Whole-System Tick Regulation

Understanding the Nested Systems That Create — or Prevent — Tick Problems

A Red Flag Report

Prepared for Regenerative Livestock Systems

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Executive Summary

Tick burdens in livestock are not a simple pest problem requiring a simple chemical solution. They are a symptom of system dysfunction — the visible expression of imbalances that cascade through soil, plant, animal, and ecosystem. This report presents an alternative framework for understanding and addressing tick challenges, grounded in emerging research that reveals the profound interconnections between soil health, plant nutrition, animal immunity, and parasite pressure.

The central insight is both troubling and hopeful: *the chemical interventions routinely used in UK livestock farming may be systematically undermining the biological systems that could regulate tick populations naturally*. Pyrethroid acaricides applied directly for tick control kill the invertebrate predators — spiders, ground beetles, ants — that would otherwise suppress tick populations. Meanwhile, avermectin anthelmintics used for worm control on the same farms degrade dung beetle populations that disrupt tick habitat, and may compromise the gut microbiome that underpins animal immunity.

This creates what we might call the **dependency trap**: intervention begets more intervention, while the underlying capacity for natural regulation is progressively degraded. The farmer becomes locked into an escalating cycle of chemical inputs with no end point, no long-term solution, and mounting concerns about resistance, residues, and environmental impact.

But there is another path. This report outlines the research supporting a whole-system approach to tick regulation — one that works with biological processes rather than against them, building the conditions in which tick populations are naturally suppressed through multiple reinforcing mechanisms. It is not a quick fix. It requires patience, observation, and a willingness to think differently about the relationship between livestock and the land they graze. But unlike the chemical path, it offers the possibility of genuine, lasting change.

The Problem Reframed

Before examining solutions, we must understand why conventional tick control has failed to deliver lasting results. The standard approach treats ticks as an external threat to be eliminated through chemical intervention — a war to be won through superior firepower. But this framing misses the essential nature of the problem.

Ticks have existed for at least 100 million years. They co-evolved with their hosts in ecosystems where natural regulation kept populations in check. The 'tick problem' as modern farmers experience it is largely a product of how we have restructured these systems — removing predators, simplifying vegetation, compromising animal immunity through breeding and management, and creating the conditions in which tick populations can explode.

From this perspective, high tick burdens are not the problem to be solved but a *symptom* of deeper dysfunction. Treating the symptom without addressing the cause ensures the problem will return — often worse than before, as the treatments themselves further degrade the systems of natural regulation.

What Ticks Actually Need

Understanding tick biology reveals why whole-system approaches are necessary. Ticks spend the vast majority of their lives off their hosts — in soil, leaf litter, and vegetation. A tick might spend 95% of its two-to-three-year life cycle in these off-host environments, vulnerable to predators, pathogens, desiccation, and starvation. They quest for hosts using sophisticated chemical detection systems, sensing carbon dioxide, body heat, and volatile compounds from hundreds of metres away.

This biology creates multiple intervention points that chemical approaches largely ignore. We can influence: the soil and vegetation environment where ticks spend most of their lives; the predator and pathogen communities that attack off-host ticks; the chemical signals that determine which hosts ticks target; and the immune responses that determine whether attached ticks succeed in feeding. Each of these represents an opportunity for regulation — and each is compromised by conventional management.

The Chemical Intervention Paradox

The paradox of chemical control becomes clear when we trace the full effects of treatment through the system. UK upland farms typically use multiple chemical interventions on the same animals and land — and each has distinct but cumulative effects on natural regulation.

Pyrethroid Acaricides: Direct Tick Treatment

For direct tick control in UK sheep, pyrethroid pour-on products are standard — cypermethrin (Crovect), deltamethrin (Butox), flumethrin (Bayticol), and alphacypermethrin (Dysect). These synthetic pyrethroids are broad-spectrum neurotoxins. They kill ticks effectively, but they also kill the invertebrate predators that would otherwise suppress tick populations naturally.

Spiders are paralysed by pyrethroids — and spiders capture questing ticks in vegetation. Ground beetles are killed — and ground beetles actively hunt tick larvae in pastures. Ants are affected — and ants raid tick egg masses. The treatment eliminates not just the target pest but the predator network that provides ongoing, free, self-sustaining tick suppression. Each application buys temporary relief while degrading the long-term capacity for natural control.

Avermectin Anthelmintics: Indirect but Significant Effects

While avermectins (ivermectin, moxidectin) are used primarily for worm control rather than tick control in UK systems, they are routinely used on the same farms and the same animals. Their effects on the broader system are significant and relevant to understanding tick dynamics.

Avermectins persist in dung for weeks after treatment, remaining active against invertebrates. Research consistently shows that avermectin-treated dung reduces dung beetle populations by 35% or more. Dung beetles are not just decomposers — they bury dung rapidly, disrupting the warm, moist microhabitats that ticks need to develop. They also attack tick eggs and larvae directly. Fewer dung beetles means more favourable conditions for tick reproduction.

Evidence is also mounting that avermectins can induce gut dysbiosis in treated animals. A 2025 review found that oral ivermectin causes significant changes to gut microbial communities across multiple mammalian species. A 2024 study demonstrated that ivermectin and moxidectin show antibiotic-like growth inhibition of gut bacterial isolates. Since gut microbiome health underpins immune function — including the inflammatory responses that determine tick feeding success — this represents another pathway through which routine farm treatments may increase long-term vulnerability to ticks.

The cumulative picture is sobering: pyrethroid tick treatments kill predators above ground; avermectin worm treatments affect the dung fauna and soil organisms below ground; and both may compromise the animal's own immune defences. The system is being degraded from multiple directions simultaneously.

The Nested Systems Framework

To understand whole-system tick regulation, we need a framework that captures how different biological systems interact and reinforce each other. The concept of a 'holarchy' — nested wholes where each level is both complete in itself and part of larger wholes — provides this framework. Unlike a hierarchy where higher levels dominate lower ones, a holarchy recognises that health and function at each level depends on and contributes to all other levels.

For tick regulation, four nested systems are particularly important: the soil system, the plant system, the animal system, and the whole ecosystem. Each contributes specific mechanisms of tick suppression, and each is influenced by how we manage the land. Understanding these systems — and how they interact — reveals both how we create tick problems and how we might resolve them.

The Soil System: Foundation of Everything

The soil is where tick regulation begins — and where it most often fails. Healthy soils teem with organisms, many of which directly attack ticks or create conditions hostile to their survival. Understanding this hidden world reveals why soil health is not peripheral to tick management but absolutely central to it.

Entomopathogenic Fungi: Nature's Tick Killers

Metarhizium anisopliae and related species are specialised insect-killing fungi that naturally occur in healthy soils. Research has demonstrated that these fungi can achieve over 90% mortality of engorged female ticks under field conditions. The fungi produce spores that attach to the tick's cuticle, germinate, and penetrate the body, eventually killing the tick and producing new spores to continue the cycle.

What makes these fungi particularly valuable is their persistence. Unlike chemical treatments that provide a brief window of protection, *Metarhizium* populations can establish permanently in suitable soils, providing ongoing population-level tick suppression. They take up residence in the same soil, leaf litter, and vegetation where ticks spend most of their lives — creating what researchers call 'hostile habitat' for tick survival.

Perhaps most remarkably, these fungi can colonise plant roots, becoming endophytic — living within plant tissue. Animals brushing through vegetation may pick up fungal spores naturally, providing a mechanism for biological tick control that requires no human intervention once established. The fungi also promote plant growth and increase plant defence against insects, creating multiple benefits beyond tick control.

Predatory Nematodes: Microscopic Hunters

Microscopic roundworms of the genera *Steinernema* and *Heterorhabditis* are entomopathogenic nematodes that actively hunt and parasitise soil-dwelling arthropods, including tick larvae and engorged females. These nematodes carry symbiotic bacteria that kill their hosts within 24-48 hours, after which the nematodes reproduce within the cadaver and release a new generation of hunters.

Combined application of *Heterorhabditis bacteriophora* nematodes with *Metarhizium anisopliae* has achieved tick control exceeding 90% in research trials — comparable to chemical treatments but without the collateral damage to beneficial organisms. These nematodes and fungi persist in healthy soils, providing ongoing suppression rather than temporary relief.

Soil Biology and Nutrient Cycling

Beyond direct tick predation, soil biology influences tick burdens through nutrient cycling. A 2022 study published in *PeerJ* found that regenerative farms had twice the soil organic matter of paired conventional farms, and crops from these soils showed higher levels of vitamins, minerals, and phytochemicals. A 2025 study in *npj Science of Food* found pasture soils with 1.4× higher organic matter produced forages with dramatically higher nutrient and phytochemical content.

The mechanism is well understood: mycorrhizal fungi extend plant root systems and dramatically increase mineral uptake, particularly phosphorus and micronutrients. Soil bacteria solubilise otherwise inaccessible minerals like iron, zinc, and copper. Heavy tillage and synthetic fertilisers disrupt these symbiotic partnerships. Research suggests that 85-90% of plant nutrient acquisition is mediated by soil microbes under healthy conditions — when these relationships are damaged, plant nutrition suffers regardless of soil mineral content.

This creates a cascade: degraded soil biology produces nutrient-depleted plants, which produce nutritionally compromised animals, which lack the immune function to resist parasites effectively. The tick problem begins underground, in the invisible microbial world we have so thoroughly disrupted.

How We Undermine the Soil System

Modern livestock management undermines soil biology through multiple pathways. Avermectin anthelmintics used for worm control persist in dung for weeks, killing the dung beetles, nematodes, and other organisms that would normally process it rapidly. Compaction from overstocking crushes soil structure and reduces the oxygen that aerobic soil organisms need. Synthetic fertilisers bypass and eventually suppress the microbial partnerships that plants depend on for nutrient uptake. Bare soil between vegetation allows UV radiation to kill surface-dwelling beneficial organisms.

The cumulative effect is soil that cannot perform its regulatory functions. Tick-killing fungi and nematodes are suppressed or eliminated. Nutrient cycling is impaired. The foundation of the whole system is compromised — and no amount of pyrethroid treatment can compensate for this fundamental dysfunction.

The Plant System: Nutrition and Medicine

Plants are the interface between soil and animal — the mechanism through which soil health translates into animal health. But plants are not passive conduits. They produce an extraordinary array of compounds that directly influence parasite resistance, and they respond to soil conditions in ways that profoundly affect the animals that graze them.

Plant Secondary Metabolites: Nature's Pharmacy

Beyond basic nutrients, plants produce thousands of 'secondary metabolites' — compounds that serve defensive and signalling functions rather than basic metabolism. These include tannins, terpenoids, alkaloids, and phenolic compounds. Many of these have direct antiparasitic activity; others support immune function in animals that consume them.

Condensed tannins have been particularly well-studied. Research demonstrates that livestock grazing plants containing 3-4% condensed tannins in dry matter show significantly lower nematode burdens. Studies on sainfoin, birdsfoot trefoil, sulla, and sericea lespedeza consistently show that animals grazing these plants have lower faecal egg counts and reduced need for anthelmintic treatment. Lambs infected with multi-resistant *Haemonchus contortus* showed 50% lower egg counts when fed sainfoin pellets compared to controls.

While most research has focused on internal parasites, the principle extends to external parasites. Animals with lower internal parasite burdens are healthier overall, with stronger immune function and better nutritional status — factors that influence tick resistance. Some plant compounds may also have direct repellent or toxic effects on ticks, though this remains an area for further research.

Self-Medication: Animals Know What They Need

Perhaps the most remarkable finding from pasture research is that animals can detect their own parasite burdens and adjust their diet accordingly. Research by Villalba, Provenza, and colleagues at Utah State University demonstrated that parasitised lambs ate more tannin-containing food than non-parasitised lambs. This preference was highest when parasite burdens were highest and decreased as burdens fell — suggesting that lambs detected parasites or associated symptoms and modified their intake of antiparasitic compounds accordingly.

This self-medication behaviour — known as zoopharmacognosy — has been documented across numerous species. Farmers consistently report similar observations: cattle preferentially browsing hawthorn, birch, and rowan at different times of year; calves with joint ill seeking out willow; animals targeting specific plants when unwell. These behaviours suggest an innate wisdom about plant medicine that monoculture pastures deny animals access to.

Deep-Rooted Plants and Mineral Access

Many plants in diverse pastures are deep-rooted, accessing mineral layers that shallow-rooted ryegrass cannot reach. Chicory, ribgrass, sheep's parsley, yarrow, and burnet bring up calcium, copper, sodium, iron, phosphorus, magnesium, and potassium from deeper soil horizons. Willow can provide zinc, selenium, and vitamin E. Research shows that browsing can constitute up to 55% of cattle diet and 76% for sheep when trees are available.

This has direct implications for tick resistance. Copper and zinc are essential for skin integrity and immune function. Selenium deficiency impairs neutrophil activity. Over 60% of beef cattle are estimated to have copper deficiency, with selenium deficiency almost as common in some regions. Animals on diverse pastures with access to deep-rooted plants and browse may naturally correct these deficiencies in ways that supplementation cannot fully replicate.

How We Undermine the Plant System

Modern pasture management systematically eliminates the plant diversity that supports animal health. Ryegrass-clover monocultures lack the secondary metabolites that provide antiparasitic effects. Improved cultivars may have had defensive compounds bred out of them. Herbicide use eliminates 'weeds' that include many medicinal plants. Trees and shrubs are removed, eliminating browse. The result is a nutritionally and medicinally impoverished diet that leaves animals vulnerable to parasites they might otherwise resist.

The 2025 *npj Science of Food* study quantified this loss: forages from pasture contained 118× higher phytochemical content than total mixed rations. Even when we try to provide adequate nutrition through supplementation, we cannot replicate the complex chemistry of diverse pastures. Grass-fed beef contained 3.1× higher phytochemical antioxidants, 2.9× more vitamin A, and 4.2× more vitamin E compared to grain-fed — differences that reflect what the animals ate, not just how they were raised.

The Animal System: From Victim to Active Defender

Within the animal itself, multiple systems influence tick burden and disease susceptibility. The gut microbiome, immune function, skin chemistry, grooming behaviour, and genetics all play roles. Understanding these mechanisms reveals why nutritional and management interventions can be as powerful as chemical treatments — and why chemical treatments may undermine the animal's own defences.

The Animal Health Pyramid: A New Framework

John Kempf's work in regenerative agriculture established a foundational principle for plant health: plants achieving their nutrition through healthy microbial partnerships can complete protein synthesis, produce healthy fats, and generate secondary metabolites that actively repel pests. Conversely, plants on degraded soils cannot fully convert nitrates and ammonia into complete proteins — and these incomplete metabolic products attract pests like aphids, which require the simple nitrogen forms that healthy plants don't produce.

Emerging evidence suggests the same principle applies to animals. A 2024 review in *Parasites & Vectors* provides the foundational insight: 'Volatile organic compounds (VOCs) are chemicals emitted as products of cell metabolism, which reflects the physiological and pathological conditions of any living organisms.' Animals, like plants, emit chemical signals that reflect their metabolic state — and parasites respond to these signals.

Perhaps most striking is research on hedgehogs: 'The fecal odor of sick hedgehogs mediates olfactory attraction of the tick *Ixodes hexagonus*.' Sick animals literally smell more attractive to parasites. This suggests a mechanism through which nutritionally stressed or immunocompromised animals might 'broadcast' their vulnerability.

Skin Chemistry and Tick Attraction

A landmark 2017 study in *Parasites & Vectors* compared tick-resistant and tick-susceptible cattle breeds and found striking differences in skin chemistry. Skin rubbings from tick-susceptible cattle attracted significantly more tick larvae than rubbings from resistant hosts. Susceptible animals expressed more genes encoding enzymes that produce volatile odoriferous compounds — the same detoxification enzymes that produce semiochemicals affecting tick behaviour.

Sweat composition includes ammonia, lactic acid, urea, and amino acids — all nitrogen-containing compounds that reflect metabolic processing efficiency. Research shows that mosquitoes prefer aged sweat with higher ammonia levels. More ammonia equals more attraction to blood-feeding parasites. Recent evidence shows urea transporter expression in sweat glands, suggesting active mechanisms for excreting nitrogen waste through skin — waste that may signal vulnerability to parasites.

This creates a direct analogy to Kempf's plant work: just as aphids are attracted to the nitrates and ammonia in nutritionally stressed plants, ticks and mosquitoes may be attracted to the ammonia, urea, and lactic acid in the secretions of nutritionally stressed animals. The animal is not a passive victim but an active signal — broadcasting either health or vulnerability through its skin chemistry.

The Gut Microbiome: Foundation of Immunity

The gut microbiome has emerged as central to understanding animal health and disease resistance. Research has established that germ-free animals have thinner gut tissue, smaller mucus layers, sparse immune cells, and reduced immunoglobulin production. Gut dysbiosis can affect distant organs through multiple pathways — the microbiome-gut-mammary axis, microbiome-gut-lung axis, and others. Rumen microbiota dysbiosis has been linked to increased mastitis severity and other systemic inflammatory conditions.

A particularly important finding from rumen research: concentrate-fed cattle showed higher diversity and abundance of antimicrobial resistance genes than forage-fed cattle. Concentrate diets increased Proteobacteria, which includes many pathogens. All cases of rumen dysbiosis in one study (eight animals) were from concentrate-fed cattle — none from forage-fed. Forage-based diets support healthier, more stable rumen microbiomes that underpin systemic immune function.

The implications for tick resistance are significant. The same immune pathways that protect against internal parasites and pathogens also influence tick feeding success. Resistant animals mount faster inflammatory responses at tick bite sites, recruiting more immune cells and destabilising tick attachment cement. Animals with compromised gut microbiomes — whether from diet, stress, or repeated anthelmintic treatment — may lack this immune capacity, making them not just more attractive to ticks but less able to mount effective responses when bitten.

Grooming Behaviour: Physical Defence

The 'programmed grooming model' is an evolutionary hypothesis supported by over 26 studies with ungulate hosts and ticks. Grooming to remove ectoparasites is regulated by a type of internal biological clock that has evolved to pre-emptively remove parasites before they can feed. Animals with poor or restricted grooming are vulnerable to excessive tick infestations.

The tongue is the primary grooming tool for cattle, and breed differences in skin mobility and tongue length influence tick resistance. *Bos indicus* cattle — with more mobile skin and longer tongues — are significantly more tick-resistant than *Bos taurus* (European) breeds. But all cattle need access to scratching structures for areas they cannot reach with their tongues.

Trees provide natural rubbing posts that allow animals to groom face, neck, and legs. Research on bears found they preferentially rub against conifers that release resinous compounds with tick-repellent properties — suggesting scratching may serve dual functions of physical removal and chemical deterrence. Cattle without scratching access show increased attempts to rub on fences and equipment, risking injury while failing to achieve adequate grooming.

Genetic Resistance: Working with Natural Selection

Breed differences in tick resistance are well-documented and substantial. *Bos indicus* breeds are significantly more resistant to ticks than European cattle. Heritability for tick burden is approximately 0.30 — sufficient for selection programmes to be effective. Studies at Rockhampton, Australia demonstrated that completely resistant lines can be developed within commercially acceptable timeframes, even from susceptible breeds.

In sheep, indigenous breeds like the Namaqua Afrikaner show stronger immune gene expression at tick attachment sites compared to commercial breeds. These locally adapted animals have evolved under tick pressure and developed multiple resistance mechanisms — faster inflammatory responses, different skin chemistry, and more effective grooming behaviours.

Chemical intervention may be masking and preventing expression of these natural resistance traits. When we treat all animals equally with acaricides, we prevent natural selection from operating. The traits that would allow some animals to thrive without treatment are never expressed, never selected for, never passed to the next generation. We breed for other traits — growth rate, conformation, milk yield — while ignoring the parasite resistance that traditional breeds developed over centuries.

How We Undermine the Animal System

Modern livestock management compromises animal defences through multiple pathways. Avermectin anthelmintics that disrupt gut microbiomes impair the immune foundation. Concentrate feeding destabilises rumen ecology. Bare paddocks without trees deny scratching access. Breeding for production traits ignores parasite resistance. Housing systems that restrict movement limit grooming behaviours. Each management choice that prioritises convenience or short-term productivity over animal agency undermines the systems that could provide lasting protection.

The 'pet lamb problem' illustrates this perfectly. Pet lambs without adequate colostrum are immunologically compromised from birth. Their skin conditions are not isolated problems but symptoms of systemic metabolic incompleteness. They may be 'broadcasting' vulnerability through altered skin chemistry — and no amount of pyrethroid treatment can fully compensate for the developmental deficits created by inadequate early nutrition.

The Whole Ecosystem: Predators, Habitat, and Balance

Beyond soil, plants, and animals, the broader ecosystem provides additional mechanisms of tick regulation. Ground-dwelling predators, vegetation structure, microclimate, and habitat complexity all influence tick populations in ways that management can either support or undermine.

The Predator Network

Ticks have numerous natural predators that operate at different life stages. Ground beetles actively hunt tick larvae in pastures. Spiders capture questing ticks in vegetation. Ants raid tick egg masses. Parasitic wasps attack engorged females. Starlings follow livestock across pastures, picking off ticks as they forage. Blackbirds and thrushes consume ticks while turning over leaves and probing soil. Grey partridges eat ticks while ground-feeding. Corvids — jackdaws, rooks, crows — are opportunistic feeders that will take ticks from vegetation and occasionally directly from livestock. Domestic chickens, where kept, can be highly effective, consuming hundreds of ticks per hour.

The effectiveness of these predators depends on habitat. Simplified landscapes with bare soil and minimal vegetation harbour fewer predator species. Pyrethroid acaricides — applied directly for tick control — kill spiders, beetles, and other beneficial invertebrates alongside ticks. The result is a landscape where tick populations face little predation pressure — even as chemical treatments attempt to compensate for the lost natural control.

Vegetation Structure and Microclimate

Tick survival is highly sensitive to microclimate, particularly humidity. Ticks can survive only about 48-72 hours in dry conditions before desiccating. Vegetation structure influences the humidity levels in the tick zone — the 15-20 centimetres above ground where most tick activity occurs. Dense, rank vegetation maintains high humidity; well-grazed swards dry more quickly and create less favourable conditions.

However, the relationship is not simple. Very short swards may increase tick-host contact by forcing animals to graze closer to ground level. Diverse swards with varying heights create heterogeneous microclimates that may reduce tick survival in some areas while providing predator habitat in others. The optimal approach likely involves creating structural diversity rather than uniformity.

Silvopasture: Multiple Benefits

Trees in pastures provide multiple benefits for tick management. They offer scratching posts for physical tick removal. Their shade creates cooler microclimates that may reduce tick activity. Browse species provide medicinal compounds. Leaf litter harbours predatory invertebrates and entomopathogenic fungi. Some tree species produce resins with tick-repellent properties.

Silvopasture systems — integrating trees, pasture, and livestock — represent a return to the savannah-woodland habitats where cattle and their ancestors evolved. These systems naturally support the predator diversity, plant complexity, and behavioural opportunities that suppress tick populations through multiple mechanisms. They require different management than bare paddocks but offer benefits that simple pastures cannot provide.

Synthesis: The Whole-System Framework

The research presented in this report paints a picture of tick regulation as an emergent property of healthy, functioning ecosystems. The components form a holarchy — nested wholes where each level is both complete in itself and part of larger wholes. Soil biology influences plant nutrition influences animal immunity influences tick attraction influences predator populations. Intervening at one level creates ripple effects throughout the system.

System Level	Contribution to Regulation	Pyrethroid Impact (Tick Treatment)	Avermectin Impact (Worm Treatment)
Soil Biology	Entomopathogenic fungi, predatory nematodes, nutrient cycling	Limited direct effect on soil organisms	Persists in dung; reduces dung beetles 35%+; affects soil fauna
Plant Nutrition	Trace minerals, secondary metabolites, phytochemicals	Indirect: reduced nutrient cycling if predators affected	Indirect: impaired dung decomposition affects nutrient cycling
Gut Microbiome	Immune function, nutrient absorption, systemic health	Minimal direct effect (topical application)	Can induce dysbiosis; antibiotic-like effects on gut bacteria
Skin Health	Physical barrier, chemical signals, tick attraction	Temporary protection; no long-term improvement	Indirect: compromised immunity may affect skin health
Natural Predators	Ground beetles, spiders, ants, parasitic wasps	Kills spiders, beetles, beneficial invertebrates	Reduces dung beetle populations that attack tick eggs/larvae

The Dependency Trap: On a typical UK upland farm, pyrethroid pour-ons for tick control kill invertebrate predators above ground, while avermectin drenches for worm control affect the dung fauna and soil organisms below ground and may compromise gut immunity. Each intervention addresses an immediate symptom while undermining systems that could provide lasting regulation. The farmer becomes locked into escalating chemical dependency with no exit strategy.

The Alternative Path: Building healthy soils that support diverse plant communities, maintaining animal nutrition through varied diets, allowing natural behaviours like grooming and self-medication, and working with genetics rather than against them creates a system that can increasingly regulate itself. This path requires patience and acceptance of some short-term costs, but it offers what the chemical path cannot: the possibility of genuine, lasting improvement.

Practical Recommendations

Transitioning from chemical dependency to whole-system tick regulation is not a simple matter of stopping treatments. It requires building alternative systems of regulation while gradually reducing inputs. The following recommendations provide a framework for this transition.

Building Soil Health

Prioritise practices that build soil biology: reduce tillage, maintain ground cover, integrate livestock for nutrient cycling, and avoid inputs that harm soil organisms. Consider strategic inoculation with entomopathogenic fungi (*Metarhizium* products are commercially available) to establish tick-killing populations in pastures. Where possible, time anthelmintic treatments to minimise dung contamination during peak dung beetle activity, or use targeted selective treatment approaches that leave some animals untreated.

Diversifying Pastures

Include tannin-containing plants in pasture mixes: sainfoin, birdsfoot trefoil, chicory, and plantain all provide antiparasitic effects. Establish diverse native swards with deep-rooted species that access subsoil minerals. Maintain or establish hedgerows and tree lines that provide browse, scratching posts, and shade. Where possible, create silvopasture systems that integrate trees throughout grazing areas.

Supporting Natural Behaviours

Provide scratching structures in all grazing areas — trees are ideal, but posts or brushes can substitute. Avoid management that restricts grooming behaviours. Allow animals choice in grazing to support self-medication. Observe and learn from animal preferences — they often indicate nutritional or health needs that management can address.

Working with Genetics

Select breeding stock that demonstrate natural tick resistance. Consider native or locally adapted breeds that have evolved under parasite pressure. When treating for tick control, consider treating only the most susceptible animals rather than the entire flock, allowing resistant genetics to be expressed and selected. Record tick burdens to identify animals for retention or culling.

Reducing Chemical Dependency

Transition gradually rather than stopping treatments abruptly. Consider targeted treatment of vulnerable animals (young stock, animals in poor condition) rather than blanket treatment. Explore alternative products: diatomaceous earth, essential oil-based repellents, and biological products may provide some control while building natural regulation. Monitor carefully and be prepared to intervene if animal welfare is compromised during transition.

Monitoring and Learning

This is genuinely uncharted territory — observations are valuable data. Record tick burdens, animal health indicators, and management changes systematically. Look for patterns: which animals resist, which areas have higher burdens, what conditions correlate with problems. Share observations with others making similar transitions. The knowledge base for whole-system tick regulation is still developing, and practical experience is essential to its growth.

Conclusion

The conventional approach to tick control has reached its limits. Resistance is increasing, environmental concerns are mounting, and decades of treatment have not produced lasting solutions. This report has argued for a fundamentally different approach — one grounded in understanding the holarchy of nested systems that create or prevent tick problems, and in working with biological processes rather than against them.

The evidence presented here supports a simple but profound insight: *tick burdens are not primarily a pest problem but a symptom of system dysfunction*. When we degrade soil biology, simplify plant communities, compromise animal immunity, and eliminate natural predators, we create the conditions in which ticks thrive. Chemical intervention then becomes necessary — but it further degrades the systems of natural regulation, locking us into escalating dependency.

The alternative is to rebuild these systems: healthy soils supporting nutrient-dense pastures, diverse plant communities providing both nutrition and medicine, animals with intact microbiomes and strong immune function, and landscapes harbouring the predators and pathogens that naturally regulate tick populations. This approach requires patience, observation, and a willingness to accept some short-term costs for long-term benefit.

For regenerative livestock systems, this research reinforces a central principle: the health of the whole determines the health of the parts. We cannot treat tick problems in isolation any more than we can treat soil degradation, plant nutrition, or animal immunity in isolation. These are all expressions of system function — or dysfunction. Addressing them requires thinking and acting at the system level.

The path forward is not easy, but it is clear. Build the soil. Diversify the pastures. Support natural behaviours. Work with genetics. Reduce chemical dependency gradually while monitoring carefully. And trust that healthy systems have an inherent capacity for self-regulation that no amount of intervention can replace.

> *The whole-system approach requires patience and observation. These interconnected systems take time to develop. But unlike the chemical path, which offers no long-term solution, this approach offers the possibility of genuine, lasting change — a system that increasingly regulates itself.*