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Selection Applied in the Angus Breeding Scheme of the New Zealand Land Development and Management Corporation

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SELECTION APPLIED IN THE ANGUS BREEDING SCHEME OF THE NEW ZEALAND LAND DEVELOPMENT AND MANAGEMENT CORPORATION

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SUMMARY

The Land Development and Management Corporation (LDMC) has established an open-nucleus Breeding Scheme within its Rotorua District to breed Angus bulls to cover 20 750 cows and 5 200 heifers. Nucleus herd numbers over the 1976-85 period were 775 cows and 357 heifers, with an average of 101 2-year-old bulls being distributed annually to LDMC herds. From 1976/77, a multiplicative breeding objective was established in the nucleus, accounting for cow and calf weights and net fertility of the cow. Primary selection was applied to yearling bulls and heifers using a selection index combining the calf's data and dam's updated data ('Yearling Index', YI). For calves born in 1976 to 1984, the average generation interval was 3.76 years. The corresponding cumulative selection differential for YI had reached 1.90σ in the final year, with similar values also for three of four component traits. For young males, the actual selection differential for YI was 1.47σ, 86% of the maximum possible. The selection applied in this industry Scheme was comparable with that recently reported in two large long-term experimental selection herds of beef cattle.

INTRODUCTION

The Land Development and Management Corporation (LDMC, formerly the Fields Directorate of the Department of Lands and Survey) is the largest farming organization in New Zealand. It is responsible for 616 260 ha of land (Department of Lands and Survey, 1985) of which 423 468 ha carry 1.006 m breeding ewes (2.0% of the national ewe flock) and 60 150 beef breeding cows (4.2% of the national beef cow herd).

In 1970, the LDMC established a performance-recorded open-nucleus Angus bull breeding scheme to supply sires to its predominantly Angus herds in the central region of the North Island (Rotorua Land Development District). The reasons behind establishing the scheme and the female screening, recording and subsequent male and female selection procedures in the initial years were described by Gibson and Dalton (1973) and Dalton and Gibson (1974).

The present study was initiated to quantify the selection applied in the Angus Breeding Scheme since index selection was introduced in 1976.

General Description

Over the years 1976 to 1985, the average beef cow population in the LDMC Rotorua District was 20 750 cows and 5 200 heifers. Corresponding nucleus herd numbers were 775 cows and 357 heifers, representing 3.7 and 6.9% of the respective base population age groups. Within the nucleus, the proportion of heifer replacements screened from the base population over this period was 21.2%, with the total nucleus herd being comprised of 47.6% screened-in females (including screened foundation cows).

An average of 101 2-year-old bulls were distributed annually to LDMC herds, representing 24.9% of all bulls born in the nucleus.

Currently, the scheme consists of a nucleus herd of 720 pregnant females on two adjacent farm blocks (Waihora and Otutira) and young male stock on a third adjacent block (Kakaho). Females 15 months of age and older are randomized within age and aggregate breeding value and joined in single-sire mating groups for 45 days. Sire-daughter, son-dam and paternal half-sib matings are avoided where possible. At least two common sires are used between the Waihora and Otutira blocks each year. All resulting progeny are retained through to the yearling stage for young bull and heifer selection and to facilitate the evaluation of sires on progeny performance.

Young female nucleus herd replacements are retained from within each block, although highly ranked 15-month heifers are transferred from Otutira to Waihora for mating (45 out of 129 heifers on Otutira in 1985). From a mean population size of 5200 heifers in the LDMC Rotorua District, an average of 47 6- to 7-month-old heifer calves have been screened on to Otutira annually, of which 38 have been reared through to 2-year-old calving alongside nucleus-bred contemporaries. The prevailing extensive farming conditions mean that heifers are screened on the basis of *unadjusted liveweight only.*

Male calves born in the nucleus herds are transferred at weaning to Kakaho and reared to the yearling stage. Averaged over the last 10 years (1976 to 1985), 3.3% of the yearling bulls have been selected as nucleus herd sires, representing 50% of all bulls used annually in the nucleus. The remainder of the nucleus sires have consisted of 46% 2-year-old bulls (comprising 9.4% purchased bulls and 36.6% home-bred bulls), and 3-year-old and older progeny tested bulls (4%).

Breeding Objective

In the 1976/77 season, the recording procedures of the scheme were revised (Nicoll, 1977; Nicoll et al., 1979). Index selection was introduced to achieve the following breeding objective (H) described by C.A. Morris, R.L. Baker and D.L. Johnson (unpublished):

$$H \text{ (net income (\$) per cow lifetime)} = .53LD_p(4.8F-1) + .06\ MD_c$$

where L = liveweight at slaughter (kg) at 30 months of age of surplus progeny;

D_p, D_c = carcass dressing out percentage (x .01) of slaughtered progeny and the culled cow respectively;

F = net fertility (average number of calves weaned per cow exposed);

M = mature cow liveweight (kg) at disposal.

The coefficients .53 and .06 represent the net income ($/kg carcass) from the slaughter of young stock and cull cows respectively. If selection per se has no effect on the life expectancy of a cow, maximizing annual net income or net income per cow lifetime are equivalent (Morris, 1979). Average cow lifetime is assumed constant (5.8 years), with the variable 4.8F indicating the number of saleable calves per cow lifetime, from which is subtracted one calf to represent the heifer retained to replace the cow.

The selection criteria include number of calves born and weaned, weaning weight and yearling weight. Selection of young herd male and female replacements is based on a Yearling Index (YI), incorporating components described below. Continued selection of cows in the nucleus herds is based on a Cow Index, incorporating the YI traits (updated for subsequent calvings of her dam) as well as the cow's own fertility and maternal weaning ability.

MATERIALS AND METHODS

Analyses consisted of data for calf YI and its four components, calf adjusted weaning (AWW) and yearling (AYW) weights, cow net fertility (F) expressed as calves weaned per mating and cow maternal weaning weight (MW, the average of accumulated records), for birth years 1976 to 1984 (since the introduction of index selection). Liveweights were adjusted for age, age of dam and sex effects within years.

Cumulative Selection

The mean cumulative selection differential for a trait measures the amount of selection background in the parents of the progeny born in a given year. As pointed out by Magee (1965), the term selection differential should only be applied to mass selection using one trait. Thus in the Angus Breeding Scheme a selection differential was calculated for YI and, for component traits of that Index, a secondary selection differential (Magee, 1965) was defined.

Cumulative secondary selection differentials (CSD) in standard measure were then calculated using the method of Newman et al. (1973), further described by Buchanan et al. (1982), and Frahm et al. (1985). Commencing with a base differential of zero in 1976, the CSD of a calf was calculated as the sum of the individual's deviation from its contemporaries and the average CSD of the sire and dam of that individual. Screened-in heifer replacements were eliminated from these computations, but dams that had been screened in as heifers were assumed to have a zero differential.

Actual and Maximum Selection Differentials of Sires

Selection differentials of sires of all progeny born from 1976 to 1984 were determined by averaging individual deviations of the selected sires from their contemporaries for AWW, AYW, F, MW and YI. Maximum potential selection differentials of sires were calculated by averaging the individual AWW, AYW, F, MW and YI deviations of those bulls (the same number as were actually selected) with the largest YI values in each year.

Index in Retrospect

An index in retrospect was calculated in standard measure to determine the relative emphasis of the component traits of the actual YI used, following the methods of Buchanan et al. (1982) and Eikje and Clarke (1986).

RESULTS

Over the nine year period under study, the average generation interval was 3.76 years (4.50 and 3.02 years for dams and sires respectively). The most advanced of the 1984-born progeny were the products of 2.14 generations of selection.

Cumulative Selection Applied

Average CSDs in standard measure are shown in table 1 to indicate the selection pressure for component traits of YI in the parents of calves born in the scheme. The regression coefficients of CSD on year were .22, .27, .17 and .25 standard deviations (σ)/year for AWW, AYW, F and MW respectively. The corresponding rate for YI was .28. With the exception of F, CSD for the component traits of YI accumulated at similar rates.

TABLE 1. Average cumulative secondary selection differentials (CSD) of component traits and the cumulative selection differential of Yearling Index (expressed in standard measure)

Year	Component trait of Yearling Index (YI)[a]				
	AWW	AYW	F	MW	YI
1976	0	0	0	0	0
1977	0	0	0	0	0
1978	.04	.34	.20	.52	.40
1979	.41	.73	.36	.94	.82
1980	.67	.96	.52	1.24	.99
1981	.71	1.12	.68	1.23	1.18
1982	1.03	1.66	1.00	1.45	1.74
1983	1.51	1.98	1.08	1.93	1.98
1984	1.54	1.85	1.20	1.70	1.90
b[b]	.22***	.27***	.17***	.25***	.28***
se	.02	.02	.01	.03	.02

[a] AWW = adjusted weaning weight; AYW = adjusted yearling weight; F = dam net fertility; MW = maternal weaning weight

[b] Regression coefficient (b) on year of birth, and standard error (se).

Index in Retrospect

The phenotypic correlations necessary to construct the index in retrospect were calculated from the data and are shown in table 2. Average actual and maximum potential secondary selection differentials (in standard measure) for the selected sires of calves are shown in table 3. In the primary trait (YI), actual sire selection differential per year was 86% of the maximum potential. Actual secondary selection differentials in sires exceeded maximum potential secondary differentials for AWW and MW, suggesting that greater emphasis was placed on these traits at the expense of F.

TABLE 2. Phenotypic correlations among traits

	Trait			
	AWW	AYW	F	MW
AYW	.70			
F	-.01	0		
MW	.58	.43	.07	
YI	.41	.84	.35	.39

TABLE 3. Mean actual and maximum potential secondary and selection differentials of selected sires, expressed in standard measure

	Component trait				
	AWW	AYW	F	MW	YI
Actual	.96	1.42	.64	1.30	1.47
Maximum potential	.74	1.54	.83	1.21	1.70

The corresponding index in retrospect is shown in table 4. The partial regression coefficients indicated that sire selection was strongly in favour of AYW. Had maximum potential selection been realized, selection would have been even higher for AYW.

TABLE 4. Selection index in retrospect for actual and maximum potential secondary and selection differentials of selected sires, expressed in standard measure

	Partial regression coefficients			
	AWW	AYW	F	MW
Actual selection	-.48	1.32	.53	.98
Maximum selection	-1.24	1.92	.71	1.05

DISCUSSION

Although several traits are generally recognized as being important in beef cattle production, including liveweight and cow fertility traits, only the former provide the basis of most beef cattle performance recording systems. The LDMC's Angus Breeding Scheme provides an interesting example of an independent commercial breeding operation in the New Zealand beef industry. It has defined a multiple-trait breeding objective that includes both liveweight and cow fertility traits.

As a non-experimental breeding programme, the generation interval (defined as the average age of parents) of 3.8 years was shorter than the mean of 4.4 years reported by Koch et al. (1982) in summarizing results from several beef selection experiments.

Cumulative Secondary Selection Differentials

The annual rates of increase in standardized mid-parent cumulative secondary selection differentials found here for AWW (.22 σ/year) and AYW (.27 σ/year) under index selection, were comparable with the corresponding rates of .24 and .24 σ/year (Buchanan et al., 1982) and .26 and .27 σ/year (Frahm et al., 1985) in experimental lines of cattle selected solely for weaning and yearling weights respectively. The cumulative secondary selection differential for cow fertility (.17 σ/year) is of particular interest, given the importance but low heritability of the trait. The actual sire selection differential for Yearling Index was 86% of the maximum potential selection differential. The loss in sire selection on Yearling Index was primarily attributable to the purchase of 'outside' sires with neither a Yearling Index nor component trait information directly comparable with that of the present scheme. Any culling for structural faults considered to affect productive performance would also have contributed to the loss in potential sire selection.

This is probably the first time that estimated secondary selection differentials for cow fertility and maternal weaning weight have been estimated in beef cattle. The following points should be made however: there was considerable variation in the ages of dams represented in the data under study (average number of dam records = 3.4); maternal trait estimates were restricted by the limited number of calvings represented; only 2.1 generations of selection in nine years have been achieved so far.

Index in Retrospect

Although selection in practice was assumed to be for a single trait (Yearling

Index), standard partial regression coefficients for the index in retrospect (table 4) provided a check on selection intentions in the Angus Breeding Scheme, averaged over the nine years. Actual sire selection favoured the Yearling Index through its component traits. The negative coefficient for AWW was not considered important in terms of response in weaning weight because of its positive genetic correlation with yearling weight (.75) in the Yearling Index and the emphasis placed on AYW in actual selection. Estimates of genetic trend for AWW and AYW in the scheme were reported by Nicoll and Johnson (1986) to be 1.6±.9 and .7±.9 kg/year respectively.

In an independent experiment measuring the progeny of bulls representing those distributed to LDMC herds from the Angus Breeding Scheme, compared with bulls normally available to LDMC herds from private industry sources, Nicoll and Johnson (1986) reported no significant difference between the two sire sources in progeny weaning weight, but heifers sired by Scheme bulls were 3.5 to 3.8 kg heavier at the yearling, 15-month and 18-month stages than those sired by industry bulls. Regression coefficients of these liveweight advantages over time were 0.9, 1.6 and 1.7 kg/year for heifer yearling, 15-month and 18-month weights respectively (Nicoll and Johnson, 1986). As dams, the Scheme-sired females weaned heavier calves *(2.7 kg)* and a greater weight of calf per unit body weight *(.7 kg/100 kg LW) than their industry-sired contemporaries.*

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