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Trends in Parasitology

Spotlight

Ticks' attraction to electrically charged hosts

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Ticks are blood-feeding parasites with limited locomotion, known for transmitting multiple pathogens to vertebrates. England *et al*. suggest that ticks can be easily pulled, via electrostatic induction, toward charged hosts with fluffy coats that are prone to accumulate higher electrostatic potentials. Thus, static electricity may influence ticks' ecology and management.

Ticks are millimeter-sized parasites known for their ambush behavior against vertebrate hosts, which consists in staying still for prolonged periods of time at the top of vegetation while keeping their front legs extended. This minimal activity is an energy-saving strategy because ticks consume only one blood meal per each of the three life stages after hatching. Furthermore, these arachnids do not have adaptations to jump or fly, a marked distinction with those of active blood-sucking arthropods, such as fleas or mosquitoes. Due to these modest behavior and locomotion constraints, it has been assumed that ticks are obligated to make direct physical contact with the host to anchor via their flexible claws and adhesive foot pads [1]. Astonishingly, recent research indicates that ticks can use electrostatic induction to quickly detach and be pulled passively for several body lengths towards a distant charged host [2]. These results are intriguing because most ticks' hosts are warm-blooded vertebrates (birds and mammals) characterized by their dense fluffy coats which can easily build up charge by triboelectrification. This occurs when animals rub against vegetation, or during intraspecific encounters. In fact, rabbit's fur rubbed against polymeric materials can produce electrical potentials up to ~5 kV [3]. Although static electricity in nonhuman mammals has been unexplored [4], we know that humans can reach tens of thousands of volts by simply walking on a carpet, as well as patients and nurses in hospitals while performing common activities [5], which can risk the correct functioning of healthcare electronics. Similarly, it has been reported that birds, such as hummingbirds during hover-feeding, can generate electrical potentials up to ~1 kV [6]. Therefore, these high potentials that birds and mammals can achieve by triboelectrification support the claim that ticks, particularly the larvae and nymphs (Figure 1, and see Video S1 in the supplemental information online) that are only ~1 mm in size, can be passively transported across relatively large gaps (~three body lengths at ~1 kV, see [2]) to effectively reach their charged hosts.

To understand how the electrical field is distributed along the host body, as well as the regions that can produce stronger attraction, England *et al.* [2] mapped the electrical field along the surface of a 3D cow standing on a grounded surface with an electrical potential of ~0.8 kV. They found that the front and top of the head, chest, inguinal region, tail, and feet, presented a higher field strength than the rest of the body. These results agree in general with the attachment location preference of ticks when infesting cattle [7]. Moreover, the computational simulation showed that the field strength can increase two orders of magnitude in the gap region between the cow surface and the tip of the vegetation, where passively host-seeking ticks are usually found. Perhaps this increment in field strength can be related to the fact that pointed objects, in this case a turf of grass, tend to accumulate more electrical charge at the very tip. It has been documented that bees interacting with long flower stigmas also create stronger electrical fields around their abdomen and head, which facilitates pollen collection via electrostatics in those body regions [8]. In fact, experiments in bumblebees indicate that they can detect electrical fields using hairs over their bodies. Electrical fields in humans are more complex to study and map because they depend on clothing materials. Some textiles, such as cotton and nylon for example, can generate, by friction, huge electrical potentials that, in turn, can induce electrostatic discharges that increase the risk of fires or explosions. A comparative analysis of the electrical field of warm-blooded animals is required to understand what regions are more prone to generate electrostatic pulling of parasites, and in general of microorganisms, on the host. Electrostatic sensing in ticks waits to be demonstrated too.

Laboratory experiments suggest that the ticks' attraction to a charged host is actuated by electrostatic induction [2], which means that exposure to either positive or negative charges will prompt ticks' pulling. This agrees with previous research on the effects of static electricity on spiderwebs versus charged prey. Experiments indicate that silk threads can deform and attract towards a charged electrode independently of its polarity [9]. The charge separation in spiderwebs seems to be associated with the liquid droplets along the threads and the dipolar nature of the water molecule. In addition, it has been recently demonstrated that the nematode *Caenorhabditis elegans* can be attracted to either positive or negative charges during nictation (i.e., standing on their tails) [10], probably due to the water coating along their body. The nature of ticks' charge separation is unknown but may be related to their sclerotized cuticle and the liquid inside their bodies. Future research is required to understand the nature of charge separation in these arthropods.

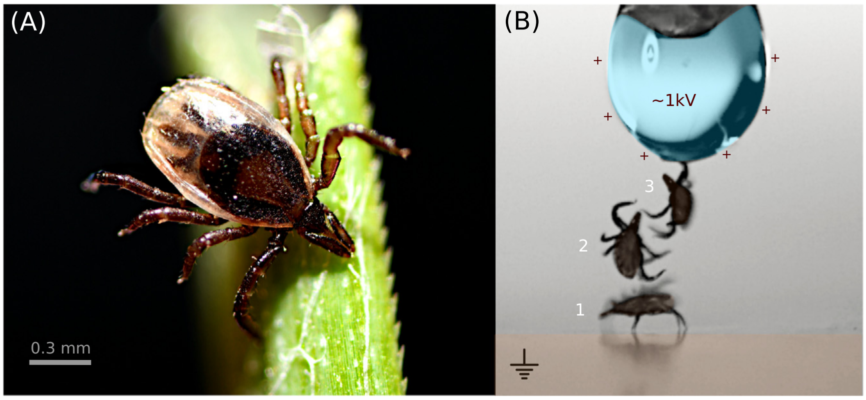

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Figure 1. Questing tick and electrostatic attraction. (A) Deer tick (*Ixodes scapularis*) nymph. (B) Trial performed by V.M.O.-J. of an individual nymph attracted to a positively charged droplet with an electrical potential of ~1 kV. Sequential numbers indicate ticks' detachment (1), mid-air flight (2), and anchoring (3) (see Video S1 in the supplemental information online).

Ticks are of major concern in terms of public and animal health around the planet, due to their role as vectors of multiple pathogens. The ranges of several species of medical and veterinary importance appear to be increasing globally due to a combination of climate and land use change, presenting a daunting management challenge. This new finding on ticks' electrostatic pulling suggests that any antistatic methods, clothing, and coatings that can reduce electrical fields on the host's body may reduce the likelihood of ticks' attachment. Additionally, electrostatic generators and searching robots potentially could be used to collect ticks more effectively in the fields infested with these parasites. Management by means of electrostatics seems a fertile ground to explore for the future.

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Declaration of interests

The authors declare no competing interests.

Supplemental information

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