

# eo20 Climate-Driven Livestock Management Shifts and Tick Populations

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## 20.1 Expert Opinion

## 20.1.2 Climate change affects management decisions

### 20.1.1 Introduction

Climate change can affect all aspects of the tick life cycle, from altering host distributions to modulating tick development and survival. However, humans are further altering tick populations via livestock management practices as managers in turn respond to climate change. Given that livestock biomass is now nearly 15 times greater than all wild mammal biomass on Earth (Bar-On *et al.*, 2018), humans can greatly affect tick populations via livestock management. This is likely to occur through at least three pathways: (i) by altering host abundance and composition; (ii) via habitat modification due to grazing and trampling; and (iii) by altering tick mortality via tick-control methods. Thus, climate-driven changes to livestock management can profoundly alter tick populations, especially in regions such as eastern and southern Africa, where high livestock density and worsening climate changes are coupled with high tick diversity and abundance.

Human agricultural systems will be severely affected by climate change, especially in many regions of Africa, necessitating both gradual and transformative adaptations (Rippke *et al.*, 2016). One such adaptation is a shift from crop production to livestock husbandry in warmer and drier environments (Jones and Thornton, 2009), which has the potential to increase large mammalian tick hosts in these areas. Indeed, in the most arid regions of Africa, total herbivore biomass is now greater than it was 1000 years ago due to livestock increases (Hempson *et al.*, 2017). These changes could lead to increases in populations of ticks that feed on livestock when animals are untreated, or reductions when tick-control measures are applied.

Climate change is not only influencing whether humans choose livestock over crop production, but also which species they choose to rear. For example, one analysis across ten African countries showed that farmers are more likely to select goats and sheep instead of cattle in warmer regions (Seo and Mendelsohn, 2007).

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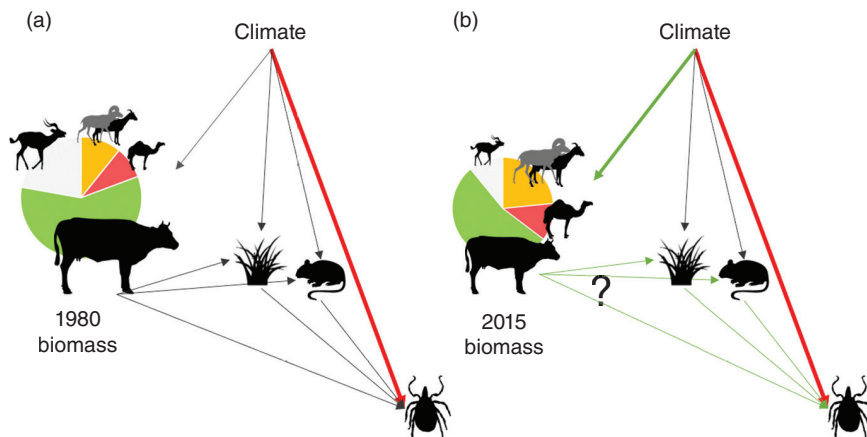
Amid increased drought risk, many livestock owners are also investing in camels and goats that can tolerate water variability more effectively than cattle, especially in the East Africa region (Kagunyu and Wanjohi, 2014). For example, between 1980 and 2015, cattle populations across Kenya declined by 25%, concurrent with 75% increases in sheep and goats and a 13% increase in camels (and a 68% drop for wildlife) (Ogutu *et al.*, 2016) (Fig. 20.1). Local-scale changes were more extreme: in Laikipia county, an area heralded for successful wildlife conservation and livestock ranching, wildlife trends varied by species (six increased, nine decreased), cattle remained relatively unchanged (+7%), sheep and goats increased by 260%, and camels increased by an astounding 18,000% (Ogutu *et al.*, 2016). These dramatic shifts towards drought-resistant species could substantially affect ticks and their pathogens across large swathes of land, especially given that livestock vastly outweigh wildlife in this region and globally. Thus, while direct climate effects on ticks and their pathogens are important, it is also critical to consider the effects on the many additional host-mediated pathways that affect ticks and their pathogens (Fig. 20.1).

### 20.1.3 Humans affect ticks and pathogens via livestock management

#### *Altered host composition*

Rising global wildlife losses have yielded secondary parasite losses, especially for parasites that specialize on few host species (Dunn *et al.*, 2009). For example, specialist ticks decline with final wildlife host reductions, often as a result of fragmentation and agricultural intensification (Ogrzewalska *et al.*, 2011; Esser *et al.*, 2019). Conversely, ticks like *Rhipicephalus (Boophilus) microplus*, which feed predominantly on cattle, have expanded globally with cattle movements (Nyangiwe *et al.*, 2018; Silatsa *et al.*, 2019). Thus, increased livestock husbandry has likely fuelled increases in tick species that prefer livestock and concurrent decreases in certain wildlife specialists.

Although generalist tick species are thought to be influenced more strongly by climatic variables than host ranges (Cumming, 1999), dramatic changes in host composition and/or biomass have notable effects on generalist tick communities as well, and this effect varies according to climatic context (Titcomb *et al.*,

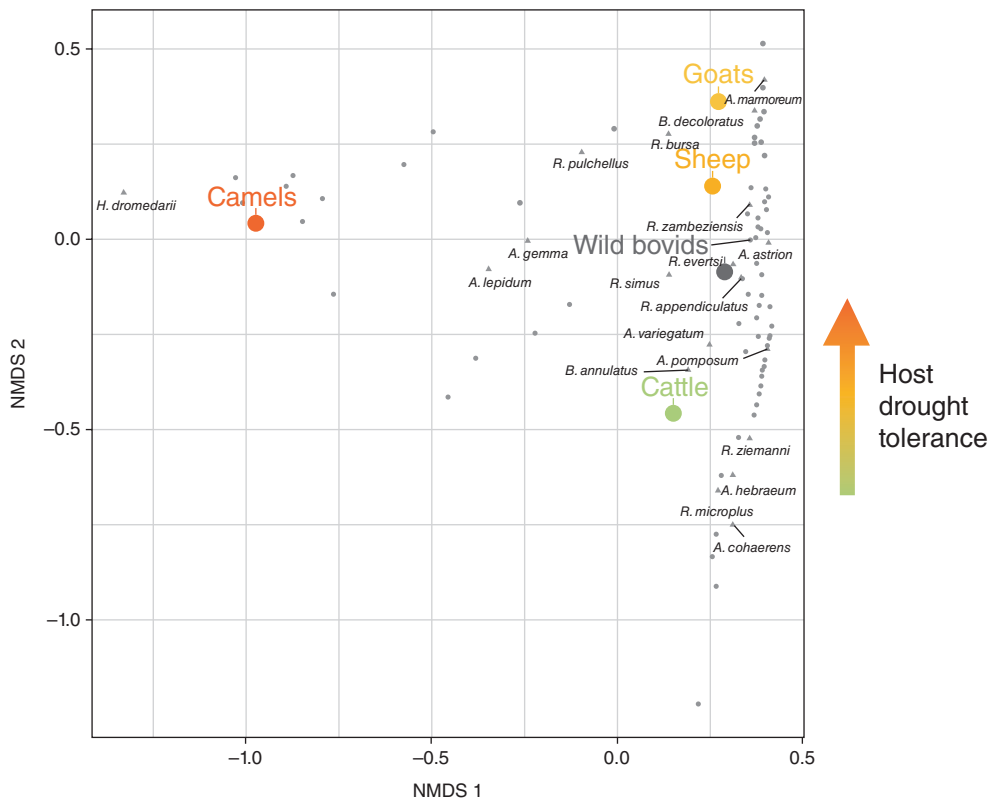


**Fig. 20.1.** Conceptual illustration of the intertwining effects of climate on hosts and ticks. (a) Direct climate effects on ticks (red arrow) form the primary basis of tick population projections, but indirect pathways (black arrows) are also important. (b) Recent drying trends in Kenya have substantially shifted large mammal composition over the past 35 years, yet these – and future – effects on ticks and pathogens (green arrows) are unknown. (Data for pie charts from Ogutu *et al.*, 2016. Author's own figure.)

2017). Furthermore, continent-level tick–host records suggest that different livestock species are parasitized by different arrays of ticks, although tick preferences will vary on local scales (McCoy *et al.*, 2013). For example, associations reported by Cumming (1998) demonstrate potential tick community differences among hosts, although replication across locations is needed (Fig. 20.2). If, on these local scales, livestock composition becomes increasingly dominated by sheep, goats and camels as opposed to cattle, ticks that thrive on these animals may increase (e.g. *Hyalomma dromedarii*; Fig. 20.2) while those that maximize their fitness on cattle may

decrease (e.g. *Rhipicephalus zambeziensis*, *R. microplus*; Fig. 20.2). More generalist tick species (e.g. *Amblyomma gemma*, *Rhipicephalus pulchellus*; Fig. 20.2) are more likely to track overall host populations (in the absence of tick-control methods). However, more data on tick preferences, ability to adapt to alternative hosts and changes to the broader wildlife community across locations will be needed to make accurate predictions of tick compositional shifts in response to host compositional shifts.

Even when generalist tick populations are independent of host compositional changes, remaining host biology can affect the pathogens



**Fig. 20.2.** Non-metric multidimensional scaling plot of host and tick species from records reported in the literature (data reported from Cumming, 1998; important ticks identified from de la Fuente *et al.*, 2008). To control for uneven sampling effort, host species records were scaled by the total number of records for each host. Tick communities on camels are more different, and therefore more distant, than communities parasitizing other herbivores, while more subtle differences in tick composition for cattle, wild bovids, and sheep and goats are reflected by their relative proximity on the plot. It is important to note that because records are collected on a continental scale, associations are also subject to geographic variation in host availability. Genera on the figure: A., *Amblyomma*; B., *Boophilus*; H., *Hyalomma*; R., *Rhipicephalus*. (Author's own figure.)

vectored. ‘Dilution’ and ‘amplification’ effect studies have shown that host community composition changes that shift overall pathogen competency can either reduce or increase pathogen risk. If different livestock species vary in pathogen competence, then pathogen distributions will shift when host composition changes. For example, in addition to parasitizing many wild mammals, *Rhipicephalus appendiculatus* can feed on cattle, sheep and goats (Cumming, 1998), but only cattle and buffalo are affected by and considered to be competent hosts for the vectored pathogen *Theileria parva*, which causes East Coast fever (Bishop *et al.*, 2004). Thus, replacing cattle with sheep and goats may reduce *T. parva* prevalence in these ticks (while potentially increasing prevalence of other pathogens).

#### *Habitat modification*

Two consequences of growing livestock biomass and shifting livestock species composition on tick life cycles are the secondary effects on vegetation and small mammal hosts (Fig. 20.1). Given that cattle, goats, sheep and camels occupy very different dietary niches (Rutagwenda *et al.*, 1990), it is possible that livestock composition shifts will impact vegetation cover, which has substantial effects on tick survival (e.g. Perry *et al.*, 1990). Furthermore, given that small mammals also respond to livestock management practices more strongly in arid contexts (Young *et al.*, 2015), shifts in livestock species composition and biomass may also alter the composition of these intermediate hosts for many tick species.

#### *Altered tick mortality*

Humans also disrupt tick survival via acaricide application. This practice has been shown to have landscape-scale effects on tick populations. For example, one large-scale experimental study in Kenya demonstrated three- to fourfold reductions in questing tick abundance in locations where treated cattle grazed (Keesing *et al.*, 2013). Similarly, other studies have found reductions in questing tick abundance after grazing acaricide-treated versus non-treated sheep. However, this was most effective when wildlife populations were low and will likely introduce toxins that impact other invertebrates and birds feeding on ticks (Keesing *et al.*, 2013; Van Wieren *et al.*, 2016).

Although acaricides are easily applied to a variety of livestock species, they are also costly to farmers who must balance tick-borne disease risk with chemical prices (Mugabi *et al.*, 2010). If acaricide application (or other control method) varies among livestock species, tick populations will likely reflect livestock compositional shifts. Furthermore, rising global concerns about growing acaricide resistance among certain tick species – notably the important cattle tick, *R. microplus* (Abbas *et al.*, 2014) – demonstrate the need for alternative tick-control strategies, avoidance of overapplication and better understanding of the effects across different livestock species and contexts.

When livestock act as competent hosts, management efforts such as vaccination or acaricide spraying can impact pathogens across a landscape. However, tick-control success will also depend on spatial overlaps with wildlife reservoirs. For example, buffalo are important wildlife reservoirs for several tick-borne diseases that strongly affect cattle, especially East Coast fever and corridor disease (de la Fuente *et al.*, 2008). However, if climate changes shift livestock populations toward animal species that either share fewer tick species with, or are less susceptible to, pathogens circulating among wildlife, then disease-control methods in these animals may be more easily achieved.

## 20.2 Future Projections

### 20.2.1 Key questions and considerations

Climate-driven alterations to underlying host community composition, population size and tick-removal strategies can substantially affect ticks and their pathogens across landscapes. However, this will likely vary by tick species, climatic region and economic factors. Making projections for future changes to tick populations and pathogen prevalence as a result of these shifts will require answering many questions, including:

1. To what extent do ticks select among different livestock species? How do livestock competencies vary for different tick-borne pathogens?
2. Do tick-control practices vary among livestock species, and to what extent do tick species vary in acaricide resistance?

3. How do livestock species alter vegetative structure and intermediate host communities that further affect tick survival?

4. To what extent do livestock species share ticks and pathogens with wildlife?

### 20.2.2 Climate futures and near-term projections

Tick population models based on climatic variables have shown range shifts for many economically important species across Africa (Olwoch *et al.*, 2007). However, agricultural responses to climate change likely have under-appreciated secondary effects on ticks and their pathogens, especially in regions where livestock, wildlife and tick populations are high. Indeed, recent rainfall reductions in East Africa have already contributed to strategic livestock shifts (Kagunyu and Wanjohi, 2014) and projected increases in extreme weather events (Niang *et al.*, 2014) will continue to force farmers to make management decisions, such as transitioning to livestock from crops, or shifting from cattle to goats and sheep.

In East and Central Africa, long-term climate projections are at odds with recent drying trends; warmer and wetter climates are predicted for the latter part of this century (Niang

*et al.*, 2014). Meanwhile, northern and southern regions of the continent are expected to experience significantly reduced rainfall (Niang *et al.*, 2014). Together these shifts will alter land suitability for different agricultural activities, potentially driving substantial livestock transitions in arid regions (Rippke *et al.*, 2016). While more integrative research is needed to better predict the specific effects of climate-induced agricultural shifts on tick and pathogen populations, increased livestock biomass in dry regions could have positive effects on generalist ticks by providing additional hosts, but negative effects by reducing vegetation cover. Shifts from cattle to other livestock species, paired with growing wildlife losses, will likely lead to corresponding shifts in tick communities and pathogen prevalence that reflect the new host assemblage. These effects will be context-dependent, subject to modification by tick-control strategies and unlikely to apply systematically across all tick species.

Future climate changes will continue to have direct effects on tick biology and pathogen transmission. However, given the enormous magnitude to which humans now control the movement and density of suitable tick hosts and vegetation via livestock management, it is critical to consider how human adaptations to climate change will further impact ticks and tick-borne diseases.

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