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Decision support tools as alternative options to improve diagnostic services for endemic livestock diseases

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Abstract

In a bid to improve diagnostic services for endemic bovine diseases in Uganda that are deteriorating as a result of non-functional veterinary laboratories, decision support tools and other hand-held tools have been developed to facilitate field diagnosis and management of cases of livestock diseases such as trypanosomosis, tick-borne diseases and helminthoses. A decision support card was developed based on a combination of pattern-matching and colour-banding techniques using quantitative information on the diagnostic value of clinical signs of endemic bovine diseases obtained through a Delphi survey on expert opinion. This tool was intended to facilitate differential diagnosis of endemic bovine diseases. The HemoCue, a hand-held haemoglobinometer, conventionally used in human medicine, was evaluated for its suitability in measuring haemoglobin of bovine blood using 65 samples. A substantial proportion of the results of the HemoCue lay within 95% limits of the reference method. Field evaluation in Tororo and Busia districts in which 7302 cattle were examined over a 12-months period revealed that combining clinical examination with detection of anaemia using the hand-held haemoglobinometer leads to detection of a significantly higher proportion of sick animals than when clinical examination alone is used (c^2 = 26.8, d.f. = 1, P < 0.01), and also improves timely institution of treatment. The decision support card and the hand-held haemoglobinometer are convenient for veterinary extension agents for field use and could substantially improve diagnostic services of endemic bovine diseases in Uganda.

Key words: Bovine disease, field diagnosis, veterinary services, Uganda

Introduction

Currently the cattle population in Uganda is estimated at 6.8 million (Anon., 2004). Cattle production in Uganda is characterized by low production levels partly because of high incidence of debilitating diseases such as trypanosomosis, East Coast fever, anaplasmosis, babesiosis, cowdriosis, parasitic gastroenteritis and fasciolosis (Anon., 2004) that are endemic in most parts of Uganda. The prevalence of trypanosomosis in cattle in Uganda is estimated to be 11.9 % under the intensive dairy system and 25 % under the communal grazing systems (Magona and Mayende, 2002). In addition, over 90% of the cattle population are at constant risk of tick-borne diseases and the overall loss of the calf crop in indigenous cattle due to tick-borne diseases is estimated to be 30% over the greater part of the Uganda (Anon., 1997). Of the deaths attributable to tick-borne diseases, East Coast fever is responsible for 79%, anaplasmosis 11%, cowdriosis 5.6% and babesiosis 4.4% (Anon., 1992). For helminthoses, the reported prevalence of fasciolosis in cattle in Uganda is 29-36% (Magona *et al.*, 1999) and 22-61% for gastrointestinal nematode infections (Sauvage *et al.*, 1974; Magona and Musisi, 1998) Unlike epidemic diseases such as CBPP and rinderpest whose control relies on vaccination, the control of these endemic diseases relies on accurate diagnosis and treatment of cases, which requires good diagnostic facilities to back-up disease control.

Like in many African countries, veterinary diagnostic laboratories in Uganda have fallen into disuse due to under-utilisation by fee-paying farmers and absence of public support (Kenyon and Nour, 1996) and decentralization of services. Only a handful of districts in Uganda have operational diagnostic laboratories. Given this scenario, veterinary extension staffs are forced to rely on clinical examination to detect and treat disease cases in the field. However, diagnosis by means of clinical examination is complicated by the occurrence of multiple disease conditions manifesting similar signs since cattle are frequently affected by a combination of intestinal and haemoparasites, which mutually aggravate each other's pathogenic effects (Dwinger *et al.*, 1994). Such a situation requires decision support tools to facilitate differential diagnosis. In addition, hand-held haemoglobinometers can provide a quantitative and more sensitive means of detecting anaemia, which is, associated with all these endemic diseases. In this paper, we describe the decision support tool and the hand-held haemoglobinometer, which could be very vital in field diagnosis of endemic cattle diseases in Uganda.

Materials and methods

Evaluation of hand-held anaemia-detection device

The HemoCue (HemoCue AB, Ängelholm, Sweden) is a hand-held haemoglobinometer that measures haemoglobin at two wavelengths as azide methaemoglobin, without dilution (von Schrenk *et al.*, 1986). The azide methaemoglobin reaction involves the erythrocyte membranes being disintegrated by sodium deoxycholate, thereby releasing the haemoglobin. Sodium nitrate then converts the haemoglobin iron from the ferrous to the ferric state to form methaemoglobin, which then combines with azide to form azide methaemoglobin (von Schrenk *et al.*, 1986). This method is based on an optical measuring microcuvette of a small volume (10µl) and short light path (0.13 mm distance between the parallel walls of the optical window). Dry reagents are deposited on the inner wall of the microcuvette cavity, and the blood sample, drawn into the cavity by capillary action, is mixed with the reagents spontaneously. The microcuvette is then placed in a HemoCue photometer, in which its absorbance is measured at 565 and 880 nm. The instrument calculates the concentration of the haemoglobin in the sample and displays the result. Haemoglobin measurement using this method involved a drop of blood (10 µl) being drawn from the vacutainer into the cavity of a microcuvette by capillary action. The microcuvette is then placed into the HemoCue photometer and a reading is obtained in 60 seconds. The HemoCue conventionally used in human medicine, was evaluated for its suitability in measuring haemoglobin of bovine blood. Its agreement with the cyanmethaemoglobin-conventional goldstandard, in the measurement of bovine haemoglobin was assessed.

Development of a decision support card

A decision support card was developed based on a combination of pattern-matching and colour-banding techniques (Cockcroft, 1999; Middleton, 2001) using quantitative information on the diagnostic value of clinical signs of eight bovine diseases: trypanosomosis, theileriosis, anaplasmosis, babesiosis, cowdriosis, parasitic gastroenteritis, schistosomosis and fasciolosis obtained through a Delphi survey (Linstone and Turoff, 1975) on expert opinion.

Utilisation of decision support tools to improve field case detection

A longitudinal study was conducted in Busia and Tororo districts in 2002 in a total of 8 villages over a 12–months period in which 7302 cattle were examined clinically and anaemia detected by use of the HemoCue, to evaluate the added value of using the Hemocue during field diagnosis of endemic bovine diseases. The aetiology of all cases encountered was confirmed by laboratory diagnosis.

Data analysis

Data was analysed using the computer packages Microsoft Excel and Minitab (Minitab Statistical Software, Minitab Inc., Pennsylvania, U.S.A). Assessment of agreement between the HemoCue with Cyanmethaemoglobin-reference method was done using Bland-Altman plots (Bland and Altman, 1986). To develop a decision support card, mean scores for signs chosen by animal health experts for each disease were standardized, least important signs for differential diagnosis of diseases eliminated, and signs were selected according their diagnostic value by use of dendrograms and some signs were combined into sign pairs. Eventually, signs and signs pairs were incorporated into a decision support card using a scoring and colour-coding system. To assess the value of the hand-held haemoglobinometer in detection of cases, the proportion of cases detected when clinical examination was combined with the hand-held haemoglobinometer was compared to the proportion of cases when using clinical examination alone using the chi-square test. Animals with a haemoglobin concentration below 8 g/dl were considered anaemic (Schalm, 1975).

Results

Evaluation of hand-held anaemia-detection devices

In Figures 1, a Bland-Atman plot depicts the agreement between the hand-held haemoglobinometer (HemoCue) and the reference method. The limits of agreements, showing the ranges between which 95% of the results of the HemoCue lie, were 3.9 g/dl below and 2.0 g/dl above the reference. Hence, a substantial proportion of the results of the HemoCue lay within 95% limits of the reference method.

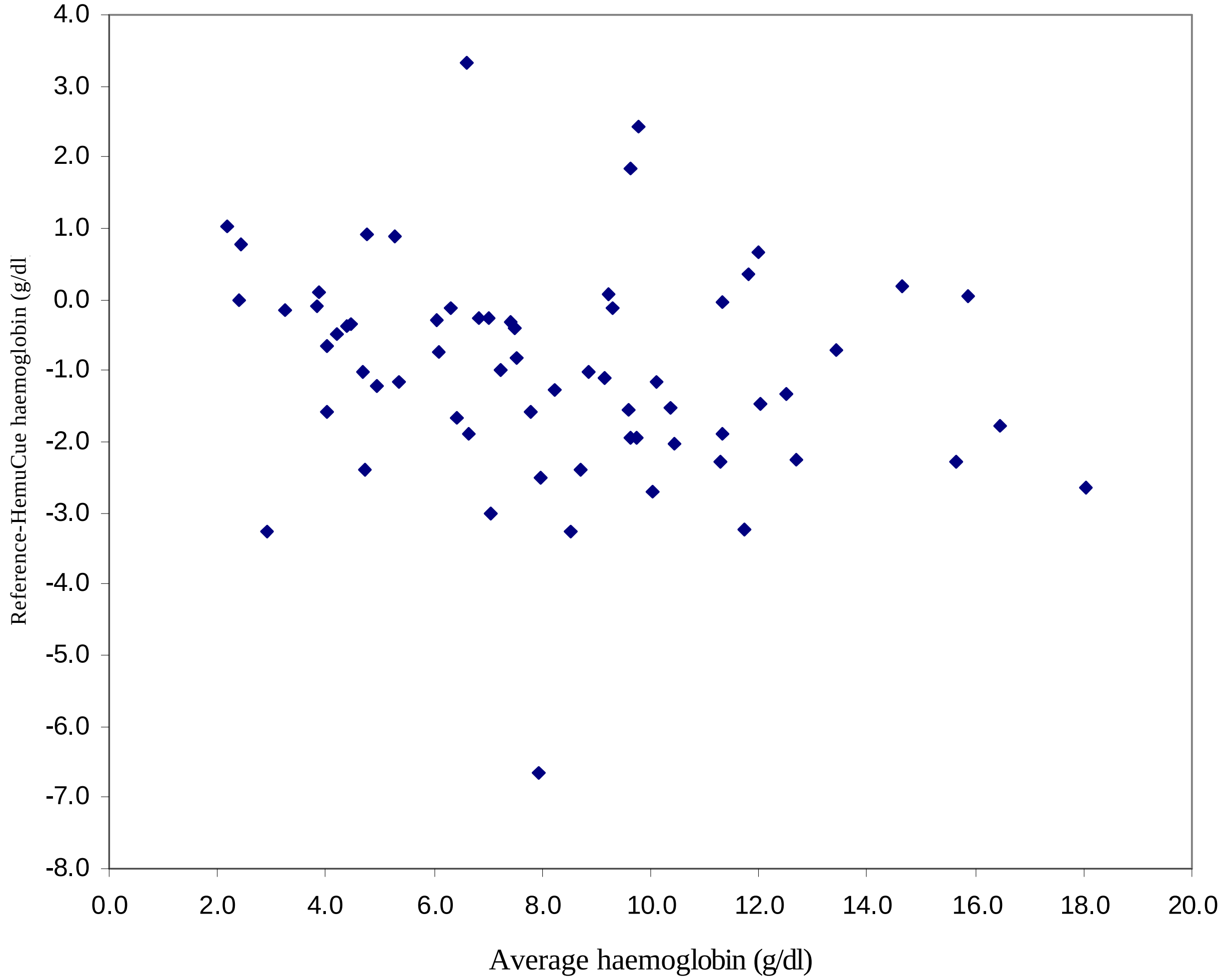

Figure 1. Bland-Altman plot depicting the agreement between the HemoCue and the reference method. Mean difference = -0.9, Upper limit of agreement = 2.0 and lower limits of agreement = -3.9

A decision support card for differential diagnosis of endemic bovine diseases

The decision support card is shown in Figure 2. It is composed of a grid on top in which diseases included are listed. The clinical signs associated with these diseases are listed on the far left column. The colour band and the score reflect the weight of a sign state in the event that a disease is present. The basis of this card is the comparison of clinical signs observed with disease profiles. A list of differential diagnoses is constructed ranked in the order in which the disease profiles match the clinical signs observed. To make differential diagnosis, scores of the various sign states of each disease are added up and overall scores of the possible differentials are ranked. The disease with the highest total is considered the leading differential diagnosis. A tie for the top rank is considered to signify a case of concurrent disease involving more than one disease.

Utilisation of the decision support tools to improve field case detection

The number of disease cases due to endemic diseases detected through clinical examination combined with the use of the hand-held haemoglobinometer and through clinical examination alone is shown in Table 1. Of the 7302 cattle examined 646 cases were detected through a combination of clinical examination and a hand-held haemoglobinometer, while 479 cases were detected through clinical examination alone. Combining clinical examination with detection of anaemia using the hand-held haemoglobinometer led to the detection of a significantly higher proportion of sick animals than when clinical examination alone was used ($\chi^2 = 26.8$, d.f. = 1, $P < 0.01$).

	Anaplasmosis	Babesiosis	Cowdriosis	Fasciolosis	PGE	Schistosomosis	Theileriosis	Trypa
Anaemia or Pallor	4	2		2	3	4	1	
Anorexia or Depression	2	2	4				3	
Ataxia or Abnormal behaviour			4					
Constipation	4							
Diarrhoea				1	3	1		
Dysentery						2	1	
Dyspnoea or Coughing							3	
Haemoglobinuria		4						
Icterus	1	2						
Lymph node enlargement							4	
Pyrexia	3	4	4				4	
Staring coat				2	2	1		
Stunted growth or pot belly				2	3	2		
Submandibular/ventral oedema				3	2			
Weakness	1	2	3	3	1	3		
Weight loss	1			3	2	3		

Figure 2. A decision support card for differential diagnosis of endemic bovine diseases

Table 1: Cattle sick with endemic diseases: trypanosomosis, tick-borne diseases and helminthoses detected in villages in Busia and Tororo districts with the help of clinical examination combined with a hand-held haemoglobinometer and clinical examination alone, 2002

Village	Total cattle examined	Disease cases detected	
		Clinical examination and a hand-held haemoglobinometer	Clinical examina alone
Bunghaji	840	97	74
Buyimini	918	62	41
Hitunga	982	65	51
Kubo	884	134	89
Magoje	876	42	32
Nanjeho	898	125	105
Ojilai	886	44	29
Sitengo	1018	77	58
Overall	7302	646*	479*

*The proportion of sick cattle detected when clinical examination was combined with a hand-held haemoglobinometer was significantly higher than when clinical examination alone was used (χ^2 = 26.8, d.f. = 1, P < 0.01).

Discussion

A decision support card to facilitate differential diagnosis of endemic bovine diseases in Uganda and a hand-held haemoglobinometer has been herein described. The decision support card is a useful aid for veterinary extension agents under field conditions in Uganda (Magona, 2004). The decision support card is simple to use, however, it is only useful in cases with at least two clinical signs. One clinical sign does not provide enough information to differentiate diseases. In addition, this tool is intended for people who have some arithmetic proficiency and veterinary training. Veterinary training would empower one to understand the epidemiology of the diseases under consideration: anaplasmosis, babesiosis, cowdriosis, fasciolosis, parasitic gastroenteritis, schistosomosis, theileriosis and trypanosomosis, particularly their presence or absence and distribution in the area where one is using the tool. However, people with colour blindness might find some difficulty in using the tool. The inclusion of the scoring system in addition to the colour coding system was aimed at eliminating this problem. To ensure durability and inexpensive production of the decision support card, it will preferably be made of a lightweight plastic or laminated cardboard, which would make it possible to re-use by writing on it with a wipe-clean marker or pencil (Magona, 2004).

Unlike an expert system that better analyses diagnosis of diseases by utilising Bayesian probabilistic reasoning such as CaDDiS and tackles conjunction occurrence of various disease signs in the same animal (McKendrick *et al.*, 2000) and thus is more accurate, the decision support card is a low technology decision support system that utilises pattern-matching and a scoring system to make differential diagnosis. The major limitation with computer-independent systems such as this is that they are usually limited to identifying differential diagnoses for a single sign or a limited number of combinations (Cockcroft, 1999). Although such decision support systems need to be simple and credible to the users, their major setback is inability to allow for uncertainty of observations, which may lead to misinterpretation or missing of subtle signs (Cockcroft, 1999).

The HemoCue is portable, easy to use, has no inter-observer error, precise and accurate, but is expensive. Field experience in Uganda has revealed that the HemoCue photometer is sensitive to temperature above 30ºC (Magona, 2004). This could be partly attributed to the hygroscopic nature of the HemoCue cuvettes in that once the sealed container is opened, the cuvettes react to the high humidity in hot and humid climates in the tropics (Sari *et al.*, 2001). A hand-held haemoglobinometers can facilitate point of care haemoglobin measurement especially under remote field conditions during detection of anaemia for disease diagnosis and treatment (Magona, 2004). Indeed, it has been demonstrated that combining clinical examination with detection of anaemia using a hand-held haemoglobinometer enables detection of significantly higher proportion of disease cases.Given deteriorating diagnostic facilities, use of a hand-held haemoglobinometer combined with clinical examination would improve case detection and enable timely diagnosis and treatment of cases of endemic bovine diseases.

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