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Using Bayesian methods to build differential diagnostic tools for cattle diseases in sub-Saharan Africa

Crawford Revie[1] and Tariku Jibat[2]

[1] CVER, Atlantic Veterinary College, University of Prince Edward Island, Canada
[2] College of Veterinary Medicine and Agriculture, Addis Ababa University, Debre Zeit/Bishoftu, Ethiopia

The Context

- Ethiopia has one of the largest livestock populations in Africa, estimated at around 50 million cattle (2014).
- To date productivity of the sector has been limited.
- In part this is due to a lack of access to veterinary services, and consequently the mis-diagnosis and incorrect treatment of endemic diseases.
- We are running field trials with a smartphone app, *VetAfrica-Ethiopia* (*VAE*), to assess its effectiveness in obtaining improved diagnostic outcomes.

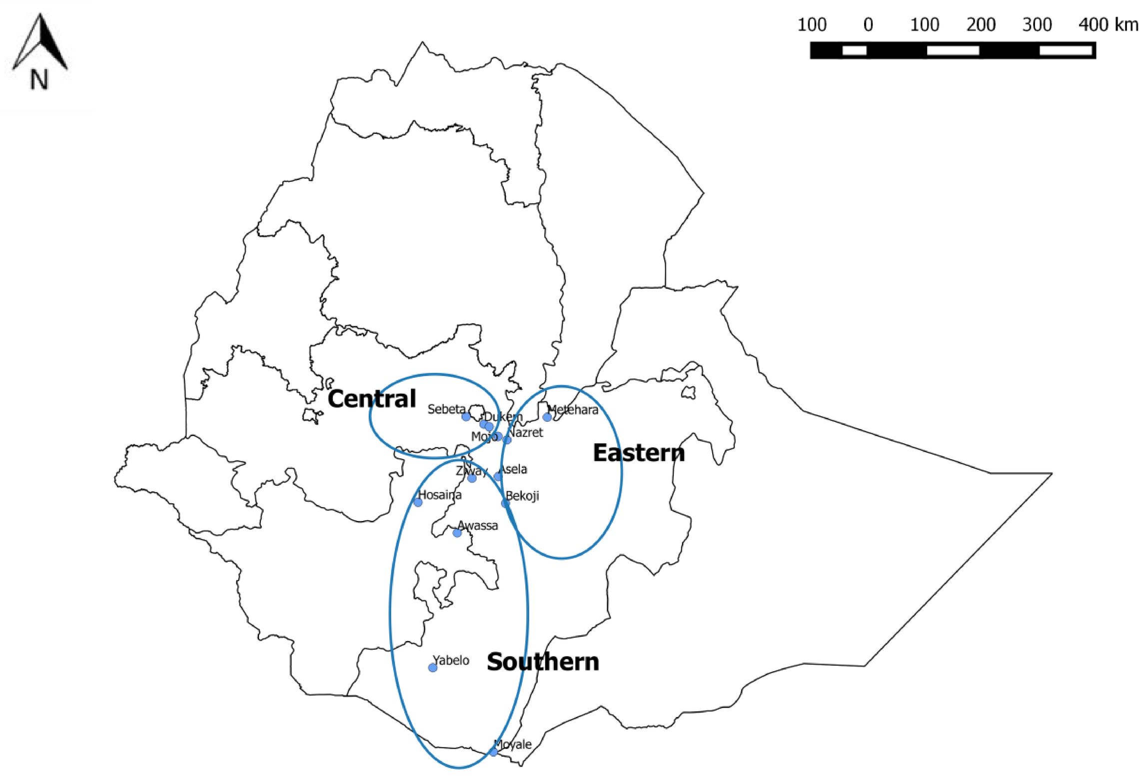


Figure 1. Map of Ethiopia indicating the three regions covered by the initial field trials.

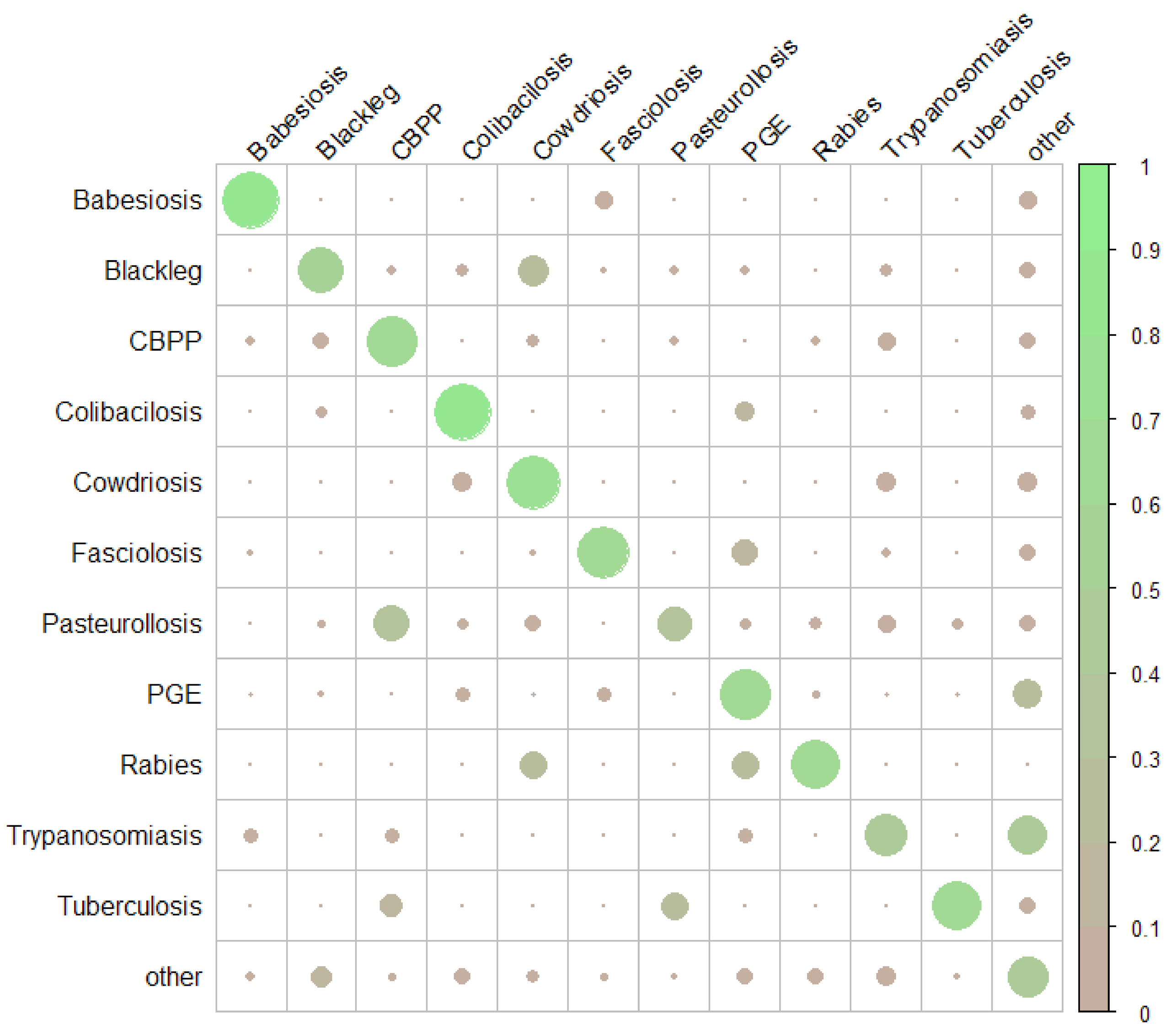
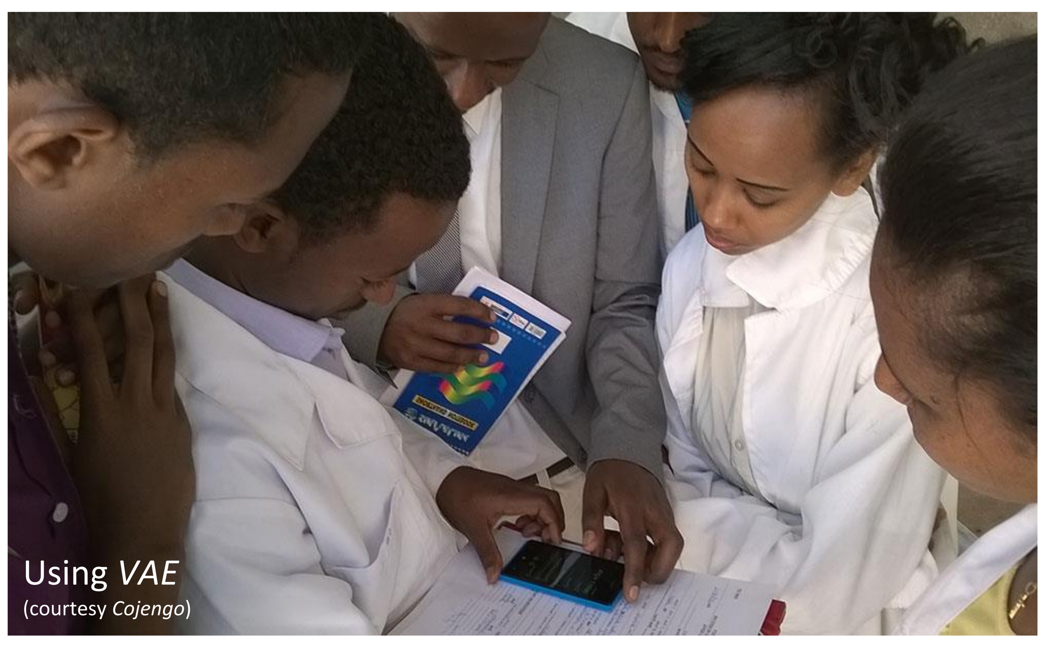


Figure 2. Mis-classification matrix indicating the level of agreement between clinician's diagnosis and that suggested by the *VetAfrica-Ethiopia* smartphone app.



Methods

- We started with a Naïve Bayes implementation of expert opinion describing the relationships between disease presence and the likely presentation of clinical signs for 12 commonly occurring diseases in Ethiopian cattle.
- *VAE* was installed on smartphones and used to collect case information on over 900 animals in three regions with differing ecologies (Figure 1) in 2015.
- Data were collected and managed using Cloud-based services (*MS Azure*).
- Uninformed priors can now be modified in light of prevalence observed by geographical location and by animal characteristics (age, sex, breed, etc.)
- Data-driven learning can be used to adjust conditional probabilities in the BBN where evidence indicates that non-independence of signs is not supported.

Results

- Initial results (using simple Naïve Bayes) were encouraging (Figure 2) but also indicated significant opportunity for improvement and refinement.
- A key challenge is finding a 'gold standard' against which to train the machine learning algorithm which updates the nodes and CPTs of the BBN.
- Diagnostic performance was not uniform across the range of 15 veterinary user who took part in the field trials of *VAE*.
- It is likely that many animals are affected by concurrent disease, while the BBN assumed that only a single disease was present at any given time.

Conclusions

- Despite the many simplifying assumptions of the Naïve Bayes approach, the initial BBN performed well; achieving accurate levels of over 80% for a number of the diseases included in the pilot version of *VetAfrica-Ethiopia*.
- Using data-driven machine learning algorithms the performance can be significantly improved and the complex interdependent structures that hold among clinical signs under different disease conditions more full understood.
- Ultimately this approach holds great promise for putting smartphone based diagnostic aids in the hands of less experienced animal health professionals and increasing animal productivity through better diagnosis and treatment.

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CVER
Centre for Veterinary Epidemiological Research

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Addis Ababa University