EC MICROBIOLOGY
Opinion

Current Status of Tick Control

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Introduction

Ticks (Acari) are blood sucking ectoparasites of a number of vertebrates including humans. They comprise two large families; Ixodidae or hard ticks and Argasidae or soft ticks. In general, people at risk for tick exposure are involved in outdoor activities in wooded areas and in areas inhabited by small rodents, which commonly serve as hosts for ticks. Tick bites are generally limited to small erythematous papules and dermatitis. More serious consequences of tick bites include tick paralysis caused by substances released by ticks during feeding and disease transmission [1]. Ticks are considered the second worldwide vectors of diseases. They transmit various deadly diseases to humans and animals such as lyme disease, tick-borne encephalitis, Rocky Mountain spotted fever, babesiosis and theileriosis during hematophagy. In addition, they can cause severe anemia to the host [2,3]. A single tick bite can transmit multiple pathogens, a phenomenon that has led to atypical presentations of some classic tick-borne diseases [4]. Therefore, control of tick is a priority for many countries especially in tropical and subtropical regions to reduce this significant economic loss [5]. The preventive strategies for ticks and tick-borne diseases are discussed below:

Personal Strategies

They include: 1) Avoiding bushes that attract ticks, 2) Wearing white or light-colored clothing so that attached ticks can be easily noticed and removed, 3) Wearing protective clothing that fit tightly about the ankles, wrists, waist and neck so that ticks cannot gain access to the skin, 4) Applying repellents to body e.g. DEET or clothes and other fabrics such as nets or tents can be impregnated with permethrin [6,7].

Ecological Strategies

Ecological control procedures involve the removal, destruction or modification of suitable environment that might favor the survival of ticks i.e. landscape management or "tickscape" practices for example, altering the landscape to increase sunlight and lower humidity may render an area less hospitable to ticks. However, these practices create a lower risk tick zone but will not eliminate many ticks [8].

Chemical Strategies

Acaricides

Organophosphates: (e.g. parathion, malathion, diazinon, chlorpyrifos and coumaphos). They irreversibly inactivate acetylcholinesterase, thus influencing cholinergic nerve transmission in insects, humans, and many other animals. Products with these chemicals are no longer used for tick control because of their toxicicity to vertebrates [9,10].

Carbamates: (e.g. carbaryl and promacyl). They act by inhibiting the target's cholinesterase with very low mammalian and dermal toxicity. Carbaryl (Sevin) is a broad-spectrum compound used for a wide variety of pests on the grass, on pets, and in the home [11].

Pyrethrins and Pyrethroids: Pyrethrum is a natural insecticide extracted from *Chrysanthemum cinerariaefolium* plants, which has a little residual effect being highly unstable in light and air. Natural pyrethrins are considered knockdown agents because they rapidly paralyze insects [12]. Synthetic pyrethroids are derivatives of the natural compounds, chemically modified to increase stability. The pyrethroids are less volatile than the natural compounds and photostable, which provides some residual activity and greater insecticidal activity [13].

Macrocyclic lactones: (e.g. avermectins (Ivermectin and doramectin) and milbemycins (moxidectin)). Macrocyclic lactones are active in very low doses for the control of ticks. Macrocyclic lactone acaricides are efficacious, but of high cost [14].

New Acaricides: 1) Benzoyl phenyl urea acts as acarine growth regulator. The most important one widely used is fluazuron (Acatak). They act through inhibition of synthesis and/or deposition of chitin which plays a critical role in the survival of the arthropods. Depending on the fact that chitin is not found in vertebrate, fluazuron becomes an efficient and highly selective control method [15,16]. 2) Spinosad is a fermentation metabolite of the actinomycete *Saccharopolyspora spinosa*. It acts by disruption of the binding of acetylcholine in nicotinic acetylcholine receptors at the postsynaptic cell. However, its efficacy is greater against nymphal and larval ticks than adults [9].

However, the use of acaricides has several side effects, including possible toxicity to humans and animals, chemical residues in meat and milk of animals, environmental contamination, and generation of chemical resistance in some tick populations [17]. All these factors have clouded the future for the chemical control of ticks.

Biological Strategies

Biological control agents are safe to use in human and animals, do not pose any threat to the environment and of less cost than chemical control measures. Biological methods of control include the regulation of tick population using biocontrol agents, including bacteria, fungi, nematodes, parasitoids and predators of ticks [18].

Biocontrol Agents

Bacteria: Some bacteria show pathogenicity to ticks. *Proteus mirabilis* is pathogenic to *Dermacentor andersoni, Amblyomma hebraeum* and *Boophilus decoloratus*. Also, bacterium *Cedecea lapagei* (*Enterobacteriaceae*) is pathogenic to *Boophilus microplus* and under laboratory conditions can produce up to 100% mortality [19,20]. The crystalline δ-endotoxin of *Bacillus thuringiensis* is produced during sporulation and disrupts insect midgut walls and kills ticks by causing toxaemia. It is the most popular biocontrol agent against ticks that produces mortality when sprayed on adults of *Argas persicu* and *Hyalomma dromedarii*. The toxicity is relatively species specific and is dependent on ingestion of the toxin [21].

Fungi: *Beauveria bassiana* and *Metarhizium anisopliae* exhibited the strongest anti-tick pathogenicity [22]. Entomopathogenic fungi are able to penetrate the cuticle of ticks and kill several stages of the same pest. However, they have slower action and lower field efficiency as they need high humidity to germinate and sporulate and they are susceptible to UV irradiation [17]. Some commercially available products contain fungi as active ingredients based on *M. anisopliae* such as Tick-EX EC, Metazam, Metarril SC 1037 and anti-termite mycoside [23,24].

Entomopathogenic Nematodes (EPNs): EPNs of the families *Heterorhabditidae* and *Steinernematidae* are known to be obligatory parasites of insects [25]. They release mutualistic bacteria that attack and kill the tick within 24 - 72h [26]. EPNs are potentially useful tools for tick control however; their use may be limited to defined ecological niches because their pathogenicity is reduced by low humidity or temperature [20].

Parasitoids: The most widespread species known to affect ticks is *Ixodiphagus hookeri* [27]. Interestingly, it was found that this parasitized *I. scapularis* did not carry the pathogen *Borrelia burgdorferi* and rarely carried *Babesia microti*. Thus, parasitoid infestation might lower pathogen prevalence in ticks, even if it does not control tick numbers [28].

Predators: Many tick predators such as ants, wasps, and many bird species feed occasionally on ticks and can help to reduce tick populations at nearly no cost [29].

Anti-tick vaccine

Tick vaccine could affect the transmission of diseases by decreasing vector numbers and more importantly it could reduce the parasite load in ticks [30]. It was found that prolonged vaccine usage led to decline in the incidence of tick-borne disease e.g. babesiosis [31].

Partial to strong immunity to tick infestation can be induced by vaccination with a variety of antigenic materials, including whole tick homogenates, gut material and cement material [32].

Two anti-tick recombinant vaccines against *Boophilus microplus*, based on the Bm86 molecule under the trade name TickGARD/ TickGARD Plus (Hoechst Animal Health, Australia) and Gavacs/ Gavac Plus (Heber Biotec S.A., Havana, Cuba) are available commercially. They have relatively little or no effect on larvae, some effect on nymphs and a significant effect on adults and their egg laying capacity. Surprisingly, it has an effect on the numbers and viability of larvae, which emerged from the egg batches of ticks from vaccinated cattle [33,34].

The challenge lies in discovering a broad-spectrum vaccine. Mejia., *et al*. [35] suggested that a pan-arthropod vaccine could be developed, with N- and O-linked glycans; being the most likely antigen candidates. Research would have to be directed towards associating more than one antigen in a vaccine for maximizing vaccine efficiency against all targeted tick species [36,37].

Future strategies

Transgenic animals resistant to ticks: Much attention has been turned to the tick-host interaction. Host resistance to ticks is manifested by reduced numbers of ticks feeding to engorgement and reduced susceptibility to tick-borne diseases [38]. Selection for higher resistance within a breed results in improvement in host resistance. However that selection is likely to be slow and the identification of animals with high resistance is a significant problem requiring genome scan [39].

Therefore, current research on the improvement of disease resistance by gene transfer aims to either influence host defense mechanisms, or disrupt genes known to cause susceptibility to disease. Successful production of transgenic livestock has been reported for pigs, sheep, rabbits and cattle. Identification of a range of anti-tick genes would considerably hasten the process of production of totally resistant animals [36].

Alternative acaricides: To overcome the multi-acaricide resistance, newer generation acaricides targeting novel metabolic pathways or bio-molecules synthesis pathway should be generated. Another innovative strategy involves the incorporation of pheromones in devices that contain acaricides. They showed higher efficacy than acaricide alone [40]. Still there is a need to continue research on the efficacy of the pheromone-based technologies.

Herbal acaricides are considered safe. Azadirachtin is a biologically-obtained insect growth regulator insecticide, derived from the Neem tree (*Azadirachta indica*). It is evaluated for acaricidal property against different life stages of *Boophilus microplus* and the initial results are highly encouraging [41]. *Vitex agnus castus* seeds were found to have a dual effect as a repellent, along with acaricidal properties [42].

Integrated tick control: Integrated tick control is the combination of a series of multi-disciplinary control measures to make the best use of each without placing too much reliance on any single component [37]. It is of much interest that some of the macrocyclic lactone acaricides, when applied on vaccinated cattle, showed greater increase in efficacy. This method effectively controls tick infestations while reducing the number of chemical acaricide treatments and consequently reduce their cost and disrupt the induction of acaricide resistance [37, 38].

Conclusion

In conclusion, control of ticks and tick-borne diseases is still unsatisfactory and requires excessive efforts. Therefore, the future of tick control lies in applying a package for integrated tick management strategy to utilize the advances in the genetics of resistance and transgenic animals, the wise use of chemicals and biological methods. The balance between different strategies may provide a cost-effective and sustainable approach of tick control.

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