Analyzing trade-offs between production, economics, land use and labour in mountain farming systems through long-term simulation

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Simulation Model: Assessment of LFS dynamics

- Mountain livestock play a number of crucial functions beyond production of food
- New management strategies will need to take into account structural, managerial and social changes occurred in recent years
- Simulation models are able to integrate the multiple factors involved in LFS dynamics
  - Reproduction and nutrition, management, animal physiology, availability of resources...
  - Throughout long periods of time
Objective

• Compare the long-term performance of mountain beef cattle herds under diverse:
  – Feeding, reproductive and land use management strategies

• Using a herd dynamics simulation model

• Analyzing derived trade-offs between production, economics, land use and labour input

The herd dynamic simulator (Nodriza): An Overview

• Beef cattle model based on an stochastic and dynamic animal sub-model presenting management –nutrition -reproduction interactions

• Parameterized and Validated under conditions of Spanish Pyrenees. Work of “La Garcipollera” research station since 1987

• The equations of the model have been programmed in Visual Basic 2005 express edition ® in order to facilitate its use. The Nodriza software designed had different visual interfaces where diverse scenarios can be defined.
**Nodriza: An Overview**

**COW-CALF SUB-MODEL**
- Individual (stochastic) and daily basis simulation
  - Compartments: Empty Body Weight → Weight
    - Total Fat → BCS
    - Calf Weight

**HERD DYNAMIC SUB-MODEL**
- Individual (stochastic) and daily basis evaluation of:
  - Sexual cyclicity
  - Mating
  - Pregnancy
  - Calving
  - Lactation, culling and mortality

**Key Management Dates**
- BCS → Postpartum Anoestrus (PPA)
- Physiological state: Lactating, Pregnant

**Feeding Plan** (Energy, ME)
- Set the Production System
- Set a management for Herd and Feeding
- Simulation

**Nodriza: User Interfaces- MAIN**

**FEEDS AVAILABLE**
**FEEDING PLAN**
**HERD MANAGEMENT**
**STOCHASTIC PARM.**
**BREED CHARACT.**

**NATURAL RESOURCES**

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3
Simulated herd

- 100-cows herd of 650±15 kg (mean±s.d.) of LW and BCS of 2.5±0.1.
- The period of time simulated was 15 years (steady state at year 6).
- Culling, replacement and random mortality and abortion assumed common for all the strategies.

Grazing management simulated

- RANGE PASTURES: SUMMER
- INTERMEDIATE FOREST PASTURES: NON-LACTATING COWS
- SPRING & AUTUMN:
  - LOW VALLEY MEADOWS
  - LACTATING COWS
  - SPRING & AUTUMN
## Simulated Strategies

<table>
<thead>
<tr>
<th>Management strategy</th>
<th>Calving length</th>
<th>Weaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter calving (WC)</td>
<td>3 months</td>
<td>180 days</td>
</tr>
<tr>
<td>Autumn calving (AC)</td>
<td>3 months</td>
<td>160 days</td>
</tr>
<tr>
<td>8 months calving (8MC)</td>
<td>8 months</td>
<td>180 days</td>
</tr>
<tr>
<td>2 calving in 3 years</td>
<td>2 months</td>
<td>170 days (2C3Y)</td>
</tr>
</tbody>
</table>

Reduction of labour costs & Better use of some natural resources

Simulation Results: Body Condition Score (BCS)
Simulation Results: Body Condition Score (BCS)

![Graph showing BCS trends over year and season for different strategies: WC, 2C3Y, 2C3Y9M.]

Simulation Results: Reproductive performance

<table>
<thead>
<tr>
<th>Strategy</th>
<th>WC</th>
<th>AC</th>
<th>8MC</th>
<th>2C3Y</th>
<th>2C3Y9M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertility (%)</td>
<td>78.0</td>
<td>88.2</td>
<td>92.2</td>
<td>93.5</td>
<td>94.4</td>
</tr>
<tr>
<td>SD (%)</td>
<td>3.71</td>
<td>2.21</td>
<td>1.83</td>
<td>0.85</td>
<td>0.52</td>
</tr>
<tr>
<td>max (%)</td>
<td>81.7</td>
<td>92.1</td>
<td>94</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>min (%)</td>
<td>70.7</td>
<td>83.9</td>
<td>90.1</td>
<td>92.8</td>
<td>93.9</td>
</tr>
</tbody>
</table>

1 WC, winter calving; AC, autumn calving; 8MC, 8 months calving; 2C3Y, 2 calving in 3 years; 2C3Y9M, 2 calving in 3 years with weaning at 9 months.

2 number of pregnant cows at the end of mating season *100/total cows
### Simulation Results: Production and labour

<table>
<thead>
<tr>
<th></th>
<th>WC</th>
<th>AC</th>
<th>8MC</th>
<th>2C3Y</th>
<th>2C3Y9M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaned calves</td>
<td>76</td>
<td>86</td>
<td>90</td>
<td>59</td>
<td>60</td>
</tr>
<tr>
<td>Calving days per year (d)</td>
<td>90</td>
<td>90</td>
<td>240</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Weight at weaning (kg)</td>
<td>219</td>
<td>197</td>
<td>204</td>
<td>201</td>
<td>298</td>
</tr>
<tr>
<td>Length of fattening (d)</td>
<td>176</td>
<td>189</td>
<td>185</td>
<td>187</td>
<td>126</td>
</tr>
<tr>
<td><strong>Labour</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total labour (h)</td>
<td>458</td>
<td>519</td>
<td>670</td>
<td>379</td>
<td>420</td>
</tr>
<tr>
<td>Grazing management (h)</td>
<td>183</td>
<td>102</td>
<td>126</td>
<td>147</td>
<td>180</td>
</tr>
<tr>
<td>Feeding in-door (h)</td>
<td>173</td>
<td>312</td>
<td>290</td>
<td>182</td>
<td>190</td>
</tr>
<tr>
<td>Calving supervision (h)</td>
<td>102</td>
<td>104</td>
<td>255</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

### Simulation Results: Land use

<table>
<thead>
<tr>
<th></th>
<th>WC</th>
<th>AC</th>
<th>8MC</th>
<th>2C3Y</th>
<th>2C3Y9M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter supplementation (d)</td>
<td>122</td>
<td>185</td>
<td>165</td>
<td>122</td>
<td>122</td>
</tr>
<tr>
<td>Supra-forest pastures (d)</td>
<td>106</td>
<td>106</td>
<td>106</td>
<td>106</td>
<td>106</td>
</tr>
<tr>
<td>Valley meadows (d)</td>
<td>42</td>
<td>16</td>
<td>38</td>
<td>20</td>
<td>65</td>
</tr>
<tr>
<td>Forest pastures (d)</td>
<td>95</td>
<td>78</td>
<td>56</td>
<td>117</td>
<td>72</td>
</tr>
</tbody>
</table>
Trade-offs: an example

**PROFITABILITY**

- AC
  - + 4,296 €

**LAND USE**

- 2C3Y
  - + 40 d
  - forest pastures

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**Simulation Results: Sensibility**

Graph showing the economic margin at slaughtering (€) against the price of concentrate for cows and calves (€/kg) for different scenarios. The graph includes two axes: one for economic margin (€) ranging from 0 to 50,000 and another for price of concentrate ranging from 0.1 to 0.4. Several lines represent different scenarios such as WC, AC, 8MC, 2CMY, and 2C3YM, each showing the trend as the price of concentrate increases.
Conclusions

• Relatively intensive strategies, such as 8MC and WC, yielded the highest economic margins, but the alternative low-labour/ extensive strategy is feasible and less sensible to increases of feed prices.

• Simulations should be used to explore new management strategies and analyze the consequences of their implementation under diverse scenarios, rather than being conclusive tests for choosing the optimal strategy.

Models (A Map)

• Construct a model is a way to summarize and order information proceeding from different sources.

• The simulations yields answers about the scenarios tested, but also questions arises (either no-information or questionable hypothesis).

• So Models are also a tool to define new research ways.