ORIGINAL RESEARCH

Effectiveness of a Repellent Containing DEET and EBAAP for Preventing Tick Bites

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Objective.—Topical repellents can provide effective personal protection from tick-borne diseases by preventing the attachment of ticks. The goal of this study was to assess the effectiveness of a commercially available repellent spray containing both *N,N*-diethyl-3-methylbenzamide, previously known as *N,N*-diethyl-*m*-toluamide (DEET), and ethyl-butylacetylaminopropionate (EBAAP) against tick bites in a population at risk in Switzerland under real-life conditions.

Methods.—The effectiveness of an insect repellent spray containing both DEET and EBAAP was evaluated in a randomized, double-blind, placebo-controlled field study. The study, requiring simple application of the repellent to exposed skin, was carried out on 276 forestry workers and orienteers under everyday conditions in Switzerland from May to September 1999. We measured total effectiveness of the repellent by the following formula: percentage effectiveness = $100 \times (T_P - T_R)/T_P$, where T_P and T_R were the average number of ticks per hour spent in wooded areas for the repellent and placebo groups, respectively.

Results.—The average number of tick bites per hour of exposure to wooded areas differed significantly between the placebo ($n = 138$) and repellent ($n = 138$) groups, 0.17 vs 0.10 ($P < .05$). Total repellent effectiveness against tick attachment was 41.1% (95% CI, 2.5–79.6). On the arms, an effectiveness of 66% (95% CI, 17.3–114.7) was observed. No significant difference in the average number of unattached ticks could be found.

Conclusions.—This study found that an easily applied repellent is moderately effective in reducing the risk of tick bites.

Key words: repellent, DEET, EBAAP, arthropods, tick, tick bites, prevention

Introduction

Awareness of ticks as vectors for infections in humans, mainly Lyme disease (LD) and the less frequent tick-borne encephalitis (TBE), is increasing. Both infections may have serious or, rarely, even fatal consequences.^{1–5}

In Central Europe, the most common tick species, and the principal vector for LD and TBE, is *Ixodes ricinus*.^{1,6–9} The 3 active stages in the usual 3-year life cycle of the ixodid tick—larva, nymph, and adult—all require blood meals primarily from a variety of small mammals (and some birds) that can be reservoirs for the pathogen of LD, *Borrelia burgdorferi* (*Bb*), and for the virus of TBE.^{1,6,10}

In Switzerland, *I ricinus* nymphs are infected with *Bb*

at rates between 5% and 34%.¹ The infection rate for the virus of TBE in *I ricinus* averages 0.1%, although regionally, it may reach 10%.⁴ *I ricinus* is widely distributed in its natural forestal biotope, especially in fallen leaves and low-lying vegetation in wooded, brushy, or overgrown grassy areas. It is absent at altitudes higher than 1500 m (5000 feet).⁶

Tick activity peaks from April through June and from August through October.¹¹ During this time, ticks seek blood meals either from the ground or by climbing onto vegetation up to a height of 150 cm and using their forelegs to cling to passing potential hosts, including humans.^{6,12} After ticks cling to a human body or clothing, they search for an attachment site on the skin. This unattached stage can last for minutes to hours. Eventually, the tick embeds its head in the skin to obtain its blood meal and becomes attached. If the tick goes unnoticed, it may remain attached to the skin,

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engorging itself with blood, for 3 to 7 days.¹⁰ The virus of TBE, *Bb* organisms, and, in different regions of the world, a variety of other pathogenic organisms can be transmitted to humans during this bite by an infected ixodid tick.^{12,13} Nymph bites are most frequently responsible for *Bb* infections in humans.^{7,9,14} Because they are small (2 mm long), attached nymphs are often overlooked during self-inspection by humans. The larva (1 mm) is rarely infected. The probability of contracting LD after a tick bite in an endemic area ranges from 1.2% to 5%, while for TBE, this probability ranges from 0.03% to 0.4%.^{4,14}

For persons who regularly spend time in forests, whether for occupational or recreational activities, tick bites and the infections they could transmit pose a considerable risk.^{15–20} A variety of personal protection measures are recommended to prevent tick bites, including (often unrealistically) avoidance of tick habitats during spring and summer, insect repellents and insecticides applied to clothes and exposed skin, and physical protective measures, such as wearing light-colored clothing to make ticks more visible, wearing long-sleeved shirts, and tucking pants into socks or boot tops to decrease tick access to skin.^{3,14,21–26} Searching for and removing ticks as soon as possible after attachment decreases the risk of infection by *Bb*.^{27,28} Habitat control by removing fallen leaves in wooded areas is practical only in selected circumstances.^{29–32} Vaccines against TBE and against the North American types of LD are available,^{4,14,33,34} but they do not offer complete protection and have been associated with serious adverse events.^{4,33,34}

Of all protective strategies against tick bites, topical insect repellents and insecticides impose the fewest limitations on activity and are effective and inexpensive,^{22,25,35–37} particularly during the warm season when protective clothing covering the arms and legs is uncomfortable.

N,N-diethyl-3-methylbenzamide, previously named *N,N*-diethyl-*m*-toluamide (DEET), is the principal active ingredient of most currently available insect repellents. Extensive testing has shown it to be an effective repellent of mosquitoes.^{38–41} Several studies have indicated that it is also effective against ticks.^{42–45} The other compound of interest in this study is ethyl-butylacetylaminopropionate (EBAAP). Its effectiveness against ticks has not been thoroughly investigated but appears to be similar to that of DEET.⁴⁶

Most trials to evaluate the effectiveness of DEET have been either laboratory studies,^{44,45} often with different tick species, or surveys conducted with small groups of volunteers.^{42,43} No published data on the effectiveness of DEET and EBAAP for preventing tick bites by the European *I ricinus* could be found. Laboratory trials on rabbits found a repellent containing DEET and EBAAP

to be efficacious against tick bites of *I ricinus* (Krober T, Guerenstein PG, Guerin PM. Effect of Parapic repellent spray on attached ticks. Institute of Zoology, University of Neuchâtel, Switzerland. Unpublished observations, 1999). However, a field study in a large population under ordinary conditions of simple application of repellent to exposed skin has not been carried out. The goal of this study was to assess the effectiveness of a commercially available repellent spray containing both DEET and EBAAP against tick bites in a population at risk in Switzerland under real-life conditions.

Methods

This study followed a randomized, double-blind, placebo-controlled prospective design. Volunteers were recruited from forestry workers in the Canton of Zurich and from orienteers in German-speaking parts of Switzerland. Orienteers run competitively using map and compass in order to localize and reach certain points in the forest, not utilizing paths. Both populations have an increased risk of being bitten by ticks and acquiring tick-borne diseases.^{15,18–20}

The commercially available repellent spray Parapic-Tick-Repellent (BIOMED AG, Dübendorf, Switzerland) contains 2 active compounds: 15.0% DEET and 15% EBAAP, as well as isopropanol. The placebo preparation contained isopropanol and propylene glycol instead of DEET and EBAAP. Both preparations were delivered by pump-spray bottles.

Recruitment of volunteers took place between August 1998 and March 1999, and the study was carried out from May to September 1999. Volunteers were recruited with a questionnaire asking about exposure to risk areas, number of tick bites experienced from May to July 1998, and interest in participating in our trial. Forestry workers were accessed through forestry offices in the Canton of Zurich. The addresses of German-speaking orienteers were obtained from the corresponding orienteers' association, with some 3000 individuals overall.

Questionnaires from 2649 individuals were evaluated. Of these, 1698 (64.1%) reported no tick bites during the corresponding 3 months, 372 (14.0%) reported 1 tick bite, 387 (14.6%) reported 2 to 5 tick bites, 77 (2.9%) reported 6 to 10 tick bites, and 45 (1.7%) reported >10 tick bites. Of these individuals, 1577 (59.5%) were willing to participate in the study. We included subjects over 12 years old who had reported at least 2 tick bites in the questionnaire and who gave written informed consent. Individuals with a history of chronic or acute skin disease, with open or nonhealing wounds, or with an inclination to use other commercially available repellents during the study period were excluded. The study protocol was reviewed and approved by the Ethics Com-

mittee of the Institute of Social and Preventive Medicine of the University of Zurich.

Overall, 355 forestry workers and orienteers were included in the study and were randomly assigned to receive placebo or repellent. The solutions were sent to the volunteers with an instruction manual and a log containing enough space to record up to 10 days of exposure. Participants were instructed to apply the preparation to uncovered skin and to the adjacent 10 cm of skin covered by clothing (excluding the face) just before spending time in the forest. No restrictions about clothing were made. Because forestry workers usually spend whole day shifts (about 8 hours) in wooded areas, they were instructed to apply the preparation twice a day, the second application 4 hours after the first. Participants were asked to examine themselves carefully for attached and unattached ticks after returning from the field. They were instructed to remove attached ticks with a pair of tweezers and place them together with any unattached ticks in alcohol-filled vials for later investigation.

The information requested in the log consisted of the date, the geographical location, and the amount of time (± 30 minutes) in the forest. The numbers of attached ticks (skin) and unattached ticks (skin or clothing), as well as the location of attached ticks, were recorded. For attachment sites, we identified body areas as head (including neck), trunk (including chest, back, abdomen, buttocks, and groin), arms, and legs. Whether or not the attachment site was covered by clothing was also recorded.

The logs and the vials containing collected ticks were returned at the end of the study. Collected ticks were examined for their stage and were classified as larvae, nymphs, or adults by the Institute of Zoology, University of Neuchâtel, Switzerland.

We measured the effectiveness of the repellent by the following formula: percentage effectiveness = $100 \times (T_P - T_R)/T_P$, where T_P and T_R were the average numbers of ticks acquired per hour in wooded areas by the repellent and placebo groups, respectively.

The Statistical Package for Social Sciences (SPSS Inc, Chicago, IL) was used for detailed statistical calculations.

The average (mean) number of ticks per hour of exposure and the SEM were calculated. To analyze the significance of differences between the groups using repellent and placebo, the 2-sided *t* test for independent samples was used. Even though the data deviated slightly from a normal distribution, the *t* test could be applied, according to the central limit theorem, because our sample was large enough.⁴⁷ A significance level of $P < .05$ was chosen.

Results

CHARACTERISTICS OF THE SUBJECTS

Among the 355 volunteers at the beginning of the main study, 276 (77.7%) followed study instructions and returned the logs. The remaining volunteers either did not return their trial materials or for personal reasons chose not to participate.

The average age of the 276 compliant volunteers was 41.4 years (range = 12–76). Among the participating subjects, 203 (73.6%) were male, and 73 (26.4%) were female. Of the participants, 68 (24.6%) were forestry workers, and 208 (75.4%) were orienteers.

Of the 355 initial volunteers, 177 received placebo and 178 repellent. By coincidence, the final 276 participating subjects were evenly distributed into 2 groups of 138. Characteristics of both groups are listed in Table 1. There were no significant differences in age or gender between the placebo and repellent groups.

CHARACTERISTICS OF EXPOSURES IN THE FOREST

Each recorded day spent in the forest, no matter how long, was defined as 1 exposure. The average number of recorded exposures in the forest during the study period was 7.7 (range = 1–10) in the placebo group and 7.5 (range = 1–10) in the repellent group. As shown in Table 1, the overwhelming majority of exposures occurred in May and June, the months of highest tick activity (94.4% for the placebo group and 92.3% for the repellent group).

The total time per person and the average time per exposure spent in the forest were 21.9 hours (range = 1–85 hours) and 2.7 hours (range = 0.5–8.5 hours) for the placebo group and 22.3 hours (range = 0.5–109.5 hours) and 3.0 hours (range = 0.5–10.95 hours) for the repellent group. There were no significant differences between the placebo and repellent groups with regard to the number and the monthly and geographical distributions of the recorded exposures, nor were there any significant differences with respect to the total time per person and the average time per exposure.

RECORDED TICKS

Overall, 174 participants (63.0%) recorded at least 1 unattached or attached tick during the study—93 subjects (67.4%) in the placebo group and 81 subjects (58.7%) in the repellent group (Pearson chi-square = 2.2, $P = .135$). At least 1 attached tick was reported by 149 volunteers (54.0%)—82 (59.4%) in the placebo group and 67 (48.6%) in the repellent group (Pearson chi-square = 3.3, $P = .07$). During the study period, 1622 ticks were

Table 1. Characteristics of the subjects and recorded exposures in the forest

<i>Characteristics</i>	<i>Placebo group (n = 138)</i>	<i>Repellent group (n = 138)</i>	<i>P</i>
Age (y)			
Mean $\pm$ SD	41.4 $\pm$ 16.2	41.7 $\pm$ 15.4	NS
Range	12 to 76	12 to 74	
Gender			
Male (%)	99 (71.7)	104 (75.4)	NS
Female (%)	39 (28.3)	34 (24.6)	NS
Forestry workers (%)	32 (23.2)	36 (26.1)	NS
Orienteers (%)	106 (76.8)	102 (73.9)	NS
No. of exposures/person $\pm$ SD	7.7 $\pm$ 2.7	7.5 $\pm$ 2.7	NS
Monthly distribution of exposures (%)			
May	42.1	41.2	NS
June	52.3	51.1	NS
July	2.9	6.3	NS
August	1.7	1.1	NS
September	1.0	0.4	NS
Total time/person $\pm$ SD (h)	21.9 $\pm$ 20.1	22.3 $\pm$ 19.1	NS
Time/person/exposure $\pm$ SD (h)	2.7 $\pm$ 2.1	3.0 $\pm$ 2.2	NS

*NS indicates not significant.

recorded—1085 (66.9%) unattached and 537 (33.1%) attached. The average number of recorded ticks per person was 5.9 (range = 0–187)—3.9 (range = 0–185) unattached and 1.9 (range = 0–42) attached. A significant correlation between the total time per person spent in the forest and the number of recorded and attached ticks was found (Spearman's $\rho = 0.191$ ($P = .001$) and 0.158 ($P = .009$), respectively). For further analysis, only the

numbers of recorded ticks per hour spent in wooded areas were considered.

EFFECTIVENESS OF THE REPELLENT

The average number of attached ticks per hour differed significantly between the placebo and repellent groups, 0.17 vs 0.10 ($P = .037$), and the calculated effectiveness

Table 2. Efficacy of the repellent against ticks†

<i>Recorded ticks</i>	<i>Placebo group (n = 138)</i>	<i>Repellent group (n = 138)</i>	<i>% Efficacy (95% CI)</i>	<i>P‡</i>
No. of all ticks	996	626		
Avg. no.	7.2 $\pm$ 1.7	4.5 $\pm$ 1.4		.230
Avg. no./h	0.374 $\pm$ 0.066	0.235 $\pm$ 0.038	37.1 (−2.8 to 77.0)	.068
No. of unattached ticks	661 (66%)	424 (68%)		
Avg. no.	4.8 $\pm$ 1.6	3.1 $\pm$ 1.4		0.417
Avg. no./h	0.204 $\pm$ 0.049	0.135 $\pm$ 0.030	33.8 (−21.3 to 89.0)	0.228
No. of attached ticks	335 (34%)	202 (32%)		
Avg. no.	2.4 $\pm$ 0.4	1.4 $\pm$ 0.2		.039*
Avg. no./h	0.170 $\pm$ 0.029	0.100 $\pm$ 0.016	41.1 (2.5 to 79.6)	.037*

†Data are numbers, averages $\pm$ SEM, or percentages.

‡2-sided *t* test.

*Significantly different at the .05 level.

Table 3. Efficacy of the repellent against ticks at different life stages†

<i>Collected ticks</i>	<i>Placebo group (n = 122)</i>	<i>Repellent group (n = 126)</i>	<i>% Efficacy (95% CI)</i>	<i>P‡</i>
No of all collected ticks	552	333		
Avg. no.	4.5 ± 0.8	2.6 ± 0.5		.051
Avg. no./h	0.27 ± 0.06	0.16 ± 0.03	39.5 (−5.6 to 84.6)	.086
No. of collected nymphs	519 (94%)	305 (92%)		
Avg. no.	4.3 ± 0.8	2.4 ± 0.5		.048*
Avg. no./h	0.27 ± 0.06	0.16 ± 0.03	40.9 (−5.4 to 87.2)	.086
No. of collected adults	33 (6%)	28 (8%)		
Avg. no.	0.27 ± 0.07	0.22 ± 0.05		.555
Avg. no./h	0.011 ± 0.003	0.010 ± 0.003	7.4 (−63.0 to 77.7)	.837

†Data are numbers, averages ± SEM, or percentages.

‡2-sided *t* test.

*Significantly different at the .05 level.

provided by the repellent was 41.1% (Table 2). No significant difference in the average number of unattached ticks per hour, 0.20 vs 0.14 ($P = .228$), was found between the placebo and repellent groups.

COLLECTED TICKS

A total of 248 participants (90% of all subjects) returned vials containing ticks, 122 subjects in the placebo group and 126 in the repellent group. Overall, 885 ticks (54.6% of all recorded ticks) were examined to determine their stage. Of these, 552 ticks came from the placebo group and 333 from the repellent group. This corresponds to 55.4% and 53.2% of recorded ticks in the placebo and repellent groups. Further, 824 ticks (93.1%) were nymphs, and 61 (6.9%) were adults. Five adults were engorged with blood. The average number of nymphs per hour was 0.27 for the placebo group and 0.16 for the repellent group ($P = .086$). The calculated effectiveness provided by the repellent against nymphs was 40.9% (Table 3).

ATTACHMENT SITES OF TICKS

A total of 537 attached ticks were reported, 335 in the placebo group and 202 in the repellent group. Of these, 530 (99%) had specifiable attachment sites. With regard to attachment sites, 59% (316 of 537) were on the legs. No significant difference in the numbers of attached ticks per hour on the head, trunk, or legs was found between the placebo and repellent groups, but the average numbers per hour of attached ticks on the arm

differed significantly: 0.022 in the placebo group and 0.007 in the repellent group ($P = .008$). The effectiveness for the arm was 66% (Table 4).

Seventy-five percent (401 of 537) of the reported attachments were on skin covered by clothing, whereas only 14% (74 of 537) were on uncovered skin. For the remaining 11% (62 of 537), it was unclear whether the skin had been covered or uncovered.

A significant difference in the average number per hour of attached ticks on skin covered by clothing was found between the placebo and repellent groups, 0.13 vs 0.07 ($P = .03$). The effectiveness of the repellent against attachment to covered skin was 46.2% (Table 4). The attachment numbers did not differ significantly between the placebo and repellent groups for uncovered skin.

DIFFERENCES BETWEEN FORESTRY WORKERS AND ORIENTEERS

As expected, our data indicated that forestry workers spent more time in the forest than orienteers per day and in total during the whole study period: 5.7 hours vs 1.9 hours and 45.9 hours vs 14.3 hours ($P < .001$), respectively. The average number of attached ticks per hour was almost 3 times lower for forestry workers than for orienteers: 0.062 vs 0.159 ($P < .001$).

INFLUENCE OF EXPOSURE DURATION

To analyze the influence of exposure duration, the effectiveness of the repellent was calculated for 2 separate subpopulations of orienteers. One subpopulation con-

Table 4. Attachment sites of ticks†

Location	Recorded ticks	Placebo group (n = 138)	Repellent group (n = 138)	% Efficacy (95% CI)	P‡
Head	No./total no. attached ticks	1/335 (0.2%)	8/202 (4.0%)		
	Avg. no.	0.007 ± 0.007	0.058 ± 0.026		.068
	Avg. no./h	0.001 ± 0.001	0.003 ± 0.002	...	.204
Trunk	No./total no. attached ticks	78/335 (23%)	55/202 (27%)		
	Avg. no.	0.57 ± 0.09	0.40 ± 0.07		.143
	Avg. no./h	0.040 ± 0.008	0.029 ± 0.007	28.0 (-24.5 to 80.6)	.295
Arm	No./total no. attached ticks	46/335 (14%)	26/202 (13%)		
	Avg. no.	0.33 ± 0.069	0.19 ± 0.045		.081
	Avg. no./h	0.022 ± 0.005	0.007 ± 0.002	66.0 (17.3 to 114.7)	.008*
Leg	No./total no. attached ticks	203/335 (61%)	113/202 (56%)		
	Avg. no.	1.47 ± 0.33	0.82 ± 0.13		.070
	Avg. no./h	0.104 ± 0.023	0.061 ± 0.012	41.4 (-9.0 to 91.8)	.107
Covered skin	No./total no. attached ticks	263/335 (79%)	138/202 (68%)		
	Avg. no.	1.91 ± 0.32	1.00 ± 0.14		.011*
	Avg. no./h	0.132 ± 0.025	0.071 ± 0.012	46.2 (4.5 to 87.9)	.030*
Uncovered skin	No./total no. attached ticks	35/355 (10%)	39/202 (19%)		
	Avg. no.	0.25 ± 0.11	0.28 ± 0.06		.818
	Avg. no./h	0.020 ± 0.007	0.015 ± 0.004	25.0 (-60.0 to 110.1)	.563

†Data are numbers, averages ± SEM, or percentages.

‡2-sided *t* test.

*Significantly different at the .05 level.

sisted of the individuals, some in the placebo group and some in the repellent group, whose average exposure duration was 1.5 hours or less. The remaining orienteers with longer exposure times constituted the other subpopulation. The effectiveness for the first population was 44%, but it dropped to 35% for the second.

Discussion

Our data indicate that a tick repellent containing DEET and EBAAP on uncovered skin and neighboring covered zones offers at least moderate protection against tick bites. The effectiveness was 41.1%. Similar results for effectiveness against attached and unattached ticks were found, but statistical significance was reached only for the more relevant attached ticks.

In contrast, when Kulkarni and Naik⁴⁵ evaluated the effectiveness of DEET repellents under laboratory conditions against 6 species of ixodid ticks other than *I ricinus*, DEET (concentrations not reported), the effectiveness was between 80% and 100% against larval, nymph-

al, and adult ixodid ticks. In a field study, Schreck et al⁴³ found that a 1-minute application of pressurized sprays of permethrin at 0.5% and DEET at 20% and 30% to the exterior surface of pants and jackets provided 100%, 86%, and 92% protection against bites by all life stages of *Ixodes scapularis*. Solberg et al⁴² evaluated the effectiveness of DEET against *Amblyomma americanum* on the skin of human volunteers in the field. Comparing a repellent-treated leg with the opposite ethanol-treated leg of 11 volunteers, Solberg and colleagues established that DEET, at 0.5 mg·cm⁻², provided 85% protection in the first hour of exposure and 55% after 6 hours. However, Schreck et al⁴⁴ showed that DEET tested on human skin in the laboratory provided no protection against *I scapularis*. From the current study, it appears that under real-life conditions, repellent effectiveness is lower than in laboratory conditions.

Maibach et al⁴⁸ reported that friction of clothing and other objects; environmental conditions that affect evaporation, such as humidity and physical exercise; absorption from the skin surface; washing by wet vegetation,

sweat, or rain; increases in temperature; and exposure to windy environments all reduce repellent effectiveness. Every 10°C increase in air temperature can lead to as much as a 50% reduction in protection time.⁴⁹

In this study, we could not control the uniformity of repellent application and the compliance of participants, but this reflects real-life application, and ultimately, effectiveness is the relevant outcome. Promising results from laboratory studies of tick repellents should not be overestimated.

All published trials tested repellents against ticks other than *I ricinus*, the most abundant tick species in Switzerland.⁶ Different species of ticks may have varied sensitivities to repellents.

Our data showed a significant reduction in the number of attached ticks on skin covered by clothing. This may not be a paradoxical result, since it was impossible for a tick to reach covered skin without passing through uncovered skin and the margin. The placebo data showed that ticks search for covered skin. It appears that treatment of the skin clothing margin leads to a particularly repulsive local environment, inhibiting access to the rest of the covered skin. The exact mechanism by which ticks are warded off by repellents is not completely understood, but ticks are believed to be repelled by mechanisms related to olfactory and taste sensations.²⁵

The greater number of attached ticks per hour on orienteers than on forestry workers could result from orienteers passing through a larger wooded area per hour than forestry workers. Other possible influences, although not investigated in this study, include greater sweating by orienteers and larger areas of uncovered skin, because orienteers often wear short pants and short-sleeved shirts. Sweating could lead to increased attractiveness for ticks and simultaneous washing off of the repellent.

Our data do not allow calculation of the exact duration of protection by the repellent. However, the highest effectiveness of the repellent appears to be in the first 2 hours after application. Schreck et al⁴⁴ established that DEET provided 2.7 hours of protection against *A americanum*. According to the American Academy of Pediatrics, insect repellents applied to the skin require reapplication every 1 to 2 hours for maximum effectiveness.²¹ For exposures associated with intense physical exercise, frequent reapplications could increase the effectiveness.

Although some effectiveness for the repellent was established, it did not offer complete protection. In addition to tick repellents, simple physical protective measures such as long-sleeved shirts and long pants tucked into socks or boot tops must still be utilized. Application of the repellent to skin covered by clothing and possibly

to clothes (if not made of synthetic fabric) could enhance the effectiveness of the repellent,⁴³ but this would have to be shown by additional trials.

In conclusion, the simple application of a repellent containing DEET and EBAAP to exposed skin and the adjacent covered skin appears to be a moderately effective method for decreasing the risk of tick bites and the subsequent risk of tick-borne diseases.

Acknowledgments

Thanks are due to all volunteers who participated in this study. Special thanks are expressed to A. Tschoop, PhD, biostatistician, for his assistance in statistical analysis and to E. Marmier, PhD, for constructive comments on early drafts of the manuscript. The author thanks Prof B. Betschard, PhD, Institute of Zoology, University of Neuchâtel, for the examination of collected ticks. BIO-MED AG financially supported this trial.

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