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Research paper

Seasonal occurrence of *Theileria parva* infection and management practices amongst Maasai pastoralist communities in Monduli District, Northern Tanzania

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ABSTRACT

Theileria parva causes an economically devastating tick-borne disease called East Coast fever (ECF), which affects cattle in central, eastern and southern Africa. Determination of seasonal infection rates for *T. parva* is crucial for epidemiological understanding and for strengthening ECF management practices. However, this information is lacking for most pastoralist areas with high livestock density, such as the Monduli District in the Maasai steppe, northern Tanzania. A cross-sectional study was carried out to estimate the prevalence of *T. parva* in wet and dry seasons, and to assess understanding of management practices associated with *T. parva* amongst pastoralists' cattle. A total of 960 cattle owned by 130 pastoralists were randomly selected from ten study villages in each season and blood samples analysed for *T. parva* prevalence using a nested polymerase chain reaction (PCR). Seroprevalence for *T. parva* in the wet season was assessed using an enzyme-linked-immunosorbent assay (ELISA). Information on relevant management practices was gathered using a standardized questionnaire. Multivariable logistic regression was used to evaluate the association between *T. parva* parasitaemia and animal, farm and village-level factors. The prevalence of *T. parva* parasitaemia was 15.9% (95% CI = 0.13–0.19) and 31.6% (95% CI = 0.28–0.36) in wet and dry seasons, respectively. All cattle were sero-positive. *T. parva* parasitaemia was significantly associated with age of the animal, sampling season, and study village. All 130 cattle owners interviewed (100%) reported that they could easily recognise ECF and the vast majority (97.7%) identified swollen lymph nodes as the most prominent sign. At least 70% reported to understand the involvement of *R. appendiculatus* in ECF transmission. The use of both commercial drugs and herbal medicines for ECF treatment was reported by 54.6% of cattle owners. Among commercial drugs reported, the most commonly used was alamycin 300 mg/ml (oxytetracycline dehydrates). Tick control by hand spraying was reported by the majority (90.8%) of cattle owners and less than half (45.4%) reported to vaccinate their cattle. This research provides evidence of widespread *T. parva* infection across Monduli District, and baseline information on seasonal occurrence. This information can assist the planning of more appropriate control strategies in pastoralist communities both now and into the future as predicted climatic changes progress in the region and potentially influence ECF occurrence and transmission.

1. Introduction

East Coast fever (ECF) is a fatal tick-borne disease of cattle that occurs in eastern, central and southern Africa (Norval et al., 1991; Kivaria, 2006). The disease is caused by the intracellular protozoan parasite, *Theileria parva*, and is transmitted by the brown ear tick (*Rhipicephalus appendiculatus*) (Gachohi et al., 2012; Abdela and Bekele, 2016). It is characterised by marked peripheral lymphadenopathy, high

Abbreviations: COSTECH, Tanzania Commission for Science and Technology; EDTA, ethylene diamine tetra acetic acid; ECF, East Coast fever; FAO, Food and Agriculture Organization of the United Nations; ICC, intra-cluster correlation coefficient; IFAD, The International Fund for Agricultural Development; IPCC, Intergovernmental Panel on Climate Change; MLD, Ministry of Livestock Development; PCR, polymerase chain reaction; PIM-ELISA, polymorphic immunodominant molecule enzyme-linked-immunosorbent assay; SUA, Sokoine University of Agriculture; TPRI, Tropical Pesticides Research Institute; TVLA, Tanzania Veterinary Laboratory Agency

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fever, respiratory distress and emaciation, and is associated with high mortality and morbidity in susceptible cattle (Morrison, 2015).

East Coast fever is an important disease that constrains development of the cattle industry in Africa (Norval et al., 1991; Gachohi et al., 2012; Gul et al., 2015). Annual economic losses associated with the disease were valued at US$ 168 million twenty-five years ago based on an estimated 1.1 million cattle deaths per year (Mukhebi et al., 1992). Current losses due to ECF are likely to be much higher given the disease remains a widely reported and leading cause of cattle death. Certainly, the disease is considered to be the major disease threat to cattle production in Tanzania (Swai et al., 2007; Laisser et al., 2017) and its importance as a cattle disease remains well documented today (Chenyambuga et al., 2010; Kazungu et al., 2015; Laisser et al., 2017). In Tanzania, ECF accounts for around 40% of livestock deaths each year, costing the livestock sector around US$ 43 million annually (Mtei and Msami, 1996; Mcleod and Kristjanson, 1999). Moreover, mortality rates as high as 80% have been documented in indigenous breed calves that are unvaccinated (Homewood et al., 1987).

East Coast fever incidence varies depending on agro-ecological zone and livestock production system (Gachohi et al., 2012; Gul et al., 2015). Agro-ecological zones differ with regard to climate suitability for the vector, with lowlands known to be more suitable for tick development and survival than highlands (Rubaire-Akiiki et al., 2004; Gachohi et al., 2012). Livestock production systems influence exposure of cattle to different ecological characteristics. Like other pastoralist communities in eastern Africa, the Maasai of northern Tanzania practice an extensive grazing system characterised by cattle being under constant tick exposure with little or no tick control (Homewood et al., 2006; Kipronoh et al., 2011; Byaruhanga et al., 2015). This pastoralist cattle management contributes to the development of endemic stability for ECF (Kazungu et al., 2015), a state where host, vector and pathogen co-exist in such a way that clinical disease is rare despite high exposure to infected ticks. Although endemic stability could be regarded as an appropriate approach to ECF control in pastoralist areas, the level of stability required to avoid clinical disease occurrence may not be fully achieved for cattle in Tanzania (Hezron et al., 2012), because of fluctuation in cattle exposure to infected ticks associated with changes in environmental conditions that are expected to become more variable with projected global climate change.

Global climate change is characterised by increasing fluctuations in temperature and precipitation and the frequent periods of extreme weather events seen in recent times (IPCC, 2013). These changes are expected to modify the context within which pathogens, vectors and their hosts interact (Patz et al., 1996; Githeko et al., 2000; et al., 2008; Van Den Bossche and Coetzer, 2008; Lafferty, 2009). While there have been numerous attempts to predict the distribution of human vector-borne diseases under climate change scenarios such as malaria (Githeko et al., 2000; Palmer et al., 2006; Caminade et al., 2014), dengue fever (Naish et al., 2014) and Chikungunya (Fischer et al., 2013), similar studies for cattle vector-borne diseases are rare. Some research suggests that *R. appendiculatus* is likely to experience shifts in population density and dynamics due to climate change that will lead to changes in the transmission and occurrence of ECF (Olwoch et al., 2007; Olwoch et al., 2008; Bett et al., 2017). According to Olwoch et al. (2009) climate change is predicted to influence tick habitat and distribution with expansion in some areas of sub-Saharan Africa and contraction in others. Research is needed to better understand cattle vector-borne disease patterns in a changing climate because this is essential for sustainable livestock disease reduction efforts (Baylis and Githeko, 2006; et al., 2008; Van Den Bossche and Coetzer, 2008; Thornton et al., 2009). This type of research requires obtaining quality data on climatic parameters and incidence of cattle vector-borne diseases over long periods of time in order to reveal trends in animal health in response to climate change. Due to the predicted severe climate change impacts in arid and semi-arid pastoral lands it is vital for these regions to identify options to improve current and future management of cattle vector-borne diseases (IFAD, 2010; Bett et al., 2017).

Detailed information on *T. parva* infection levels in contrasting seasons and an understanding of pastoralist knowledge, attitudes and management of ECF is needed to forecast the potential effects of climatic variation on ECF occurrence, and to guide appropriate advice to pastoralist communities in northern Tanzania regarding ECF control now and into the future. Accordingly, the objectives of this study were to estimate the prevalence of *T. parva* in cattle in wet and dry seasons, establishing a baseline for seasonal occurrence of ECF against which future disease levels can be compared, and to improve understanding of the existing management practices for ECF in pastoralist community settings of northern Tanzania. To maximise detection and improve upon most previous studies on ECF epidemiology in northern Tanzania that relied on microscopic examination of blood smears, we implemented highly sensitive and specific molecular and serological diagnostic tests in this study.

2. Materials and methods

2.1. Study area

This study was conducted in Monduli District, northern Tanzania during March to May 2015 (wet season; first round of data collection) and August to October 2015 (dry season; second round of data collection). Monduli District was selected for this study because: (i) the district experiences relatively high levels of cattle vector-borne diseases (Homewood et al., 2006; Swai and Kaaya, 2012; Haji et al., 2014), (ii) the district is homeland to pastoralist communities whose livelihoods depend largely on livestock keeping (Homewood et al., 2006), and (iii) 70% of the district is classified as lowland agro-ecological zone, with a semi-arid to arid climate that is characterised by climate variability and change including increasing drought periods and unpredictable rainfall for the past decade (Galvin et al., 2004; Msoffe et al., 2011).

Monduli District is located at latitude 3°20′S and longitude 36°15′E (Fig. 1). At the latest census (2012) Monduli District had a human population of 158,928, with an average of 4.3 people per household. The district population is estimated to be growing at a rate of 4.3% person per household (URT, 2016). The major ethnic group inhabiting Monduli District is the Maasai people (97%). The Maasai largely depend on livestock for their livelihoods, with some subsistence farming activities also practiced, predominantly in agro-pastoral communities (Theodory and Malipula, 2014). Over 95% of cattle kept in the district are indigenous (*Bos indicus*) zebu-type. Monduli District has a bi-modal rainfall pattern with the wet season occurring between March and May and the short rains occurring between November and December. The dry periods of the year are termed the short dry spell from January to February, the cool dry season from June to July and the long dry season from August to October (FAO, 2006).

2.2. Cattle owner knowledge, attitudes and practices survey

2.2.1. Selection of villages and participants

A list of all pastoralist villages in the lowland agro-ecological zone of Monduli was obtained from the Monduli Livestock Department. Ten villages were randomly selected from this sampling frame. Before survey commencement the research team visited each village to introduce the project to the village leaders and compile a list of all cattle owners. Twelve cattle owners were randomly selected per village providing a total of 120 cattle owners to participate in the cattle owner knowledge, attitudes and practices survey, and their cattle were included in the cattle survey. Ten cattle owners were not present during the second round of cattle blood collection. Therefore, to ensure complete data were available, ten additional cattle owners were randomly selected from the sampling frame for interview. Thus in total, 130 cattle owners were interviewed.