A modelling framework to evaluate benefits of animal adaptive capacity for livestock farming systems

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Levers for robust and resilient LFS

Robustness & resilience

LFS level

Farmer

Resources

Animals

Adaptive capacities
Role of the animal biological component

Using animal adaptive capacities to cope with perturbations

Where do we come from?

Benefits of animal robustness
Low control of environment
Gibon, 1994; Blanc et al., 2006; Nozières et al., 2011

Costs of lack of animal robustness
High control of environment
Rauw et al., 1998; Knaus, 2009; Web & Casey 2010
Role of the animal biological component

Where are we going?

Producing & transferring knowledge in the field...

→ Toward a tool for analysing and quantifying the effects of management, selection and environmental conditions on the expression of animal adaptive capacities
Role of the animal biological component

Which strategy? → Using models

Formalising
Integrating K

Predicting
Quantifying

Environment
Stress

Management
Selection

Animal

Herd

f(t)

Function

Option Explicit
Option Base 1

Public Distribution As String, D As String, estimator As String, Equation As String
Public x() As Double, xmin As Double, xmax As Double, dx As Double, xinf As Double, xsup As Double, ord As Double
Public pi As Double, u As Double, pdf As Double, m As Double, v As Double
Public Parameters(), z(), mv()
Objective

An animal model representing different types of robustness
Modelling diversity of robust animals

- Robustness & adaptive capacities
  → Trade-offs among biological functions
  → Acquisition and allocation of resource
- Trade-offs → key concept in ecology
- Enrich animal representation by adopting ecology point of view
  - Differences in the drivers of phenotypic traits
    = Natural selection and adaptation
    ≠ Production potential
  - Similarities with animal sciences
    Nutrient partitioning
    Phenotype as expression of genotype in an environment
Modelling diversity of robust animals

Biological events
- Birth
- Conception
- Weaning
- Birth
- Parturition
- Mortality
- Mature

Environment
- BreadSeason_Start
- BreadSeason_End
- Food_Res
- BreedSeason

Life records
- Alive_Stat[1...1000]
- Birth_Date[1...1000]
- Death_Age[1...1000]
- Age[1...1000]
- Gest_Stat[1...1000]
- Gest_Time[1...1000]
- Gest_Nb[1...1000]
- p_SD[1...1000]
- p_AchGen[1...1000]
- p_F[1...1000]
- p_EWGen[1...1000]

Acquisition
- AcqRelative[1...1000]
- Acq_Cost_Pct[1...1000]
- Acq_Cost[1...1000]
- Acq_Pct[1...1000]

BW
- BW[1...1000]
- Threshold_BW[1...1000]
- Growth[1...1000]
- B_Variance[1...1000]
- BW[1...1000]
- BW[1...1000]
- BW[1...1000]
- BW[1...1000]
- BW[1...1000]

Progeny
- Progeny_ThreshMort[1...1000]
- Progeny_AliveStat[1...1000]
- Progeny_TotAlive[1...1000]
- Progeny_TotDead[1...1000]
- Progeny_ME[1...1000]

Genetic parameters
- Acq_Aival[1...1000]

Allocation coefficients
- F_R[1...1000]
- F_S2R[1...1000]
- F_R2S[1...1000]
- F_S2A[1...1000]

Energy utilization
- ME_In[1...1000]
- ME_Alloc[1...1000]
- ME_Mit[1...1000]
- ME_Model[1...1000]
Modelling diversity of robust animals

• Utilization of energy: core of the animal model
  - Fuel biological functions
  - Result of energy acquisition (environment & cost) & allocation (priorities among functions)

• Conversion of energy into BW
  - Growth, storage and depletion

• Feedback of BW on survival and reproductive success

• Maternal energy investment → progeny survival

• Genetic parameters (BW, allocation & acquisition) transmitted throughout generations
Modelling diversity of robust animals

- Simulation of an ungulate population
  - How selection shapes the allocation and acquisition parameters?
  - Which types of animals are the fittest?
Modelling diversity of robust animals

• Disappointing results .... Importance of the concept of costs !
  - Acquisition: energy for organs and metabolism
  - Fitness: individual and progeny survival

• Next step → working on costs

Challenge to merge concepts from ecology and animal sciences... at least at the scale of a post doc!
Conclusion

• Thinking concepts with simple models to gain insights on complex issues (robustness, resilience, phenotypic plasticity, ….)

• Benefits from interdisciplinarity: reconsidering animal representation

Passive material convertor
Organism with its own agenda
Organism interacting with its environment
Thanks for your attention

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