SELECTION FOR HIGH AND LOW PROLIFICACY IN RAMBOUILLET SHEEP

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SUMMARY

Selection for reproduction in Rambouillet sheep was begun in 1969. Ewes were randomly divided into 2 lines, a low(L) and a high(H). Rams and ewes were selected within line on the basis of an index of their dams' reproductive rate. In 1972, all remaining foundation ewes removed from L and H and used to establish a random bred control line(C). The mean yearly selection differentials for rams were -.31, .38 and .03 and for ewes were -.08, .07 and -.06 for L, H and C respectively. The regression of cumulative selection differential on year of birth for rams were -.051, .085 and .014 and for ewes were -.065, .048 and -.014 for L, H and C respectively. Response to selection as measured by the regression of the least-squares means for index within line on year of birth was -.013, .022 and-.011 for L, H and C, respectively. The realized heritabilities (h_R) within line were .19, .036 and -.13 for L, H and C, respectively.

INTRODUCTION

Selection for improved reproductive rate in domestic animals generally was not considered to be practical because of the low heritability estimates for reproductive traits. However, the results of several long term selection experiments with mice and sheep indicate that considerable progress from selection can be achieved. Falconer(1960) and Bradford(1969) through divergent selection were able to significantly change litter size in mice. Clark(1972) reported a gradual but erratic annual increase of .0175 lambs born per ewe compared to the random bred control line but little change in the low line. Turner(1978) reported an increase in reproductive rate and in the number of multiple births in response to selection for increased multiple births.

The objective of this experiment was to evaluate the effectiveness of selection for changes in reproductive rate.

MATERIALS AND METHODS

This study was initiated in the fall of 1968. Rambouillet ewes were assigned at random within age to one of two selection lines, H or L. In the fall of 1972 all remaining foundation ewes were removed from the H and L lines and used to establish C.

Management of Ewes. All ewes were managed as one group throughout the year except at breeding. On approximately November 10 each year ewes were placed in single sire breeding pens with rams of their respective lines. Ewes remained in the breeding pens for 20d and at the end of the 20d period all ewes were returned to the range and exposed to black face rams for an additional 15d. All ewes were wintered together as part of a larger group of ewes and were grazed on winter range composed primarily of blue-bunch wheatgrass(Agropyron spicatum) and Idaho fescue(Festuca idahoenes). They were supplemented with 227 g/head/d of a 20% protein pellet(approximate composition: 48% barley, 5% wheat millrun, 27% soybean meal, 5% dehydrated alfalfa, 6% molasses, 7.5% dicalcium

phosphate and salt) during the winter and fed mixed alfalfa and grass hay only when snow cover was to deep too permit grazing, usually about 5d each winter. Each year the ewes were shorn during the first week of April and fleece weights were recorded. At this time, the ewes were moved to a large pen and subjected to 24h observation for lambing. Upon lambing, ewes were moved to small individual pens approximately 1.3 m^2. All lambs were individually ear tagged and birth weights were recorded within 24h of birth. The ewes remained in these pens for 1 to 3d, depending upon the number of lambs and condition of the lambs and ewe. The ewes and lambs were then moved to larger pens containing 6 to 8 ewes for 2 to 3d and subsequently outside to larger pens. Generally ewes with twins were kept separate from ewes with singles for the first two to three weeks after lambing. All ewes and lambs were herded on unfenced areas of the research ranch until early July when they were weighed. Until 1977 all ewes and lambs were trucked to high mountain Forest Service grazing allotments for the remaining summer grazing until the last week of August when the lambs were weighed and weaned. After 1977, all ewes and lambs remained on the research ranch for the remainder of the summer.

Selection procedures. Ram selection occurred at weaning each fall. Rams were selected on the basis of their dams past reproductive performance. A simple index was calculated for each individual in H and L. The index was: I= total lambs born per ewe/(age of ewe - 1). This index is the average number of lambs born in the ewe's lifetime up to the time that the individual was born, including years that the ewe was exposed for breeding and failed to lamb. The four rams with the highest indexes within H (not paternal half-sibs) and the four rams with the lowest indexes within L (not paternal half-sibs) were selected for use the following year. Four reserve rams were also selected within each line. In C, eight rams and four reserve rams were selected at random again with the restriction that no paternal half-sibs could be used. The only other restrictions were that the rams could not have a closed face or horns. Rams were used for only one breeding season at approximately 19 months of age.

Ewes in H and L were selected on the same basis as were the rams, but selection occurred at approximately 16 months of age and no restriction was made as to paternal half-sibs. Ewes in C were selected at random. The number of ewes born per year ranged from 28 to 77, 33 to 81 and 23 to 62 for L, H and C, respectively with percent of ewes selected ranging from 27.5 to 67.5, 18.5 to 67.9 and 12.5 to 71.0 for L, H and C, respectively. All ewes were culled at 6 years of age and the only other reasons for disposal were failure to lamb two consecutive years or physical problems such as mastitis.

Measures of selection applied. Selection applied is generally measured by the average selection differential of the parents, which is the difference in the performance of the selected parents compared to the unselected group from which they came. The selection differentials(S) were computed separately for sires and dams within each line. The cumulative selection differential(CS) can be measured as the average selection differential of the parents plus the average CS from each previous generation and can be carried forward as a simple averaging of the parental values.

In sheep there is considerable overlap of generations producing lambs in any one year. The generation of selection was measured by calculating a generation number(g_i) according to the formula suggested by Turner and Young(1969): $g_i = 1+[(g_s + g_d)/2]$ where g_s and g_d are the generation numbers for the sire and dam, respectively with the foundation animals are taken to be generation zero.

Response to selection. Response to selection was measured by calculating each ewe's index and then analyzing the index values. The index value was the dependent variable in least-squares analysis (Harvey, 1977) with the independent variables being year of birth of the ewe(YB; 1969-1983), number of years the ewe produced(YP; 1-5), selection line (H, L and C) and all two factor interactions. In some models g_i was added as a continuous independent variable. The regression of the least-squares YB by line means for index on year of birth and the regression of index on g_i were used to evaluate the phenotypic time trends.

Another method to evaluate response to selection is that of Richardson et al.(1968) which is a multiple regression procedure. This procedure uses all available data from contemporaries to estimate yearly environmental effects. Time trends for YB were then estimated by subtracting the least-squares means for YB by line from the yearly environmental estimates and then regressing these values on YB.

Response per unit of selection applied, h_R, was calculated within line as the regression of the least-squares YB by line means for index on the YB by line means for CS. Realized heritabilities come directly from the solutions to the ordinary least-squares equations when the CS are included (Richardson et al., 1968).

RESULTS AND DISCUSSION

Selection applied. S of the ewes and rams are shown in figure 1. Mean yearly S $\pm$ SD for selected rams in L, H and C were $-.31\pm.11$, $.38\pm.20$ and $.03\pm.22$ and for the selected ewes were $-.08\pm.10$, $.07\pm.09$ and $-.06\pm.04$ index units, respectively. CS of the ewes and rams are shown in figures 2. Regression of CS on YB was -.051, .085 and .014 for L, H and C rams and -.065, .048 and -.014 index units per year for the L, H and C ewes, respectively. The fact that S and CS are negative for the C line ewes is probably the result of more mortality in the twin born lambs than in the single born lambs causing more chance for random selection to occur in lambs that were born to ewes with higher incidence of singles making their index valves lower. The mean survival to weaning, for these lambs, was 87.4% and 75.3% for single and twin born lambs, respectively (Subandryo, 1984).

Selection response. The least-squares analysis of variance of ewe index (table 1) indicated that YB, line, YP and YB x line were significant sources of variation. The least-squares means $\pm$ SE for line were $1.13\pm.02$, $1.34\pm.02$ and $1.30\pm.02$ for L, H and C, respectively and for YP were $1.10\pm.03$, $1.20\pm.03$, $1.24\pm.03$, $1.38\pm.03$ and $1.36\pm.02$, respectively for 1 through 5 years. The least-squares means for YB are shown in figure 3 and the regression coefficients of index on YB and g_i and the means adjusted for environmental effects by the method of Richardson et al. (1968) are present in table 2. These results do not separate the genetic from the environmental time trends, but tend to indicate that the low and control indexes decreased while the high line index did not change significantly over time. However, if one subtracts the control line means from the high and low line means and then calculates the regression of the deviation of index from the control line on YB, the b values are $.015\pm.013$ and $.009\pm.012$ for L and H, respectively. This assumes that the control line adequately evaluates the environmental trends. However, h_R (table 2) indicates that progress per unit of selection was positive in both L and H, but was negative in C by both methods of calculation. The negative h_R in C may indicate that natural selection is changing this population in addition to the environmental effects. Thus, unless the same natural selection is working in H and C where artificial selection was applied the

deviation from C does not adequately estimate environmental trends and therefore the genetic change is not well estimated.

These results are different from those reported by Clarke (1972) in that little positive response was observed in H while a larger negative response was observed in L. However, it is difficult to assess the effects of the environment in this study and the "genetic" change based on the control line was positive for both L and H and actually larger in L than H.

TABLE 1. Least-squares analysis of variance of ewe index

Source of variation	df	ms
YB	14	.474**
Line	2	3.959**
YP	4	1.588**
YBxYP	24	.173 *
Error	889	.113

* (P .05).
**(P .01).

TABLE 3. Regression coefficients of time trends for response to selection and realized heritabilities.

Selection	Regression coefficient			h^R	
line	YB	g_i	R^a	B	R^a
L	-.013	-.033	-.0045	.192	.132
H	.022	.066	.0065	.036	.182
C	-.011	-.040	-.0072	-.134	-.215

[a]Method of Richardson et al. 1969.

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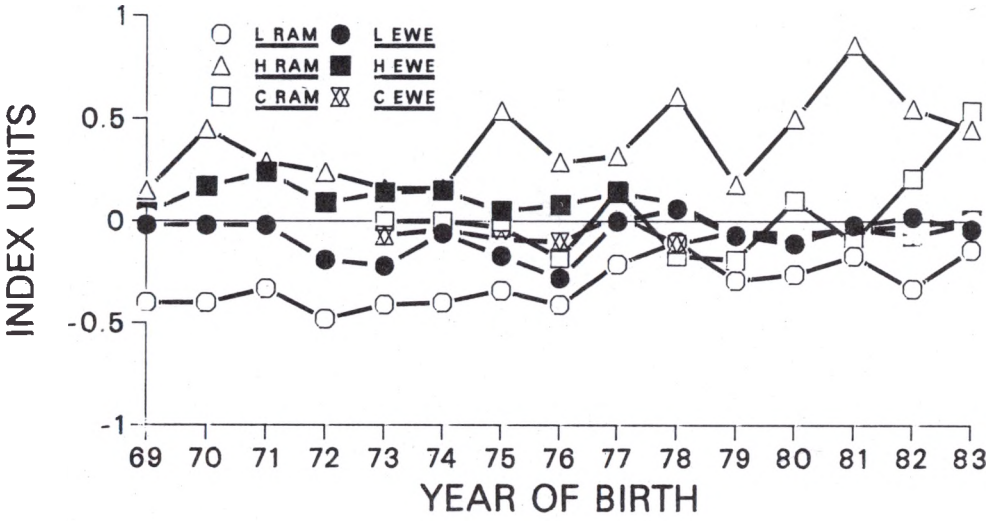

Figure 1. Yearly selection differentials for rams and ewes.

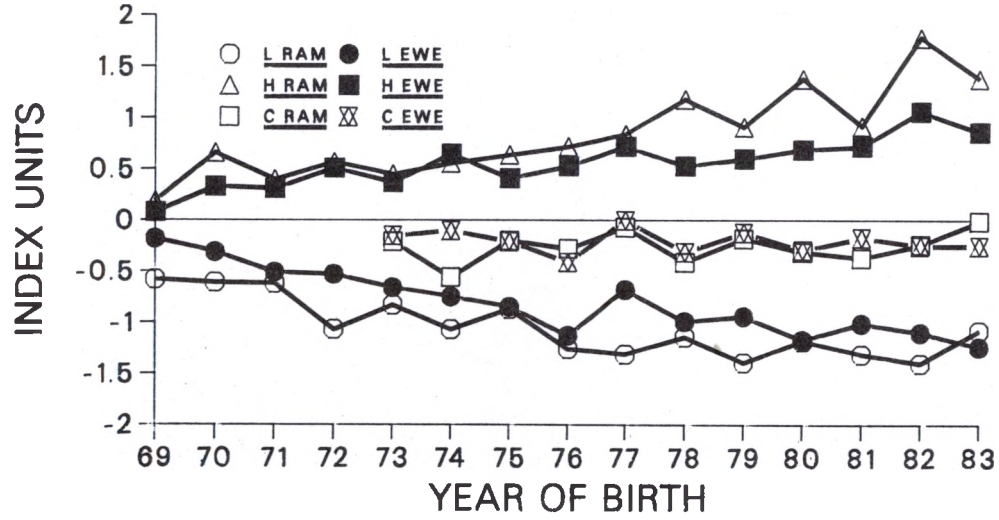

Figure 2. Cumulative selection differentials for rams and ewes.

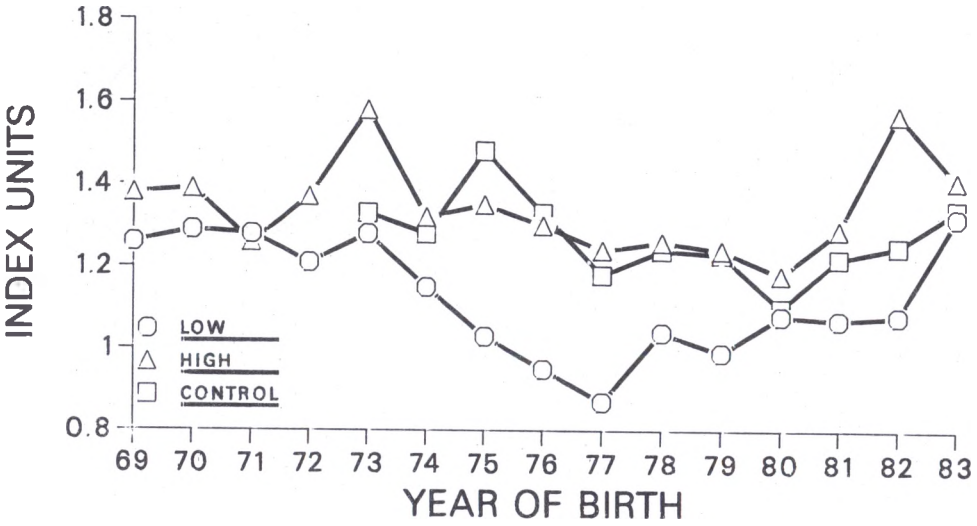

Figure 3. Yearly means for index based on year of birth of selected ewes in L, H and C.