Measuring feed intake

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(After Fraser, 2000)
Intake measurement

• Can be done
  – Under confinement (ideal for conserved forages)
  – Under confinement with artificial pastures
  – At pasture (ideal for grazed forages)
Determining intake in confined animals
Zero-grazing:

Animal is confined in pens / stalls or tethered
Zero grazing criteria

- Representativeness of grazing conditions
- Frequency of feeding & refusal collection
- Refusal analysis
- Duration of adaptation period
- Housing & no. of animals
- Feeding level choice & definition of *ad libitum* i.e. when is selection optimized?
Zero-grazing:

Pros

• Easier replication than grazing
• Ideal for conserved forages

Cons

• Selection is reduced
• Affected by wilting / deterioration
• Labor intensive
• May be unrealistic for pasture assessments
  — No sward structure effects
  — No competition / social interaction
Electronic gates

- E.g. Calan gates / Broadbent doors

- **Pros**
  - Allows single animal access to designated manger
  - Frees animals from confinement, allowing social interaction & exercise

- **Cons**
  - Cost + training of animals
  - Stealing often occurs
  - Ideal gate dimensions depend on animal size
  - Circuits may fail
Calan gates at the BRU

Calan gates used for individual feed consumption research.
Continuous-reading mangers

- E.g. hoko feeders / Grow-safe system
- Mangers placed on pressure sensors / strain guages
- Monitor weight loss of manger every 10 s
- Indicates intake kinetics (meal patterns)
- Other pros & cons as for Calan gates
Hoko feeder
Grow safe system
Determining intake from artificial pastures
What is being eaten & how quickly is it eaten?

- Methods for determining sward-structure & intake rate include using:
  1. Perforated boards
  2. Turves
Quantifying intake from bite size

Bite area × Bite depth

Bite volume × Bulk density

Intake = Bite weight × Bite rate × Grazing time

Short-term

Long-term
Perforated (Sward-) boards:

**Method**

Originated in 84 to look at effect of forage available on intake rate
Perforated (Sward-) boards:

• Pros
  – Allow precise sward description e.g. density, establishment etc.
  – Indicates bite area, bite depth etc.

• Cons
  – Short term – 30 s – 1 min.
  – Representativeness of artificial pasture

• Alternatively, some studies limit access to 0.6 x 0.5 m in a pasture
Turves:

Method

• Sow trays or cut from swards
• Weigh tray & take height measurements
• Offer to animal
• Re-weigh & measure height
• Correct for evaporation weight losses with controls
Turves:

Pros

• Accounts for sward structure
  — Useful for showing effects of real swards vs mixtures

• Less deterioration of forage

Cons

• Short-term
• Is it representative
Measuring intake at pasture

Cattle on flatwoods-type pasture.
Grazing cages:

**Pros**
- Accounts for sward structure

**Cons**
- Time consuming
- Short term
- Is it representative
- No competition etc.
Herbage mass measurements:

**Method**

- Cut samples within quadrats to certain height
- Position exclusion cages
- Allow animals to graze
- Take second set of quadrat cuts
- Take cuts from within cages
- Correct for plant growth with exclusion cage samples.
Herbage mass measurement
**Pros**
- No animal handling

**Cons**
- Need uniform sward (height) & even soil surface
- Must be < 3 d in duration to ↓ pasture growth
- Intensive sampling required
- Error sources
  - Sampling & fouling, trampling, insect / other herbivore feeding
  - Representativeness & diet selection
  - Leaf senescence & soil contamination

**Herbage measurements:**
Short-term BW measurements:

- Weigh animal \( (W_1) \)
- Allow animal to graze
- Re-weigh animal \( (W_2) \)
- Account for weight losses during grazing
  - feces (F), urine (U) & insensible loss (I)
  - And any weight gain due to drinking (L)
- Intake = \((W_2 + F + U + I) - W_1 - L\)
Short-term BW measurements:

Pros

• Longer term than sward-boards (5 mins ?)
• Animals graze real pasture

Cons

• Water intake & insensible loss quantification
• Environment affects results
  — Wind, moisture etc affect result
  — Can use polytunnels – unrealistic
  — Ignores diurnal variation in intake
• Should account for non-forage intake e.g soil, minerals etc but does not
Measuring grazing time/behavior:

- **Procedure**
  - Watch / video animals at pasture
  - Record no of bites

- **Pros**
  - Can be used on wild & domestic animals

- **Cons**
  - Observer may affect behaviour
  - Usually short durations
  - May be subjective
  - Assumes bite mass constant
Vibracorders

- **Procedure**
  - Works like truck tachographs
  - Vibrations from pendulum attached to neck recorded on a chart
  - Measures grazing time when head is lowered for grazing

- **Cons**
  - Equipment may affect intake
  - Head lowering may not reflect biting (Need to correct this by recording head jerks)
Jaw recorders

- **Procedure**
  - Resistance on meter changes as jaw moves
  - Data downloaded onto PC.
  - Differentiate rumination from eating cause of differences in jaw movements

- **Cons**
  - May not work on temperamental cows
  - Equipment may affect intake
Watch what you eat!!!!

Python regrets gulping gator in the Everglades
Indirect intake estimation methods

- Generally based on relating digestibility or fecal output or fecal composition of the grazed grass to intake
Total feces collection:

Procedure

- Measure feces with collection bags
- Take representative herbage samples for digestibility determinations in vitro

• DM Intake = Fecal DM output \( \frac{1-(DMD/100)}{\text{Fecal DM output}} \)
Total feces collection

Pros

• Gives individual intakes (with individual feeding)
• Requires only DM & ash determinations

Cons

• Fecal bags may affect intake, selection & distort hind legs
• Loss of fecal matter on low DM diets
• Diarrhoea????
• More appropriate for sheep due to drier feces
Markers:

Method

- Avoids the need for feces bags
- Dose animals with marker (1 or 2 x daily / ruminal bolus)
- Collect fecal samples
- Fecal output = [Marker feed]/[Marker feces]
Internal markers

- Main problem is getting a representative sample of what is grazed.

- Most investigators have concluded that it is virtually impossible to accurately, representatively sample what an animal eats from a pasture by hand.
Internal markers

- E.g lignin, AIA, silica, fecal N, indigestible NDF, chromogens (indigestible plant pigments)

- Main problem is getting representative sample of what is grazed.

- Options
  - Manual selection (subjective)
  - Use oesophageally cannulated animal (saliva / rumen fluid contamination)
**Internal marker problems**

- Silica is incompletely recovered & influenced by soil contamination
- Lignin in feces subject to diurnal variation
- iNDF is incompletely recovered
- Chromogens best for lush pasture, not drought/stressed pasture.
- AIA concentration in forages is low, hence large samples required
External Markers - chromic oxide:

Pros

• Gives individual intakes (with individual feeding)
• Suitable for long term studies for different spp.

Cons

• Carcinogenic – not used in UK, used in US
• Laborious & stressful if daily dosing employed
• Large diurnal variations in fecal marker concentration with 1 x dosing
• Continuous release devices may vary in manufacturer-prescribed & actual release rates
Effect of treatments on hay intake (Krueger et al., 06)

Markers can affect performance
Markers - Alkanes

- Main component of plant surface (epicuticular) wax
- Hydrocarbons with 21 - 37 C atoms
- > 90% have odd # of C atoms in straight chains
- C_{29}, C_{31} & C_{33} are the most common in pastures.
- Inert and relatively easy to analyze, hence widely used to estimate digy, intake, passage rate etc.
Alkanes \((C_nH_{2n+2})\)

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Markers - Alkanes:

- Straight chain, hydrocarbons
- Epicuticular plant alkanes can be used to measure intake & digestion
- Plants have high levels of odd-chained alkanes, and low levels of even-chained alkanes
- Alkane digestibility decreases with chain length e.g. recovery of C33 =0.37; C35= 0.95
- Alkane profile of each plant is unique
  - Fecal n-alkane profiles can also be used to identify diet composition in grazing ruminants
Alkanes contd.

- Fecal recovery of individual alkanes is incomplete,
- But recovery of adjacent homologues is similar e.g. C33 & C32 have similar recoveries
- Therefore, we can dose with C32, measure fecal recoveries of C32 & C33
- Because the ratio of C32/C33 in feces is constant, incomplete recovery of either alkane does not matter
Measuring intake with alkanes:

- Dose with pair of odd and even chained alkanes e.g. C\textsubscript{32}/C\textsubscript{33} (most effective).

- Measure concentrations of both in feces

- The odd chained alkane is the natural, plant-based internal marker

- The even chained alkane is obtained from purified preparations and is the external marker
Calculations

• DM Intake (kg) = \( \frac{\text{Fecal}_{33} \times \text{Dosed}_{32}}{\text{Fecal}_{32} \times \text{Herbage}_{33}} \)

• Digestibility = 1 - (\( \frac{\text{Feed}_{36}}{\text{Fecal}_{36}} \))
Alkane analysis

• Alkanes in a sample are separated by saponification with KOH or extraction with non-polar solvents e.g. Heptane / hexane (safer)

• This removes fatty acids as soaps or removes the lipids, both of which can interfere with the analysis

• The alkanes are present in the non-lipid, or unsaponifiable fraction and are measured by GC
Alkanes continued

Pros

• Gives individual intakes for various spp.
• New developments being made – slow release boluses – only administered once

Cons

• Requires several lab. analyses
• Relies on accurate alkane extraction
• Relies on representative sampling
  — difficult with mixed swards;
  — alkanes vary with spp & plant parts (low in C$_4$ grasses)
Fecal index methods

• Based on inverse relationship b/w fecal N & digestibility
• Relationship varies with animal & sward factors, hence different equations required for different species.
• Fecal NIRS spectra have also been used to predict digy. and therefore, intake
Pasture composition
Diet selection: depends on

- Plant community
  - Individual plant
    - Plant part

Accurate representative sampling depends on diet selected.
Diet selection also varies with spp

Grazers

Browsers
Diet selection:

Factors affecting diet selection

• Animal
  — Spp. & Size of animal
  — Mouth morphology & gut type
  — Physiological state
  — Parasite burden

• Forage
  — Leaf to stem, weeds
  — Sward structure

• Environment
  — Social environment – dominance, copying others
  — Physical environment – weather etc
Methods of estimating diet composition
Snip samples:

**Method**
- Cut or pick samples by hand

**Pros**
- Quick and cheap

**Cons**
- Difficult to mimic grazing
Cages:

Method

• Compare forage under exclusion cage with grazed pasture

Pros

• Improved accuracy

Cons

• Cages don’t suit all vegetation types
• Number of cages required for patchy sward
**N-alkane markers:**

**Principle**
- Alkane profile in a mixture arises from a combination of the profiles of the components
- Based on differences in alkane concentration in different species

**Method**
- Analyse feces/ esophageal samples & hand plucked samples
- Use simultaneous/ complex equations to calculate composition
N-alkane markers:

Pros

• Useful when # of alkanes > # of diet components

Cons

• Complex computations
• # of alkane profiles available dictates # of species identifiable
• Requires accurate control of dose rate
• Requires plant profiles – plant composition & their alkane contents
• Alkane contents vary with plant parts, soil type
Fecal analysis:

Method

• Collect fecal samples
  — Doesn’t have to be fresh
• Examine under microscope for plant tissue fragments
Fecal analysis:

**Pros**

- Minimal disturbance of animals
- Can be used with free-ranging animals

**Cons**

- Accuracy
- Under-estimates digestible component of diet & over-estimates indigestible components
**Method**

- Shoot/kill animal *(humanely)*
- Collect samples from rumen or gut

**Pros**

- Animals may be getting shot anyway

**Cons**

- Is only an estimate of what it ate last
- No scope for repeating measurements
- Partial digestion will affect results
Surgical modification:

• Prepare animal
• Create fistula
• Familiarize animal with sampling procedure
• Collect samples (especially esophageal extrusa)

Pros

• Repeatable & Accurate

Cons

• Ethical issues, short sampling time
• Assumes behaviour of fistulates is similar to that of intact animals
Conclusion:

There is no right answer
References

- See website articles by Coleman.