A Model to Estimate the Economic Value of Using Individual Fleece Fibre Diameter Measurements to Class Wool

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ABSTRACT

Woolclassing in Australia traditionally relies upon a subjective visual appraisal of fleeces. A new approach to woolclassing, termed objective classing, has been adopted by some woolgrowers. In objective classing, fine and broad lines of wool are created using pre-measured individual fibre diameter data rather than the subjective appraisal of the classer. This paper describes a computer model that estimates the optimum clip preparation and the expected economic value of objective classing. The effect of mean and standard deviation of fibre diameter, test precision, wool market conditions, and clip preparation on expected economic value was examined. Results indicated that objective classing was not of universal benefit. The value of objective classing was greatest for fine wool, particularly if sold when there was a large premium for fine wool and a high market indicator. The economic value of objective classing rapidly reduced if the standard deviation of the fibre diameter test fell below 0.5 μm, or if the clip was sub-optimally prepared. In many circumstances objective classing was not economically justifiable unless the fibre diameter measurements were used for other purposes, such as a genetic improvement program.

KEYWORDS: wool, classing, economics, fibre diameter

INTRODUCTION

Woolclassing is the process by which fleeces of a similar fibre diameter and style are lotted together to prepare the wool for sale. In Australia, woolclassing is regulated by a Code of Practice (Anon, 1989) that describes the classer's responsibilities. These include "producing as few lines as possible from the clip, while maintaining an appropriate degree of uniformity within each line". The classing of fleeces from one flock into fine and broad lines was discouraged after studies showed that the ability of a classer to visually distinguish wools of differing fibre diameter is poor (Whitely and Wilkins, 1973).

In recent years inexpensive tests to estimate the mean fibre diameter of individual fleeces have become widely available. The premium for fine wool has also increased, reaching a peak in the late 1980's. These developments have prompted a new approach to woolclassing, termed objective classing. In objective classing, fine and broad lines from the one flock are created using pre-measured individual fibre diameter data rather than the subjective appraisal of the classer. Despite a lack of scientific evidence, objective classing has been promoted as an important way for wool farmers to increase net returns.

This paper describes a computer model (CLASSER) that estimates the most profitable clip preparation and the expected economic benefit from objective classing.

MATERIALS AND METHODS

A computer simulation model was written using a commercial spreadsheet, Supercalc 5 (Computer Associates Inc., San Jose, California), running on MS-DOS. The program is menu driven by MACRO commands that set all the screens, arrange the graphs and prints all outputs. A MACRO is a set of instructions that automates spreadsheet use. CLASSER can therefore be used by a person who has no knowledge of spreadsheets and minimal knowledge of microcomputer use.

Program aim

The aim of the program is to estimate the net financial return from objective classing compared to traditional classing. The program can therefore be used as a decision support system for producers wishing to know if they should objectively class their wool clip. A negative financial return indicates that the costs of objective classing outweigh the benefits, in which case it would be economically irrational to objectively class. A positive financial return indicates that the benefits from objective classing outweigh the costs, in which case it may be economically rational to objectively class, depending upon the marginal rate of return.

Program overview

The flowchart in Figure 1 illustrates the structure of the program. An algorithm was developed to estimate the clip preparation that maximises net return from objective classing, given the constraint that any one line may only contain 20, 30, 40, 50, 60, 70, 80 or 100%, of fleeces. A total of 7 two-line, 15 three-line, and 10 four-line preparations are possible under this restriction. The expected net return from each of these preparations is calculated for a given series of biological and economic inputs, and the preparation that gives the highest net return is defined as the optimum.

The expected net return from classing all fleeces into a single line without objective measurement is subtracted from the net return of the optimum preparation to determine the expected net return per fleece from objective classing.

The program requires both biological and economic inputs. Population mean fibre diameter and standard deviation of fibre diameter can be varied by the user to allow the program to simulate the woolclip from any flock or mob of sheep. The precision of the fibre diameter test is also a variable within the program. Wool prices, wool tax, and the cost of fibre diameter testing are all calculated from user inputs. Consequently, the program can estimate the net financial return from objective classing for any economic situation.

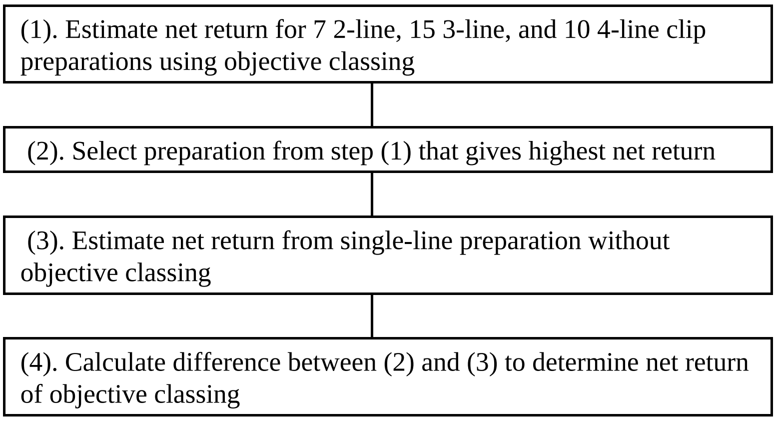

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Fig. 1. Flow diagram showing an overview of the structure of the program

Biological parameters

In this analysis, the effect of population mean fibre diameter, standard deviation of fibre diameter, and test precision on net financial return from objective classing was examined.

For all calculations, the covariance between fibre diameter and clean fleeceweight was fixed at 0.2.

The mean fibre diameter of a selected proportion, p, of the finest fleeces was calculated from the mean fibre diameter of the total population of fleeces using the formula:

$$f_s = f_t r y \sigma_f / p \qquad (1)$$

where f_s= the mean fibre diameter of the selected group; f_t = the mean fibre diameter of the flock; r= the correlation coefficient between the test result and the true fibre diameter; y=the height of the ordinate of the normal curve; σ_f= the standard deviation of individual fibre diameters within the flock; and p=the proportion of the population selected (Dunlop and McMahon, 1973).

The value y was estimated from p using the algorithm developed by Griffiths and Hill, (1985).

The correlation co-efficient (r) was determined from the standard deviation of the fibre diameter test using:

$$R = ((\sigma^2_t - \sigma^2_{t/f})/\sigma_t^2)^{1/2} \qquad (2)$$

$$\sigma^2_t = \sigma^2_f + \sigma^2_{t/f} \qquad (3)$$

and

where σ^2_t=the variance of the measured fibre diameter; σ^2_f=the variance of the true fibre diameter; and $\sigma^2_{t/f}$=the variance of the measured fibre diameter, given the true fibre diameter (Kleinbaum and Kupper, 1978).

The weight of clean wool in a selected line of fleeces was calculated, allowing for the phenotypic correlation between fibre diameter and clean fleeceweight, using the following equation:

$$w_s = w_t + (\sigma_{w,f}(f_s - f_t))/\sigma_t^2 \qquad (4)$$

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where w_s he mean clean fleece weight of the selected group; w_t = the mean clean fleeceweight of the flock; and $\sigma_{w,f}$ = the covariance between fibre diameter and clean fleeceweight.

The mean fibre diameter for each fleece line was calculated as the weighted mean of the fibre diameter of the fleeces within the line.

Wool prices

In the model, price (P) for wool of a given fibre diameter (f) is calculated using the general equation:

$$P = m(a + bf\ cf^2 + df^3) \qquad (5)$$

where m = the value of Australian Wool Corporation overall Market Indicator; and a, b, c, and d are regression co-efficients. The values of a, b, c and d vary according to user inputs for wool market category indicators and are estimated by least-squares multiple regression.

In this analysis the effect of a low, medium and high market indicator and the effect of a low, medium and high premium for fine wool was examined.

The value for m was set at 500, 750 and 1000 cents, representing a low, medium and high wool market respectively.

Low, medium and high premiums for fine wool were defined after analysis of the Australian wool market statistics between 14 January 1977 and 28 June 1991. The ratio between 19 and 24 μm category indicators was calculated for each end of week quotation (n = 575). Values for the ratio ranged between 1.029 and 3.252. The median value of 1.508 occurred in the week ending 30 March 1984 and the category indicators for that week were used to calculate a medium premium for fine wool:

$$P = m(49.8348 - 6.3859f + 0.281144\ f^2 - 0.00416\ f^3) \qquad (6)$$

$$r^2_{adj} = 0.994$$

Ninety and ten percent deciles (2.564 and 1.115) corresponded to the weeks ending 11 March 1988 and 21 October 1977 respectively. Category indicators from these two periods were used to calculate wool prices in markets with high and low premium for fine wool respectively.

high premium

$$P = m(77.0584 - 9.2525f + 0.378385f^2 - 0.00522f^3) \qquad (7)$$

$$r^2_{adj} = 0.996$$

$$P = m(0.679157 + 0.62842f - 0.00203f^2) \qquad (8)$$

$$r^2_{adj} = 0.992$$

Costs

Wool tax of 12% of and further selling costs of 4% were deducted from the gross return.

A testing fee of $30 was incurred for each line created. For all analyses, the cost of fibre diameter testing was set at zero.

RESULTS

Figure 1a shows the relationship between the expected monetary value per fleece from objective classing and mean fibre diameter for the three fine wool premiums with the market indicator at 500 cents. Figures 1b and 1c show the same relationship with the market indicator at 750 cents and 1000 cents respectively. Co-efficient of variation of fibre diameter was 7.5% and the standard deviation of the test was 0.6 μm.

The effect of standard deviation of fibre diameter on expected monetary value per fleece is shown in Figure 2. The market indicator was set at 750 cents with a medium premium.

Figure 3 shows the effect of test precision on the value of objective classing, based on a 21 μm flock with a standard deviation of 1.575 μm, a market indicator of 750 cents and a medium premium for fine wool. The decrease in test precision also lead to a reduction in the difference in fibre diameter between fine and broad lines (Figure 4).

The relationship between the proportion of wool in the fine line for a two line clip and the value of objective classing is shown in Figure 5. The value of objectively classing into three lines ranged from a maximum of $0.70 down to a minimum of $0.44 depending upon the preparation of the lines. The range for a four-line preparation was from $0.58 to $0.70.

DISCUSSION

Since the cost of the fibre diameter test was set at zero, all the results presented in this paper estimate the economic value of objective classing prior to paying for the cost of the test. The calculated economic value of objective classing from this program can be compared directly to the cost of the fibre diameter test to allow the woolgrower to decide whether objective classing will be profitable.

The results from these analyses show the economic value of objective classing to be highly variable and sensitive to a number of parameters.

Objective classing can only be of economic benefit if there is a non-linear relationship between fibre diameter and wool price. The relationship between fibre diameter and wool price approaches linearity as the premium for fine wool decreases. Under these circumstances, any additional price received for a fine line is equally matched by a discount for the broad line that is created. For example, using the low premium for fine wool, in which the ratio of 19 to 24 μm category indicators was 1.029, objective classing resulted in a net loss regardless of fibre diameter or market indicator.

The strength of the wool market, as measured by the market indicator, had a significant effect on the value of objective classing. A doubling of the market indicator from 500 to 1000 cents approximately doubled the value of objective classing for most fibre diameter lines.

The mean fibre diameter and the standard deviation of fibre diameter in the flock were also major determinants of the value of objective classing. Objective classing was of greater value to fine wool flocks. At a 750 cent market indicator, there was a decrease in the potential benefit of about $1/head between 19 and 23 μm wools at either medium or high premium levels.

The standard value used for coefficient of variation of fibre diameter was 7.5%, which corresponds to published values for genetically similar single-age, single-sex sheep grazing together (Quinnell et al., 1973). The coefficient of variation of fibre diameter may increase to 9% in mixed-age or mixed-sex flocks (Kidman, 1973). Since the value of objective classing increased with increasing standard deviation of fibre diameter, a greater economic response to objective classing could be expected from mixed-age flocks.

An underlying assumption of equation (1) is that fibre diameter is normally distributed within a flock. Analysis of our own data indicate that this assumption is reasonable.

Not surprisingly, the average fibre diameters of fine and broad lines converged as the precision of the test decreased, eroding potential gains. A survey of commercial wool testing laboratories in Australia reported within-laboratory standard deviations ranging between 0.10 and 1.05 μm, with mean of 0.6 μm (Morgan, 1990). Within the range of 0.1 to 0.5 μm, the monetary value of objective classing was not greatly affected by test precision. In contrast, small changes in test precision at a test standard deviation of 1.0 μm resulted in relatively large changes in the value of testing. Testing laboratories should aim to keep test precision below 0.5 μm.

It can be calculated from correlation estimates (Whitely and McKinnon, 1973) that the standard deviation of visual classing is about 5 to 7 μm. The results presented here confirm previous studies that found no economic benefit from visual classing of clips into fine and broad lines (Charlton and David, 1987).

The optimum clip preparation was found to vary with fibre diameter and the premium for fine wool. Generally a four-line preparation optimised returns, except when the expected value of objective classing was low, in which case two and three line preparations were more profitable.

Much of the potential economic benefit from objective classing was lost when fleece lines were not optimally prepared. For example, up to 50% of the benefit of objectively classing into two lines was lost by sub-optimum preparation.

The algorithm used in the simulation model to optimise returns placed restrictions on the number of preparations possible for a given woolclip. This mimics the real situation. Woolgrowers prepare their clips for sale in minimum quantities of 180-200 kg (bales) and incur price penalties if the size of a sale lot falls below about four bales. The minimum allowable lot size in the model was 20% of fleeces, corresponding to approximately four bales of wool from a flock of 800 sheep. Lines containing a lower proportion of fleeces could be prepared from larger flocks.

The 1991 price for an individual fibre diameter test ranged from $1.80 to $2.60. It has been suggested that this cost can be effectively reduced by using the data for subsequent shearings as well as for the immediate shearing. An estimate of the yearly change in mean fibre diameter can be made by re-testing a sample (10%) of the sheep each year rather than every sheep. The estimate of the mean change in fibre diameter is then added to each of the original measurements to produce an estimate of the new fibre diameter. The adjustment factor does not have a variance of zero and is consequently an additional source of error that reduces the precision of the estimate. More information is required on the standard deviation of yearly changes in fibre diameter. In the small data sets that we have analysed, the standard deviation of the adjustment factor has been about 1 μm. At this level of precision, the value of objective classing is reduced by 40 to 50% in comparison to using direct measurements.

The cost of fibre diameter testing can also be offset by using the fibre diameter measurements for selecting replacement sheep. Significant economic gains are possible from a genetic improvement program incorporating objective fleece measurements of young sheep (Morley, 1990).

Objectively prepared lines should have reduced fibre diameter variation than traditionally classed lines, but only marginally so, as the greatest source of fibre diameter variability is between fibres in a staple and not between fleeces (Quinnell et al., 1973). It is unclear if objectively classed lines will attract a premium in comparison to lines of wool of the same mean fibre diameter prepared in the traditional manner.

In summary, objective classing was not of universal economic benefit. The value of objective classing was greatest for fine wool, particularly if sold when there was a large premium for fine wool and a high market indicator. There was a wide range of circumstances under which the cost of fibre diameter testing was likely to outweigh the benefit from objective classing. However, some or all of the cost may have been recuperated if the measurements were used over a period of several years, or as part of a flock improvement program.

The potential benefits of objective classing were substantially eroded if the clip was sub-optimally prepared. For the full value of objective classing to be realised, a computer program such as that described in this paper is needed to determine the clip preparation that maximises the expected net return accruing from objective classing.

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LEGENDS TO ILLUSTRATIONS

(Not included with this version of the paper)

Fig. 1. Flow diagram showing the basic steps of the program.

Figs. 2a, 2b, and 2c. Expected monetary value of objective classing for fleece wools of various mean fibre diameters, with a market indicator of 500 cents (a), 750 cents (b), and 1000 cents (c).

Fig. 3. Effect of co-efficient of variation (CV) of fibre diameter in a flock on the expected monetary value of objective classing.

Fig. 4. Effect of test precision on the expected monetary value of objective classing for 21 μm fleece wool.

Fig. 5. Effect of test precision on the difference between mean fibre diameter of the broad and fine lines of a two-line preparation.

Fig. 6. Effect of clip preparation on the expected monetary value of objectively classing 21 μm fleece wool into two lines.