Heterosis Coefficients and Genetic Trends by Breed Type from Across Breed Dairy Genetic Evaluations in the United Kingdom

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Introduction

Until 2010, United Kingdom (UK) dairy genetic evaluations were undertaken within evaluation groups defined by breeds; Holstein/Friesian, Shorthorn, Ayrshire, Jersey and Guernsey (Mrode *et al.,* 2005). Animals were assigned to evaluation groups based on breeder assigned breed codes that describe the breed and country of origin. The breed code was limited in its ability to accurately reflect the breed makeup of cows as it only allowed 1 breed to be recorded making it difficult to identify crossbred animals. Heterosis effects were only considered for the Holstein/Friesian evaluation where percentage Holstein genes were calculated.

With increasing emphasis on non-production traits (e.g. fertility) there has been increased interest in cross breeding as a way of achieving broader breeding goals. A pilot study for an across breed evaluation in the UK estimated that just under half the dairy cows with production records were cross bred (heterosis coefficients >25%) and that in 2004 27% of cross bred animals were the result of a Holstein x Non-Friesian cross (Mrode *et al.,* 2008). In 2010, the BLUP analysis for the UK dairy genetic evaluations were undertaken on an across breed basis (Winters, 2010). Consequently, the overall computational time decreased, the reliabilities of Progeny Transmitting Abilities (PTAs) increased because of extra information and for the first time crossbred and purebred animals from different breeds were evaluated on the same scale (however, for publication purposes the individual breeds are rebased separately). There were several aims of this paper. The first was to compare heterosis coefficients computed on the proportion of each breed type (PEB) in an across breed evaluation with the Holstein/Friesian evaluation where heterosis coefficients computed using breed proportions supplied by the breed society. Given new methodology to accurately measure the breed makeup of animals the remaining aims were to examine the genetic trends of purebred and first cross cows and to compare PTAs of purebred cows with different geographic ancestries.

Material and methods

Breed makeup, breed types and heterosis coefficients: To calculate heterosis coefficients accurate knowledge of the breed makeup of animals was required. Animals could have multiple breeds contributing to the breed makeup with the sum of the contributing breeds being 100%. The breed makeup was calculated sequentially (oldest animals first) for all animals in the pedigree. The breeder assigned breed code was only used to determine the breed makeup for unknown parents. The breed makeup of an unknown parent was assumed to be 100% of the breeder assigned breed code of the progeny. If the breeder assigned breed code of the progeny was UK Holstein, additional rules based on birth years and known information about the other parent were considered to determine if the unknown parent should actually be recorded as a UK Friesian instead of a UK Holstein. Once unknown parents were assigned breed makeups, the breed make up of animals were simply half the breed makeup of each parent. Given the large number of breeds and countries of origin, 4 breed types (PEB) were defined for computing heterosis coefficients; Holstein (HOL), Friesian (FRI), Red and White (RAW) (e.g. Ayrshire) and Channel Island (CHI) (e.g. Jersey). The breed makeup of animals was then expressed as a proportion of the breed types with the sum of the 4 breed types being 100%. For example, in the case where a mostly Holstein sire (50% UK (breed code=1), 40% American (breed code=65) and 10% UK Shorthorn (breed code=2)) was mated to a purebred UK Shorthorn dam. The resulting breed makeup of the progeny would be 25, 20 and 55% of breed codes 1, 65 and 2, respectively. The PEB of the progeny would be 45% HOL and 55% RAW. The across breed evaluation has meant that for the first time, the small proportion of the Shorthorn breed type in the mostly Holstein Sire has been accounted for rather than ignored. The 4 breed types resulted in 6 cross breeding combinations; HOL×FRI, HOL×RAW, HOL×CHI, FRI×RAW, FRI×CHI and RAW×CHI. The heterosis coefficient for each of these crosses were calculated via the following formula; $HET(A\times B) = ((Sire_{PEB(A)} \times Dam_{PEB(B)}) + (Sire_{PEB(B)} \times Dam_{PEB(A)})) / 100$.

Genetic trends: The published PTAs from the first official across breed evaluation of 2010 were used to calculate genetic trends. Although all animals were evaluated simultaneously in the across breed evaluation, published PTAs were only directly comparable within the evaluation groups given that each evaluation group was rebased individually. Using the PEB, cows were identified that were purebred (i.e. >87.5% of the breed type) or a first cross (i.e. only 2 breed types of approximately equal contributions) cow.

Results and discussion

Heterosis coefficients: The average heterosis coefficients for the across breed and Holstein/Friesian evaluations are presented in Table 1 for animals with =>25% heterosis coefficient.

Table 1: Average heterosis coefficients for the six breed type combinations for animals with a coefficient >=25% (number of animals in italics)

Year of birth	1985	1990	1995	2000	2005
Holstein/Friesian evaluation (August 2009)					
HOL×FRI	57.7 *(131865)*	46.0 *(455284)*	52.3 *(723640)*	50.1 *(645616)*	38.9 *(375799)*
Across breed evaluation (January 2010)					
HOL×FRI	55.7 *(211824)*	59.5 *(393260)*	61.4 *(543492)*	56.4 *(446268)*	46.5 *(197123)*
HOL×RAW	53.2 *(361)*	55.3 *(1244)*	64.7 *(4265)*	64.4 *(9162)*	61.5 *(11765)*
HOL×CHI	51.0 *(60)*	61.1 *(255)*	62.6 *(595)*	60.6 *(836)*	70.6 *(1574)*
FRI×RAW	58.3 *(594)*	60.5 *(1507)*	66.1 *(2834)*	57.5 *(2645)*	47.1 *(1972)*
FRI×CHI	61.9 *(95)*	62.5 *(396)*	67.4 *(383)*	59.4 *(192)*	50.1 *(402)*
RAW×CHI	50.0 *(2)*	75.0 *(34)*	79.4 *(119)*	67.2 *(140)*	59.2 *(153)*

With the exception of 1985 born cows, fewer HOL×FRI crossbred cows were identified in the across breed evaluation. HOL×FRI heterosis coefficients between the runs were similar in 1985 but were higher for the across breed evaluation in more recent years. These results suggest that cows were falsely identified as being crossbred previously and thus this may have lowered mean coefficient values for the Holstein/Friesian evaluation. Improving the heterosis coefficient will result in crossbred animals having more accurate and unbiased genetic evaluations available. In the across breed evaluation, the largest heterosis coefficients were observed for Holstein and coloured (RAW, CHI) crosses with the number of HOL×coloured crossbred cows increasing over time.

Genetic trends: Genetic trends for purebred and first cross Holstein cows were shown in Figure 1 along with trends from all cows in the Holstein evaluation group. These genetic trends were based on average 98,107, 23,406, 291 and 75 purebred, HOL×FRI, HOL×RAW and HOL×CHI first cross cows per year. The genetic trends showed that purebred Holstein cows produced more milk compared to all animals in the evaluation group but in particular compared to first cross Holstein cows. This was similar for the other production traits. However, when fitness traits such as life span were considered, first cross cows were generally genetically superior to purebred Holstein cows. With greater milk production capability purebred Holstein cows have higher PLI indices. However, with increased emphasis on fitness traits the PLI gap between purebred Holstein and Holstein×Coloured first cross cows has decreased in recent years. These results show that although Holsteins have higher production PTAs, the colored breeds have favorable fitness PTAs and this is making cross breeding with coloured breeds more popular and profitable in recent years. The availability of across breed evaluations means that Holstein×Coloured crossbred cows can now be fairly compared in genetic evaluations enabling more effective selection

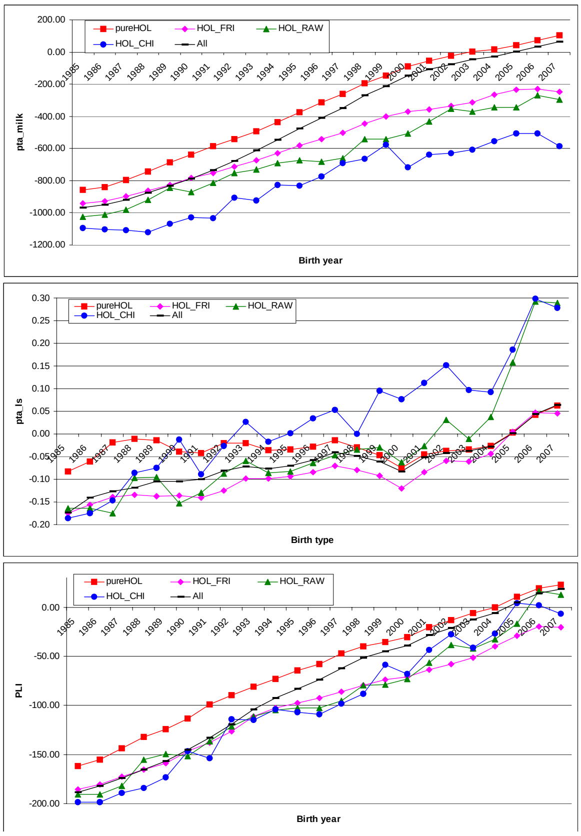

Figure 1: Genetic trends for purebred and first cross Holstein cows from the re-based Holstein genetic evaluation

decisions and improved genetic responses. Similar conclusions were drawn when examining purebred and first cross genetic trends of other breeds.

Ancestry of purebred cows: The new methodology in the all-breed evaluation enabled comparisons of cows from the same breed but different ancestry. Table 2 shows the average PTA's of 2005 born purebred Holsteins with different geographically ancestries. Of the 155,166 purebred Holstein cows born in 2005, the majority were derived from North American Holstein cows. There were differences in the average PTAs between the different geographical regions. Holstein cows with more than 50% of their ancestry being North American or European on average had more favorable PTAs compared with purebred cows with UK or Oceanic origins. Similar trends were also observed for Ayrshire, Jersey and Guernsey evaluation groups. For these breeds, the cows with foreign ancestry tended to have higher PLI values. However, when the individual PTAs were considered in some cases the locally derived cows had more favorable PTAs. For example the average LS PTA of purebred UK Holsteins was higher (0.11) than the PTA of purebred North American Holsteins (0.00) despite the differences in PLI. The majority of Friesian and Shorthorn cows had local origins.

Table 2: Average Holstein PTAs of 2005 purebred cows with different ancestries

Ancestry	N	MILK	LS	PLI
Pure bred Holstein	155166	42.80	0.00	10.64
>50% UK	639	-168.44	0.11	-7.29
>50% European	198	31.95	-0.04	20.79
>50% Nth American	151640	47.11	0.00	10.75
>50% Oceanic	67	-505.90	0.10	-5.28

Conclusion

The recent implementation of across breed evaluations and the inclusion of cross bred animals have resulted in numerous benefits for the UK dairy genetic evaluations. The methodology changes have improved the calculation of heterosis coefficients for HOL×FRI cows and also allowed for the first time estimates including coloured breed types. This paper demonstrated the benefits of cross breeding with coloured breeds to achieved broader breeding goals including fitness traits. The across breed genetic evaluation allowed the comparison of cows with different geographically ancestry. It was shown for 2005 born cows that those with foreign ancestry tended to have higher production PTAs but not always favorable fitness PTAs compared to cows with local ancestry.

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References

Mrode, R., Brotherstone, S., White, I., Swanson, G., Coffey, M., Jones, H., and Thompson, R. (2005*). Interbull Bulletin*, 33:211–214.

Mrode, R., Coffey, M., Sawalha, R., and Wall, E. (2008*). Interbull Bulletin*, 38:48–51.

Winters, M. (2010). In *British Cattle Conference*, Digest 65, *(in press).*