Visualizing Packed Cell Volume in Cattle: An Analysis in East Africa

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Introduction

Blood parameters are an important indicator of animal health and, in the case of domesticated livestock, can consequently affect human health and the agriculture industry (Turkson and Ganyo, 2015). Packed cell volume represents the proportion of red blood cells in the whole blood and is a standard indicator for anaemia (Turkson and Ganyo, 2015). In rural locations and lower-income countries, PCV measurements are noted to be more cost efficient and easier to complete than other methods (Quinto *et al.*, 2006). This analysis builds on data from a study that measured the PCV values of cattle in 119 sites in Malawi; 170 sites in Zambia; and 144 sites in Mozambique. The researchers used the microhaematocrit centrifugation technique to measure and record the PCV values (Jain, 1986). Using the raw PCV data, this analysis investigates the spatial distribution of the PCV values to inform cattle management and assess possible areas of disease outbreaks correlated with low PCV values. The analysis used QGIS software to map the average PCV values from each sample site. PCV means per district were calculated and visualized within each country. Only one area, the Eastern District of Zambia, displayed a mean PCV value less than the standard 30%. However, the analysis did not localize the data beyond the district level, which could provide additional, smaller hotspots of low PCV values.

Background

Packed cell volume measures the proportion of red blood cells in whole blood and is used across species, including humans, as a health assessment (Turkson and Ganyo, 2015). In cattle, mean PCV can indicate a range of health issues. One 2011 study found an association between reduced PCV values and tick-born pathogens in Zambia: Cattle that were heavily infested with ticks showed an average 14.44% drop in PCV value (Simuunza *et al.*). Cattle age has also been associated with decreased PCV values (Rowlands *et al.*, 1995; Simuunza *et al.*, 2011).

In multiple Africa countries, bovine trypanosomiasis is a significant constraint to livestock production and, thus, economic security (Muhanguzi *et al.,* 2014). In Ethiopia, the disease is associated with annual losses of $200 million to the national economy (Lelisa *et al*., 2014). Numerous studies have found correlations between the disease and low PCV values. Studies in Zambia have found significant correlation between trypanosomal infections in cattle and decreased PCV values, independent of age and sex of the animals (Van Den Bossche and Rowlands, 2001; Marcotty *et al*., 2008). Similarly, in Ethiopia, 92.2% of surveyed cattle that tested positive for trypanosomes pathogens also displayed PCV values less than 25% (Lelisa *et al*., 2014). Marcotty *et al*. note that, in combination with parasitological examinations, measuring PCV values could be a cost-effective method for increasing accuracy of bovine trypanosomiasis diagnoses in the field (2008). The correlations with PCV values demonstrate how such infections can ultimately lead to fatal anaemia in cattle populations (Riond *et al.,* 2008).

Methods

This analysis used QGIS software to visualize the data provided from the PCV survey.

Beginning with open access shape files for Africa, including national districts, the surveyed countries—Malawi, Mozambique, and Zambia—were then extracted. Mean PCV point data from the sample sites had been provided and were added as new layers to the GIS project. As the Mozambique data was provided in degrees-minutes-seconds form, the standard formula—*Degrees + (Seconds/3600) + (Minutes/60)*—was used to convert the data to decimal degrees in the original CSV file. This data was uploaded as delimited text and then saved as a GIS shape file.

The site data were segmented by mean PCV values

- less than 25 (visualized by a red dot);
- greater than or equal to 25 and less than 30 (grey triangle);
- greater than or equal to 30 (black square); and
- all other values (white square).

As shown in Fig. 1, each site's data was visualized with the distinct symbols noted above; expressions corresponding to the segmentation, e.g., "Mean PCV" < 25, were used for the GIS layer's symbology.

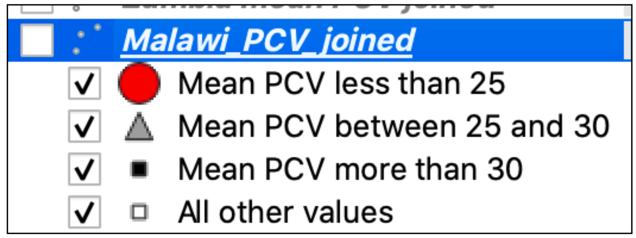

Fig. 1: Layer symbology for site-specific mean PCV values

To calculate the mean PCV values by district, the Statistics by Category function was used on each country's point layer, with statistics calculated by the mean PCV field and the district selected as the category field. A copy of the extracted country polygon layer was then made, and the Dissolve function was used for the District field. A new field for mean PCV was added to the dissolved layer, and the mean PCV values from the Statistics by Category function were manually added.

As shown in Fig. 2, the mean PCV values by district were again segmented to highlight areas with cattle PCV values lower than the standard of 30%. As above, the layer symbology was adjusted to visualize districts by mean PCV value

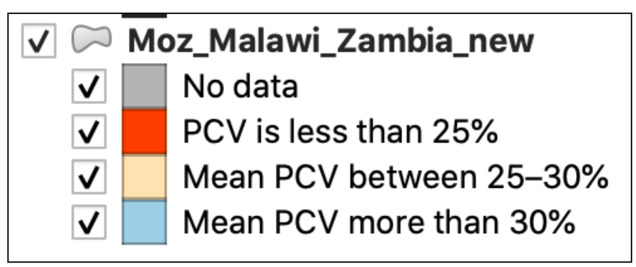

Fig. 2: Layer symbology for district-level mean PCV values

- less than 25 (orange fill);
- greater than or equal to 25 and less than 30 (yellow fill);
- greater than or equal to 30 (light blue fill); and
- no data (gray fill).

Both maps were exported into QGIS print layouts, with appropriate scales, titles, and legends added.

Results

No sample sites in Mozambique and only one site in Malawi (Mikoko in the Southern District) had a mean PCV lower than 25%. However, as shown in Fig. 3, multiple sites in the Eastern District of Zambia revealed low mean PCV values (less than 25%), concentrated near the borders with Malawi and Mozambique. Note, eight sites in Zambia and one in Mozambique were missing mean PCV data and are shown as white squares in Fig. 3.

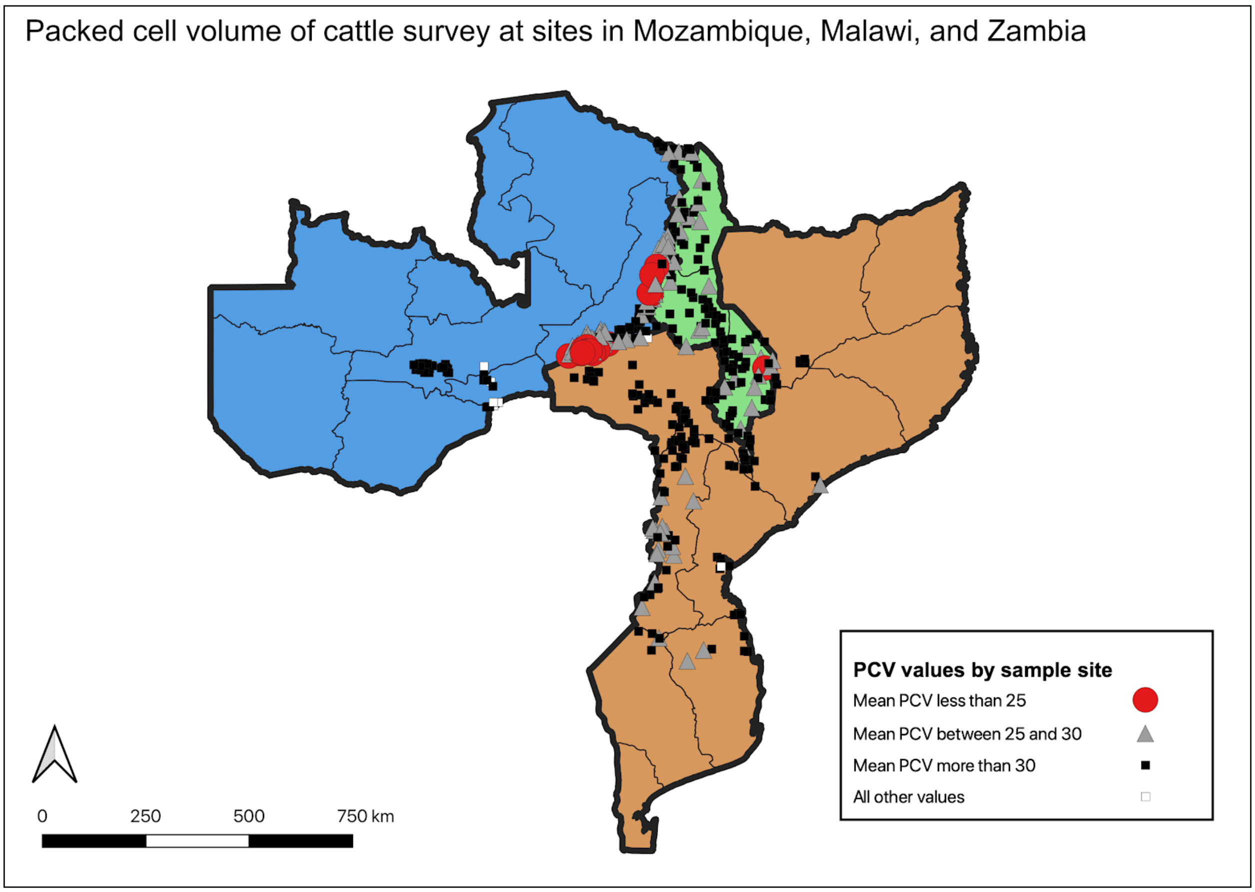

Fig. 3: Map of mean PCV data by sample site in Malawi, Mozambique, and Zambia

The mean PCVs by district range from 28.28% to 36%. Out of the fourteen districts with sampled PCV data, thirteen have a mean PCV higher than 30%. These are shown in light blue in Fig. 4. In alignment with the site-specific data, the Eastern District of Zambia also showed the lowest mean PCV, visualized in yellow in Fig. 4.

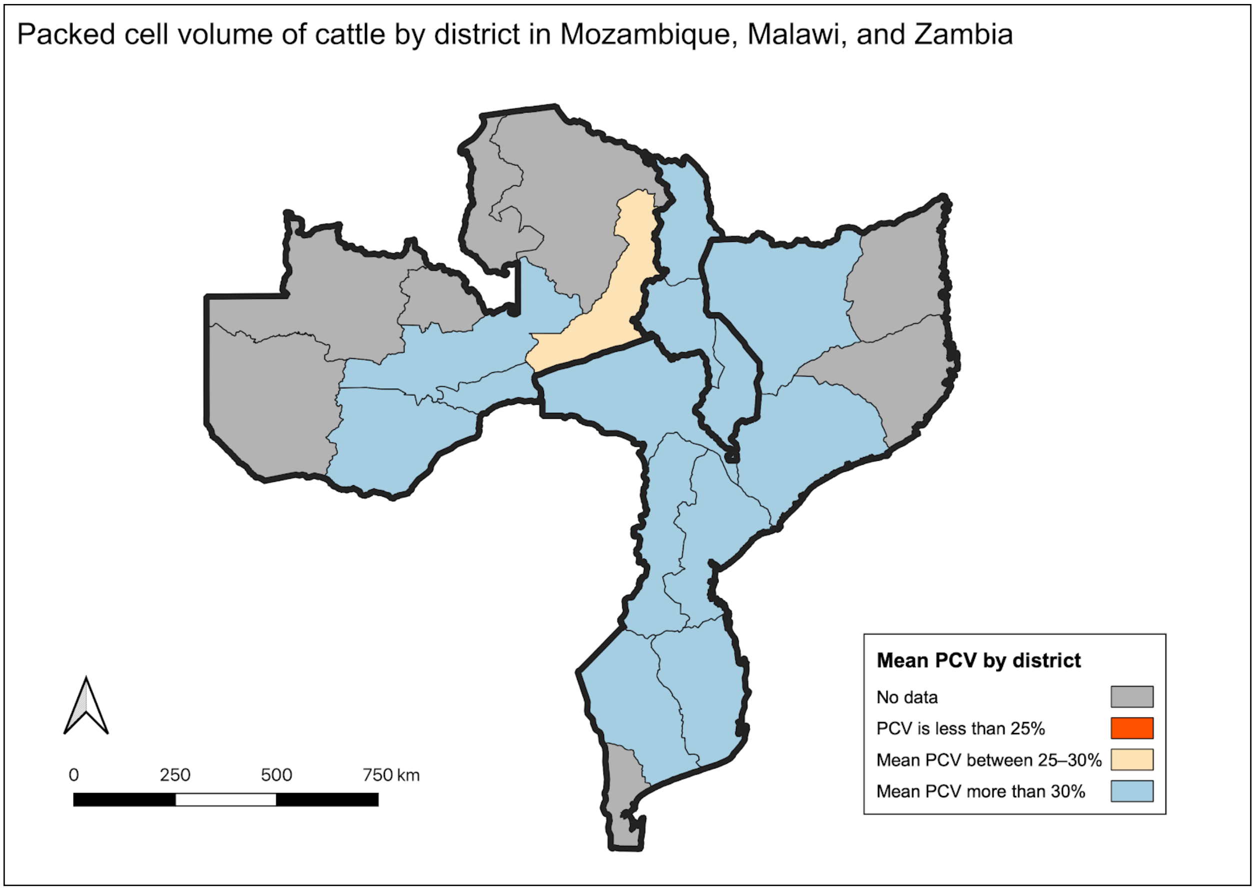

Fig. 4: Map of mean PCV data by district in Malawi, Mozambique, and Zambia

Discussion

Using survey data from sites in three East African countries, the spatial visualization highlights only one district in Zambia with an average PCV value less than 30%. Since low PCV values are known to correlate with fatal cattle diseases, most notably trypanosomiasis, these findings indicate lower risks of some diseases in the surveyed areas (Van Den Bossche and Rowlands, 2001; Marcotty *et al*., 2008; Riond *et al.*, 2008).

In the Eastern District of Zambia, additional research is needed to better understand the drivers of the low PCV values and potential consequences. Given the known disease correlations, it is recommended that future studies prioritize the prevalence of tick-borne illnesses and trypanosomiasis infections in the livestock populations. Further monitoring of the district's livestock would also build understanding of how PCV values relate to cattle mortality. The outcome of trypanosomosis infections can vary significantly, from chronic to fatal, depending on factors such as cattle breed, trypanosome species, and innate host resistance (Marcotty *et al*., 2008; Biyazen, Duguma, and Asaye, 2014). Thus, research in Zambia's Eastern District could provide insight into these factors and improve communities' abilities to respond to trypanosomiasis outbreaks. Similarly, if the low PCV values appear to be correlated with tick-borne diseases, long-term monitoring could begin to fill knowledge gaps about specific disease pathogens and mortality rates (Simuunza *et al.*, 2011).

Though this analysis identified one district to prioritize for additional monitoring, the district-level analysis may neglect smaller hotspots of low PCV values. For example, in Fig. 3, there are clusters of sample sites with mean PCV values between 25–30% (grey triangles), most notably along Mozambique's southwestern border. The district averages are too broad to identify these smaller areas of low PCV values. It is recommended that the survey data be further segmented and analyzed, with smaller buffer zones (e.g., 50km) created around each survey site.

Additional surveys should also be undertaken to provide comparison data during different seasons. As noted by Simuunza *et al.*, the prevalence of tick-borne diseases, in particular, can vary greatly by season and there may be corresponding variation in the PCV values at the surveyed sites (2011). Likewise, there are often seasonal differences in cattle's diets and grazing habits that may affect PCV values (Simuunza *et al.*, 2011).

This analysis provides a preliminary overview of average PCV values in livestock in the national districts of Malawi, Mozambique, and Zambia, which can be used by governments and decision makers to prioritize interventions to improve cattle health. Additional analyses would be beneficial in identifying more localized problem areas, disease correlations, and factors contributing to the reduced red blood cell levels.

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