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ORIGINAL ARTICLE

Evaluation of three commercial tick removal tools

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Objective.—To evaluate three commercially available tick removal tools against medium-tipped nontissue tweezers.

Methods.—We evaluated three commercially available tick removal tools against medium-tipped tweezers. Three inexperienced users randomly removed attached American dog ticks (*Dermacentor variabilis* Say) and lone star ticks (*Amblyomma americanum* L.) from laboratory rabbits in a university animal facility using all tools during one removal session.

Results.—Tick damage occurring from removal and quantity of attachment cement were compared. No tool removed nymphs without damage and all tools removed adults of both species successfully. American dog ticks proved easier to remove than lone star ticks, whose mouthparts often remained in the skin.

Conclusions.—Nymphal ticks were consistently removed more successfully with commercial tools when compared with tweezers but with more difficulty than adults were removed. The commercial tick removal tools tested are functional for removal of nymphs and adults and should be considered as viable alternatives to medium-tipped tweezers.

Key words: tick removal, *Amblyomma americanum, Dermacentor variabilis,* Lyme disease

Introduction

Although mosquitoes transmit a greater number of pathogens than all other arthropods, tick-borne Lyme disease remains the most commonly reported arthropod-borne disease in the United States [1]. Tick-borne diseases, including Rocky Mountain spotted fever, babesiosis, anaplasmosis, and ehrlichiosis tend to be of regional significance with few areas free of risk.

Ticks, potentially infected with disease-causing agents, present an often-unrecognized risk associated with wilderness habitat. Many people ignore the most obvious method to prevent transmission; that is, to do frequent tick checks and interrupt feeding. The most effective method of interrupting tick feeding and of stopping potential disease agent host/tick exchange is to mechanically remove the tick [2].

The attachment period required to initiate an infection varies for each specific pathogen. The intervals required for *Borrelia burgdorferi* (Lyme disease) to be transmitted by the eastern black-legged tick (*Ixodes scapularis*; commonly known as the "deer tick") and the western black-legged tick (*Ixodes pacificus*) are reported to be >24 hr for nymphal and 36 hr for adult *I. scapularis* [3,4] and 96 hr for *I. pacificus* nymphs [5]. In the European sheep tick (*Ixodes ricinus*) the interval required for *B. burgdorferi* to be transmitted by ticks is slightly less (16.7 hr) [6]. These transmission times are not absolute and can be shortened if a tick has a systemic rather than the more typical gut infection. Other published potential "safety intervals" include transmission times for *Rickettsia rickettsii* (Rocky Mountain spotted fever bacterium) at more than 24 hr [7] and *Babesia microti* (babesiosis) at greater than 54 hr [8]. Much more information is needed to account for many unknown variables before reliable safety intervals can be established. Part of the lag interval associated with pathogen transmission is likely a symptom of the continual attachment process. Attachment involves inserting the hypostome (Fig. 1) into the skin and depositing cement. Cement is a white substance secreted into the wound where it serves as both a gasket and a holdfast material. Cement abundance, deposition time, and location within/on the skin vary greatly between genera [9] and may delay initial true feeding in some species. Removal of this cement is

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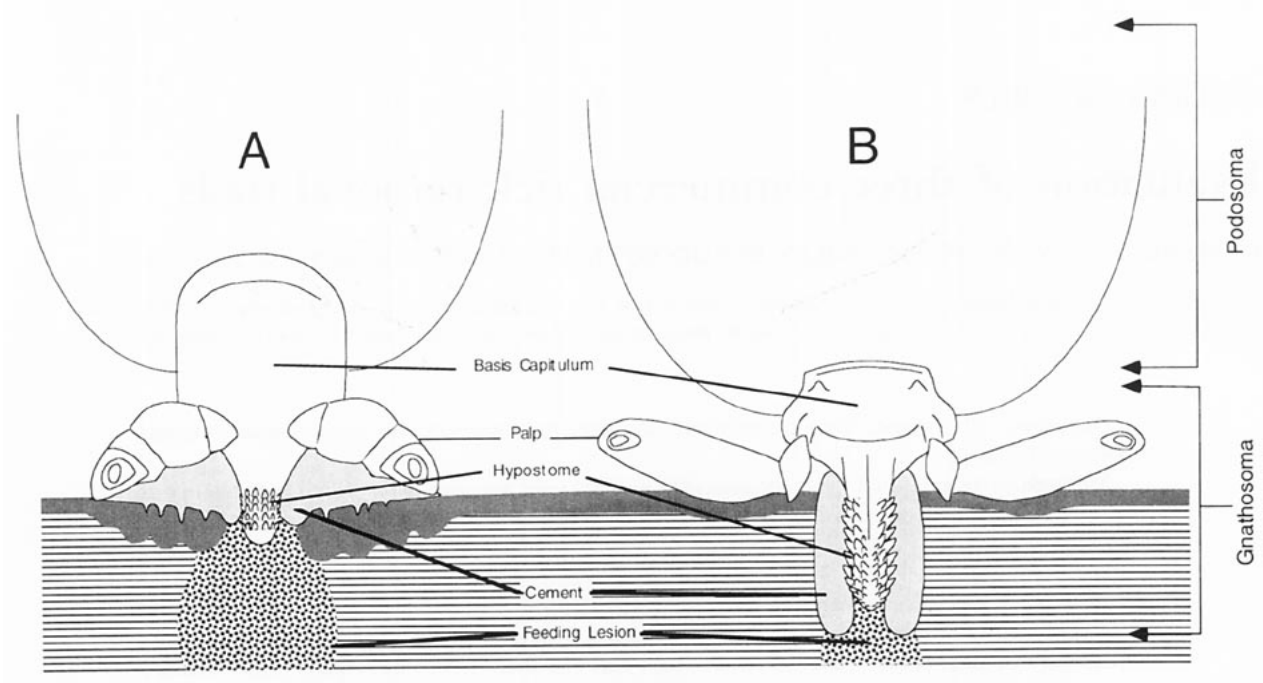

Fig. 1. Diagram of tick feeding. Tick A represents a superficial species, such as the American dog tick (*Dermacentor variabilis*). Tick B represents a more deeply attached species, such as the lone star tick (*Amblyomma americanum*). The leg-bearing section is denoted the podosoma, the head region, the gnathosoma. When removal is attempted, the target region for contact with any removal instrument is between the podosoma and gnathosoma at the basis capitulum.

desirable because any left behind may harbor pathogens [10] and be a source of additional inflammation.

The question most frequently asked of acarologists is, "How do you remove a tick?" This question is commonly followed by, "What should I use?" A good answer requires knowing the relative merits of "folk" methods as well as new innovative removal tools. A few articles have been published concerning "folk" methods, and several evaluate removal tools that are no longer available; however, little comparative information is available detailing the relative effectiveness of new removal tools. The purpose of this laboratory study was to evaluate three novel tools compared with medium-tipped tweezers.

Methods

Lone star ticks (*Amblyomma americanum*) and American dog ticks (*Dermacentor variabilis*) were obtained from a colony maintained at Oklahoma State University. Lone stars attach deep into the skin, and their mouthpart morphology is similar in length to ticks of the genus *Ixodes*. The American dog tick has shorter mouthparts and attaches superficially into the skin (Fig. 1). These two species were chosen as representatives for their two distinct attachment strategies and because they are extremely common pests in the United States.

All ticks were removed from the shaved backs of laboratory rabbits by three untrained volunteers 23–30 hr postinfestation. Our untrained individuals (ages 27–31 years) did not wear protective eyewear and used no magnification during removal, and, because no ticks were handled, they did not wear protective gloves. Volunteers had no prior experience with the removal tools nor did they work with tweezers on a daily basis. Eight separate tick feedings (four for each species) were performed, and ticks of a single species were placed on the dorsum of each rabbit. Despite placing equal numbers of ticks on each animal, attachment numbers varied. One tool was utilized during each removal event by each of the volunteers. Each volunteer would remove a single tick until all the volunteers had used the tool (they took turns). This procedure was continued until all the ticks were removed. By this method, each volunteer was subjected to a brief period of inactivity, and the number of removals was few (average, 10/session) so that familiarity with the tool would be avoided. Volunteers were encouraged to follow the manufacturer's instructions or were handed tweezers without instruction. Once the ticks were removed, they were placed in 70% ethanol for microscopic evaluation of mouthparts and associated cement.

The makers of these tools employ two distinct removal strategies. One design strategy is to grasp the

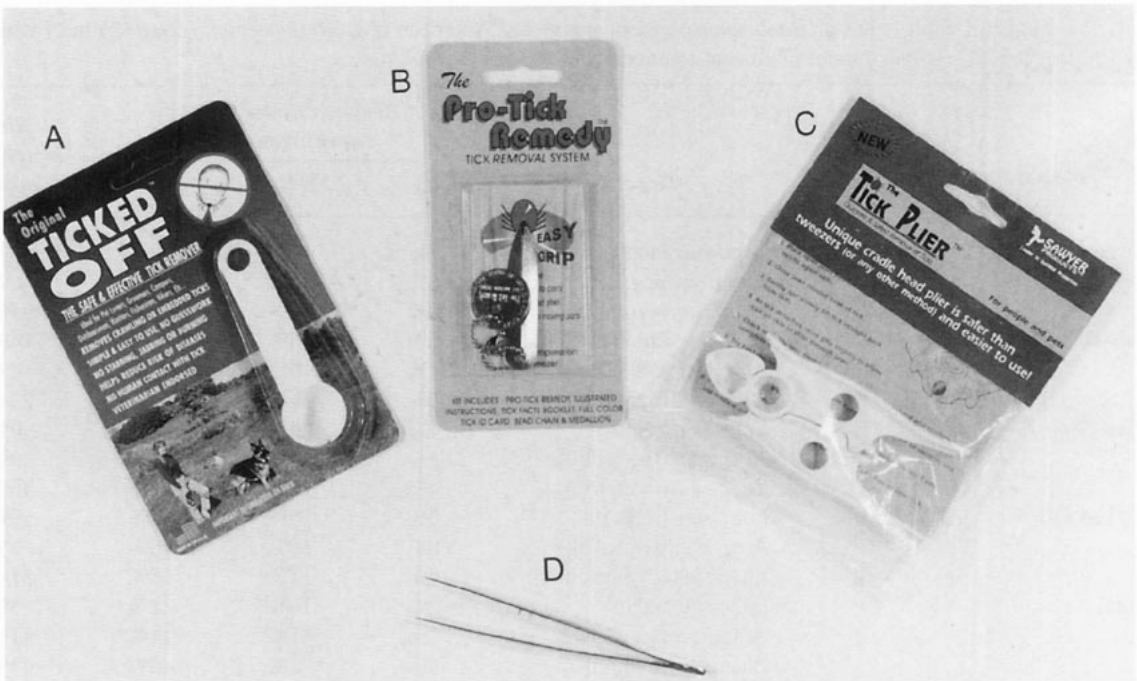

Fig. 2. Several commercially available tick removal tools. **A,** The Original Ticked Off™. **B,** The Pro-Tick Remedy™. **C,** The Tick Plier™, also called the Tick Nipper™. **D,** Medium-tipped tweezers.

mouthparts with fine edges or points at the bite site and remove the tick by gently pulling it away from the skin. Both medium-tipped nontissue tweezers (weight = 11.5 g; Fisher) and Tick Nipper™ (17.3 g) function in this manner. The other design is to use a slit in the removal tool large enough to accommodate the mouthparts but too narrow for the tick's body to pass. This strategy forces the tick's mouthparts within a "V" slot through the forward motion of the tool and then the tick is lifted from the skin. The Pro-Tick Remedy™ (3.4 g) and Ticked Off™ (2.2 g) tools are designed for this function (Fig. 2).

Results

DEEPLY ATTACHED ADULT TICKS (*A. AMERICANUM*)

One hundred forty-eight lone star ticks were removed by untrained individuals. Very little attachment cement was removed and occasional mouthpart damage was observed for all four tools. Removal with Tick Nipper™ (n = 30) and Ticked Off™ (n = 55) yielded slightly better results than medium-tipped tweezers (n = 42) and Pro-Tick Remedy™ (n = 21). Using Tick Nipper™ or Ticked Off™ resulted in no mouthpart damage, whereas removing with tweezers or Pro-Tick Remedy™ resulted in 2% and 14%, respectively, with mouthpart damage (Table 1).

SUPERFICIALLY ATTACHED ADULT TICKS (*D. VARIABILIS*)

Eighty-two American dog ticks were removed from rabbits by the same three untrained volunteers. American dog ticks have short mouthparts and deposit larger amounts of cement on the surface of the skin surrounding the wound. No damage occurred to mouthparts during removal with the Tick Nipper™ (n = 19), Ticked Off™ (n = 20), or Pro-Tick Remedy™ (n = 25), whereas some mouthpart damage was observed when ticks were removed with tweezers (n = 18). Rank of tool ability to remove large amounts of cement is as follows: Pro-Tick Remedy™ (84%), Ticked Off™ (80%), and Tick Nipper™ (63%) (Table 1).

NYMPHAL LONE STAR TICK REMOVAL

One hundred twelve nymphs were removed with commercial tools and medium-tipped tweezers. Of these, 47 (42%) left their mouthparts in the skin. Success, measured by removal with mouthparts attached, varied greatly between the commercial tools and tweezers. Medium-tipped tweezers (n = 19) are ineffective for the removal of nymphal lone stars. Ninety-five percent of the ticks removed with tweezers left their mouthparts in the skin, and 89% of those were actually crushed by the tweezers, causing their contents to be dispersed over the tweezer tips. The commercial tools all performed better in the

Table 1. Percentage of adult lone star (*Amblyomma americanum*) and American dog (*Dermacentor variabilis*) ticks with mouthpart damage and relative amount of cement removed with the use of each tool.

Tool	Tick	Amount of attachment cement removed*			With mouthpart damage
		Large	Medium	Small	
Tweezers (medium-tipped)	Lone star (adult)	7%	12%	79%	2%
	American dog (adult)	78%	11%	6%	6%
	Lone star (nymph)	0%	0%	5%	95%
Pro-Tick remedy™	Lone star (adult)	0%	5%	81%	14%
	American dog (adult)	84%	0%	16%	0%
	Lone star (nymph)	0%	11%	61%	28%
Tick Nipper™	Lone star (adult)	0%	20%	80%	0%
	American dog (adult)	63%	26%	11%	0%
	Lone star (nymph)	4%	0%	61%	36%
Ticked Off™	Lone star (adult)	0%	15%	85%	0%
	American dog (adult)	80%	10%	10%	0%
	Lone star (nymph)	14%	17%	38%	31%
Total	Lone star (adult)	2%	14%	82%	3%
	American dog (adult)	77%	11%	11%	1%
	Lone star (nymph)	4%	8%	46%	42%

*Cement amount was subjectively rated as large, medium, or small by one individual (RLS). Large amounts of removed cement are consistent with secreted quantities, whereas small amounts consist of insignificant pieces attached to the hypostome.

hands of untrained individuals for nymphal removal. The Pro-Tick Remedy™ (n = 36), Ticked-Off™ (n = 29), and Tick Nipper™ (n = 28) removed 72%, 69%, and 64%, respectively, of the nymphs with their mouthparts attached.

Discussion

Tick attachment strategy, mouthpart morphology, and body size clearly influence how well devices work in the hands of novice users. Deeply attached adult lone stars were difficult to remove by all methods, whereas American dog tick adults presented little or no difficulty. The two methods utilized by these instruments, grasping the tick or providing a "V"-shaped slot too narrow for the tick's body to pass, appeared to have little influence on tool effectiveness. However, the Tick Nipper™ and medium-tipped tweezers appeared slightly more effective than Pro-Tick Remedy™ and Ticked-Off™ for removing adult lone stars (compare relative amount of cement and mouthpart damage in Table 1). The narrow opening of the "V" slot may cut the mouthparts at the base because the major differences between strategies were observed solely in the mouthpart region. The use of medium-tipped tweezers or the Tick Nipper™ for removing lone star adults yields slightly better results than the other two tools although they functioned adequately.

The removal of deeply attached nymphs presented problems for both removal designs. Fewer difficulties were observed with instruments using the "V"-shaped slot rather than grasping the tick. Because 95% of the nymphs removed with tweezers were removed without their mouthparts and anterior body halves, we do not recommend using medium-tipped tweezers for removing deeply attached nymphs unless no other tool is available. Exposing the internal contents of ticks can be hazardous because otherwise-isolated pathogens could enter the wound. Of the three commercial devices evaluated for nymphal removal, use of the Pro-Tick Remedy™ and Ticked Off™ yielded slightly better results than the Tick Nipper™ because fewer ticks left their mouthparts in the skin and more cement was removed. We recommend using any of the three commercial instruments over tweezers because tweezers are ineffective for the removal of nymphs.

Timely removal is critical for avoiding tick-transmitted diseases by reducing the interval for pathogen entrance into the host. Numerous manuals and textbooks continue to recommend methods that extend the time a tick is attached and many are dangerous or simply fail. The most popular methods are passive and include applying ointments, ether, gasoline, or petroleum, so the ticks will release their hold [11–19]. Others have endorsed applying fingernail polish [13] and "using a suture needle (FS-2 cutting) to apply pain to the tick's face for removal" [14]. One even says "a punch biopsy will

remove the tick with certainty" [14]. Although this is true, what happens when one walks through vegetation that contains hundreds of "seed" (immature) ticks? Needham [2] tested several of these "folk" methods, fingernail polish, petroleum jelly, a glowing hot match, and 70% isopropanol, for their ability to induce ticks to "back out" or release from the host. He found that none of these methods initiated self detachment in adult lone star or American dog ticks. Confirmation of failure of these methods was recently published [20]. More modern "emergency" methods have also been tested. Injection of local anesthetics (lidocaine, lidocaine with epinephrine and chloroprocaine) also failed to initiate self detachment [21]. Although chemicals exist that will initiate self detachment [22,23], health risks are associated with use of these chemicals, making their risk/benefit ratio unfavorable [24].

Timely detection and removal are the most important factors in avoiding tick-borne diseases. Quick methods are therefore essential. At least three new and novel manufactured tick removal devices are available to the general public that could serve this role. This laboratory study evaluated their worthiness for safe removal. Although our criteria failed to distinguish the use of one tool above the others, all three were effective for deeply and superficially attached adult and nymphal ticks. Tick removal is essential to avoid tick-borne diseases, and the sooner a tick is removed, the less likely a pathogen will have enough time to infect the host. We advocate immediate removal with any of the three commercial tools over medium-tipped tweezers because tweezers were ineffective for removing nymphs following the revised guidelines developed by Needham [2] (see below):

1. Avoid handling ticks with uncovered fingers; use tweezers or commercial tools designed for removal. If index finger and thumb must be used, protect them with rubber gloves, plastic, or even paper towel.
2. Place the tips of tweezers or edges of other removal devices around the area where the mouthparts enter the skin.
3. With steady slow motion, pull the tick away from the skin or slide the removal device along the skin (read the directions for each commercial tool). Do not jerk, crush, squeeze or puncture the tick.
4. After removal, place the tick directly into a sealable container. Disinfect the area around the bite using standard procedures.
5. Attempt to keep the tick alive for a month in case symptoms of tick-borne disease develop. Place it in a labeled (date, patient), sealed bag or vial with lightly moistened paper towel then store at refrigerator temperature.

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