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Genetic parameters for birth difficulty, lamb vigour and lamb sucking ability in Suffolk sheep

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Abstract

This study investigates the genetic basis of lamb vigour (defined as neonatal lamb activity and sucking ability) and lambing difficulty as potential traits to be included in selection programmes to improve ewe and lamb welfare. Scores for lamb birth difficulty, vigour and sucking ability were collected shortly after birth on 1,520 lambs born in 2006 in 19 different flocks that were members of the UK Suffolk Sire Referencing Scheme. Scores evaluated each trait on a scale of 1 to 4; 1 being no assistance given either during birth or to suck, or excellent vigour, through to 4 where a large degree of assistance was required, or poor vigour. Genetic parameters (heritabilities, genetic correlations) were estimated by fitting an individual animal model using ASREML. Variance components obtained from univariate and bivariate analyses were averaged to provide genetic parameter estimates. Heritabilities for birth difficulty and vigour were moderate but heritability for sucking ability was not significant. The genetic correlation between vigour and sucking ability was positive and high, that between vigour and birth difficulty moderately negative, and that between birth difficulty and sucking ability not significant. Birth difficulty and vigour could be included in Suffolk breeding programmes to help reduce health and welfare problems associated with these traits in Suffolk sheep, and in flocks producing crossbred lambs sired by Suffolk rams. Further work is required to evaluate correlations between these traits and performance traits and to comprehensively validate the scoring system once more data become available.

Keywords: *animal welfare, birth, genetics, sheep, sucking, vigour*

Introduction

Traditionally, sheep production in the UK is associated with a high degree of human intervention at lambing time, particularly with lowland sheep breeds that lamb indoors, to ensure lambs are delivered quickly and ingest colostrum soon after birth. However, margins are becoming increasingly tight and many producers are looking to reduce inputs and move towards systems which require less labour, often termed easy-care systems. Breeds that have received considerable human intervention at lambing, such as the Suffolk, have a greater incidence of birth problems, produce lambs that take longer to stand after birth and require more assistance to suck than more extensively managed breeds (Dwyer *et al* 1996; Dwyer & Lawrence 2005a). These studies demonstrated that more than 25% of Suffolk ewes required lambing assistance and nearly 40% of Suffolk lambs needed assistance to suck successfully from their mothers. Thus, these animals may experience welfare problems with prolonged deliveries and high lamb mortality if human intervention is not provided. Reducing the requirement for human intervention, both to assist with birth and to ensure lambs have suckled, will help cut labour costs and reduce lamb mortality in which early suckling is an important factor (Nowak & Poindron 2006). Reducing the need for human intervention in the neonatal period would also have the further advantages of reducing the likelihood of problems associated with ewe reproductive tract infections and disruption of ewe-lamb bonding (Fisher & Mellor 2002) that may result from human intervention. Reduction in birth difficulties and improvement in lamb vigour and sucking ability should thus lead to improved lamb and ewe welfare, in addition to improving profitability of the sheep enterprise.

Breed differences in lambing ease and lamb vigour are well-documented (eg reviewed by Dwyer & Lawrence 2005b; Dwyer 2008a), and persist when different breeds are managed identically. In addition, line differences within breed (Dwyer *et al* 2001; Cloete *et al* 2002) and sire effects within breed (Dwyer *et al* 2005) have been reported. That breed, line and sire differences exist in these traits suggests that there is likely to be a genetic component and thus genetic selection within breed to reduce birth difficulty and to improve lamb vigour and sucking ability may be possible. Furthermore, selection for improved lamb survival has been carried out successfully (Knight *et al* 1988; Kilgour & Haughey 1993; Cloete & Scholtz 1998), demonstrating that this selection is possible, although selection on survival in flocks receiving a high degree of human intervention is unlikely to be successful as the intervention can mask genetic propensities for survival traits.

Traditionally, genetic selection in terminal sire breeds has focused on growth and carcase traits with little specific emphasis on health, welfare, reproduction or easy-care traits. Given the trend towards lower input systems in the commercial sheep sector, the range of traits considered in genetic selection is now increasing to try to meet commercial sheep producers' demands for sires that contribute favourably to these systems. As such, it is timely to investigate the genetic basis of lambing difficulty, early lamb vigour and sucking ability. This study aimed to determine the extent of genetic variation in neonatal lamb behaviour traits (birth difficulty, lamb vigour and sucking ability) in Suffolk sheep and determine the genetic correlations between these traits. As accurate recording of actual lamb behavioural traits on sufficient animals to permit genetic analysis was practically impossible, scoring systems were devised to allow capture data of the behavioural traits by the shepherds. This had the additional benefit, if successful, that data could be collected and used in a practical manner on farm to improve responses to the traits.

Materials and methods

Data collection

A scoring system for birth difficulty, lamb vigour and lamb sucking ability has been developed, based on extensive investigation of lamb behavioural development (Dwyer 2003) and following discussion with the flock owners that would be recording the traits. To reduce the subjectivity associated with the scores, each flock owner was given a detailed description of the behaviours associated with each trait. All traits are scored on a scale of 1 to 4. Birth difficulty score represents the ease of lambing with 1 being an unassisted delivery or easy, uncomplicated delivery, 2 when minor assistance was required (eg straightforward correction of presentation required before the lamb was delivered with little effort), 3 when major assistance was required (eg lamb either incorrectly presented and some effort required to correct presentation and deliver lamb, or lamb correctly presented and stuck requiring effort to deliver the lamb), and 4 when veterinary assistance was required or a decision was made to cull the ewe due to a difficult delivery. Lamb vigour score is a score representing the activity and vigour of the lamb at five minutes after birth with 1 being a very active and vigorous lamb that has stood at some point, is standing or trying to stand, 2 is an active, vigorous lamb which is holding its head up and is on its chest with its knees underneath, 3 is a weak lamb which is still lying fairly flat although able to hold up its head, and 4 is a very weak lamb which has not yet raised its head. Lamb sucking score represents how much assistance was required for the lamb to suck from the ewe, with 1 being the lamb sucking well unaided within two hours, 2, the lamb given assistance to suck from the ewe or tube-fed on no more than two occasions in the first 24 h of life, 3, the lamb given sucking assistance or tube-fed more than twice, and for more than 24 h, but less than three days and, 4, the lamb was given sucking assistance or tube-fed for more than three days. It should be emphasised that for all three behaviour scores a higher value indicates a less favourable score, requiring a greater labour input to ensure lamb survival.

Lamb birth difficulty, lamb vigour and lamb sucking ability scores were collected on 1,887 lambs born in 2006 in 19 different flocks that were members of the Suffolk Sire Referencing Scheme (SRS) in the UK and therefore genetically linked (see Simm *et al* 2001 for more details on SRS). The behaviour scores were recorded by the flock owner following a comprehensive set of guidelines on the scoring system. Lambs in this SRS are also evaluated for performance traits including live weights at both eight weeks and 20 weeks and ultrasound muscle and fat depths at 20 weeks.

Statistical analysis

Some lambs, for which there were behaviour records, could not subsequently be matched to the pedigree from the Suffolk SRS and were therefore removed from the analysis leaving a total of 1,520 lambs with pedigree records and behaviour data. The pedigree structure is shown in Table 1. Means and standard deviations of each of the traits are shown in Table 2. The association between birth difficulty, vigour and sucking ability and whether an animal was subsequently performance recorded or not was examined using ANOVA in Genstat (2006) fitting a factor of performance recorded (1) or not (0). Lambs that were not subsequently performance recorded were considered to have died or to have left the flock in which they were born for some other reason.

Genetic parameters for each trait were estimated by fitting an individual animal model using ASREML (Gilmour *et al* 2002). The linear mixed model used to describe birth score and sucking score included fixed effects of contemporary group (the combination of flock, birth year, sex and management group) and dam age (1, 2, 3, 4, 5, 6 and 7+) and birth weight as a linear covariate. Litter size was also considered for inclusion in the model but it was not significant. For lamb vigour score, the linear mixed model used included the fixed effects of contemporary group, litter size (1, 2 and 3+) and birth weight as a linear covariate. Dam age did not significantly affect lamb vigour score. The linear mixed model for vigour score also included birth score as a fixed effect to enable the genetic basis of vigour regardless of ease of birth to be determined, similarly the model for sucking score included vigour score as a fixed effect to enable the genetic basis of sucking ability to be determined regardless of vigour score.

The random effects considered were direct additive and maternal effects along with the residual. The data available came only from one year of recording so it was not possible to separate maternal additive effects, maternal permanent environmental effects and temporary environmental effects for these traits. A series of univariate

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Table 1 Pedigree structure for birth difficulty, lamb vigour and lamb sucking ability scores (behaviour scores) (total number of animals in pedigree = 157,032).

Trait	Records	Sires‡	Dams†	Litters	FYSG‡
Birth difficulty score	1,514	67	1,006	1,006	65
Lamb vigour score	1,456	65	965	965	63
Sucking score	1,512	67	1,006	1,006	65

† Number of sires or dams with offspring with records.
‡ Number of flock-year-sex-management groupings.

analyses were conducted using ASREML (Gilmour *et al* 2002) fitting the combinations of random effects (direct effect alone, or direct effect along with maternal effect). Log-likelihood ratio tests (–2 × deviation of log likelihood from more comprehensive model) were used to assess model goodness of fit in order to determine the most appropriate random effect model for each trait. For all three behaviour traits the model including the maternal effect in addition to the direct additive effect and the residual was most appropriate with log-likelihood ratio tests of –134.8, –10.4 and –97.7 for birth difficulty score, vigour score and sucking score, respectively.

The chosen univariate mixed model for each trait was used to construct bivariate models. Bivariate analyses were then conducted using ASREML (Gilmour *et al* 2002) between each of the lamb behaviour traits. The direct additive covariances between pairs of traits was fitted. Variance components obtained from univariate and bivariate analyses were averaged and used to construct matrices of heritabilities (h^2), and phenotypic and genetic correlations. The ratio of the maternal effect to phenotypic variance (σm^2) was also calculated for each trait.

Results

Effect of neonatal behaviour scores on probability of later performance recording

Lambs with no recorded eight-week weight had, compared to lambs with a recorded eight-week weight, poorer vigour (1.72 vs 1.48, respectively; $P < 0.001$, SED = 0.049) and poorer sucking ability (1.79 vs 1.52, respectively; $P < 0.001$, SED = 0.045). Lambs with no recorded ultrasound data (20 weeks) had, compared to lambs that were subsequently recorded for ultrasound traits, poorer vigour (mean = 1.39 vs 0.52; $P < 0.001$, SED = 0.030) and poorer sucking ability (1.66 vs 1.47; $P < 0.001$, SED = 0.036). Lambs that were not subsequently performance recorded were no different in birth difficulty score from lambs that were recorded either at eight weeks (1.53 vs 1.54, respectively; $P = 0.890$, SED = 0.031) or twenty weeks (1.61 vs 1.52, respectively; $P = 0.203$, SED = 0.040).

Table 2 Mean (± SD) scores for lamb birth difficulty, vigour and sucking ability scores.

Trait	Score
Birth difficulty score	1.52 (± 0.663)
Lamb vigour score	1.43 (± 0.613)
Sucking score	1.52 (± 0.703)

Fixed effects on neonatal behaviour scores

Lambs with higher birth weight in general had a more difficult birth (regression coefficient 0.0603, SE = 0.0208; $P < 0.01$) but were more vigorous (regression coefficient –0.055, SE = 0.0195; $P < 0.01$) and needed less sucking assistance (regression coefficient –0.121, SE = 0.0224; $P < 0.001$). Lambs of older dams needed less assistance during birth than lambs of one-year old ewes (regression coefficient 1.747, SE = 0.5916; $P < 0.05$) or two-year old ewes (regression coefficient 0.148, SE = 0.0726; $P < 0.05$). Lambs of older dams also needed less assistance for sucking than lambs of two-year old ewes (regression coefficient –0.220, SE = 0.0646; $P < 0.05$) although there was no significant difference in lamb sucking ability between lambs of older ewes and one-year old ewes. Dam age did not significantly affect lamb vigour. Lambs born as triplets were less vigorous than twins (regression coefficient –0.522, SE = 0.0169; $P < 0.01$) with no significant difference between singles and twins. Litter size did not significantly affect lamb birth difficulty or sucking ability. Lambs having a more difficult birth were less vigorous (regression coefficient 0.151, SE = 0.0311; $P < 0.001$) and less vigorous lambs needed more assistance to suck (regression coefficient 0.314, SE = 0.0431; $P < 0.001$).

Genetic parameters

Table 3 shows the genetic parameters estimated for birth difficulty score, vigour score and sucking score. In all three traits, a greater proportion of the phenotypic variance was explained by maternal effects than by direct additive genetic

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Table 3 Mean (± SE) estimates of phenotypic variance (V_p), genetic variance (V_g), ratio of maternal effect variance to phenotypic variance (σ_m^2), and heritabilities (in bold on diagonal), phenotypic correlations (above diagonal) and genetic correlations (below diagonal) for birth difficulty, vigour and sucking behaviour scores in Suffolk sheep.

	Birth	Vigour	Sucking
V_p	0.360 (± 0.011)	0.210 (± 0.013)	0.311 (± 0.019)
V_g	0.074 (± 0.018)	0.071 (± 0.032)	0.009 (± 0.016)
σ_m^2	0.711 (± 0.045)	0.239 (± 0.074)	0.646 (± 0.043)
Birth	**0.206** (± 0.053)	–0.109 (± 0.041)	0.027 (± 0.027)
Vigour	–0.396 (± 0.097)	**0.335** (± 0.141)	0.228 (± 0.052)
Sucking	0.184 (± 0.217)	0.734 (± 0.147)	**0.030** (± 0.051)

Standard errors are the average of values given from univariate and bivariate analyses.

effects. This was particularly the case for sucking score where the heritability was not significantly different to zero. Heritabilities for birth difficulty score (0.206; SE = 0.053) and for vigour (0.335; SE = 0.141) were moderate. The genetic correlation between vigour and sucking score was positive and high (+0.734; SE = 0.147) but that between vigour and birth difficulty was moderately negative (–0.396; SE = 0.097). The genetic correlation between birth score and sucking score was not significantly different to zero.

Discussion

Lamb preweaning survival is affected by several factors, particularly the birth process and neonatal adaptation to postnatal life (Mellor & Stafford 2003). In addition, the quality of the ewe-lamb relationship can affect lamb welfare (Dwyer 2008b) and is affected by neonatal vigour and the formation of adequate ewe-lamb bonds. Thus, there are clear impacts of lamb birth difficulty, vigour and sucking ability on ewe and lamb welfare, and lamb survival, as well as the profitability of the sheep enterprise. Assisting ewes at parturition, ensuring lambs are able to find the udder and helping weak lambs to suck adequate colostrum are labour intensive and, although human assistance can improve lamb survival, there is also evidence that such interventions might disrupt the ewe-lamb bonding process (Fisher & Mellor 2002), at least in some systems. Furthermore, there is the ethical consideration that we should not be breeding animals that are unable to survive without constant human intervention, although it is recognised that monitoring of ewes and lambs at lambing time is essential to prevent serious welfare problems. Thus, improving lambing ease, vigour and sucking ability, would reduce the need for human inputs and improve the chance of lambs getting adequate nutrition in early life, overall lamb and ewe health and welfare, lamb survival, and profitability.

A lamb's ability to stand up and move to the udder to suck is a critical step in the early acquisition of colostrum, and several studies have shown a correlation between rapid neonatal behavioural progress and survival (Alexander 1958; Owens *et al* 1985; Cloete 1993; Dwyer *et al* 2001). That survival is also linked to the neonatal behaviour scores is demonstrated by the observation that behaviour score records on an animal could not always be matched to performance data. This indicates that some lambs scored for birth difficulty, vigour and sucking ability either did not survive to the point when performance traits such as liveweight were recorded or were not considered of good enough quality to be worth performance recording. Probability of being performance recorded later in life was not affected by birth difficulty score, possibly because in purebred pedigree Suffolks lambing indoors, the level of care and assistance available is able to prevent a great deal of trauma. A similar finding was noted by Nawaz and Meyer (1992) in several other breeds of sheep, and Binns *et al* (2002) recorded reduced levels of stillbirths in indoor lambing systems with high levels of assistance. However, both vigour and sucking ability did affect the probability of being performance recorded in later life. Lambs that were later performance recorded had better scores on average for vigour and sucking ability compared to animals that were not later performance recorded. This provides some evidence that improved lamb vigour and sucking ability may result in more lambs being alive and performing well in later life (up to 20 weeks).

The effects of birth weight, dam age and litter size on the behaviour scores in the present study were in the direction expected from previous studies of these traits (Owens *et al* 1985; Nawaz & Meyer 1992; Dwyer 2003). These effects were such that lambs with higher birth weights were more likely to have had a difficult birth, lambs of older dams needed less assistance during birth and to suckle, lambs born as triplets were less vigorous than twins, lambs having a more difficult birth were less vigorous, and less vigorous lambs needed more assistance to suck. These effects were accounted for within the models fitted to estimate genetic parameters. Birth difficulty was included in the model for vigour and vigour score was included in the model for sucking ability. Thus, genetic parameters for vigour score are independent of birth difficulty, and those for sucking ability are independent of vigour score.

Birth difficulty and vigour scores had moderate heritabilities (0.206 and 0.335, respectively) indicating that they could be improved by selection. There are few estimates of heritability for lamb behaviours but unpublished data on similar scores in Scottish Blackface sheep show lower heritability (h^2 = 0.16; CM Dwyer & J Conington, unpublished data) compared to those reported here for Suffolk sheep. Behaviour scores in sheep in general tend to have heritabilities ranging from low to moderate, for example, scores of maternal behaviour (h^2 = 0.13, Lambe *et al* 2001; h^2 = 0.09, Everett-Hincks *et al* 2004) and temperament (h^2 = 0.14 to 0.48, Boissy *et al* 2005; h^2 = 0.02 to 0.39, Wolf *et al* 2008).

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Interestingly, the heritabilities for both birth difficulty and vigour in Suffolk sheep in this study are similar to the range noted by Sawahla *et al* (2007) for lamb survival ($h^2 = 0.18$ to 0.33). Given that birth difficulty and vigour are two important components of lamb survival the similarity in heritability between the study by Sawahla for lamb survival and this study is sensible.

The heritabilities reported here were estimated based on data from a single year, thus separation of maternal additive genetic, permanent environmental (eg environmental effects that affect all lambs born to an individual dam such as udder damage) and temporary environmental effects (eg environmental effects that change from litter-to-litter, such as ewe condition score) was not possible. Early life traits are usually strongly influenced by all of these effects. It is likely that the direct additive genetic effect reported in this study also encompasses some part of the maternal genetic effects. Exclusion of maternal components from models estimating genetic parameters is likely to lead to upward bias in heritabilities (Clement *et al* 2001; Maniatis & Pollott 2002; Fozi *et al* 2005). Therefore, separation of maternal genetic and environmental effects will need to be investigated for these traits when more data become available. This will provide more reliable genetic parameters estimates.

Although both birth difficulty score and lamb vigour are heritable, the genetic correlation estimate in this study is negative. This is unexpected since it might have been assumed that a more difficult birth (higher score) would lead to poorer vigour (higher score). The negative correlation suggests the opposite relationship between these two traits. A possible explanation for this lies in the knowledge that lambs that are heavier at birth have more birth difficulties but heavier lambs usually are more vigorous than lighter lambs (Dwyer 2003). Birth weight was included in the model for both birth difficulty and vigour to exclude variation due to birth weight but this negative correlation will require more investigation.

Sucking ability is also an important component of lamb survival but in the present study this trait had a very low, non-significant heritability. This could be due to the fitting of vigour score in the model since much of the variation in sucking score is related to lamb vigour, as evidenced by the high genetic correlation between these traits. This result indicates therefore that selection for vigour score is likely to be sufficient to also improve sucking score, which might help to reduce the time-consuming recording protocol at lambing time for pedigree breeders. In addition, this score may have been measured less precisely since the successful sucking by a lamb also encompasses co-operative behaviour by the ewe, and the score did not rule out the potential for different decisions to be made by shepherds about when and how frequently lambs needed assistance to suck from their mothers.

Improving ease of lambing, lamb vigour and sucking ability will lead to benefits for increased standards of lamb and ewe welfare with reduced human intervention, lessened likelihood of infections and improved ewe-lamb bonding. These factors should also improve productivity and reduce costs at lambing time. It should be noted that while recording of such traits requires some work at lambing time for pedigree sheep breeders, the main benefits of improving lambing ease and lamb vigour and sucking ability are for the commercial lamb producer who purchases purebred sires to use on ewes to produce crossbred lambs for slaughter. It is primarily these producers who are seeking to reduce labour costs and improve profitability although pedigree breeders would also benefit from lesser requirements for intervention at lambing time other than recording. It will be important therefore to evaluate lamb birth difficulty, vigour and sucking ability in crossbred lambs sired by animals with good and poor estimated breeding values (EBVs) for these traits when such EBVs become available. In order to produce EBVs for lamb birth difficulty, vigour and sucking scores that can be used in a selection programme, a comprehensive set of genetic (co)variances is required including these traits alongside the performance traits such as live weight, ultrasound muscle and fat depths and fat and lean weights measured using X-ray computed tomography.

This report of heritabilities for lamb birth difficulty, vigour and sucking scores demonstrates that selection on such scores, as used in this study, could result in improvements in these traits. However, response to selection for any particular trait of interest depends not only on the heritability of the trait but also on the phenotypic variation in the trait, the selection intensity applied and the accuracy of measurement. The 1 to 4 scoring systems used here resulted in a relatively large number of lambs being given score 1 and fewer animals given the other scores. This has two implications. Firstly, there is not as wide a variation within these traits as might be seen in performance traits. This might limit the selection response that could be achieved. Consideration of altering the scoring system to provide a wider range of categories of behaviour, particularly at the lower end, might therefore be useful. Secondly, the distribution of these traits is such that the properties of a normal distribution are unlikely to apply. It might be useful therefore to test whether transformation of the data would improve the distribution and therefore provide better estimates of genetic parameters.

It is unlikely that breeders would solely select their animals based on the neonatal behaviour scores evaluated in this study. These scores would be integrated into their selection decisions, which are based largely on growth and carcase traits. Therefore, selection intensity for the neonatal behaviour traits is unlikely to be high. How these traits are genetically correlated with the performance traits, such as live weight and carcase composition, is of particular interest. If birth difficulties and/or poor vigour and sucking ability are genetically correlated with higher live weights then it is likely that historic and current selection emphasis for live weight may have exacerbated lamb birth, vigour and sucking difficulties and thus monitoring and inclusion of these traits in breeding programmes is important.

The accuracy of measurement of the trait itself also affects response to selection; less accurate measurements leading to poorer response. The scoring systems used here contained an element of subjectivity, although the guidelines in applying the scores were designed to reduce this, and scores were carried out by a large number of different assessors (individual breeders). Ensuring that these scoring systems do accurately reflect the underlying lamb behaviours is essential and recent validation of the scores against behavioural observation demonstrates that they do represent the variation in neonatal lamb behaviour (Matheson *et al* in preparation). Therefore, the scores provide sheep breeders with a robust system to help improve these traits within their breeding programmes.

Animal welfare implications

Lamb mortality remains a significant welfare concern for the sheep industry with nearly 10% of all lambs dying before weaning (Binns *et al* 2002) even in indoor lambing environments where human intervention can reduce these losses. Difficult births and poor lamb vigour contribute significantly to lamb mortality, and are also areas where staff time is heavily engaged to prevent lamb death. Thus, moves towards lower input systems, and a reduction in labour availability at lambing, will lead to increased lamb losses from these causes. Although management at lambing can reduce and prevent some of these deaths, genetic solutions are permanent and cumulative and can contribute to improving ewe and lamb welfare. Here, we show that it is feasible to collect data on these traits on-farm, and that heritabilities of lambing ease and lamb vigour are sufficient that they can be improved by genetic selection.

Conclusion

This study reports the first estimates of genetic parameters for lamb birth difficulty, vigour and sucking ability in UK Suffolk sheep. Both birth difficulty and vigour had low to moderate heritabilities and thus appear to have potential for selection within a breeding programme. Genetic variation in sucking ability is largely explained by that in vigour, indicating that a reduced scoring system incorporating only birth difficulty and vigour is likely to be sufficient to effect improvements in all three traits. Further work is required in two areas. Firstly, evaluation of correlations between these neonatal behaviour scores and traditionally recorded performance traits is essential to enable neonatal traits to be included in a breeding programme. Secondly, analysis of data from several years is required to better separate the different maternal and environmental components to provide more accurate genetic parameters.

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