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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 12 (6): 545-547, 2009
ISSN 1028-8880

Describing Variation in Rump P8 Fat Depth of Crossbred Cattle from Birth to Slaughter

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Abstract: A Principal Component Analysis (PCA) was conducted on the matrix of correlations among P8 fat measures at seven different ages for steers and heifers. The P8 fat measures were collected from 1143 steers and heifer calves that were born to Hereford (h) dams inseminated with semen from seven different sire breeds: Angus, Belgian Blue, Hereford, Jersey, Limousin, South Devon and Wagyu, over a 4-year period (1994 to 1997). The first two principal components explained 61 and 57% of the total phenotypic variation in fatness for steers and heifers, respectively. The first component was positively correlated to all measures and was interpreted as a measure of overall fatness. The second component was positively correlated to fatness approximately pre-weaning and negatively correlated thereafter and thus was interpreted as maturity type but could be a function of milk supply. When estimated from a sire model, the heritability estimates were high for the first component (0.59 and 0.67 for steers and heifers, respectively) but low for the second component (0.05 and 0.19). The results demonstrate the value of combining information across multiple measurements to build accuracy, even when relatively crude methods are used.

Key words: P8 rump fat, crossbred cattle, principal component analysis

INTRODUCTION

Variability in the growth traits of cattle has important impacts on the economic costs and returns of both the cattle producer and processor. Optimisation of cattle production systems including the evaluation of alternative management and marketing strategies require knowledge of the variation in those growth traits such as subcutaneous fat depth (Hoffman *et al*., 2008; McKiernan *et al*., 2008; McPhee, 2006; Williams, 2005). Subcutaneous fat depth taken at the P8 rump site, using ultrasonic scanning devices, provides a better description of live weight measurements and allows one to assess whether the difference in weight is due to muscle or fat (McPhee *et al*., 2008; Sainz and Hasting, 2000; Thonney *et al*., 2003). For an individual animal this relationship between weight and fatness is known as maturity type (a high fat level for a given weight is considered as early maturing, a low level is considered as late maturing).

Principal Component Analysis (PCA) has been a useful method for studying variations concerning fatness (Kirkpatrick and Meyer, 2004; Mayer, 2005). Those authors suggested that multivariate analyses could be simplified by estimating only the leading, principal components (PC) for a set of traits. This technique has been already used to characterize breeds (Sacco *et al*., 2005; Traoré *et al*., 2008; Zembayashi, 1999), to construct genetic selection indices (De Los Campos and Gianola, 2007; Janssens and Vandepitte, 2004) and to predict market specification (McPhee *et al*., 2008). The present study uses principal component analysis to investigate the main sources of shared variability in P8 fat measures at different ages and to deduce the factors that describe these traits.

MATERIALS AND METHODS

The data from the Southern Crossbreeding Project (1994-2000) have been used for this research. The Southern Crossbreeding Project was designed to characterize between and within breed variations with the aim of improving utilization of existing breeds for meeting a range of market specifications in southern Australia (Pitchford *et al*., 2002). The cattle in this project were raised in a typical Mediterranean environment characterized by cool, wet winters and hot, dry summers. Calves were born on two South Australian properties (Struan and nearby Wandilo).

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The P8 rump fat depth on 573 steer and 570 heifer calves born over a 4-year period were obtained to describe and characterize growth of seven sire breeds raised in various management groups. Purebred Hereford cows (581) were artificially incriminated with semen of sire breeds Angus (11 sires), Belgian Blue (16 sires), Hereford (10 sires), Jersey (12 sires), Limousin (16 sires), South Devon (15 sires) and Wagyu (17 sires). Each year calves born were weaned in summer (mid December-early January) at 250 to 300 days of age. Calves stayed with their dams on pasture until weaning and calves were grown until 12-18 months of age and then transported to a commercial feedlot (Pitchford *et al*., 2002). Traits considered were P8 rump fat depth at the so-called P8 site approximately equidistant between the hooks and pins of the animal.

Principal Components Analysis (PCA) of the correlation matrix was performed on the rump fat thickness (P8) measures over time taken from steers and heifers of seven crossbreds using (PROC PRINCOMP) (SAS Institute Inc., 1999). The principal component analysis in this study was calculated from a correlation matrix rather than covariance matrix, because the variance of the P8 fat measures increases greatly as the animals grow. All principal components in this study (PC_j) of the following form:

$$PC_{ij}\ Z_i = C_{1j}Z_1 + C_{2j}\ Z_2 + ... + C_{nj}Z_n$$

where, C_{ij} is the coefficient of ith P8 fat measures in the jth component and Z_i is the ith standardized P8 fat measure.

The new variable is therefore a weighted sum of the original variables. Standardized measures were calculated as the deviation of the individual's measure from the mean of the character divided by the standard deviation of the character. The projections of the variables across ages into the ordination space (biplot) were carried out to relate the predicted means of breeds resulting from mixed model analysis of principal components to the original variables.

A mixed model analysis (PROC MIXED) was applied to the data transformed by the coefficients of the Principal Components (PC scores) for both steers and heifers. The linear mixed model contains fixed effects of birth month (March or April), sire breed (seven levels) and management group, indicating year effects (a total of 30 levels describing pre- and post-weaning measures, 2-6 per year) and random effects of sire. Birth month was fitted to examine age effects rather than a linear covariate of birthday to avoid bias (high leverage) resulting from the small number of very early and very late calves. Sex was not included in the model because PCA and mixed model analyses were performed for heifers and steers, separately.

RESULTS AND DISCUSSION

The first two principal components accounted for 61 and 57% of the total variation in the correlation structures of these measurements for steers and heifers, respectively. The first component (PC_1) in steers and heifers accounted for 39 and 42% of the total variation respectively. PC_1 was interpreted as a measure of overall fatness because it was positively correlated with all measurement times (Table 1). The second principal component (PC_2) accounted for 23 and 15% of total variability. It was generally positively correlated with pre-weaning measures and negatively correlated post-weaning. Thus, PC_2 was interpreted as a maturity type component which could be a function of milk yield.

Factors affecting principal components of P8 fat measures: Overall fatness and maturity component in both steers and heifers were significantly affected by year and management groups (Table 2). Birth month was most likely an age effect but was generally not significant for the two components. Heritability estimates for the first component (overall fatness) were very high (steers 0.59 and heifers 0.67, Table 2). In contrast, the heritability for the second component was low (0.05 and 0.19).

Pitchford *et al.* (2002) reported the heritability of carcass P8 fat depth from the same project was 26%. While that was for a carcass measure and not a live scan, it is probably safe to assume that the primary difference to the estimates herein is the effect of combining information across multiple measurements. PCA is one of a number of methods of combining information across traits, but the more than doubling of the heritability demonstrates the importance of doing such combining.

The very low heritability of the second component also fits expectation if it is primarily reflecting milk supply and little genetic variation would be observed with a sire model. The fact that there was some genetic variance may indicate there is truly sire variation in rate of maturation which is a trait that could have some market value.

Table 1: Eigen values and eigen vectors of the correlation matrix for rump fat of steers and heifers over time (days)

	Steers		Heifers	
Age	PC_1	PC_2	PC_1	PC_2
170	0.28	0.45	0.33	0.28
230	0.38	0.49	0.43	0.24
280	0.39	0.31	0.44	-0.04
330	0.37	0.08	0.31	-0.53
530	0.46	-0.35	0.43	-0.12
590	0.36	-0.43	0.45	-0.17
Slaughter	0.39	-0.38	0.15	0.74
Eigen values	2.70	1.58	2.92	1.05
Variance (%)	39.00	23.00	42.00	15.00
Cumulative variance (%)	39.00	61.00	42.00	57.00

Table 2: Tests of significance and estimates of heritability and phenotypic variance of the first two principal components

	Steers			Heifers		
Fixed effects	df	PC_1	PC_2	df	PC_1	PC_2
Years	3	<0.0001***	<0.0001***	3	<0.0001***	<0.0001***
Manage. Groups	9	<0.0001***	<0.0001***	12	<0.0001***	0.01*
Birth month	1	0.67	0.01*	1	00.12	0.09
Breed	6	<0.0001***	0.02*	6	<0.0001***	0.63
Phenotypic variances		1.82	0.60		2.26	0.61
Heritability		0.59	0.05		0.67	0.19

*p<0.05, ***p<0.0001

As expected, breed differences were highly significant for the first component (Table 2) demonstrating differences in overall fatness. However, breed differences in the second component were less significant for steers and not significant for heifers. The heifer result adds credence to the hypothesis that the component reflects milk supply from the dam. However, the significant steer result suggests there are breed differences in maturation of fatness. That said, the variation between breeds in the second fat component was dwarfed by the overall fatness results with Angus sired calves being fattest and Belgian Blue leanest, as reported from the carcass data (Pitchford *et al*., 2002).

In conclusion, the results demonstrate that even relatively crude methods of combining data across multiple measures (in this case principal components) will result in increased accuracy. More advanced methods such as random regression should be utilized where possible and are the focus of subsequent work on this data set.

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