GENOTYPE AND MATING SYSTEM TIMES ENVIRONMENT INTERACTIONS FOR PRODUCTION TRAITS IN SHEEP

Intéraction entre génotype et systèmes de reproduction avec l'environment dans les caractéristiques de production chez les ovins

Tendencia genealógica y apareamiento multiplicados por el influjo del medio ambiente en los rasgos de la reproducción ovina

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Introduction

The existence of breed × environment interactions in sheep could dictate that different breeds be chosen for specific physical and/or managerial environments. Mating system × environment interactions could mean that the existence or magnitude of heterosis was dependent upon environment. In this study, both genotype × environment and mating system × environment interactions for growth and carcass quality in sheep are examined. Environmental variables were years and systems of pastoral management in the same area. Genotypes were all possible straightbred and reciprocal crossbred combinations among three mutton breeds.

Materials and methods

Statistical analyses were by least squares analysis of variance. The basic mathematical model included environmental effects (management system, years, management system × year interaction, age of dam, sex and birth and rearing type), breed and breed × environment interaction effects, and heterosis and heterosis × environment interaction effects. In addition, sires nested within breed, management system and year were included. For carcass quality traits, carcass weight was substituted for the effects of age of dam and birth and rearing type, and an effect for whether the lamb was slaughtered at weaning or after additional feeding was added.

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Dependent variables were birth weight (1209 observations), weaning weight adjusted to 136 days of age (1209 observations), carcass weight per day of age or WDA (749 observations) and the following measures of carcass quality: carcass conformation, finish, leg conformation and quality grades, estimated % kidney and pelvic fat, fat thickness over the *longissimus* muscle between the 12th and 13th rib, and cutability computed according to the USDA (1969) formula (749 observations each).

Results and discussion

Growth rate. The effects of sex, age of dam and type of birth and rearing upon growth rate were consistent with reports from the literature and are reported elsewhere (Hohenboken, Kennick and Bogart, 1974). Year effects were significant for weaning weight and carcass WDA. Intensive management resulted in lower values for all measures of growth. Rainfall distribution in the area is such that forage quality and quantity are not generally a limiting factor for lamb preweaning growth on either type of pasture. The lower growth under intensive management likely resulted from greater concentration of stock creating greater health and parasite problems. Thus, intensive management could be considered a higher stress environment for the lambs.

Sires nested within breeds was significant ($P < 0.05$) for birth weight and carcass WDA but accounted for only 1.7 and 1.4 % of the variation in the two traits, respectively.

There were no significant breed $\times$ environment interactions for birth weight. For weaning weight and carcass WDA, breed of sire $\times$ management system was significant ($P < 0.01$). Extensive management allowed more rapid growth and greater expression of breed differences for additive genotype, while under intensive management, breed effects were essentially equal for both weaning weight and carcass WDA. There were no significant dam breed $\times$ management system or year interactions. Thus, relative maternal performance appeared consistent over years and management systems.

Percent heterosis for birth weight from all crosses did not differ significantly from zero. Pooled crosses of Hampshires $\times$ Suffolks were 2.6 % lighter than the midparent average, while progeny of blackface $\times$ Willamette crosses showed approximately 3 % heterosis. These differences were significant at $P < 0.05$. Hampshires and Suffolks are more closely related genetically than either Hampshires or Suffolks to Willamettes. In two of three cases, reciprocal crosses differed significantly in percent heterosis. In both of these cases, the lower value was associated with Suffolk dams. This observation may have resulted from detrimental Suffolk maternal effects in prenatal, uterine environment. (The analysis yielded a negative estimate for Suffolk maternal component for birth weight.)

For both weaning weight and carcass WDA heterosis from all crosses was approximately 6 %. The greatest hybrid advantage was from Hampshire $\times$ Willamette crosses and the least heterosis from Hampshire $\times$ Suffolk crosses in each case. Only two of six reciprocal cross comparisons differed significantly in the amount of heterosis. In both cases, the lower % heterosis was expressed in the reciprocal cross with the dam breed of lower estimated maternal component.

Thus the data suggest that the magnitude of heterosis is limited by the maternal ability of the female parent. None of the interactions of sire × dam breed with management or year was significant. Thus the effect of mating system was not dependent upon management system or year, and the magnitude of heterosis appeared independent of those environmental variables.

Carcass quality. Intensive management resulted in fatter lambs (greater % kidney fat and carcass fat thickness and lower cutability). Year effects were significant for all carcass variables. Wether lambs scored lower for overall and leg conformation, quality grade and finish score, had less kidney fat and external fat cover and higher cutability. Lambs slaughtered at weaning had more kidney fat but less external fat cover and superior cutability to lambs slaughtered after additional feeding. All variables increased significantly with advancing carcass weight.

The effect of sires nested within breed, management system and year was significant for all carcass variables. The percent of total variance attributable to sires was approximately 3 % for quality grade, 4 % for finish score, 6 % for leg score, 8 % for both conformation score and % kidney fat, 9 % for fat thickness and 11 % for cutability score. Breed differences themselves were not large.

Breed of sire × management system interactions were significant for finish score and USDA quality grade. As was true for sire breed × management interactions for growth traits, extensive management allowed greater expression of breed differences. Sire breed × year interactions were significant for finish score ($P < 0.01$), % kidney fat and fat thickness ($P < 0.05$). Important breed rank changes did not occur for any of the three interactions. The interaction for finish score was attributable to less year variation in Hampshire than in either Suffolk or Willamette sired lambs. The interactions for % kidney fat and fat thickness were attributable to greater variation in breed effects in some years than in others.

The only significant dam breed × year effect was for percent kidney fat ($P < 0.01$) in which breed of dam effects were more variable in some years than in others. No important rank changes occurred.

Breed of sire × breed of dam interactions were absent for all measures of carcass merit, while both breed effects and sire effects within breeds were significant. Other than − 2.5 % for fat thickness and 3.1 % for % kidney fat, all heterosis percentages were near zero. No three-factor interaction of sire breed × dam breed with management system or with year was significant.

SUMMARY

Genotype and mating system × environment interactions for growth performance and carcass quality are reported from a diallel cross among three breeds of sheep replicated over three years and two grazing management systems. Breeds were the Hampshire, Suffolk and Willamette (a synthetic strain with Columbia, Dorset Horn and Border Cheviot ancestry). Management systems were improved dryland hill pastures *vs.* irrigated and heavily fertilized lowland pastures. Management system affected most growth and carcass traits. Hill pasture grazing resulted in lambs that were larger at birth, grew more rapidly and had superior

carcass cutability. There were significant sire breed × management system interactions for growth and for carcass quality grade. There was little breed variation on irrigated pastures but on hill pastures, breed differences were expressed. For several carcass variables, there were greater sire breed differences in some years than in others, but no important rank changes occurred. Heterosis for weaning weight and carcass weight per day of age were each about 6 %, and the magnitude of heterosis was independent of environmental variables. Heterosis was greater from blackface × whiteface crosses than from Suffolk × Hampshire crosses.

Significant differences between reciprocal crosses for % heterosis always favored the reciprocal whose female parent had the higher maternal productivity. Heterosis for carcass traits was not significant.

RESUME

Les interactions entre génotype et systèmes de reproduction avec l'environnement dans les résultats pour la croissance de l'animal et la qualité de la viande, sont considérées du point de vue d'un croisement en diallel entre trois races de moutons et furent répétées pendant une période de trois ans et dans deux systèmes d'élevage différents. Les races étaient Hampshire, Suffolk et Willamette (un croisement entre Columbia, Dorset Horn et Cheviot). Les types de pâturages étaient des pâturages améliorés sur collines de type sec comparés à des pâturages en terres basses irriguées et améliorées par engrais. Le système d'élevage a influé le plus sur les caractéristiques de la croissance et de la viande. L'élevage en pâturages de collines à produit des agneaux plus gros à la naissance qui se développèrent plus vite et produisirent plus de viande. On a noté des interactions importantes entre la race des béliers et le système d'élevage qui affectèrent la croissance et la qualité de la viande. Dans les pâturages irrigués, il y eut peu de différences, mais sur les collines, on a noté des différences selon la race. Les interactions entre les races de béliers et l'année qui amenèrent des variantes dans la qualité de la viande manifestèrent une plus grande différence entre les races selon l'anée. Cependant, il n'y a pas eu de variantes dans le classement. L'hétérosis pour le poids au sevrage et le poids en viande débitée était d'environ 6 % chaque. L'hétérosis pour les caractéristiques de la viande n'était pas important. On n'a pas relevé d'interactions entre le système de reproduction et l'environnement pour la croissance ni pour la qualité de la viande.

RESUMEN

El genotipo y el sistema de apareamiento, multiplicados por el influjo del medio ambiente en cuanto al nivel de crecimiento y calidad de la canal se manifestaron por medio de una alogamia entre tres razas de ovejas, repetida a lo largo de tres años y en dos sistemas de régimen controlado. Las razas fueron la Hampshire, la Suffolk y la Willamette (esta última, una estirpe sintética de origen Columbia, Dorset Horn y Border Cheviot). Las zonas estudiadas fueron pastaderos cultivados, áridos y montañosos, contra pastaderos en tierra baja abundantemente irrigados y fertilizados. El régimen de cada zona influyó; en la mayoría de los sitios montañosos dio por resultado corderos más grandes, que

aumentaban de peso más rápidamente y con carne de superior calidad. Hubo modificaciones importantes producidas por el genotipo del animal padre combinado con el sistema de explotación en cuanto a crecimiento y calidad de la canal. En los pastaderos irrigados hubo poca variación en la prole, pero en los pastaderos montañosos, tales diferencias se manifestaron. El genotipo del padre, combinado con las influencias ambientales variables en cuanto a la canal, dio por resultado una mayor variación en algunos años que en otros, pero no hubo cambios importantes. La heterosis en cuanto al peso al destete y al peso de la canal por día de edad resultó ser en ambos cerca del 6 %. La heterosis en la calidad de la canal no fue significativa, pero la prole cruzada tuvo más grasa de riñonada que la de pura raza. No se obtuvieron datos sobre el genotipo y el influjo del medio ambiente, ni en cuanto al crecimiento ni a la calidad de la canal.

LITERATURE CITED

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