Assessing quantity and quality of grazed forage on multi-species swards

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Multi-species swards as a methodological challenge

Multi-species swards:
Functionally complex vs. functionally simple swards

⇒ better provision of ecosystem services

⇒ potentially higher spatial heterogeneity of:
  − standing biomass
  − biomass quality
  − forage intake (selectivity!)

⇒ Assessment of forage intake more difficult?
Estimation of forage intake using a double-sampling method

**Large** number of sampling points:
Compressed Sward Height (CSH) measured using a rising plate meter (fast and easy)
→ covers heterogeneity of sward structure

**Small** number of sampling points:
Calibration samples of known CSH (labour-intensive)
→ calibration models to calculate standing biomass from CSH
→ calculate quality of grazed biomass from quality of pre- and post-grazing standing biomass
Hypotheses

Hypothesis 1
Rising-plate-meter *calibration models* for standing biomass differ between *diverse* and *grass-dominated* swards.

Hypothesis 2
At the same calibration sample size,

a) better estimates can be obtained for *standing biomass* (double sampling method) than for *biomass quality*

b) better estimates of standing biomass and biomass quality can be obtained in *grass-dominated* than in *diverse* swards.
Methods: Grazing treatments

Animal species
- **Cattle** (suckler cows + calves)
- **Sheep** (dry ewes)

Sward type
- **Diverse** (moderately species-rich *Lolio-Cynosoretum*)
- **Grass-rich** (herbicide application against dicots in 2006 and 2009)
Methods: Pasture system

- Site: Relliehausen, Solling uplands, Germany
- Paddock size: 0.5 ha
- Rotational pasture
  - three consecutively grazed blocks
  - three rotations
- Grazing intensity
  - stocking density: 12 livestock units ha\(^{-1}\)
  - stocking rate: 0.7 livestock units ha\(^{-1}\) a\(^{-1}\)
Methods: Data collection

⇒ 2nd rotation 2012, 12-27 June

Compressed sward height (CSH)
rising plate meter 30 cm ∅
50 measurements per paddock  ★ pre-stocking and ★ post-stocking

* Block A ★ Block B ★ Block C ★
⇒ 15 samples each ⇒ 8 samples each ⇒ 8 samples each

Calibration samples
sampling points of 30 cm ∅
15 / 8 samples per paddock  ★ pre-stocking and ★ post-stocking

CSH
standing biomass
yield shares of functional groups
biomass quality:
crude protein (CP)
acid detergent fibre (ADF)
Data analysis I: Optimum calibration model
Sward height $\rightarrow$ standing biomass

**Basic Model**

$$\text{Standing Biomass} \sim \text{CSH}$$

**Full Model**

$$\text{Standing Biomass} \sim \text{CSH}$$

- sward type
- grazer species
- sampling time (pre-/post- stocking)
- block

up to three variables and their interactions with CSH and with each other

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**Model selection**

dropping non-significant terms to minimize Akaike's Information Criterion (AIC)
Data analysis II: Effect of sample size on quality and standing-biomass estimates

Calibration samples Block A
- pre-stocking, grass-rich (n=30)
- pre-stocking, diverse (n=30)
- post-stocking, grass-rich (n=30)
- post-stocking, diverse (n=30)

random draw of subsamples (n=4, 6, ..., 16)

mean CP/ADF concentration

mean standing biomass

calibration model CSH → standing biomass

Coefficient of variation for 5000 random draws per variant
Botanical composition of the grazing treatments

Cattle
- Diverse
  - Grasses
  - Forbs
  - Legumes
- Grass-rich
  - Grasses
  - Forbs
  - Legumes

Sheep
- Diverse
  - Grasses
  - Forbs
  - Legumes
- Grass-rich
  - Grasses
  - Forbs
  - Legumes

Legend:
- Grasses
- Forbs
- Legumes
Relationship between sward height and standing biomass

standing biomass (g m$^{-2}$)

CSH (cm)

Diverse
- pre-stocking
- post-stocking

Grass-rich
- pre-stocking
- post-stocking
Calibration equations: sward height $\rightarrow$ standing biomass

Best model:

$$\text{Standing Biomass} \sim \text{CSH} \times \text{sward type} \times \text{sampling time} \times \text{block}$$

### Pre-stocking

- **Graph**
  - X-axis: CSH (cm)
  - Y-axis: standing biomass (g m$^{-2}$)
  - Colors:
    - Red: diverse grass
    - Green: grass-rich

### Post-stocking

- **Graph**
  - X-axis: CSH (cm)
  - Y-axis: standing biomass (g m$^{-2}$)
  - Colors:
    - Red dashed: diverse grass
    - Green dashed: grass-rich
Estimation of forage uptake using different calibration models

Forage uptake (g m$^{-2}$) for different models and sward types:

- **Model 1**
  - Cattle, grass-rich: 2108
  - Cattle, diverse: 2142
  - Sheep, grass-rich: 2179
  - Sheep, diverse: 2271

- **Model 2**
- **Model 3**
- **Basic Model**

AIC (smaller is better)

- Model 1: 2108
- Model 2: 2142
- Model 3: 2179
- Basic Model: 2271

Factors included in the models:
- Block
- Sward type
- Sampling time
- Animal
Influence of sample size per treatment on variability of predicted values

<table>
<thead>
<tr>
<th>Coefficient of variation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>4 6 8 10 12 14 16</td>
</tr>
<tr>
<td>0.2</td>
<td>4 6 8 10 12 14 16</td>
</tr>
<tr>
<td>0.3</td>
<td>4 6 8 10 12 14 16</td>
</tr>
</tbody>
</table>

Crude protein

Acid detergent fibre

Standing biomass

- diverse, before stocking
- diverse, after stocking
- grass-rich, before stocking
- grass-rich, after stocking
Conclusions

- Calibration models for biomass estimation from CSH were improved by co-variables:
  - block, not sward-type, was most important ➔ Hypothesis 1 ✗
  - biomass intake estimates varied considerably between models with different co-variables, but similar fit

- At the same sample size,
  - estimates of standing biomass had a higher variability than estimates of biomass quality ➔ Hypothesis 2a ✗
  - standing biomass estimates were more variable in diverse than in grass-dominated swards ➔ Hypothesis 2b (√)

➔ Assessing quantity and quality of grazed forage on (multi-species) grassland swards remains a challenge
Thanks…

… to my colleagues
Camille Bienvenu
Barbara Hohlmann

… and to the audience!

Photographs: Jerrentup

http://www.multisward.eu