# Estimating the heritability of nitrogen and carbon isotopes in the tail hair of beef cattle

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# Background

- $\delta^{15}N$ ($^{15}N$ : $^{14}N$), $\delta^{13}C$ ($^{13}C$ : $^{12}C$)
- Significant variations between $\partial^{15}N$ and $\partial^{13}C$ between the individuals
- Animals with lower $\partial^{15}N$ and higher $\partial^{13}C$ values of the tail hair are more nitrogen use & feed efficient
- More $^{14}N$ and $^{13}C$ lost in urine (negative, and favourable correlation)
- Animals with lower $\partial^{15}N$ experienced higher ADG, more frequent pregnancy and lactation
- Research gap in the industry if $\partial^{15}N$ and $\partial^{13}C$ are heritable traits

# Hypothesis

The $\delta^{15}N$ and $\delta^{13}C$ of the tail hair are heritable in tropically adapted beef cattle

# Why Tail hairs' isotopes vs plasma or body tissues:

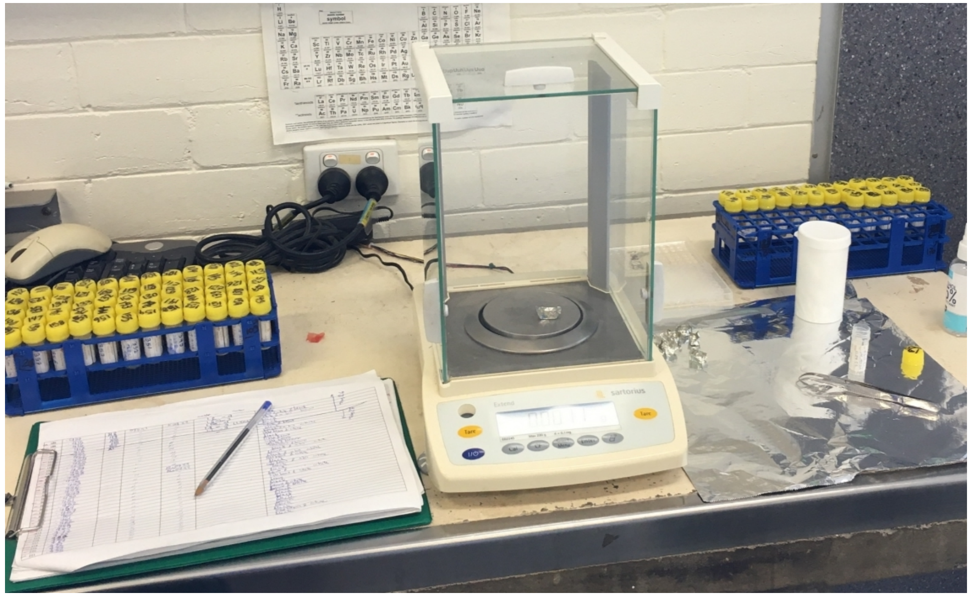
- Easy, quick and non-invasive
- Tail hair archives long-period isotopic information & grows continuously
- Store a long time at room temperature


# Methods

- 492 steers (268 Brahman & 224 Droughtmaster)
- 3 generations full pedigree
- 2 years 2019 & 2020
- Queensland, Australia
- Low-quality tropical pasture

# Methods

- The segment of hair represents the driest period and low protein diet
- Nitrogen recycling and conservation mechanisms
- Analysing 10 mm for isotopes = Isotopic history for two weeks



# Statistical analysis

- Model fixed effects are determined in RStudio using linear regression
- All the fixed effects were highly significant ($p \leq 0.01$) for both $\partial^{15}N$ and $\partial^{13}C$ traits
- 6 significant fixed effects are fitted in the model; ADGP1, ADGP2, ADGP3, age, breed, and year (as contemporary groups)

# Heritability analysis

- WOMBAT software using 3 generations of available pedigree
- Univariate and bivariate analyses were performed using the multibreed data ($n = 492$)

# Variance components

- Variance components were estimated using the model:
  - $\mathbf{y} = \mathbf{Xb} + \mathbf{Z_A a} + \mathbf{e}$
  - **y** is a vector of observations of $\partial^{15}N$ or $\partial^{13}C$, **X** is an incidence matrix relating observations to fixed effects, $\mathbf{Z_A}$ is an incidence matrix relating observations to direct genetic effects, **b** is a vector of fixed effects, **a** is a vector of direct genetic effects and **e** is a vector of residuals.
  - Furthermore, var(**a**) = $\mathbf{A}\sigma^2_a$ and var(**e**) = $\mathbf{I}\sigma^2_e$ where **A** is the numerator relationship matrix, **I** is the identity matrix, $\sigma^2_a$ is the direct additive genetic variance and $\sigma^2_e$ is the residual error variance.

# Results

## Heritability analysis

**Table 1**. Estimated genetic variance ($\sigma^2_A$), residual variance ($\sigma^2_E$), phenotypic variance ($\sigma^2_P$) and heritability ($h^2$) of $\partial^{15}N$ and $\partial^{13}C$ estimated in a multibreed population of Brahman and Droughtmaster steers (standard errors in parentheses)

| **Items** | **$\partial^{15}N$** | **$\partial^{13}C$** |
|---|---|---|
| **$h^2$** | 0.43 (± 0.14) | 0.41 (± 0.15) |
| **$\sigma^2_A$** | 0.19 (± 0.07) | 0.47 (± 0.18) |
| **$\sigma^2_P$** | 0.44 (± 0.03) | 1.14 (± 0.08) |
| **$\sigma^2_E$** | 0.25 (± 0.06) | 0.67 (± 0.15) |

# Results

## Phenotypic and Genetic correlation

**Table 2**. Bivariate estimates (correlations between $\partial^{15}N$ and $\partial^{13}C$) for Phenotypic correlation ($r_P$) and Genetic correlation ($r_g$) for multibreed (standard errors in parentheses)

| **Items** | **Correlation coefficient** |
|---|---|
| Phenotypic correlation ($r_P$) | -0.40 (± 0.04) |
| Genetic correlation ($r_g$) | -0.78 (± 0.16) |

# Conclusion and Implication

## Conclusion

- The ∂$^{15}$N of the tail hair is heritable **$h^2$= 43%**
- The ∂$^{13}$C of tail hair is heritable **$h^2$= 41%**
- These two traits are in favourable high and moderate negative genetic and phenotypic correlations (**-0.78** and **-0.40**, respectively)

## Implication

- The first research to estimate the heritability of these traits in cattle
- Supports the  potential to use N and C isotopes in the early selection of more efficient animals
- Less environmental nitrogen pollution (Water and total greenhouse gas emissions)

# Further research

- More animals, breeds, years, sexes, and other ruminant species

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