Grazing behaviour in dairy cows as a predictor of grass intake

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Introduction

- Grazing of dairy cows is appreciated by society
- Netherlands ~ 70% of the dairy cows are grazed
- Grazing tends to decline

- Increasing number cows/farm
- Area of grassland near the farm is a limiting factor

- High stocking densities (6 cows/ha)
- Need for **supplementary feeding**

Introduction

Supplementary feeding

Grassland
Herbage allowance
Sward structure
Pasture mass

Behaviour
Grazing, ruminating, idling time

Objective

- Develop a method to estimate individual grass intake
    - As a tool for feeding management
    - As a tool for grassland management
- Provide commercial cow sensor data useful information?
    - Rapid development
    - Technology becomes cheaper

Materials and methods

Grazing experiment

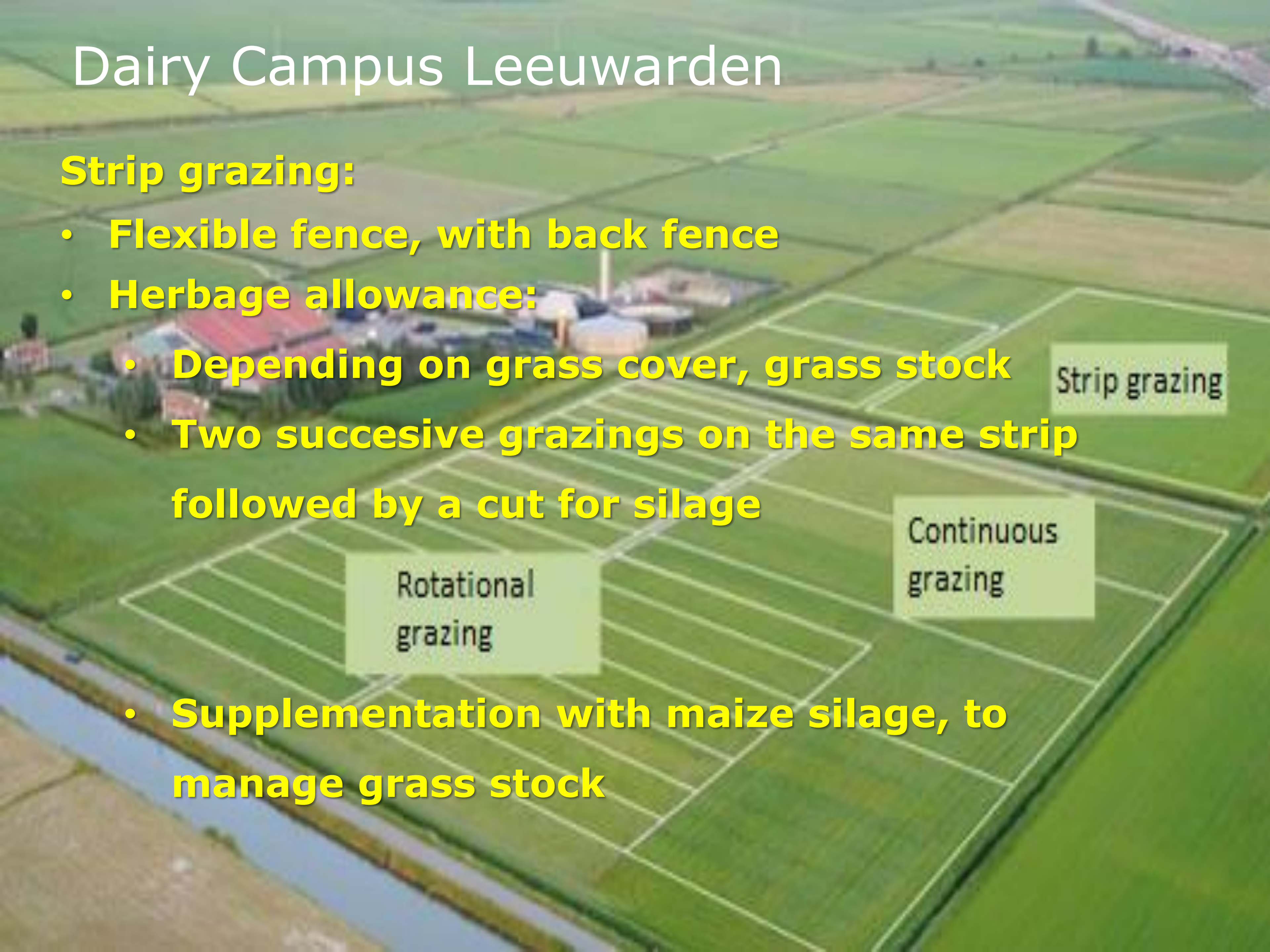
- Dairy Campus Leeuwarden
- Comparison of 3 grazing systems:
    - Strip grazing
    - Rotational grazing
    - Continuous grazing
- 20 cows per system on 3.3 ha (6 cows / hectare)
    - 6.5 kg DM concentrate/day
    - Variable amounts of maize silage supplementation

Dairy Campus Leeuwarden

Dairy Campus Leeuwarden

Strip grazing:

- **Flexible fence, with back fence**
- **Herbage allowance:**
  - **Depending on grass cover, grass stock**
  - **Two succesive grazings on the same strip followed by a cut for silage**
  - **Supplementation with maize silage, to manage grass stock**



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Rotational grazing:

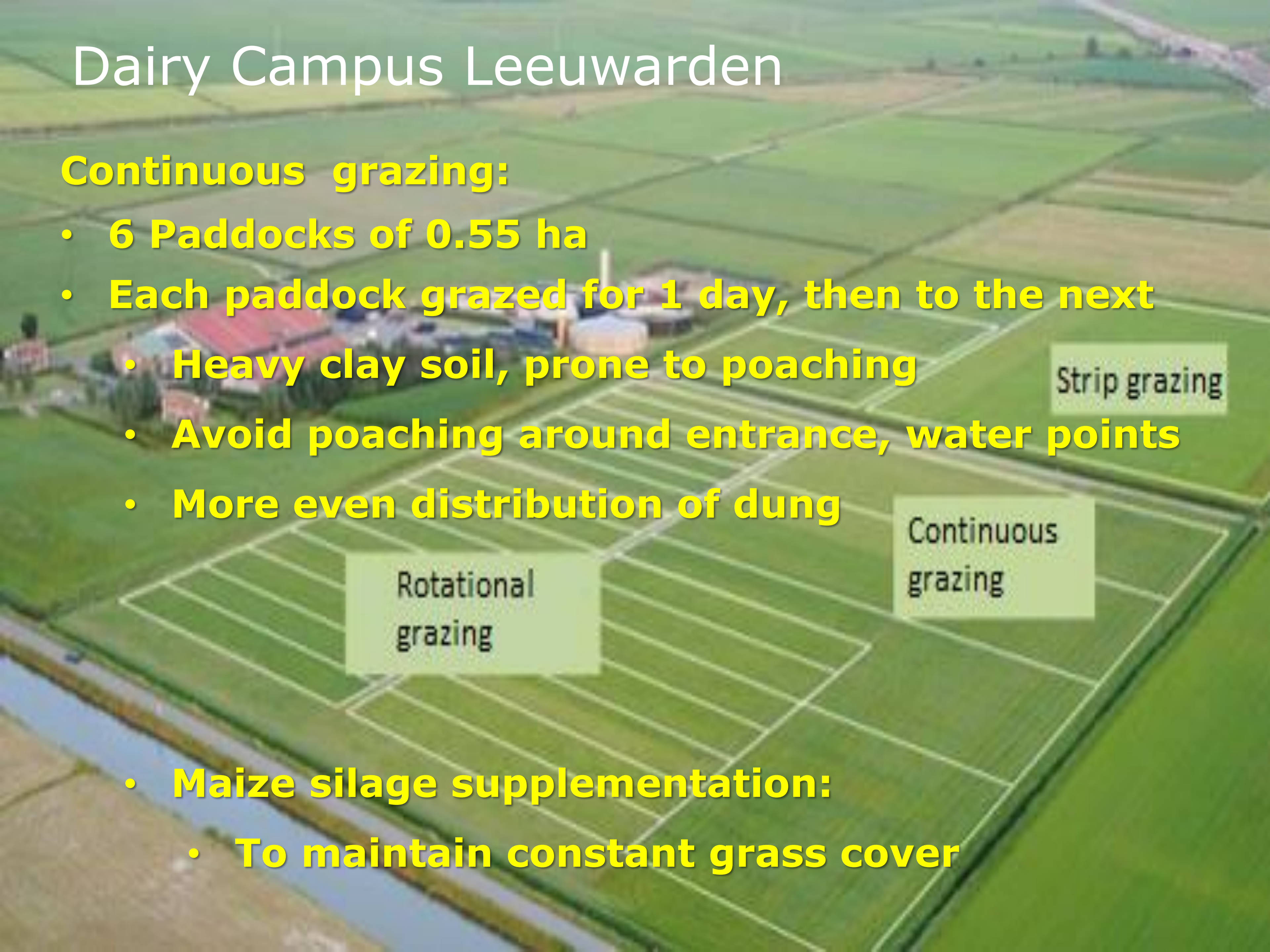
- **24 fixed paddocks of 0.14 ha**
  - **Grass completely consumed in 1 day**
  - **Post grazing SSH ~ 4 cm**
  - **Cutting for silage making >2200 kg DM/ha**

- **Maize silage supplementation:**
  - **Grass allowance < 16 kg DM**

Dairy Campus Leeuwarden

Continuous grazing:

- **6 Paddocks of 0.55 ha**
- **Each paddock grazed for 1 day, then to the next**
  - **Heavy clay soil, prone to poaching**
  - **Avoid poaching around entrance, water points**
  - **More even distribution of dung**



- **Maize silage supplementation:**
  - **To maintain constant grass cover**

Material and methods

Measurements

- Milk production (daily)
- Milk composition: protein, fat urea, SCC (weekly)
- Body weight and BCS (monthly)
- Intake Supplemental feeds silage & concentrates (daily)
- Grass height – pre and post graze (daily)
- Sensor data – cow behaviours (24/7)

Material and methods

Measurements

Sensor data

Grazing time

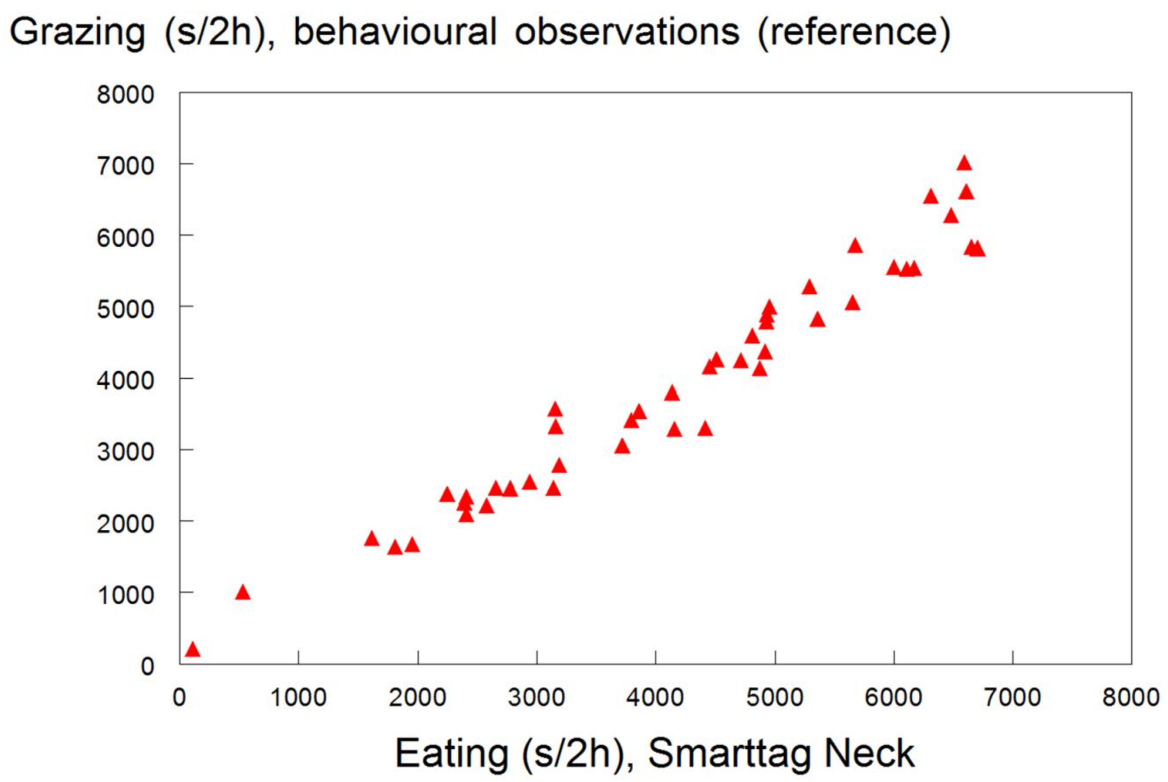
'Smarttag Neck'

Standing/lying & no steps

'IceQube'

Material and methods

Previous validation study Smarttag Neck (van Reenen et al. 2015)



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Material and methods

Measurements

- Individual grass and maize silage DM intake
- N-alkane method
  - Grass intake C32/C33 alkane pairs
    - Daily dosed with C32 labelled concentrate
  - Maize silage intake
    - Maize silage mixed with C36 labelled soybean meal fixed ratio
  - Collection of faeces
    - Samples pooled per cow per week

Material and methods

Data analysis - approach

Multivariate regression analysis ⟶ models

y = constant + **X1** + **X2** + **X3** + ..

<u>Dependent variable</u>

Grass DM intake (GDMI)

<u>Covariables / Predictors</u>

Cow data

Grass height data

Sensor data

Grazing system

Material and methods

Data analysis - approach

y = constant + **X1** + **X2** + **X3** + ..

Grazing system:

- Not included as a fixed effect with three levels (only relevant for estimation of effects)
- Translated into a continuous covariable: grazing area/cow (ha)

Results & Discussion

- Dairy cow performance (intake measurement period)

Treatment	Strip	Rotational	Continuous	Significance	s.e.d.
	Grazing system				
Grass intake (kg DM)	**13.2**	**14.5**	**11.8**	**n.s.**	**1.17**
Maize silage (kg DM)	**5.8**	**0.0**	**5.6**		
Concentrate (kg DM)	**6.3**	**6.1**	**6.0**		
Total DMI (kg)	**25.3[a]**	**20.6[b]**	**23.4[a]**	**P<0.001**	**0.98**

Results & Discussion

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Concentrate (kg DM)	6.3	6.1	6.0		
Total DMI (kg)	25.3[a]	20.6[b]	23.4[a]	P<0.001	0.98
Milk (kg)	**29.5**	**29.5**	**29.0**	**n.s.**	**1.77**
FPCM (kg)	**29.8**	**29.8**	**30.6**	**n.s.**	**1.68**
Milk protein %	**3.23**	**3.38**	**3.37**	**n.s.**	**0.09**
Milk fat %	**4.14**	**4.06**	**4.44**	**n.s.**	**0.19**
Protein yield (kg)	**0.94**	**1.01**	**1.01**	**n.s.**	**0.05**
Fat yield (kg)	**1.28**	**1.21**	**1.24**	**n.s.**	**0.06**
Milk urea mg/100 ml	**11.1[a]**	**18.7[b]**	**15.5[c]**	**p<0.001**	**1.12**
Live weight (kg)	573	576	574	-	-
Body condition score	2.3	2.3	2.2	-	-

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Results & Discussion

- Grass composition

	Grazing system		
Treatment	Strip	Rotational	Continuous
Dry Matter (g/kg)	180	205	203
Ash (g/kg DM)	87	85	83
Crude Protein (g/kg DM)	177	191	148
Ether Extract (g/kg DM)	31	35	27
Sugar (g/kg DM)	153	163	191
Crude Fiber (g/kg DM)	222	208	213
NDF (g/kg DM)	499	468	467
OMD (%)	83.4	84.0	82.3

Results and discussion

Do we need a multivariate approach?

Single predictors:

- Milk production – 30% of variation in GDMI explained – correlation = 0.60 ($P < 0.001$)
- Grazing time – 20% of variance of GDMI explained – correlation = 0.50 ($P < 0.001$)
- ..

Yes

Results and discussion

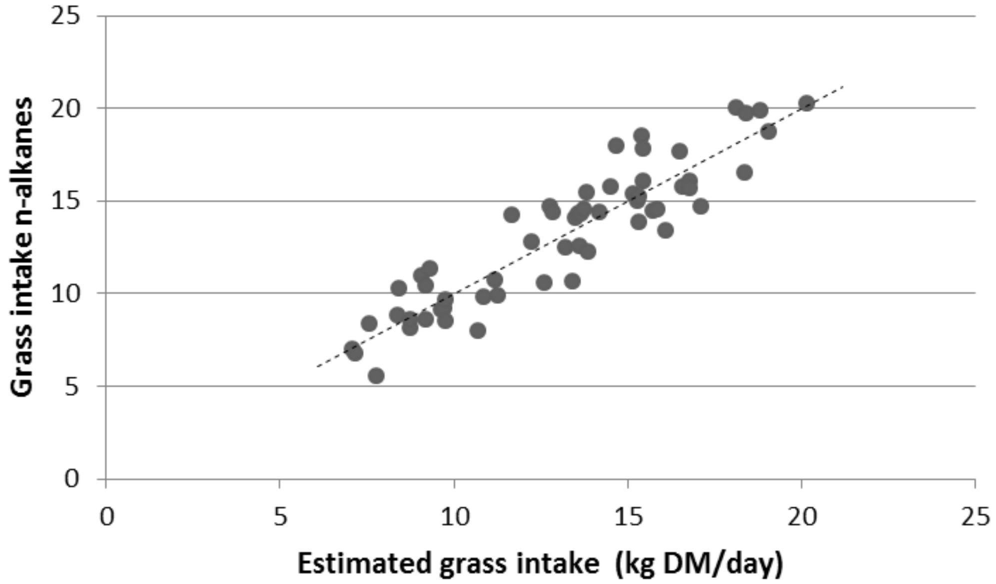
The best model overall – Model 1

Parameter	Estimate	SE	P-value
Constant (intercept)	-23.72	3.68	<0.001
Grazing area/cow	-162.6	21.2	<0.001
Milk yield	0.4677	0.0438	<0.001
DIM	0.01433	0.00444	0.002
Milk protein	3.79	1.12	0.001
Milk urea	0.2388	0.0522	<0.001
Time spent grazing	0.003288	0.000741	<0.001

85% of variation in GDMI explained

Results and discussion

Model 1:



Correlation between y and X: 0.92 (N=58; $P < 0.001$)

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Results and discussion

- Milk composition not always (immediately) available
- Alternative model without milk composition as explanatory variable

Results and discussion

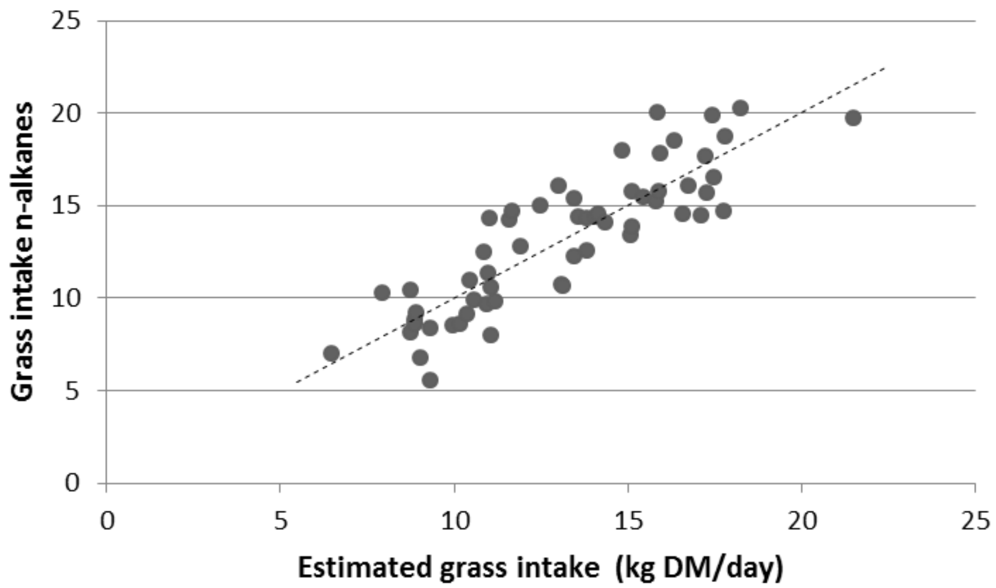
Model without measures of milk composition – Model 2

Parameter	Estimate	SE	P-value
Constant (intercept)	-13.35	2.54	<0.001
Grazing area/cow	-116.2	25.9	<0.001
Milk yield	0.4287	0.0528	<0.001
DIM	0.03033	0.00419	<0.001
Number of steps	0.001591	0.000382	<0.001
Time spent grazing	0.003032	0.000891	0.001

74% of variation in GDMI explained

Results and discussion

Model 2



Correlation between y and X: 0.87 (N=58, *P* < 0.001)

Results & discussion

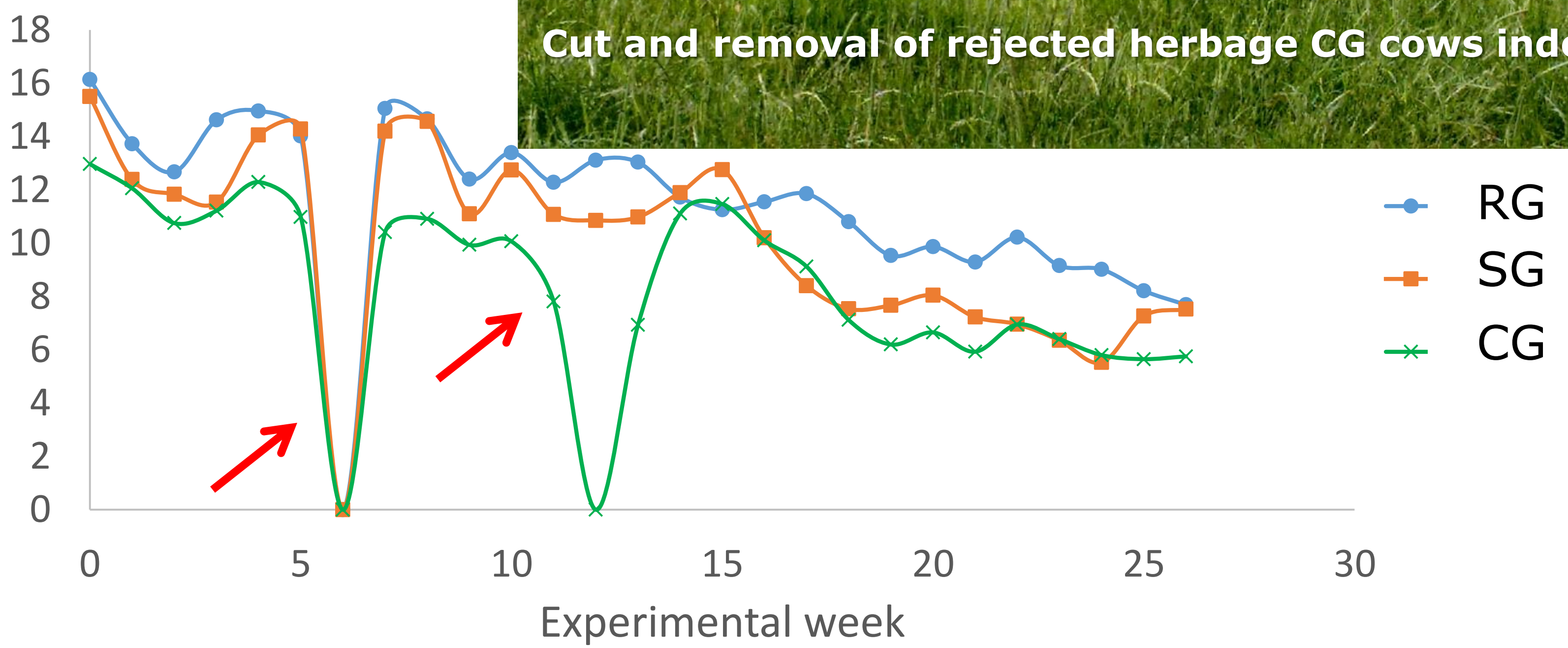
Average GDMI at herd level (N=58)

	Average GDMI (kg DM/cow/day)
n-alkane method	13.172
Estimated with model 1	13.171
Estimated with model 2	13.167

Prediction model highly accurate at herd level

Results & discu

Estimated GDMI ac



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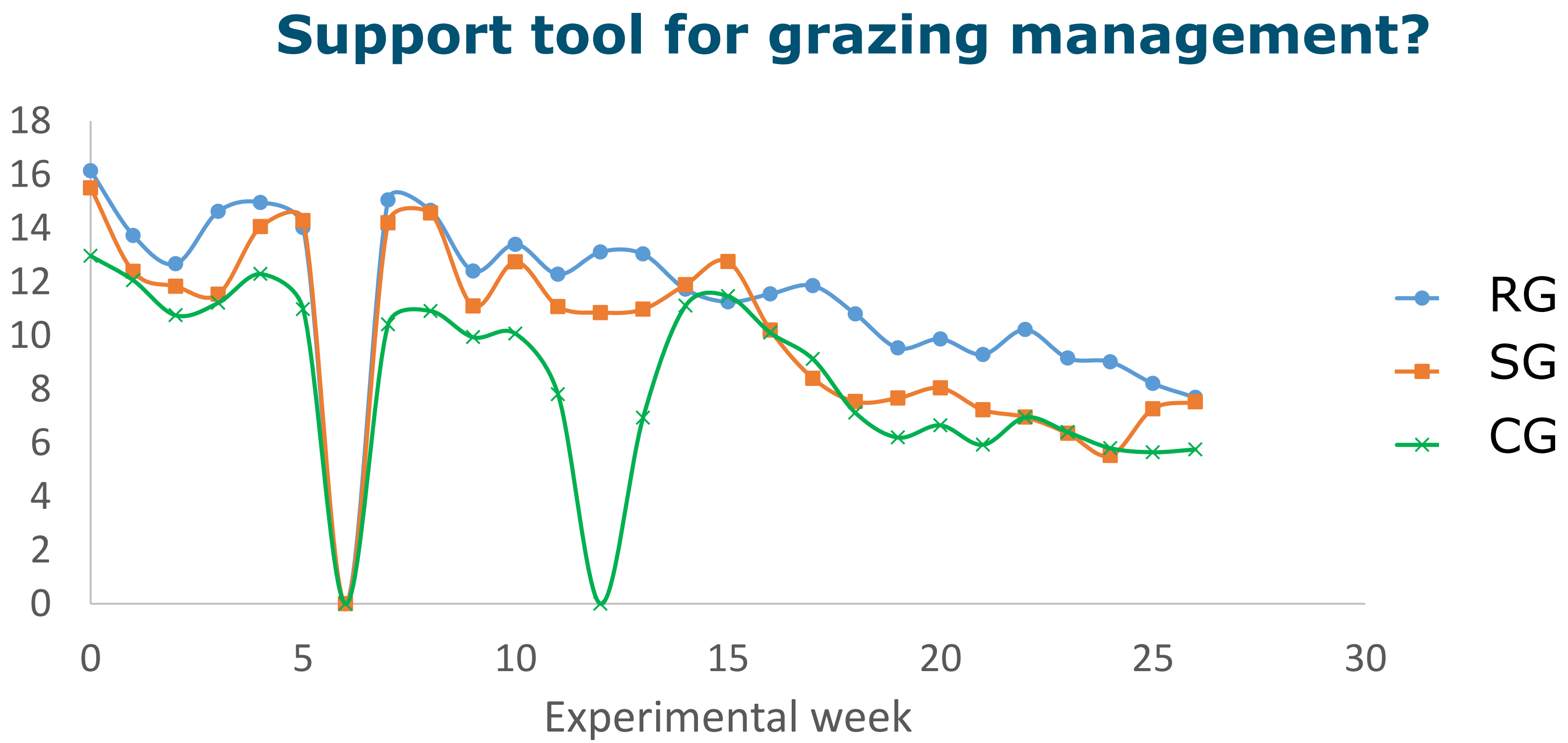
Results & discussion

Estimated GDMI across grazing season



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Conclusions

- Grass DM intake can be accurately estimated with multivariate regression models
- Different predictor models may be selected based on the availability of predictor data
- Models may represent potential management tools
- Models have to be validated:
    - Different times of year
    - Different pasture conditions
    - Different herds

Follow-up studies are in progress


?
Any questions ?
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Thank you for your attention

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Measurements during whole season

Measurement	Frequency	Analysis/ Device
Milk production	Daily	In Milking parlor
Milk composition	4 successive milkings each week	Protein, fat, urea, SSC etc.
Animal weight	2 successive days each month	Weighing
Condition score	At same time as animal weight	Visual observation
Silage intake	Daily for each treatment	Weighing
Concentrate intake	Daily per animal	Feeding during milking
GH	Daily pre and post graze for each treatment	Rising plate meter
Animal behaviour	All the time	By pedometer, neck sensor and ear sensor

Behaviour sensors

Pedometer
IceQube, IceRobotics, United Kingdom

Smarttag neck sensor
NEDAP, Groenlo, the Netherlands

Ear sensor
SensOor, Agis Automatisering BV, Harmelen, the Netherlands

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Experimental week

- Individual HDMI determined with alkane method
- Alkanes are long indigestible carbon chains
- The wax layer of grasses contain odd chain alkanes (C33 and C35)
- By adding even chain alkanes to the supplemental feed, the HDMI can be calculated from the ratio in the faeces
- HDMI (kg DM/ day) $= \dfrac{\frac{F_{33}}{F_{32}}(D_{32}+I_c \cdot C_{32}) - I_c \cdot C_{33}}{H_{33} - \frac{F_{33}}{F_{32}} \cdot H_{32}}$ Mayes et al. (1986)
- Data from this week was statistical analysed with ANOVA in GenStat 17thh edition.

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Estimating HDMI from other variables

- General Linear Model (GLM)
- $Y_{ij..} = \mu + x_i + x_j + \ldots + \varepsilon_{ijk}$
- Y_{ijkl} = Response variable (HDMI estimations from alkane method)
- μ = Overall mean predicted by model
- $x_i + x_j + \ldots$ = Animal performance and behaviour data
- ε_{ijkl} = Residual, assumed to come from a Normal distribution with

  mean zero and variance σ^2

- Stepwise multiple regression analyses for highest adj. R^2

Results

Animal performance and behaviour

Sensor	Measure	Unit	Grazing system RG	SG	CG	s.e.d.	sig.
	HDMI	kg DM·cow^{-1}	14.53	13.24	11.82	1.17	0.076
	Milk urea	mg·kg^{-1}	18.68^{a}	11.05^{b}	15.45^{c}	1.12	0.001
Pedometer	Walk/ hour outside	sec·h^{-1}	2742^{a}	3115^{b}	2912^{c}	73.12	<0.001
	Lying/ hour outside	sec·h^{-1}	906^{a}	538^{b}	719^{c}	73.12	<0.001
Neck sensor	Eating / hour outside	sec·h^{-1}	1853^{a}	2200^{a,b}	2248^{b}	83.10	<0.001

^{a,b,c} Means in the same row with different subscript differ significantly for α=0.05

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GLM to estimate HDMI

Source	d.f.	s.s.	m.s.	v.r.	F pr.
Regression	6	673.4	112.231	45.61	<.001
Residual	51	125.5	2.461		
Total	57	798.9	14.015		

Percentage variance accounted for 82.4

Standard error of observations is estimated to be 1.57.

Parameter	Unit	Estimate	s.e.	t pr.
Constant μ		-23.72	3.68	<.001
Area per cow	$ha \cdot cow^{-1}$	-162.6	21.2	<.001
Mean milk yield	litre	0.4677	0.0438	<.001
DIM	days	0.01433	0.00444	0.002
Milk protein	%	3.79	1.12	0.001
Milk urea	mg/100gr	0.2388	0.0522	<.001
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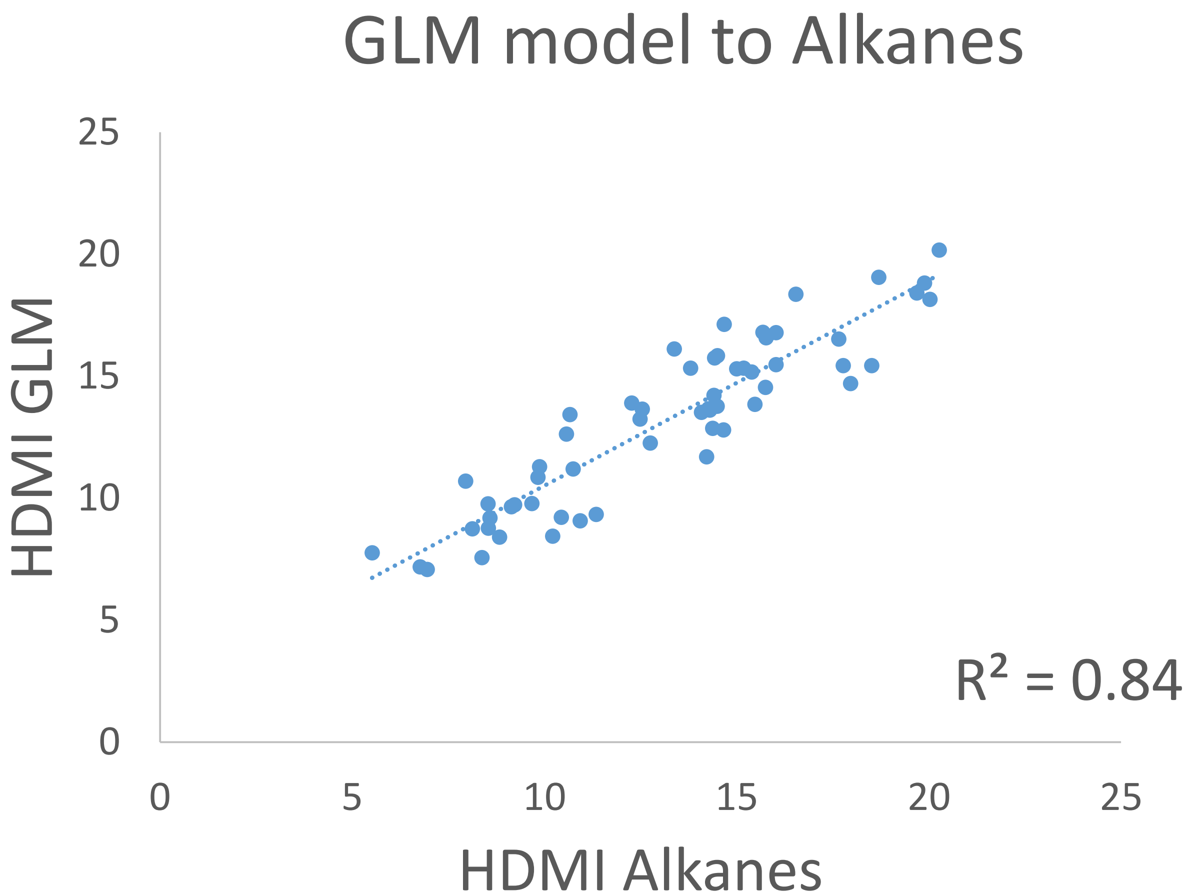
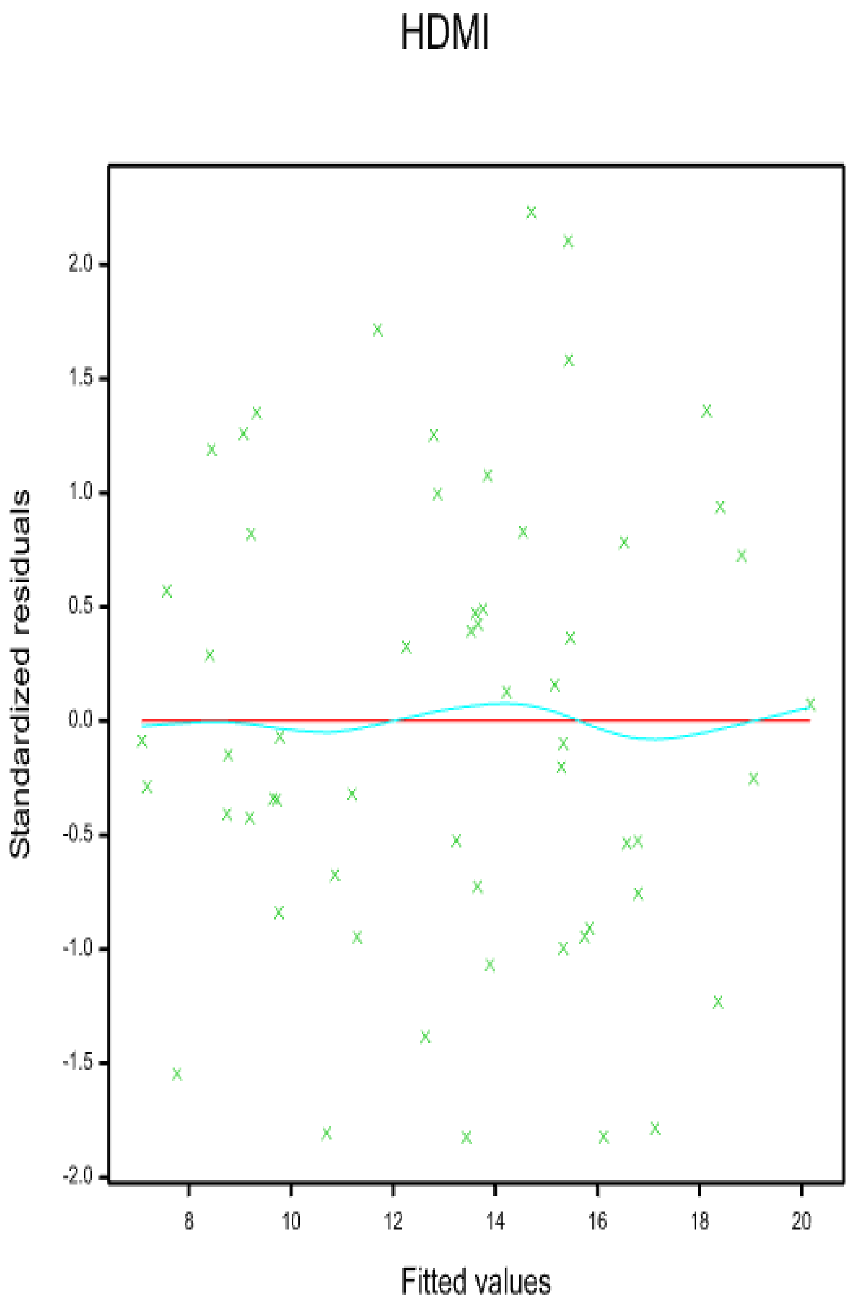
HDMI from alkanes vs HDMI estimated with GLM



Model check

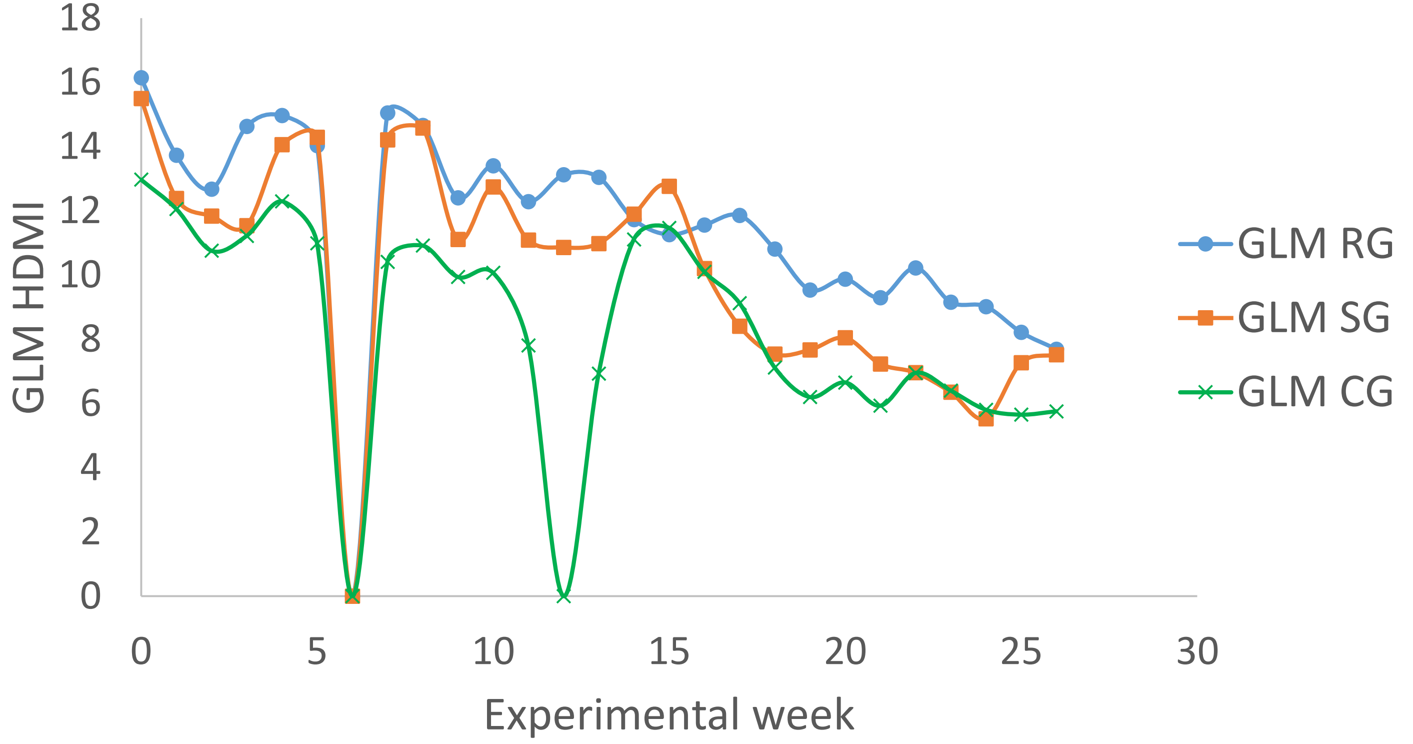

HDMI
Standardized residuals
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
8
10
12
14
16
18
20
Fitted values

Estimating mean HDMI of herd

		Alkane method		GLM model		
	n	Mean	CV (%)	Mean	CV (%)	Mean diff.
All cows	58	13.17	28.2	13.17	25.9	0.00
RG	19	14.53	18.9	14.35	16.8	0.18
CG	20	11.82	31.6	11.84	29.1	0.02
SG	19	13.23	30.2	13.40	27.8	0.16

HDMI estimation with GLM over whole season

Y = -23.72 -162.6·AREA + 0.4677·Milk Yield + 0.01433·DIM + 3.79·Milk protein + 0.2388·UREA + 0.003288·Eating time



Discussion (Treatments)

- HDMI similar
  - Adapt grazing behaviour to grazing system (Taweel et al., 2004; Pulido and Leaver, 2003)

- SG highest walking and lowest lying behaviour
  - Small area → social interactions

- Eating behaviour highest for CG, lowest for RG
  - Short grass for CG → more time needed to ingest same HDMI (Pulido and Leaver, 2001,2003; Oudshoorn et al., 2013)
  - SG longest grass, not shortest grazing time → previous strip?

Discussion (Model)

- GLM to estimate mean individual HDMI for first time in the Netherlands
  - Animal performance variables (Pulido and Leaver, 2001; Delagarde and O'Donovan,2005)
  - Model with only behaviour (Chacon et al., 1976; Oudshoorn et al., 2013; Chilibroste et al., 2015)

- Estimating HDMI with model on herd level in Ireland (O'Neill et al., 2013)
  - Similar variables
  - GLM for each season and on herd level
  - R^2 = 0,59 – 0,87
  - More practical to have 1 model

Future research

- Critical points of obtained model:
    - No weather variables were included
    - No sward variables were included

  Seasonal changes

    - No supplemental feed could be included
        - Individual supplementation of silage is not done in practice

Conclusions

- HDMI in pasture can be accurately estimated with the obtained model for each grazing system
- Reliable HDMI estimation can potentially be used as management tool