

**Embrapa**

Pecuária Sudeste

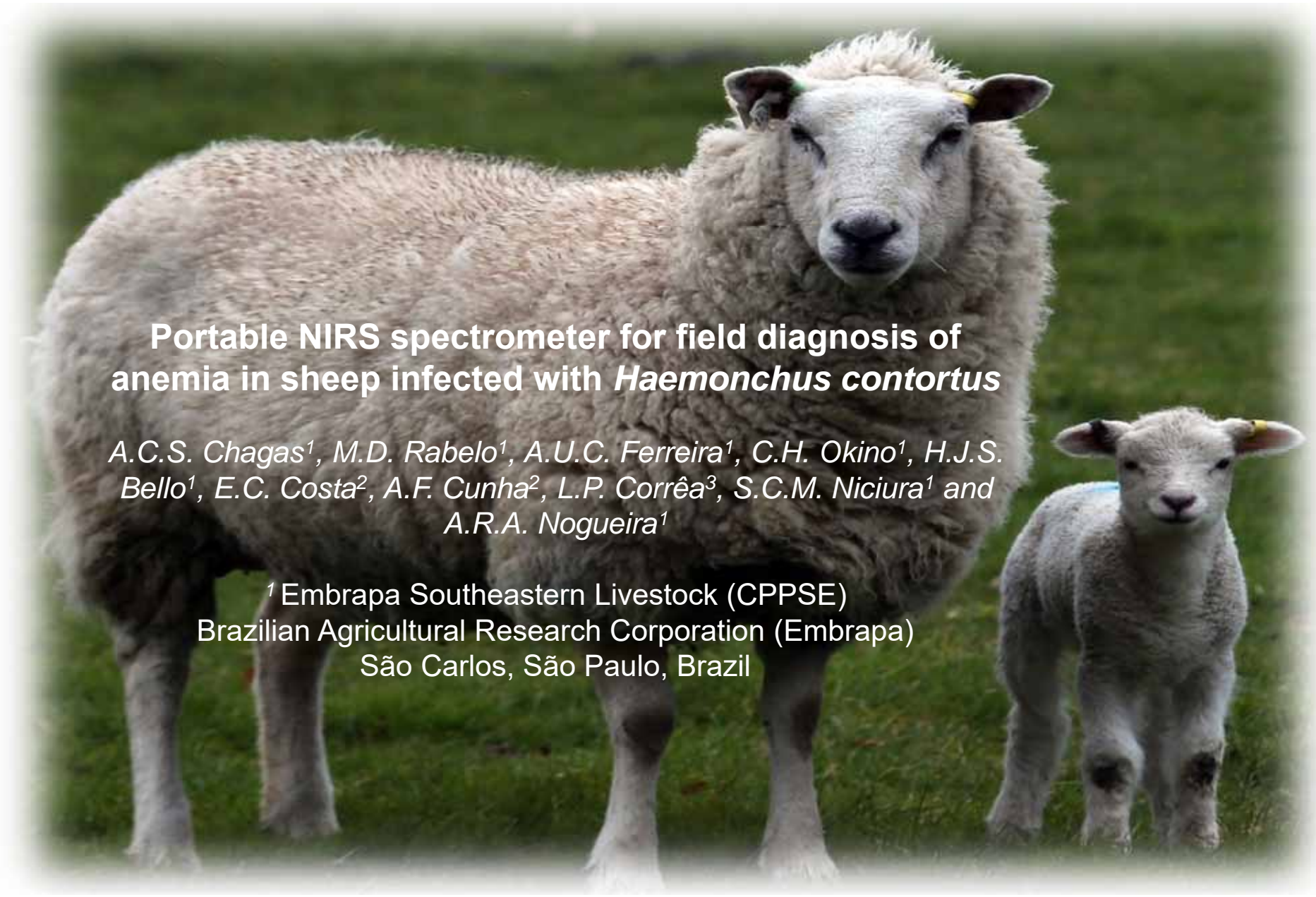


**Portable NIRS spectrometer for field diagnosis of anemia in sheep infected with *Haemonchus contortus***

A.C.S. Chagas<sup>1</sup>, M.D. Rabelo<sup>1</sup>, A.U.C. Ferreira<sup>1</sup>, C.H. Okino<sup>1</sup>, H.J.S. Bello<sup>1</sup>, E.C. Costa<sup>2</sup>, A.F. Cunha<sup>2</sup>, L.P. Corrêa<sup>3</sup>, S.C.M. Niciura<sup>1</sup> and A.R.A. Nogueira<sup>1</sup>

<sup>1</sup> Embrapa Southeastern Livestock (CPPSE)  
Brazilian Agricultural Research Corporation (Embrapa)  
São Carlos, São Paulo, Brazil

**FAPESP**



# Introduction

## The Unseen Threat Draining Flock Vitality

The Parasite



The Impact



The Biomarker



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**Hypothesis:** Santos et al. (2023) - Systems that integrate portable spectrometers with cloud-hosted models, which explore the technological concept of "Internet of Things" (IoT), represent a strategic solution for on-site use.

## Translating Invisible Light into Clinical Insight

### Core Mechanism

The device reads unique spectral signatures spanning 1350 to 2500 nm directly from the unadulterated blood sample, requiring zero chemical processing.

### The Target

Changes in hemoglobin concentration physically alter how near-infrared light is absorbed and reflected, providing a direct optical measurement of anemia.



Morada Nova Breed

# Driving Assertive Treatment Under Real Field Conditions

## The Outcome

The NIRS portable spectrometer extends diagnostic reliability, offering veterinarians the agility required to make rapid, assertive anthelmintic treatment decisions instantly.

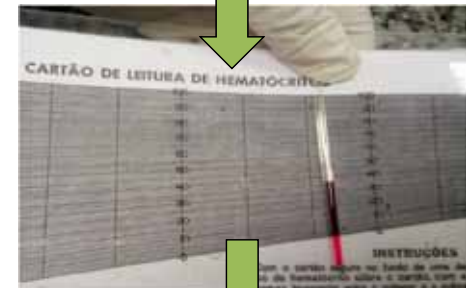
## The Impact

Eradicating the laboratory delay protects flock vitality, drastically reduces wasted medical treatments, and effectively neutralizes the threat of *Haemonchus contortus* directly at the point of care.

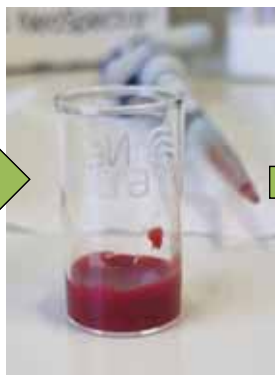


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Lab

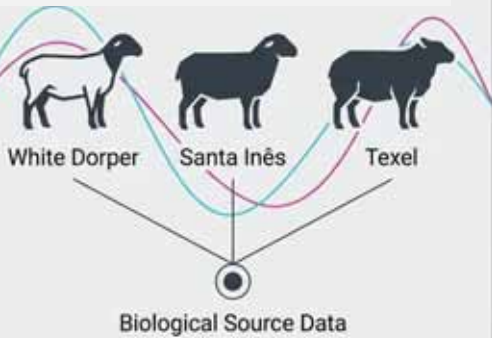


Field



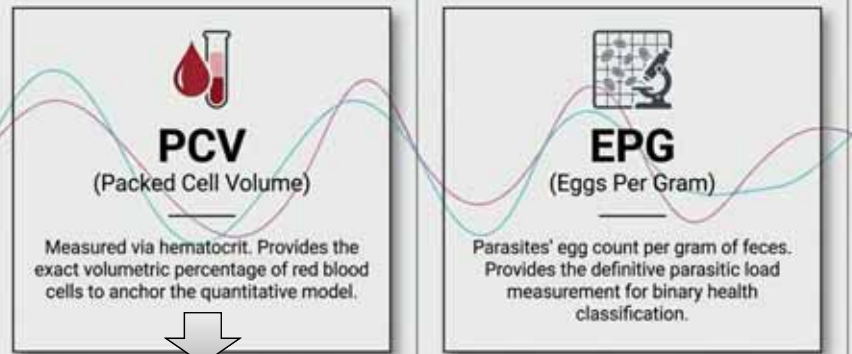
## Experimental design

### 1,170 blood samples



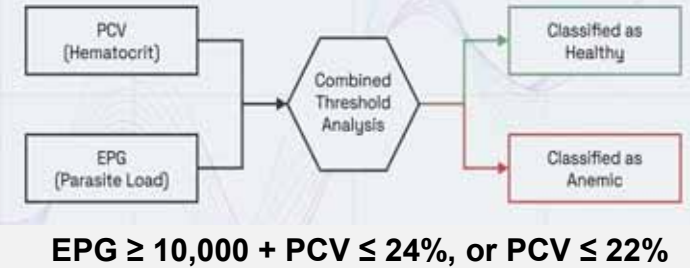
kept on naturally GIN infected pasture

### Establishing the Biological Ground Truth

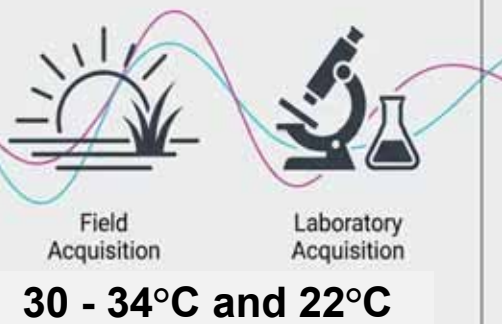


PCV\_Ref

### The Clinical Classification Logic Gate

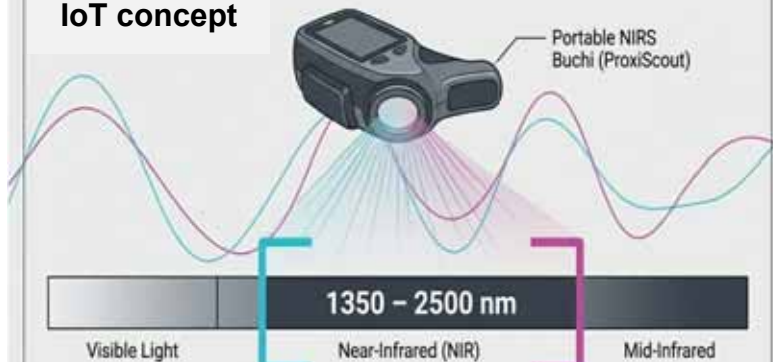


### Dual-Environment Acquisition



### Hardware Integration and Spectral Acquisition Range

#### IoT concept



### Multivariate Modeling: Validation and Application

The Analytical Engine Matrix		
	PLS (Partial Least Squares)	PLS-DA (Partial Least Squares Discriminant Analysis)
Model Paradigm	Quantitative Modeling	Binary Classification
Predictive Output	Predicting exact PCV percentage based on spectral absorbance.	Categorizing as Healthy or Anemic based on concatenated threshold logic.

PCV\_Pred

healthy or anemic

## Clinical results

- 85% *Haemonchus contortus*;
- The diagnostic criteria for TST (EPG  $\geq 10,000$  and PCV%  $\leq 24\%$ , or PCV  $\leq 22\%$ ) was adequate. Coefficient of determination ( $R^2 = 0.9754$ ) observed in the relation between EPG and PCV\_Ref.
- PCV\_Ref values close to 22% associated with EPG  $> 10,000$ , and 24% with EPG  $> 7,000$  (Fig. 1).

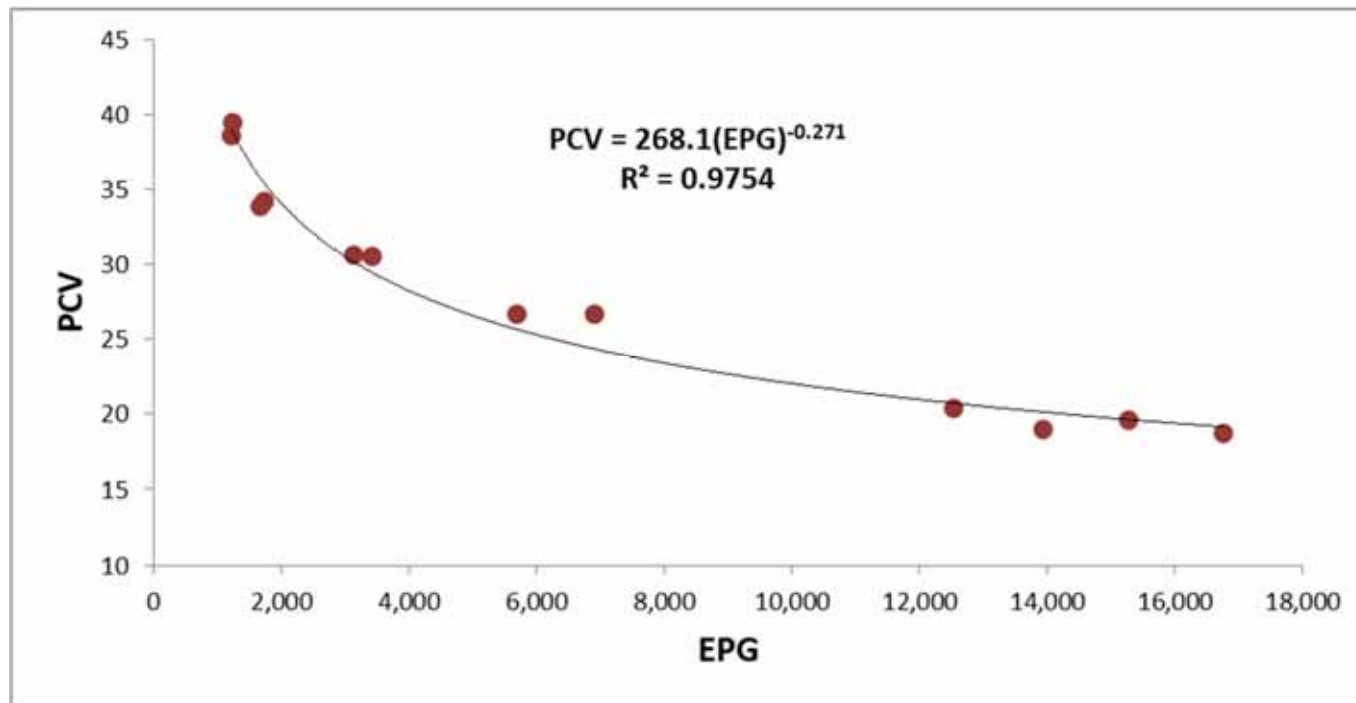



Figure 1. Nonlinear regression between fecal egg count (EPG) and packed cell volume measured by hematocrit (PCV\_Ref) in sheep, described by a power regression model ( $R^2 = 0.9754$ ).

## NIRS results

- The spectral acquisition environment (PLS\_Field or PLS\_Lab) didn't impact the predictive quality of the models (RMSEC, RMSECV, RMSEP, and  $R^2$ \_Pred).
- In comparing the PCV\_Pred with PCV\_Ref: difference of  $\pm 2.7\%$  across 9 collections  **safer!**

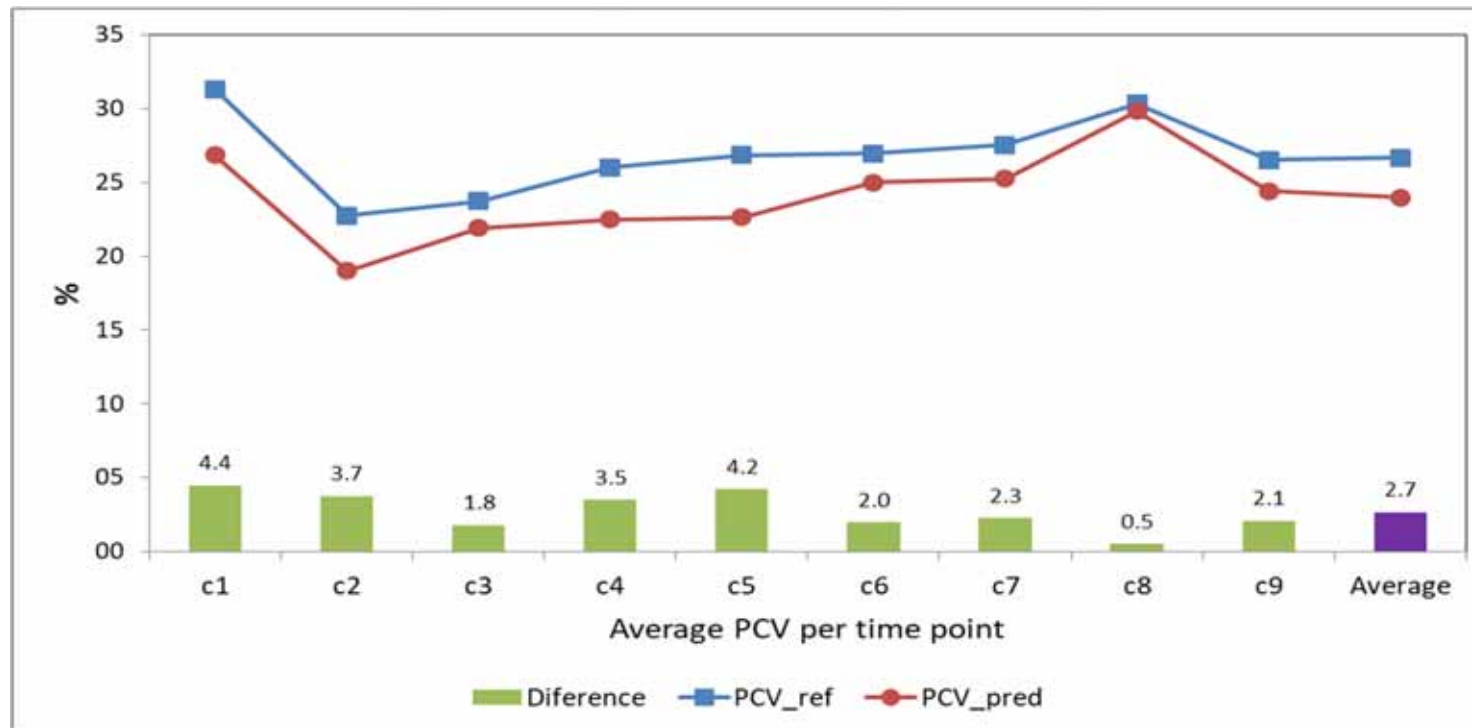


Figure 2. Mean packed cell volume (PCV) values obtained by hematocrit (PCV\_Ref) and by NIRS combined with PLS (PCV\_Pred) through nine distinct sampling collections in sheep.

Table 1. Confusion matrix from PLS and PLS-DA models based on NIR spectra of sheep blood samples of animals clinically classified as anemic or healthy due to *H. contortus* infection based on packed cell volume (PCV) and eggs per gram of feces (EPG).

Model	TP	TN	FP	FN	FPR (%)	NPV (%)	Accuracy (%)	Precision (%)	Sensitivity (%)	Specificity (%)	F1 Score
PLS	111	234	36	0	13	100	91	76	100	87	0.86
PLS-DA	39	268	2	72	1	79	81	95	35	99	0.51

TP: true positive; TN: true negative; FP: false positive; FN: false negative; FPR: false positive rate; NPV: negative predictive value.

- **72**: only 2.9% presented EPG  $\geq 10,000$ , therefore, with a lower risk of death.
- Limited sensitivity has also been reported for FAMACHA<sup>®</sup>, (Kaplan *et al.*, 2004; Cintra *et al.*, 2018), reinforcing the importance of the combined use of diagnostic tools.



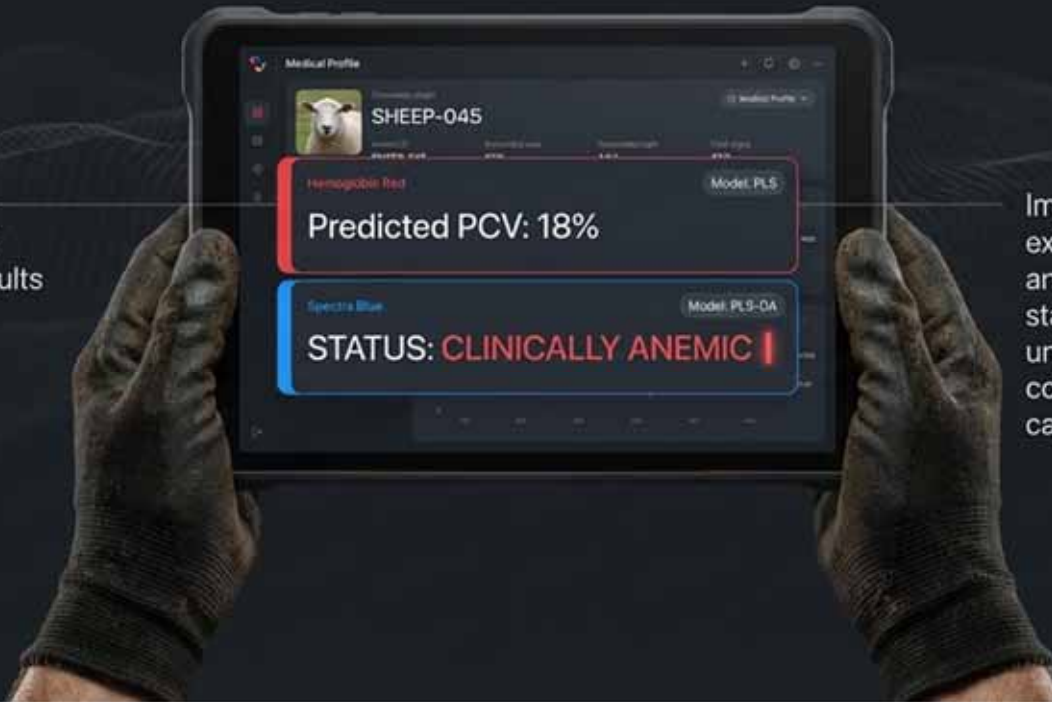
**Adjust diagnostic thresholds to the user's objectives, thereby modulating the model's performance (EPG  $\geq 10,000$  and PCV%  $\leq 24\%$ , or PCV  $\leq 22\%$ ).**



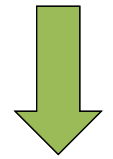
**Conclusion:** PLS stands out as the most reliable cloud-hosted model for decision-making in parasite control programs, allowing for rapid and assertive TST strategies under field conditions.

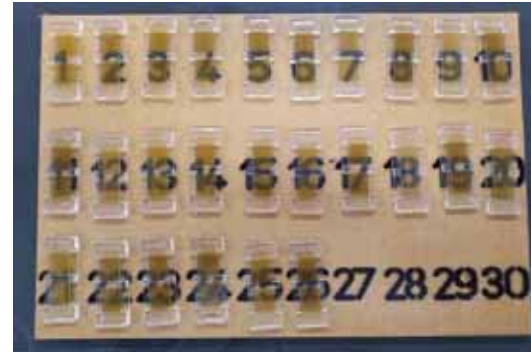
## The Concomitant Diagnostic Interface

Vets do not choose between models; the system generates results concomitantly.



Immediate access to both exact quantitative metrics and definitive categorical status unlocks unprecedented diagnostic confidence at the point of care.





# Thank you

[carolina.chagas@embrapa.br](mailto:carolina.chagas@embrapa.br)

[marcio.rabelo@embrapa.br](mailto:marcio.rabelo@embrapa.br)

