New Insect Repellents

by BERNARD V. TRAVIS

THE OLD MIXTURES of citronella and pennyroyal that had been used for generations to ward off mosquitoes and punkies and blackflies had little value on Bougainville and Guadalcanal. They gave inadequate protection; they had an objectionable oiliness; they did not last long enough, especially on wet and sweating men. In fact, scientists who undertook to discover new and better repellents for the Army found 500 organic chemicals, of the 7,000 they tested for insect repellency, that are superior to the older repellents containing the aromatic oils. More than comfort was involved for the soldiers.

Early in the war it was recognized that men in the outer perimeter of the combat zones would have to rely on repellents for personal protection from the bites of mosquitoes and other insects; at that time control procedures were not known that would quickly eliminate the disease-carrying insects from the active-combat zones, and repellents offered an important means of protection for isolated troops.

Civilians also need good preparations to keep insects away. In certain areas permanent control measures for mosquitoes, sand flies, punkies, and chiggers may be impossible because of unfavorable terrain. In other places control is possible, but the low value of the land or sparse population make it unwise to levy sufficient taxes for the installation and maintenance of permanent control. Large sections of our finest recreational land are unusable because of the extreme annoyance from biting insects during vacation seasons; besides parks and other playground areas, there are sections that remain undeveloped where insects seriously interfere with agriculture or commerce during at least part of each year. For those areas, where control of the pests is either impossible or impractical, good insect repellents and miticides can give satisfactory protection.

In an effort to find improved repellents and to supply the armed forces with information, a project was initiated by the Bureau of Entomology and Plant Quarantine at Orlando, Fla., under the sponsorship of the Office of Scientific Research and Development. In this project chemicals were tested in the customary manner as a skin application and also as a clothing treatment.

In 1944 A. H. Madden, A. W. Lindquist, and E. F. Knipling reported that when the new organic insect repellents were applied to their clothing they received almost complete protection from chigger or red bug bites. Before that protection from chiggers was obtained largely by dusting sulfur on clothing. The sulfur method gives only partial protection and is objectionable to many persons. The Australians later showed that the repellent materials acted on chiggers largely as toxicants rather than as repellents; therefore, in discussing chiggers, the term "miticide" is used here instead of repellent. Between 1942 and 1946, F. M. Snyder and others of the Orlando laboratory tested about 7,000 materials on cloth in their search for better miticides. Many materials were found to be effective as fresh treatments, but only about 300 were outstanding in their resistance to removal by water.

In the investigations we encountered a number of important problems for which we do not yet have answers. Because most of our work was to test the effectiveness of chemicals as repellents, we had little time to get fundamental information as to how the chemicals repel insects. As basic information is accumulated on the repellent mechanism, it may be possible to develop superior repellents.

Another problem is the variation in effectiveness of individual chemicals when tested against different insects. Certain materials that are satisfactory against some species may fail to repel others. Dimethyl phthalate, for instance, is a good repellent for the common malaria vector in the United States, *Anopheles quadrimaculatus* Say, but it is almost worthless for one of the South Pacific malaria vectors, *Anopheles farauti* Laveran. Also, during certain periods, an insect species may bite immediately on skin that has been freshly treated, but at other times it may be repelled completely for several hours.

There is considerable variation in the effectiveness of repellents when used on different individuals. The same material may protect one person for several hours, but on another it may be effective for only a few minutes. The insects will bite readily on any spot either on exposed skin or through clothing where no repellent has been applied or where it has been rubbed off. All repellents are washed from the skin easily with water or excessive perspiration.

Repellents have some rather undesirable characteristics, and efforts are being made to discover new materials that do not have these properties. All of the better liquid repellents now in use are rather viscous

and feel oily on the skin. Most of the repellents are plastic solvents and will damage paints, varnishes, and many other plastic materials and synthetic cloth, but they can be applied safely to cotton or wool. Care must be taken in their use, as they cause temporary smarting of tender skin or mucous membranes.

Of all the thousands of chemicals tested, fewer than 10 percent showed sufficient promise to be of service as insect repellents, and only about 15 percent as miticides. After the toxicologists eliminated those that were too toxic or irritating for frequent use, only a very few were left that can be recommended for use on man.

Because of the extreme variation in effectiveness of individual chemicals as repellents, it is impossible now to name even one that will be effective against all species. For instance, Indalone (*n*-butyl mesityl oxide oxalate) has been found to be one of the most effective repellents against the stablefly, *Stomoxys calcitrans* (L.), dimethyl phthalate is the best for our malaria mosquito, *Anopheles quadrimaculatus* Say, and such materials as dimethyl carbate and Rutgers 612 (2-ethyl-1,3-hexanediol) are excellent repellents for various pest mosquitoes of the *Aedes* group. Selected mixtures of repellents are effective against a wider range of species than any one of the individual chemicals. The most satisfactory mixtures now known are composed of 60 percent dimethyl phthalate and 20 percent Indalone; the other 20 percent may be any of the chemicals that are particularly effective against *Aedes* mosquitoes. The famous 6-2-2 insect repellent developed during the war is composed of 6 parts dimethyl phthalate, 2 parts Rutgers 612, and 2 parts Indalone. Mixtures containing only two repellents have proved better than single chemicals, but they are generally not so effective as the mixtures containing three selected chemicals.

Any of the repellents I have named may be used for protection from chigger bites if used as a clothing treatment. Dimethyl phthalate is the preferred repellent to use because of its effectiveness, availability, and low cost. Its chief weakness is that it is quickly removed by washing. Benzyl benzoate is much superior to dimethyl phthalate because it is quite resistant to water. However, it is a poor mosquito and fly repellent, and the cost is rather high. If a person wishes protection from chiggers for only short periods and does not expect to get wet, dimethyl phthalate or any of the other repellents may be used with excellent results. If it is desired to use a chemical that is resistant to water and that will remain effective even after the clothes are laundered, benzyl benzoate is by far the most effective available chemical.

Simple water emulsions can be made with either dimethyl phthalate or benzyl benzoate by using emulsifiers such as Stearate 60-C-2280, Tween 60, Tween 80, or a polymerized glycol monostearate. These emulsions are useful for impregnating clothing with miticides or repellents.

Insect repellents must be applied in a thin, uniform film to hands, faces, arms, or other places where insects bite. They must be reapplied as often as needed. This may be every few minutes or every few hours, depending on the species of insects and the conditions of use. Usually the repellent is applied to the skin by pouring a few drops into the palms of the hands and rubbing the hands where a film of the repellent is desired. The repellents should be applied with caution to tender places, such as eyelids and lips, because they will cause a temporary smarting. This reaction is more pronounced on sweaty skin. The same procedure may be used for applying the repellents to clothing, such as socks, shirts, or trousers, where bites occur. Care should be taken not to apply the repellents to clothing that may be damaged by the chemical, such as synthetic cloth. If the numbers of insects are unusually high, it may be desirable to spray the repellent on the clothing or use the water emulsion method described in the next paragraph, although the dilution of the repellent-emulsion mixture with water should be less—1 quart of the mixture to 1 gallon of water.

The principal use of miticides is on clothing, because the chemicals are not so long lasting as skin applications. The materials may be applied by rubbing the chemicals on the clothing by hand or with a sprayer. If these methods are used, special attention should be given to apply the chemical heavily along the openings to the clothing and on the socks both above and below the shoe tops. When complete protection from chiggers is desired, and the exposure to their bites is severe, clothing may be treated with water emulsions of the miticides. The most practical way to use the emulsions is to dissolve 10 parts of the emulsifier in 90 parts of the dimethyl phthalate or benzyl benzoate by weight. Use one-half pint of this mixture to 1 gallon of water. It is best to agitate vigorously 1 part of the concentrate in 2 or 3 parts of water to form a creamy emulsion and then dilute with the remainder of the water. Agitate the emulsion while using to assure a uniform emulsion. Repellents applied to the suit, or shirt and trousers, will greatly reduce the bites from ticks and fleas.

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