AN ENTERPRISE GROSS MARGIN MODEL TO EXPLORE THE INFLUENCE OF SELECTION CRITERIA FOR BREEDING PROGRAMS AND CHANGES TO MANAGEMENT SYSTEMS

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ABSTRACT

The profit model developed was used to investigate and provide insight into two scenarios – the profitability of restricted feeding in grower rabbits and the relative importance of some selection traits for rabbit breeding. Using published parameters for production levels and cost inputs, the model calculated outputs that were consistent with survey values for the best 25% of French rabbit breeders. The model demonstrated that restricted feeding of growers, which was introduced in France to help combat epizootic rabbit enterocolitis (ERE), may be a profitable undertaking regardless of the presence of ERE, due to improvement of feed conversion ratio. Under the assumptions used, the relative importance of traits in the breeding objective was highest for production traits, reproduction being the highest then growth, with fitness traits, such as resistance to ERE and longevity, contributing much less to profit. However, relative economic values need to be viewed in the light of associated changes in other traits, and traits such as longevity may indeed have a higher value if used as a *de facto* trait to select for poor fertility and disease resistance in breeding does.

Key words: Relative economic value, Fitness traits, Rabbits, Restricted feeding, Breeding objectives.

INTRODUCTION

Profit models are useful tools for both the animal breeder and the enterprise manager. They can be used to estimate the relative economic value (REV) for traits in the breeding objective and to assess the impact of management changes on profit. The basic assumption of a profit function is that there is a mathematical relationship between inputs and outputs and this can be expressed by a series of equations (Amero and Blasco, 1992) or modelled dynamically in more complex whole enterprise situations (Wood and Buddiger, 2007). The Crusader Enterprise Model (Eady, 2004) has been used to explore the value of selection criteria for rabbits in Australia, in particular the introduction of fitness traits such as disease resistance and doe longevity (Eady and Garreau, 2007). To do the same for French rabbit breeding programs requires an enterprise model that reflects the structure of the industry in France, where there is a cross-breeding system and widespread use of AI. The model also needs to accommodate restricted feeding of grower rabbits, a practice that is becoming widespread as a means of combating epizootic rabbit enterocolitis (ERE) (Boisot *et al.,* 2003). The objective of the work described in this paper was to develop such a model and use it to explore the inter-relationship between feed intake, growth rate and feed conversion ratio (FCR) and their effects on profit, and to investigate the REV of current and potential traits for selection programs.

MATERIALS AND METHODS

Model development and assumptions

Assumptions for inputs are given in Table 1, and are consensus values drawn from literature, industry publications and consultation with industry members. A spreadsheet model was developed using relationships between these parameters to estimate an overall gross margin (net of labour and fixed costs). The spreadsheet model is available from the authors.

Table 1: Assumptions used to construct gross margin model for meat rabbit production in France

Parameter	Assumed value
Maintenance feed requirement for dry does (kg/day)[a]	0.195
Extra maintenance feed requirement during pregnancy (kg/day)[a]	0.052
Extra maintenance feed requirement during lactation (kg/day)[a]	0.065
Extra maintenance feed requirement during pregnancy + lactation (kg/day)[a]	0.091
Extra feed for each gestated rabbit (kg/kit/day)[a]	0.003
Extra doe feed requirement for each kitten during lactation (kg/kit/day)[a]	0.007
Kitten feed intake pre-weaning (kg/kit/day)[a]	0.037
Maintenance feed requirement for replacement does (kg/day)[a]	0.195
Interval between AI (days)	42
Pregnancy rate %[b]	0.8
Age at weaning (days)[c]	33
Number of kittens born per litter[b]	10.43
Number of kittens born alive per litter[b]	9.88
Number of kittens weaned per litter[b]	8.4
Cost of feed without medication (€/kg)	0.18
Wastage rate for feed (%)	10
Age at first mating (weeks)	19.5
Semen costs per AI (€)[b]	1.05
Price of one day old females (€)[b]	7.00
Veterinary cost per AI (€) including medication in feed[b]	2.70
Turn-over rate for does (%)[b]	112
Proportion of culled does yielding meat income (%)	60
Liveweight of culled does (kg)	4.5
Price per kg liveweight for culled does (€/kg)	0.44
Feed intake *ad libitum* day 34 to 54 of age (g/day)[c]	112.7
Feed intake 83% of *ad libitum* day 34 to 54 of age (g/day)[c]	93.6
Feed intake 62% of *ad libitum* day 34 to 54 of age (g/day)[c]	70.2
Feed intake *ad libitum* day 55 to 70 of age (g/day)[c]	167.3
Feed intake *ad libitum* for rabbits previously fed 82% *ad libitum* (g/day)[c]	136.5
Feed intake *ad libitum* for rabbits previously fed 63% *ad libitum* (g/day)[c]	135.8
Feed conversion ratio day 34 to 54 *ad libitum*[c]	2.36
Feed conversion ratio day 34 to 54, 82% of *ad libitum*[c]	2.26
Feed conversion ratio day 34 to 54, 63% of *ad libitum*[c]	2.18
Feed conversion ratio day 55 to 70, *ad libitum*[c]	4.37
Feed conversion ratio day 55 to 70, previously fed 82% *ad libitum*[c]	3.21
Feed conversion ratio day 55 to 70, previously fed 63% *ad libitum*[c]	2.85
Average age at turnoff (days)[c]	70
Weight at weaning (g)[c]	903
Mortality of grower rabbits post-weaning in the absence of ERE (%)	7.7
Price per kg liveweight for growers (€/kg)	1.75

[a]Amero and Blasco, 1992; values scaled by 1.3 to more closely reflect current level of intake; [b]Maurel, 2007; [c]Boisot *et al.*, 2003

Investigation of scenarios

To build an understanding of the inter-relationship between feed intake, growth rate and FCR, the results for non-ERE infected rabbits (Boisot *et al.*, 2003) were used to set up the growth section of the model. This enabled an evaluation, in the first instance, of the effect of restricting feed intake on profit in the absence of disease. Boisot *et al.* (2003) restricted feed from day 34 to 54, with target levels of 80% and 60% of *ad libitum*; the levels achieved were 83% and 62%, respectively. The model was built to mimic these parameters, which allowed outputs to be checked against the experimental results. The relative importance of traits in a breeding objective can be determined by assessing the financial contribution of one phenotypic standard deviation change in the trait, while keeping all other traits constant. The REV was estimated for production and fitness traits for rabbits in an environment where ERE was present.

RESULTS AND DISCUSSION

Validation of model

With all models one must recognise that the outputs are only as good as the assumptions used to build the model. There are means of checking model outputs, for instance, by checking that intermediate and final results are consistent with reported values that have not been used originally to set up the equations. A range of such values are given in Table 2. Compared to industry averages of 15 kg/AI for saleable meat yield, average FCR (*ad libitum* feeding) of 3.4 (Maurel, 2007), 51.1 for rabbits slaughtered/doe/year and margin after paying for feed of 114.6 € /AI (Azard, 2006), the model outputs are above average, similar to the figures achieved by the top 25% of farms.

The model would benefit from a broader review of studies on feed intake, growth rate and FCR under restricted feeding, to make the growth section more robust for investigating a greater range of scenarios. Enterprise profit is particularly sensitive to changes in these parameters. Most of the other input costs have a small effect on gross margin with the exception of veterinary costs (2.70 €/AI). Further estimation of costs in this area would be warranted to confirm these results. Even though based on a limited set of parameters, the model serves as a useful tool to investigate the scenarios proposed in this study.

Table 2: Key production and financial performance indicators calculated from the model

Parameter	Level of feeding from day 34 to 54 of age		
	Ad libitum	82% ad libitum	63% ad libitum
Saleable meat yield (kg/AI)	19.53	19.02	18.16
Liveweight of sale rabbits (g)	2518	2453	2342
Rabbits slaughtered/doe/year	53.9	53.9	53.9
Feed consumed by whole enterprise (kg/doe/year)	492	437	406
Average feed conversion ratio for rabbits 34 to 70 days	3.27	2.71	2.50
Gross income from meat sales (€/AI)	27.49	26.78	25.57
Total cost of feed (€/AI)	12.77	11.17	10.27
Margin after paying for feed only (€/doe/year)	130.83	138.59	135.90
Gross margin accounting for all costs except labour, electricity, water, taxes and depreciation (€/AI)	10.62	10.95	10.65

Effect of feed restriction on profit

A commonly adopted approach to controlling ERE in France is to restrict the feed intake of growing rabbits from immediately post-weaning for a period of 3-4 weeks, to a level of approximately 80-85% of *ad libitum.* An initial assumption is that growth rate will be reduced and saleable yield of meat will be lower resulting in less profit. This assumption is challenged by the results produced by Boisot *et al.* (2003). Although final liveweight is lower for restricted rabbits (2519 g, 2451 g and 2337 g for *ad libitum*, 83% *ad libitum* and 62% *ad libitum*, respectively) our modelling shows that the marked improvement in FCR (3.13, 2.70 and 2.57, respectively) for the overall growing period more than compensates for slower growth (Table 2). This outcome is in the absence of ERE, suggesting that regardless of disease status, it is more profitable to restrict feed intake, thereby optimising FCR and reducing feed costs. In the presence of ERE the benefits gained from lower mortality would increase the profitability of this strategy. Further development of the model is required before a thorough investigation of the relative merits of each feeding level can be evaluated in the presence of ERE.

Relative importance of selection traits

An understanding of the REV of selection traits ensures that the overall profit function of a selection index is maximised as new traits are added. Sometimes traits are components of others, e.g. FCR is a component of growth rate, while other traits if changed, may cause some detrimental flow-on effect, e.g. if litter size increases over a certain level then pregnancy rate or kitten survival may fall. In assessing the real improvement offered by selection for a particular trait a good understanding is required of the mathematical and biological relationships between traits, as well as the mean production level. We used the profit model to estimate a REV for one phenotypic standard deviation improvement for each of the traits in Table 3, evaluated in the above average production environment created by the parameters in Table 1. ERE was present and rabbits were fed 83% *ad libitum* from day 34 to 54, then *ad libitum* for the remaining period to 70 days. Assumptions were set for mortality and morbidity from ERE: an additional 8% of growers died from ERE (giving overall mortality of 15.7%) and morbidity was 12.1%, with 66% of the rabbits showing signs of ERE subsequently dying. An assumed standard deviation for each trait was used to calculate a REV for the trait (Table 4). Heritabilities for each trait are also given to allow an overall assessment of the relative contribution to a selection index that each trait would make.

Table 3: Assumptions for changes induced by 1 phenotypic standard deviation in selection trait

Selection trait	Associated changes in other parameters
Kittens weaned/AI (number/litter) increases by 2.7, from 8.4 to 11.1.	Kittens born increase by 3; kittens born alive increase by 2.85; pregnancy rate remains constant.
ADG increases by 4.2 g/day, from 41.9 g/day to 46.2 g/day.	Assume 50% gain is from an improvement in feed conversion ratio and 50% gain is from increased intake. This relationship has a genetic component.
Resistance to ERE improves by 0.27 units.	ERE morbidity drops from 12.1% to 8.9%. Growth rate of affected rabbits is 75% that of healthy rabbits, resulting in improved growth for 3.2% of rabbits that are no longer affected by ERE. Mortality drops by 2.2%.
Longevity increases by 92 days, with annual turnover dropping from 1.12 to 0.88.	Pregnancy rate and litter size remain constant, i.e. selection for longevity is not *de facto* selection for reproductive performance.

Table 4: Phenotypic standard deviation, heritability, relative economic value and contribution to selection index for traits of meat rabbits. Average variance parameters drawn from a range of sources

Trait	Assumed standard deviation	Heritability	Relative economic value (€/doe/yr)	Contribution to index
Kittens weaned (number/litter)	2.7	0.05[a]	45.52	23.2%
Average daily liveweight gain (g/d)	4.2	0.35[bcd]	11.82	42.1%
Ratio feed:liveweight gain in growers	0.2	0.27[c]	10.26	28.2%
Resistance to ERE	0.27	0.08[d]	4.41	3.6%
Longevity (days)	93	0.12[efg]	2.41	2.9%

[a]Blasco, 1996; [b]Larzul *et al.*, 2005; [c]Larzul *et al.*, 2006; [d]Garreau *et al.*, 2008; [e]Sánchez *et al.*, 2004; [f]Piles *et al.*, 2006; [g]Youseff *et al.*, 2000

There are a number of points to note about the REVs. The high values for production traits compared to fitness traits show how important these remain for profit. However, the assumptions for improving each trait need to be carefully considered. The introduction of selection for feed efficiency in practice will not contribute 28% to the index, as indicated, as part of the gain in FCR is already being obtained by selection for growth rate, due to the genetic correlation between growth rate and FCR being >0. Also, is it realistic to expect number weaned to increase by 2.7 kittens and see no detrimental effect on other reproductive traits? There may be a minimum birth weight to ensure survival (Rochambeau, 1988) and does may fail to conceive at the next AI or succumb to illness after rearing a larger litter. The critical issue is to ensure that everything is accounted for when assessing the merit of such changes. By selecting on number weaned rather than number born alive there is a “built-in” protection against unfavourable responses, such as sub-optimal birth weight. However, failure to conceive at the next AI or susceptibility to disease is not accounted for with increased selection for litter size at weaning. To prevent any deterioration in doe performance there needs to be a trait in the index that reflects this. To this end, longevity is a reasonably pragmatic trait to use in a system where does are being culled for disease and failure to fall pregnant. In this case longevity becomes a *de facto* measure of disease resistance and pregnancy rate. With this new scenario, the REV for longevity needs to be reviewed so that it reflects not only a lower replacement cost for does, but also the increase in costs associated with missed conceptions and sick animals.

CONCLUSIONS

The profit model developed was able to investigate and provide insight into two scenarios – the profitability of restricted feeding in grower rabbits and the relative importance of selection traits for rabbit breeding. Using published parameters for production levels and cost inputs, the model calculated outputs that were consistent with survey values for the best 25% of French rabbit breeders. The model demonstrated that restricted feeding of growers, introduced to help combat ERE, may be a profitable undertaking regardless of the presence of ERE, due to improvement of FCR. Under the assumptions used, the relative importance of traits in the breeding objective was highest for production traits, reproduction being the highest then growth, with fitness traits contributing much less. However, REVs need to be viewed in the light of associated changes in other traits, and traits such as longevity may indeed have a higher value if used as a *de facto* trait to select for poor fertility and disease resistance in breeding does.

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