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Spatial Biopolitics of Tick-Borne Disease Control Practices in Laikipia, Kenya

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ABSTRACT

Tick-borne diseases (TBDs) are major constraints for wildlife, livestock production and human health. Chemical acaricides are widely promoted for the control of TBDs despite the uncertainty that farmers and state support can manage TBDs. This paper explores how spatial biopolitics related to TBDs are enacted by livestock keepers in Laikipia, Kenya. The results show that control of TBDs is the product of indigenous knowledge of pastoral farmers and western veterinary thought with two different logics, sometimes converging but often at odds. The analysis reveals power relations, tensions and contradictions emerging from an attempt to impose a western model for the management of TBDs resulting in marginalization of the pastoralists and their livestock. This paper shows that a practice-based approach, focused on situated agency, can provide an empowering way of understanding the spatial biopolitics of acaricide use and management of TBDs.

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Introduction

Livestock production, wildlife management and human health in tropical drylands of Africa are threatened by tick-borne diseases (TBDs) such as East Coast fever, anaplasmosis and babesiosis, affecting many livelihoods (Chepkwony et al. 2020). TBDs account for ~10–80% of livestock mortalities and human infections (Cleaveland, Laurenson, and Taylor 2001). Moreover, the spread of TBDs is also an impediment to livestock trade due to a possible ban on livestock-related products locally, regionally and internationally. Hence, controlling TBDs can permit higher levels of livestock production, safeguard human health and improve the livelihoods of many farmers in the tropical drylands of Africa (Minjauw and McLeod 2003; FAO, IFAD and UNICEF 2017).

In the recent past, there has been a general decline in the effectiveness of control practices of TBDs in the tropics (Walker, Klein, and Levin 2014; Wilcox et al. 2019). Livestock owners control ticks using chemical acaricides, pasture destocking and

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keeping indigenous varieties of livestock thought to be resistant to tick attacks (Walker, Klein, and Levin 2014). Although acaricide application remains a dominant strategy for tick control, it has proven to be challenging for many pastoralists (Minjauw and McLeod 2003; Walker, Klein, and Levin 2014). Mutavi et al. (2018) showed that the local pastoral farmers in Laikipia, Kenya, often prefer to use their methods – such as mixing perceived weak acaricides with crop pesticides, herbicides, fungicides and insecticides with the hope of improving their efficacy – instead of following the advice of these public extension services. The question that puzzled us is why do pastoralists dilute and mix acaricides in the way that they do – even though this goes against the advice of extension officers and veterinary experts who claim that these practices are less effective and lead to acaricide resistance among ticks?

In literature, attempts to explain these local practices of acaricide use by pastoralists have resulted in a debate between authors that conclude that local pastoralists, for whatever reason, lack knowledge, skills or awareness of correct acaricide application (a 'blame the victim' argument in behavioral choice and social capital approaches) and authors that claim that local pastoralists have been constrained by structural forces outside of their control such as market access (a 'blame the system' argument underlying political-ecology and postcolonial approaches). The 'blame the victim' studies aiming at understanding acaricide practices by pastoralists in Africa have assumed that rational choice and cognitive factors guide individual actions and thus have mostly focused on understanding behavioral choices (Jones et al. 2016; Aguirre et al. 2019). For instance, to understand why and how pastoralists use acaricides, researchers have studied the economic, financial, educational, technical, ecological and demographic factors influencing TBDs practices (Adakal, Stachurski, and Chevillon 2013). Local acaricide practices are here often framed as a lack of knowledge and the proposed solution is therefore often to educate pastoralists and raise awareness of 'correct' acaricide application.

The 'blame the system' studies aiming at understanding acaricide practices by pastoralists in Africa have analyzed how structural factors such as finances, policies and regulatory controls affect the adoption of technologies such as acaricides by pastoralists (Mudliar and Koontz a). For example, Dzingirai et al. (2017) in their analysis of Lyssavirus in Sierra Leone, the henipah virus in Ghana, Rift Valley fever in Kenya and trypanosomiasis in Zimbabwe, suggested that exposure and vulnerability to zoonotic diseases are contextually related to wealth, gender, ethnicity, class, etc. Hence, scholars have argued that responses to zoonoses cannot be understood without taking into account the wider social and political context of the problem (Woldehanna and Zimicki 2015) as well as the structural power dynamics that favor certain practices while marginalizing others (Wallace et al. 2015). The proposed solution is often to address inequalities in society and restructure the dominant systems that create these inequalities.

In this paper, we argue that both approaches are problematic. Instead of framing acaricide use by pastoralists as a malpractice or framing acaricide use as a marginalization effect, we start from the assumption that pastoralists are 'knowledgeable' and 'capable' to solve their everyday problems within the limits of the environmental, normative or social-political context in which they operate (Giddens 1984). This draws attention to the situated agency of pastoralists and the way that they position themselves

with regard to technological interventions – such as acaricides – that promote a certain type of development. Hence, pastoralists may have very good reasons for doing what they are doing as long as we are willing to take their perspectives seriously (Waller and Homewood 2017; Dong et al. 2011). So-called 'malpractice' or 'misuse' of acaricides could in fact represent the enactment of a different rationality with regard to what constitutes 'good' management of zoonotic diseases (after Long and van der Ploeg 1989). In this article, we will investigate the so-called 'spatial biopolitics' of acaricide use associated with these clashing worldviews and we are particularly interested in how these are enacted in practice.

Analytical Framework

The concept of spatial biopolitics offers an analytical lens that allows us to understand how a new technology – such as acaricides – is part of a larger political project that has very real effects on people and animals by organizing space in particular ways. Biopolitics was introduced by Foucault in 1977 (140) and it is "to ensure, sustain, and multiply life, to put this life in order." Although biopolitics is mostly used in relation to populations instead of space, it has increasingly been taken up in spatial studies (Rutherford and Rutherford 2013; Hinchliffe et al. 2013). Drawing on the work of Blue and Rock (2011), we define spatial biopolitics as the classification and evaluation of life as it unfolds in complex, technologically mediated landscapes. In our research, the prefix 'spatial' points to the boundaries, borders and barriers in the landscape that enable or constrain the mobility of people and animals. The 'politics' refers to the surveillance, monitoring and measures that subsequently serve to delineate safe and healthy space from wild and unsanitary spaces thereby excluding and marginalizing certain groups of people and animals.

The analytical approach that we used to study spatial biopolitics is inspired by the "What is the Problem Represented to be Approach," a post-structuralist approach that was developed by Carol Bacchi (2009) and further developed in more recent years together with Susan Goodwin (Bacchi and Goodwin 2016). According to this approach, and in line with what others have also observed (Entman 1993), our framing of problems shape our framing of possible solutions to these problems, as well as our framing of groups or people, objects or places that are held responsible for creating the problems. As a consequence the representation of a problem has very real consequences for certain people, objects of spaces in terms of what can be thought and what can be said (discursive effects); how they are thought of and how they are made to think about themselves (subjectification effect) and how they are treated and how this treatment impacts the material impact on their lives (the lived effects) (Bacchi 2009).

In relation to spatial biopolitics, this means that we asked ourselves what the problem of zoonotic diseases is represented to be if the solution that is presented is the use of acaricides. To do so, we worked backwards and traced how this solution and its associated problem representation has come about. In other words, we conducted a genealogy of the problem representation tracing it back in time and identifying the moments when key decisions were made. We paid special attention to the underlying spatial categories and binaries –civilised/uncivilised, safe/unsafe, sanitary/unsanitary,

legal/illegal – that are associated with this problem representation and how these categories and binaries have come about. Tracing the genealogy of the problem representation also gave us insight into the competing problem representations that were present once upon a time as well as the power relations and the wider context of institutions that allowed this particular problem representations to become dominant and taken for granted and last but not least, it gave us insight into the silences that are created by marginalizing some groups while benefitting others (Bacchi 2009).

If we would have stopped here, we would have been back to the 'blame the system' argument. As mentioned in the introduction, we wanted to bring a situated actor-oriented perspective to the study of spatial biopolitics– without falling into the 'blame the victim' trap. To do so, we drew on work that shows that hegemony is not always complete and alternative problem representations might still (partially) exist in subaltern spaces (Long and van der Ploeg 1989). And even Michel Foucault (1977, 95–96) argued that "where there is power there is resistance" meaning that marginalized people will try to find ways to express their situated agency. So even though spatial biopolitics can marginalize certain groups of people, this does not mean that marginalized groups are necessarily powerless victims. Practice-based approaches have analyzed the ways in which marginalized groups interpret, translate, appropriate, ignore, utilize and re-negotiate planned interventions, projects and policies – representing dominant problem representations – in their everyday practices (Long and van der Ploeg 1989; Scott 1989; Cleaver 2017; Arts et al. 2014). This expression of situated agency can take various forms. On the one hand, people may actively resist dominant problem representations and their institutional and technological solutions by means of lethargy, evasion, feigned ignorance or 'sloppy' work (Scott 1989). On the other hand, people can also use their situated agency in the form of institutional bricolage (Cleaver 2017) to pragmatically adopt and/or adapt those parts of the dominant institutions and technologies that suit them while ignoring the parts that do work for them in practice. By mapping the practices and interactions of the different groups of people with regard to acaricide use, we inferred the alternative problem representations that underpin them. As each of these problem representations has a spatial element to them, this implies a landscape of different practices that do not cohere but still fit together – for better or for worse. By investigating how people use their situated agency to navigate the landscape of practices, we could get better insight into the way in which spatial biopolitics are enacted in practice.

Methods

The study was conducted in Laikipia County, Kenya, located at 0°18′ S and 0°51′ N, 36°11′ and 37°24′ E. The county is semi-arid and occupies an area of 10,000 km^2. The human population was $>$ 520,000. The area is a wildlife conservation "hotspot" and attracts many actors including the public and private health-related institutions with divergent views under the domains of wildlife and livestock production (Allan et al. 2017; Chepkwony, van Bommel, and van Langevelde 2021). Hence, the entry of new actors in the control of TBDs in the area is likely to tilt the power balance and impact collaborative efforts. Two main farming systems in the area comprise the intensively

managed commercial ranches owned by mostly descendents of settlers with a few by pastoral communities involved in livestock ranching, wildlife conservation and eco-tourism. Secondly, there is the semi-intensive pastoralism by nomadic pastoralists with strong social and communal norms (Mugambi, Wesonga, and Ndungu 2012). The communal ranches are collectively owned by pastoralist communities and with varying degrees of management through customary institutions. The commercial ranches are mostly owned by descendants of former settlers (Lesorogol 2003). We purposively chose four study sites: two commercial ranches, Ol Pejeta Conservancy and Loldaiga Hills, and two pastoral areas, Naibunga and Segera-Endana. In the pastoral areas, the grazing areas are open and communally utilized for livestock grazing. Conversely, the commercial ranches have clear boundaries demarcated by fences which separate pastoralist livestock from commercial livestock but still allow wildlife to move through. The two dichotomous farming systems adequately replicate what happens in the wider area and conceal important information on TBDs, critical for understanding and transforming the processes.

Study Design

We employed semi-structured interviews with 62 participants of male and female gender with prior informed consent, participant observation, focus group discussions (FGDs) and archival document analysis to understand how control of TBDs and governance is enacted by livestock owners in Laikipia County from February 2018 to September 2019.

The participants varied in age distribution from 18 to 65 years, prime livestock herding age for herders or workers. The literacy levels for the interviewees ranged from illiterate herders up to those from tertiary level institutions. Initial study questions which guided data collection were developed by the authors and the interviews were conducted in Kiswahili and/or English languages; each interview ranged from one to one and a half hours. Interviews and discussions were conducted in private locations, usually identified by the participant(s) at his/her convenience on a scheduled date after verbal consent was sought from each anonymised participant. All interview data were recorded in field notebooks as "statements" based on the themes and existing literature on TBDs in Kenya. The discussions consisted of demographic questions, questions related to control practices for TBDs, challenges and mitigation, familiarity with TBDs, extension services and networks, knowledge sharing and questions related to the livestock-wildlife encounter. Since we were not interested in making generalizations about the study, we looked for an information saturation point at which no new information was further generated (Saunders et al. 2018).

We observed the acaricide application process vis-a-vis the status of the equipment used (i.e., broken, leaking), use of personal protective equipment and disposal of acaricide and packaging materials (Adakal, Stachurski, and Chevillon 2013). We took photographs to complement the field observations. We hosted three reflective FGDs involving the representatives of the pastoralists-grazing committees, livestock managers of ranches and institutions operating in the locality to evaluate responses from the participants.

Finally, we employed document review (historical books, journals, reports) to map the historical context which enabled us to understand how land uses, privatization and livestock management practices, discrepant inequalities and the situated agency of the main pastoralist farmers were enacted in the area (Lesorogol 2003; Mizutani et al. 2005; Chepkwony, van Bommel, and van Langevelde 2018; Mutavi et al. 2018). We used the archived documents stored in government offices, local libraries and online searches to map the genealogy of the zoonotic disease management and the enactment of the discrepant power relations (biopower) by actors. We considered parliamentary issues on disease control as the political class is responsible for policy formulation and legislation and impact disease management and governance. The archived documents contained information on land tenure systems, maps on old stock routes, reports of disease control initiatives and past policies.

Because of the iterative nature of the study, we coded our narrative accounts, review of documents, field observation notes and the FGDs into the three concepts: *context*, *practices* and *interactions*. Patterns and linkages between quotes, themes and existing literature were then explored in-depth to identify areas of convergence and divergence, and how these themes and linkages shape the historical contexts, practices and interactions relating to the control of TBDs in different farming domains.

Findings

Historical Context of the Control of Zoonotic Disease in Kenya

The management of zoonoses, especially tick control, in Kenya cannot be understood without taking the historical context of colonialism into account. It is during this period that the assumed dichotomy between "traditional" pastoralism and the "modern" livestock sector emerged and policies on zoonoses became interlinked with boundary maintenance and conflicts over space (Davis and Sharp 2020). Before the British colonization, Laikipia was under pastoralism, primarily by Maasai and Samburu communities (Wiesmann et al. 2000). However, under British colonialism, Laikipia became very popular among settlers that were interested in cattle ranching (Morgan 1963), leading to large-scale relocation of the Maasai in favor of European settlement.

The European commercial producers did not know how to live with zoonoses as an unavoidable part of the Kenyan environment in the way the pastoralists had always done. They perceived zoonoses as something that had to be battled and preferably, to be completely eradicated (Waller 2004; Waller 2012). White commercial producers feared that the uncontrolled movement of pastoralists' livestock would spread TBDs, infecting their stock jeopardizing the capital that they had invested in them. As the settlers started to import exotic varieties of cattle and cross-breed them with local varieties, the risk of zoonoses increased because the imported breeds were more vulnerable to these diseases. With respect to the local varieties, Waller (2004, 49) states that already in 1920 more than 50% of the settler-owned cattle were cross-breeds and this increased to just under 75% by WWII. The exotic varieties of cattle were also more expensive (Waller 2012). Commercial cattle ranches called on the policymakers, researchers and veterinarians to combat TBDs to eliminate the threat (Waller 2004).

To control the spread of these zoonoses, quarantine "barriers" were erected to protect the herds of the settlers against infection emanating from the pastoralists herds. In the early 1920s quarantine was the only way to control foot and mouth disease and bovine pleuro-pneumonia (Waller 2012). Quarantine was intended to restrict movement of cattle unless very strict rules and regulations had been met. Animals that were suspected of having become infected with zoonoses were slaughtered, with or without compensation. The Veterinary Department assumed that TBDs were everywhere, imposing a blanket quarantine for the whole country. Quarantine boundaries prevented pastoralists from using their traditional stock routes and also denied them access to water and pasture (Waller 2004; Waller 2012). The colonial regime tried to prevent illegal migration and control movement using "branding, counting, and registration" (Davis and Sharp 2020, 5). The colonial zoonoses control forced the colonial government to assess the relative value of pastoralism versus colonial stock-keeping and led them to prioritize colonial practices while at the same time marginalizing pastoralist practices (Porter 2016; Waller 2012). This policy turned pastoralists into subjects that needed surveillance, 'control' and boundaries to contain them. Some of this was intentional as the British-Kenyan protectorate regime wanted to suppress "pernicious pastoral proclivities" (Governor Belfield 1913, in Sorrenson 1968, 219). To collect taxes, the government needed sedentary, productive and taxable growers, instead of the migratory pastoralists that seemingly did not contribute to the economy and were difficult to manage for a state (Waller 2012; Davis and Sharp 2020). So the restrictions on movement and surveillance were not only put in place because of disease control but these were also part of a larger and systematic program of civilization and a pre-determined state formation.

In practice, the colonial government could not enforce the quarantine measure in the entire country due to the scarce resources and consequently the blanket quarantine caused trade depressions. Because trade was no longer feasible, pastoralists could not sell their cattle and therefore they were also not able to pay their taxes. Instead of imposing blanket quarantine, areas were categorized, segregated and labeled 'clean' or 'dirty' depending on the presence of TBDs (Waller 2012; Davis and Sharp 2020). Areas where ticks were endemic, were described in colonial writing as 'dirty', whereas in areas where ticks could not thrive or diseases had been eradicated, were described as 'clean'. Pastures could, it was believed, be 'cleansed' or kept 'clean' by regular dipping of livestock to kill infective ticks. The pastoralists cattle were thus viewed as the main sources of infection and were categorized 'dirty' and therefore fences were created to keep them out or separate them from the colonialist's cattle, presumed uninfected and categorized as 'clean', and needed to be protected by fencing them in. It was thought that this would break the chain of transmission by stopping the zoonoses from spreading and would protect the future of colonialist cattle ranching. The dichotomy between 'clean' and 'dirty' was stark and legally manifested in the way they managed fences, roadside dips and quarantine stations. Moreover, the difficulties and expense of control posed by a patchwork of endemically stable (otherwise 'dirty') and unstable (otherwise 'clean') areas were obvious (Waller 2004; Waller 2012; Davis and Sharp 2020).

The pastoralists neither accepted the policies of the colonial veterinary department nor shared the assumptions underlying these policies. For the pastoralists, the zoonoses were part of the environment and instead of eradicating it, they saw them as something

to live with. Their management strategies allowed them to endure the zoonoses by building up herds to allow losses, selecting migration patterns that allowed them to prevent infection and recognition that continued exposure could allow cattle to develop herd immunity. Ticks were controlled by close grazing of a succession of animals, pasture was frequently burned, and dangerous areas were avoided. Endemicity allowed cattle to develop resistance to epidemics and those that became immune to zoonoses were highly valued. In this pastoralist worldview, fences, roadside dips and quarantine did not make sense and instead were seen as an unwelcome limitation on migration that pastoralists had tried to avoid as much as possible (Waller and Homewood 2017; Davis and Sharp 2020).

The influence of colonization in Laikipia is still visible today. The population consists out of descendants of the original European settlers and ex-pats as well as various pastoralist communities. Some commercial ranches combine commercial cattle ranching with wildlife conservation and ecotourism, while others have converted completely to wildlife conservation. In addition to the commercial ranches, there are also several communally owned 'group ranches' that are used by pastoralists.

The commercial and the communal ranches seem quite similar. They both share their environment with wildlife species that frequently move through the area. However, commercial and communal ranches are very different from their livestock management perspectives. In Laikipia, there is no official policy for livestock management and both the commercial and communal ranches can decide on how they want to manage their livestock. In practice, this means that due to historical, political and economic factors the differences in resource management and tick control are stark (Yurco 2017).

Management of Ticks Based on the Logic of Eradication

Commercial ranches often combine livestock production with nature conservation and ecotourism, using rotational pasture management within the ranch as well as management of ticks or vaccination schemes (Yurco 2017). Furthermore, commercial ranches work within an economic framework focused on the market value of the stock, necessitating a dire need for the protection of valuable animals and the general improvement of stock quality. Hence, ranches control TBDs using a system of 'cattle spraying' which involves a systematic application of chemical acaricides to eradicate ticks and treatment of livestock. Acaricides must be applied universally and spraying must be carried out weekly to be effective.

So as practice, commercial ranches rely on highly mechanical infrastructure for regular livestock 'spraying' to prevent cattle from becoming infected with TBDs. We observed that at the ranches, livestock are sprayed weekly but occasionally a spike in tick loads in livestock may warrant a reduction on the application intervals to less than five days. Firstly, the cattle were rounded up and mustered into a cattle yard. Then one by one the animals were herded into an increasingly narrowing cattle race that was lined by strong poles. The spray race can be described as a modernized dip, where cattle walk through a structure where livestock is sprayed with acaricides using high-pressure nozzles directed to all parts of an animal's body. The tunnel construction allows for continual stock movement through the spray race. After they left the spray race, the

animals entered a second cattle yard with a sloping concrete floor that allowed for the collection and possibly recycling of the acaricides that dripped off the animals after spraying. The passageway into and out of the spraying cubicle was blinded by a cotton sack to prevent excessive de-ionisation of the acaricides and possible aerosol poisoning of the workers. Running of the spray races was technically quite demanding and operators had to be correctly trained to make sure that the spray race functioned properly.

We observed that ranches consistently used one brand of acaricide, Triatix, a variant of Amitraz, to prevent resistance in ticks, as illustrated by a livestock manager: "*We have consistently used Triatix for many years and we do not have problems with it. We buy them directly from the manufacturers in large quantities to reduce costs and ensure quality.*" The application of acaricides in the ranches is based on the directions of the user manuals and the advice of the livestock management teams professionally trained on livestock husbandry. To mix their acaricides, we observed that the employees of the ranches used calibrated equipment, clean water and often boosted the concentrations of the acaricides by adding more chemicals regularly as the cattle were being sprayed. Consequently, TBDs were prevented because of the reliability of the acaricide treatment.

The spray race is a more advanced and technological-oriented system in which elaborate infrastructure is needed so that disease control becomes a technocratic activity of biomedical control, where ranch owners rely on technology and control of TBDs protocols in their livestock. Similar to colonial times, the commercial ranches are "protected, clean spaces in the landscape" where western veterinary knowledge is applied for controlling TBDs (Waller 2004). Commercial livestock keepers are constantly responding to TBDs with strict tick treatment, fencing and/or boundary control to keep potentially infected livestock out.

Management of Ticks Based on the Logic of Herd Immunity

Pastoralists in Laikipia are mostly living in communal ranches, dating back to the early 1970s when it was thought that this would support pastoralists by giving them autonomy. The land is owned collectively by several clans or families (Fox 2018). Diversification has always been an important livelihood strategy for pastoralists and some heads of the household have moved to towns to look for employment thereby leaving the herding of their livestock up to other members of the community. This has led to institutional changes within pastoralist communities in which nowadays herdsmen are hired by the household for a monthly fee to provide herding services. This means that for some households' livestock keeping has become an investment instead of subsistence.

Traditionally pastoralists have managed and treated zoonoses based on their experiential knowledge, which is strongly linked to their spiritual practices and their relationship with their environment. In their worldview, there is no clear distinction between people, animals and the environment. As such human and animal life and the environment are interlinked and contrary to the western way of separating these forms of life into neat categories, the pastoralists tend to see them all as connected. Livestock is not only a livelihood activity but their relationship with the animals is also part of "their traditional belief systems, stories, songs" and it is integrated into their culture as well as

into their everyday ways of being (Davis and Sharp 2020, 5). Livestock is an investment, but it is also the basis of their social network, their cosmology and their subsistence. In this pastoral life world, diseases are part of all of that too. Pastoralists are aware of the vulnerability of animals without acquired immunity, and traditionally used movement and controlled exposure to endemic disease as a way of protecting herds against epidemic outbreaks. Management of TBDs is predicated on the constant presence of disease and tended to work with rather than against the ecological grain. The restriction of movement-related colonization and state formation has eroded the resource base of pastoralists thereby reducing their ability to manage herd immunity and leaving their livestock at higher risk of zoonoses (Davis and Sharp 2020).

Pastoralists being pragmatists and pluralists accept western veterinary treatments if these treatments are perceived to serve their interests (Waller and Homewood 2017). Disease management is a hybrid practice, based on the plurality of knowledge and bricolage (Beinart and Brown 2013). The pastoralists that we worked with treated their livestock against ticks by hand-spraying them with acaricides in small enclosures. In the early morning hours of our fieldwork, we often encountered some pastoral farmers preparing to spray their animals before taking them out to graze. Mostly the acaricides were poured into a recycled cooking oil container of 20 liters modified by having the top part cut open. This container was then filled with water from a nearby stream. The pastoralists did not use any calibration equipment to estimate the acaricide-water ratio. They did not wear hats, protective gloves or masks but were only in their 'red' cotton clothes, gumboots or fleece jackets. We observed the livestock owners/workers as they stirred the chemical mixture gently using a tree branch. They sprayed one animal after another with two operators: one operating the hand spray and another one busily directing the "whitish" chemicals to the predilection sites of an animal that includes the tail, ears, the groin and other tick-infested body regions. While spraying the animals, we observed that the hand spray at times sputtered because of broken nozzles tied in black rubber bands, thereby spilling the chemicals out onto bodies of both people and animals.

Although hand spraying is less effective than dipping, it is cheaper and easier to organize since each pastoralist can decide on his schedule, acaricide type and mixing ratio. Pastoralists would inspect their livestock for ticks and based on their observations, they treated the animals focusing on the tick-infested body regions instead of spraying the whole body. Most of the pastoralists purchased chemicals from town or bought chemicals from informal retailers. We observed a kind of pragmatic common-sense caution in the way that the acaricides were used by the pastoralists. Most operators applied the acaricides without reference to any material or competent authority: "*I mix the chemicals based on my own experience after doing this for many years. So, I mix 5 ml of the acaricides in 20 litres of water. Based on my experience I don't need any assistance.*" Few pastoralists correctly followed the instructions and used sub-optimal concentration levels based on 'their experience'. Overall, respondents suggested that tick control had become less effective than it had been in the past, possibly because of growing resistance to the acaricides. To deal with this, they used multiple brands and frequently changed the type of acaricides.

What looks like malpractice from a western-based logic of eradication, is not so irrational when viewed from a logic of herd immunity. According to pastoralist logic

and experience, disease simply cannot be eradicated. Interventions, such as tick control using acaricides, might be required to curb undue loss but a disease-free state is not necessarily desirable. The tick management practices of pastoralists seemed to reflect this logic. What we observed was prudent stock owners making cautious and selective use of what western veterinary science has to offer, based on an assessment of how it might contribute to herd immunity and the survival of the herds, and of whether there is a rationale accorded with their knowledge and experience.

The extension officers or veterinarians confided to us that the altered practices of pastoralists were an expression of pastoralists "ignorance" or an indication of their "lack of understanding." According to extension officials: "*I don't think the pastoralists have adequate knowledge on how they prepare the acaricides, most of what they do is guesswork. They rarely seek our advice."* And indeed, a gap exists between expert and pastoralist knowledge. Pastoralists scrutinize and select rather than fully embrace western veterinary aid. In continuing to accept the limited loss to safeguard the herd and to defend the value of their system of medical knowledge by 'passive resistance', pastoralists are following the harsh logic required to maintain subsistence pastoralism under increasingly adverse conditions. According to most pastoralists: "*I have to check how many animals I have and the tick loads then I prepare the chemicals or change them accordingly since the chemicals are expensive and we have to use it well*." This response is inevitably construed as backward, apathetic and even obstructive by hard-pressed veterinarians and administrators.

Navigating a Landscape of Interdependent, Disconnected Practices

In Laikipia, the problem of controlling TBDs is embedded in the coexistence of two different kinds of practices and worldviews, one western and commercial, the other pastoralist and livelihood based system (Waller 2004). The commercial ranch owners and the pastoralists have different ways of valuing livestock and have different ideas about TBDs and the way these should be managed. "*I keep livestock since we the Maasai are pastoralists and livestock is our food, source of wealth and identity. It is our bank. I often have to deal with ticks and diseases and buy acaricides and change them frequently to increase the probability of killing ticks and during the dry season I have to take part of my stock to the ranches and the rest to Mt Kenya to save them*." However, according to most ranch managers, "*We buy the acaricides directly from the manufacturers to ensure the quality of the products and we to keep the diseases control standards high since our beef is for local and international markets. We spray our livestock using mechanized sprayraces on a weekly-basis following the directions of our professionally trained staff*." Although the livestock on the ranches is fenced in and the pastoralists livestock on the communal ranches is thereby fenced out, many pastoralists are working in both spaces and thus frequently crossing the artificial borders and boundaries (Yurco 2017).

Firstly, pastoralists are commonly hired by the commercial ranches as professional cattle herders. The practice of hiring pastoralists as professional livestock herders started when Kenya was still a British colony and when 'rangeland landowners were absentee and hired third-party pastoralists to manage their livestock' (Riginos et al. 2012). As professional herders, pastoralists are required to do what they have been doing for

generations, namely herding livestock, but at the commercial ranches, they are now required to follow western management practices. This means that they need to follow the rotational grazing schemes as determined by the manager of the ranch, making sure that all livestock is treated for tick infestation weekly in a spray race. When having some time off, many professional cattle herders return home to spend time with their families, and during their visit home, they may herd their livestock in the communal ranches based on their pastoralist logic. But as soon as they return to the commercial ranch, they need to step back into their role as professional herders. According to a pastoralist, *"I work at Loldaiga ranch but I have my livestock with the family at home and I often go home to check on how my stock is faring. I control ticks based on my experience, so I have to do what I think is best for me since the chemicals are expensive although we buy part some of it from the ranches. I use a hand-spraying machine since it is convenient to move it with our livestock during the dry season."* The boundaries that they cross while traveling from the communal ranch to the commercial ranch are not only symbolic but also material. As soon as they are back on the commercial ranch they must conform to the logic of the ranch; follow the rules and regulations applicable, which also involves different roles and responsibilities and a different way of life (Yurco 2017).

Secondly, the elders from communal ranches have the authority to negotiate agistment (synonym: lease) arrangements with the commercial ranches which allow the pastoralists to graze a predetermined number of cattle and sheep in certain allocated areas of the commercial ranches. During the dry season, this gives the pastoralist community access to additional pasture and water. Not all commercial ranches open their grazing up to pastoralists and on those that do, the conditions for grazing, restrictions on herding practices, and the number of livestock that are allowed, vary. Usually, a communal ranch is allocated a quota and livestock owners decide how to divide the quota amongst the communal ranch members (Ameso et al. 2018). In Ol Jogi and Ol Pejeta conservancy, for example, the agistment fee is 200 shillings per head of cattle and a specific area within the commercial ranch is allocated to the pastoralists. While grazing at the commercial ranch, the pastoralist livestock is obliged to adhere to the livestock management plan of the property, including vaccination and weekly dipping. According to the livestock managers in the ranches: "*I allow members of the adjacent community to bring in their livestock during the dry season for a fee based on an agreed quota determined by their grazing committee. When they come here they have to conform with our rules including how they control ticks*." On the one hand, the pastoralists welcome the grazing arrangements, while on the other hand by being allocated under grazed areas, they also feel that their livestock is being used to 'mop' up the ticks off of the pasture with resultant heavy tick loads. This is illustrated by one pastoral farmer from Endana-Segera areas: "*We don't have any other options for our animals during the dry season but to take them to the ranches to save them from severe drought although we are allocated areas with a lot of ticks, yet we still pay for it*." Furthermore, pastoralists feel wholly negative about having to pay pasture and water that they consider to be theirs according to customary rights.

These two examples show that pastoralists navigate the landscape of disconnected practices in Laikipia by pragmatically adhering to the strict weekly dipping schedule when grazing on the commercial ranches, but going back to their tick management

practices when grazing in communal areas. Pastoralists realize that they no longer live entirely in a world in which they can apply their traditional management practices, but they also realize that the world that they live in also does not allow them to fully adopt western practices either. The western way of tick control comes with enclosing pasture and it comes with the individualization of land and water resources. Among pastoralists, sedentarisation is seen as the last survival strategy available to community members that have lost their livestock and thus it is not the preferred option. Although permanent settlement is now increasingly becoming an investment for community members that moved to towns in search of employment and who can now afford to hire herdsmen to take care of their herds, this comes at the cost of identity loss. For what is "pastoralist" when the herding family's treasure would not exist without the support of urban or out-of-country members? Thus, pastoralists hang suspended between the two types of management practices, navigating them as well as they can and using their situated agency to do so.

Discussion and Conclusion

This study analyzed the way in which spatial biopolitics in enacted in relation to the management of zoonotic diseases through acaricide use in Laikipia, Kenya. We can conclude that the problem of zoonotic diseases is predominantly represented as a problem of eradication and control. It portrays the rangelands of Kenya both as a landscape that is purifiable and supposedly to be pure (free of TBDs). In line with Davis and Sharp (2020), Hinchliffe et al. (2013) and Hinchliffe (2017), spatial biopolitics create differences by categorizing the landscape into areas that are labeled 'clean' or 'dirty' and creating boundaries to contain tick infestation and prevent spreading of TBDs. The pastoralists then become a bio-security risk; they spread TBDs and this legitimizes politics that make their movements legible and controllable using branding, counting and registration. These spatial biopolitics subjectify people and animals determining who belongs where in the landscape depending on the presence of TBDs (see also Setten 2004 and Shortall and Brown 2021 for a similar discussions) which benefits the commercial ranches at the expense of the pastoralists and their livestock (Waller 2012; Davis and Sharp 2020). We also note that the historical colonial setting of disease management is not the same as the contemporary context. We can roughly distinguish three spatial biopolitical strategies. During colonial times, *indigenous reserves* were meant to separate pastoralists from commercial ranches through displacement or resettlement in order to prioritize commercial ranches. After independence, *communal ranches* were meant to promote co-existence of pastoralists and commercial ranches in the same landscape although both were still separated spatially by means of fences. *Grazing agistment arrangements* that allow pastoralists to graze their cattle on the land of commercial ranches is meant to further overcome the spatial separation of pastoralists and commercial ranchers, although in practice the herds of the pastoralists and the herds of the commercial ranch are often still kept separate by allocating them to different parts of the ranch. So over time the logic of management of zoonotic diseases has not changed. It is still based on control of movement and a categorization of clean spaces versus dirty spaces as well as clean livestock versus dirty livestock. As such our analysis supports the

findings of Cavanagh (2014) and Li (2014) who show that spatial biopolitics is an important part of a (post)colonial governmentality. As issues of colonialism, ethnicity and state formation have been notably absent from earlier discussions on spatial biopolitics and the control of zoonoses (Davis and Sharp 2020), we suggest that these could be explored more, especially in post-colonial contexts.

We can also conclude that local pastoralists use their situated agency to deal with these spatial biopolitics. For them, zoonotic diseases are a problem of 'herd immunity'. Similar to the findings of Mutavi et al. (2018), our analysis shows that the pastoralists combine the use of acaricide with their own traditional practices of managing zoonotic diseases. However they do not adopt the prescribed practices of acaricide use directly as intended by the extension officers and agro-vets but instead they adapt these prescriptions to make them work in their local contexts. The hybridized practices resemble a form of institutional bricolage as described by Cleaver (2017). We have not found any evidence that the hybridized practices serve as means of deliberately undermining (post)colonial power relations in the area while advancing their own interests as a form of 'everyday resistance' (Scott 1989). Instead the practices by pastoralists are pragmatic and creative ways to accommodate multiple, non-coherent realities in a landscape of disconnected practices.

The effect of the spatial biopolitics is that, ironically, it has increased the vulnerability of both commercial producers, who depend on the domain of western prophylaxis for eradication, as well as the vulnerability of subsistence pastoralists, who do not fully embrace western practices and whose resource base is needed for herd immunity is being eroded (Waller 2012). So the paradox is that too much regulation and control can create the ideal conditions for an outbreak of infectious diseases, some of which may be far more serious than would otherwise have been the case (Hinchliffe et al. 2013). This has also been demonstrated in recent studies on the control of emerging and reemerging zoonotic diseases such as avian influenza (H5N1) (Brown et al. 2017) and bovine viral diarrhea (Shortall and Brown 2021). From this perspective, pastoralists, commercial keepers, livestock, ticks and spaces are co-constructing their vulnerability to zoonotic diseases in interaction (Shaw, Robbins, and Jones 2010; Ingold 2021) and policies on land use and governance of zoonoses, need to recognize this and take this into account.

The implication of these findings is that both the 'blame the system' approaches (found for example in post-colonial approaches and political ecology) as well as the 'blame the victim' approaches (found for example in institutional or social capital approaches) of analyzing and understanding acaricide use are missing the point. By ignoring people's agency, a 'blame the system' analysis of acaricide use risks reifying the disempowerment of marginalized groups by portraying them as victims of dominant systems. Similarly by ignoring the very real structural constraints that marginalized groups are operating under, a 'blame the victim' analysis of acaricide use risks overestimating peoples situated agency thereby blaming individuals for their own predicament. We argue that it is more empowering for marginalized groups to be portrayed as knowledgeable and creative in navigating the complex social circumstances that are outside their control (Long and Long 1992; Arce and Long 1999). This paper shows that a practice-based approach, focused on situated agency, can provide a more empowering way of understanding the spatial biopolitics of acaricide use and management of TBDs.

Credits

All authors participated in the conceptualization of the research proposal. RC participated in field data collection, while SVB did the document review. All authors wrote together the manuscript.

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References

Adakal, H., F. Stachurski, and C. Chevillon. 2013. Tick control practices in Burkina Faso and acaricide resistance survey in *Rhipicephalus (Boophilus) geigyi* (Acari: Ixodidae). *Experimental & Applied Acarology* 59 (4):483–91. doi:10.1007/s10493-012-9610-5.

Aguirre, A. A., N. Basu, L. H. Kahn, X. K. Morin, P. Echaubard, B. A. Wilcox, and V. R. Beasley. 2019. Transdisciplinary and social-ecological health frameworks—Novel approaches to emerging parasitic and vector-borne diseases. *Parasite Epidemiology and Control* 4:e00084. doi:10.1016/j.parepi.2019.e00084.

Allan, B. F., H. Tallis, R. Chaplin-Kramer, S. Huckett, V. A. Kowal, J. Musengezi, S. Okanga, R. S. Ostfeld, J. Schieltz, and C. M. Warui. 2017. Can integrating wildlife and livestock enhance ecosystem services in central Kenya? *Frontiers in Ecology and the Environment* 15 (6):328–35. doi:10.1002/fee.1501.

Ameso, E. A., S. A. Bukachi, C. O. Olungah, T. Haller, S. Wandibba, and S. Nangendo. 2018. Pastoral resilience among the maasai pastoralists of Laikipia County, Kenya. *Land* 7 (2):78. doi:10.3390/land7020078.

Arce, A., & Long, N. (Eds.). 1999. *Anthropology, Development & Modernities*. London: Taylor & Francis.

Arts, B., J. Behagel, E. Turnhout, J. De Koning, and S. Van Bommel. 2014. A practice based approach to forest governance. *Forest Policy and Economics* 49:4–11. doi:10.1016/j.forpol.2014.04.001.

Bacchi, C. 2009. *Analysing policy*. Malaysia: Pearson Higher Education AU.

Bacchi, C., and S. Goodwin. 2016. *Poststructural policy analysis: A guide to practice*. Berlin: Springer.

Beinart, W., and K. Brown. 2013. *African local knowledge & livestock health: Diseases & treatments in South Africa*. Woodbridge: Boydell & Brewer Ltd.

Blue, G., and M. Rock. 2011. Trans-biopolitics: Complexity in interspecies relations. *Health* 15 (4):353–68. doi:10.1177/1363459310376299.

Brown, I., P. Mulatti, K. Smietanka, C. Staubach, P. Willeberg, C. Adlhoch, D. Candiani, C. Fabris, G. Zancanaro, and J. Morgado. 2017. Avian influenza overview October 2016–August

2017. *EFSA Journal. European Food Safety Authority* 15 (10):e05018. doi:10.2903/j.efsa.2017.5018.

Cavanagh, C. J. 2014. Biopolitics, environmental change, and development studies. In *Forum for Development Studies* 41 (2):273–94. doi:10.1080/08039410.2014.901243.

Chepkwony, R., C. Castagna, I. Heitkönig, S. Van Bommel, and F. Van Langevelde. 2020. Associations between monthly rainfall and mortality in cattle due to East Coast fever, anaplasmosis and babesiosis. *Parasitology* 147 (14):1743–51. doi:10.1017/S0031182020001638.

Chepkwony, R., S. van Bommel, and F. van Langevelde. 2018. Citizen science for development: Potential role of mobile phones in information sharing on ticks and tick-borne diseases in Laikipia, Kenya. *Wageningen Journal of Life Sciences* 86–87 (1):123–35. doi:10.1016/j.njas.2018.07.007.

Chepkwony, R., S. van Bommel, and F. van Langevelde. 2021. Interactive effects of biological, human and environmental factors on tick loads in Boran cattle in tropical drylands. *Parasites & Vectors* 14 (1):1–8. doi:10.1186/s13071-021-04683-9.

Cleaveland, S., M. K. Laurenson, and L. H. Taylor. 2001. Diseases of humans and their domestic mammals: Pathogen characteristics, host range and the risk of emergence. *Philosophical Transactions of the Royal Society of London. Series B* 356 (1411):991–9. doi:10.1098/rstb.2001.0889.

Cleaver, F. 2017. *Development through bricolage: Rethinking institutions for natural resource management*. New York: Routledge.

Davis, A., and J. Sharp. 2020. Rethinking one health: Emergent human, animal and environmental assemblages. *Social Science & Medicine* 258:113093. doi:10.1016/j.socscimed.2020.113093.

Dong, S., L. Wen, S. Liu, X. Zhang, J. P. Lassoie, S. Yi, X. Li, J. Li, and Y. Li. 2011. Vulnerability of worldwide pastoralism to global changes and interdisciplinary strategies for sustainable pastoralism. *Ecology and Society* 16 (2):art10. doi:10.5751/ES-04093-160210.

Dzingirai, V., S. Bukachi, M. Leach, L. Mangwanya, I. Scoones, and A. Wilkinson. 2017. Structural drivers of vulnerability to zoonotic disease in Africa. *Philosophical Transactions of the Royal Society B* 372 (1725):20160169. doi:10.1098/rstb.2016.0169.

Entman, R. M. 1993. Framing: Towards clarification of a fractured paradigm. *McQuail's Reader in Mass Communication Theory* 390:397.

FAO, IFAD & UNICEF. 2017. *The state of food security and nutrition in the world*. Rome, Italy: Food and Agriculture Organization of the United Nations.

Foucault, M. 1977. *Discipline and punishment*. New York: Pantheon.

Fox, G. R. 2018. Maasai group ranches, minority landowners, and the political landscape of Laikipia County, Kenya. *Journal of Eastern African Studies* 12 (3):473–93. doi:10.1080/17531055.2018.1471289.

Giddens, A. 1984. *The constitution of society: Outline of the theory of structuration*. Berkeley: Univ of California Press.

Hinchliffe, S. 2017. More than one world, more than one health: Re-configuring inter-species health. In *Global Health and Geographical Imaginaries*, 159–75. Milton Park: Routledge.

Hinchliffe, S., J. Allen, S. Lavau, N. Bingham, and S. Carter. 2013. Biosecurity and the topologies of infected life: From borderlines to borderlands. *Transactions of the Institute of British Geographers* 38 (4):531–43. doi:10.1111/j.1475-5661.2012.00538.x.

Ingold, T. 2021. *Being alive: Essays on movement, knowledge and description*. Milton Park: Routledge.

Jones, N. A., S. Shaw, H. Ross, K. Witt, and B. Pinner. 2016. The study of human values in understanding and managing social-ecological systems. *Ecology and Society* 21 (1):15. doi:10.5751/ES-07977-210115.

Lesorogol, C. K. 2003. Transforming institutions among pastoralists: Inequality and land privatization. *American Anthropologist* 105 (3):531–41. doi:10.1525/aa.2003.105.3.531.

Li, T. M. 2014. Fixing non-market subjects: Governing land and population in the Global South. *Foucault Studies* 18:34–48.

Long, N., and A. Long. 1992. *Battlefields of knowledge: The interlocking of theory and practice in social research and development*. London, UK: Routledge.

Long, N., and J. D. van der Ploeg. 1989. Demythologizing planned intervention: An actor perspective. *Sociologia Ruralis* 29 (3–4):226–49. doi:10.1111/j.1467-9523.1989.tb00368.x.
Minjauw, B., and A. McLeod. 2003. Tick-borne diseases and poverty: The impact of ticks and tick-borne diseases on the livelihoods of small-scale and marginal livestock owners in India and eastern and southern Africa. In: *DFID animal health programme, centre of tropical veterinary medicine*. Edinburgh UK: University of Edinburgh.
Mizutani, F., E. Muthiani, P. Kristjanson, and H. Recke. 2005. Impact and value of wildlife in pastoral livestock production systems in Kenya: Possibilities for healthy ecosystem conservation and livestock development for the poor. *Conservation and development interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock and Human Health*, 121–32. Kenya: Pastoral Livestock Production.
Morgan, W. T. W. 1963. The 'white highlands' of Kenya. *The Geographical Journal* 129 (2): 140–55. doi:10.2307/1792632.
Mudliar, P., and T. M. Koontz. 2021. Locating power in Ostrom's design principles: Watershed management in India and the United States. *Society & Natural Resources* 34 (5):639–58. doi:10.1080/08941920.2020.1864535.
Mugambi, J. M., F. D. Wesonga, and S. G. Ndungu. 2012. Ticks and tick-borne disease control in a pastoral and an agro-pastoral farming systems in Kenya. *Livestock Research for Rural Development* 24 (5):1–8.
Mutavi, F., N. Aarts, A. Van Paassen, I. Heitkönig, and B. Wieland. 2018. Techne meets Metis: Knowledge and practices for tick control in Laikipia County, Kenya. *Wageningen Journal of Life Sciences* 86–87 (1):136–45. doi:10.1016/j.njas.2018.08.001.
Porter, N. 2016. One health, many species: Towards a multispecies investigation of bird flu. In *Humans, animals and biopolitics*, 138–53. London: Routledge.
Riginos, C., L. M. Porensky, K. E. Veblen, W. O. Odadi, R. L. Sensenig, D. Kimuyu, F. Keesing, M. L. Wilkerson, and T. P. Young. 2012. Lessons on the relationship between livestock husbandry and biodiversity from the Kenya Long-term Exclosure Experiment (KLEE). *Pastoralism* 2 (1):1–22. doi:10.1186/2041-7136-2-10.
Rutherford, S., and P. Rutherford. 2013. Geography and biopolitics. *Geography Compass* 7 (6): 423–34. doi:10.1111/gec3.12047.
Saunders, B., J. Sim, T. Kingstone, S. Baker, J. Waterfield, B. Bartlam, H. Burroughs, and C. Jinks. 2018. Saturation in qualitative research: Exploring its conceptualization and operationalization. *Quality & Quantity* 52 (4):1893–907. doi:10.1007/s11135-017-0574-8.
Scott, J. C. 1989. Everyday forms of resistance. *The Copenhagen Journal of Asian Studies* 4:33. doi:10.22439/cjas.v4i1.1765.
Setten, G. 2004. The habitus, the rule and the moral landscape. *Cultural Geographies* 11 (4): 389–415. doi:10.1191/1474474004eu309oa.
Shaw, I. G. R., P. F. Robbins, and J. P. Jones. III, 2010. A bug's life and the spatial ontologies of mosquito management. *Annals of the Association of American Geographers* 100 (2):373–392. doi:10.1080/00045601003595446.
Shortall, O., and K. Brown. 2021. Enacting and resisting biosecurity citizenship: More-than-human geographies of enrolment in a disease eradication scheme in Scotland. *Environment and Planning E: Nature and Space* 4 (2):564–584. doi:10.1177/2514848620923590.
Sorrenson, M. P. K. 1968. *Origins of European settlement in Kenya*. Nairobi: Oxford University Press.
Walker, J. G., E. Y. Klein, and S. A. Levin. 2014. Disease at the wildlife-livestock interface: Acaricide use on domestic cattle does not prevent transmission of a tick-borne pathogen with multiple hosts. *Veterinary Parasitology* 199 (3–4):206–214. doi:10.1016/j.vetpar.2013.11.008.
Wallace, R. G., L. Bergmann, R. Kock, M. Gilbert, L. Hogerwerf, R. Wallace, and M. Holmberg. 2015. The dawn of structural one health: A new science tracking disease emergence along circuits of capital. *Social Science & Medicine* 129:68–77. doi:10.1016/j.socscimed.2014.09.047.
Waller, R. 2004. Clean' and 'Dirty': Cattle disease and control policy in colonial Kenya, 1900–40. *The Journal of African History* 45 (1):45–80. doi:10.1017/S0021853703008508.

Waller, R. 2012. Pastoral production in colonial Kenya: Lessons from the past? *African Studies Review* 55 (2):1–27. doi:10.1353/arw.2012.0039.

Waller, R., and K. Homewood. 2017. Elders and experts: Contesting veterinary knowledge in a pastoral community. In *Western medicine as contested knowledge*, 69–93. Manchester: Manchester University Press.

Wiesmann, U., F. N. Gichuki, B. P. Kiteme, and H. Liniger. 2000. Mitigating conflicts over scarce water resources in the highland-lowland system of Mount Kenya. *Mountain Research and Development* 20 (1):10–15. doi:10.1659/0276-4741(2000)020[0010:MCOSWR.2.0.CO;2]

Wilcox, B. A., P. Echaubard, M. de Garine-Wichatitsky, and B. Ramirez. 2019. Vector-borne disease and climate change adaptation in African dryland social-ecological systems. *Infectious Diseases of Poverty* 8 (1):1–12. doi:10.1186/s40249-019-0539-3.

Woldehanna, S., and S. Zimicki. 2015. An expanded One Health model: Integrating social science and One Health to inform study of the human-animal interface. *Social Science & Medicine* 129:87–95. doi:10.1016/j.socscimed.2014.10.059.

Yurco, K. 2017. Herders and herdsmen: The remaking of pastoral livelihoods in Laikipia, Kenya. *Pastoralism* 7 (1):1–11. doi:10.1186/s13570-017-0086-0.