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Food Resources Allocation in Pastoral Dairy Production Systems

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Overview

Introduction

Importance of Dairy Production in Uruguay

- Important productive sector (9,3% GVP)
- Land area devoted to dairy (6%).
- Highest per capita producer in Latin America

Current Situation and Objective

- Current management.
- **Objective:** To maximize dairy production.
- The problem can be modeled as a combinatorial optimization problem.

Pastoral Systems

Pastoral Dairy Production Systems

- World dairy production systems.
- Simple system: Production determined by individual production.
- Differences according to season. Using supplements.
- Uruguayan dairy production.

Assignment Problems

OR Applied to Agricultural Problems

- Least cost combination (Waugh, 1951)
- Individual components integration (Ridler et al., 2001)
- Most profitable mix of forage species (Neal et al., 2007)
- Effect of stocking rate (Macdonald et al., 2008)
- Post-grazing residual pasture mass model (Doole et al., 2012 y Doole et al., 2013)

Assignment Problems

Food Resources Allocation Problem

- Based pastoral systems with supplementation.
  - Supply structure.
  - Demand structure.
- Uruguay, two daily milkings.
- Proposed solution.
  - Dairy production model NRC-2001 (Correa, 2001)
  - Allocation model.

Assignment Problems

Dairy production model NRC-2001

$$ae = ace - eReq \tag{1}$$

$$ace = w \times cal \tag{2}$$

$$potCons = (0,372 \times potencialProduction + 0,0968 \times bw^{0.75}) \times (1 - e^{-0,192 \times (lw + 3,67)}) \tag{3}$$

$$eReq = bReq + mReq \tag{4}$$

$$bReq = 0,08 \times bw^{0,75} \tag{5}$$

$$mReq = DistanceInKm \times 2 \times 0,00045 \times bw \tag{6}$$

$$ENl = 0,0929 \times f + 0,0547 \times p + 0.192 \tag{7}$$

$$production = \frac{ae}{ENl} \tag{8}$$

Mathematical Formulations

Resource Allocation Problem Formulations

- Single Basic Formulation considering one milking.
- Single Basic Formulation considering several milkings.
- Group Basic Formulation.

Mathematical Formulation

Group Basic Formulation

$$max \frac{\sum_{o}\sum_{z}(w_{oz} \times cal_z - y_{oz} \times (bReq + mReq_z))}{ENI}$$

Mathematical Formulation

Group Basic Formulation

$$max \frac{\sum_{o} \sum_{z} (w_{oz} \times cal_z - y_{oz} \times (bReq + mReq_z))}{ENI}$$

sa :

$$\sum_{z} y_{oz} = M \qquad \forall o \in O \qquad (9a)$$

Mathematical Formulation

Group Basic Formulation

$$max \frac{\sum_{o} \sum_{z} (w_{oz} \times cal_z - y_{oz} \times (bReq + mReq_z))}{ENI}$$

$sa:$

$$\sum_{z} y_{oz} = M \qquad \forall o \in O \tag{9a}$$

$$\sum_{o} w_{oz} \leq Food_z \qquad \forall z \in Z \tag{9b}$$

Mathematical Formulation

Group Basic Formulation

$$max \frac{\sum_{o}\sum_{z}(w_{oz} \times cal_z - y_{oz} \times (bReq + mReq_z))}{ENI}$$

$sa:$

$$\sum_{z} y_{oz} = M \qquad \forall o \in O \qquad (9a)$$

$$\sum_{o} w_{oz} \leq Food_z \qquad \forall z \in Z \qquad (9b)$$

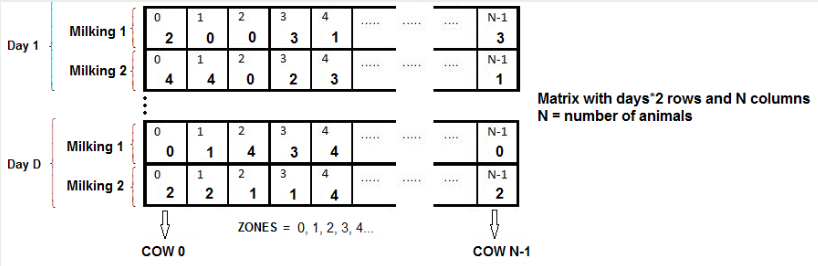
$$w_{oz} \leq y_{oz} \times potCons \qquad \forall o \in O, \forall z \in Z \qquad (9c)$$

$$y_{oz} \in \mathbb{N}, w_{oz} \in \mathbb{R} \qquad \forall o \in O, \forall z \in Z$$

Genetic Algorithms

Single Encoding

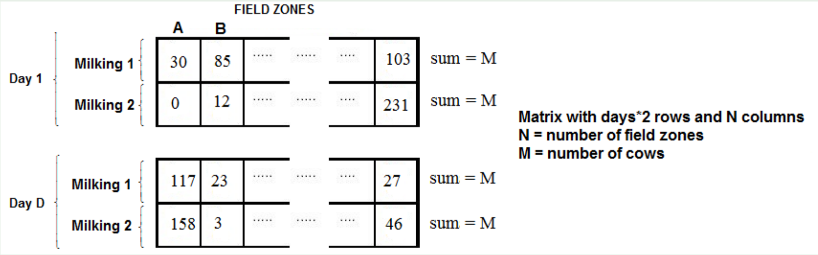
- Structure.
- Advantages.
- Selection, recombination y mutation.
- Initial population.
- Fitness function.



Genetic Algorithms

Group Encoding

- Structure.
- Advantages.
- Selection, recombination y mutation.
- Correcting procedure.
- Fitness function.



Computational Experiments

Experiments

- Exact algorithms experimental analysis.
- Genetic algorithms experimental analysis (Calibration).
- Comparison between exact methods and genetic algorithms.

Computational Experiments

Scenario definition

- Execution platform.
- Dairy herd description.
- Food resources description.

Zone	Resources(Kg DM)
1	1100
2	1800
3	1800
4	4500
5	4500

Scenario A

Zone	Resources(Kg DM)
1	11000
2	18000
3	18000
4	45000
5	45000

Scenario B

Zone	Resources(Kg DM)
1	110000
2	180000
3	180000
4	450000
5	450000

Scenario C

Zone	Resources(Kg DM)
1	110000
2	180000
3	180000
4	450000
5	4500000

Scenario D

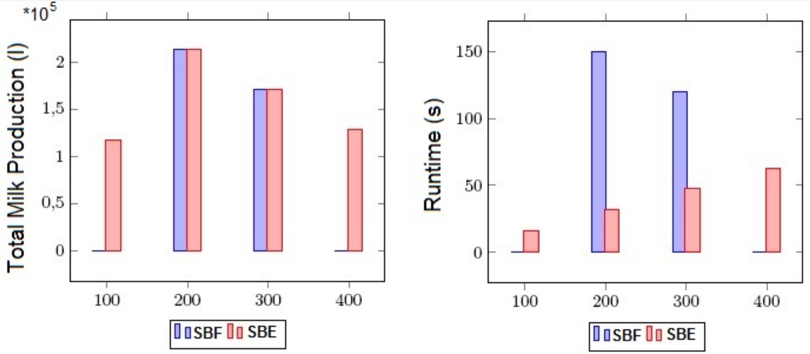
Zone	Resources(Kg DM)
1	1100000
2	1800000
3	1800000
4	4500000
5	4500000

Scenario E

Computational Experiments

Exact Method vs GA

Exact Method vs GA: SBF (several milkings)



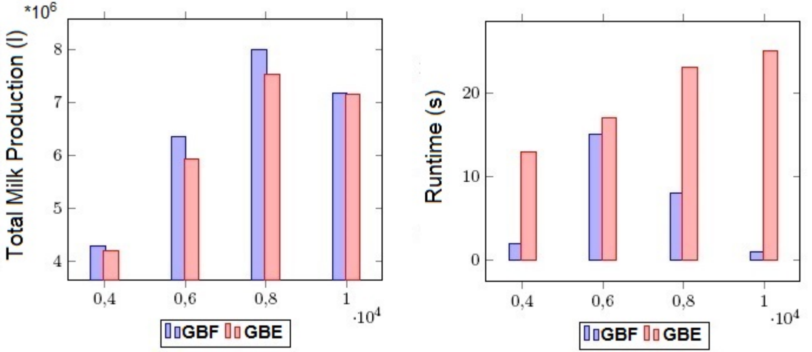
Milk production comparison
Scenario B

Runtime comparison
Scenario B

Computational Experiments

Exact Method vs GA

Exact Method vs GA: GBF (several milkings)



Milk production comparison
Scenario D

Runtime comparison
Scenario D

Conclusions and Future Work

Conclusions

- Exact method obtains good solutions in GBF.
- GA has very close values and provides more diversity in the solution structure.
- Computing time evolution.

Conclusions and Future Work

Future Work - Modeling

- Extending the dairy model.
  - Heterogeneous model.
  - Agronomic approach.
  - Economic approach.
- Experimentation with other metaheuristics or heuristics.
- Incorporating an "intermediate model".

Future Work - Applications

- Compare solutions found over solutions implemented in current practice.
- Estimating forage method.

The End

Thank you for your attention!

Questions?