diet bulls had about 3 kg less muscle and 3 kg more fat than L diet bulls. Fig. 1 shows the relative growth of the major tissues as a proportion of CSW (obtained by the transformation of the values fitted by the original allometric equation). The pattern of bone was shown for both diets but they were not significantly different. In the graph, percentages are shown rather than absolute values to allow prompt commercial interpretation of the data.

Reduction in energy intake during the growth period generally results in a lower proportion of carcass fat (Jarrige, 1972) but other studies indicate that the magnitude of the response depends on the breed and on the extent of energy reduction. Fortin et al. (1981) found that the level of energy intake altered the relative growth of muscle, fat and bone in Angus, but not in Holstein bulls. For Martinsson and Olsson (1993) the allometric coefficients of the tissues of Friesian bulls were not sensitive to the feeding level even if differences between the intercepts of the allometric equation produced a higher percentage of fat and a lower percentage of lean in the H than in the L diet group. In contrast, in Danish Friesian bull the relative growth of fat decreased and that of lean increased progressively as the feeding level was reduced from ad libitum to 85 or 70% of ad libitum (Andersen et al., 1984). In Red Danish bulls (Andersen, 1975) a reduction to 70% of ad libitum intake led to an increase in the allometric coefficient of muscle and a decrease in that of fat, but no variations were noted with only a reduction to 85% of ad libitum intake; moreover, bone never changed its relative growth rate. A reduction of 18% and 13% of ad libitum intake resulted in a very slight reduction in carcass fatness in Charollais and Limousin bulls respectively (Béranger and Robelin, 1977). In the present experiment the energy intake of the L group was about 80% that of the H group (Giorgetti et al., 1995) but the long developmental range may well have accentuated diet differences in the relative growth of the different tissues.

The percentage of tissue growth (Fig. 1) with the H diet can be compared with results on beef bulls receiving a high concentration ration (Shahin and Berg, 1985; Robelin et al., 1977). At side weight of 160 kg, Chianina bulls presented more bone (increase of 4–6 percentage points) than Hereford, Beef Synthetic, Double Muscled and Limousine; less fat than Hereford, Beef Synthetic and Double Muscled; more muscle than Hereford and Beef Synthetic but less muscle than Limousine, which exhibited 75% lean on carcass.

Several researchers express growth of tissues in relation to bone weight (Berg and Butterfield, 1966; Berg et al., 1978; Shahin and Berg, 1985) or in relation to muscle + bone weight (Mukhoty and Berg, 1971; Fortin et al., 1981) to avoid the wide varia-

Table 2
Average and instantaneous allometric coefficients of TSM and TSF weight in relation to TSB weight

| | Allometric coefficient | | | | $R^2$ |
|---|---|---|---|---|---|
| | average | instantaneous at TSB | | | |
| | | 17 kg | 27 kg | 36 kg | |
| TSM | | | | | |
| H and L diet [a] | 1.20±0.03 | 1.20±0.09 | 1.26±0.06 | 0.86±0.12 | 0.97 |
| TSF | | | | | |
| H diet [a] | 2.05±0.11 | 1.66±0.47 | 2.69±0.28 | 0.64±0.35 | 0.91 |
| L diet | 1.70±0.11 | | | | 0.89 |

$R^2$ refers to the equation of the highest degree.
[a] The allometric equation of the third degree is significant ($P < 0.05$).

tions resulting from adipose tissue weight, and to detect differences among breeds or sex in relation to the muscle:bone ratio. Table 2 shows the allometric parameters of TSM and TSF as a proportion of TSB. While the average allometric coefficients of TSF differed between the diets, the coefficients of TSM were identical, in contrast with the results obtained in relation to CSW (Table 1). Therefore the feeding reduction here undertaken did not compromise muscular development relative to skeletal growth in Chianina young bulls. Fortin et al. (1981), in Angus and Holstein bulls also found that differences caused by feeding level on the fat growth rate in relation to the whole carcass were accentuated when compared with the defatted carcass, but such differences on the muscle growth rate were removed. The average growth coefficient of TSM was higher than that of a breed pool (Berg et al., 1978) and of Hereford and Beef Synthetic (Shahin and Berg, 1985), but it was lower than that of Double Muscled (Shahin and Berg, 1985). Moreover, while the allometric relationships of the tissues relative to CSW were of the first degree (Table 1), the relative growth of TSM with both diets, and of TSF with the H diet, was better described by a logarithmic equation of the third degree when related to TSB (Table 2 and Fig. 2). The instantaneous allometric coefficient $(dY/Y)/(dX/X)$ of both tissues varied according to a parabolic trend over the developmental range, increasing in the first phase but declining at higher TSB weights. The maximisation of the function $(dY/Y)/(dX/X)$ occurred at about 22.1 and 23.4 kg of TSB (corresponding to 340 and 360 days of age) respectively for TSM (1.34) and for TSF on the

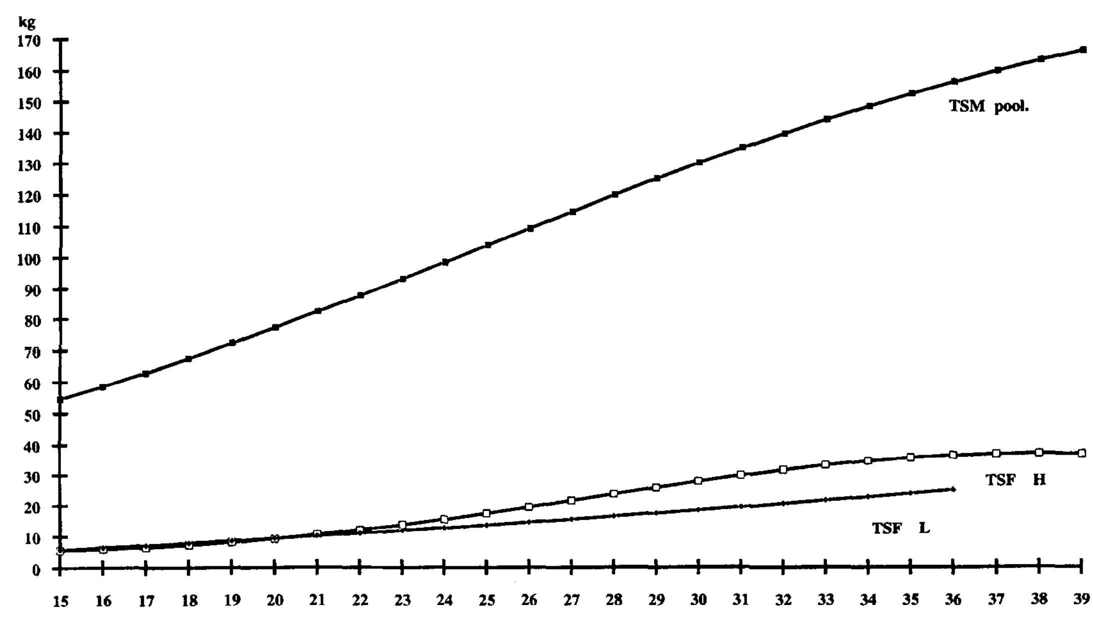


Fig. 2. Growth patterns of TSM and TSF in relation to TSB ($X$) TSMpool = $10^{(291.33 - 200.44 \log X + 46.442(\log X)\hat{}2 - 3.5633(\log X)\hat{}3)}$, TSF H = $10^{(1835.4 - 1263.17 \log X + 289.764(\log X)\hat{}2 - 22.1052(\log X)\hat{}3)}$, TSF L = $10^{(-3.328 + 1.696 \log X)}$.

Table 3
Average allometric coefficients of TSM and TSF weight in relation to TSB weight at various growth periods

| Period (month) | TSM | | TSF | |
|---|---|---|---|---|
| | H diet | L diet | H diet | L diet |
| 6–12 | 1.20±0.08 | 1.13±0.09 | 2.00±0.21 | 1.79±0.22 |
| 6–14 | 1.21±0.06 | 1.17±0.07 | 2.30±0.20 | 1.71±0.21 |
| 6–16 | 1.24±0.06 | 1.25±0.06 | 2.43±0.18 | 1.80±0.18 |
| 6–18 | 1.28±0.05 | 1.29±0.05 | 2.51±0.16 | 1.80±0.15 |
| 6–20 | 1.24±0.05 | 1.23±0.04 | 2.32±0.14 | 1.77±0.13 |
| 6–22 | 1.21±0.04 | 1.21±0.04 | 2.14±0.12 | 1.74±0.12 |
| 6–24 | 1.19±0.04 | 1.21±0.04 | 2.05±0.11 | 1.70±0.11 |

H diet (2.94). With the L diet, however, the growth coefficient of TSF remained constant (no significant deviation from linearity). No such pattern has been reported in previous studies on beef cattle, because few authors have investigated changes in the relative growth rate, or because the period they examined was too short (e.g. Robelin et al., 1977). However, multiphasic growth is well documented and studied in a number of species (Grossman and Koops, 1988; Koops, 1989; Koops and Grossman, 1991), and a third degree logarithmic equation has been employed to describe the relative growth of some traits in pigs from birth to maturity (Walstra, 1980). The wide range of live weight found in the present study can therefore explain the need for higher degree equations, yet it is remarkable that the decrease in the relative growth rate of muscle and fat relative to bone weight should contradict the classic pattern of development of the tissues. This result is due to the in vita performance of Chianina bulls (Giorgetti et al., 1995). With both diets the daily dry matter intake increased markedly up to 12 months of age but levelled off again after 18 months. Consequently the BW growth rate declined progressively, especially after 18 months of age and in the H diet bulls, which were 70 kg heavier than the L bulls at that age and therefore had a greater energy expense for maintenance. The pattern of development of the major tissues indicated that bone growth remained a priority up to 24 months in Chianina bulls, and the classical gradient of development was confirmed only when the energy intake allowed the later developing tissues to express their growth potential as well. The decrease of DWG with aging was therefore caused not by the increasing allocation of energy to fat build-up, but simply by a lack of nutrients for growth. It is likely that the use of an even more concentrated diet at the more mature growth stages would allow the expression of the maximum potential of muscular growth in the Chianina bull.

To better explain this phenomenon, the allometric relationship of TSM and TSF relative to TSB was examined at intervals from six months to various ages according to the experimental design (Table 3). The average growth rate of TSM with both diets and of TSF with the H diet was found to increase up to 18 months and to decline thereafter. Up to the age of 18 months neither the TSM nor the TSF equation deviated from linearity, indicating that any variation in relative growth occurred only at a later age. With the diets employed Chianina bulls therefore attained their maximum performance in terms of muscle:bone ratio at about 18 months of age.

Table 4 shows the equations used to estimate carcass and tissue proportions in relation to the BW of six-month-old calves, obtained from the eight subjects slaughtered at the start of the trial. The low levels of some $R^2$ values (mainly for percentage of fat) are due to the limited variability of those data, expressed as percentages, but basically the rsd values were also rather low. However, in analogous experi-

Table 4
Equations of carcass and tissues incidence on body weight in calves at the beginning of the trial (8 subjects)

| | Equation | Rsd | $R^2$ |
|---|---|---|---|
| Carcass/BW (%) | $= 82.87 - 0.487 * \mathrm{HP} + 0.238 * \mathrm{CG}$ | 2.30 | 0.74 |
| Lean/BW (%) | $= 57.70 + 0.0125 * \mathrm{BW} - 0.411 * \mathrm{HP} + 0.192 * \mathrm{CG}$ | 0.61 | 0.80 |
| Fat/BW (%) | $= 2.31 + 0.0066 * \mathrm{BW}$ | 0.39 | 0.21 |
| Bone/BW (%) | $= 26.9 - 0.0081 * \mathrm{BW} - 0.074 * \mathrm{AGE}$ | 0.43 | 0.80 |

BW = body weight in kg. AGE in days. HP = height at pelvis in cm. CG = chest girth in cm.

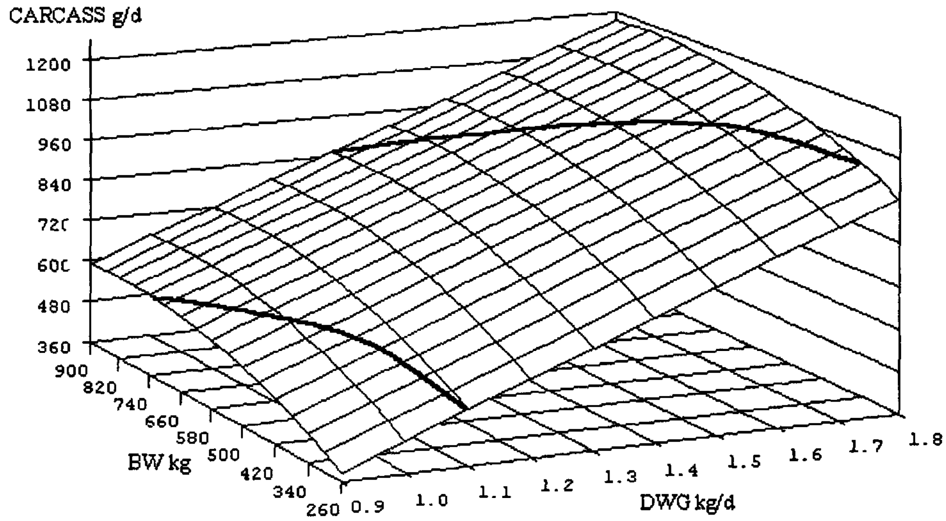


Fig. 3. The relationship between average daily carcass gain, average daily body weight gain and body weight.

ments, Toelle et al. (1986) estimated the rate of tissue gain by using the total weight of tissue at slaughter divided by the time from 70 days (start of trial) until slaughter, without considering the initial body composition; while Korver et al. (1987) adjusted tissue gain on the basis of estimated amount of tissue at the start of the growing period by assuming that the initial dressing percentage and the tissue proportions relative to BW had always remained constant. In contrast, our results indicated that, at least in Chianina calves older than 70 days, carcass or tissues proportions were sensitive to BW, age, and morphological proportions expressed by two measurements, and that the suggested equations improved the estimates of body composition.

Table 5 shows the parameters of the regression equations for average daily gain of carcass and tissues on BW, as well as average daily weight gain. As specified in Section 2, in this analysis the diet effect was not considered since any such effects

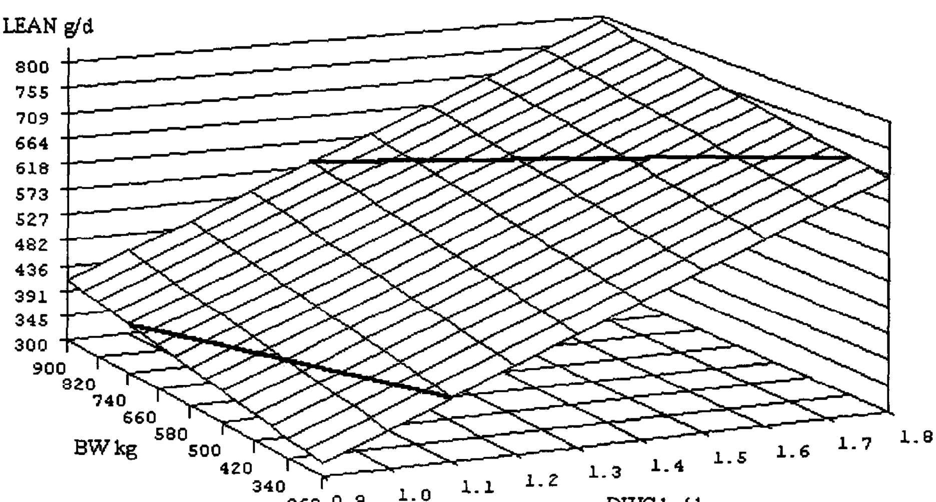


Fig. 4. The relationship between average daily lean gain, average daily body weight gain and body weight.

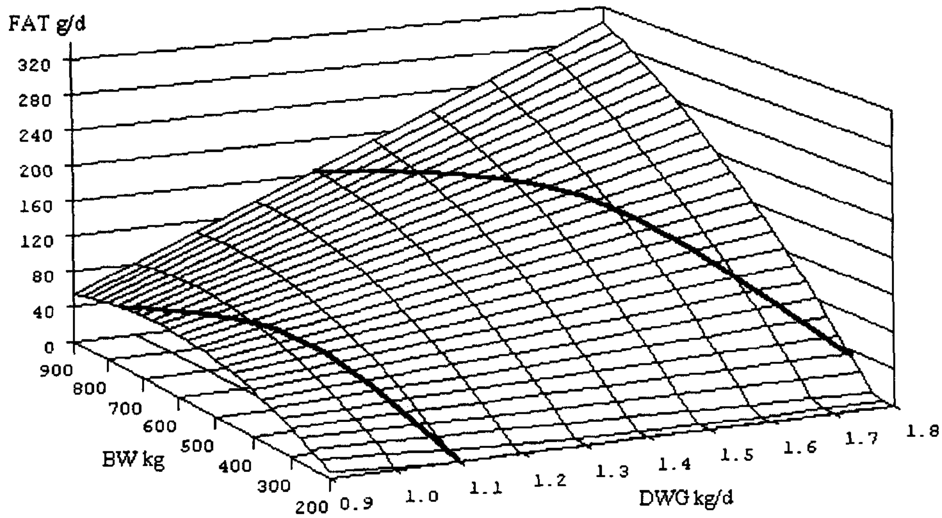


Fig. 5. The relationship between average daily fat gain, average daily body weight gain and body weight.

were assumed to have been entirely absorbed by individual differences in the DWG. Figs. 3–6 graphically represent the relative response surfaces. To interpret the graphs it must be considered that average DWGs ranged from 1100 to 1800 g at 8 months of age and from 900 to 1300 g at 24 months. The corresponding BWs were 250–350 kg and 720–900 kg at the two ages.

Only the average daily gain of lean was linear with both independent variables (Fig. 4). Daily gain of lean in Chianina bulls increased by 424 g per kg of DWG and improved as BW increased (13.5 g/100 kg BW). Carcass daily gain was 648 g/kg DWG and also increased with BW, mainly during the first stage of development, as indicated by the negative partial coefficient of the second degree (Fig. 3). For

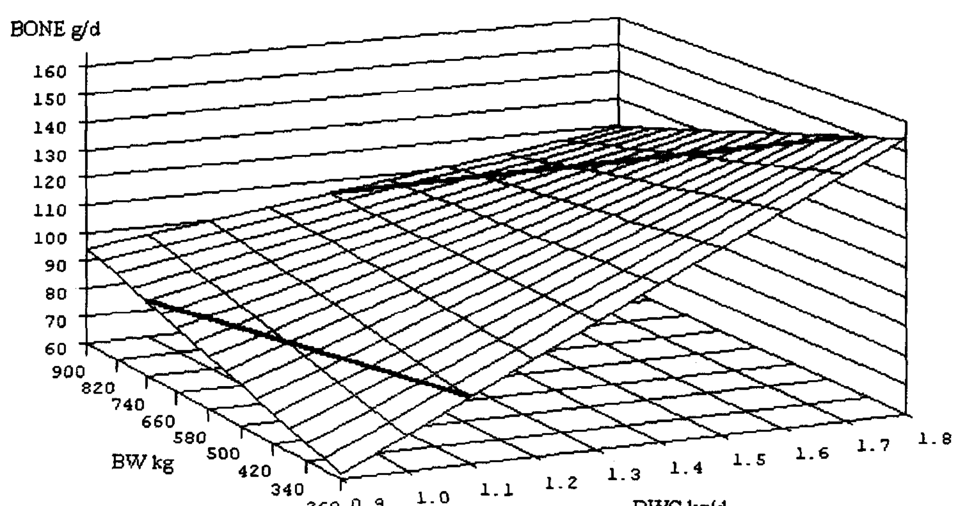


Fig. 6. The relationship between average daily bone gain, average daily body weight gain and body weight.

Table 5
Parameters of regression equations for average daily gain (g) of carcass and tissues in relation to body weight (BW in kg) and daily weight gain (DWG in kg) according to a general model $Y = a + b_1 * \mathrm{BW} + b_2 * \mathrm{DWG} + c_1 * (\mathrm{BW})^2 + c_2 * (\mathrm{DWG})^2 + d * (\mathrm{BW} * \mathrm{DWG})$

| | $a$ | $b_1$ | $b_2$ | $c_1$ | $d$ | Rsd | $R^2$ |
|---|---|---|---|---|---|---|---|
| Carcass | −436.6 | 1.09 | 648 | −0.00066 | | 58.4 | 0.83 |
| | | (0.29) [a] | (36) | (0.00024) | | | |
| Lean | −93.35 | 0.135 | 424 | | | 48.6 | 0.75 |
| | | (0.038) | (30) | | | | |
| Fat | 57.04 | −0.011 | −131 | −0.0003 | 0.453 | 27.7 | 0.65 |
| | | (0.204) | (62) | (0.00012) | (0.109) | | |
| Bone | −70.94 | 0.156 | 133 | | −0.117 | 12.0 | 0.59 |
| | | (0.058) | (27) | | (0.047) | | |

The $c_2$ coefficient never attained significance.
[a] s.e.

the average daily gain of fat (Fig. 5) and bone (Fig. 6) the significance of the interaction BW∗DWG is noticeable, positive for fat and negative for bone; this complicates the interpretation of the individual partial regression coefficients. An analogous study was performed by Toelle et al. (1986) and Korver et al. (1987) on bull progenies of several dairy and beef cattle breeds from 320 to 560 kg BW. In the first of these studies, Toelle et al. (1986), the lean daily gain was always in relation to DWG and was influenced by the interaction BW∗DWG in all sire-breed groups, excluding Charolais–Piedmontese for which, however, BW was not important either. The fat gain, instead, was influenced in a sporadic manner across the breed group and no curvilinearity of the response surface was found. Working on the same data, Korver et al. (1987) found that the interactions between BW and DWG were important only in the medium sized dual-purpose breeds as predictors of average daily fat gain. Even if comparisons with these studies must be made with caution because of experimental differences (mainly the duration of the developmental test period), on the whole, the Chianina bull behaved in a manner similar to that of Charolais–Piedmontese group in not showing an interaction BW∗DWG in lean gain. Unlike those breeds, however, Chianina increased its average daily lean gain as BW increased.

The figures show that in any case the Chianina breed is well suited for meat production. The grower-finisher operator can expect a strong daily lean growth even at the higher liveweights, despite the natural decrease in the average daily gain, and this allows him to decide on a slaughter weight in response to economic parameters under quite volatile market conditions. High average daily growth rates at low liveweights, or slow and delayed growth rates leading to a heavy BW favour daily bone weight gain, which is however relatively less important for the high growth rates obtained at the high BW. Conversely daily fat gain responds positively to this interaction, but is slow when the BW is low regardless of the growth rate, and at high BW when the growth rates are rather modest (about 1 kg of ADG).

## 4. Conclusion

The relative growth rate of the major tissues in Chianina bulls in relation to CSW confirmed the classic pattern of development and did not change from 6 to 24 months of age, despite the long duration of the developmental test period. Relative growth of bone was not sensitive to the different diets which did, however, influence lean and fat development. In relation to TSB, on the other hand, there were clear variations in the average allometric coefficients of TSF and TSM, which declined after 18 months of age, probably because of the lower availability of nutrients for growth as a result of the levelling off of feed intake and the increase in body mass. At that age, therefore, with the employed diets, Chianina bull attained its maximum lean to bone ratio. Moreover, it was also evident that skeletal growth remained a priority even with a high BW, confirming the late development of this breed. Average daily lean gain increased not only with average weight gain, but also with BW, showing that Chianina young bulls can profitably be slaughtered even at a very high live weight.

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