OPTIMISING THE ALLOCATION OF BEEF CATTLE TO MARKET ENDPOINTS

B. J. Walmsley[1], C. Gondro[1,2], J.H.J. van der Werf[1] and B.P. Kinghorn[2]

[1] School of Rural Science and Agriculture, [2]The Institute for Genetics and Bioinformatics,
University of New England, Armidale, NSW 2351

SUMMARY

The diversity of the markets available to Australian beef cattle production systems offers the opportunity to utilise variation in growth potential to improve efficiency. The optimisation algorithm - Differential Evolution, used an extension of the Random Keys Representation to optimise the allocation of animals from a cohort to different market endpoints with the objective of maximising profit in a simulated production system. The drafting system was found to react sensibly to changes in the prevailing production system. When the value of the Japanese B3 market was reduced, more animals were allocated to the Heavy Supermarket and European Union markets. When drought conditions were simulated fewer animals were allocated to the grass-fed European Union market.

INTRODUCTION

The efficiency of animal production is dependent on the efficiency of individuals and the efficiency of producing these individuals (Kinghorn 1985). The diversity in the carcass requirements of the markets targeted by Australian beef enterprises offers the opportunity to take advantage of natural variation in animal growth potential to increase efficiency.

The colloquial term “butter ball” (Handley 2005, pers. comm.) has been used to describe animals grown for the lower end Japanese markets (e.g. B2) that deposit excessive quantities of subcutaneous fat. It could be concluded that such animals have been allocated to the incorrect market and would be more suited to markets that do not target marbling and require lower carcasses weights (e.g. European Union). Appropriate allocation of animals has roll-on effects for entire supply chains.

Allocating animals to markets that match their growth potential has similarities to the well researched Travelling Salesman Problem (TSP) (Johnson 1997). A method has been recently proposed for combining Genetic Algorithms with the Random Key Representation (RK) for solving the TSP (Snyder and Daskin 2006). RK is based on the concept that any sequence of numbers can be sorted and it uses random numbers to allow the optimisation procedure to make small and continuous changes to the RK order without compromising its validity. However, a mechanism is required to optimise drafting age(s) before RK is adequate for allocating animals to market endpoints.

The aim of this study was to extend RK to allow an heuristic optimisation algorithm - Differential Evolution (DE) (Price and Storn 1997) to optimise the allocation of animals to markets appropriate to their growth potentials and the age that these allocations occur in a simulated production system.

MATERIALS AND METHODS

The simulated production system only considered a cohort of Angus steers to reduce the complexity associated with whole beef cattle production systems while remaining representative of Australian production systems. The animal and carcass characteristics of the markets targeted in the simulated production system were taken from NSW Agriculture (1997). Animals were marketed on a carcass weight basis with price grids obtained from stock and station agents in the Glen Innes (NSW) area. The pricing system for the Japanese B2 and B3 markets was modelled using a linear approach with marble scores from 2 to 6 (Barwick and Henzell 1999).

Pasture production was modelled using the GrassGro decision support system (Moore *et al.* 1997) based on a Northern Tablelands pasture system (Ayres *et al.* 2001). Animal growth was modelled using the growth model presented by Amer and Emmans (1998) with extensions made to include nutrient partitioning, milk production and feed intake. Body composition was predicted using models developed by Walmsley (2007) with allometric equations and linear regressions.

There were 100 individuals simulated by randomly allocating growth model input parameters (mature protein (P_m), mature lipid:protein ratio (Q) and scaled rate parameter (B_s) - see Walmsley (2007)). Input parameter means and standard deviations were estimated from real production data of Angus steers grown in a serial slaughter experiment (Perry and Arthur 2000). Parameter values were drawn from a uniform distribution to obtain model outputs that would fully demonstrate the functionality of the drafting system developed. For this reason a correlation was also established between P_m and B_s. Three production scenarios were explored that included a base scenario (1), a scenario (2) where the value of the Japanese B3 (B3) market was reduced and a final scenario (3) that simulated drought conditions. All scenarios targeted the Heavy Supermarket (HS), European Union (EU) and B3 markets. Further details concerning the simulated production system and growth and composition models used to predict animal growth are available in Walmsley (2007).

RK uses a sequence of random numbers usually in the range [0, 1], that are sorted to provide an event order. In this study this order was used to allocate animals to market cohorts. Figure 1 illustrates the extensions made to RK to allow (DE) to optimise the proportion of animals allocated to market endpoints and the age of drafting. The threshold values split the cohort into market groups. DE was allowed to run for 2500 DE-generations. The optimisation criterion was simply a measure of profit (income minus costs) accumulated across animals.

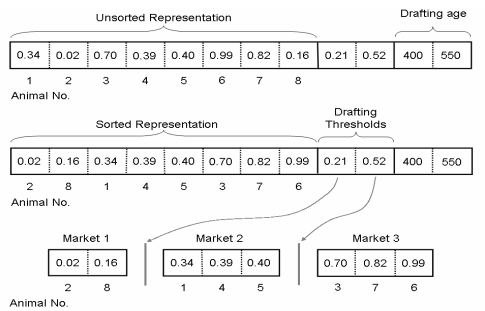

Figure 1. The Random keys representation extended to include drafting ages and thresholds.

RESULTS AND DISCUSSION

DE was used to determine the optimal proportions of animals to allocate to each target market in the base scenario and the optimal ages for splitting cohorts resulting in the allocation of individual animals to these markets. The first optimal drafting age was determined to be 550 days where 24 animals where directed towards the HS market and the remaining 76 were maintained as a single cohort. At 700 days this cohort was split to partition 35 to the B3 market and the remaining 41 to the EU market. In scenario 2, RK reallocated all animals destined for the B3 market in scenario 1 to the EU market. This had two consequences. The first was a reduction in the optimal age of slaughter for the EU market. This occurred to compensate for animals with larger P_m and B_s values and thus faster growth rates being included in the EU market. The second was the reallocation of animals from the EU to the HS markets. This occurred as a result of these animals having lower P_m and B_s values preventing the carcass requirements of the EU market being achieved at this younger age (Figure 2a).

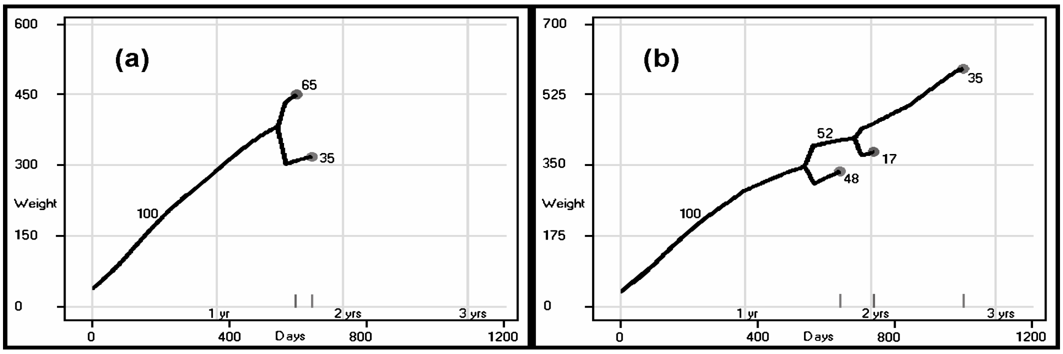

Figure 2. Drafting points and partitioning of animals between market endpoints in scenarios 2 (a) and 3 (b).

In scenario 3, animal allocation occurred in a similar pattern to scenario 1. In this scenario, the same number of animals were allocated toward the B3 market as scenario 1 due to these animals being the only animals capable of achieving the required carcass characteristics. However, reallocation occurred between the HS and EU markets with more animals partitioned to the HS market and less to the EU market compared to scenario 1 (Figure 2b). The reallocation of animals to the HS market was a consequence of reduced pasture production from the simulated drought conditions. These conditions suppressed growth, which either reduced the capacity of animals that tended to have lower P_m and B_s values to reach the carcass requirements of the EU market, or prevented animals producing carcasses of high value to the EU market.

Table 1. Comparison between predicted carcass characteristics and profitability of animals 7 and 9 if grown for the Heavy Supermarket and European Union markets, in scenarios 2 and 3.

Animal	Market	Cwt (kg)	P8 (mm)	Price ($/kg)	Income ($)	Cost ($)	Profit ($)
Scenario 2:							
7	HS	265.0	16.5	3.45	913.73	97.25	816.48
	EU	243.0	14.5	3.60	873.99	82*	791.99
9	HS	270.5	17.0	3.35	906.08	97*	809.08
	EU	266.0	16.5	3.70	983.93	87.28	896.65
Scenario 3:							
7	HS	249.5	15.0	3.45	861.53	105*	756.53
	EU	242.5	14.5	3.60	873.00	112.82	760.18
9	HS	255.5	15.5	3.45	880.67	105.60	775.07
	EU	246.0	15.0	3.60	886.48	115*	771.48

*Average production cost of animals allocated to the HS and EU markets in scenarios 2 and 3.

The reasons discussed above for animal allocation are illustrated in Table 1 for animals 7 and 9. In scenario 2, animal 7 was allocated to the HS market because of its lower B_s value compared to animal 9 (0.017 vs 0.022). This value would have prevented animal 7 from achieving a minimum carcass weight required for the EU market at a slaughter age of 590 days. The higher B_s value of animal 9 allowed it to achieve such a carcass weight, even though both animals had similar P_m values (48.82 vs 47.78). In scenario 3, the B_s value of animal 7 interacts with the age of slaughter for the EU market. The later slaughter age of 700 days allows animal 7 to achieve a carcass weight that results in greater profit in the EU market than that achievable in the HS market. The difference in profit between the HS and EU markets for animal 7 displayed in Table 1 is also expected to be greater than that presented given the lower production cost of this animal compared to the average cost of animals in the EU market. The higher B_s value of animal 9 allowed it to achieve a carcass weight comparatively higher than animal 7 in the HS market which resulted in greater profit being achieved compared to that possible in the EU market.

In reality, the low level of recording in beef production systems would make estimating P_m and B_s for individuals unviable and an alternative would be to use population/cohort input parameter estimates to create distributions around model outputs. Proportions of these distributions would subsequently be allocated to market endpoints. Market allocation would then be based on matching observed production traits to the equivalent model output distributions, at each decision point. Future research would need to focus on the accuracy and potential benefits of such a drafting system.

CONCLUSIONS

The drafting system behaved in a sensible manner when confronted with changes in the production system as a result of changing market prices and environmental conditions. DE used the interactions between growth model input parameters and slaughter ages to partition animals to market endpoints, which optimised the profitability of the whole production system while in some cases compromising the profitability of individual animals. This work points to the feasibility of using growth models, production data and decision support systems with optimisation engines to help drive a wide range of management decisions to best exploit animal performance and market opportunities, e.g. QTL use.

ACKNOWLEDGMENTS

This research was funded by the Cooperative Research Centre for Beef Quality.

REFERENCES

Amer, P. R. and Emmans, G. C. (1998) *Animal Science* **66:** 143.

Ayres, J. F., Dicker, R. W., McPhee, M. J., Turner, A. D., Murison, R. D. and Kamphorst, P. G. (2001) *Australian Journal of Experimental Agriculture* **41:** 959.

Barwick, S. A. and Henzell, A. L. (1999) *Australian Journal of Agricultural Research* **50:** 503.

Johnson, D. (1997) In "Local Search in Combinatorial Optimisation" pp. 215-310, editors E. H. L. Aarts and J. K. Lenstra, John Wiley and Sons, London, UK.

Kinghorn, B. (1985) *Journal of Animal Breeding and Genetics* **102:** 241.

Moore, A. D., Donnelly, J. R. and Freer, M. (1997) *Agricultural Systems* **55:** 535.

NSW Agriculture (1997). "The New South Wales Feedlot Manual," Orange.

Perry, D. and Arthur, P. F. (2000). *Livestock Production Science* **62:** 143.

Price, K. and Storn, R. (1997) *Dr Dobb's Journal* **264:** 18.

Snyder, L. V. and Daskin, M. S. (2006) *European Journal of Operational Research* **174:** 38.

Walmsley, B. J. (2007) PhD Thesis, University of New England.