HoloRuminant
Understanding microbiomes of the ruminant holobiont

CORE RUMEN MICROBES: THE FUNCTIONAL BACKBONE OF THE RUMINANT ECOSYSTEM

Insights from Tovar-Herrera et al., 2025 (Nature Ecology & Evolution)

Metabolically independent core microbes synthesize essential amino acids, vitamins, and cofactors that neither non-core microbes nor the host can produce, and through microbial turnover in the rumen, these nutrients become a direct nutritional source for the cow.

Every complex ecosystem contains a small set of elements that remain stable even when everything else changes.
Cities rely on essential infrastructure. Forests maintain characteristic trees.
Ruminant gut ecosystems follow the same rule: a small group of microbes consistently persists across animals, diets, and geographies.

These are the **core rumen microbes** — functional pillars of digestion, host nutrition, and ecosystem stability.

WHY THE RUMEN CORE MATTERS

Hidden inside the rumen — the fermentation chamber of cows, sheep, goats and buffalo — live thousands of microbial species.
But only **14 microbial groups appear in nearly every ruminant worldwide,** according to the largest global analysis of rumen data to date (≈1,700 animals).

These microbes may hold solutions to:

- **Improving digestive efficiency**
- **Reducing methane emissions**
- **Strengthening food security**
- **And designing microbiome-based livestock strategies**

HoloRuminant
Understanding microbiomes of the ruminant holobiont

WHAT MAKES A MICROBE “CORE”?

1 They are globally persistent.

Core taxa were found across continents, diets, breeds, and ruminant species

2 They are functional generalists.

Core microbes have:

- **Larger genomes** (+15% on average),
- **Broader metabolic potential** (more KEGG modules),
- **Greater resource use** (almost double the number of carbon sources),
- **Higher strain diversity** (≈17 strains/sample vs ≈12).

This makes them highly independent, adaptable, and resilient.

3 They produce essential metabolites — for themselves, for other microbes, and for the host.

Core microbes synthetize:

- **Essential amino acids** (e.g., lysine, methionine, histidine),
- **Vitamins** (riboflavin, pantothenate),
- **Nucleotides and cofactors.**

Because **cows cannot synthesize these nutrients**, digesting core and non-core biomass provides them directly to the animal.

4 They support non-core microbes.

Non-core microbes often cannot produce essential metabolites and therefore rely on core taxa for survival — a classic example of the **Black Queen Hypothesis**. Experiments confirmed:

- **93% of core isolates grew in nutrient-depleted media,**
- **Only 45% of non-core isolates could,**
- **But non-core isolates thrived when supplemented with metabolites produced by core microbes.**

This cross-feeding is a stabilizing mechanism in the rumen ecosystem.

WHY ARE CORE MICROBES SO IMPORTANT FOR RUMINANTS?

They are the metabolic backbone of the rumen.
Core microbes:

- **Degrade plant fibre (cellulose, hemicellulose, pectin),**
- **Produce volatile fatty acids, amino acids, and vitamins,**
- **Maintain essential functions even when microbial composition shifts.**

They help maintain ruminant health and productivity.
By supplying nutrients cows cannot produce, core microbes are key to:

- **Milk and meat production,**
- **Feed efficiency,**
- **Resilience to diet changes,**
- **Methane-related metabolic pathways.**

They stabilize the entire gut ecosystem.

Their redundancy and metabolic breadth ensure essential rumen functions persist despite diet, environment, or microbial turnover.

Implications for Food Security & Climate

Understanding and modulating core microbes could allow us to:

- **Improve fibre digestion and nutrient extraction,**
- **Design microbiome-based feed strategies,**
- **Reduce methane emissions,**
- **Enhance animal resilience under changing climates,**
- **Support global food production, sustainably.**

Because these microbes are found in almost every ruminant on the planet, their potential impact is enormous.

Take-home message

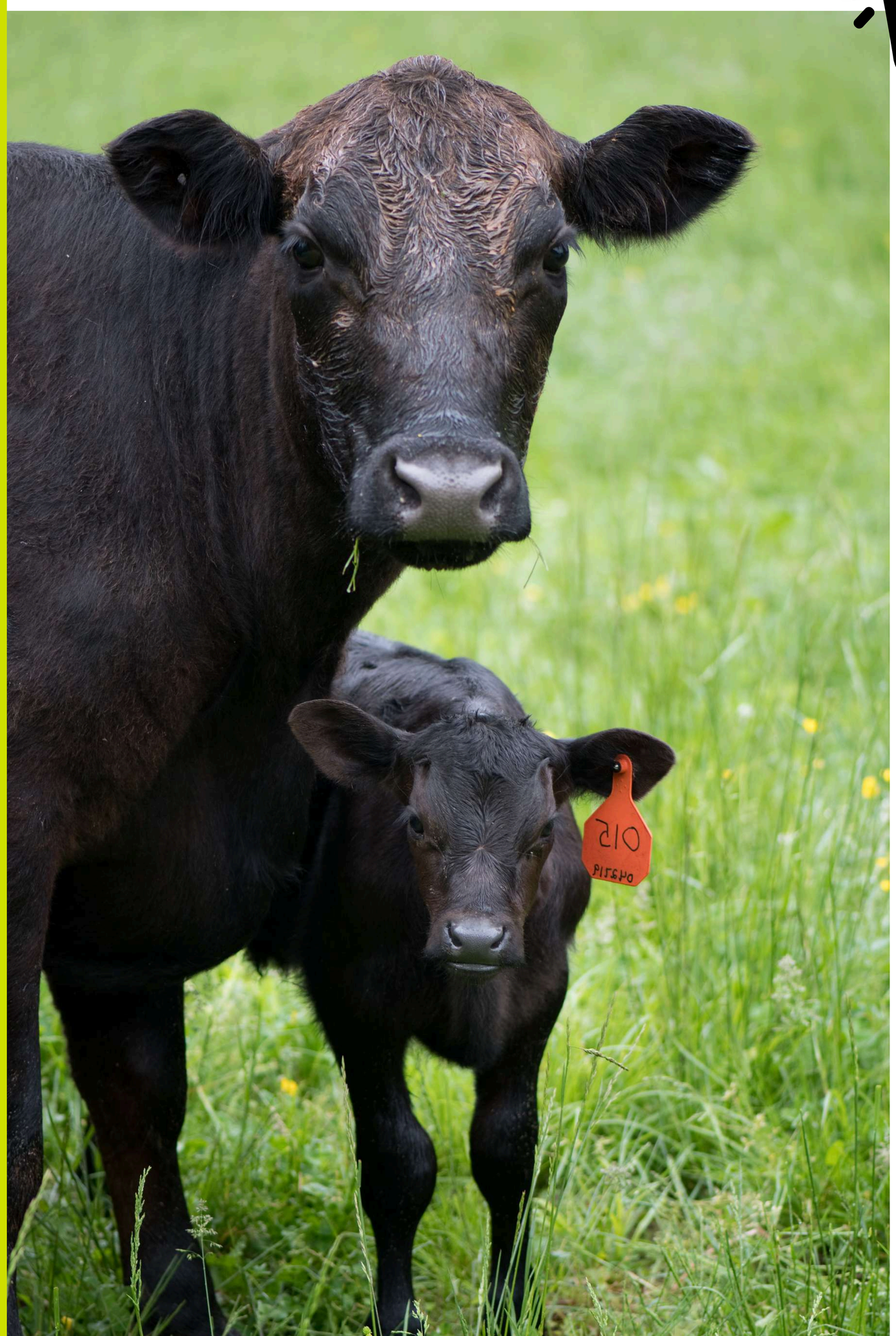
Core microbes are not just “common”. They are functional generalists, metabolic engines, and ecosystem stabilizers.

They persist because they can:

- **Use many substrates,**
- **Synthesize their own essential compounds,**
- **Support the rest of the microbiome,**
- **And reliably nourish the host.**

In return, ruminants provide a stable home and constant food supply,
a mutualistic partnership that has sustained agriculture for millennia.

For more information on auxiliary rumen microbiome, check out the blog post *“The auxiliary rumen microbiome: early microbes that stay for life”*.



HoloRuminant
Understanding microbiomes of the ruminant holobiont

Follow us!

and subscribe
to our **mailing list**

The HoloRuminant project has received funding from European Union’s Horizon 2020 research and innovation program under Grant Agreement No 101000213.