How Efficient Are Permethrin-Treated And Deet-Treated Uniforms in Protecting Soldiers from Tick Bites?

Student X

SYNOPSIS

ORIGINAL ARTICLE

OBJECTIVE
Three different permethrin and deet treatments of military battle dress uniforms (BDUs) were compared in their effectiveness in protecting soldiers from tick bites of the three major tick species.

DESIGN AND INTERVENTION
BDUs of following four treatment categories were exposed to field populations of ticks: untreated (control), deet-treated *, permethrin-impregnated (PI) †, and permethrin-sprayed (PS). Six sites of 1ha (2.5 acres) were selected for a relative abundance of ixodid ticks. Sites were selected to ensure maximum exposure to (1) the ticks of all three growth stages — larval, nymphal, and adult, and (2) to all three major species in the area — A americanum, D. variabilis, and I. dammini. Each of the six sites was divided into 6 lanes 110m long, each of which was further divided into 4 sub-lanes.

For each trial, human subjects were randomly assigned to a treatment category and a lane, using a stratified random method ‡. During each trial, a subject walked down a sub-lane for 5 min and sat down at its end for 10 min. Afterwards, the subject removed all ticks from the his uniform using a sticky lint roller. Then, the subject recorded the numbers of recovered ticks by species, growth stage, gender, and condition. There were three types of condition, according to the next qualitative criteria: "normal, exhibiting typical cactivity; moribund, erratic or sluggish movements; dead, no movement even when stimulated by prodding or by breathing on them." This procedure was repeated as the subject walked back along an adjacent sub-lane. The trials were repeated 4 times per day and for 21 days except when raining. Test sites were rotated on a daily basis so that each site was used every third test day.

To measure changes in fabric chemical concentration over wear time, three additional uniforms were used as 'analytical controls': one deet-treated, one PI, and one PS. On test days, these were exposed to identical field conditions as the ones that were worn and tested by the human subjects. A piece of fabric was cut from each analytical control for fabric concentration analysis, immediately following the weekly washings of the uniforms.

OUTCOME MEASURES
The differences in the mean infestation of ticks were compared between treatment categories. The comparison was based on the total ticks, as well as on species, growth stage, and condition. Protection efficiencies were determined as following: (1) the mean tick levels for the repellent-treated uniforms were subtracted from those for untreated uniforms, and (2) those differences were expressed as a percentage of the untreated uniform mean. Fabric concentrations of the repellents were plotted over wear time.

* Deet-treated BDUs were prepared by applying lotion base deet product to the surface of the fabric
† PI BDUs were prepared by soaking them in permethrin solution before use
‡ Stratified Random Method: a random design that ensures all subgroups are adequately represented. Each treatment category was tested at least once during a day
RESULTS
Total of 14,039 ticks were collected. Three species of ticks included were *A. americanum*, *I. dammini*, and *D. variabilis*, which represented 97.8%, 1.5% and 0.6%, respectively, of the total collection. In general, both permethrin groups were significantly lower in the mean tick numbers than untreated or deet-treated groups (P < 0.001). Deet-treated groups were also significantly lower than untreated in the mean (P < 0.001). However, the permethrin groups did not differ significantly from each other. Overall, the mean number of ticks decreased in the following order of treatment category: untreated, deet-treated, PI, and PS. This trend was also true when only the ticks of normal condition were considered. As a corollary, the protection efficiency of the treatment groups increased in the same order. Protection efficiencies were 98.4%, 97.4%, and 59.8%, for PS, PI, and deet, respectively. Protection efficiencies of both permethrin groups showed little fluctuation on a daily basis. Those of deet group were not only lower than those of permethrin groups, but also varied more widely overtime. Analytic controls revealed that the fabric concentrations of permethrin decreased for PI uniforms but it increased for PS uniforms. In addition, even after a total of 12 spray treatments for the PS uniform, its fabric concentration was lower than initial value of the PI uniform. The high and consistent protection efficiency over time indicates both permethrin treatments are effective over wear time and washing.

CONCLUSION
Permethrin, whether applied to clothing as a spray or an impregnant, provided an excellent protection from tick bites and was more effective than deet when used on clothing only. It showed consistency in efficacy over wear time and washings. Moreover, spraying of permethrin was shown to be slightly more effective than impregnation of permethrin.

CRITIQUE
ANALYSIS
The *Journal of Medical Entomology* is published by the Entomological Society of America (ESA). ESA is self-described as "the largest organization in the world serving the professional and scientific needs of entomologists" [1]. The journal is peer-reviewed. It "publishes reports on all phases of medical entomology (scientific study of insects) and medical acarology (study of mites and ticks)...of public health and veterinary significance" [2]. One of the authors, G. W. Korch, is the current commander of U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID). He had been the chief of medical, chemical and biological defense research of the Defense Department's Defense Threat Reduction Agency. He has published various studies on virology and infectious diseases. S. R. Evans and M. A. Lawson are authors of few papers in the field of acarology and pest control, respectively. The authoritativeness of this paper seems reasonable given the accomplishments of the authors.

Although the article was published in 1990, the methodology of the experiment seems fairly valid even today. However, the repellent application protocols for military, as described in the study, may have since been modified or may no longer be used. If true, this may limit the application of the study's findings to today's military situations. Tests were conducted at Entomological Sciences Division, U.S. Army Environmental Hygiene Agency in Maryland. The study was supported by the U.S. Army Medical Research. The source of financial support and the location of the study do not seem to suggest any bias in the result.

CONTENT ANALYSIS
This study is mostly well-designed, with the exception of a few limitations which do not greatly undermine the validity of the results. It should be noted that, in comparing the infestation means between treatment categories, the authors use not only those for ticks of all conditions, but also those for only the ticks of normal condition. Since only normal ticks pose a biting threat, the latter comparison of the means is especially valuable in consideration of this experiment's purpose. One limitation to the design is that it controls neither the fabric chemical concentrations nor the medium of the repellents; permethrin is applied as liquid while deet is applied as lotion. Ideally, these variables should be controlled to truly isolate the differences between the protection efficacies of the treatment categories. However, such absence of control is acceptable in light of the experiment's objective, which was to compare the efficiencies of pre-defined treatment methods. Next, the value of the results is limited
in that all trials are 15 min long. It is arguable whether the results adequately model situations where subjects are exposed to field population of ticks for longer periods of time. Lastly, the study is limited in that the sample is extremely biased towards larvae of *A. americanum*, which represents 90.4% of the entire sample. However, authors acknowledge this anomaly and analyze the data in two ways: once including that population and once excluding it.

In analyzing their outcomes, the authors make over-generalizations that cannot be supported by their own results. First, the authors claim that "PS uniforms caused a greater immediate reduction in numbers of ticks than did PI uniforms". This is an over-generalized claim in light of the result: "two permethrin treatment groups did not differ significantly from each other". In an effort to exaggerate the significance of that difference, the authors cite another study by Schreck et al., which "showed higher protection efficiencies for PS than for PI for all stages of *A. americanum*" [3] (p. 832). Thus, the authors' claim that PS uniforms are more efficient than PI uniforms is mainly based on a secondary source, which undermines confidence in their own conclusion. Furthermore, since the cited study investigated *A. americanum* only, it is highly dangerous to rely on Schreck's study to make a generalization that includes other two species as well; however the authors fail to qualify their claim. Another reason for which the same claim cannot be generalized to include all three species is that there is an unequal representation of each species. The sample populations of *I. dammini* and *D. variabilis* are minimal for PS and PI treatment categories (all below 10). Thus, insofar as these two species are concerned, any difference between the mean numbers for PS and PI treatment groups is too insignificant to lead to a viable claim. Lastly, the authors mention that the numbers of recovered ticks were also recorded by gender. But they fail to discuss any gender differences in their discussion.

**BOTTOM LINE**

Overall, the authors' claims are misleading owing to over-generalizations and thus do not precisely meet the study's objective. Indeed, permethrin-treated uniforms seem to be more effective than deet-treated uniforms for all species and for all growth stages. Nevertheless, the claim that permethrin is more efficient as a spray than as a permethrin is questionable, at least statistically; in practical sense, both permethrin treatments are highly efficient and the difference between them does not bear any importance. If the said claim were to be made however, with confidence in a secondary source, it should be qualified to include *A. americanum* only. In their discussion, the authors fail to acknowledge their limitations in results and to make qualifications.

**ACKNOWLEDGEMENTS**

I would like to thank my Writing 20 colleagues for their constructive criticism. I would like to thank Dr. Cary Moskovitz for guidance throughout the writing process.

**REFERENCES**


The Effectiveness of Deet and Permethrin Sprays on Military Clothing as Protection from Deer Ticks
Student Y

SYNOPSIS

ORIGINAL ARTICLE

Objective
To compare military clothing sprayed with permethrin, 20% deet, and 30% deet as protection against deer ticks.

Design and Intervention
6 volunteers each participated in 12 one-hour “blocks,” during which they aimlessly walked, stood, sat, lay, etc. in one of 7 two- to four-acre tick-inhabited test plots. For each block, the volunteers wore U. S. military battle dress uniforms either sprayed with permethrin, 20% deet, 30% deet, or untreated (two, one, one, and two volunteers, respectively). Each volunteer rotated between three different treatments for every three blocks, and to simulate actual use, each sprayed his/her own clothing as uniformly as possible for 30 seconds per garment immediately before wear. The cuffs of the pants were either taped to the top of the boots or tucked inside them to prevent tick attachments. During test periods, ticks found attempting to attach were removed and their presence recorded.

Outcome Measures
Data was collected on the number, life stage, and gender (for adults) of ticks removed during each block and remaining on the volunteers after each block.

Results
The permethrin spray provided complete protection from all ticks, and the 20% and 30% deet sprays provided 86% and 92% protection, respectively, compared to the control (Table 1). The differences between the control group, the permethrin spray and the deet sprays as a group were all statistically significant (P<0.05), though the differences between the two deet sprays were not.

Table 1: Average number of live ticks per person

<table>
<thead>
<tr>
<th></th>
<th>0.5% permethrin</th>
<th>20% deet</th>
<th>30% deet</th>
<th>untreated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larvae</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.67</td>
</tr>
<tr>
<td>Nymphs</td>
<td>0</td>
<td>0.25</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>Adult Females</td>
<td>0</td>
<td>0.67</td>
<td>0.5</td>
<td>5.08</td>
</tr>
<tr>
<td>Adult Males</td>
<td>0</td>
<td>0.83</td>
<td>0.58</td>
<td>5.5</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>1.75</td>
<td>1.08</td>
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</tbody>
</table>

Conclusion
Both deet and permethrin sprays effectively repel deer ticks. Permethrin is the more effective of the two, perhaps because it kills ticks rather than just repelling them. Higher concentrations of deet may provide more protection.
CRITIQUE

Context Analysis
This article comes from the Journal of Medical Entomology, which is peer-reviewed, authoritative, and clearly relevant to the topic of ticks and acaricides. The authors, Carl Schreck, Edward Snoddy, and Andrew Spielman, all come from research institutions: The Insects Affecting Man and Animals Research Laboratory of the Agricultural Research Service, the Fisheries and Aquatic Ecology Branch of the Tennessee Valley Authority, and the Department of Tropical Public Health in Harvard's School of Public Health, respectively. Both Schreck and Snoddy have authored multiple papers on the specific subject of permethrin's effect on ticks, and Spielman was a well-known expert on ticks and tick-borne diseases (he unfortunately passed away last year at the age of 76). This study was funded in part by the National Institutes of Health, the National Institute of Allergy and Infectious Disease, and the U.S. Army Medical Research and Development Command, none of which have obvious stakes in the outcome of the study. One possible problem with this study is that it was conducted more than 20 years ago. However, permethrin sprays are still used and sold as insect repellents today, and we can assume that neither the compounds tested nor the ticks themselves have changed significantly in the last 21 years, so these results should still be applicable. This leaves nothing to complain about in Schreck, Snoddy, and Spielman's article. It is timely, authoritative, and unbiased.

Content Analysis
Aside from a few minor shortcomings, this study was very well arranged and implemented. It has a very specific objective, and while it succeeds admirably in meeting that goal, its results may, unfortunately, have limited applicability to situations other than the one specifically modeled. The use of human test subjects in any study is not without risk, but it is also often the most logical and expedient choice. The researchers took sufficient precautions to prevent harm to the subjects, so in this case their choice was well-made. The researchers also did a good job of replicating conditions under which military personnel are likely to encounter ticks, and thereby making the results easily applicable to real-life situations. The chance variations made possible by allowing the test subjects free reign outside the laboratory is nullified by using many volunteers and having them rotate through multiple treatments and test plots. This randomization assures that peculiarities in the wandering pattern of individual volunteers and variations in tick densities among or within test plots will average out overall.

The largest problem with this study is the lack of statistically significant differences between many of the results. This is a likely effect of the military clothing that the volunteers wore, which was closely woven and difficult for ticks to hang onto even in the untreated trials. Since tick counts were low overall, it would require more trials to establish statistically significant differences between the smaller numbers. The only other options would be to test this treated clothing against a different species of tick entirely, one that can grasp clothing more firmly (the authors suggest lone star ticks), or for volunteers to wear courser clothing that is easier to grasp. But since both of these specifics are determined by the very goals of the study, changing them would defeat the purpose.

Bottom Line
One might wonder why these goals were chosen in the first place, because the researchers must have known that they would limit the applicability of the results. Simply looking at the range of relevant research in this field makes it clear that very similar tests have already been performed for most other practically relevant ticks in the United States, and the choice to focus on deer ticks was very intentional. The choice of clothing is simply a product of the intended audience: military rather than civilian. It is probably acceptable, however, to generalize these results to other types of clothing. Although differences in the clothing (weave, color, etc.) may change the ability of ticks to hold onto it (as seen in this study), these
differences are unlikely to change the relative efficacy of repellents applied to the clothing. It is harder to generalize the results of this study to species of ticks other than the deer tick without knowing a great deal about tick physiology. But if one assumes a similar susceptibility to acaricides among all types of ticks because they are in the same order or family (which is supported by most other research in the field), then it is not wrong to assume that permethrin and deet will have similar effects on other ticks as they did on deer ticks in this study.

References