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PREFERENCE-BASED APPROACHES TO DERIVING BREEDING OBJECTIVES: APPLICATION TO SHEEP AND PLANT BREEDING

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SUMMARY

A preference-based approach, using the internet-based software *1000Minds*, was used to derive part-worth utilities of farmers' assessments with respect to traits in the definition of a breeding objective for sheep in Ireland and pasture plants in Australia. The most critical issue in developing such approaches is the clear definition of traits and the use of realistic ranges of variation in trait performance in order to define alternatives. Conversion of part-worth utilities (percentages) into economic values requires that the economic value is generated within the survey by providing respondents with options that relate to traits which can be defined in economic terms. In presenting alternatives, application of discounted gene-flow principles to breeding objectives in survey-based methods depends on the way questions are asked. It was apparent that respondents' understanding of traits (attributes, levels), experience with the traits, and how alternatives are presented are very important in using preference-based approaches to define breeding objectives. Issues related to separation of true differences in preferences, confounding and double counting (in animal breeding objectives) are challenges in development of breeding objectives from such preference approaches.

INTRODUCTION

To develop a breeding objective, it is necessary to develop the appropriate criteria on which selection candidates should be evaluated as either the potential parents to drive genetic gain or during the subsequent choice by producers (Harris 1970). Although breeding objectives expressed in economic or profit terms (e.g. Smith *et al*. 1986; Ponzoni 1989; Amer and Fox 1992) provide clear economic drivers in breeding programs, these traditional approaches often overlook the indirect value of subjective traits, which may contribute to profitability in production systems (Sölkner *et al.* 2008), and also traits linked to animal and/or environmental welfare (Nielsen *et al.* in press). For example, Fisher and Webster (2009) refer to 'quality-of-life' considerations, while Olesen (2006) discusses 'environmental concerns', both of which are difficult to define economically, and may influence farmers' decisions. In this respect, two examples might be a farmer's reluctance to intensively house animals, or a concern about the high nitrogen demands of some early-season ryegrasses. Hence, the development of well-researched definitions of breeding objectives may never be used in practice if those definitions fail to include the perceptions of the breeders or commercial farmers for whom they are designed (Dekkers and Gibson 1998).

Forage plant breeders generally regard the derivation of breeding objectives as being too difficult in practice (Smith and Fennessy in press) and hence replace the optimal index approach with various methods involving family selection, often utilising the application of independent culling (e.g. the presence of rust, low winter yield, persistence, etc). However, independent culling approaches to multiple trait selection problems can be highly inefficient, particularly when large numbers of traits are under consideration. Recent approaches to deriving economic weights for animal breeding programs have used stated-preference techniques to elicit consumer or farmer preferences and to estimate willingness-to-pay for goods or services (e.g. Tano *et al*. 2003; Nielsen and Amer 2007). Given the issues with the breeding of pasture plants, we also see considerable potential in such approaches.

This paper outlines development of conjoint-analysis surveys using the internet-based software known as *1000Minds* (www.1000minds.com) to capture the part-worth utilities of farmers' assessments with respect to traits in the definition of a breeding objective for sheep in Ireland and pasture plants in Australia. The survey development process and the methodology by which economic values are calculated from part-worth utilities (in percentage preference) are presented. Some strengths and weaknesses of the approach are discussed.

APPLICATION OF *1000Minds*

In a stated-preference experiment, respondents are asked to respond to a series of paired statements/questions; each statement features two or more options differentiated on a set of attributes (with differing levels of performance) where respondents are asked to choose their preferred option (Caussade *et al.* 2005). This representation of options in terms of a set of attributes is consistent with Lancaster's theory of consumer demand whereby consumers derive utility not from the goods themselves but rather from the good's underlying characteristics (Lancaster 1966). In the present context, we have applied this to sheep and pasture cultivars and it has involved analysing farmers' preferences in terms of the benefits that they perceive will be generated from changes in genetic traits (Tano *et al.* 2003).

The *1000Minds* software used to implement the conjoint-analysis survey applies a method for deriving part-worth utilities known by the acronym PAPRIKA (**P**otentially **A**ll **P**airwise **R**an**K**ings of all possible **A**lternatives) (Hansen and Ombler 2009). In the present context, respondents are asked to pair-wise rank a series of pairs of hypothetical alternatives with respect to their relative desirability. These relate to either (1) the most desirable features that an individual farmer might consider when selecting a flock of sheep or (2) the most desirable features that an individual farmer might consider when renewing a pasture under a particular set of environmental conditions. In each case, the alternatives were defined in terms of just two traits at-a-time, where one of the alternatives ('flock' or 'pasture') in the pair has a higher level on one trait and a lower level on the second trait than the other – thereby requiring the respondent to confront a trade-off when deciding which alternative he or she prefers (Figure 1). The number of such questions (and the burden on respondents) is minimised because each time a question is answered, PAPRIKA eliminates all other possible questions that are implicitly answered as corollaries of those already answered (via the logical property of 'transitivity'). From the respondent's answers (individual or group consensus), the software uses mathematical methods to calculate part-worth utilities which represent the relative importance of the attributes to the respondent(s). In this approach, part-worth utilities are expressed as percentages such that the ideal hypothetical alternative (the highest-ranked levels on all traits) has a total score of 100% (the maximum hypothetically possible).

SURVEY DEVELOPMENT

The most critical issue in developing such approaches is the clear definition of traits and the use of realistic ranges of variation in trait performance in order to define the alternatives. In this respect, consultation and the application of pilot surveys (involving experts) to test assumptions and to obtain feedback particularly around the clarity of the questions or alternatives are invaluable. For example, the trait must be clearly defined such that it can be parameterised; two examples from the separate user/farmer survey of priorities to be considered in flock selection (lambing difficulty) and pasture renewal (pasture survival) are presented in Table 1. However this is not always straight-forward and it can be very difficult to parameterise some traits – pest resistance and survival over summer in pasture and lamb survival are examples. However the comparison of the current situation with a future option using terms such as PER 100 EWES has enabled an adequate parameterisation in the sheep model in practice and using terms such as ALWAYS has enabled an adequate parameterisation in the pasture renewal model in practice.

In applying *1000Minds*, it is necessary to define the order of the least-preferred to the most-preferred levels for each trait. In the sheep study, the levels for each trait, and also their logical (or 'natural') ranking, were based on meaningful variations in trait performance consistent with farmer experience in the context of the Irish production-system. For example, one week of lamb growth represents 0.5 and 0.7 kg of carcase weight and is worth, in gross economic terms, approximately €2 per lamb; hence levels of 1 week and 2 weeks earlier to slaughter were applied respectively.

Table 1. Examples of parameterisation of traits

LAMBING DIFFICULTY
AS IT IS
5 LESS EWES HAVE DIFFICULTY PER 100 EWES
10 LESS EWES HAVE DIFFICULTY PER 100 EWES
PASTURE SURVIVAL
PASTURE SURVIVAL in HOT DRY SUMMER is SAME AS NOW
PASTURE ALWAYS SURVIVES in HOT DRY SUMMER

CALCULATION OF ECONOMIC WEIGHTS

Part-worth utilities expressed as percentages are converted into economic values, and can then be incorporated into breeding objective equations. This requires that the economic value can be generated within the survey by providing respondents with options that relate to traits which themselves can be defined in economic terms (Orme 2010). For example, this is achieved by defining lamb value at the meat processor as: as it is, €2, and €4 more per lamb. An example of a question involving lambing difficulty and lamb value at the processor is presented in Figure 1.

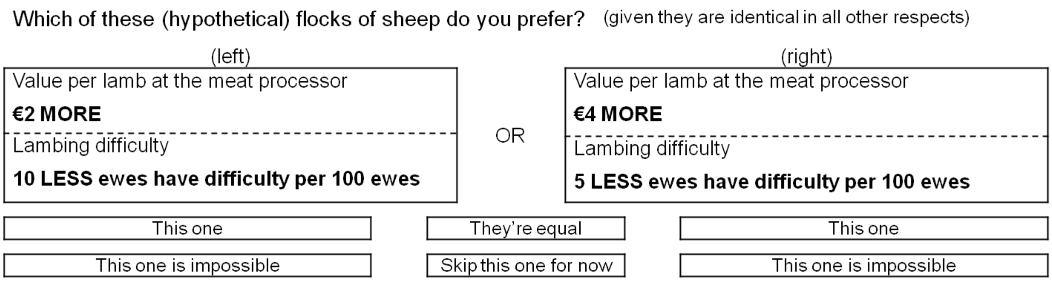

Figure 1. An example of a pair-wise ranking question (Byrne *et al.* in submission)

The derivation of economic weights in breeding objectives requires that differences in the timing and frequency of expression of different traits are accounted for (McClintock and Cunningham 1974). In animal breeding terms when using survey-based methodology, Nielsen and Amer (2007) commented on the implications of the way animal group definitions are formulated when presenting alternatives to respondents, and suggested that the application of discounted gene-flow principles to breeding objectives in survey-based methods depends explicitly on the way the questions are asked. The survey for sheep in Ireland posed the following question in relation to a number of alternative features of a hypothetical flock of sheep: *Which of these (hypothetical) sheep flocks do you prefer?* (Figure 1). Presented in this way, the question prompts the respondent to choose his or her preferred alternative flock from the two on offer, assuming the implications of the choice will occur to the respondent instantaneously, on reading the alternatives.

This approach leaves the application of discounted gene-flow principles to a second step of the process, rather than requiring respondents to implicitly account for the differences.

CONSIDERATIONS AND OPPORTUNITIES

Results (Byrne *et al.* in submission) from using *1000Minds* to develop breeding objectives for sheep in Ireland indicate that respondents regarded some aspects of trait performance as being not directly proportional to monetary benefits or costs associated with changes in trait performance. For example, the average economic weight per fat class was −€1.39 from surveys, but −€3.44 from economic models (Byrne *et al.* 2010). For pasture plant breeding, preliminary analyses indicate the potential to use preference-based tools in development of breeding objectives where breeders regard the derivation of economic breeding objectives as being too difficult. Importantly, the application of survey-based methodology presents an opportunity in development of breeding objectives in situations where production and price data are not readily available, or where it is difficult to assess economic implications of changes in subjective, albeit important, traits.

The studies indicate that respondents' understanding of traits (attributes, levels), experience with the traits, and how alternatives are presented will be very important in using preference-based approaches to define breeding objectives. Issues related to the separation of true differences in preference and confounding and double counting (in animal breeding objectives) represent major challenges in the development of breeding objectives from preference-based approaches.

REFERENCES

Amer P.R. and Fox G.C. (1992) *Animal Production* **54**: 341.

Byrne T.J., Amer P.R., Fennessy P.F., Cromie A.R., Keady T.W.J., Hanrahan J.P., McHugh M.P. and Wickham B.W., 2010. *Livestock Science* **132:** 135.

Caussade S., Ortúzar J.d.D., Rizzi L.I. and Hensher D.A. (2005) *Transportation Research Part B: Methodological* **39**: 621.

Dekkers J.C.M., Gibson J.P. (1998) *J. Dairy Sci.* **81:** 19.

Fisher M.W. and Webster A.J.F. (2009) *Proceedings of the New Zealand Society of Animal Production* **69:** 135.

Hansen P. and Ombler F. (2009) *Journal of Multi-criteria Decision Analysis* **15:** 87.

Harris D.L., 1970. *J. Anim Sci.***30**: 860.

Lancaster K.J. (1966) *Journal of Political Economy* **74**: 132.

McClintock A.E. and Cunningham E.P. (1974) *Animal production* **18:** 237.

Nielsen H., Olesen I., Navrud S., Kolstad K. and Amer P. (In press) *Journal of Agricultural and Environmental Ethics*.

Nielsen H.M. and Amer P.R. (2007) *animal* **1:** 1254.

Olesen I., Navrud S. and Kolstad K. (2006) *8th World Congress on Genetics Applied to Livestock Production*, Belo Horizonte, Minas Gerais, Brazil.

Orme B.K. (2010) In: Orme, B.K. (Ed.), *Getting Started with Conjoint Analysis: Strategies for Product Design and Pricing Research*. Research Publishers LLC, Madison, pp. 77-88.

Ponzoni R.W. (1989) *Proceedings of the 9th Conference of the Australian Association of Animal Breeding and Genetics*, pp. 55-66.

Smith C., James J.W. and Brascamp E.W. (1986) *Animal Production* **43:** 545.

Sölkner J., Grausgruber H., Okeyo A., Ruckenbauer P. and Wurzinger M. (2008) *Euphytica* **161:** 273.

Tano K., Kamuanga M., Faminow M.D. and Swallow B. (2003) *Ecological Economics* **45:** 393.