
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

The role of computer software in the feeding of farm livestock

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ABSTRACT

Planned feeding programmes for farm livestock often require the use of repetitive calculations that vary in complexity. This paper outlines some of the planning tasks which can be performed using computerised models. These include: (i) calculation of nutrient requirements for specific production targets and/or production achievable from specific nutrient intakes (ii) diet formulation using linear programming to provide optimum combinations of dietary ingredients at minimum cost (iii) allocation of pasture to grazing animals based on functions relating herbage allowance or residual dry matter to herbage intake and (iv) medium to long-term feed planning using models that range from simple feed budgets to dynamic whole farm simulations. The planning applications of computers can be complemented with monitoring and record keeping software that allow predicted outcomes to be compared with actual events. Desirable features of computer software include ease of use, flexibility, capacity to link with other programmes, and regular revision and up-dating.

Keywords Feed budgeting, computer simulation, nutrient requirements, diet formulation, pasture allocation, expert systems.

INTRODUCTION

A farm can be considered as a system which consists of a group of inter-related components interacting for a common purpose and reacting as a whole to external or internal stimuli (Spedding, 1988). Within this system exist a number of sub-systems including such components as plants, animals, people, money, soil and atmosphere. Feeding farm livestock can be considered as one such sub-system but the wider implications of the interactions with other sub-systems within the whole farm must always be recognised. The complex inter-relationships between components of a livestock system, can be modelled by using mathematical expressions which are quantifiable and adequately reflect real life. These models may vary from relatively simple abstractions of only one aspect of livestock feeding, to detailed whole-farm simulations. In either case, computers are useful in modelling because of their ability to perform complex and repeated calculations at high speed and to store and utilise large amounts of data. This paper will describe some of the computer software used to devise feeding programmes for livestock, particularly those in grazing systems.

NUTRIENT REQUIREMENTS AND ANIMAL PERFORMANCE

Estimates of nutrient requirements for specific levels of animal production, or the converse, provide basic input data on which to base feeding strategies. These have been published as feed tables, but their use generally requires interpolation between data points (Townsley, 1985). This limitation can be overcome by using differential equations, integrated with respect to time, in computer models which allow estimates of feed requirements to be calculated for any liveweight and level of productivity specified. The equations used to estimate feed requirements have, in many cases, been based on empirical regression relationships between dietary nutrients and their concentration in animal tissues and products (Agricultural Research Council, 1980). These relationships only apply within the limits of the original data sets, and outside these limits predictions may not be accurate. An alternative approach is to construct whole animal simulation models consisting of an integrated series of mechanistic models that represent the mechanisms controlling biological events (Black *et al.*, 1990). The validity of predictions provided by these models depends on the precision with which parameters such as the physical and chemical characteristics of the diet, the climatic environment around the animal and disease status are described. Such data are often not available for commercial enterprises, particularly in pasture-based systems where sward characteristics vary considerably over short periods of time and between parts of the farm.

Most models that predict nutrient requirements and animal performance are deterministic in nature, that is, a single (usually average) estimate is provided for one set of inputs. In practice, biological variability between animals means that estimates actually lie within a range of values and are therefore stochastic. To allow for this, feed tables may incorporate safety factors to ensure all animals receive above minimum requirements. Where the extent of such variability can be assessed, it may be possible to incorporate this into stochastic models. Alternatively, the rapid process time of computers allows the possible response surface to be estimated by running the model for the likely range of values for each input.

DIET FORMULATION

If nutrient requirements of livestock are known, linear programming procedures can be used to formulate diets from a range of commodities and additives. Information regarding nutrient composition and costs of each dietary ingredient has to be supplied, perhaps in a data base, as input to the programme. The solution obtained is unique and gives the mix of ingredients which meet specified requirements within imposed nutritional constraints, at the lowest possible cost. The programme will also identify limiting nutrients and provides shadow prices for these.

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Mixes which meet specifications but which are marginally more expensive may not be identified. This technique is almost universally employed to formulate balanced diets in intensive livestock systems (Moughan and Smith, 1992). Packages are available in which ruminant nutrient requirements estimated from bio-mathematical models, are linked to linear programmes. These will formulate least cost rations for fixed levels of production or devise rations to maximise income above feed costs (Hulme *et al.*, 1986).

Diet formulation has not been used extensively to date in grazing systems because of the reliance on pasture as a dominant and lowest cost feed. It is also difficult to express the complexities of a pastoral-based system in mathematical form. In particular, the variability in nutrient composition of pasture throughout the year makes provision of accurate feed data difficult. The situation is likely to change in the future as improved techniques for providing farmers with temporal data on the nutrient composition of the sward are developed.

ALLOCATION OF PASTURE TO GRAZING ANIMALS

To ensure grazing animals achieve a desired level of nutrient intake, appropriate amounts of pasture must be allocated. Characteristics of the sward, and the physiological status and behavioural constraints of the animal have major influences on pasture intake (Poppi *et al.*, 1987). Allocation of pasture to stock is generally based either on a pasture allowance prior to grazing or a target residual post-grazing herbage mass (Milligan *et al.*, 1987). The functions relating these parameters to animal intake depend on such variables as animal demand, herbage mass and quality, and relative rates of pasture disappearance (Hodgson, 1984). Models which do not account for these variables may have limited application for different pasture types or at different times of the year. A model incorporating empirical relationships between pasture mass and animal intake that is relevant to temperate pastures under mob-grazing management has been described by Bircham and Sheath (1986).

FEEDING PLANS

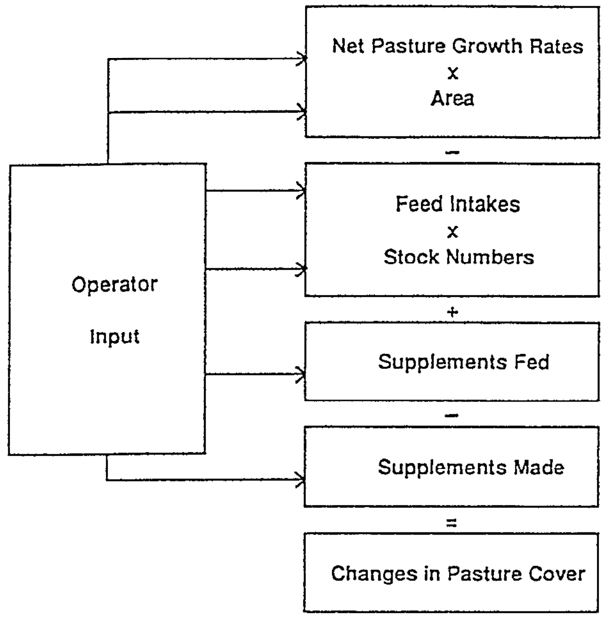
Feed planning on pastoral farms describes feed supply, in the form of pasture and supplements, in comparison with feed demand (Wright, 1986). Short term plans involve the allocation of pasture to animals that are grazing intermittently (eg the number of days grazing provided by particular paddocks). Longer term planning for the whole farm can be undertaken to make:

(i) Strategic decisions. Plans are based on likely patterns of feed supply and demand, usually for periods of a year or more, and define the livestock policy in terms of variables such as stocking rate, calving or lambing date, weaning or drying-off date and conservation policy. Model inputs are usually entered for intervals of two weeks or longer.

(ii) Tactical decisions. These plans usually cover periods of less than a year, and are used to assess whether feed deficits/surpluses may arise and to develop methods of dealing with them (Parker, 1987). Inputs are usually provided for shorter intervals than for strategic plans.

All pasture feeding plans require estimation of feed supply, typically represented by net pasture growth and purchased supplementary feed, and feed demand, represented by feed consumed and supplementary feed conserved. The relationship between these is illustrated in Fig. 1.

FIGURE 1 Simple feed budget.



Simple feed budgets involve computation of the relationship between feed supply and demand using aids such as hand calculators or computer spreadsheets (Wright 1986). The operator inputs data on pasture growth, feed requirements and supplementary feeds. Interpretation of the output requires both theoretical and practical expertise as no allowance is made in the model for adjustment of input variables for changes in output eg. if pasture covers are reduced, this may affect both net pasture growth and animal intake. A further refinement can be achieved by linking feed budgeting models to a variety of sub-routines (Fig. 2), that for example,

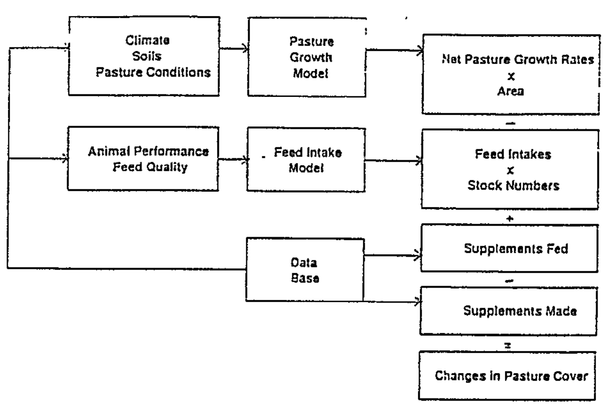
(i) Calculate feed requirements for target performance levels.

(ii) Calculate net pasture growth rates from inputs describing climate, soil and pasture conditions (eg Baars and Rollo, 1987).

(iii) Provide information on supplementary feeds from a data base.

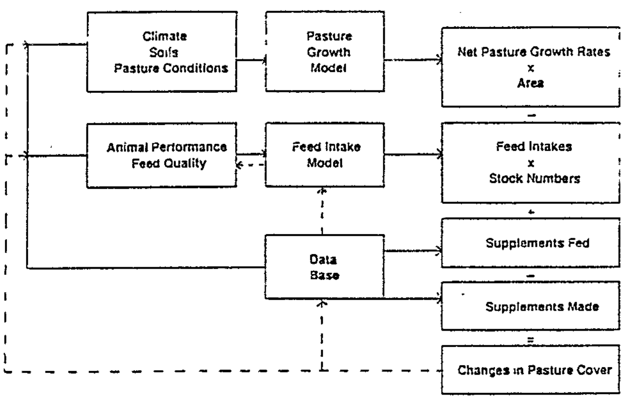
(iv) Link with financial models that calculate outputs such as gross margins.

FIGURE 2 Feed budget with data input.



The more complex dynamic whole farm simulation models are often constructed by linking static feed budgets to component models which predict the accumulation and quality of pasture, the quantity and quality of herbage consumed by stock and the partitioning of nutrients to various physiological functions in the animal, and animal performance (Fig. 3).

FIGURE 3 Dynamic simulation model.



Inputs to these models can be both manual and from data base files, and outputs can include physical data for individual paddocks and whole farm data. Links with financial models enable outcomes from different simulation runs to be compared and in some models, production and financial optimising functions may also be available. The integrated sets of relationships required in such models may contain assumptions which are not applicable to individual farms. By providing user access to default settings within the model, changes can be made if the requisite information is available (Larcombe, 1989; McCall *et al.*, 1991).

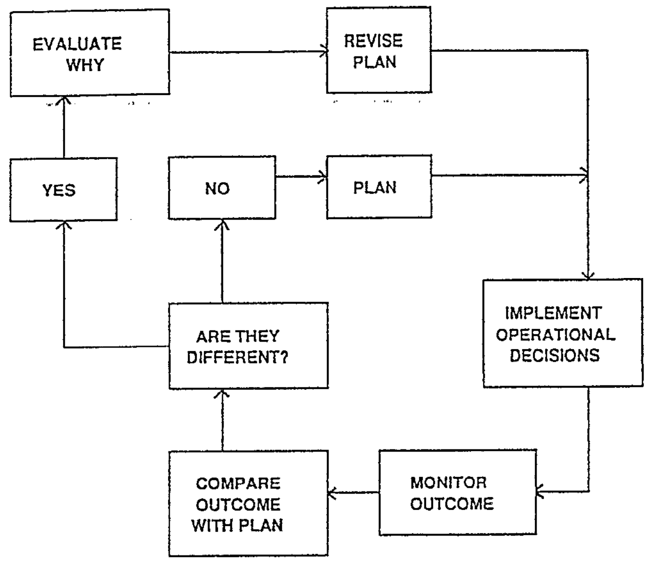
A future development will be to provide knowledge-based or Expert System models to help producers diagnose problems and interpret predictions from planning models. An Expert System could incorporate decision rules that describe the problem-solving process for feed allocation decisions. The output might include the management strategy, including economic outcomes, that is most likely to provide optimum production and enterprise profitability (Gray *et al.*, 1992). An explanation facility that describes the reasoning for decisions could be provided. The inclusion of an Expert System routine may help to improve the useage of feed budgeting by allowing producers to use models which would otherwise be beyond their ability.

MONITORING FARM PERFORMANCE

To manage effectively, it is necessary not only to plan, but also to compare predicted outcomes with actual events and modify management decisions where appropriate (Fig. 4).

To monitor farm performance, data describing production situations needs to be collected. A variety of electronic technologies are available which can be linked directly to computers to update farm record data bases. These include pasture meters, electronic scales and livestock identification, devices to measure milk yields and composition, and climate recorders (Black and Vickery, 1986). Automatic data recording and software that will process data into information used for decision-making should improve management efficiency response time (Garrick *et al.*, 1990).

FIGURE 4 The planning process.



CONCLUSION

Computer software can assist agricultural users in many ways eg financial planning, record keeping, word processing and family entertainment, as well as feed budgeting. As hardware costs decrease, and the range and power of computer software increase, greater opportunities will exist for computers to be applied to agricultural problems.

In future, feed planning models will more closely simulate the dynamic nature of pastoral farms, as mathematical equations which more accurately describe such features as pasture growth and decay, intakes of grazing livestock and the conversion of dietary nutrients to animal products are formulated. However, the user will remain responsible for collecting, entering and interpreting data and therefore require an understanding of the logic of the problem and its solution. Although computer models are useful as aids to this understanding, they can never act in its place.

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