Data from the Swedish Beef Recording Scheme were analysed for different non-genetic factors that have an influence on body weight at different ages in beef breeds. These factors were type of birth, sex, breed group, parity, season year and age of calf at weighing. The breeds included were Hereford, Charolais, Simmental and Limousin. Twin calves had a relative weight compared to single born calves at birth of 77-80%, at weaning 86-94%, and at one year of age 91-99%. Heifers had a relative weight at birth of 93-95%, at weaning 89-92% and at one year of age 82-89% of that of bulls. Calves born at first parity had 8-14% lower weight at birth and weaning relative to those born at parities 4-8. Calves born by older cows had 2-6% lower weights. Adjustment factors for these effects were developed. By comparing the within-class standard deviations and coefficients of variation after multiplicative and additive adjustment respectively, the appropriate type of adjustment was found. Additive factors were preferred for the effects of type of birth, parity and season, whereas multiplicative factors were most appropriate for the effects of sex, breed group and age of calf when birth weight was registered. Regression equations were developed to adjust for the effect of age of calf when observing weaning and yearling weight.

INTRODUCTION

In 1967 an on-farm performance beef recording scheme started in Sweden for beef cattle and the purpose was to register different production traits to be used for within-herd management and selection. The registered traits were birth weight, live weight at 200 days of age and live weight at one year of age.

Adjustments of body weights were made for sex, age of calf at weighing and age of dam at calving. Adjustment factors for twin births have not been available in the Swedish Beef Recording Scheme, and thus twin calves have not been included in any index calculations for selection purposes.

The aim of this investigation was to analyse the effects of non-genetic factors on birth weight, weaning weight and yearling weight in beef breeds and to develop new adjustment factors for these effects that were found to systematically influence these traits, viz., type of birth, sex, breed group, season, parity and age of calf at weighing.

MATERIAL AND METHODS

The material was collected from the Swedish Beef Recording Scheme covering the period 1968-1986. The data included 81,619 calf records from four beef breeds, viz. Charolais (39,083), Hereford (30,787), Simmental (8322) and Limousin (3427). The traits studied were birth weight, weaning weight and yearling weight.

To estimate the non-genetic effects ordinary least-squares and maximum likelihood methods were used (Harvey, 1977).
The different breeds were analysed separately. The statistical model contained the effects of sire, type of birth (singleton or twin), sex, breed group (purebreds or crosses), season (6 periods), year-class (8 classes), parity (13 classes), day of age at weighing, two-factor interactions between type of birth, season and year of birth and the regression of weaning weight or yearling weight on age at weighing. Since the sires in this study was 100% purebreds, crossbred calves received their "foreign" genes from the dam. The foreign genes could be from any breed, beef or dairy. The calves were defined as purebred when they had at least 87.5% of the genes from one breed.

In the final analysis those effects which proved to be non-significant in the first analyses were excluded, in order to receive more accurate estimates of the significant effects. These estimates were used to calculate additive and multiplicative adjustment factors for the non-genetic effects. When these factors were used to adjust the data new means, standard deviations and coefficients of variation were obtained. The type of adjustment factor that minimized the change in standard deviation and coefficients of variation within sub-classes was chosen as the most appropriate. (Danell, 1981, Emanuelson, 1985).

RESULTS

The effect of type of birth was significant for birth weight, weaning weight and weight at one year of age, except for Limousin at one year of age. Birth weight was 8-10 kg lower for twins, which corresponds to 77-80% of the weight of singletons, depending on breed. In this study the relative birth weight for twins was higher compared to other studies. Thus, Turman et al. (1971), Kögel et al. (1980), Frebling et al. (1982), Diskin & Sreenan (1982, 1984, 1985) and Williams & Evans (1985) reported relative birth weights of 73-75% on average. The relative weaning weight of twins varied between 86% (Hereford) and 94% (Limousin). At one year of age the range of relative weights for twins were from 91% (Hereford) to 99% (Limousin).

The effect of sex on body weight was significant for all breeds and weights. Contrary to type of birth the effect of sex increased with age. Heifers were 5.5-7% lighter at birth compared to bulls. The sex differences between calves at birth were less for Hereford and Limousin compared to the other breeds. The sex differences at weaning were highest for Simmental, 10.6% and smallest for Limousin, 7.7%. These differences were somewhat bigger than those reported by Cundiff et al. (1966), Anderson & Willham (1979), Nelson & Kress (1981) and Leighton et al. (1982). At one year of age the sex differences were 16-18% depending on breed. Similar results were shown by Kalm et al (1978).

The effect of crossbred vs. purebred calves on body weight varied depending on breed and was significant for all breeds and ages except for Charolais at weaning and Limousin at one year of age. At birth Hereford and Limousin crossbreds weighed 105% and 103% respectively of the purebreds. Charolais and Simmental crosses weighed 97% of the purebreds. The weaning weight of Simmental crosses dropped to 91% of that of the purebred calves. Hereford and Limousin crosses still weighed some percentages more than the purebreds. At one year of age only the Hereford crosses weighed more than the purebreds, while Simmental and Charolais crosses had a relative weight around 93%. Kalm et al (1978) had similar results concerning Charolais and Hereford.

The effect of season on birth weight was significant for all breeds except Limousin. Calves born from March to May showed higher birth weights in Hereford and Simmental but in Charolais higher weights were shown for calves born in June to December. This effect was also shown by Kalm et al. (1978), in their study
with Hereford and Charolais. Cundiff et al. (1966) showed the same trend in their Hereford-Angus study as was obtained for Simmental and Hereford in this investigation. At weaning the effect of season was significant for all breeds. Charolais and Hereford were the only breeds that showed significant effects of season at one year of age. At weaning the calves born from July to March were heaviest. This trend was also valid for the yearling weights.

The *annual variation in birth weight* was significant for all breeds except for Simmental. Year of birth also showed a significant influence on weaning weight in all breeds. For yearling weight the effect of year of birth was significant for all breeds except Limousin.

The *effect of parity* was significant for weight at different ages in all breeds. On average calves born in parities 4–8 had the highest weight at all ages. At birth and weaning calves born at first parities had 8–14% lower body weight than calves born at parities 4–8. Calves born by older cows, parity 9 and higher, had 2–6% lower weights at birth and weaning.

The *effect of day at weighing* on calf's birth weight was significant for all breeds except for Limousin. During the first four days Hereford, Charolais and Simmental calves increased their body weight 1.8–3.0 kg. For Limousin the increase was 3.8 kg.

Three *two-factor interactions* between non-genetic factors, viz. type of birth x season, type of birth x year and season x year were analysed. The level of significance for these interactions varied between breeds and they were in some cases non-significant. Type of birth often showed non-significant or only weak interactions with season or year. A season by year interaction was demonstrated in most cases except for birth weight and weaning weight in Limousin.

Adjustment factors were calculated for all the effects analysed except for that of year. For practical use there is no reason to apply pre-adjustment factors for an interaction e.g. between type of birth and year and between season and years, since the effect of year just belongs to these particular years in the data.

Adjustment factors for the effect of age at weighing on weaning weight and the weight at one year of age, could be calculated from the coefficients of regression.

Table 1 shows type of adjustment factors appropriate for the different non-genetic factors found to be significant for the breeds investigated.

<table>
<thead>
<tr>
<th>Table 1 Type of adjustment factors for different traits, M-multiplicative factors, A-additive factors and R-regression factor. H-Hereford, C-Charolais, S-Simmental and L-Limousin.</th>
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<tbody>
<tr>
<td><strong>Effect</strong></td>
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<td>Twin</td>
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<td>Sex</td>
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<td>Breed group</td>
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<td>Parity</td>
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<td>Season</td>
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<td>Day of weighing</td>
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DISCUSSION

Great similarities were found between the breeds as regards both which factors that influenced calf weights at different ages and the mode of effect. The discrepancies sometimes found especially for Limousin could be an effect of a much smaller data set for this breed.

The twins in this study had higher birth weight than has been reported in other studies. A reason for that is probably a higher intensity of feeding in the Swedish beef cattle production systems compared to many other countries with lower producing pastures or range conditions.

The lower value of the relative weight at weaning for Hereford twins can be explained by the lower milk production in Hereford cows. From the results it can be concluded that Hereford cows rear their twin calves rather unefficient, whereas Limousin twins reached the body weight of single born calves faster than calves of any other breed. Higher sex differences at weaning in this study might also be explained by the intensity of the production system. High intensity leads to more milk and pasture to the calf and the possibility for bull calves to utilize their growth capacity. The year effects were generally significant, but as Kalm et al. (1978) pointed out, it is not necessary to adjust for the effect if the selection of replacement takes part within years.

For some of the non-genetic effects, as sex, type of birth and parity, it is possible to do pre-adjustments before estimating breeding values. To take the year effect into consideration a simultaneous solution, i.e. BLUP should be preferred. The season effect is probably also best considered by a simultaneous solution, since there exist significant interactions between season and year in some cases. Thus, it is difficult to predict this effect from year to year and to accurately pre-adjust for this effect.

REFERENCES

FREBLING, J., GILLARD, P. and MENISSIER, F. 1982. 2nd World Congress on genetics applied to Livestock Production. 8: 351-355.