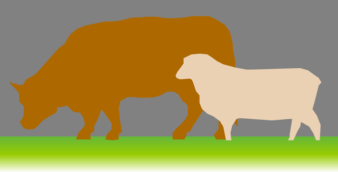

A methodology for predicting cattle's dung position in pasture

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Introduction

Background

- Livestock excrement is one of the major sources of greenhouse gas (GHG) emission in grazed pasture.
- It is important for farmers to understand the mechanisms of these gases production from agricultural fields and the factors that control these mechanisms.

Where do livestock spend their time and when do they excrete?

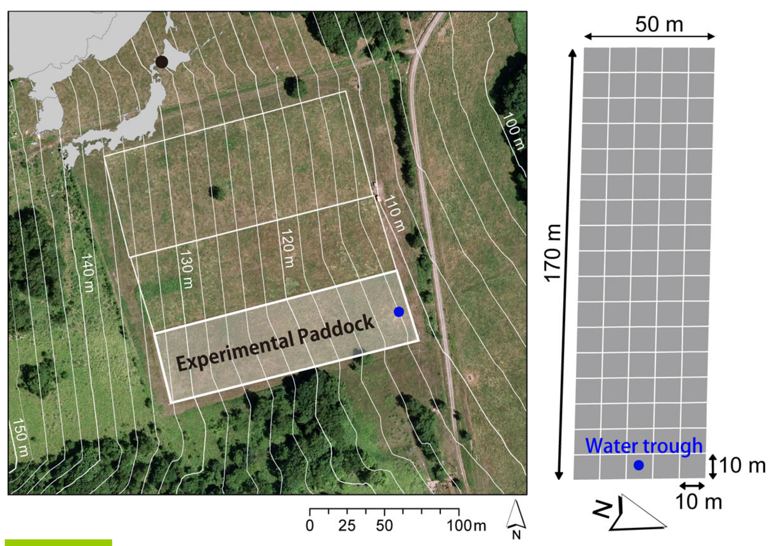
→ GHG palliative economically and efficiently

Objective

Estimating spatial distribution of cattle's excrement in a slope grazed pasture of Hokkaido, Japan.

Materials & Methods

Study site



Location

NARO Hokkaido Agricultural Research Center (42º 59'N, 141º 24'E), Japan

・A mixed sown pasture (0.85 ha)
・Northeast slope (115–135 m above sea level)
・20 cows were grazed (4 cows were fitted with GPS tracking collars).

Data set

The number of dung per 100 m² grid cell

4	10	19	9	6
6	19	22	35	9
1	6	27	32	22
2	3	12	16	16
1	8	11	13	12
1	3	9	18	11
3	1	9	10	10
4	4	13	15	10
6	8	5	11	9
6	12	6	20	14
2	9	12	17	11
10	13	11	13	10
3	8	12	14	10
6	14	16	18	9
13	26	24	20	16
16	27	21	35	24
8	16	33	27	17

Average	12.7
Standard deviation	8.0
Min	1
Max	35

Date

Grazing trial: June 16–18, 2010

After the grazing treatment, we set 10 m × 10 m grid cell in the paddock and counted the number of dung in each cell.

- GPS tracking collar (1-min interval)
  → geographic information
- Accelerometer (4-second intervals)
- Grazing observation by 3 trained observers (1-min interval, 15 hours data)
  → animal activity for 4 cows. Yoshitoshi et al. (2013)
- Vegetation survey
  → GBM (green herbage biomass), CP (crude protein)

GIS data per grid (10m × 10m)

- Response valuable: **the number of dung**
- Explanatory valuable: **animal activity** (active[**G**] or inactive[**O**]), **GBM**, **CP**, **slope**, **distance from water trough** and **fence**, **easting** and **northing**

Modeling methodology

Intrinsic Gaussian CAR (conditional autoregressive) model

$$\text{number of dung} \sim Poisson(\lambda_i)$$

$$\log(\lambda_i) = b_1 + b_2\text{GBM} + b_3\text{distance from water trough} + rho_i(\text{spatial random effects})$$

$$b_1 \sim Uniform(-10,10), b_2 \sim Uniform(-10,10), b_3 \sim Uniform(-10,10)$$

$$rho_i \sim CAR(Adj[], Weights[], Num[], tau), tau \sim Gamma(0.0001, 0.0001)$$

where b_1 is intercept, b_2 and b_3 are coefficient. The *rho* is spatial random effects from each grid position.

The detail of MCMC (Markov chain Monte Carlo method)

- Number of chains : 3
- Number of draws from posterior for each chain : 100,000
- Number of draws to discard as burn in : 30,000
- Thinning rate : 100

R statistical software, version 2.12.1
OpenBUGS, version 3.2.2.

Results

Comparison among GLM, GLMM and CAR models

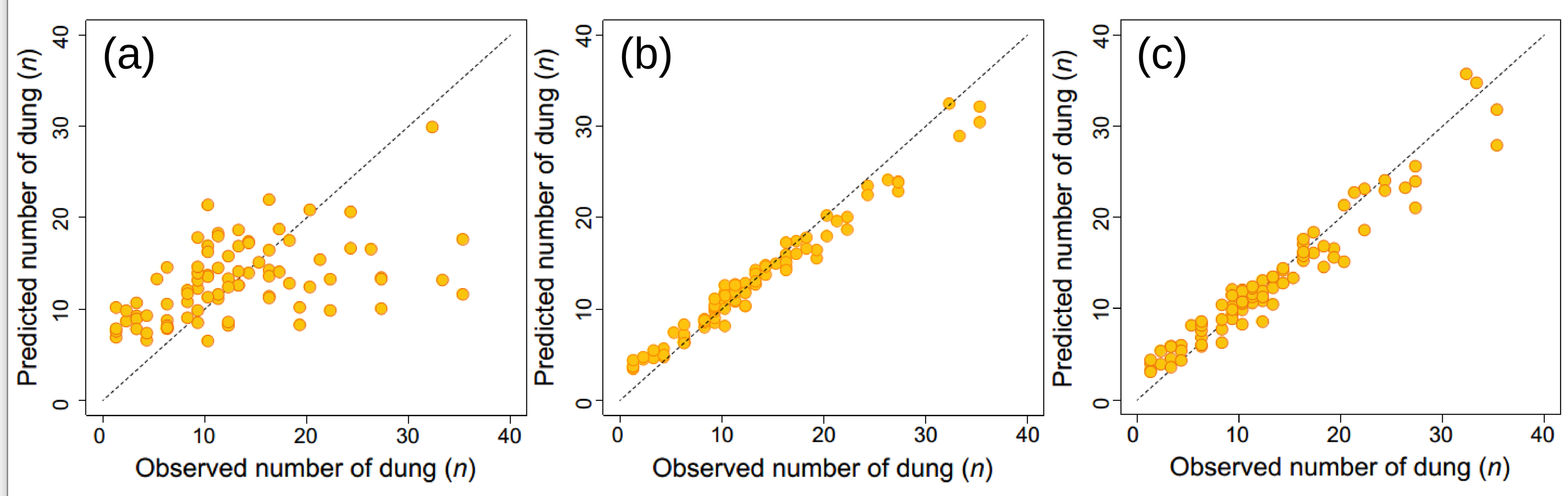


Figure 1: Actual and predicted values of the number of cattle's dung (n) in each grid (10 m × 10 m) using GLM (a), GLMM (b) and CAR model (c).

Results of CAR model

Table 1: Posterior means (PMEAN), posterior standard deviations (PSD), 95% posterior probability intervals (PPI) obtained by MCMC.

Parameter	PMEAN	PSD	2.5%	50%	97.5%
b_1	2.366	0.039	2.288	2.367	2.441
b_2	0.233	0.064	0.105	0.234	0.357
b_3	−0.240	0.116	−0.468	−0.240	−0.011
tau	3.454	1.024	1.924	3.300	5.897

R hat were 1 and effective sample size were enough for each parameter.

- CAR model had a posterior mean b_1 of 2.37, with 95% PPI of 2.29 to 2.44, a posterior mean b_2 of 0.23, with 95% PPI of 0.11 to 0.36 and a posterior mean b_3 of −0.24, with 95% PPI of −0.47 to −0.01.
- All parameters didn't have 0 with 95% PPI.

Actual and predicted values of the number of dung

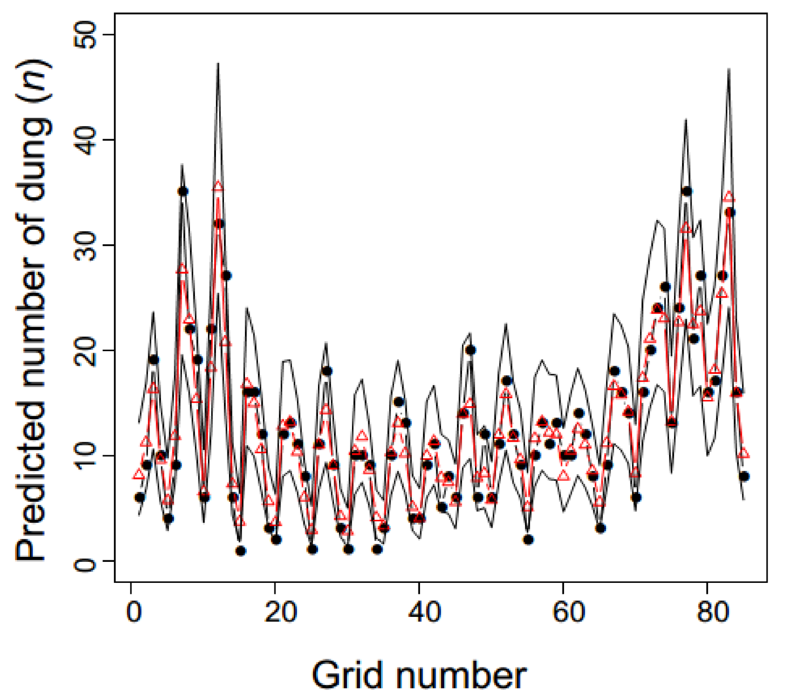


Figure 2: Actual and mean of predicted values and 95% PPI based on CAR model.

Conclusions

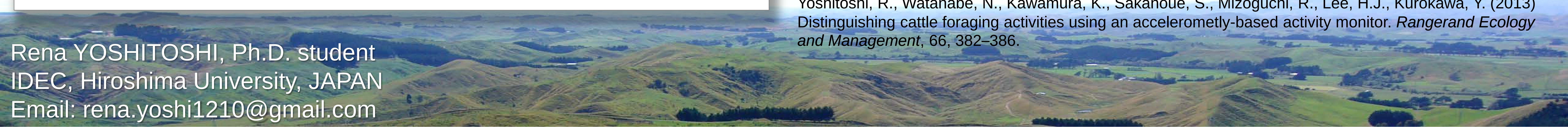
1. Spatial data analyses for estimating spatial distribution of dung by cows need to considering random effect **(Figure1)**
2. GBM and distance from water trough affects the distribution of dung **(Table1)**
3. Bayesian model is available to estimate spatial distribution of cattle's excrement in grazed pasture. **(Figure2)**

Future study

- Other parameters to be evaluated - In this study, we used two: GBM and distance from water trough as explanatory valuable.
- Feasibility of the model in other paddocks to be validated.
- Combined measured GHG emissions from cattle's excrement.

Reference

Yoshitoshi, R., Watanabe, N., Kawamura, K., Sakanoue, S., Mizoguchi, R., Lee, H.J., Kurokawa, Y. (2013) Distinguishing cattle foraging activities using an accelerometry-based activity monitor. *Rangerand Ecology and Management*, 66, 382–386.



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