

GENOTYPE AND MATING SYSTEM TIMES ENVIRONMENT INTERACTIONS FOR REPRODUCTION IN SHEEP

Interactions entre génotypes et systèmes de reproduction
avec l'environnement dans la reproduction des ovins

Tendencia genealógica y apareamiento multiplicado por el influjo
del medio ambiente en la reproducción ovina

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INTRODUCTION

Optimum reproduction is critical to the success of any livestock enterprise. The existence of breed genotype \times environment and, particularly, of mating system \times environment interactions for components of reproduction have not been thoroughly investigated. Should important genetic \times environment interactions of these sorts exist, choices of mating systems and breed combinations for specific physical or managerial environments would be affected. In this study, both genotype \times environment and mating system \times environment interactions for reproductive traits are examined. Environmental variables were years and systems of pastoral management in the same area, and genotypes were all possible straight-bred and crossbred combinations among three mutton breeds.

MATERIALS AND METHODS

The experimental design was a diallel cross among three breeds of sheep replicated over three years and two management systems. Breeds were the Hampshire, Suffolk and Willamette. (The latter is a synthetic strain developed at the Oregon Experiment Station from 15 years of closed flock selection, under hill pasture conditions, from a base of Border Cheviot \times Columbia mated reciprocally to Dorset Horn \times Columbia). Each year, 288 ewes (96 per breed) were maintained under each management system. Each ram was mated to eight ewes

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of each breed and was used for only one breeding season. Over the three years, 36 rams were used and each sired both straightbred and crossbred progeny. Ewes remained under the same management regime for the duration of the trial but were rerandomized to breeding groups each year.

The two management systems were «extensive» hill pastures vs. «intensive» irrigated pastures. The extensive system was grazing on improved but lightly phosphate fertilized hill pastures. Approximately 87 ha. in six pastures were available for the 144 ewes and their lambs. Predominant forage species were perennial rye grass (*Lolium perenne*) and subterranean clover (*Trifolium subterraneum*). Pasture growth was from March through mid-June with some growth in September thru November accompanying fall rains. Pastures were dry and dormant during the summer. Ewes and lambs were set-stocked during lactation. Following weaning in mid to late June, ewes were returned to the dry pastures.

The intensive management system was on lowland irrigated pastures of tall fescue (*Festuca arundinacea*), orchard grass (*Dactylis glomerata*) and New Zealand white clover (*Trifolium repens*). Approximately eight ha. in ten lots were available for the 144 ewes and their lambs. These pastures were heavily fertilized with nitrogen and were sprinkler irrigated from June into September. Ewes and lambs were set-stocked until weaning in mid to late June. Both groups were shed lambed February through mid-March in common facilities, and ewes and lambs were returned to the appropriate pastures as soon as weather and forage growth permitted. (Each year, hill pasture ewes were on pasture two to four weeks earlier than those under intensive conditions.) None of the lambs was creep fed, and average age at weaning was 136 days.

Statistical analyses were by least squares analysis of variance. The basic mathematical model included environmental effects (management system, years, ewe age and, for some traits, ewe weight change during the breeding season and day of lambing within the lambing season), breed and breed \times environment interaction effects (breed of sire, breed of dam and the interactions of each with management system and year) and heterosis and mating system \times environment effects (sire \times dam breed interaction and the three factor interactions of sire \times dam breed with management and year). In addition, sires nested within breed, management system and years were included.

Dependent variables were fertility (ewes lambing per ewe exposed to mating), prolificacy (total number of lambs born per ewe lambing), survival (lambs weaned per lamb born), and total productivity (Kg of lamb weaned per ewe mated).

RESULTS AND DISCUSSION

Fertility. Ewe fertility averaged 88.6% and was not influenced significantly by sire breed, sires nested within breeds, nor by any of the environmental variables. Though main effects of dam breeds did not differ, there was a marked dam breed \times environment interaction ($P < 0.05$). Under intensive management conditions, where feed supply was fairly equitable throughout the year, dam breed differences were slight (ranging from 87.1 to 88.4%). Under extensive management, where feed quality varied with seasons, Willamettes excelled while Suffolks were inferior in fertility. Sire breed \times management was not significant, nor were

sire or dam breed \times years. Heterosis for fertility was 5.7%, probably due to enhanced embryonic survival of the crossbred fetus. Percent heterosis was similar for each two-breed combination. There was no evidence that mating system interacted importantly with management or with year.

Prolificacy. Intensive management allowed higher prolificacy (1.76 vs. 1.52, $P < 0.01$). Years was significant ($P < 0.01$) and the effect of ewe age ($P < 0.01$) was consistent with reports from the literature.

Prolificacy was negatively associated with weight change during mating ($b = -0.012$ lamb per Kg., $P < 0.05$) and was positively related to day of lambing within the season ($b = 0.0059$ lamb per day, $P < 0.05$). Of the possible breed \times environment interactions, only sire breed \times year was significant ($P < 0.05$). Sire breed rank for prolificacy changed from year to year, and no explanation for the changes was apparent. Heterosis for prolificacy was not significant and averaged only 1.8%. There was no evidence of interaction between mating system and management regime or year.

Survival. Genetic and environmental effects and interactions did not significantly influence the ratio of lambs born alive to total lambs born (97.6%). Extensive management did allow greater survival from birth to weaning (92.0 vs. 82.4%), probably because of less crowding and confinement under hill pasture conditions. None of the other effects was significant. Survival of all crossbred lambs was 3.2% greater than survival of all straightbred lambs.

Total ewe productivity. Kilograms of lamb weaned per ewe exposed to mating combines the effects of fertility, prolificacy, survival, maternal ability and growth rate. Effects on Kg of lamb weaned per ewe lambing and a more complete discussion of these data is presented elsewhere (HOHENBOKEN, CORUM and BOGART, 1974). Extensive management resulted in greater net productivity (55.2 vs. 47.8 Kg.). Year differences were large (range of 19.8 Kg). Ewe productivity increased with age from two thru six years. Kilograms weaned was also positively associated with weight change during mating ($b = 0.61$ Kg per Kg weight change, $P < 0.05$). Sire breed did not interact with either management system or year. The dam breed \times management system interaction was significant ($P < 0.05$) and important. Each ewe breed performed better under extensive than intensive management. Hampshires were lowest in net productivity in both. Under intensive management Suffolks exceeded Willamettes by 4 Kg, but under extensive management, Willamettes exceeded Suffolks by 4.9 Kg.

Heterosis for Kg of lamb weaned was 13.5%, and the percentages of heterosis from each two-breed combination were similar. Two of the three comparisons of heterosis from reciprocal crosses were significantly different. For Suffolk rams \times Hampshire ewes vs. its reciprocal and for Willamette rams \times Hampshire ewes vs. its reciprocal, heterosis differed. The least heterosis was associated each time with Hampshire ewes. The Hampshire breed of dam effect on Kg weaned was less than either Suffolk or Willamette effects. Suffolk rams \times Willamette ewes vs. the reciprocal cross had nearly identical percentages of heterosis. Breed of dam effects from these two breeds on Kg weaned were nearly equal. These results suggest that the magnitude of heterosis is limited by the maternal productivity of the dam breed in the cross.

Sire breed \times dam breed \times management system was significant ($P < 0.05$), suggesting interaction of mating system with environment. Under extensive manage-

ment, the net advantage from crossbreeding was slight, only 1.4 % heterosis. Under intensive management, however, which resulted in less overall productivity, heterosis was 30.1 %. Possibly hybrid vigor allowed the crossbred lambs to cope more adequately with the higher stress environment whereas extensive management stressed neither group sufficiently to allow differences in adaptability to be expressed.

SUMMARY

Genotype and mating system \times environment interactions for reproduction and ewe productivity 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 Cheviot ancestry). Management systems were improved dryland hill pastures *vs.* irrigated and heavily fertilized lowland pastures. Hill pasture management resulted in lower prolificacy but greater lamb survival to weaning and more Kg of lamb weaned per ewe exposed to mating. There were no important sire breed differences or sire breed \times management system or year interactions. Dam breed and the dam breed \times grazing management interaction both influenced ewe productivity. On irrigated pastures, Suffolks excelled, Willamettes were intermediate and Hampshires were lowest for Kg of lamb weaned per ewe mated. On hill pastures, Willamettes and Suffolks switched ranks. Percentages of heterosis for fertility, prolificacy, survival and total productivity, respectively, were 5.7 %, 1.8 %, 3.2 % and 13.5 %. There was an important mating system \times environment interaction for total productivity. Under the irrigated (greater stress) environment, heterosis was 30.1 %, while on hill pastures it was only 1.4 %.

RESUME

Les interactions entre génotype et système de reproduction avec l'environnement dans la reproduction et la productivité des brebis 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 améliorés sur collines de type sec comparés à des pâturages en terres basses irriguées et améliorées par engrais. L'élevage dans les pâturages de collines a donné comme résultat une fécondité réduite mais un plus grand nombre d'agneaux survivant au sevrage et un plus grand poids par agneau sevré pour chaque brebis fécondée. Il n'y a pas eu de différences importantes provenant des béliers. Il n'y a pas eu d'interactions entre les races de béliers, les systèmes de pâturages et l'année. L'interaction entre la race des béliers d'une part et la race des béliers plus le système de pâturage d'autre part, a affecté la productivité des brebis. Ainsi, dans les pâturages irrigués, les Suffolk donnèrent les meilleurs résultats, les Willamette des résultats moyens, et les Hampshire des résultats moindres par kilo d'agneau sevré pour chaque brebis fécondée. Dans les pâturages de collines, les Willamette furent les meilleurs

et les Suffolk les moyens. Les taux de pourcentage d'hétérosis pour la fertilité, la fécondité, la vie, et la productivité totale furent respectivement 5,7 %, 1,8 %, 3,2 % et 13,5 %.

Pour la productivité totale, il y eut une interaction élevée entre le système de reproduction et l'environnement. Dans l'environnement irrigué (moins productif), l'hétérosis était de 30,1 % alors que sur les collines, il était de 1,4 %.

RESUMEN

La tendencia genealógica y apareamiento multiplicados por el influjo del medio ambiente en la reproducción y en el rendimiento ovino se manifestaron por medio de una alogamia entre tres razas de ovejas, repetida a lo largo de tres años y 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 Cheviot). Las zonas de registro fueron pastaderos laboreados, áridos y montañosos, o bien pastos en tierra baja abundantemente irrigados y fertilizados. Las zonas montañosas dieron por resultado una menor fecundidad, pero una mayor supervivencia de corderos y un mayor peso en kilogramos por descorderado en cada oveja parida. No hubo diferencias importantes ni en cuanto a la descendencia del padre ni a la del padre en relación con la zona controlada o con los intercambios estacionales. La prole de la madre y la prole de la madre en relación con la zona controlada fueron importantes fuentes de variación en cuanto a la fecundidad de las ovejas. En los pastaderos irrigados sobresalieron los Suffolk con los Willamette intermedios; los Hampshire fueron inferiores en cuanto a kilogramos de carne por oveja parida. En los pastaderos montañosos cambiaron de rango los Willamette y los Suffolk. Los porcentajes de vigor híbrido en cuanto a fecundidad, supervivencia y rendimiento total, respectivamente, fueron de 5,7 %, 1,8 %, 3,2 % y 13,5 %. Para el rendimiento total hubo una condicionalidad procedente del influjo del medio ambiente. En el medio ambiente irrigado menos productivo, el vigor híbrido fue de 30,1 %, mientras que en las pastaderos montañosos fue solamente de 1,4 %.

LITERATURE CITED

- HÖHENBOKEN, W. D.; CORUM, Kathleen, and BOGART, R. (1974): Genotype and Mating System \times Environment Interactions in Sheep. I. Reproduction. *J. Animal Sci.*, 39. (In press.)

