

Spread of ticks and tick-borne infections: Does Kandyan Home Garden system facilitate them?

Kandyan Home Garden (KHG) is globally recognized as one of the oldest agroforestry systems in Asia. It has been an effective land use method in Sri Lanka for centuries; yielding multiple functions and providing alternative income sources for households being an integral part of our culture. The districts of Kandy, Matale, Nuwara Eliya, Kegalle, Rathnapura, and Badulla, located mainly in the central highlands of the island, are the main areas having the KHGs. The KHGs are structured in such a way that it is composed of natural inhabitant fauna and flora in the surroundings as well as farmers' choices of crops and livestock that meet the household needs (Figure 1). The KHG system combines agriculture, forestry, and livestock; trees are grown in a multi-layer arrangement, with mixed cropping of trees yielding timber, firewood, fodder, and those producing food and medicine. In general, the products of KHGs help the self-reliance of households. The KHG also provides other ecosystem services, provisioning and regulating cultural and support services while making an attractive living environment for its community. Above all, the KHGs connect the fragmented natural forests creating a biodiversity-friendly land use system.

Wild animals such as barking deer, wild boars, mongoose and porcupines are common in the KHGs. However, a significant increase in their presence in the neighborhoods is noted during the last two decades mainly due to the deforestation of upland habitats and partial abandonment of gardens and paddies making convenient foraging grounds for them. In addition, monkeys from tourist sites, such as Kandy city have been relocated into pine plantations that do not provide necessary feed for monkeys but provide them habitat corridors to frequent in settled areas. These unmanaged wild animals have reduced the contribution of KHG provisioning services to livelihood sustainability.

Wild animals roaming in KHGs can serve as hosts of many ectoparasites and reservoirs of vector-borne pathogens. Pathogen spillovers are likely to occur when humans and domestic animals encounter potentially infected wild animals. Among all arthropod-borne diseases, ticks transmit the most diverse array of infectious agents to both humans and domestic animals. Tick-borne infections are caused by pathogenic bacteria, viruses, and protozoans. Bacterial infections include anaplasmoses, Lyme disease, rickettsioses, and ehrlichioses; viral infections include tick-borne encephalitis and Crimean-Congo hemorrhagic fever; and protozoan infections are babesiosis and theileriosis. With increased contact with wildlife, the incidence of human tick-borne infections is emerging globally. As such, the KHGs appear to be a determining factor for the gradual emergence of tick-borne infections in pets and humans.

Ticks as ectoparasites infest many vertebrate species, while humans are only accidental hosts. Sri Lanka has a very diverse tick fauna consisting of at least 31 species belonging to 11 genera. The tick life cycle has four stages: eggs and three active parasitic stages, including larva, nymph, and adult stages (male and female). All stages, except for the eggs, need a blood meal, and while feeding, they may acquire pathogens from infected hosts and transmit them to naïve hosts. Most species have the potential to feed on a wide range of host species that share common habitats but may have preferences dictated by host availability. Smaller mammals like non-volant rodents harbour the immature stages in the tick life cycle. In comparison, larger mammals carry the mature stages and play a significant role as tick-maintenance hosts and reservoirs of tick-borne pathogens. Ticks and tick-borne infections have coevolved with various wild reservoirs and often live in a state of equilibrium. Although wild animals typically do not exhibit clinical diseases unless immune-compromised or stressed, humans and domestic animals can often exhibit clinical diseases when bitten by infected ticks or by contact with infected animal tissues or blood.

Many tick-borne infections are reported in humans, domesticated animals, and wildlife in Sri Lanka. The first record of clinical and laboratory diagnosis of human spotted fever rickettsioses in Sri Lanka was from the central hills in 2001. The western slope of the central hills has been identified as a tick belt, reporting many tick-borne infections, such as murine typhus, scrub typhus, and spotted fever group rickettsia in humans. KHGs in these areas facilitate such disease-spreading threats by spillover effects due to the intensity and frequency of human interactions with livestock, pets, and wildlife in the KHGs.

Exposure to tick bites can occur either when wild animals come into the human neighborhoods or when people are involved in outdoor activities such as collecting firewood, rearing animals, cutting grass for livestock, etc. Women and children are primarily engaged in these activities. Studies have shown that the main risk factors of otoacariasis (presence of ticks in the external ear canal) in the wet zone of Sri Lanka are engagement in outdoor activities and the presence of wildlife in and around households. Wild boar, a frequent visitor to home gardens, is the primary host of tick species, *Dermacentor auratus*, the causative agent of human otoacariasis in Sri Lanka. Traditional fencing is of limited protection against repeated incursions of wild animals into home gardens. An increase in the wild boar population is linked to the significant decline of the jackal population, which is used to maintain the food chain and stabilize prey populations.

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The Flora and Fauna Protection Ordinance (FFPO 1937) states that “no animal shall be hunted, killed or taken” unless caught harming crops. Among the wild animals frequently visiting the KHGs, the law protects some. The conservation law enacted in 1964 bars the sale of wild boar meat, even if the animals are killed legally. Farmers generally do not dare to kill wild animals due to religious or cultural practices linked with the animal. The traditions of Sinhalese Buddhists consider the realm of animals a microcosmic representation of human society in which all animals’ lives are protected. Culturally, hunting is regarded as a taboo, and the rights of animals are preserved with the “no kill” regulations restricting hunting for population control. A permanent solution to reduce some of the wild

animals in the neighborhoods is to enrich the predator habitats while enforcing culling laws for sustainable conservation. Predation is a natural way of reducing a prey population, however, it takes a long time to control the population and show the progress of population declines of wild boars and other wild animals that have become pests. Culling is a relatively faster approach and can be used as a temporary solution. Locally hunted porcupine and boar are consumed by rural folks in Sri Lanka. Wild boar meat is in high demand in urban areas presenting a significant livelihood supplement opportunity. Diverting investment to introduce interventions to control potential reservoir animals may significantly affect regulating tick infestations and tick-borne infections in the KHGs.



Figure 1. Kandyan Home Garden system: an age-old traditional agroforestry system practiced in the central hilly areas and in some other districts in Sri Lanka. This system combines agriculture, forestry and livestock; trees are grown in a multi-layer arrangement; mixed cropping of trees yield timber, small wood, fuelwood, fodder, together with crops producing food and medicine. Maximum utilization of space, both vertical and horizontal is ensured in this system.

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