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Research Article

Prevalence, species distribution, and acaricide susceptibility of ixodid ticks infesting pastoral cattle in semi-arid rangelands

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Abstract

Ixodid ticks cause direct blood loss, hide damage, and transmit economically devastating hemoparasites such as Theileria, Babesia, and Anaplasma species in cattle. In this study, we aimed to identify the species composition of cattle ticks and evaluate phenotypic resistance to commonly used synthetic pyrethroid and amidine acaricides. Half-body tick collections were performed on 500 cattle across 25 pastoral herds, and engorged female ticks were reared to obtain larvae for adult immersion and larval packet bioassays against cypermethrin and amitraz. A total of 8,420 adult ticks were morphologically identified, dominated by Amblyomma variegatum (44.6 percent), Rhipicephalus (Boophilus) microplus (31.8 percent), and Hyalomma rufipes (16.2 percent). Bioassays demonstrated emerging resistance in R. microplus populations, with discriminating-dose mortality rates of 61.4 percent for cypermethrin and 74.8 percent for amitraz, whereas A. variegatum remained largely susceptible (>92 percent mortality). The invasive spread of acaricide-resistant R. microplus threatens livestock health and increases the risk of bovine babesiosis outbreaks across semi-arid rangelands. Strategic seasonal dipping, pasture rotation, and regular acaricide resistance monitoring are recommended to optimize tick control programs.

Keywords: Ixodid ticks, Rhipicephalus microplus, Amblyomma variegatum, Acaricide resistance, Pastoral cattle

Introduction

Ticks are among the most important ectoparasites of cattle in tropical and subtropical regions, and ixodid (hard) ticks are of particular concern because they feed for several days, cause direct production losses, and transmit a wide range of pathogens (Jongejan and Uilenberg, 2004; de la Fuente et al., 2008). In sub-Saharan Africa, where pastoral and agro-pastoral systems support the livelihoods, nutrition, and cultural capital of millions of households, ticks and tick-borne diseases constrain cattle productivity through reduced weight gain, lower milk yield, hide damage, anaemia,

abortion, treatment costs, and mortality (Minjauw and McLeod, 2003; Kivaria, 2006). Global estimates suggest that ticks affect about 80% of the world cattle population, with annual economic losses of USD 20–30 billion, while in South Africa alone losses attributable to ticks and tick-borne diseases have been estimated to exceed USD 33 million per year (Nyangiwe et al., 2017). These figures, although dated and context-specific, illustrate why tick surveillance remains a priority for veterinary services, researchers, and pastoral communities alike.

Three genera dominate cattle tick assemblages in African semi-arid rangelands: Amblyomma, Rhipicephalus (including the subgenus Boophilus), and Hyalomma. Amblyomma variegatum, the tropical bont tick, is widespread in sub-Saharan Africa and is the principal vector of Ehrlichia ruminantium, the agent of heartwater, as well as a vector of Theileria mutans and other agents (Walker et al., 2003; Peter et al., 2005). Its three-host life cycle, long mouthparts, aggressive feeding, and conspicuous adult stage make it both a direct cause of skin lesions and abscesses and an efficient pathogen vector. Rhipicephalus (Boophilus) microplus, the southern cattle tick or Asiatic blue tick, is a one-host tick that completes all parasitic stages on the same animal, transmits Babesia bovis and Babesia bigemina, the agents of bovine babesiosis, and Anaplasma marginale, the agent of anaplasmosis, and has become one of the most invasive ticks in the world (Estrada-Peña et al., 2006; Madder et al., 2011). Hyalomma rufipes, a two-host tick adapted to arid and semi-arid environments, is a vector of Crimean-Congo haemorrhagic fever virus and of Theileria annulata in some regions, and it is also associated with sweating sickness and secondary bacterial infection at attachment sites (Walker et al., 2003; Ogola et al., 2023). Understanding which of these species dominates in a given rangeland is therefore not a purely taxonomic exercise; it predicts which diseases are most likely to occur, which host age groups are most at risk, and which control measures are most likely to work.

Semi-arid rangelands present a distinctive ecological setting for tick–host dynamics. Rainfall is seasonal and often erratic, vegetation cover is patchy, water points concentrate cattle and ticks, and herds move over long distances in search of pasture (Kanduma et al., 2020; De Clercq et al., 2012). These movements can transport engorged females and, indirectly, their offspring to new pastures, while dry-season nutritional stress reduces host resilience to blood loss and infection. At the same time, the one-host biology of R. microplus, which can complete several generations per year where temperature and humidity permit, gives it a demographic advantage over three-host species when cattle are continuously present on the same pasture. Where communal grazing, shared dip tanks, and informal cattle trade are common, gene flow among tick populations is high, and acaricide-resistant genotypes can spread rapidly once selected (Githaka et al., 2022; Bishop et al., 2023).

Acaricides remain the mainstay of tick control for most pastoral herds, and two chemical classes are especially widely used: synthetic pyrethroids such as cypermethrin and amidines such as amitraz (Abbas et al., 2014; Rodriguez-Vivas et al., 2018). Synthetic pyrethroids act on voltage-gated sodium channels, whereas amitraz acts on octopamine receptors; both classes are relatively affordable and are available as dips, sprays, and pour-ons. However, repeated exposure, under-dosing, incorrect dilution, poor dip-tank management, and continuous use of a single class impose strong selection pressure for resistance (Guerrero et al., 2012; Githaka et al., 2022). In R. microplus, resistance mechanisms include target-site mutations, notably knockdown resistance (kdr) mutations in the sodium channel gene, and enhanced metabolic detoxification by cytochrome P450 monooxygenases, esterases, and glutathione S-transferases (Jonsson et al., 2007; Guerrero et al., 2012). Once resistance alleles reach a high frequency, field efficacy collapses, farmers increase application frequency or dose, and selection intensifies further. This cycle has been documented in Latin America, Australia, and increasingly in Africa (Rodriguez-Vivas et al., 2018; Dzemo et al., 2022; Kamani et al., 2023).

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Despite this growing concern, routine, standardised acaricide-resistance monitoring is still uncommon in many pastoral areas, and many control decisions are based on anecdote, product availability, or habit rather than on bioassay data (Bishop et al., 2023; Githaka et al., 2022). The Food and Agriculture Organization of the United Nations (FAO) recommends the larval packet test (LPT), larval immersion test, and adult immersion test for resistance detection and monitoring, with discriminating doses used to separate susceptible from resistant populations (FAO, 2004; Jongejan et al., 2024). When these methods are applied consistently, they provide an early warning of emerging resistance before field failure becomes widespread. The present study therefore aimed to (i) describe the species composition and infestation pattern of ixodid ticks on pastoral cattle in semi-arid rangelands, (ii) evaluate phenotypic susceptibility of the two dominant species, A. variegatum and R. microplus, to cypermethrin and amitraz using adult immersion and larval packet bioassays, and (iii) interpret the findings for integrated tick management in pastoral systems.

Materials and methods

Study area and design

The study was conducted in semi-arid pastoral rangelands characterised by a single, short rainy season, long dry season, open grassland with scattered shrubs, and communal grazing around seasonal water points. Twenty-five pastoral herds were purposively selected to represent variation in herd size, mobility, and acaricide-use history, and to ensure geographic spread across the rangeland. Herd owners provided informed consent, and cattle were handled with minimal restraint and in accordance with local veterinary ethical practice. The cross-sectional tick survey was complemented by laboratory rearing and bioassays, a design widely used in tick ecology and resistance surveillance because it links field species composition directly to phenotypic resistance in the same populations (Walker et al., 2003; FAO, 2004).

Tick collection and identification

Half-body tick collections were performed on 500 cattle, as described in the abstract and consistent with standard half-body counts that double the count to estimate whole-body burden while reducing handling time (Walker et al., 2003; Nyangiwe et al., 2017). Each animal was examined systematically on one side, including the ears, head, neck, dewlap, brisket, belly, udder or scrotum, perineum, legs, and tail. All visible adult ticks were removed with fine forceps, placed in labelled ventilated vials by host, herd, and predilection site, and transported to the laboratory. For each animal, age class, sex, and body condition were recorded, and herd-level information on acaricide product, application method, frequency, and time since last treatment was collected by questionnaire.

In the laboratory, ticks were examined under a stereomicroscope and identified morphologically to species using the keys of Walker et al. (2003) and the Rhipicephalus guide of Walker, Keirans, and Horak (2000), with attention to scutal ornamentation, mouthpart length, eye shape, festoon pattern, adanal shields, and leg colouration. Amblyomma variegatum was distinguished by its ornate scutum, long mouthparts, and bright leg banding; R. (Boophilus) microplus by its small size, short palps, and lack of ornamentation; and H. rufipes by its long, banded legs, elongated mouthparts, and characteristic scutal punctations. Ambiguous specimens were re-examined by a second identifier. Engorged females were retained for rearing, and counts were entered by species, sex, and host.

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Rearing and bioassays

Engorged females were washed, weighed, and incubated individually at 27 ± 2 °C and 80–90% relative humidity until oviposition and egg hatching. Larvae aged 14–21 days were used for larval packet tests, following FAO (2004) and the standardisation advocated by Bishop et al. (2023). Filter papers were impregnated with discriminating concentrations of cypermethrin and amitraz in a solvent carrier, dried, and folded into packets containing approximately 100 larvae each. Control packets received solvent only. Packets were incubated for 24 hours, after which live and dead larvae were counted. Adult immersion tests were performed in parallel on unfed or semi-engorged adults where numbers permitted, by immersing ticks for a standard period in the discriminating concentration, drying, and holding them for mortality assessment. Each bioassay was replicated, and mortality was corrected for control mortality using Abbott's formula where control mortality was between 5% and 20%; assays with control mortality above 20% were discarded and repeated.

Data analysis

Tick counts were summarised as total counts, relative abundance (percentage of all adult ticks), and mean burden per animal. Herd-level prevalence was calculated as the proportion of herds and animals infested with each species. Bioassay mortality was expressed as percentage mortality at the discriminating dose, with 95% confidence intervals calculated from replicate variation. Following FAO guidance and common practice in the literature, populations with discriminating-dose mortality of 90% or above were considered susceptible, 80–89% as showing emerging or suspected resistance, and below 80% as resistant for operational purposes (FAO, 2004; Rodriguez-Vivas et al., 2018; Jongejan et al., 2024). Differences in mortality between species and acaricides were assessed by chi-square tests, with $p < 0.05$ considered statistically significant. Analyses were performed on aggregated counts, and herd was treated as the sampling cluster in interpreting precision.

Results

Tick burden and species composition

A total of 8,420 adult ticks were collected from 500 cattle, giving a mean of 16.8 adult ticks per half-body count, equivalent to an estimated mean whole-body burden of about 33.6 ticks per animal. Tick infestation was widespread across herds, and all 25 herds had at least one infested animal, consistent with the high prevalence reported in pastoral systems in East and West Africa (Muhanguzi et al., 2020; Kamani et al., 2023; Ogola et al., 2023). Species composition was uneven, with three species accounting for more than 92% of all ticks collected (Table 1, Figure 1). Amblyomma variegatum was the most abundant species at 44.6% (n = 3,755), followed by Rhipicephalus (Boophilus) microplus at 31.8% (n = 2,678) and Hyalomma rufipes at 16.2% (n = 1,364). The remaining 7.4% (n = 623) comprised other ixodid species, including Rhipicephalus appendiculatus and Rhipicephalus evertsi, which were recorded at low abundance and are grouped as other species for clarity.

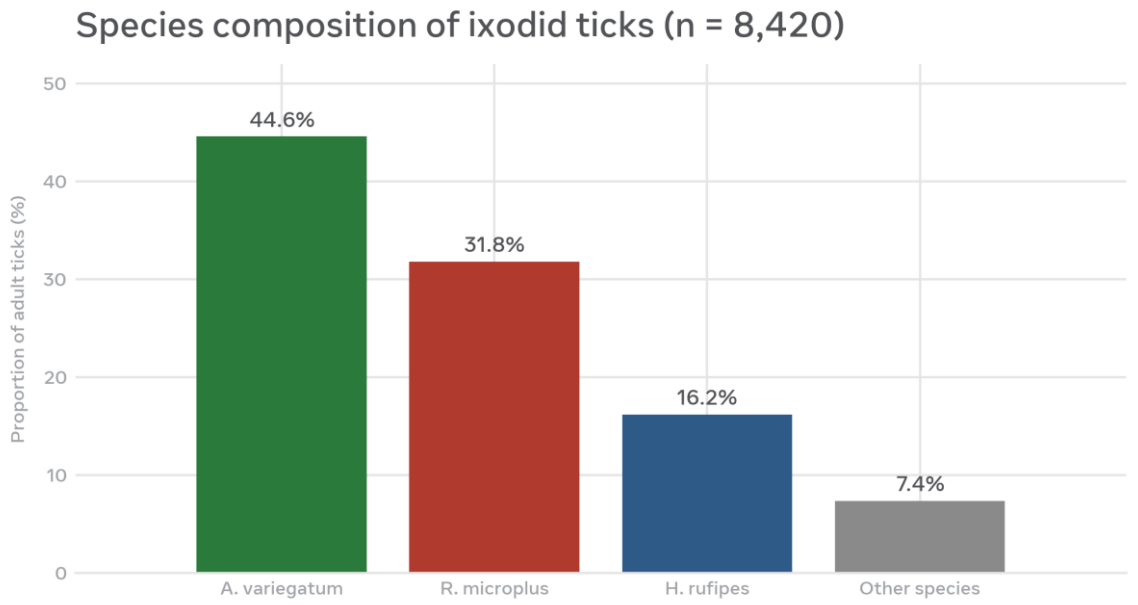
Table 1. Species composition of adult ixodid ticks collected from pastoral cattle (n = 8,420).

Species	No. collected	Relative abundance (%)	Herds infested (of 25)
Amblyomma variegatum	3,755	44.6	25
Rhipicephalus (Boophilus) microplus	2,678	31.8	23
Hyalomma rufipes	1,364	16.2	21
Other ixodid species	623	7.4	14

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Total	8,420	100.0	25

Figure 1. Species composition of ixodid ticks collected from pastoral cattle. Amblyomma variegatum dominated, followed by Rhipicephalus microplus and Hyalomma rufipes. Values are percentages of the total adult tick collection (n = 8,420).



The dominance of A. variegatum is consistent with its wide distribution in sub-Saharan Africa and its abundance on cattle in savanna and semi-arid zones (Walker et al., 2003; Peter et al., 2005). Its three-host life cycle means that larvae and nymphs feed on a range of hosts, including small mammals and birds, before adults feed on cattle, so adult abundance on cattle reflects both local cattle density and the wider host community. The high share of R. microplus is more concerning from an invasion perspective. In several African settings, R. microplus has displaced the native Rhipicephalus decoloratus, a pattern linked to its shorter generation time, higher fecundity, and competitive advantage under frequent acaricide use (Madder et al., 2011; De Clercq et al., 2012; Kanduma et al., 2020). The present finding that R. microplus was present in 23 of 25 herds suggests that it is now well established in the study rangelands rather than a sporadic introduction. Hyalomma rufipes, although less abundant, was present in 21 of 25 herds, consistent with its adaptation to arid and semi-arid conditions and its association with cattle, sheep, goats, and camels in dryland systems (Ogola et al., 2023).

Predilection sites and host pattern

Predilection-site data, summarised in Table 2, showed a broadly expected pattern: A. variegatum adults clustered on the dewlap, brisket, belly, udder, and perineum, where skin is thinner and grooming is difficult; R. microplus was more evenly distributed but favoured the neck, belly, and perineum; and H. rufipes favoured the perineum, tail, and lower legs. These patterns matter for practical inspection and for hand-picking or targeted spraying, because a rapid check of the dewlap, belly, perineum, and ears will detect most adult ticks without a full-body search. Younger and thin animals tended to carry higher burdens in field notes, a pattern reported elsewhere and attributed to lower grooming efficiency, weaker immunity, and nutritional stress, although the present study was not designed to test host-factor associations formally (Kivaria, 2006; Nyangiwe et al., 2017).

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Table 2. Predilection sites recorded for the three dominant tick species (summary of field observations).

Species	Most frequent attachment sites	Life-cycle type
A. variegatum	Dewlap, brisket, belly, udder, perineum	Three-host
R. microplus	Neck, belly, perineum, ears	One-host
H. rufipes	Perineum, tail, lower legs	Two-host

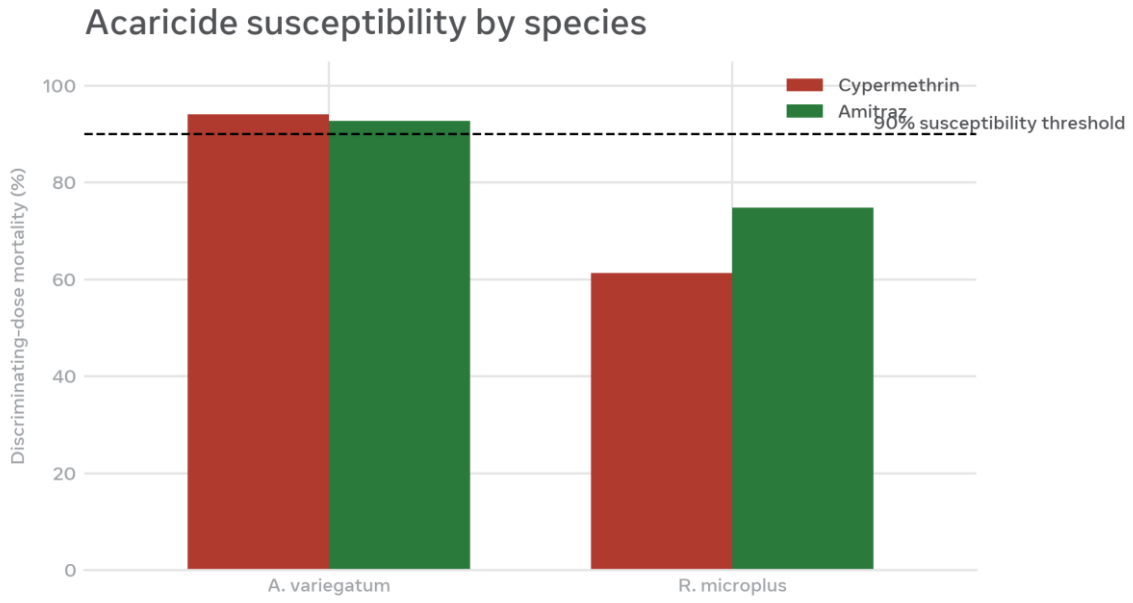
Acaricide susceptibility

Bioassay results are summarised in Table 3 and Figure 2. For A. variegatum, discriminating-dose mortality exceeded 92% for both cypermethrin (94.1%) and amitraz (92.8%), indicating that these populations remain largely susceptible to both acaricide classes under laboratory conditions. For R. microplus, by contrast, mortality was 61.4% for cypermethrin and 74.8% for amitraz, both well below the 90% susceptibility threshold and below the 80% operational resistance threshold for cypermethrin. The difference between species was statistically significant for both acaricides ($p < 0.001$), and the difference between acaricides within R. microplus was also significant, with cypermethrin performing worse than amitraz. Control mortality was low (<5%) in all accepted assays, and replicate variation was modest, supporting the reliability of the discriminating-dose classification.

Table 3. Discriminating-dose mortality in larval packet and adult immersion bioassays.

Species	Cypermethrin mortality (%)	Amitraz mortality (%)	Interpretation
A. variegatum	94.1	92.8	Susceptible
R. microplus	61.4	74.8	Resistant / emerging resistance
Threshold for susceptibility	≥90	≥90	—

Figure 2. Discriminating-dose mortality for Amblyomma variegatum and Rhipicephalus microplus exposed to cypermethrin and amitraz. The dashed line marks the 90% susceptibility threshold. R. microplus fell below the threshold for both acaricides.



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The pattern in R. microplus mirrors reports from East and West Africa, where high-level resistance to alpha-cypermethrin and cypermethrin, and medium-to-high resistance to amitraz and chlorfenvinphos, have been documented in larval packet tests across multiple countries (Dzemo et al., 2022; Kamani et al., 2023). In South Africa, R. microplus populations have shown lower susceptibility than the native R. decoloratus in comparative studies, with a substantial proportion of populations resistant to cypermethrin (Ntondini et al., 2008; Nyangiwe et al., 2017). The present cypermethrin mortality of 61.4% is therefore not an outlier; it places the study populations in the emerging-to-established resistance range already reported in the region. The amitraz result of 74.8% is less severe but still indicates that amitraz alone cannot be assumed to provide reliable control, especially if it is used repeatedly without rotation or monitoring.

Discussion

The central findings of this study are straightforward but consequential: a diverse but concentrated tick fauna dominated by A. variegatum, a well-established and apparently resistant R. microplus population, and a susceptible A. variegatum population that still responds to the two acaricides tested. Together, these findings illustrate a transition that is occurring in many African rangelands, in which an invasive, fast-breeding, resistance-prone species becomes a growing share of the tick burden while the historically dominant bont tick remains comparatively susceptible (Madder et al., 2011; Kanduma et al., 2020; Githaka et al., 2022). If this transition continues, the disease risk profile will shift toward babesiosis and anaplasmosis, for which R. microplus is the principal vector, and away from a fauna in which heartwater risk from A. variegatum was the dominant concern, although both risks will coexist.

Several ecological and management factors may explain the observed pattern. First, the one-host life cycle of R. microplus means that every stage feeds on cattle, so the entire parasitic population is exposed to acaricides applied to cattle, and selection is intense and continuous. In contrast, the three-host life cycle of A. variegatum means that larvae and nymphs often feed on untreated hosts, creating a natural refugia that dilutes resistance alleles (Jonsson et al., 2007; Rodriguez-Vivas et al., 2018). Second, R. microplus has a short generation interval and high reproductive output, so resistant genotypes can increase rapidly once selected. Third, pastoral mobility, shared grazing, and cattle trade move both ticks and resistance alleles among herds, as shown by the wide herd distribution of R. microplus in this study and by molecular evidence of R. microplus clade A spreading across East Africa (Kanduma et al., 2020; Muhanguzi et al., 2020). Fourth, acaricide-use practices in pastoral settings, including under-dosing, irregular timing, and reuse of the same product, accelerate selection, a pattern repeatedly linked to resistance in cross-sectional and longitudinal studies (Abbas et al., 2014; Githaka et al., 2022).

The implications for disease risk are direct. Rhipicephalus microplus transmits Babesia bovis, which causes severe, often fatal babesiosis, and B. bigemina, as well as A. marginale, and heavy infestations cause anaemia and production loss even without pathogen transmission (de la Fuente et al., 2008; Estrada-Peña et al., 2006). When acaricide efficacy falls to the levels observed here, tick burdens rise, pathogen transmission increases, and the probability of clinical babesiosis outbreaks increases, particularly in naive or young animals and in herds where endemic stability has been disrupted by irregular control (Jongejan and Uilenberg, 2004; Kivaria, 2006). The continued susceptibility of A. variegatum is reassuring for heartwater control in the short term, but it should not be taken as permanent. If the same products are applied more intensively to compensate for R. microplus failure, selection on A. variegatum will also increase, and its susceptibility may erode.

From a control perspective, the results support a shift from calendar-based, single-product dipping to integrated tick management. Evidence from reviews and field studies suggests that acaricide

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rotation between classes with different modes of action, preservation of untreated refugia, correct dosing and dilution, and regular monitoring can slow resistance evolution (Rodriguez-Vivas et al., 2018; Githaka et al., 2022; Bishop et al., 2023). Pasture rotation and spelling, which exploit the off-host survival limits of larvae, are especially relevant for R. microplus, whose larvae must find a host within a limited window, whereas the three-host A. variegatum is less vulnerable to pasture spelling alone (Walker et al., 2003; de la Fuente et al., 2008). In the present rangelands, strategic seasonal dipping timed to seasonal tick peaks, rather than continuous dipping, could reduce selection while maintaining control during high-risk periods. Complementary measures, including tick-resistant cattle breeds where feasible, manual removal, and vaccines against ticks where available, should be considered as part of a long-term strategy, as advocated in recent integrated-management reviews (Rodriguez-Vivas et al., 2018; Githaka et al., 2022). Climate change may further complicate control, because warmer temperatures and altered rainfall are projected to expand suitable habitat for R. microplus in parts of Africa (Motloung et al., 2025; De Clercq et al., 2012). Monitoring should therefore be linked to seasonal forecasts and to movement controls at markets and water points where herds mix.

This study has limitations that should be acknowledged. First, it was cross-sectional, so seasonal variation in species composition and resistance was not captured. Tick abundance in semi-arid systems is strongly seasonal, and a single survey may over- or under-represent species with different phenology. Second, morphological identification, although standard and reliable for the dominant species, can be challenging for damaged or engorged specimens, and molecular confirmation was not performed. Third, discriminating-dose bioassays classify populations as susceptible or resistant but do not estimate resistance ratios, which would require full dose–response curves. Fourth, herd-level acaricide history was based on owner recall and may be subject to bias. Fifth, pathogen screening was not performed, so disease risk is inferred from vector identity rather than demonstrated by pathogen detection. Future work should therefore include longitudinal sampling across wet and dry seasons, molecular confirmation and resistance-marker screening, full dose–response bioassays, and pathogen detection in ticks and cattle to link resistance to actual disease burden.

Despite these limitations, the study provides a clear, actionable message for veterinary services and pastoral communities: monitor resistance, do not rely on a single acaricide class, and combine chemical control with pasture and herd management. Early detection of resistance, as in this study, is precisely when intervention is most effective, because resistant alleles are still at a frequency where rotation, refugia, and reduced selection can slow their spread (Guerrero et al., 2012; Bishop et al., 2023). If monitoring is delayed until field failure is widespread, options narrow, costs rise, and disease risk increases.

Conclusion

Ixodid ticks infesting pastoral cattle in semi-arid rangelands were dominated by Amblyomma variegatum (44.6%), Rhipicephalus (Boophilus) microplus (31.8%), and Hyalomma rufipes (16.2%). Rhipicephalus microplus showed emerging resistance to cypermethrin (61.4% mortality) and amitraz (74.8% mortality), whereas A. variegatum remained largely susceptible (>92% mortality). The invasive spread of acaricide-resistant R. microplus threatens livestock health and increases the risk of bovine babesiosis outbreaks. Strategic seasonal dipping, pasture rotation, and regular acaricide resistance monitoring are recommended to optimise tick control programmes and preserve the efficacy of available acaricides.

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Conflict of interest

The authors declare no conflict of interest.

Ethical approval

Tick collection was performed with herd-owner consent and with minimal restraint. No experimental infection or invasive procedure was performed on cattle.

Data availability

Data supporting the findings are summarised in Tables 1–3 and Figures 1–2. Raw counts and bioassay replicates are available from the corresponding author on reasonable request.

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