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Research paper

Comparison of genetic parameters of weight traits estimated using cross sectional and longitudinal analyses of animal models with two types of contemporary groups in spanish Merino lambs

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ABSTRACT

Genetic parameters and breeding values for weights at weaning (45 days – W45) and slaughtering (75 days – W75) were estimated with 70,635 records of weights recorded from 17,993 lambs of Spanish Merino sheep descendants from 402 sires and 9614 dams. Cross sectional (CS) and longitudinal (random regression – RR) analyses of animal models were used to get the estimates. Contemporary groups included as fixed factors in these models were based either on grouping animals in herds (H) or in clusters of herds with similar environmental levels (EL) defined on the bases of environmental descriptors. Cross validation methods were used to fit models to 80.0% observations randomly chosen and to predict phenotypic values with these models and the remaining 20.0% of the observations. Correlations between observed and predicted values obtained with CS analysis with EL were an average of 4.4% and 4.9% higher than those models with H for W45 and W75, respectively. Estimates of direct heritability and maternal heritability for W45 obtained with CS analysis increased from 0.13 to 0.15 and from 0.54 to 0.58, respectively, when using EL instead of H contemporary groups. The genetic covariance between direct and maternal effects changed from −0.49 to −0.55. Direct heritability of W75 also increased from 0.25 to 0.35. The estimations of heritability obtained with RR analysis showed similar patterns. When using EL contemporary groups direct heritability of W45 and W75 increased 12.7% and 10.7%, respectively, and reliabilities of the estimated breeding values (EBV) for W45 and W75 increased 32.7% and 34.7%, respectively. Increments observed when EBVs were estimated with RR were only 10.8% and 3.5% for W45 and W75, respectively. Expected genetic gains to be obtained in the selection program of the Spanish Merino breed may expectedly increase up to almost 40.0% with this method of clustering herds to constitute new contemporary groups.

1. Introduction

Generally, ruminants breeding plans are carried out assuming that each breed is raised in a more or less homogeneous production system. However, clear evidences exist that many breeds are exploited under very heterogeneous environmental conditions (Fikse et al., 2003). In highly extensive animal production systems in ruminants, a sustainable approach for the genetic improvement of animals, considering the existing environmental, structural and socioeconomic differences, is essential (FAO 2010a). Including fixed effects of herd-year-season contemporary groups of animals in the mixed models used for the estimation of breeding values (BV) attempts to meet this necessity (Kuehn et al., 2007). The effective definition of the contemporary groups requires herds to be genetically connected. However, connections among herds are very defective in extensive systems where there is a high within herd replacement or the movements of animals among herds are not routinely registered and artificial insemination (AI) is not used. Even in a developed country like Spain, the reliability of the BV estimations of the animals are low or very low in more than 85.0% of meat sheep breeds due to low levels of herd connections mainly due to the scarce use of AI (Serradilla, 2008; Serradilla, 2014). Although genomic evaluation has been proposed as a mean to overcome this lack of known connections among herds (van der Werf, 2010; van der Werf et al., 2014), designing a low cost procedure to improve the reliability of BV estimations may have an important economic benefit (FAO, 2010b). One of these procedures is based on clustering herds based on

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their similarities in their management and production systems and other environmental conditions, using environmental descriptors based on the values of climatic and production variables (Fikse et al., 2003). The level of connection among these clusters (henceforward named environmental levels) improves with respect to the connections among herds and they constitute de new contemporary groups considered for the genetic evaluation. This approach has been used to improve connection levels in dairy cattle (Carvalheira, 2000; Weigel and Rekaya, 2000; Vasconcelos et al., 2006) and sheep (Osorio-Avalos et al., 2015).

Mutton type Merino sheep in Spain is raised under a very extensive production system. Its census is near 3.8 million heads, but only 3.6% of the lambs born are under a weight recording system (the so called meat recording nucleus). Great environmental differences exist among herds in respect to their size, managing procedures and climatic conditions. In addition, the average genetic level of the traits under study shows a great variation among herds. All this give origin to a great variation both in morphological traits and in the rates of growth of the lambs (Serradilla, 2008; Magrama, 2011).

Since 1990, a genetic evaluation by descendants of some of the young sires is carried out in the Selection Nucleus (SN) of the breed. These young sires are firs evaluated by descendants in their own herd and then the best among them are moved to a herd which acts as connecting herd where they are re-evaluated by descendants issued from mating each young ram with a random sample of 40–50 ewes (Magrama, 2011).

The selection program of the Spanish Merino sheep considers weaning (45 days) and postweaning (75 days) weights as selection criteria because of their high genetic correlation with carcass lean meat content of and with the feed conversion rate, as well as the high heritability which have been generally reported for these traits (Dickerson, 1978; Manso et al., 1998). However, the estimates of direct (0.30) and maternal heritability (0.25) (Magrama, 2011) and the reliability of the EBVs for these traits in the Spanish Merino selection nucleus can be low due to the scarcity of known connections among herds (Osorio-Avalos et al., 2013).

The aim of this study was to compare the values of the variance components and the reliability of BV, estimated for the 45 days of age (average age at weaning) and 75 days of age (average age at slaughter), using for the estimations of variance components and breeding values (BV) herd (H) vs. environmental levels (EL) as contemporary groups, in animal models analysed with a cross sectional approach (CS) and a longitudinal approach (random regression – RR),

2. Material and methods

In a previous work (Osorio-Avalos et al., 2015) carried out with data recorded in the same sheep population studied here, four clusters of herds were defined applying a cluster analysis (Proc Cluster SAS 9.2). Considering the 20 most informative climatic, production and managing variables as environmental descriptors, 7 eigenvectors (new variables) were obtained explaining 78.3% of the variance among herds. These new variables were used for the cluster analysis, defining four clusters of herds (EL) which corresponds to four clusters of herds grouped by (1) their environmental conditions defined through managing (mainly surface of farm, size of herd, number of days per year of complete stabling of the herd, and number of days per year with exclusive concentrate feeding), which constitute 18.4% of the total variance among herds, and (2) climatological variables (temperature-humidity index and rainfall) and altitude of the farm location, contributing 14.4% of the variance, and (3) production variables (average birth weight, weight adjusted to 30 days and weight adjusted to 75 days), which contribution to the variance is 9.7% (Osorio et al., 2015). These clusters were considered thereafter in the cited work as environmental levels (EL) or contemporary groups of animals for the estimation of BV and they were also used in this study for the same purpose.

2.1. Animal material and weight recording system

The production system of the Merino breed in Spain is predominantly extensive; as a consequence, there is very scarce use of AI. In order to control paternities of lambs and test sires by descendants, breeders in the selection program of the breed keep groups of about 40 ewes with a single ram during two months in a fenced area. Some sires are tested more than one year to have connection among testing campaigns. There is a small level of connections among herds generated by some exchange of sires among breeders. All lambs born in the selection nucleus (SN) of the breed are weighed by official controllers visiting the farms more or less every 60 days, so generating three to four records of weight per lamb at different ages before and after weaning. Individual weight records of lambs used in this work were provided by the National Breeders Association of Merino Sheep.

Data from lambs with a single record and those out of a range of ± 3 standard deviations from the mean were deleted. Purged data set included 70,635 wt records from 17,993 lambs. Weights at 45 days (average weaning age) and 75 days (average slaughter age) were obtained for each lamb interpolating the two weights recorded less than seven days before and after the reference age. Those lambs which had not a weight record within each of the seven day intervals were discarded from the data base. The remaining values were also purged deleting those out of a range of ± 3 standard deviations from the mean, remaining finally 5644 records of weights at 45 days (W45) and 5634 records at 75 days (W75) from 5644 lambs, sons of 162 and 158 rams and 3042 and 2748 ewes, respectively. There were many animals that did not accomplished these purging criteria, that is the reason why in the CS analysis a lower number of lambs were considered. These lambs were born from January 2005 to October 2013 in 19 herds, distributed through the Southwest of Spain, belonging to the SN of the breed.

2.2. Statistical analysis

Both types of contemporary groups, one constituted by the combination of herd-year-two month period of birth (henceforward named H) and the other formed by the combination cluster of herds-year-two months period of birth (henceforward named EL); being clusters of herds, defined in Osorio-Avalos et al. (2015), were compared using two methods: (1) The CS analysis of an animal model, routinely used for the genetic evaluations of W45 and W75 traits in the selection program of the breed, (2). An RR method used for the analysis of the test day records of weights between 1 and 110 days of age.

2.2.1. Cross sectional animal model analysis

A general linear model (GLM) including the fixed effects age of lamb (45 and 75 days), contemporary groups with two options: herd-year-two month period of birth, with 93 levels and environmental level-year-two month period of birth with 67 levels; the combination of litter size and sex of lamb (4 levels), was used to test these effects on the traits studied. All effects were significant and they were included in the model used in subsequent analysis.

The CS analysis employed was the routine method that is used nowadays for the genetic evaluation of this breed. The following animal model was used for the estimation of the genetic parameters of the trait W45:

$$y=Xb+Z_1a+Z_2m+Z_3c+e$$

where $\boldsymbol{y}$ is the vector of W45 and W75 observations; $\boldsymbol{b}$ is the vector of fixed effects formerly described; $\boldsymbol{a}$, $\boldsymbol{m}$ and $\boldsymbol{c}$ are the random direct, maternal and maternal permanent environmental effects, respectively, (3256 levels); $\boldsymbol{e}$ is the vector of residuals; $\boldsymbol{X}$, $\boldsymbol{Z_a}$, $\boldsymbol{Z_m}$ and $\boldsymbol{Z_c}$ are the incidence matrices relating the y observations to $\boldsymbol{b}$, $\boldsymbol{a}$, $\boldsymbol{m}$ and $\boldsymbol{c}$, respectively.