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Breeding objectives for beef cattle used in different production systems: 1. Model development

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Abstract

A bio-economic model was developed to evaluate utilization of beef bulls in a variety of production systems. The model can simulate life-cycle production of both beef and dairy cow herds with or without an integrated feedlot system. The Markov chain approach is used to simulate herd dynamics. The herd is described in terms of animal states and possible transitions among them. Equilibrium herd structures of the integrated production systems are calculated in their stationary states. The economic efficiency of each system is a function of biological traits of animals and of management and economic parameters. The model allows estimation of marginal economic values for 16 traits separately in each system. The economic weight for each trait or direct and maternal trait component in each selection group and breed of interest is then calculated as the weighted sum of the economic values for the trait in all production systems in which the selection group has an impact. Weighting factors for each system are computed as the product of the number of discounted expressions for direct and maternal trait components transmitted in that system by the selection group and the proportion of total cows belonging to each system.

Keywords: Cattle; Bio-economic model; Economic weight; Breeding objective; Production system; Profit function

1. Introduction

Beef cattle farming is an important component of sustainable agriculture in much of Europe. Maintenance of rural landscape was one factor favoring the maintenance of a wide spectrum of beef breeds, while improving carcass and meat quality of slaughter animals produced in dairy farming systems is a second important utilisation of beef bulls. The increasing number of cows in non-dairy systems has encouraged development of breeding programmes for beef breeds (Schäfer et al., 1998; Phocas et al., 1998; Coopman et al., 1999; Amer et al., 2001; Albera et al., 2002; Fuerst-Waltl et al., 2002).

Definition of the traits in a breeding objective and estimation of their economic values are important

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steps in developing a breeding programme. The breeding objective should reflect production and economic conditions in those environments in which breeding animals have a genetic influence. The large variety of environmental, management and marketing conditions for beef farming makes it almost impossible to define a general breeding goal, even within a breed. In such situations, a general bio-economic model describing the divergent production, feeding, management and breeding strategies is an important tool for defining alternative breeding objectives.

Several models for the estimation of economic values for traits in beef cattle have been published in recent years. Most of them are situation specific. They may, for example, apply to pasture (Urioste et al., 1998) or to in-door systems (Albera et al., 2002). In some, economic weights are calculated separately according to production of purebred beef or crossbred progeny (Phocas et al., 1998) and then integrated into a general breeding goal.

Growth, carcass composition and feed requirement in beef cattle have been mathematically described (Davis et al., 1994; Koots and Gibson, 1998; Tess and Kolstad, 2000). Such models do not, however, include the option to assign economic values of traits in beef bulls according to their utilisation in different breeding systems (pure-breeding or cross-breeding with beef or dairy cattle, for example) (Wilton and Danell, 1981; Amer et al., 2001).

The aim of the present study was to develop a general model to compute economic weights of a variety of traits in a wide range of breeding and management systems and under marketing and economic conditions in which beef bulls may be used.

2. Model description

2.1. Definition of production and management systems

The model is applicable to important production systems in which beef bulls may be used. They can be divided into four main groups (Fig. 1):

System 1 : Purebred beef cow-calf pasture systems producing females and males for own replacement and for other systems. Both seedstock production and purebred commercial herds are included.

System 2 : Crossbred beef cow-calf pasture systems (rotational crossing) producing their own replacement females but buying breeding bulls or their semen.

System 3 : Crossbred cow-calf pasture systems (terminal crossing) importing their female replacements from dairy or dual purpose cow herds or from herds of beef dam lines and buying beef bulls or their semen for terminal crossing.

System 4 : Dairy or dual purpose milking herds (in-door system) applying terminal crossing with beef bulls to part of the herd.

System 1 is the only one which is closed and can therefore exist independently of the other production systems. The remaining three systems require purchase of male and/or female replacement stock and usually constitute part of a complex, vertically integrated production system.

Some portion of the male calves from System 1 (the breeding herds) are performance tested on station or in the field and are selected as breeding bulls. These bulls are expected not to change their owner until sold to an AI station or to other herds for natural mating.

Within each production system, up to four marketing strategies are allowed for surplus calves and/or heifers: (i) selling (export) weaned calves outside the system, (ii) fattening weaned calves within the system, (iii) selling surplus breeding heifers before mating and (iv) selling surplus pregnant heifers. The last two strategies are allowed only in Systems 1 and 4. Various combinations of these strategies are possible.

Intensive indoor fattening is assumed for bulls in all systems, whereas intensive indoor or extensive pasture finishing can be chosen for heifers and castrates in Systems 1 to 3. In System 4, an intensive indoor feedlot is assumed. Heifers, bulls and castrates are fattened to a fixed optimal slaughter weight that depends on the maturity type (mature weight) of the parental breed or breeds.

Deterministic models are used for all systems. Fractions of animals are allowed in the calculations (a non-integer model), but the number of cows entering each reproductive cycle in each year (both