



Tick-borne pathogens in Ghana: Emerging threat to animal and human health

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ABSTRACT

Ticks continue to spread worldwide transmitting pathogens that affect animal production and human health. With the transboundary movement of herdsman and their livestock through the borders into Ghana, there is likely to be the introduction of new tick species and their associated pathogens. This review provides information on the distribution of livestock ticks and tick-borne pathogens, emphasising the threat to both human and animal health. A search was done using terms about tick-borne pathogens and livestock ticks in Ghana from Google Scholar, PubMed and Scopus. This review examined information from 47 published papers on ticks and tick-borne pathogens infecting livestock and humans. *Amblyomma variegatum* is the predominant tick species mostly infesting cattle. However, recent studies have reported the presence of other species such as *Rhipicephalus microplus*, *Hyalomma marginatum*, *Hyalomma dromedarii* and *Rhipicephalus turanicus*. Diverse pathogens of zoonotic and veterinary importance such as Crimean Congo Haemorrhagic Fever Virus (CCHFV), *Rickettsia africae*, *Coxiella burnetii* and *Anaplasma capra* have been detected in ticks, livestock and abattoir workers. There is an increasing risk of tick-borne pathogen infections in the human and animal populations. The implementation of control methods aimed at efficiently managing tick populations and halting the spread of zoonotic tick-borne pathogens is urgently needed.

1. Introduction

Ticks are obligate blood-feeding ectoparasites that carry and spread disease-causing organisms to humans and animals around the globe [1]. Particularly in developing nations, tick-borne infections have a substantial economic impact [2]. It has been suggested that tick-borne infections have increased significantly and will probably continue to increase, especially in the era of ineffective control measures [3]. Due to the rapid population growth in Africa, there is an increasing need for animal products, which has led to cross-regional livestock trade and an increase in the risk of livestock spreading infectious diseases [4]. However, disease surveillance is inadequate or non-existent close to the borders of many Sub-Saharan African nations, despite the possibility that livestock trade could aid in the transmission of infectious pathogens [5].

In Ghana, it is common to find inhabitants within various communities, especially in the northern sector, engaged in livestock rearing, either as a food source or as income [6,7]. This puts individuals at risk of infections since these animals may serve as amplifying hosts for zoonotic pathogens [8]. Ghana is bordered by countries including Côte d'Ivoire, Togo and Burkina Faso. However, with the frequent trade of livestock through the border of Burkina Faso into Ghana, there is the constant risk of ticks and tick-borne pathogens invasion. Although studies in Ghana have reported the presence of diverse tick species and the occurrence of tick-borne pathogens of zoonotic and veterinary importance, not much attention has been paid to the potential implications it will have on human health and livestock production. This review aims to present an update on livestock ticks and tick-borne pathogens in Ghana, highlighting the risk posed to human and animal health.

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Table 1

Tick-borne pathogens in tick species.

Tick species	Pathogen/Symbiont (Type)	Location (Region)	Diagnostic method	Reference
<i>A. variegatum</i>	Dugbe virus (Virus)	Greater Accra	PCR, Next generation sequencing	[121]
	CCHFV (Virus)	Upper East, Ashanti	PCR	[18,85,113,114]
	<i>E. canis</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[57]
	<i>T. velifera</i> (Parasite)	Upper East, Ashanti	PCR, Sanger sequencing	[20,96]
	<i>R. aeschlimannii</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[16]
	<i>C. burnetii</i> (Bacteria)	Upper East, Northern, Ashanti, Greater Accra	PCR	[11,16,85]
	<i>R. africae</i> (Bacteria)	Upper East, Bono East, Ashanti, Greater Accra	PCR, Sanger sequencing	[16,20,30,31,85]
	<i>Candidatus</i> Cryptoplasma californiense (Bacteria)	Upper East	PCR, Sanger sequencing	[20]
<i>Amblyomma</i> sp.	Balambala tick virus (Virus)	Greater Accra	PCR, Next generation sequencing	[122]
<i>H. excavatum</i>	CCHFV (Virus)	Ashanti	PCR	[113]
<i>H. rufipes</i>	CCHFV (Virus)	Upper East	PCR, Next generation sequencing	[18,114]
	<i>R. aeschlimannii</i> (Bacteria)	Upper East, Ashanti, Greater Accra	PCR, Sanger sequencing	[16,20,30,31,85]
	<i>C. burnetii</i> (Bacteria)		PCR	[11,16]
	<i>Candidatus</i> Midichloria mitochondrii (Bacteria)	Upper East, Ashanti	PCR, Sanger sequencing	[20,85]
	<i>R. africae</i> (Bacteria)	Upper East, Northern, Greater Accra	PCR, Sanger sequencing	[30]
<i>Hyalomma</i> sp.	Balambala tick virus (Virus)	Greater Accra	PCR, Next generation sequencing	[122]
<i>H. truncatum</i>	CCHFV (Virus)	Upper East	PCR	[114]
	<i>E. canis</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[20,57]
	<i>E. minasensis</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[57]
	Uncultured <i>Ehrlichia</i> sp. (Bacteria)	Ashanti	PCR, Sanger sequencing	[85]
	<i>B. occultans</i> (Parasite)	Upper East	PCR, Sanger sequencing	[20,96]
	<i>Babesia</i> sp. Xinjiang (Parasite)	Upper East	PCR, Sanger sequencing	[96]
	<i>R. aeschlimannii</i> (Bacteria)	Upper East, Greater Accra	PCR, Sanger sequencing	[16,20,31]
	<i>C. burnetii</i> (Bacteria)	Upper East, Greater Accra	PCR	[11,16]
	<i>Candidatus</i> Midichloria mitochondrii (Bacteria)	Upper East	PCR, Sanger sequencing	[20]
	<i>R. africae</i> (Bacteria)	Ashanti Region, Greater Accra	PCR, Sanger sequencing	[30,85]
<i>R. evertsi</i>	<i>E. canis</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[57]
	<i>T. ovis</i> (Parasite)	Upper East	PCR, Sanger sequencing	[96]
	<i>C. burnetii</i> (Bacteria)	Upper East	PCR	[16]
	<i>R. africae</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[16,30]
<i>Rhipicephalus</i> spp	putative Phlebovirus (Odaw virus) (Virus)	Greater Accra	PCR, Next generation sequencing	[121]
	<i>A. marginale</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[57]
	Dugbe virus (Virus)	Greater Accra	RT-PCR, Next generation sequencing	[122]
	Odaw virus (Virus)	Greater Accra	PCR, Next generation sequencing	[121]
	<i>R. africae</i> (Bacteria)	Upper East, Greater Accra	PCR, Sanger sequencing	[30]
	<i>C. burnetii</i> (Bacteria)	Upper East, Greater Accra	PCR	[11]
<i>R. microplus</i>	<i>R. africae</i> (Bacteria)	Greater Accra	PCR, Sanger sequencing	[31]
<i>Rhipicephalus</i> (<i>Boophilus</i>) sp.	<i>E. canis</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[57]
	<i>A. capra</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[57]
	<i>R. africae</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[30]
<i>R. sanguineus</i> (s.l)	<i>R. africae</i> (Bacteria)	Upper East, Greater Accra	PCR, Sanger sequencing	[30]
	<i>C. burnetii</i> (Bacteria)	Upper East, Greater Accra	PCR	[11]
<i>R. geigy</i>	<i>E. canis</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[20]

2. Review methodology

2.1. Search strategy and data sources

To find pertinent published articles on ticks and tick-borne pathogens in Ghana, a thorough literature search was carried out. PubMed,

Google Scholar, and Scopus were the databases used for the search. “Ticks,” “tick-borne pathogens,” “tick-borne diseases,” and “Ghana” were among the key search terms used to narrow down the results. The goal of the search was to find published studies that have discussed the prevalence, distribution, molecular identification, and epidemiology of ticks and tick-borne pathogens affecting livestock and humans.

2.2. Study selection and eligibility criteria

Studies that satisfied the following requirements were deemed eligible:

- Original studies, reviews, or surveillance reports of Ghanaian ticks and tick-borne diseases.
- Research about the molecular or morphological identification of tick species or the detection of tick-borne pathogens in humans, animals, or ticks.
- Publications available in English.

Among the exclusion criteria were:

- Research carried out outside of Ghana unless it clearly relates to cross-border tick migrations that impact livestock.
- Articles with inadequate methodological detail or unavailable full texts.
- Research on unrelated infectious pathogens or non-tick vectors.

2.3. Data extraction and synthesis

A standardised spreadsheet was created by methodically extracting data from the studies that qualified. The study location, tick species identified, tick-borne pathogens found, host species sampled, diagnostic techniques employed, and significant discoveries pertinent to epidemiology and public health issues were among the extracted data. The distribution of tick species and pathogens was summarised, and new risks to human and animal health in Ghana were highlighted through a qualitative synthesis of the data.

Information from 47 published papers on ticks and tick-borne pathogens infecting livestock and humans was examined and included in this review.

3. Distribution of tick species infesting livestock in Ghana

In Ghana, studies have reported the occurrence of livestock tick species of the genera *Amblyomma*, *Hyalomma* and *Rhipicephalus* (Table 1). These ticks mostly infest cattle and to a lesser extent sheep and goats [9]. The predominant tick species mostly infesting cattle is *A. variegatum* [10–13]. *Amblyomma variegatum* transmits various pathogens and is present in more than 30 African countries [14]. Tick species affect livestock production by causing host blood loss, diminished weight and appetite, and tick-borne disease transmission [15]. Furthermore, *A. variegatum* spreads zoonotic pathogens such as *Rickettsia africae* [16]. No other *Amblyomma* species has been reported to infest livestock. *Hyalomma* species including *H. rufipes*, *H. truncatum*, *H. marginatum*, *H. excavatum*, *H. albiparvum* and *H. dromedarii* have been reported [9,17–19]. These ticks transmit zoonotic pathogens such as Crimean-Congo Haemorrhagic Fever virus (CCHFV) and pathogens of veterinary importance such as *Babesia occulta* [18,20]. *Rhipicephalus* ticks are widely distributed worldwide and spread many pathogens of zoonotic and veterinary importance [21]. *Rhipicephalus* species identified include *R. (Boophilus) annulatus*, *R. (Boophilus) decoloratus*, *R. evertsi*, *R. (Boophilus) geigy*, *R. lunulatus*, *R. (Boophilus) microplus*, *R. sanguineus* (s.l.), *R. senegalensis* and *R. turanicus* [9,11–13,17,22]. *Rhipicephalus turanicus* was recently identified [17] and has been reported in the Afrotropical and Palaearctic regions, infesting cattle, sheep and dogs [14]. Ticks of emerging concern include two notable *Hyalomma* species that were recently reported, *H. marginatum* and *H. dromedarii* [17]. *Hyalomma marginatum* transmits CCHFV and has been reported to often infest migratory birds [23]. However, it could have entered Ghana through the continuous livestock trade. *Hyalomma dromedarii* mostly infests camels compared to cattle, sheep and goats [24]. *Rhipicephalus microplus* is an invasive species resistant to major acaricides, reproduces at a fast rate to populate an area and transmits pathogens that affect

Table 2

Tick-borne pathogens in livestock.

Host	Pathogen	Location	Diagnostic method	Reference
Cattle	<i>E. ruminantium</i> (Bacteria)	Upper East & West, Northern, Bono East, Ashanti, Eastern, Volta, Greater Accra, Central, Western	Microscopy, PC-ELISA, MAP1-B ELISA, PCR, Next generation sequencing	[52–54,56,144]
	<i>A. centrale</i> (Bacteria)	Eastern	PCR	[54]
	<i>A. marginale</i> (Bacteria)	Eastern	PCR	[54]
	<i>T. mutans</i> (Parasite)	Greater Accra	Microscopy	[70]
	<i>T. velifera</i> (Parasite)	Greater Accra	Microscopy	[70]
	<i>B. bigemina</i> (Bacteria)	Eastern, Greater Accra	Microscopy, PCR	[54,56,70]
	unidentified <i>Anaplasma</i> sp. (Bacteria)	Greater Accra	Microscopy	[70]
	<i>Eperythrozoon</i> sp. (Bacteria)	Greater Accra	Microscopy	[70]
	<i>Borrelia</i> sp. (Bacteria)	Greater Accra	Microscopy	[70]
	<i>B. bovis</i> (Parasite)	Greater Accra	PCR	[54,56,94]
	<i>A. capra</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[67]
	<i>Rickettsia</i> spp. (Bacteria)	Upper East	PCR	[67]
	<i>A. marginale</i> (Bacteria)	Greater Accra	PCR	[56]
	<i>Babesia</i> sp. Lintan (Parasite)	Upper East	PCR, Sanger sequencing	[67]
Sheep	<i>A. ovis</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[67]
	<i>A. phagocytophilum</i> (Bacteria)	Upper East, Ashanti	PCR, Sanger sequencing	[32,67]
	<i>C. burnetii</i> (Bacteria)	Ashanti, Volta	ELISA	[38,39]
	<i>E. ruminantium</i> (Bacteria)	Upper East & West, Northern, Bono East, Ashanti, Eastern, Volta, Greater Accra, Central, Western	Microscopy, PC-ELISA, MAP1-B ELISA	[52,53,144]
	unidentified <i>Anaplasma</i> sp. (Bacteria)	Greater Accra	Microscopy	[70]
	<i>Theileria</i> sp. (Parasite)	Greater Accra	Microscopy	[70]
	<i>Borrelia</i> sp. (Bacteria)	Greater Accra	Microscopy	[70]
	<i>A. capra</i> (Bacteria)	Upper East, Ashanti	PCR, Sanger sequencing	[32,67]
	<i>Rickettsia</i> spp. (Bacteria)	Upper East	PCR	[67]
	<i>Babesia</i> sp. Lintan (Parasite)	Upper East	PCR, Sanger sequencing	[67]
	<i>T. orientalis</i> (Parasite)	Upper East	PCR, Sanger sequencing	[67]
	<i>E. ruminantium</i> (Bacteria)	Upper East & West, Northern, Bono East, Ashanti, Eastern, Volta, Greater Accra, Central, Western	Microscopy, PC-ELISA, MAP1-B ELISA	[52,53,144]
	unidentified <i>Anaplasma</i> sp. (Bacteria)	Greater Accra	Microscopy	[70]
	<i>Theileria</i> sp. (Parasite)	Greater Accra	Microscopy	[70]
	<i>Borrelia</i> sp. (Bacteria)	Greater Accra	Microscopy	[70]

(continued on next page)

Table 2 (continued)

Host	Pathogen	Location	Diagnostic method	Reference
Goat	<i>T. parva</i> (Parasite)	Upper East	PCR, Sanger sequencing	[67]
	<i>A. ovis</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[67]
	<i>A. marginale</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[67]
	<i>C. burnetii</i> (Bacteria)	Ashanti, Volta	ELISA	[38,39]
	<i>T. ovis</i> (Parasite)	Ashanti	PCR, Sanger sequencing	[32]
	<i>E. ruminantium</i> (Bacteria)	Greater Accra	Microscopy, PC-ELISA	[52,53]
	unidentified <i>Anaplasma</i> sp. (Bacteria)	Greater Accra	Microscopy	[70]
	<i>A. capra</i> (Bacteria)	Upper East, Ashanti	PCR, Sanger sequencing	[32,67]
	<i>Rickettsia</i> spp. (Bacteria)	Upper East	PCR	[67]
	<i>A. marginale</i> (Bacteria)	Upper East	PCR, Sanger sequencing	[67]
Horse	<i>C. burnetii</i> (Bacteria)	Ashanti, Volta	ELISA	[38,39]
	<i>R. aeschlimannii</i> (Bacteria)	Ashanti region	PCR, Sanger sequencing	[32]
	<i>T. equi</i> (Parasite)	Greater Accra	PCR	[104]

Table 3
Tick-borne pathogens in humans.

Host	Pathogen	Location	Diagnostic method	Reference
Human	<i>C. burnetii</i> (Bacteria)	Ashanti region, Greater Accra, Western Region	ELISA, IFA, PCR	[32,45,46]
	<i>B. henselae</i> (Bacteria)	Greater Accra, Volta	IFA	[74]
	<i>B. quintana</i> (Bacteria)	Greater Accra, Volta	IFA	[74]
	<i>B. clarridgeiae</i> (Bacteria)	Greater Accra, Volta	PCR	[74]
	CCHFV (Virus)	Ashanti region	ELISA	[113]
	<i>R. aeschlimannii</i> (Bacteria)	Ashanti region	PCR, Sanger sequencing	[32]
	<i>R. africae</i> (Bacteria)	Ashanti region	PCR, Sanger sequencing	[32]

cattle [25]. Because herders and their livestock travel across borders, there is a higher chance of varied tick infestation. Regular surveillance operations are necessary to gather the relevant data required to create tick control strategies.

4. Bacterial diseases transmitted by ticks in Ghana

4.1. Rickettsiosis

Rickettsia infections are typically spread via the bite of an infected tick through the process of acquiring a blood meal [26]. The spotted fever group (SFG) of *Rickettsia* is made up of about thirty species that are transmitted by ticks and can cause tick-borne spotted fever group rickettsioses in humans and animals [26]. Two *Rickettsia* species, *R. africae* and *R. aeschlimannii*, have been reported to occur in ticks, humans and animals (Tables 1, 2 and 3).

In humans, spotted fever group (SFG) rickettsioses primarily present

with fever, headache, muscle soreness, and a rash that can be maculopapular or, in more severe cases, vesicular or purpuric [27]. Ticks belonging to the *Amblyomma* genus, specifically *A. variegatum* in West Africa, are the vectors of *R. africae* which causes African tick-bite fever (ATBF) [27]. These ticks feed readily on humans, and as a result, their infection rate with *R. africae* can reach 100 % [28]. The most often reported cause of fever in visitors returning from sub-Saharan Africa, after malaria, is ATBF [29]. *Rickettsia africae* has been detected in *A. variegatum*, *H. truncatum*, *H. rufipes*, *R. sanguineus* (s.l.), *R. evertsi*, *Rhipicephalus* spp., *R. microplus* and *Rhipicephalus* (*Boophilus*) sp. [16,30,31]. With the abundance of *A. variegatum*, there is an increased risk of *R. africae* transmission, especially to animal handlers [32]. Another *Rickettsia* species identified in *A. variegatum*, *H. rufipes*, and *H. truncatum* is *R. aeschlimannii* [16,30,31]. Since *Hyalomma* ticks readily feed on humans, animal handlers are at risk of infections [33]. *Rickettsia aeschlimannii* was detected for the first time in 2024, in abattoir workers and a slaughtered goat [32] (Tables 2 & 3).

As is frequently the case throughout Africa, health professionals in West Africa frequently fail to recognise ATBF, possibly as a result of a lack of knowledge about the condition and diagnostic tools, as well as the fact that the illness is typically benign and that mild rashes and eschars are more difficult to spot on people with black skin [26]. Given the limited diagnostic capacity and *Rickettsia* infections mimicking symptoms of febrile illnesses like malaria, cases will most likely go unnoticed and unreported. The findings highlight the heightened risk faced by abattoir workers, whose occupational exposure involves frequent contact with animals that may act as amplifying hosts for tick-borne pathogens.

4.2. Q fever or coxiellosis

Coxiella burnetii is a zoonotic gram-negative bacterium that causes the disease Q fever in humans and coxiellosis in animals [34]. Humans, livestock (such as cattle, sheep, and goats) and wild animals are susceptible to infection by *C. burnetii* [35]. The primary reservoirs of *C. burnetii* are cattle, sheep, and goats although ticks and rodents are thought to be the natural reservoirs [36]. Since the majority of *C. burnetii* infections in domestic ruminants are asymptomatic, the illness may go undiagnosed [37]. Livestock including cattle, sheep and goats have been exposed to *C. burnetii* [38,39].

The occasional finding of *C. burnetii* in ticks has raised questions about the tick's role in the spread of Q fever [40]. However, ticks that obtain blood meals from infected animals can pass on *C. burnetii* to their next stage of life through transovarial and transstadial routes [41]. Ticks might be an important factor in the natural cycle of coxiellosis transmission among livestock and wild animals [42]. *Coxiella burnetii* may diversify its virulence and resistance characteristics by overcoming these species barriers [43]. *Coxiella burnetii* DNA has been detected in *A. variegatum*, *H. rufipes*, *Rhipicephalus* spp., *R. sanguineus* s.l., *R. evertsi* and *H. truncatum* [11,16].

Q fever, traditionally associated with animal exposure, is a significant occupational zoonosis with considerable socioeconomic impact. Nonetheless, because inhalation of contaminated dust or aerosols constitutes the primary transmission route to humans, the disease is now recognised as a broader public health concern [44]. The remarkable resilience of *Coxiella burnetii* allows it to be disseminated by wind over considerable distances, facilitating human exposure without direct animal contact [44], and contributing to epidemic outbreaks in multiple regions worldwide. Children and adults in rural communities of the Ashanti region of Ghana were found to be exposed to *C. burnetii* [45]. In a study focused on acute febrile patients, it was observed that malaria-positive patients were also Q fever seropositive [46]. In a more recent study, *C. burnetii* DNA was detected in a worker in the Kumasi abattoir [32]. The detection and exposure of the pathogen in Ghana highlights the zoonosis's hidden burden and risk to farmers and abattoir workers.

4.3. Ehrlichiosis

The disease Ehrlichiosis is a bacterial zoonosis that is transmitted through the bite of infected ticks [47]. The species responsible for infections in humans include *E. ewingii*, *E. chaffeensis*, and *E. muris* while infections in domestic animals are caused by *E. canis*, *E. ewingii* and *E. ruminantium* [48]. Information readily accessible indicates that human ehrlichiosis, often caused by *E. chaffeensis*, is becoming more common over time [3]. Heartwater (cowdriosis) is caused by *E. ruminantium* in ruminants [49]. The disease has had a major negative impact on food and nutritional security in West Africa and caused a considerable economic loss in the continent's ruminant production [50]. Despite being one of the most significant tick-borne infections infecting ruminants in sub-Saharan Africa, little is known about the spread of *E. ruminantium* [51]. A prior study has suggested that *E. ruminantium* may be transmitted zoonotically [50]. However, additional research is necessary to completely comprehend this zoonotic nature of the organism.

Heartwater was first reported in the Northern region of Ghana in 1933 [10]. It was found to infect ruminants and was believed to be spread by *A. variegatum* infesting the livestock. However, the main goals of tick control were to lessen animal harm and tick-related anxiety, with disease control connected with tick bites coming in second [10]. This has not changed over the years even though more studies have reported *E. ruminantium* in livestock [52–56]. The density of ticks, degree of tick exposure, climatic factors, and traits unique to a particular animal are risk factors for *Ehrlichia* infection in a given setting [48]. Despite the high seroprevalence of *E. ruminantium* in livestock, the failure to detect it in ticks suggests either a limitation in detection methods, the presence of an unknown vector, or the existence of atypical strains. It is important to note that, *E. canis* has been identified in *A. variegatum*, *H. truncatum*, *Rhipicephalus* (*Boophilus*) sp., *R. evertsi* and *R. geigy* [20,57]. Furthermore, *E. minasensis* was reported in *H. truncatum* sampled in the Upper East region [57]. *Ehrlichia minasensis* is a recently identified species that exhibits a broad geographic distribution and is spread by a variety of tick species [58]. With the transboundary movement of livestock, there will be a continuous introduction of ticks and their associated tick-borne pathogens.

4.4. Anaplasmosis

The bacterial species of the genus *Anaplasma* are responsible for the tick-borne disease anaplasmosis, which affects humans and a variety of domestic and wild animal hosts [59]. While six different species of *Anaplasma* have been identified, including *A. bovis*, *A. central*, *A. marginale*, *A. ovis*, *A. phagocytophilum* and *A. platys*, new species like *A. capra* continue to emerge [59–61]. *Anaplasma* infections in mammals typically manifest as subclinical infections or co-infections, with fever, anaemia, ataxia, anorexia, jaundice, or enlarged lymph nodes among the clinical signs [62]. The species detected in Ghana are *A. phagocytophilum*, *A. capra*, *A. centrale*, *A. ovis*, *A. marginale*, and unidentified *Anaplasma* sp.

Anaplasma phagocytophilum is a zoonotic pathogen that can infect humans and a wide variety of domestic and wild animals [63]. When cattle contract this disease, they become infertile, experience fever, respiratory problems, and reduced milk production [64]. Infections can also range in severity from mild to severe, resulting in multiple organ failure and death [65]. The risk of contracting the disease is higher among those who work closely with animals or live in rural areas where ticks are common [66]. *Anaplasma phagocytophilum* has been identified in cattle [67] but not in ticks or humans.

Another zoonotic pathogen identified to infect livestock and ticks is *A. capra* [32,57,67]. Ruminants, wild animals, and humans are all susceptible to infection by this zoonotic pathogen [65,68]. An instance of *A. capra* infection in humans was later reported from China in 2015, following the pathogen's first discovery in asymptomatic goats [65].

Sheep and goats can have mild to severe infections, exhibiting signs such as fever, weight loss, decreased milk supply, miscarriage, and even death [69].

In Ghana, while *Anaplasma centrale*, *A. marginale*, *A. ovis* and unidentified *Anaplasma* sp. have been reported in livestock [54,56,67,70–72], *A. marginale* has been detected in *Rhipicephalus* spp. [57]. These pathogens cause significant damage to livestock production hence there is a need to enforce control measures. Some observations suggest that husbandry procedures may have an impact on the occurrence of *Anaplasma* [63]. Appropriate husbandry techniques and tick control strategies will reduce the risk to human and animal health and halt the spread of *Anaplasma* infections.

4.5. Bartonellosis

The four *Bartonella* species that have been isolated from domestic and wild ruminants thus far are *B. capreoli*, *B. schoenbuchensis*, *B. chomelii*, and *B. bovis* [73]. One of the main ways that diseases spread is through interactions of humans with wildlife. Because they roost in cities and humans collect their meat, the straw-coloured fruit bat, *Eidolon helvum* and humans engage in frequent contact in Ghana. There is an increased risk of zoonotic infections as *E. helvum* is infected with different *Bartonella* strains. This led to a study that found humans infected with *B. clarridgeiae* and seropositive for *B. henselae* and *B. quintana* [74]. Furthermore, cats in Ghana were found infected with *B. henselae* [74]. However, no infections have been detected in ruminants in Ghana. *Bartonella* species are spread by vectors, and it has been shown that some hematophagous arthropods including ticks [75] transmit different strains of the bacteria. Although *B. henselae* has been identified in *Rhipicephalus* ticks collected from dogs in Kumasi [76], no *Bartonella* species have been detected in ticks sampled from livestock.

4.6. Other bacterial pathogens and symbionts

A study has reported the presence of *Eperythrozoon* sp. and *Borrelia* sp. in the blood smears of cattle and sheep [70]. *Eperythrozoon* sp. infects different animal hosts and humans [77–79]. *Borrelia* species have also been reported in ticks, animals and humans [80–82]. No other study in Ghana has since reported the occurrence of *Eperythrozoon* or *Borrelia* species. Nation-wide surveillance will be key to establishing the distribution of these species and the risk level to humans and animals. The symbiont *Candidatus* *Cryptosporidium californiense* has been identified in *A. variegatum* [20]. This bacterium is an Anaplasmataceae species, identified in *Ixodes pacificus* sampled in California [83]. The potential of this organism to cause infections in humans and animals remains unclear, hence further research will be needed to establish this [84]. *Candidatus* *Midichloria mitochondrii* has also been identified in *H. rufipes* and *H. truncatum* in Ghana [20,85]. This organism is a bacterial endosymbiont that inhabits the mitochondria of diverse tick species, but mostly *Ixodes ricinus* [86]. There is little information on the spread of *Candidatus* *M. mitochondrii* in Africa, despite reports of it in *R. microplus* in Mozambique [87] and *Ixodes aulacodi* in Ghana [88]. When a tick obtains a blood meal, it is thought to be transmitted to a vertebrate host [89]. However, it is not apparent if *Candidatus* *M. mitochondrii* plays a role in tick-borne disease transmission [90].

5. Parasitic diseases transmitted by ticks in Ghana

5.1. Babesiosis

Parasites belonging to the genus *Babesia* are the cause of babesiosis [91]. Although numerous species of *Babesia* infect cattle, only three have been shown to produce clinical babesiosis: *B. divergens*, *B. bovis*, and *B. bigemina* [92]. Infections in vulnerable cattle cause symptoms like fever, anaemia, and jaundice [92]. Due to deaths, decreased milk production, and the expense of proper treatment and prevention, the

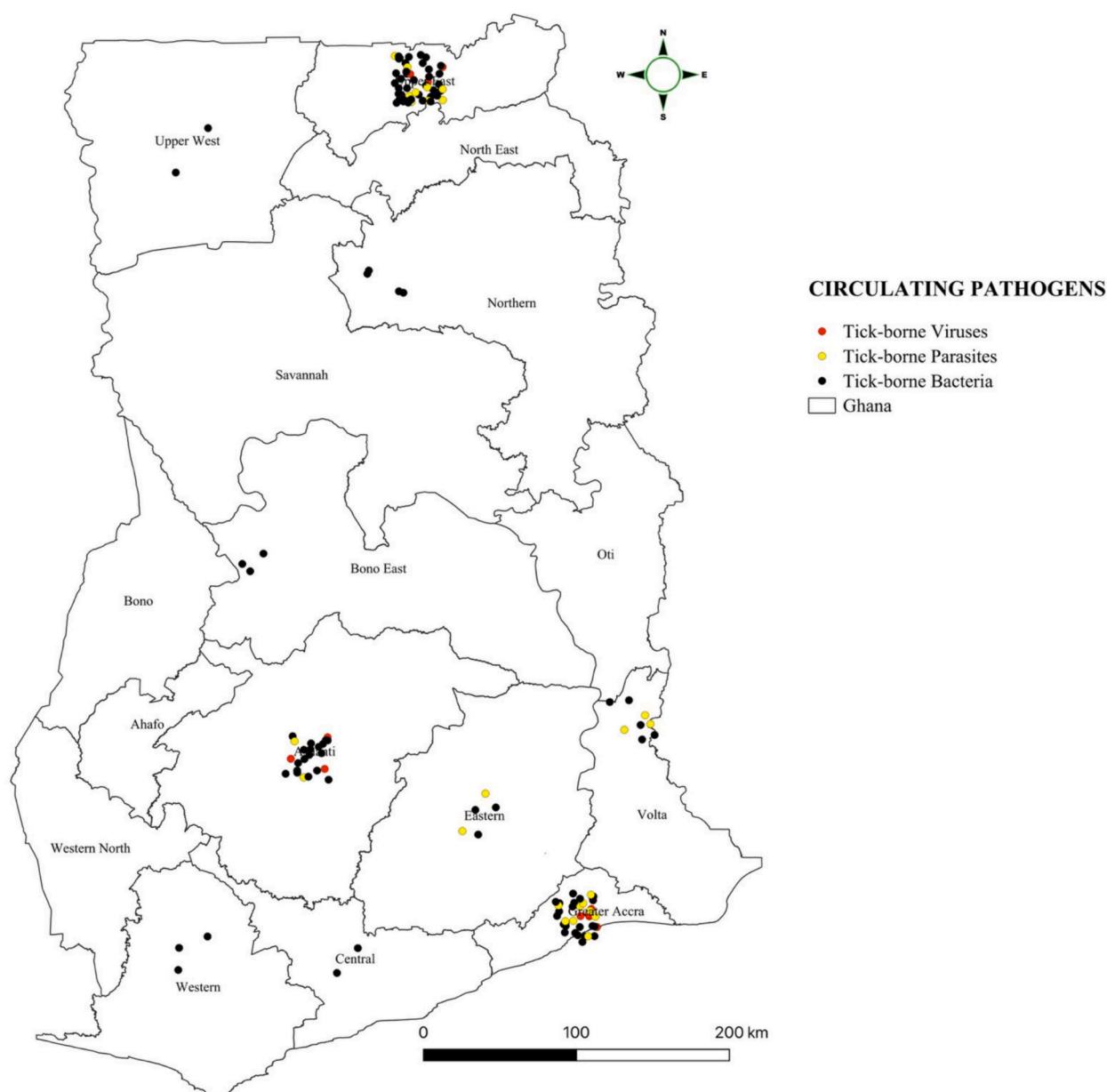


Fig. 1. A map showing the areas in Ghana where tick-borne viruses, bacteria and parasites have been reported.

disease significantly reduces the livestock industry's profits [93]. In Ghana, cattle and sheep have been found infected with *Babesia* sp. Lintan, *B. bovis* and *B. bigemina* [54,56,67,70,94,95]. Given the different *Babesia* species infecting livestock, there is a need to create effective control measures to prevent infection spread. This can be achieved by the use of vaccines, controlling tick populations, using anti-babesia medications, or a combination of these methods.

There has been a first report of *B. occultans* and *Babesia* sp. Xinjiang in *H. truncatum* [20,96]. Even though *B. occultans* is not as harmful, cases of clinical signs in cattle that have been infected have been documented [97]. Due to its widespread distribution in China, *Babesia* sp. Xinjiang poses a serious health risk to sheep and goats as well as having a substantial financial impact on the production of small ruminants [98]. Since the pathogen's infections are typically asymptomatic [98], infections will probably go unreported or unrecognised in a place with limited resources like Ghana.

Only a small number of *Babesia* species are known to cause babesiosis in humans, although over 100 species have been shown to exist globally

and infect a variety of wild and domesticated animals [99]. Human babesiosis can be contracted by the bite of an infected tick, congenital transmission, and blood transfusion [100]. Even though a study suspected *Babesia/Theileria* infection in blood samples from humans based on microscopy, PCR results were negative [101]. No active surveillance efforts focus on *Babesia* infections in humans, since it is not recognised as a public health threat. This might be because cases of *Babesia*, which have symptoms resembling those of malaria, are unreported or misdiagnosed [102].

5.2. Theileriosis

Theileria parasites infect both domestic and wild animals and inflict major economic losses on livestock production [103]. It is known that *Theileria annulata*, *T. mutans*, *T. orientalis*, *T. parva*, and *T. velifera* are the pathogens that cause bovine theileriosis [103]. In Ghana, a study has reported *T. mutans* and *T. velifera* infections in cattle, sheep and goats [70]. Again, *T. equi* has been detected in horses [104]. In recent studies,

T. orientalis, *T. ovis* and *T. parva* have been reported in sheep [32,67]. *Theileria parva* is the most common cause of lethal infections in numerous cattle in sub-Saharan Africa, resulting in significant financial losses for farmers [105]. *Theileria orientalis* on the other hand causes the moderate or benign form of the disease [106].

Ticks belonging to the genera *Amblyomma*, *Haemaphysalis*, *Hyalomma*, *Ixodes*, and *Rhipicephalus* have been found to harbour and spread *Theileria* species [107]. In Ghana, *T. ovis* and *T. velifera* have been identified in *R. evertsi* and *A. variegatum* respectively [20,96]. The majority of *T. velifera* infections in cattle are asymptomatic and animals infected at earlier ages have lifetime infections [108]. With the high incidence of *A. variegatum*, there is an increased likelihood of *Theileria* transmission to cattle, which would severely reduce animal production. *Theileria ovis* infects small ruminants and shows transstadial transmission in the *Rhipicephalus* species [107]. The discovery of this pathogen for the first time raises concerns about the production of small ruminants and highlights the need to assess the extent of infections to stop its spread.

6. Viral diseases transmitted by ticks in Ghana

6.1. Crimean-Congo hemorrhagic fever

The zoonotic disease Crimean-Congo hemorrhagic fever (CCHF) is spread by ticks and is common in Africa, Asia, and Eastern Europe [109]. The disease poses a serious risk to public health and can have a major impact on medical professionals and those working in abattoirs, particularly in nations with limited resources [110]. The virus known as CCHFV is mainly spread by tick species belonging to the *Hyalomma* genus, while it can also spread by other tick species that coexist alongside *Hyalomma* [111]. Furthermore, CCHFV can spread through transstadial and transovarial transmission, passing on from the parent to its offsprings [112]. In Ghana, CCHFV has been detected in *A. variegatum*, *H. excavatum*, *H. rufipes* and *H. truncatum* [18,113,114]. Two genetically different strains of the virus have been identified in tick species sampled from cattle in the Upper East region of Ghana. The first had its S, L and M segments clustering with other strains in the genotype III group [114]. The second strain had experienced reassortment with its S and L segments clustering with strains in the genotype III group whereas the M segment clustered with strains in the genotype I group [18]. It is believed that CCHFV's pathogenicity is influenced by the reassortment of its M segment [115].

Human case-fatality ratios vary from 5 % to 80 %, contingent upon the degree of typical clinical presentation at diagnosis and the availability of quality medical care [116]. Many African nations have low levels of CCHFV risk, and infections are typically ignored or misdiagnosed [117]. Human infections are characterised by haemorrhages, fever, painful headaches, confusion and diarrhoea [118]. In Ghana, abattoir workers have been found exposed to CCHFV [113]. Since animals serve as amplifying hosts for CCHFV [119], people in close contact would be at risk of infections. Again, workers at abattoirs are especially susceptible to the disease because of the handling of animal tissues and possibly infected bodily fluids [120]. It is not clear how long CCHFV has persisted in the country or the risk level to people in close contact with animals that serve as amplifying hosts.

6.2. Other tick-borne viruses

In addition to the well-recognised pathogens in this review, other tick-associated viruses have also been identified in Ghana. In the Greater Accra region, a novel putative Phlebovirus, termed Odaw virus, was detected in *Rhipicephalus* species, while Dugbe virus was identified in *Amblyomma variegatum* [121]. More recently, Balambala tick virus was reported in *Amblyomma* and *Hyalomma* ticks, and Dugbe virus was further detected in *Rhipicephalus* ticks [122]. These findings highlight the diversity of tick-borne viruses in the region and reinforce the

importance of implementing effective tick control strategies to limit their potential spread (Figs. 1 & S1).

7. Tick control practices in Ghana

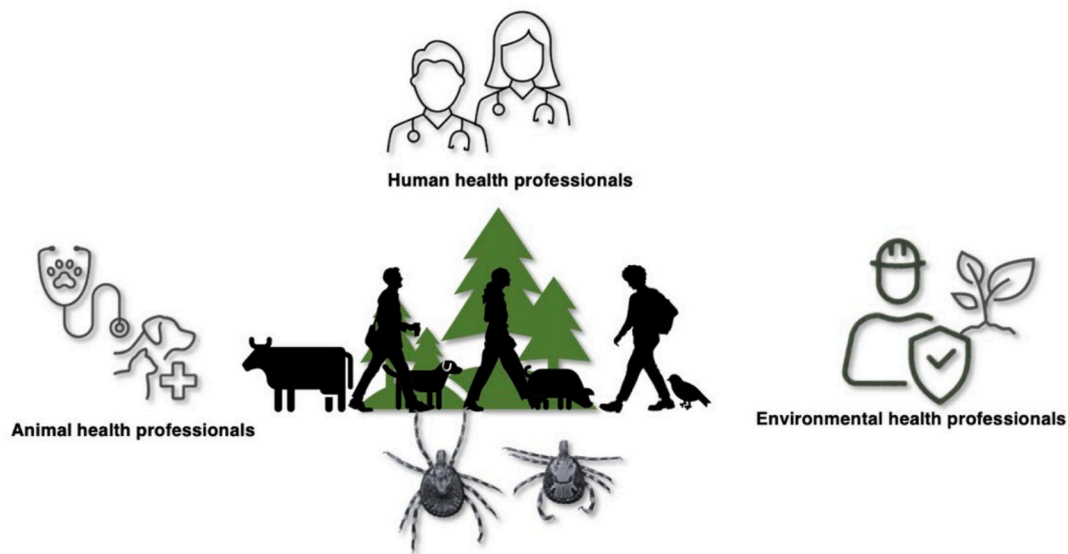
It has been reported that while a lapse in the regular acaricidal treatment of ticks led to an outbreak of tick-related disorders, regular tick control also controlled associated diseases [123,124]. As such, the primary strategy for safeguarding Ghana's cattle industry from the detrimental effects of ticks and tick-borne diseases has been the use of acaricides to suppress tick populations [125,126]. However, tick resistance inevitably develops, especially when acaricides are used exclusively to manage tick populations. Acaricide-resistant ticks render otherwise effective acaricides ineffective, which causes tick control failures and the spread of diseases.

Acaricide resistance in livestock ticks raises the possibility of acaricide residues in milk and meat as well as environmental pollution [127]. Even though acaricide-resistant ticks have been found in the country [128,129] and acaricides are still often used to reduce tick populations [130,131], there are currently no practical methods for dealing with this resistance.

Acaricide resistance is caused by intricate, multifaceted mechanisms. Four primary resistance mechanisms have been identified worldwide: behavioural resistance, decreased penetration resistance, target site insensitivity and metabolic detoxification [132]. About 20 acaricidal products in the group's macrocyclic lactones, pyrethroids, amidines and organophosphates are being used in Ghana to control tick populations [133]. Despite the paucity of comprehensive molecular research on resistance mechanisms in Ghana, the evidence is consistent with these worldwide trends. The resistance seen in *A. variegatum* and *R. microplus* is probably caused by target site shifts and increased enzyme activity. The genetic bases of resistance highlight the necessity of developing diagnostic assays and conducting molecular surveillance to identify resistance early. There is also a need to find alternative control measures, as resistance to these acaricides has been reported across Africa [134]. In light of this, plant-based acaricides offer a desirable, environmentally friendly substitute or supplement to chemical acaricides. In Ghana, studies have reported the acaricidal effects of plant extracts, including *Hoslundia opposita* and *Chromolaena odorata*, on *A. variegatum* larvae [135] and oviposition of *R. microplus* [136] respectively. With a lower likelihood of resistance, these plants provide locally sourced, ecologically friendly, and possibly economical control choices. Investing in and promoting plant-based acaricides is essential. They can be incorporated into tick control initiatives to lessen the usage of chemical acaricides and postpone the emergence of resistance. To turn these botanical possibilities into useful instruments for wider deployment, more study on formulation, efficacy testing, and field application is needed.

Nonetheless, a nationwide surveillance effort will be necessary to determine the current use of acaricides and the acaricide resistance status of the diverse tick species. This will provide information that can be used to create management strategies for controlling tick populations. Farmers need to be educated on the safe use of acaricides to prevent acaricide resistance and the spread of tick-borne pathogens.

Despite pathogen exposure in humans [113] and the increasing risk of zoonotic infections especially in animal handlers [16,18,30,114], little attention has been given to enforcing preventive measures. Abattoir workers and people in close contact with animals need to adopt measures to prevent tick bites and avoid being infected with tick-borne pathogens. These measures can include the use of gloves when handling animal meat and products, personal checks for attached ticks and regular checks for tick bites.



Illustrator: Christopher Nii Laryea Tawiah-Mensah, NMIMR

Fig. 2. A one-health concept. Humans and animals are at risk of tick infestation and tick-borne diseases. The survival of ticks depends on environmental conditions suggesting that a change in temperature, relative humidity, and atmospheric pressure, will significantly impact tick prevalence and the transmission of tick-borne diseases. This however necessitates the engagement of animal, environmental, and human health professionals to collaborate and foster a one-health approach to tick surveillance in Ghana.

8. The increasing risks of zoonotic transmission of tick-borne pathogens: a need for one health approach

Zoonotic pathogens, found in animal reservoir species and can occasionally spread to human populations are evolving at a rapid pace [137]. To better understand the ecology of vector-borne infections, there is a need to comprehend the dynamics of pathogen transmission from infected animal hosts to vectors. Increased interactions between humans and livestock in restricted spaces due to population growth influence zoonotic pathogen transmission [138]. These interactions pose a risk to public health, particularly in developing countries with inadequate standards for animal husbandry. Because zoonoses account for more than 60 % of all human diseases worldwide, minimising human-animal contact is particularly crucial [138]. These zoonotic infections are effectively transmitted from animals to humans by ticks [1]. In Ghana, especially in Northern Ghana, most households rely on cattle as a source of income [6,7]. However, ticks carrying zoonotic pathogens infest these cattle [16,114]. Frequent contact with the livestock would provide an avenue that would promote tick bites and the spread of pathogens.

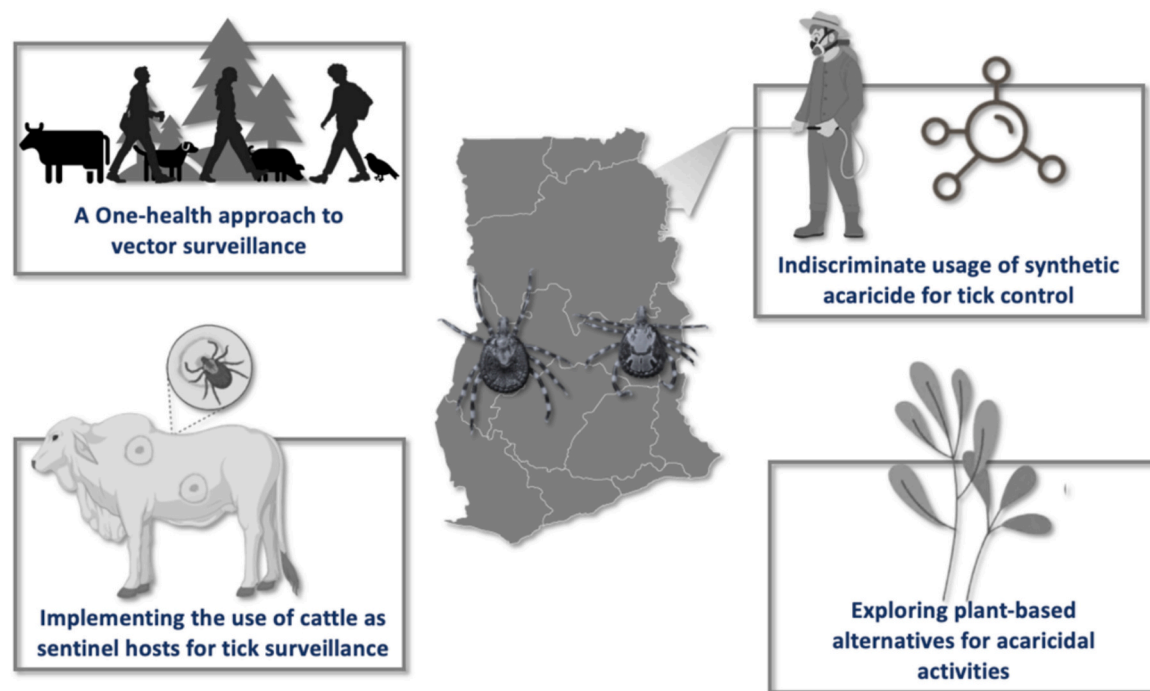
To better safeguard public health, the World Health Organisation (WHO) created and promoted the One Health concept, an interdisciplinary strategy for the study of disease transmission between animals and people [139]. The goal of One Health studies is to demonstrate how the environment, human health, and animal health are inextricably linked [139]. The survival of tick species is closely related to environmental and animal host conditions, and tick-borne diseases can have a substantial effect on public health as well as livestock production. Ticks carry diverse pathogens that can harm both human and animal health. To ensure optimum health results for humans, animals, plants, and the shared environment, professionals in the fields of human health, animal health, environment, and other areas of expertise must coordinate, share information, and work together (Fig. 2). Adopting this approach in Ghana will significantly reduce the spread of ticks and tick-borne pathogens.

9. The potential use of sentinel animals as early warning system

Ghanaian communities frequently raise animals as a common activity. It makes a substantial contribution to the national economy by providing food, income, and social capital. Livestock, however important to Ghanaian society, also poses a risk to human health due to their role as reservoirs for the growing number of zoonotic pathogens [140]. On the other hand, these livestock can be effective sentinel animals for surveillance. An animal that acts as an early warning system for a pathogen and helps identify threats to people is known as a sentinel animal. In addition to helping with early outbreak detection, which is essential for the success of control and prevention efforts [141], using an appropriate sentinel animal can also lessen the scope of subsequent epidemics [142]. Some research issues, such as identifying diseases in a new area, tracking changes in the incidence or prevalence of a particular pathogen over time, determining the pathogen's direction of travel, and assessing the effectiveness of management measures, can be answered with the use of sentinel animals [143]. However, the utilisation of the data acquired from livestock populations is necessary for the effective implementation of sentinel animal surveillance. Based on the findings from Ghana which indicate cattle to be most infested with diverse tick species, they will be the appropriate livestock to serve as sentinels for monitoring tick and tick-borne pathogen distribution.

10. Conclusion

The wide variety of tick species that infest livestock in Ghana is highlighted in this review, with *Amblyomma variegatum* predominating in several ecological zones. Many tick-pathogens of zoonotic and veterinary significance are confirmed to be in circulation using molecular detection. The persistence and distribution of tick-borne pathogens highlight the critical need for integrated surveillance and control methods that take into account both veterinary and public health perspectives. The true incidence of these diseases is probably underestimated, delaying prompt actions, because human cases are underrecognized due to nonspecific symptoms and inadequate diagnostic infrastructure. Conventional chemical-based control is



Illustrator: Christopher Nii Laryea Tawiah-Mensah, NMIMR

Fig. 3. An illustrative summary of the review. This study highlights the need for a one-health approach to better understand the transmission of zoonotic tick pathogens. Cattle have been identified as sentinel hosts for tick surveillance as they are the most preferred host for most tick species. Indiscriminate use of synthetic acaricides has enhanced selective resistance pressure on tick species in Ghana, however, alternative sources could be explored for acaricidal activities. Plant extracts have proven useful to control some tick species in Ghana.

compromised by acaricide resistance, which raises the possibility of disease spread and livestock infestations. These difficulties will worsen in the absence of efficient resistance management and the use of innovative control strategies. Particularly in environments with limited resources, the creation and use of botanical acaricides offer a practical and sustainable path moving forward (Fig. 3). There is a need for a coordinated One Health approach involving the agricultural, environmental, and health sectors to effectively control ticks and tick-borne diseases. It is recommended that a nationwide surveillance program be established to monitor ticks and tick-borne pathogens distribution and the acaricide resistance status. Diagnostic capacity on tick-borne pathogen detection needs to be improved, and community awareness increased to promote early detection and treatment. There is a need to invest in plant-based acaricides and their application as environmentally friendly and sustainable substitutes, with the ultimate goal of scaling them up for general application in Ghanaian livestock systems.

CRediT authorship contribution statement

Seth Offei Addo: Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Margaret Addo:** Writing – review & editing, Investigation. **Christopher Nii Laryea Tawiah-Mensah:** Writing – review & editing, Investigation. **Richard Odoi-Teye Malm:** Writing – review & editing, Investigation. **Jane Ansa-Owusu:** Writing – review & editing, Investigation. **Stacy Amoah:** Writing – review & editing, Investigation. **Millie-Cindy Aba Aude Koffi:** Writing – review & editing, Investigation. **Selma Nurudeen Salley:** Writing – review & editing, Investigation. **Patrick Kwasi Obuam:** Writing – review & editing, Investigation. **Danielle Ladzekpo:** Writing – review & editing, Investigation. **Samuel K. Dadzie:** Writing – review & editing, Investigation, Conceptualization.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.parint.2026.103230>.

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