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The evolution of liveweight variance in angus steers and strategies for control

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ABSTRACT

The effect of year of birth and nutritional treatment on liveweight variance in mobs of Angus steers from birth until approximately 30 months-of-age is examined. Significant ($P < 0.01$) differences in liveweight variance at 30 months-of-age were recorded between years. The environment of the calves over the first 20 days of life appeared to affect the development of mob variance, steers which experienced early life on a sawdust pad showing higher variance at 30 months-of-age in liveweight and carcass weight. Restricted nutrition during the first winter of the steer's life was associated with a significantly ($P < 0.05$) higher variance in 30 month liveweight (standard deviation 24.0 *v* 37.8 kg). Within mob, lower rates of liveweight change were associated with an increase in liveweight variance ($r = -0.72$). A mathematical model was used to assess the effects of controlled mating strategies on mob variance. Minor improvements were possible.The implications of controlling mob variance for farm quality assurance management is discussed.

Keyword: Variance; cattle liveweights; quality assurance.

INTRODUCTION

The advent of on-farm quality assurance schemes has as a goal the delivery by the farmer of animals for slaughter which have a relatively uniform weight. That is, the standard deviation of the animal liveweight should be low. A uniform weight at slaughter provides advantages as modern distribution networks increasingly rely on a consistent product in order to function. For example, a restaurant may require steak size to be within certain limits in order to provide a customer with the service the customer seeks.

The demand for consistency drives the need for information on the factors affecting the size of the variance of liveweight in a group of animals. Agricultural science has provided extensive information on the effect of various factors on the mean of animal weight, while generally ignoring the factors effecting the size of the variance.

This paper reports the effect of a number of factors on the size of the liveweight variance in cattle raised for slaughter, and suggests some strategies which would assist in minimising the size of the liveweight variance at slaughter.

MATERIALS AND METHODS

The liveweights of Angus steers raised together from birth to slaughter over three consecutive years were examined. Year 1 consisted of 45 animals born in the spring of 1976 and raised on hill pasture at Tuapaka, Massey University's hill country property, until slaughter at 30 months of age. There were 20 animals from three year old dams and 25 animals from older mixed age cows. An early nutritional restriction was imposed on 26 of the calves from the mixed age dams by retaining them on a sawdust pad for between 20 and 40 days after birth. Thereafter both groups of steers were managed together until slaughter. The ration fed to the cows on the sawdust pad restricted their milk yield compared to their contemporaries managed on the hill pasture (Pleasants and Barton, 1985).

Year 2 consisted of 59 animals born in the spring of 1977 and raised at Tuapaka until slaughter. As in year 1 an early nutritional restriction was imposed on 36 animals by confining them to a sawdust pad with their dams for the first 20 days after birth. Thereafter both groups of steers were managed together until slaughter.

Year 3 consisted of 66 animals born in the spring of 1978 and raised on hill pasture at Tuapaka but divided into two nutritional treatments after weaning when the mob averaged 270 days of age and weighed 179 ± 2.1 kg. After 138 days on the trial the Steady (S) nutritional group weighed 242 kg and the Restricted (R) nutritional group weighed 218 kg. Over the following time until slaughter both groups were grazed together. All groups of steers were slaughtered together at an average age of 30 months.

The comparison of liveweight gain with the liveweight variance was made by using the liveweight gain calculated over the time interval preceding the liveweight measurement.

A mathematical model of a calving frequency distribution developed by Pleasants (1997) and extended to include the control of oestrus in cows by the use of CIDRs by Pleasants and Macmillan (1998) was used to study the utility of different mating strategies to control the variance in a group of animals by managing calf birthdate. Two strategies were examined. Mating for 2 oestrous cycles *v* mating for 3 oestrous cycles, and mating with CIDRs for 2 oestrous cycles *v* natural mating for 2 oestrous cycles. It was assumed that 95% of the cows would have 2 oestrous cycles in 47 days in naturally mated cows and in 28 days in cows treated with CIDRs.

Statistical analysis

The null hypothesis that two variance estimates, s_1^2 and s_2^2 are independent random samples from the same normally distributed population is tested by the ratio $\frac{s_1^2}{s_2^2}$

where s_1^2 is the larger estimate. Significance is established by referring values of this ratio to tables of the F distribution with the appropriate degrees of freedom for each estimate. (Snedecor and Cochran (1967). The correlation between the time series of liveweight change and variance change within a mob is taken as the cross-correlation coefficient between the two time series of measurements.

RESULTS

The variance of all groups increased through time as shown in Figures 1 to 3.

FIGURE 1: Liveweight through time, and liveweight variance through time for steers born on the hill or the sawdust pad in year 1.

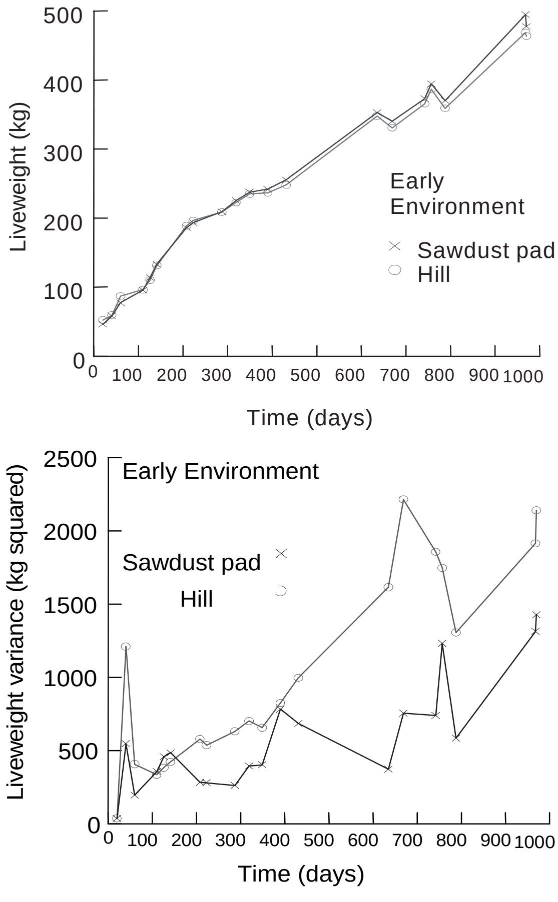
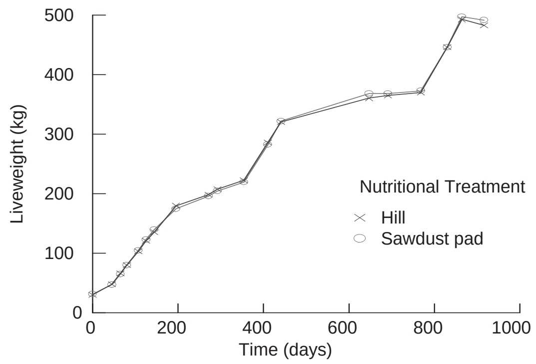


FIGURE 2: Liveweight through time, and liveweight variance through time for each of the nutritional treatments in year 2.



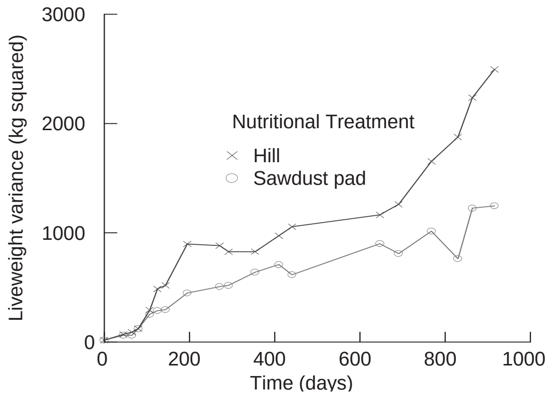
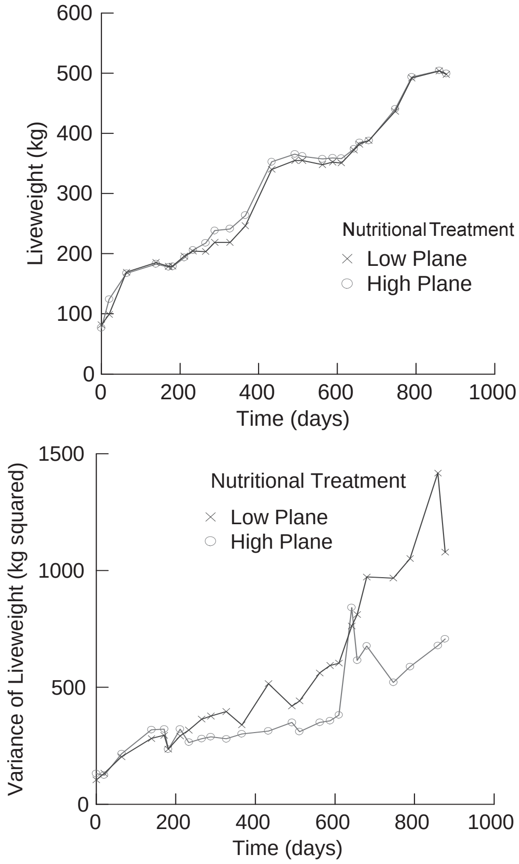


Figure 3. Liveweight through time, and liveweight variance through time for each of the nutritional treatments in year 3



The standard deviations of liveweight at 30 months-of-age for each group of steers is shown in Table 1.

Table 1. The standard deviation of liveweight at 30 months-of-age for steers on different nutritional regimes in each of the 3 years.

	Age (days)	Liveweight (kg)	Standard deviation of liveweight (kg)
Year 1 Hill	970	464	46.3
Year 1 Sawdust Pad	970	477	37.8
Year 2 Hill	916	492	50.0
Year 2 Sawdust Pad	916	483	35.3
Year 3 High Plane	877	499	24.0
Year 3 Low Plane	877	498	32.8

The variance of liveweight at slaughter at 30 months of age was smaller (P < 0.01) for the animals in year 3 than for the steers in years 1 and 2. This was not related to differences in liveweight (also shown in Figures 1 to 3) as the coefficient of variation was 0.1 for the steers in years 1 and 2, but 0.06 for the steers in year 3.

The change in variance of liveweight was related to the change in liveweight in year 1 (correlation –0.72, P < 0.01). That is, if liveweight change in the herd increased then the liveweight variance in the herd decreased. This may have been due to an increased variance of gut fill in the mob under nutritional restriction, but there was no significant relationship between liveweight variance and liveweight change within treatment groups in years 2 and 3.

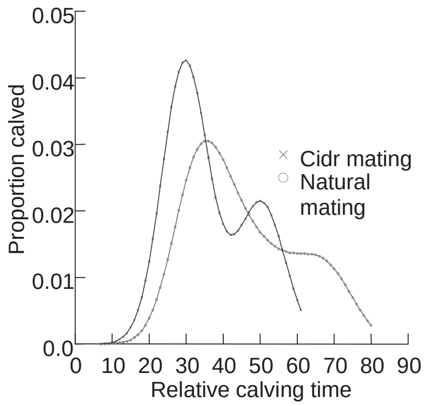
A greater spread in the age of steers in the herd was a significant factor in the variance of liveweight at 30 months of age in year 2. Here age effects the variance by affecting the mean liveweight, i.e. as a factor in a regression analysis (regression –0.90 kg per day; P < 0.01), and a weak effect in year 3 (regression –0.672 kg per day; P<0.1). There was a weak quadratic effect of liveweight at 30 months of age in year 1 (P<0.07). Steers born to two-year-old dams did not differ significantly in the variance of liveweight at 30 months of age compared to steers born to older cows (standard deviation 24.1 kg *v* 28.9 kg).

In years 1 and 2 where the nutritional treatment took place at an early age there is no discernible effect of the treatment on the liveweight at any time. However, there is a clear effect on the variance of the liveweight, with animals spending their early life on the hill having higher liveweight variance than animals spending their early life on the sawdust pad. The difference in variance (but not in the mean) for carcass weight between steers raised on the hill and the sawdust pad was significant (P < 0.02) in year1 (mean and standard deviation; hill 239 ± 28.2; pad 248 ± 18.7). In year 2 the liveweight variance differed, again steers raised on the pad having a significantly lower variance (P < 0.05) than steers raised on the hill (carcass weights were unavailable for this group). The Calves born on the hill did not differ in the variance of birthweight from calves born on the sawdust pad in year 1 (standard deviation 4 kg for both), but had a greater variance (P < 0.01) than calves born on the sawdust pad (standard deviation 4.44 kg *v* 3.05 kg) in year 2. All the steers were run together after 20 days-of – age, so differences in gut fill are unlikely to be an issue. When the central 83% of the birthweights of the calves born on the hill were selected these had a standard deviation of birthweight of 2.91 kg. These steers had a liveweight standard deviation of 38.1 kg at 30 months of age, not significantly different from the 30 month variance of the steers born on the pad. Thus the variance established early in life was magnified as the steers aged.

In year 3 where the nutritional treatments were applied after weaning there is a significant (P < 0.05) response in liveweight variance, the steers experiencing the lower rate of winter growth having the highest liveweight variance. However, at slaughter there was no significant difference in either the mean or variance of the carcass weights suggesting that in this case the R group steers experienced an increase in gut fill variance.

Evaluating the effect of mating for 42 days (2 oestrus cycles) compared to the traditional 63 days (3 oestrus cycles) using the model of Pleasants (1997) showed that the standard deviation of the calf liveweight at 100-days-of-age decreased marginally from 17.5 kg to 13.0 kg. This advantage was insignificant compared with the increase in liveweight variation post weaning. The effect on the calving frequency distribution of using CIDRs compared to the effect of natural mating is shown in Figure 4.

FIGURE 4: The proportion of cows calving on different days of the calving period under natural mating or using CIDR's to induce oestrus. Mating for 2 oestrus cycles which is 28 days in the CIDR herd and 47 days in the naturally mated herd. Cows begin calving on day 10.



The standard deviation of calf liveweight was 13.2 kg for the naturally mated herd and 10.0 kg for the herd treated with CIDRs.

DISCUSSION

There are factors known to affect not only the mean liveweight of a group of animals but also the variation in liveweight among animals in the group. Treatment effects of the type applied to the steers in year 3 are an example. Age effects whereby animals born earlier are heavier are another example. These factors have been extensively studied in the past, and these issues are not the point here. However, the existence of an age effect on the liveweight of the steers at 30 months of age, though weak in years 2 and 3 should be noted.

The interest of this paper is in those factors affecting the variance of the group of animals independently of an effect on the mean. For example, Table 2 shows that in Year 2 steers experiencing different environments before 20 days of age did not differ significantly in average liveweight at slaughter (492 kg Hill *v* 483 kg Pad), but did differ significantly (P < 0.01) in the variance of liveweight at slaughter (standard deviations 35.3 kg Hill *v* 50.0 kg Pad). The trend is similar for the year 1 steers, animals born on the hill having a higher, though not significant increase in the variance of liveweight over time. An effect also occurred in Year 3 where steers which were restricted in nutrition over the first winter showed an increase in the rate at which liveweight variance increased through time, even when both groups of steers were run together.

In Year 3, animals on restricted (R) nutrition over the first winter increased in liveweight variation over the animals on a steady plane (S) of nutrition. This may have been due to competition for feed among animals as this became limiting within the R group. However, the difference in the liveweight variance between the treatment groups continued to increase even when the R animals were returned to S plane of nutrition. This difference in the liveweight variance was reduced to statistical insignificance in the carcass weight variance, suggesting that gut fill was primarily responsible for the increase in the liveweight variance of the R group. However, it is not apparent why the gut fill variance should increase so much in the R group. It suggests that restriction in nutrition increased differences in foraging ability between animals.

The early environment on the sawdust pad marginally decreased the mean birth weight (hill 30.6 kg *v* pad 28.4; $P < 0.08$), but significantly decreased variance of the liveweight of the steers in year 2. The cause of such greater uniformity in liveweight on the pad was not apparent, although the increased birthweight variance on the hill is implicated in year 2. However, the sawdust pad was better protected from the weather, and this may have assisted the growth of calves prone to suffer due to climatic effects.

Webby *et al.,* (1993) also studied the increase of liveweight variance through time in a mob of cattle. They found the increase in liveweight variance to be linear, which was not the case in this study. These authors noted that the increase in liveweight variance was not associated with a constant coefficient of variation, in agreement with the observations recorded here.

The model suggests that mating strategies designed to reduce the variance of liveweight and hence the variance of carcass weight in a mob of animals raised for slaughter may be insufficient for practical variance control. However, there is the suggestion in the year 2 results that an increase in liveweight variance at birth may result in larger increases as the animal's age. This issue deserves further examination as it may give an economic advantage to oestrous control strategies.

The practical implications of these results is that managing a group of animals to have a standard deviation of 17 kg in liveweight at slaughter means that 95% of the steers will have liveweight within a band of 66 kg, with say, carcass weights within 33 kg. On the other hand, managing a group of animals to have a standard deviation of liveweight of 50 kg means that the band of liveweights within a mob will be 196 kg, with carcass weights within 98 kg. Clearly the mob with the high standard deviation will be costly to the farmer to manage, and costly to the supply chain to distribute. Researchers have paid little attention to factors affecting changes in the variance of a group of animals. This paper suggests that as quality assurance becomes an important issue in the future more attention should be directed to this problem.

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