# The effect of compensatory growth on feed intake, growth rate and efficiency of feed utilization in sheep

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Sixty Merino lambs were randomly allotted to one of six feeding levels. The feeding levels were: *ad libitum* (control) and 0,82; 0,72; 0,65; 0,55 and 0,45 of *ad libitum*. Feeding levels were calculated from the average weekly feed intake of the *ad libitum* group. From 25 to 33 kg live mass, the lambs received restricted feeding except for the control group. At 33 kg live mass, half of each group were slaughtered, whilst the remainder were fed *ad libitum* up to 45 kg live mass when they were slaughtered. The 0,55 and 0,45 groups were prematurely put on *ad libitum* at 31 and 28 kg live mass respectively because the *ad libitum* group reached 45 kg live mass before the 0,55 and 0,45 groups reached 33 kg live mass. Individual feed intakes and live masses were determined weekly. With the aid of the allometric-autoregression model, daily feed intake, growth rate and efficiency of feed utilization were calculated during the restriction and realimentation phases. During the restriction phase digestibility of the diet increased, whereas growth rate and efficiency of feed utilization decreased progressively with increasing restriction. During the realimentation phase there were progressive increases in feed intake, growth rate and an improvement in feed utilization from the 0,65 and to the *ad libitum* group. More severe restrictions decreased feed intake, growth rate, and efficiency of feed utilization progressively.

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Sestig Merino lammers is ewekansig aan een van ses voedingspeile toegeken. Die voedingspeile was *ad libitum* (kontrole) en 0,82; 0,72; 0,65; 0,55 en 0,45 van *ad libitum*. Die voedingspeile is vanaf die gemiddelde weeklikse voerinname van die *ad libitum*-groep bereken. Vanaf 25 tot 33 kg lewende massa het die lammers, behalwe die kontrolegroep, beperkte voeding ontvang. Op 33 kg lewende massa is die helfte van elke groep geslag en is die res op *ad libitum* tot op 45 kg lewende massa geplaas waarna hulle geslag is. Die 0,55- en 0,45-groepe is voor 33 kg lewende massa op onderskeidelik 31 en 28 kg lewende massa op *ad libitum* geplaas aangesien die *ad libitum*-groep 45 kg lewende massa bereik het voordat eersgenoemde groepe 33 kg lewende massa bereik het, en toe geslag is. Individuele voerinnames en massas is weekliks bepaal. Met behulp van die allometriese-outoregressiemodel is daaglikse voerinnames, groeitempo's en doeltreffendheid van voerverbruik gedurende die beperkings- en realimentasiefase beraam. Soos voerinnamebeperking gedurende die beperkingsfase toegeneem het, het die verteerbaarheid van die dieet verhoog. Groeitempo en doeltreffendheid van voerverbruik het daarenteen afgeneem. Gedurende die realimentasie-fase was daar 'n progressiewe verhoging in voerinname, groeitempo en doeltreffendheid van voerverbruik vanaf die 0,65- tot die *ad libitum*-groep. Meer drastiese beperkings het voerinname, groeitempo en doeltreffendheid van voerverbruik toenemend laat afneem.

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## Introduction

South Africa is a country regularly subjected to wide seasonal variation in both pasture quantity and quality. This may cause poor growth of young sheep, increased mortality and a delayed first mating of females. These effects can be reduced by supplementation but it is a costly procedure. Knowledge of the effects of feed restriction on growth rate and efficiency of feed utilization is important because the producer needs to manage his animals at the lowest possible cost. Normally after a time of feed restriction, restricted animals exhibit a growth rate higher than the growth rate of their unrestricted contemporaries. This effect has been termed compensatory growth (Bohman, 1955).

The effect of compensatory growth in animals has been reviewed by Wilson & Osbourn (1960) and Allden (1970). According to Thomson, Bickel & Schürch (1982), compensatory growth can be explained in terms of a reduction of maintenance requirements, a decrease in the energy value of the body mass gains, and an increased efficiency of feed utilization. Furthermore, increased appetite and its associated gutfill effects, are also important contributory factors.

Higher feed intake after a period of feed restriction has been reported in the majority of experiments (Wilson & Osbourn, 1960; McManus, Reid & Donaldson, 1972; Graham & Searle, 1975), though not in all. The reports of Meyer & Clawson (1964), Allden (1968) and Drew & Reid (1975) are notable exceptions.

Andersen (1975) reported that most experiments with cattle indicate more efficient feed conversion on restricted feeding compared with *ad libitum* feeding. Meissner, Hofmeyr & Roux (1977) found the same effect in sheep and detected a change in composition of growth, which indicate that more protein but less fat was deposited. Meyer & Clawson (1964) found an increase in efficiency of feed utilization during the realimentation phase but also found that restricted lambs and mice became fatter than normal. These results agree with the conclusion of Wilson & Osbourn (1960). However, other workers found increased protein deposition in sheep (Keenan, McManus & Freer, 1969; Reid, Bensadoun, Bull, Burton, Gleeson, Han, Joo, Johnson, McManus, Paladines, Stroud, Tyrrell, van Niekerk & Wellington, 1968; McManus, *et al.*, 1972; Drew & Reid, 1975). These contradictions may possibly arise from the different restriction periods applied by the various researchers. Different protein levels (Ørskov, 1977) as well as the fact that animals of different ages were used, could also have been a contributing factor. A further contributing factor is that different breeds of animals were used, among which the large differences between ages of maturity may play a part. However, there is still disagreement concerning the involvement of some causal factors. According to the ARC (1980) this problem needs further elucidation.

For these reasons an experiment was conducted to study the effect of various feeding levels on feed intake, growth rate, and efficiency of feed utilization during restriction and realimentation.

## Material and Methods

### Design and Diet

This has been described by Greeff, Meissner, Roux & Janse van Rensburg (1986).

A clear break in feed intake of the *ad libitum* group occurred at about 33kg live mass. Possible reasons for this phenomenon are discussed later. See also Greeff, Meissner, Roux & Janse van Rensburg (1986).

### Animal management

Sixty Merino lambs of about 6 months of age were inoculated against enterotoxaemia and dewormed with a broad spectrum anthelmintic. Lambs were housed in individual pens, from about 2 weeks prior to the beginning of the experiment, until slaughter.

Animals were fed individually and the allocated amount of feed of each group was weighed out at the beginning of each week. Daily amounts of feed were given to restricted groups in two equal portions. Drinking water was freely available.

It was thus necessary to fit separate regression equations for the *ad libitum* group during the restriction and realimentation phases. Certain lambs of the 0,55 and 0,45 *ad libitum* groups showed no mass increase at the beginning of the experiment. These lambs only showed a mass increase at about 4 – 6 weeks after the beginning of the experiment. As these lambs stayed at a constant mass, it was concluded that they were fed at maintenance. Thus it was decided to use only the data of the growth phase following the maintenance phase for statistical analysis.

### Digestibility of the diet

As lambs were fed different feeding levels, differences in digestibility of the diet were expected. Thus the digestibility of the diet was determined *in vivo*. Lambs were distributed at random between weeks of faeces collections, with each lamb completing at least three periods of collection before slaughter.

### Statistical analysis

Statistical analyses are based on the allometric relationships between cumulative digestible energy (DE) intake and body mass until slaugher, as an animal at any given time is the product of all the feed previously consumed. An estimate of feed intake from conception to 25 kg live body mass was calculated from the slope ($b$) and intercept ($a$) of ln(body mass) against ln(cumulative feed intake) of lamb W15 of Meissner (1977).

The allometric equation to describe growth is given by

$$y = ax^b \qquad \ldots 1$$

or

$$\ln y = \ln a + b \ln x$$

where $y$ = body mass or any component of the body and $x$ = cumulative feed intake.

Roux (1976) showed that ln(cumulative feed intake) and ln(body mass) or ln(component of body mass) described a straight line when measured in temporal sequence on the same animal or group of animals. In statistical terms, all the information is then incorporated in the slope ($b$) and the intercept ($a$). According to Roux (1981), it is normally an optimal procedure to use cumulative feed intake as the independent variable, $x$, as $x$ is measured with a small relative error compared to body mass. Ordinary statistical tests could be applied to these parameters and differences between groups were established by means of an analysis of variance procedure (Snedecor & Cochran, 1967).

From the regression parameters, $a$ and $b$, the efficiency of feed utilization can be estimated by differentiating the allometric equation

$$y = ax^b \qquad \ldots 2$$

$$\text{then } dy/dx = abx^{b-1}$$

$$dy/dx = b.y/x \qquad \ldots 3$$

$$dx/dy = 1/b.x/y \qquad \ldots 4$$

Roux (1976) also indicated that growth against time can be described by the equation

$$y(t) - \alpha = \rho\,\{y(t-1) - \alpha\} + \varepsilon(t) \qquad \ldots 5$$

or

$$y(t) = \alpha - \{\alpha - y(0)\}\,\rho^t + \sum_{j=0} \rho^j\,\varepsilon\,(t-j) \qquad \ldots 6$$

where $y(t)$ = ln (mass) at time $t$; $y(0)$ = ln (mass) at time (0); $\rho$ = slope of the autoregression; $\alpha$ = limit mass (assumed equivalent to mature size); $\varepsilon$ = error term.
As $t \rightarrow \infty$ then $y \rightarrow \alpha$ if $|\rho| < 1$

A similar equation holds for $x$ (cumulative feed intake). From Roux (1981) it can be expected that the autoregression slopes of all the components of body mass will be the same.

The regression parameters $a$ and $b$ were calculated from the regression of ln(live body mass) as the dependent variable against ln(cumulative DE intake) as the independent variable. The slope of the autoregression, $\rho$ was calculated from ln(cumulative DE intake).

In the following equation alpha ($\alpha$) is estimated from the intercept ($a$) and slope ($\rho$) of the autoregression from

$$\alpha = a/(1-\rho)$$

As cumulative feed intake from conception until the beginning of the experiment is unknown, it had to be estimated. The slope and intercept of ln(body mass) against ln(cumulative feed intake) of lamb W15 of Meissner (1977) were used to determine a cumulative DE intake at the start of the experiment. A precise value is not essential as the relative error decreases quite rapidly as cumulative DE intake increases.

Statistical parameters obtained are presented in Table 1. Where no significant differences between treatments in these parameters were found, pooled values were used.

## Results and Discussions

### Apparent digestibility of the diet

The digestibility values of each lamb were pooled and subjected to variance analysis. Average values for each group during the restriction and realimentation phases are indicated in Table 2.

Highly significant differences ($P < 0,01$) were found between feeding levels during the restriction phase. Digestibility increased as feeding level decreased, probably caused by a longer retention time in the rumen. This also indicates that lambs of different groups consumed different amounts of digestible energy. Hence, the data were analysed in terms of

**Table 1** Intercept (*a*) and slope (*b*) of ln(body mass) against ln(cumulative DE intake), slope (ρ) of the autogression of ln(cumulative DE intake) and $\alpha_f$, the logarithm of cumulative DE intake at limit mass for each treatment during the restriction and realimentation phases.

| Treatment | | Parameter | | | |
|---|---|---|---|---|---|
| | | *a* | *b* | ρ | $\alpha_f$ |
| *Ad libitum* | 1* | 0,6417 | 0,3915$^c$ | 0,8903 | 7,8229 |
| | 2* | −0,2076 | 0,5041 | 0,9583 | 8,7423 |
| 0,82 *ad lib.* | 1 | 0,6107 | 0,3915$^c$ | 0,9204 | 7,8229 |
| | 2 | −0,7201 | 0,5717 | 0,9583 | 8,7423 |
| 0,72 *ad lib.* | 1 | 0,8271 | 0,3561 | 0,9377 | 7,9637 |
| | 2 | −0,7142 | 0,5717 | 0,9438 | 8,4384 |
| 0,65 *ad lib.* | 1 | 0,7832 | 0,3561 | 0,9552 | 8,1876 |
| | 2 | −1,5259 | 0,6735 | 0,9438 | 8,7423 |
| 0,55 *ad lib.* | 1 | 0,7384 | 0,3561 | 0,9702 | 8,3405 |
| | 2 | −1,5726 | 0,6735 | 0,9302 | 8,4384 |
| 0,45 *ad lib.* | 1 | 1,4995 | 0,2439 | 0,9702 | 8,3405 |
| | 2 | −0,5827 | 0,5468 | 0,9438 | 8,4384 |

* 1 = Restriction phase; 2 = Realimentation phase; $^c$ Where no significant differences were found between treatments, the data were pooled and a common parameter calculated.

**Table 2** Energy digestibility (DE) of the diet of the different treatments during the restriction and realimentation phases

| Treatment | Restriction phase ($F$ = 19,1) $\bar{X} \pm SE$ | Realimentation phase ($F$ = 0,7) $\bar{X} \pm SE$ |
|---|---|---|
| *Ad libitum* | 73,3$^a$ ± 0,69 | 73,3$^a$ ± 0,98 |
| 0,82 *ad lib.* | 74,2$^{ab}$ ± 1,23 | 74,2$^a$ ± 0,49 |
| 0,72 *ad lib.* | 74,5$^{ab}$ ± 0,60 | 74,6$^a$ ± 0,63 |
| 0,65 *ad lib.* | 75,6$^{bc}$ ± 0,22 | 74,6$^a$ ± 0,89 |
| 0,55 *ad lib.* | 75,8$^{bc}$ ± 0,38 | 74,3$^a$ ± 0,49 |
| 0,45 *ad lib.* | 76,2$^c$ ± 0,47 | 74,3$^a$ ± 0,80 |

$^{abc}$Means in the same column that do not have a common superscript differ significantly ($P < 0,05$)

digestible energy (DE) units. During the realimentation phase no significant differences in digestibility of the diets were found between treatments.

## Duration of experiment

The times taken for each group to complete the restriction and realimentation phases are indicated in Table 3. As the level of restriction increased, it took progressively longer to complete the restriction phase. It should be kept in mind that unlike the other four groups the 0,55 and 0,45 *ad libitum* groups did not complete the total restriction phase but only reached 31 and 28 kg live mass, respectively, when they were put on *ad libitum* feed intake. This resulted in these two groups having had to grow an additional 2 and 5 kg respectively, above that of the *ad libitum* and 0,82; 0,72 and 0,65 *ad libitum* groups which only had to put on 12 kg to reach 45 kg livemass. The general tendency during the realimentation phase was that as the previously imposed restriction increased, the time to complete the realimentation phase decreased up to the 0,65 *ad libitum* group whereafter it increased.

**Table 3** Average time to complete the restriction and realimentation phases for the different treatments

| Phase | Treatment | Mass range to complete phase (kg) | Time ± *SE* (days) |
|---|---|---|---|
| Restriction | *Ad libitum* | 25 − 33 | 58,4$^a$ ± 4,2 |
| | 0,82 *ad lib.* | 25 − 33 | 79,8$^b$ ± 4,3 |
| | 0,72 *ad lib.* | 25 − 33 | 98,0$^c$ ± 4,7 |
| | 0,65 *ad lib.* | 25 − 33 | 127,4$^d$ ± 4,4 |
| | 0,55 *ad lib.* | 25 − 31 | 147,0$^e$ ± 2,5 |
| | 0,45 *ad lib.* | 25 − 28 | 142,1$^f$ ± 1,1 |
| Realimentation | *Ad libitum* | 33 − 45 | 103,8$^a$ ± 6,1 |
| | 0,82 *ad lib.* | 33 − 45 | 93,8$^{ab}$ ± 5,7 |
| | 0,72 *ad lib.* | 33 − 45 | 72,8$^{bc}$ ± 15,1 |
| | 0,65 *ad lib.* | 33 − 45 | 51,8$^{bc}$ ± 11,8 |
| | 0,55 *ad lib.* | 31 − 45 | 70,0$^{bc}$ ± 6,3 |
| | 0,45 *ad lib.* | 28 − 45 | 114,8$^a$ ± 10,0 |

$^{abcdef}$Means in the same column within phases that do not have a common superscript differ significantly ($P < 0,05$)

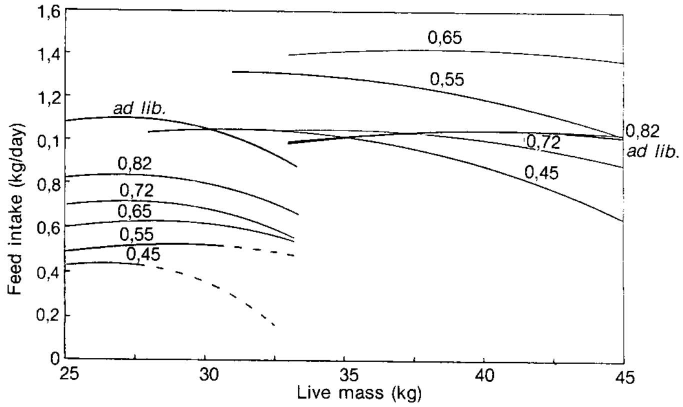

**Figure 1** Feed intake levels during the restriction and realimentation phases

## Feed intake

Feed intake during the restriction and realimentation phase of the different treatments, at different body masses, calculated from the allometric autoregression model is indicated in Figure 1, while the direct averages and their standard errors are indicated in Table 4. However, discussion will be based on the graphs.

It is clear that feed intake during the restriction phase was rather low for the restricted groups. During the realimentation phase an increase in feed intake occurred in all restricted groups. The feed intake pattern of the *ad libitum* group showed a clear break at about 33 kg live mass. The most likely cause for this phenomenon is that season had a significant influence on appetite and efficiency of feed utilization. Greeff (1984) and Greeff, Meissner & Roux (1984) indicated that this was the case in lambs of the same experiment which received *ad libitum* feed intake for the complete duration of the experiment. Blaxter & Boyne (1982) showed that season can affect fasting metabolic rate in sheep. They indicated that fasting metabolism reached a maximum at about midsummer and a minimum at about midwinter. Webster, Smith & Mollison (1982) also presented evidence that metabolism in cattle may change with season. Thus, it was postulated that the 0,82 and 0,72 *ad libitum* groups were affected by the same phenomenon, as the feed intake pattern of these two groups showed the same tendency of a break in feed intake, coinciding with that of the *ad libitum* group.

During the restriction phase, the *ad libitum* group had the highest feed intake of 1,15 kg at a live body mass of about 27 kg, while during the realimentation phase nearly the same

**Table 4** Average daily feed intake, growth rate and efficiency of feed utilization during the restriction and realimentation phases

| Treatment | $n$ | Feed intake (kg/day) ($\bar{x} \pm SE$) | Growth rate (kg/day) ($\bar{x} \pm SE$) | Efficiency of feed utilization ($\bar{x} \pm SE$) |
|---|---|---|---|---|
| Restriction phase | | | | |
| *Ad libitum* | 10 | $0{,}967^{a} \pm 0{,}009$ | $0{,}144^{a} \pm 0{,}004$ | $0{,}148^{a} \pm 0{,}003$ |
| 0,82 *ad libitum* | 10 | $0{,}790^{b} \pm 0{,}002$ | $0{,}101^{b} \pm 0{,}002$ | $0{,}131^{b} \pm 0{,}002$ |
| 0,72 *ad libitum* | 10 | $0{,}695^{c} \pm 0{,}001$ | $0{,}081^{c} \pm 0{,}001$ | $0{,}119^{b} \pm 0{,}002$ |
| 0,65 *ad libitum* | 10 | $0{,}619^{d} \pm 0{,}001$ | $0{,}060^{d} \pm 0{,}001$ | $0{,}098^{c} \pm 0{,}002$ |
| 0,55 *ad libitum* | 10 | $0{,}534^{e} \pm 0{,}002$ | $0{,}045^{e} \pm 0{,}001$ | $0{,}085^{cd} \pm 0{,}001$ |
| 0,45 *ad libitum* | 10 | $0{,}424^{f} \pm 0{,}000$ | $0{,}030^{f} \pm 0{,}001$ | $0{,}072^{d} \pm 0{,}002$ |
| Realimentation phase | | | | |
| *Ad libitum* | 5 | $1{,}187^{a} \pm 0{,}014$ | $0{,}119^{a} \pm 0{,}003$ | $0{,}124^{a} \pm 0{,}003$ |
| 0,82 *ad libitum* | 5 | $1{,}208^{ac} \pm 0{,}007$ | $0{,}140^{ab} \pm 0{,}004$ | $0{,}132^{a} \pm 0{,}005$ |
| 0,72 *ad libitum* | 5 | $1{,}282^{ac} \pm 0{,}039$ | $0{,}144^{ab} \pm 0{,}011$ | $0{,}131^{a} \pm 0{,}007$ |
| 0,65 *ad libitum* | 5 | $1{,}481^{b} \pm 0{,}034$ | $0{,}210^{c} \pm 0{,}011$ | $0{,}156^{a} \pm 0{,}007$ |
| 0,55 *ad libitum* | 5 | $1{,}385^{a} \pm 0{,}014$ | $0{,}162^{b} \pm 0{,}006$ | $0{,}144^{a} \pm 0{,}005$ |
| 0,45 *ad libitum* | 5 | $1{,}188^{c} \pm 0{,}030$ | $0{,}109^{a} \pm 0{,}007$ | $0{,}126^{a} \pm 0{,}004$ |

$^{abcdef}$Means in the same column within phases that do not differ significantly ($P < 0{,}05$) from each other have the same superscript.

feed intake occurred only at a live body mass of 42 kg.

The 0,82 *ad libitum* group's feed intake increased up to that of the *ad libitum* group, whilst the 0,72 *ad libitum* group had a slightly higher feed intake than that of the *ad libitum* group. Daily feed intake increased from about 0,60 kg up to 1,4 kg, a 133% increase, and remained constant until 45 kg live mass.

The 0,55 *ad libitum* group also showed a dramatic increase in feed intake from about 0,45 kg up to 1,3 kg feed at a body mass of 31 kg. Feed intake declined as this group increased in body mass, with the result that they had the same feed intake as the *ad libitum* and 0,82 *ad libitum* groups at 45 kg live mass.

The 0,45 *ad libitum* group showed a significant increase in feed intake from about 0,40 kg at 28 kg body mass, up to 1,1 kg, but which is still lower than the *ad libitum* group. Thus this group showed no signs of compensatory growth. From about 33 kg live mass feed intake declined as in the case of the 0,55 *ad libitum* group, and from 35 kg live mass had the lowest feed intake of all treatments. At 45 kg live mass, when slaughtered, they had an average feed intake of only about 0,70 kg per day.

These results agree with the general findings of Graham & Searle (1975), Wilson & Osbourn (1960), Allden (1968) and Thornton, Hood, Jones & Re (1979) that feed intake increases after a period of feed restriction. It also shows that it can be expected that an increase in feed intake will only occur after a restriction of about 0,82 *ad libitum*, whereafter feed intake will increase until a previous restriction of about 0,65 *ad libitum*. A restriction more severe than this, will result in a declined response in feed intake. Thus there appears to be upper and lower limits above and below which a previous restriction will not cause increased feed consumption.

## Growth rate

Figure 2 illustrates the growth rate calculated from the allometric-autoregression model and Table 4 indicates the averages obtained directly with their standard errors of the various treatments during the restriction and realimentation phases.

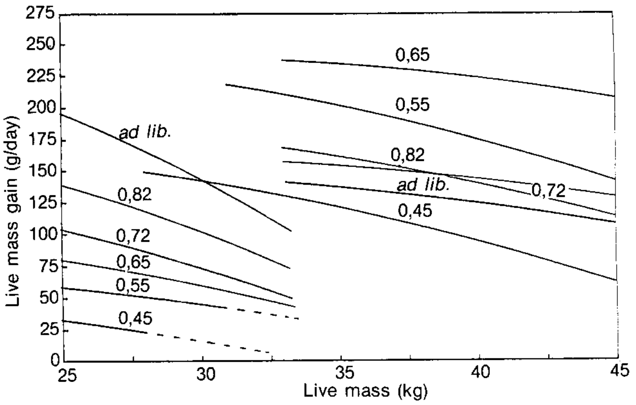

**Figure 2** Live mass gain at different feed intake levels during the restriction and realimentation phases

As the restriction increased, growth rate decreased, while during the realimentation phase there was an increase in growth rate, as the restriction during the restriction phase increased up to the 0,65 *ad libitum* group, whereafter it declined again. It is also noticeable that the growth rate of the 0,72 *ad libitum* group declined faster than that of the other restricted groups. This can be ascribed to the low limit mass calculated for this group which was used in equation 5. Interpretation of the data is complicated by the possible seasonal effect that occurred in the *ad libitum* and other groups. It is clear that all the restricted groups except the 0,45 *ad libitum* group showed compensatory growth during the realimentation phase. Increased appetite and its associated gut-fill effects were also important contributory factors responsible for compensatory growth especially at the beginning of the realimentation phase.

According to Wilson & Osbourn (1960), Brody (1926) demonstrated that growth, at least in the final stages, proceeds as if it were aiming to reach a certain mature size, and that the rate of growth is proportional to the growth remaining before mature size is reached.

Limit mass ($\alpha_m$) may be an indication of mature size. It can be calculated from

$$\alpha_m = a + b\,\alpha_f$$

where $a$ = intercept of body mass against cumulative feed intake; $b$ = slope of body mass against cumulative feed intake; and $\alpha_f$ = cumulative feed intake when limit mass is reached.

The limit mass of each treatment during the restriction and

**Table 5** Limit mass ($\alpha_m$) of the different treatments during the restriction and realimentation phases

| Treatment | Restriction phase ($\bar{X} \pm SE$) | Realimentation phase ($\bar{X} \pm SE$) |
|---|---|---|
| *Ad libitum* | $40{,}6^a \pm 0{,}95$ | $66{,}6^a \pm 4{,}38$ |
| 0,82 *ad libitum* | $39{,}4^a \pm 0{,}51$ | $72{,}1^a \pm 2{,}99$ |
| 0,72 *ad libitum* | $38{,}9^a \pm 0{,}28$ | $60{,}9^a \pm 2{,}32$ |
| 0,65 *ad libitum* | $40{,}4^a \pm 0{,}38$ | $78{,}4^a \pm 8{,}85$ |
| 0,55 *ad libitum* | $40{,}8^a \pm 0{,}76$ | $61{,}0^a \pm 1{,}47$ |
| 0,45 *ad libitum* | $34{,}3^b \pm 0{,}60$ | $56{,}3^a \pm 1{,}97$ |

$^{ab}$Means in the same column that do not have a common superscript differ significantly ($P < 0{,}05$)

realimentation phases is shown in Table 5. Although no significant differences were found during the realimentation phase it is clear that during the restriction and realimentation phases, the limit mass of the 0,45 *ad libitum* group was drastically reduced, especially during the restriction phase which affected this group's feed intake and growth rate.

### Efficiency of feed utilization

Efficiency of feed utilization for the restricted and realimentation phases is indicated in Figure 3 and the directly calculated means and standard errors are indicated in Table 4.

It is clear that as the restriction increased, efficiency of feed utilization declined. The 0,45 *ad libitum* group showed a dramatic decrease in feed utilization. At a live body mass of 27 kg, feed utilization was about 20 kg feed intake per kilogram mass gain.

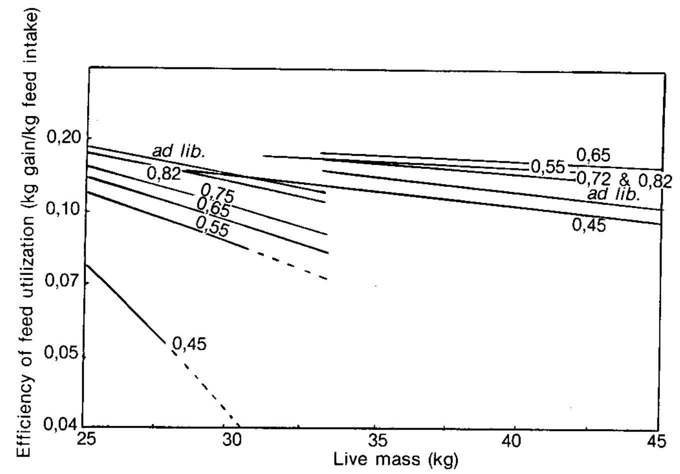

**Figure 3** Efficiency of feed utilization during the restriction and realimentation phases

During the realimentation phase, efficiency of feed utilization improved in all cases even in the *ad libitum* group. According to Greeff (1984), this was caused by the effect of season. Efficiency of feed utilization increased as the previously imposed restriction increased up to a restriction of 0,65 *ad libitum*. Hereafter efficiency declined up to that of the 0,45 *ad libitum* group which had a lower efficiency of feed utilization than the *ad libitum* group.

These results are in contrast to the results of Meyer & Clawson (1964), Allden (1968) and Jacobs (1972) which indicate that during realimentation gross efficiency of feed utilization is not influenced.

Only the data from the second week of the realimentation phase were used in the regression analysis. Average DE intake, body mass gains, and efficiency of feed utilization during the first week of the realimentation phase are indicated in Table 6. No significant differences were found between groups owing to the large variation within groups, especially with regard to body mass, but there was a clear increase in efficiency as the restriction increased, from 66,5 to 15,3 MJ/DE kg body mass gain from the *ad libitum* to the 0,45 *ad libitum* group. Rumen fill could have had an effect as Allden (1970) and Wilson & Osbourn (1960) proposed. An analysis of variance was done on the DE intake of the first week and no significant differences were found between groups, owing to the large variation within groups, but a definite increase in efficiency was found as Table 6 shows. The fact that the 0,82; 0,72; 0,65 and 0,55 *ad libitum* groups had about the same DE intake, while there was a noticeable increase in efficiency, indicates that, depending on the restriction, lambs reduce their fasting metabolic rate and that this effect is carried over to the realimentation phase. This agrees with the findings of Ørskov, McDonald, Grubb & Pennie (1976), Blaxter & Wood (1951) and Webster, *et al.* (1982). According to Graham & Searle (1975) this effect does not last longer than a week.

Lopez Saudibet & Verde (1976) indicated that one reason for compensatory growth was a reduction of maintenance requirements but they attributed this to the lower body mass in the beginning of the realimentation phase. This may have been a contributing factor for the 0,55 *ad libitum* group as this group was put on *ad libitum* at a live body mass of 31 kg body mass, but does not explain why the 0,65 *ad libitum* group had a better efficiency of feed utilization than the 0,55 *ad libitum* group (Figure 3).

An important question is whether efficiency over the whole

**Table 6** Digestible energy (DE) intake, body mass gain and efficiency of feed utilization during the first week of realimentation.

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| Item | *Ad lib.* | 0,82 *ad lib.* | 0,72 *ad lib.* | 0,65 *ad lib.* | 0,55 *ad lib.* | 0,45 *ad lib.* |
| Average DE intake (MJ) | 79,8 | 98,4 | 100,2 | 98,4 | 98,1 | 48,9 |
| *SE* | ±4,11 | ±4,11 | ±4,74 | ±5,69 | ±3,16 | ±4,43 |
| Average body mass gain (kg) | 1,2 | 1,7 | 2,0 | 2,9 | 3,3 | 3,2 |
| *SE* | ±0,22 | ±0,19 | ±0,35 | ±0,51 | ±0,38 | ±0,22 |
| Energy utilization (MJ DE/kg body mass gain) | 66,5 | 57,9 | 50,1 | 33,9 | 29,7 | 15,3 |
| Efficiency of feed utilization (kg body mass gain / kg feed intake) | 0,21 | 0,24 | 0,27 | 0,40 | 0,46 | 0,89 |

period from 25 to 45 kg was better for certain groups than for others. Table 7 indicates the feed conversion for the total period and was calculated from the actual DE intake of each group.

The 0,82 and 0,72 *ad libitum* groups showed a tendency towards better feed conversion than the *ad libitum* group but there were no significant differences between the *ad libitum*, 0,82, 0,72 and the 0,65 *ad libitum* groups. The efficiency of feed conversion in the 0,55 and 0,45 *ad libitum* groups was significantly lower than in the other four groups as indicated in Table 7. This agrees with the findings of Wilson & Osbourn (1960) and indicates that the advantage of an increase in efficiency during realimentation is completely eliminated by the reduced efficiency during the restriction phase.

**Table 7** Energy utilization (MJ DE intake/kg body mass gain) calculated for the total period from actual DE intake

| Treatment | Feed conversion (MJ DE intake/kg body mass gain) ($x$ ± *SE*) |
|---|---|
| *Ad libitum* | $104{,}08^{a} \pm 0{,}99$ |
| 0,82 *ad libitum* | $102{,}73^{a} \pm 3{,}13$ |
| 0,72 *ad libitum* | $102{,}69^{a} \pm 3{,}10$ |
| 0,65 *ad libitum* | $104{,}95^{a} \pm 3{,}23$ |
| 0,55 *ad libitum* | $113{,}78^{a} \pm 1{,}56$ |
| 0,45 *ad libitum* | $131{,}45^{a} \pm 1{,}49$ |

$^{ab}$Means with the same superscript do not differ significantly ($P < 0{,}05$)

Their results do not agree with the general trend described by Meissner (1983) that between a feed intake of *ad libitum* and 0,70 *ad libitum* there could be an improvement in efficiency of feed utilization above that of *ad libitum* feed intake. It does, however, indicate that when the restriction is more severe than 0,65 *ad libitum* it would inhibit production quite drastically and that it would not be an economically feasible practice to restrict animals to obtain an increased efficiency of feed utilization.

## Conclusion

An attempt has been made to elucidate the phenomenon of compensatory growth in sheep. It was found that compensatory growth only occurred after a previously imposed feed restriction of about 0,80 *ad libitum*.

Restrictions more severe than this increased the compensatory growth response until a restriction of 0,65 *ad libitum*. However, the compensatory growth response declined until a stage was reached when recovery in growth did not occur in relation to that of the *ad libitum* group. With a previously imposed restriction of 0,45 *ad libitum*, a drastic decline in feed intake, efficiency of feed utilization and thus growth rate, can be expected during realimentation. Mature size may also be permanently reduced. Thus it appears as if there are restriction limits above and below which a previous restriction will not cause increased feed consumption and growth rate.

Even though various researchers found no increase in efficiency of feed utilization during the realimentation phase, significant increases were found in this experiment which basically followed the same pattern as for growth.

It is concluded that sheep can be subjected to a feed restriction up to 0,65 *ad libitum* and will still recover completely after the feed restriction is lifted.

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