INTRODUCTION
Within methods suggested for economic value derivation, bioeconomic simulation models better allow the description of complex livestock productions systems (Groen, 1989). Such models have often been used to develop breeding objectives in beef cattle (Koots and Gibson, 1998a; Hirooka et al., 1998a). In the Piemontese breed predicted breeding values for beef traits (Albera et al., 2001) and calving ease (Carnier et al., 2000) are available, but still there is a need for an economic definition of the breeding goal in order to implement a selection index. In this study a bioeconomic model has been developed to describe a typical Piemontese cattle farm integrating suckler cows and fattening production systems. The model allows the simulation of inputs and outputs and the evaluation of the economic and biological efficiency of the farm. Several studies reported the influence of production circumstances on economic values (Groen, 1989; Koots and Gibson, 1998b). Hence, an analysis is also conducted to evaluate sensitivity of computed economic values related to changes in the traits levels and prices assumed or to situations where a limitation on the input or output occurs.

MATERIAL AND METHODS

General aspects. The model is deterministic, allows non-integers and assumes absence of genetic variation within the animals of the farm. An integrated beef cattle farm is modelled, with breeding of suckler cows and fattening of the males and females not used for replacement. The number of cows is fixed with the exception of the situation when restrictions on the input or output are set, in those situations cows number is rescaled. Annual revenues and costs of the farm are considered, but some activities are simulated on a daily basis. Revenues are from the sale of fattened young bulls, heifers, culled cows, manure and from subsidies. Cost components include housing, feeding, labour, machinery, veterinary and inseminations cost, interest on the animal, housing and machinery capital. All feeds are assumed to be bought at market prices. Purchasing of animals is not allowed, therefore fattening is restricted to the animals born at the farm. Traits considered in the model are postweaning average daily gain (ADG), live fleshiness scores (FLESH), calving ease (CE) and calving interval (FERT). A general overview of the model is given in figure 1.

Detailed description. The herd consists of 50 suckler cows. Calvings are distributed over the whole year and their number is a function of female fertility, expressed by the average calving interval. Calves are weaned at 6 months of age. Male calves are fattened as young bulls and slaughtered at a fixed weight (580 kg). Number of female calves reared for replacement is a function of cows culling rate, mortality and disposal during rearing period. Females not
necessary for replacement are fattened and slaughtered at a fixed weight (450 kg). First insemination of heifers takes place within 18 months of age and all fertile females are assumed to calve for the first time at the age of 28 months. Three age classes are defined for reared heifers: 6 to 12, 12 to 18 and 18 to 28 months. For suckler cows 2 age classes have been defined, first and later parities cows. Fixed levels of involuntary culling during rearing and respective age classes are assumed.

Figure 1. Schematic representation of the elements of the model

Daily feeding of animals is simulated as a function of live weight, growth, gestation and lactation requirements. Nutrient requirements are from Jarrige (1988) for breeding animals and fattened heifers and from Bittante (1984) for young bulls. Dynamic of growth of calves before weaning and during fattening is considered to be linear. For heifers and cows growth is modelled by the Von Bertalanffy function, but within age classes a linear growth is considered.

In Piemontese slaughter animals are marketed on the basis of the value per kg of live weight, which reflects their muscular development. For selection purposes muscular development is evaluated through live fleshiness scores (Albera et al., 2001). A relationship between live fleshiness scores and market values of the animals has been established through a linear regression (Albera, unpublished data). The value per kg of live weight of slaughter animals is then expressed as a function of base market price and live fleshiness scores.

Costs related to dystocia are modelled separately for first and later parities according to the incidence of calving scores (Carnier et al., 2000) and include veterinary costs, additional labour, stillbirth, reduced fertility and increased culling rate as a consequence of a difficult calving (Albera et al., 1999).

As slaughter weight of fattened animals is fixed, costs of labour, machinery use, bedding and health care are considered as fixed per animal per day, reflecting that these costs are dependent on the length of the fattening cycle. For cows and breeding heifers the same costs are fixed per animal. Housing costs, depreciation of machinery and interest on investments are fixed for the farm.

The economic value of each trait is derived by calculating the change in the farm profit due to a marginal (1 %) increase in the genetic merit of the trait. The economic value of CE has been computed using the methodology proposed by Meijering (1986) for categorical data.
RESULTS AND DISCUSSION

Simulated profit of the farm was positive. Feeding of animals, accounted for 50% of the costs of the farm. The contribution of labour to total costs was moderate (10%). Similarly to Hirooka et al. (1998b) genetic improvement of growth rate led to improved biological efficiency of production in terms of MJ of energy per kilogram of beef.

Economic values and their sensitivity to production circumstances are presented in table 1.

Table 1. Economic values for beef production traits and their sensitivity to production circumstances (Euro per year per trait unit \(^\text{A}\) per cow)

<table>
<thead>
<tr>
<th>Traits</th>
<th>ADG</th>
<th>FLESH</th>
<th>CE</th>
<th>FERT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>0.13</td>
<td>48.02</td>
<td>2.61</td>
<td>-1.99</td>
</tr>
<tr>
<td>ADG –10 %</td>
<td>0.52</td>
<td>45.07</td>
<td>2.59</td>
<td>-1.78</td>
</tr>
<tr>
<td>ADG +10 %</td>
<td>0.13</td>
<td>48.90</td>
<td>2.54</td>
<td>-2.04</td>
</tr>
<tr>
<td>FLESH –10 %</td>
<td>0.12</td>
<td>43.22</td>
<td>2.64</td>
<td>-1.94</td>
</tr>
<tr>
<td>FLESH +10 %</td>
<td>0.13</td>
<td>52.82</td>
<td>2.59</td>
<td>-2.03</td>
</tr>
<tr>
<td>CE –10 %</td>
<td>0.13</td>
<td>48.48</td>
<td>2.94</td>
<td>-1.93</td>
</tr>
<tr>
<td>CE +10 %</td>
<td>0.12</td>
<td>47.62</td>
<td>1.22</td>
<td>-2.03</td>
</tr>
<tr>
<td>FERT –10 %</td>
<td>0.15</td>
<td>51.78</td>
<td>2.86</td>
<td>-2.45</td>
</tr>
<tr>
<td>FERT +10 %</td>
<td>0.11</td>
<td>44.95</td>
<td>2.41</td>
<td>-1.64</td>
</tr>
<tr>
<td>Price of energy –10 %</td>
<td>0.14</td>
<td>48.02</td>
<td>2.62</td>
<td>-2.06</td>
</tr>
<tr>
<td>Price of energy +10 %</td>
<td>0.12</td>
<td>48.02</td>
<td>2.61</td>
<td>-1.91</td>
</tr>
<tr>
<td>Fixed input (energy)</td>
<td>0.05</td>
<td>48.02</td>
<td>2.36</td>
<td>-1.42</td>
</tr>
<tr>
<td>Fixed output (live weight)</td>
<td>0.05</td>
<td>48.02</td>
<td>2.00</td>
<td>-1.00</td>
</tr>
</tbody>
</table>

\(^\text{A}\)g/day for ADG, point (scale 1-9) for FLESH, 1% in the liability scale for CE, 1 day for FERT.

In general economic values were poorly affected by production circumstances with the exception of ADG, that showed non-linearity and a marked sensitivity to the level of growth. At lower level of growth the economic value was four times higher compared to the basic situation, while it remained unchanged when trait value was increased of 10%. This is a consequence of the definition of fixed slaughter weights and restriction to the purchase of calves from outside the farm. In such a situation a shortening of the fattening period as a consequence of a faster growth, does not allow the fattening of more animals, but only allows to save production factors which have a limited alternative use. On the other hand, compared to the basic situation, when growth of animals is lower, the fattening period becomes longer, variable and fixed costs per animal per day increase, and a lower proportion of animals can be fattened per year. Hence, a marginal increase of ADG has a higher effect because saved production factors can be used to fatten more animals available within the farm. Bekman and
Van Arendonk (1993) obtained a similar pattern for the economic value of daily gain in a situation with fixed slaughter weight. Hirooka et al. (1998b) also showed a non-linearity of the economic value when the level of growth was increased.

FLESH showed little sensitivity to the conformation of animals and to the reduction of calving interval which increases the number of animals available for fattening.

Albera et al. (1999) reported an economic value for dystocia in Piemontese twice as low compared to this study. However, in their model stillbirth and reduced fertility resulting from calving problems were modelled in terms of loss of new born calves (evaluated at market price) and not in the frame of a beef integrated farm involving also fattening of animals. CE was affected by the level of dystocia and showed a higher economic value when calving problems were increased consistent with literature reports (Koots and Gibson, 1998b; Munoz-Luna et al., 1988). The economic value of FERT had a moderate sensitivity to fertility level and was higher at low level of the calving interval in opposition with results of Groen et al. (1994) for dairy cattle.

In general, economic values were sensitive to restriction both in the energy inputs and live weight outputs, indicating that alternative use of production factors has a low profitability compared with the use within the production system.

REFERENCES