

USES AND METHODS OF APPLYING INSECTICIDES AND REPELLENTS
RECOMMENDED TO THE ARMED FORCES

Since the investigations on repellents and insecticides for the Armed Forces were initiated by the Orlando, Fla., laboratory, a number of insecticidal compositions and repellents have been recommended for practical application. The methods of preparation and direction for use of some of these materials have been briefly described previously, however, this report included a discussion of all materials and brings up-to-date suggestions on methods of application for all the different treatments recommended. The methods of use as suggested here in some cases are based largely on observations made in connection with experimental investigations. It is realized that conditions in various parts of the world differ greatly and the most effective dosage and means of application may have to be determined by men in the field taking into account the local conditions and differences in resistance and habits of the various species of insects and arachnids.

This report is divided into four parts as follows:

- Part I - Methods of application and conditions under which insect repellents should be used for protection of troops from mosquitoes, sandflies (Culicoides and Phlebotomus), dogflies or stableflies (Stomoxys), blackflies (Simuliidae), fleas, mites (chiggers or redbugs), ticks, and other arthropods.
- Part II - Use of DDT (2,2-bis-(para-chlorophenyl)-1,1,1-trichloroethane) in various forms as a larvicide for the control of Anopheles and other mosquitoes.
- Part III - Methods of application of aerosols, spray residue and dusts for the control of mosquitoes, flies, bedbugs and cockroaches.
- Part IV - Methods of application of various recommended treatments for the control of the body louse, head louse, pubic louse, scabies, and fleas on military dogs.

Of the various insects investigated most consideration has been given to development or improvement of control measures for malaria mosquitoes and for the body louse, vector of typhus. Malaria has been by far the most important disease problem of our Armed Forces in this war and typhus is potentially of great importance to our troops and especially to civilians in the war-torn combat areas.

It is believed that information contained in this report will be useful to those concerned with the control of, or protection from, insects of importance to the Armed Forces and civilians in occupied territories. It should be emphasized, however, that those engaged in the control of disease vectors and pests (using the treatments discussed) can contribute materially towards the improvement of the treatments herein recommended and

can make further contributions by observing results under different conditions of use and against species of insects that are not available to investigators engaged in the basic research. Reports on results obtained and improvements in methods of application should be made through regular channels in order that others engaged in research or control may profit by the experience of the men in the field.

This report covers only investigations made at Orlando, Fla., dealing with methods of protecting personnel from insect pests. Additional methods will be needed for protection from bites or for reducing the incidence and severity of disease, such as by the use of vaccines, drugs, fumigants, screens, drainage, etc. The enforcement of military discipline is highly important in reducing insect-borne disease and insect annoyance among troops and civilians in occupied areas.

For further information regarding the uses of materials discussed in this report communications should be addressed to the Office of the Surgeon General or to Dr. W. E. Dove, In Charge of Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C.

PART I - INSECT REPELLENTS

(For use against mosquitoes, sandflies, biting flies gnats, mites, fleas and ticks)

Three different insect repellents have been recommended for protection of troops from mosquitoes and other flying and biting insects and from mites (chiggers or redbugs) fleas, and ticks. These repellents are dimethyl phthalate, Formula 612 and Indalone. In some cases these materials have been labeled as formula 0262, 0375, and 09 respectively. More recently a mixture of the three individual repellents has been recommended. Experimental tests have shown that one repellent may vary greatly in effectiveness against different species and may actually fail to repel some important species. For this reason a mixture of all three repellents was considered likely to be more effective for general use and this has been confirmed by tests against several species of insects. The use of one repellent for all insects will also greatly simplify the supply problem.

A. Repellents for Mosquitoes, Flies etc.

1. Methods of application of mosquito repellents

The repellents must be uniformly distributed over the area to be protected, as the insects will seek out and bite areas where applications are too thin, or where the material has been rubbed off. Care should be taken not to apply the material too liberally on the forehead, as the chemical causes a temporary stinging sensation if it gets into the eyes. All of the repellents are solvents of paints, varnishes and many of the plastics, such as watch crystals and synthetic cloth, and should be used with caution where these materials are part of the uniform or equipment.

a. Application to the skin

Shake the repellent into one hand, rub hands together and apply in a thin layer to exposed skin. About one-fourth teaspoonful is sufficient to treat the face, one arm, or one leg. The present G.I. repellents will give protection up to 3 to 5 hours depending on a number of factors, such as: rate of application, the individual, the species of insect involved and the amount of perspiration, and rubbing of treated areas.

b. Application to clothing

The repellent materials now used are effective for a number of days when applied to clothing, whereas on skin they may repel insects for only a few hours. The following methods of application of repellents on clothing are suggested.

(1) Hand application to clothing

Under field conditions where no equipment is available, fair protection may be obtained by hand applications. Shake about one-fourth teaspoonful into one hand, rub the hands together and apply lightly by rubbing hands on socks, shirts, or trousers where bites occur.

(2) Sprayer application to clothing

Probably the most satisfactory method of applying repellent materials to clothing is by means of a sprayer. Ordinary hand fly sprayers are satisfactory, but for large groups of men knapsack sprayers or paint spray guns are preferred. A sprayer that delivers a rather "wet" type of spray is better for this purpose than one that delivers a "fog" or small droplet (with a fog spray much of the repellent material floats away). An application of about 2 to 4 fluid ounces to fatigue coveralls or shirt and trousers is a desirable dosage. If more than 4 ounces is applied the clothing may be slightly "oily" and have a tendency to pick up dirt. Two methods of spray applications are suggested.

First: If the sprayer is of the "wet" spray type, the men can be sprayed with their clothing on, taking care to protect the eyes and not to breathe the spray material.

Second: If the sprayer is of the "fog" type, there is considerable loss of material if sprayed on the clothing while on the men, but this loss can be largely avoided by spraying clothes while they are not being worn. This is rather rapidly done by spraying into garments that have been turned inside out and buttoned. One man can hold shut the openings of the sleeves and neck

of the shirt and the bottom of the legs of the trousers, while another sprays into these bag-shaped garments. The "wet" type of spray may also be applied in this manner.

2. Conditions under which mosquito repellents should be used

The value of repellents and their importance in the prevention of diseases, such as malaria, sandfly fever, filariasis and other insect-borne diseases transmitted by mosquitoes and other flying and biting species is dependent to a great extent on the situation under which troops are living or working and what other means of protection may be feasible.

Repellents and protective clothing are frequently the only means of protecting troops in forward combat positions or while on the march in areas where the disease vectors are present. Repellents should be applied directly to the exposed skin and clothing should be sprayed or otherwise treated with repellents to prevent mosquitoes from biting through. Repellents should be used especially during the period that the disease vector is most active. In the case of anopheline mosquitoes this would be during the night, particularly at dusk and dawn.

Troops in temporary cantonment areas, on maneuvers, at work, on guard duty or when otherwise exposed outdoors should use repellents in the manner described. Under these conditions troops may be in a position to rely to some extent on other means of protection from mosquitoes, such as use of screens, bednets, aerosols, spray residue and larvicides.

For troops in permanent contonment areas the same conditions under which repellents may be useful will apply in this situation as described for the temporary contonment area.

B. Repellents for Mites, Ticks and Fleas

The same repellents issued for use as mosquito repellents can also be used to protect individuals from mites, ticks and fleas.

1. Mites (chiggers or red bugs)

a. Method of application

Mites in the Southern United States have been found to be effectively repelled by any of the three individual repellents or a mixture of them. Because of its availability and lower cost, dimethyl phthalate is recommended for use against chiggers, however, any of the regular issue can be used effectively.

Although the repellents can be applied to the legs and arms, as described for use against mosquitoes, this method is not recommended. Protection can be obtained more effectively and for a much longer period of

time by application to clothing.

Clothing should be treated prior to exposure. The repellents can be applied by spraying or by dipping the clothing in a suitable volatile solvent, such as benzene, or alcohol, containing approximately 10 per cent of the repellent. Since the latter method required special equipment and considerable time and material, the simplest method and one which has proven very effective is to apply the repellent to clothing in the following manner:

"Draw mouth of 'bottle along cloth, apply a thin layer 1/2 inch wide along all openings of uniform on inside of neck, fly and cuffs of shirt; waist, fly and cuffs of trousers; socks above shoes, and all edges of leggings. Clothing may be treated several days before it is worn and one application is effective until uniform is normally changed for laundering."

b. Conditions under which chigger repellents should be used

It is important that chigger attack be anticipated and troops in infested territory should apply the repellent prior to exposure. Troops working, on maneuvers, or those going into combat should treat themselves in the manner described.

Individuals exposed to chiggers are not aware of their presence for some hours after exposure. By the time irritation is noticed the damage has been done and even though the attached chiggers are destroyed, the irritation will persist perhaps for several days or weeks and secondary infections may result from scratching or rubbing. In certain areas chiggers are of greater importance because they are responsible for the transmission of mite typhus.

2. Ticks

The directions given for use of repellents against chiggers can be followed for ticks except that the application of the repellent as a spray at the rate of approximately 3 to 4 ounces (100 milliliters) to the entire outer garment has proven more effective than the barrier treatment described for chiggers. The repellent treatment has been found highly effective against larval or seed ticks and moderately effective (approximately 90 per cent) against the nymphal ticks. Results against adult ticks have not been as successful as desired, however, some protection can be obtained with the repellent treatment.

3. Fleas

The regular G.I. repellents mentioned can be applied to the exposed skin to protect individuals from fleas. The method of application to the skin is the same as that described for mosquitoes. Repellents should also be applied to clothing by spraying from 3 to 4 ounces (50 to 100 cc.)

on the outside of the garment. This is important when going into flea infested areas.

PART II - MOSQUITO LARVICIDES

Research at Orland, Fla., on the development of new mosquito larvicides has led to the recommendation of DDT for the control of anopheline and other mosquito larvae. This material has proven outstanding and other previously known larvicides do not approach DDT in effectiveness. Since the material is an organic compound, soluble in a number of organic solvents including petroleum oils, it can be used in various ways not practical with larvicides such as the arsenicals. Small quantities of the material will control mosquito larvae on large areas. This will simplify greatly the transportation and supply problem, which is an important consideration especially in combat areas.

DDT is a crystalline product and can be used as a dust with inert diluents or in liquid form when dissolved in oils or other solvents. When dissolved in organic solvents the solution can be applied straight or when in combination with wetting agents it can be applied as an aqueous emulsion.

In studies on larvicides most emphasis has been devoted to the development of effective larvicides for anopheline mosquitoes, however, certain culicine mosquitoes are likewise important in the transmission of diseases. DDT is highly effective against both types of mosquitoes. Because of the high toxicity of DDT to mosquito larvae and the many different ways it can be applied, the material will have far reaching possibilities in mosquito control. Much remains to be done on the most effective and practical means of applying DDT, however, great progress has already been made. DDT has been recommended to the Office of Scientific Research and Development for use by the Armed Forces in three ways: (1) In petroleum oils, (2) in water miscible concentrates for use as aqueous emulsions, and (3) for use in dust form. The methods of application of DDT in the three forms mentioned will be discussed separately and brief mention will be made of other methods which are being investigated.

In the present efforts to control malaria and other mosquito-borne diseases every known practical method of control should be put into effect in order to accomplish the desired purpose of protecting the individual and reducing the mosquito population so as to cut down the disease incidence in the shortest time possible. This is true especially in the present type warfare when new bases are established and manned with large numbers of men within a few days or weeks. In some situations the use of repellents and protective clothing discussed in Part I of this report are likely to be the most feasible, in others the use of aerosols, insecticidal spray deposits, screens, etc. (Part III) should be relied on for the most effective results, and in others the control of mosquitoes may be most practical by the application of larvicides or destruction of breeding places by engineering or biological methods. Because of the importance of malaria and other diseases transmitted by mosquitoes, consideration should be given to the adoption of every practical or feasible method that will contribute to-

wards the control of such diseases.

It is important to recognize, however, that the destruction of larvae by larvicidal treatments or elimination of breeding places may not accomplish the desired purpose in some situations. For example, reliance upon larvicidal treatments in new areas to be occupied by troops for a minimum period of 2 weeks, or longer in some cases, may have little or no effect in reducing the incidence of the disease. It is important, therefore, that those concerned with mosquito control realize the shortcomings and benefits that may be derived from various methods of control. These will vary in different parts of the world, depending on the local conditions and habits of the vector.

A. Application of DDT for the Control of Anopheline Larvae

1. Use of DDT in petroleum oil solutions

a. Preparation of oil solutions

Men in the field will likely be supplied the commercial grade of DDT in crystalline form. For use in oils it should be added at concentrations up to 5 per cent. At ordinary temperatures the DDT crystals are somewhat slow to dissolve in the oil and reserve stocks of oil containing 5 per cent of the insecticide should be on hand. To prepare a 5 per cent solution the DDT should be added at the rate of 2 pounds for each 5 gallons of oil. Unless some heat is used to hasten solubility at least 24 hours will be required for the DDT to go into solution. Either kerosene, Diesel oil, fuel oil or crankcase oil may be used.

b. Application of oil solutions containing DDT

Although numerous methods of applying oils have been used in mosquito control, two methods of applying DDT in oil have been given most consideration. One method consists in pouring or squirting oil containing DDT on the water surface. The second method consists of using spray equipment for applying oils containing DDT. The two methods will be discussed separately.

(1) Application of oils by pouring or use of squirt cans, etc.

As indicated this method consists of applying oil containing DDT to the water surface in the simplest manner possible. The oil is applied at different places in the pool or stream and the dispersion of DDT is dependent of the spreading properties of the oil. In some situations remarkable kills of larvae have been obtained with relatively small quantities of oil. Waste crankcase oil, as shown by Dr. Barber in extensive tests, can be readily utilized for this method of control although Diesel oil or fuel oil can be used in a similar manner.

The quantity of oil containing DDT needed per acre of water surface is dependent on the amount of vegetation, debris and the distance that oil will spread. These points can best be determined by men in the field, however, with DDT in the oil kills will be obtained with even the very light films. When oils spread readily effective killing dosages can be obtained with quantities as low as 1 quart of 5 per cent DDT per acre applied at several points over the area.

The most serious objection to this method of application of DDT is the variable results obtained. The effectiveness of the treatment is dependent entirely on the spreading properties of the oil. In some breeding areas oils do not spread sufficiently to make this method reliable. However, where the method can be used effectively applications can be made with a minimum amount of equipment and labor.

(2) Application of oils containing DDT, with spray equipment

Although equipment is necessary this method is considered most reliable under a wide range of conditions. Due to the remarkable toxic action of DDT the amounts needed for effective control are extremely small. This must be realized to take full advantage of the potential savings in materials and labor.

Whereas straight oil is generally applied at the rate of about 25 gallons per acre in mosquito larvicide operations, equally or more effective control can be obtained with 5 per cent DDT oil solutions when applied at the rate of 2 quarts per acre or even less provided the oil is sprayed in the form of a very fine spray so as to obtain coverage over the area.

Since waste crankcase oil may cause clogging of spray nozzles, regular mosquito larvicide oils, such as Diesel oil, fuel oil or kerosene are recommended. The present spray nozzle available to field men should be adjusted to liberate as fine a spray as possible and at a slow rate. The oil should be sprayed so as to obtain as much drift as possible. A swath width of approximately 50 to 100 feet is suggested although experimentally using a DeVilbiss spray atomizer effective control has been obtained for several hundred feet from a point of release when applied at the rate of 1 quart of oil per acre. A quart of 5 per cent DDT per acre gives a dosage of 0.1 pound of active ingredient per acre. This dosage should not be expected to give more than an initial kill of larvae present.

For residual toxicity where wind and waves will not affect the larvicide, a dosage of 1 pound of DDT per acre should be used.

Investigations are under way to develop more satisfactory nozzles for use on spray equipment now available to the Armed Forces. Any developments along this line will be reported at the earliest possible date.

2. Use of DDT as an aqueous emulsion

Considerable effort has been devoted to the development of DDT concentrate solutions for use in aqueous emulsion sprays. One very effective and stable formula has been developed in connection with the louse project (see Part IV), spray residue treatments (see Part III) and in connection with the larvicide investigations. Although more expensive and requiring several materials, the concentrate has the advantage of being ready to use and without further preparation can be diluted with water from the larval breeding places and applied. A small quantity will effectively control mosquito larvae on relatively large areas which simplify the supply problem. It appears also that the DDT emulsion is more effective against culicine mosquitoes than DDT in oils.

The DDT-Triton-xylene emulsion produces larvicidal action in part as a suspension in water. However, the material has a tendency to remain concentrated on the water surface when sprayed as a fine mist and when distributed throughout the water has a tendency to rise to the surface so that it is semi-surface acting and the volume of water within limits need not be taken into consideration in practical use.

For anopheline control the material is diluted with water to obtain the desired concentration of DDT. With finely broken up or atomized sprays the same procedure as described for the application of oils containing DDT can be used in applying the emulsion. The addition of one part of concentrate to three parts of water for a spray containing 5 per cent DDT can be used. If spray equipment is adjusted so as to produce a fine spray with a slow rate of delivery effective control can be obtained with 1 to 2 quarts of the 5 per cent spray. If a greater volume of liquid is needed for adequate coverage the rate of dilution can be increased to give any desired concentration. At a dosage of 1 to 2 quarts of spray per acre attention should be called to the fact that only 0.5 to 1 pint of concentrate would be necessary.

In small breeding places the diluted emulsion can also be applied by pouring the material in the water and dispersing the insecticide by wading or other methods of agitation.

The dosages suggested are considered killing dosages without regard to lasting effects. Some residual action is indicated and the time for retreating should be governed by results of dipping records.

When applied in higher dosages perhaps of one part of DDT to one million parts of water in stabilized pools, the treatment may prevent breeding for several weeks. This would require approximately 13.5 pints of the 20 per cent DDT concentrate per acre/foot. Dosages higher than one part of DDT to ten million parts of water will prove fatal to fish life and where fish are present higher dosages are not recommended.

The higher dosages also are not practical in situations that are likely to flood or dry up for excessive dosages would be wasteful of material.

Application of sprays from airplanes - No recommendations have as yet been made regarding the use of larvicidal sprays from airplanes, however, investigations have shown that oils containing DDT and the DDT-Triton-xylene emulsion are highly effective when applied from a plane. Dosages as low as 2 quarts per acre of either solution containing 5 per cent DDT have given effective control. Larvicidal sprays from airplanes have not been given much consideration in the past because none were sufficiently effective to give satisfactory results without the use of excessive weight of material. With the highly effective DDT sprays, area covered with a given load weight is as great or greater than dust applications, such as paris green. Because of certain advantages of liquids over dusts, it is felt that sprays from a plane will be more effective and practical than previously known dust treatments. Due to the effectiveness of DDT in small quantities the development and availability of suitable equipment may make practical and feasible the treatment of large sections without regard to size of breeding area and degree of infestation. This will allow the immediate application of larvicides without the loss of time and labor of technical men now required to make surveys. Such procedure may make practical the treatment of advanced combat areas.

3. The use of DDT in dust form

Considerable research has been conducted on the value of DDT in dust form. DDT is from 10 to 100 times more toxic than paris green to larvae of Anopheles quadrimaculatus.

Although effective control of Anopheles larvae can be obtained with DDT applied in dust form at the rate of 0.1 pound or less of DDT per acre, the commercial grade of DDT has certain undesirable physical properties that makes DDT in dust form less desirable than DDT sprays for use under war conditions. The material is difficult to grind to the desired degree of fineness without the addition of diluent and after grinding the material has a tendency to pack and lump. A commercial finely ground product can be produced containing 20 per cent DDT, however, in furnishing this material it becomes necessary to ship 4 pounds of inert material for each pound of active ingredient. The problem of having on hand in the field sufficient diluent is also a major consideration, especially in countries having considerable rain fall. Mixing dusts in the field is also more difficult than preparing the spray solutions previously mentioned.

Objections mentioned make DDT dust applications less desirable, although where such dusts can be supplied the treatment can be used effectively and can be applied readily with ordinary ground dusting equipment. The DDT in dust form was shown, by Tennessee Valley Authority workers, to be unsatisfactory for application from an airplane because of the tendency of the dust to pack. Another objection is the lightness of the material which prevents effective control of swath width. Studies are being continued to improve the effectiveness of the dust applied from a plane.

4. Other methods of application

The methods of application of DDT larvicide suggested are the ones most generally used. Under the wide range of conditions throughout the world where mosquitoes are breeding, various methods may be employed that may prove highly satisfactory. The use of DDT in oil drip cans, or the moistening of sand or other materials with oil containing DDT and broadcasting the larvicide in the same manner as the paris green oil combinations may be effective.

Other methods are under investigation at present, however, sufficient data are not available to recommend the treatments.

Entomologists and engineers can contribute greatly towards the further development of the treatment by trying various methods suggested and others that may be applicable under different conditions. Observations on the effectiveness and lasting effects of various dosages are also needed under different conditions and against different species.

B. Use of DDT against Culicine Mosquitoes

Laboratory and field tests have established that DDT is also outstanding as a larvicide for various species of Culex and Aedes mosquitoes. In comparative tests DDT proved at least 50 times as toxic as phenothiazine to larvae of Culex quinquefasciatus and Aedes aegypti.

Although most emphasis has been placed on the development of anopheline larvicides the same materials and methods of application have been tried on several species of culicine larvae. Results have shown that DDT is effective against both types of mosquitoes, which is an important consideration in mosquito control.

1. Use of DDT in petroleum oils

Control of pest mosquitoes has been obtained at 0.1 pound per acre of DDT in fuel oil. Only a limited number of tests have been made. In general the culicines require a heavier dosage than anopheline larvae.

2. Use of DDT as an aqueous emulsion

DDT has been tested more extensively in the form of the DDT-

Triton-xylene emulsion than in oil solution or in dust form.

This emulsion is very effective applied as a spray. Effective control has been obtained in field tests against *Aedes taeniorhynchus*, *A. aegypti*, *A. sollicitans*, *Psorophora ciliata*, *P. columbiae*, *Culex nigripalpus*, *C. salinarius*, and *C. quinquefasciatus* at dosages as low as 0.05 p.p.m.

Lt. R. P. Holdsworth of the U. S. Naval Hospital, Key West, Fla., has cooperated in tests against *Culex* and *Aedes* breeding in cisterns, wells, etc. The DDT emulsion proved more effective than DDT in oils under such conditions.

For field application the DDT-xylene emulsion should be applied in the same manner as described for the control of *Anopheles* larvae. Higher dosages may be necessary for certain species depending on the conditions. Results of the spray applied from a plane have been equally as encouraging against the culicine mosquitoes as with the anophelines.

3. Use of DDT in dust form

DDT applied as a dust is not an efficient way to obtain maximum larvicidal efficiency of DDT against below surface feeders such as *Culex* and *Aedes* and at present dust applications are not recommended. Higher dosages of dust are indicated to be necessary for the control of such species, however, dusts are indicated to be effective at practical dosages if this method of applying DDT is the most feasible.

PART III - AEROSOLS AND SPRAY RESIDUE

The use of sprays in dwellings or other confined spaces is one of the most widely used methods of protecting the individual from insect annoyance. Various modifications of the ordinary household type hand sprayer have, for the most part, been relied on for application of the insecticides. The recent development of the liquified gas (Freon)-pyrethrum bomb or cylinder by Goodhue and Sullivan of the Bureau of Entomology and Plant Quarantine has given the Armed Forces a convenient and effective self-propelled insecticidal spray which, because of the fineness of the particles, which are colloidal in size, is called an aerosol. The present aerosol bomb is highly effective against mosquitoes and no doubt against related insects which are responsible for the major disease problems of the U. S. Armed Forces. However, it is relatively ineffective against flies at dosages recommended and under conditions used because of the high percentage of recovery, although it does produce rapid knock-down action. Investigations at Orlando, Fla., have shown that the addition of DDT to the pyrethrum aerosol formula greatly improves the effectiveness of the aerosol for general use as will be discussed under aerosol investigations.

Since the conventional method of destroying insects in dwellings, such as mosquitoes, flies and bedbugs, has been a direct contact spray,

practically all research has been devoted to the development of more effective contact sprays or aerosols. Little thought has been given to the development of sprays that will kill on contact and also leave a toxic spray deposit or residue that will destroy insects that later enter treated buildings.

Investigations with this objective in mind were given early consideration and encouraging results were obtained on bedbugs using proper concentrations of various types of pyrethrum sprays. The application of spray residue treatments for mosquito control using pyrethrum sprays was also considered. However, the shortage of pyrethrins prevented the use of this material. Some of the better known synthetic organic insecticides proved relatively ineffective from a residual standpoint, and until DDT was tested in this manner little promise was indicated for a practical treatment that could be recommended under present conditions. Tests with DDT, however, showed that this material possessed remarkable residual insecticidal properties against bedbugs, houseflies, mosquitoes and other insects. It is felt that these developments may change the concepts as to the most effective means of controlling, under certain conditions, several species of insects, and results may be far reaching in importance especially with respect to the control of malaria and other insect-borne diseases.

Although the use of sprays is generally considered applicable only in confined spaces or limited areas outdoors, DDT and pyrethrum may prove to be a feasible means of control of adult mosquitoes, flies and possibly other important insects by treatment of large areas outdoors around cantonment areas, and perhaps even in the front lines.

The studies on aerosols for use in confined spaces; spray deposits for dwellings; and sprays, dusts and aerosols for use under outdoor conditions will be discussed separately.

A. The Use of Aerosols in Confined or Semiconfined Spaces

The present pyrethrum aerosol provides an effective and convenient method of destroying mosquitoes in tents, barracks, bomb shelters, trenches, gun emplacements and other somewhat confined spaces. The greatest value of aerosols is probably in temporary cantonment areas where other available means of control or protection may not be organized. Aerosols are also useful in permanent camps although other methods of control, such as screening, larviciding and drainage may be well established. The use of aerosols in trenches, fox holes and similar situations by first line troops is indicated. However, opportunities for their use may be limited and repellents and protective clothing are the chief means of protection in such situations.

Directions for the application of aerosols are stamped on the bombs. The coordinated use of aerosols at regular intervals will not only aid in protecting the individual from annoyance but of greater importance is the reduction in incidence of malaria and other mosquito-borne diseases

resulting from their use. Research on improving the present aerosol formula is under way at the Orlando laboratory. Although revised formulae may not be issued until some future date, important progress has been made.

Several investigators, among which may be mentioned Brigadier Covell of the British Army and Colonel Russell of our Army, have shown that the weekly spraying of adult mosquitoes in dwellings and other resting places in native villages will control malaria. The coordinated use of the aerosols can therefore be expected to be an effective means of reducing the disease incidence and the method can be employed for immediate results. Every mosquito killed will reduce the chance of being bitten by infected mosquitoes. With the exception of wild species of mosquitoes that do not stay in human habitations, the mosquitoes resting in dwellings or other hiding places on or near the camp site are the most likely to be infected. Therefore, disease control may result even though the mosquitoes destroyed are soon replaced by others that have recently emerged or that fly into the area giving the appearance of no overall reduction in the mosquito population.

Details regarding the frequency and methods of application of aerosols have been issued to responsible malariologists new in the service, however, the development of more effective treatments for adult killing of mosquitoes and other insects as a means of disease control is considered highly important and much of the research effort during the past few months at the Orlando laboratory has been directed toward that end.

As already pointed out the present pyrethrum aerosol formula although effective against mosquitoes is not satisfactory for control of flies. Investigations with DDT in the aerosol have shown that this insecticide is much more effective than pyrethrum against flies at concentrations that are practical. Pyrethrum on the other hand is more effective against mosquitoes and possesses much more rapid paralytic action, although the presence of DDT in the formula also adds to the effectiveness of the aerosol to mosquitoes. A combination of pyrethrum and DDT is therefore more desirable and effective than the present formula and every effort is being made to have such an aerosol formula substituted for the one now used.

The residual action of DDT, which will be discussed fully in the next topic, is also a valuable feature of the pyrethrum-DDT aerosol. Studies indicate that the regular use of the DDT-pyrethrum aerosol will build up a toxic residue on the walls and objects in tents, barracks, etc., which will destroy some of the mosquitoes and flies that subsequently enter.

B. The Use of DDT Spray Residue Deposits in Dwellings

The potentialities of the DDT spray residue deposit as a means of mosquito and fly control are based on extensive laboratory tests and

only on a limited number of field tests. However, on the basis of these results and observations, it is felt that this method of control of the domestic type of insect and consequently the diseases which they transmit, promises to be the most effective known. This method of treatment may be most applicable in permanent and temporary cantonment areas, and at present its effective use in the front lines is not indicated.

The primary objective in the application of DDT spray residue deposits is not to destroy the insects present at the time of treatment, although this will automatically occur if they are contacted by the treatment. The major purpose is to form an insecticidal deposit that will destroy for several weeks or perhaps months after treatment the insects which rest or crawl over the treated areas. In this respect, DDT has insecticidal properties of unusual duration. The material is very toxic to insects and at the same time is very stable. The insecticide seems to be absorbed readily by insects which contact the spray deposit and apparently it acts as a nerve poison. This method of insect control is a distinct departure from the direct contact spray method and it is important to understand how it works so that the material can be applied intelligently so as to insure maximum results. The habits of the particular insects should be fairly well known, and for this reason detailed general directions for application of the insecticide cannot be given but will have to be worked out by men in the field.

The following general procedure for controlling flies, mosquitoes and other similar domestic insects around Army establishments and native villages is suggested:

1. Methods of application and type of spray and spray equipment

DDT may be dissolved in kerosene at a concentration of approximately 5 per cent. Lower concentrations can be used, such as the 1 per cent DDT fly and mosquito spray recommended by McGovran of the Bureau of Entomology and Plant Quarantine. However, to obtain a desired dosage of insecticide the higher concentrations allow the spraying of less liquid. (Concentrations of spray higher than 5 per cent would in some situations be more desirable except for objection to the use of higher concentrations because of danger of physiological reaction and because higher concentrations of DDT in kerosene would necessitate the use of an auxiliary solvent.)

The finished solution should be applied as a wet spray. The knapsack type sprayers can be used, however, the nozzle should be adjusted to make a fine but not a mist spray. Power sprayers can be used in the same manner. The ordinary paint sprayer nozzle produced too fine a mist and much of the spray may fall to the floor or escape into open air. The constant breathing of the spray mist may also be hazardous to the operator. If the paint sprayer nozzle is the only type available, it should be held close to the object to be sprayed in order for the liquid to remain as a spray deposit. An ordinary hand sprayer can be used, however, this will require considerable time and labor.

Use of DDT-Triton-xylene emulsion: The DDT emulsion concentrate discussed in connection with the mosquito larvicide project (Part II, page 9) and the Louse control project (Part IV, page 24) can be used instead of the DDT-kerosene solution. The same spray equipment and method of applying discussed for the kerosene spray can be used. The concentrate, which contains 20 per cent DDT, can be added to water for any desired concentration of spray solution. One part of the concentrate to three parts of water will produce a 5 per cent DDT spray, which is the one recommended for most situations.

2. Conditions under which spray residue deposits are suggested

a. Mosquitoes

The spray should be applied to the inside of barracks, tents, latrines, dugouts, mess halls, under bridges and any artificial or natural resting places for mosquitoes within the camp site. Particular attention should be given to the favorite resting places. This may include all of the inside of the dwelling, especially in the darker places, such as under beds and behind objects, in corners, etc. If screens are present, they also should be treated, preferably by painting, since a spray would result in excessive waste. The many mosquitoes, flies and other insects that land on screens in their attempts to enter buildings would thereby be exposed to the insecticide.

The most economical rate of application has not been determined, however, a dosage of from 50 to 200 milligrams per square foot of surface area is suggested. This would represent a deposit of 1 to 4 cc. of spray solution per square foot. At this rate of application, a large barrack would require approximately 1 to 4 gallons of the 5 per cent spray.

Since the source of mosquito-borne diseases frequently originates from native people, the control or reduction of the disease among them may prevent disease among troops. Where this situation exists and where it is feasible to apply treatments to native habitations, the same general procedure in the application of the spray can be followed as suggested for camp sites. The objective would be to treat all favorable resting places for mosquitoes so as to destroy those subsequently landing or resting on the treated surfaces.

Although the adoption of the methods suggested involves considerable initial material and labor, results of experimental investigations indicate that a single application will remain effective against mosquitoes entering the treated building for 2-1/2 to 3 months and perhaps longer. During the interim the deposit will be constantly killing mosquitoes not only before they have an opportunity to bite, or destroying them after biting but during the 10-day to 2-weeks period before they become infective.

The treatment suggested for mosquitoes also should control other susceptible insects that enter the dwellings, including flies, fleas, some, species of ants, and perhaps many forms which have not been studied. However, if treatments are directed specifically towards certain insects, such as flies, bedbugs and roaches, special consideration should be given to their habits in applying the treatment.

b. Houseflies

DDT spray residue should be used where flies are concentrated. The interior of mess halls and kitchens, including the inside and outside of window screens and screen doors; latrines, garbage racks; and other favorable places should be sprayed or painted. The effectiveness of the deposit against the housefly is illustrated by practical tests around dairy barns. The treatment of several dairies, which included the application of a spray deposit inside of the milk barn, feed room and other favorite places, resulted in a reduction in fly population conservatively estimated at 95 per cent. What is more important is the fact that without additional treatment the fly population continued to remain at such low level for a period of at least 3 months.

c. Bedbugs

Bedbugs have been eradicated from civilian homes and Army barracks by the thorough application of DDT spray residue to the mattresses, beds, and cracks and revices in the walls.

In the control of bedbugs, it is important to apply a complete coverage to the entire mattress and bedstead. The spray should be directed particularly to the springs, joints, and corners of the bedstead. Barracks walls should be treated to a height of about 6 feet, with special attention to all cracks and crevices. Although the spray is highly effective in destroying bugs contacted, it is practically impossible to reach all of them in their numerous hiding places. However, the DDT residue remaining on the walls, bedsteads and mattresses will destroy any bugs that escaped treatment and later crawl on the treated areas and attempt to live in the treated beds. This also pertains to bugs introduced from other sources. About 3 gallons of spray is required to treat all beds and the side walls of an ordinary 74-man barracks. A single thorough application, as described, has given complete reduction in bedbug population and reinfestations have not occurred during a period of at least 3 months in barracks, and for at least 6 months in civilian homes. Sufficient time has not elapsed to determine the maximum effective period of control afforded.

Where sprays can be applied this method is recommended for bedbug control. However, DDT in dust form is also effective against bedbugs. Troops in the field having the DDT louse powder can apply it to their beds, bedding, and cracks of the walls, thereby obtaining protection.

d. Cockroaches

The DDT spray applied thoroughly in the mess halls and kitchens has given promising results as a means of control for cockroaches, however, information on the value of the spray deposit and duration of effectiveness has not been fully determined.

The use of DDT in dust form applied in cracks to favorable hiding places of roaches, such as crevices and behind objects, has proven an effective means of control.

3. The use of aerosols, sprays and dusts under outdoor conditions

Investigations on the use of aerosols and sprays for application under outdoor conditions for the control of mosquitoes have been given considerable attention, but no recommendations for practical use have been made. Results have been encouraging and will be discussed briefly. The pyrethrum aerosols now issued as well as DDT aerosols, sprays and dusts have been tested against Aedes taeniorhynchus.

Tests have been made of aerosols, sprays and dusts applied from the ground and of sprays and dusts applied from an airplane. Results of these studies show that the standard pyrethrum aerosol now issued can be used effectively to eliminate mosquitoes in thickly wooded areas by releasing the aerosol as the operator walks back and forth in the area to be treated. The aerosol should be released systematically, taking swaths 20 to 40 feet wide, as close to the ground as possible. One bomb has effectively controlled A. taeniorhynchus in 1 to 2 acre plots in thickly wooded areas. Similar results have been obtained by atomizing as small an amount as one quart per acre of kerosene containing 5 per cent DDT, or the same amount of the DDT-hylene emulsion (diluted to 5 per cent DDT).

The shortage of pyrethrum aerosol bombs and the difficulty in applying finely atomized sprays are factors that at present prohibit the recommendation of such treatments except where conditions warrant the use of the aerosol or the utilization of the labor for the spraying. Such measures on small areas also are only temporary, and mosquitoes from the surrounding untreated area will soon infiltrate into the area treated.

DDT applied as a dust, using about 6 pounds containing 5 per cent DDT, has also given good control of Aedes mosquitoes when applied from the ground, although results have not been as good as aerosols and sprays. Dusts containing DDT applied from an airplane have not given satisfactory control of adult mosquitoes in thickly wooded areas in a few preliminary tests.

The application of DDT sprays from a plane appears to be effective and further investigations are under way. A kerosene spray containing 5 per cent DDT applied at the rate of 2 to 3 quarts per acre in thickly wooded areas has given good control of Aedes taeniorhynchus. The spray apparently acts both by contact and by the residue deposit on the

vegetation. Tests have not as yet been made against Anopheles mosquitoes, however, the application of the spray to large areas for the control of certain species of mosquitoes is indicated to be feasible. In open areas where planes can fly low, such as in rice fields and the open tundra of the North, applications of sprays or dusts over large areas should prove very effective and entirely practical. At dosages of 2 quarts per acre the material cost would be approximately 35 cents per acre, and if the price of DDT is reduced this would be correspondingly decreased.

Since flies appear to be equally or more susceptible than mosquitoes to DDT, sprays and spray residue deposits applied by plane around cantonment areas also may prove effective in the control of flies over large areas.

PART IV

METHODS OF APPLICATION OF LOUSICIDES FOR THE CONTROL OF HUMAN LICE¹

Three species of lice attack man, namely the body louse, head louse, and crab louse. Because of the wide differences in habits each species requires special consideration in applying control methods. The body louse is the only species known to transmit typhus and other louse-borne diseases. For this reason, most emphasis has been devoted to the development of control measures for the body louse. Because of the close morphological and physiological relationship, however, between the body louse and head louse, the latter variety may also be incriminated in the transmission of diseases. The crab (pubic) louse is not known to transmit diseases, but infestations are widespread and common among troops and civilians, and effective methods of control are necessary.

Investigations on control methods for the species of lice have led to several treatments which have been recommended to the Armed Forces. These treatments include two powder formulas, two liquid formulas, and one treatment for louseproofing garments.

The first louse powder recommended, known as the MYL formula (QM Item 51-I-173), consists of 0.2 per cent pyrethrins, 2 per cent N-isobutylundecylenamide, 2 per cent 2,4-dinitroanisole, and 0.25 per cent Phenol S, in an inert diluent, Pyrophyllite. The second and most recent formula, known as the DDT louse powder (QM Item 51-I-180), contains 10 per cent DDT 2,2-bis-(p-chlorophenyl)-1,1,1-trichloroethane) in Pyrophyllite.

The two liquid formulas were developed for application to the body and head for the control of head lice, crab lice, scabies, and for body lice that occasionally attach eggs to hair on the body. The formula first recommended (SYLN formula) consists of 0.2 per cent pyrethrins, 0.5 per

¹ One of the types of louse treatments is also recommended for scabies. See the last section of this report.

cent N-isobutylundecylenamide, 2 per cent 2,4-dinitroanisole, and 10 per cent benzyl benzoate in ethyl alcohol (95%). Due to the shortage of pyrethrum and the development of a more desirable ovicide, a formula (EEAY formula) has been recently recommended to replace the first formula. This EEAY formula consists of 1 per cent DDT, 2 per cent p-aminobenzoate (Benzocaine) and 10 per cent benzyl benzoate in ethyl alcohol (95%).

The method of louseproofing garments for the control of the body louse is accomplished by impregnating garments with DDT using a volatile solvent or an aqueous emulsion containing DDT.

The basic research leading towards the recommendations of these treatments herein discussed was done at the Orlando, Florida, laboratory. Information on effectiveness of the treatments has been obtained and improved methods of application in the field have been developed by personnel in the Armed Forces and by members of The Rockefeller Foundation, who have been investigating the control of lice among civilians.

The body louse: The body louse is sometimes referred to as the clothes louse and is seldom found on the body of the host, but clings to the clothing. In looking for body louse infestations, the clothing should be examined for lice and nits along the seams and folds of clothing, especially on the inside of the underwear. Because of the habits of this species, control measures should be largely directed toward the treatment of clothing. Louse powders now issued to the Armed Forces are available for this purpose, and methods of impregnating garments have been recommended and materials and equipment may be available at some future date. The 10% DDT powder will be the standard issue.

A. Use of the DDT Louse Powder (Q.M. Item 51-I-180)

This powder is available in 2 oz. sifter-top cans for use by the individual and is also available in bulk for application to large numbers of persons by the use of mechanical dusting equipment.

1. Application by the individual

A liberal application of the powder from the sifter-top can should be made over the entire inner surface of the underwear, paying special attention to the seams. As the powder is applied, the garment should be rubbed lightly by hand to spread the powder more evenly. The seams of the inside of the shirt and trousers should be treated in a similar manner. Approximately one ounce of powder, or one-half the contents of the can, will be necessary for one application.

The treatment is highly effective against body lice. Although relatively slow in action, complete mortality of lice can usually be expected in 24 hours. The powder has no ovicidal properties, consequently eggs are not destroyed by the treatment. The residual action of the powder, however, will persist and complete control of lice hatching

from eggs in clothing or bedding can be expected for 3 weeks with a high degree of control for a month after treatment. Since eggs of body lice normally hatch in less than 2 weeks and seldom after 3 weeks, a single application may eradicate the infestation.

Since the lasting effect of the treatment is due to residual action of the powder remaining on the treated clothing, it will be necessary to reapply the powder if the underwear is changed.

If infestations are present in stabilized military units, every individual should be treated in the manner described, and all personnel should be treated about the same time. The powder should also be dusted in the bedding between the sheets and blankets, and on the mattress.

Personnel not infested with lice but mingling with lousy troops or civilians, or living in infested quarters, should apply the powder in the manner described as a prophylactic measure. Medical officers and men, nurses and Red Cross workers especially should apply the powder as a prophylactic measure.

Although it is desirable to apply the powder thoroughly and uniformly to the clothing, soldiers in the field may not find it possible to remove their clothing for treatment. Experiments indicate that complete control of lice can be obtained without removing clothing by unbuttoning the shirt and trousers and distributing the powder as effectively as possible by dusting the inside of the underwear, and shirt and trousers.

2. The mass treatment of troops and civilians with dusting equipment

This method of treatment has not been investigated at the Orlando laboratory, however, directions for the control of lice among large bodies of troops by use of mechanical dusters have been given by General Blesse¹. These directions are very complete and thorough, and if carried out should result in complete eradication of lice from infested units. The following is quoted from General Blesse's directions:

"6. Procedure for powdering a man.

"a. Powdering with dust gun.

"(1) The powder compartment of the Superbuilt Duster (Q.M. Item No. 41-D-3750) is filled about 3/4 full of louse powder. The delivery of powder should be tested in the open with the duster so rotated that the delivery tube is on the upper side.

1 Circular Letter No. 43, "Typhus Fever Control", from Headquarters North African Theater of Operations, Office of the Surgeon.

"(2) In using the dust, the operator should remember that powder should be distributed on the inner surfaces of the inner garments and on the skin itself. Those doing the work for the first time should have the clothing removed from the first persons powdered to observe the results obtained. If dusting has been done properly, the entire inner garments should be more or less completely covered with powder, and there should be visible powder on the body hairs of the chest, back, thighs, armpits, and of the pubic and perineal regions. Since body lice are most often found in the seams of the clothes about the neck, armpits, waist, shirt tail, and crotch of the pants, these areas are particularly important ones to be powdered.

"(3) The dusting of individuals should follow a certain routine to avoid missing some parts of the clothing, as must occur, at times, where each person is handled differently. The following routine has been found useful:

"(a) Dust inside of hat and replace hat on head.

"(b) With arms extended at shoulder height at the sides (not in front) of the body, insert delivery tube up first the right and then the left sleeve and pump powder in between the skin and the innermost garment. Powder should reach well into the armpit and the position of the gun should be shifted to get powder all about the shoulder.

"(c) In case the subject is wearing more than one layer of clothing, dust should be applied between his underwear and shirt as well as between the underwear and the skin.

"(d) The delivery tube is inserted next at the back of the neck and a liberal charge of powder shot down the back, care being taken to dust the neckband itself.

"(e) The tube is inserted next inside the clothing from in front, and powder sprayed, first on one side, then on the chest, and last on the other side, special care being taken to reach the armpits again.

"(f) The tube is inserted next, after the trousers are loosened, inside the innermost garment and a good dose of powder delivered to the crotch and pubic area. With the tube still in contact with the skin, the underclothing is powdered, special attention being paid to the waist and side seams.

"(g) With the trousers still loose, the tube is inserted down the rear of the pants, next the skin, and powder is shot down over the buttocks and rear of the crotch.

"(h) Note: If more than one layer of clothing is being worn, steps c, d, e, and f, above are repeated for the second layer from the skin.

"7. Procedure for powdering extra clothing, blankets and bedding,

"a. Although probably 95% of all lice generally are to be found on the person and the clothing in use, extra clothing and bedding may be infested and may be a serious source of reinfestation.

"b. In dusting extra clothing and bedding with the hand duster the delivery tube should always be between two of the surfaces to be dusted, thus speeding up the work and avoiding waste of powder. Clothing is dusted without turning inside out, with delivery tube well inside the garment. A mattress is dusted by placing a blanket over it and dusting between the two. (Care should be taken to dust sides and seams of mattresses.) Blankets are dusted by piling one on top of another, or by folding and dusting between two layers of fabric. Where plenty of help is available, folded blankets may be held in the air, but where help is limited, blankets are folded twice, piled one on top of the other and dusted between each layer. The larger pieces of bedding are dusted and all of the powdered pieces piled up together. When finished, this pile is given several hard blows to fluff the powder about in the blankets, into seams, patches, etc.

"8. Amount of powder needed.

"a. The powder required for dusting a person varies with the amount of clothing worn. About 1-1/2 ounces is required for the average adult male in fall or winter dress and 2 ounces per man often will be used. Those supervising dusting should constantly check the amount of powder being used and insist on the use of an adequate amount (1-1/2 average).

"b. The powder used on bedding, likewise, varies with the type and amount of bedding. With men equipped for camp life, it may equal or exceed the amount required for their clothing. In making preliminary estimates, one case of powder (60 lbs.) should be allowed for each 250 men.

"9. Rate of dusting.

"a. Where the men to be dusted are under discipline, a team of two men with hand duster can dust about 35 to 40 men and their bedding per hour, with the help of the men themselves in handling their bedding."

B. Louseproofing Garments for Control of the Body Louse.

The louseproofing of garments by impregnating with DDT has not been adopted as a method of control, although recommendations and reports have been made to the OSRD for use of this method by the Armed Forces.

Although the mechanics of treatment and distribution of impregnated garments to military personnel may present some difficulty, the method largely eliminates the personal factor and provides more permanent

control of body lice than the use of powder. Impregnated with about 2 per cent of their weight of DDT, garments worn continuously and washed once each week are effective in eliminating lice for 6 to 8 weeks. If washed less often the garments will be effective for an even longer period. Troops provided with two DDT-impregnated garments would probably remain free of lice during the season of the year when lice are most prevalent.

Two methods of impregnating garments may be used: (1) The volatile solvent method and (2) aqueous emulsion method. By the first method underwear to be worn by troops is dipped into dry cleaning solution such as Stoddard's solvent or gasoline containing: 1 to 2 per cent DDT. The excess solution is removed by wringing and sufficient time is allowed for the solvent to evaporate before treated garments are worn. If clothing is impregnated in a central plant; the same process used in dry cleaning clothing can be used. The percentage of DDT needed in the solution will depend on the amount of liquid remaining in the clothing after the whirling process, but a dosage of 15-20 grams of DDT is recommended for the regular G. I. winter-weight 50 per cent wool underwear.

In using the aqueous emulsion method, a concentrate having the following composition has been developed: DDT 20 per cent; Triton NE 20 per cent; and xylene 60 per cent. This concentrate can be added to water to give any concentration of DDT desired, which will probably (?) be $1^{1/2}$ to 2 per cent DDT. Ordinary laundry facilities can be used to impregnate garments in this emulsion, however, a portable impregnating unit has been developed by Randall Latta of the Bureau of Entomology and Plant Quarantine, for use in the field. The equipment consists of a metal stand for supporting the regular G. I. Lister bag, and a small clothes wringer. Clothing can be dipped into the DDT emulsion in the bag and wrung out through the clothes wringer.

In situations where louseproofed garments can be provided, more effective control can be expected because the treatment remains effective for long periods and the application of louse treatment is not dependent on the individual.

C. Application of Spray to the Body for the Control of Lice and Eggs Attached to the Hair of the Body

The two spray formulas mentioned on page 19 of this report are for use in the control of head lice and pubic lice, however in some situations it is desirable to eliminate all lice present on groups of individuals in a short period. This involves the destruction of lice and eggs in garments by methyl bromide fumigation or steam sterilization. Since these methods provide no residual action, it is important to destroy any lice and eggs that remain on the hair of the individual.

The methods used in the application of the spray have been worked out by Army personnel, and the sprays have been applied to prisoners of war in

conjunction with the delousing process.

The prisoners are stripped, and while their clothing is being deloused, they are given the spray treatment. The spray is applied by means of a power sprayer with a paint spray nozzle, to the pubic and anal regions, under the armpits, and on other hairy portions of the body. The spray is also applied to the head for the control of head lice. While the spray is applied the individual being treated holds his fingers over his eyes to prevent the spray from getting into the eyes or on the eyelids. The treated individuals should not bathe, preferably for at least 24 hours after treatment or longer. The treatment will destroy lice and eggs present and the residue remaining will destroy any escaped lice for several days to a week after treatment. An average of about 20 cc. of spray is required for a thorough treatment in the manner described.

Control of Head Lice

The presence or suspected presence of head lice can be readily determined by the eggs or nits in the hair of the individual. Either of the two liquid formulas given on page 19 of this report is an effective treatment for control of the head louse, and the treatments are recommended as most desirable and effective. However, the louse powders are available to troops and since they may be the only treatment available, they are also recommended.

A. Use of Liquid Preparations.

The two liquid formulas are about equally effective and are applied in the same manner. The treatment can be applied as a spray as described under "g" of the Body Louse section of this report, or can be applied by the individual. The liquid is applied to the head, rubbing the hair while applying, so as to obtain an equal distribution. About 10 to 15 cc. is required for a thorough application, depending on the amount of hair present. The alcohol soon evaporates, leaving a residue similar to a hair oil application.

The treatment is effective in destroying within several hours all lice and eggs present on the head, however as a prophylactic measure it is recommended that the treatment be allowed to remain on the head until the hair would be normally washed. Either of the two treatments, if allowed to remain in the hair, will prevent infestations for 2 weeks or more. A number of head louse preparations are effective in destroying lice and eggs present on the head at the time of treatment, however, unless the material possesses residual action the subject is liable to reinfestation from lice in bedding, hat, clothing, or other personal effects. Since eggs may also be present in such situations, hatching lice from these eggs may also serve as a source of reinfestation for a week or more after treatment.

Troops mingling with infested natives can prevent infestation by

using the material as a hair oil, applying the treatment at intervals of about 2 weeks.

B. Use of Powders.

The two types of louse powder available to troops are applied in the same way. The powder is merely dusted in the hair, using the hand to distribute the powder. Since neither treatment can be depended upon to kill all of the eggs, at least one additional treatment should be made one week to 10 days later. The head should not be washed for at least 24 hours after each treatment, and preferably the powder should be allowed to remain in the hair as a prophylactic measure to prevent reinfestations.

The Crab Louse

Infestations of the crab or pubic louse are common among military personnel, as well as civilians. Although not known to be responsible for the transmission of diseases, crab lice may cause annoyance and dermatitis. The presence of crab lice on some individuals also exerts a demoralizing influence.

The same treatments recommended for the control of head lice can also be used effectively against the crab louse. In the treatment of crab louse infestations, it is highly important that the material be applied thoroughly. Since infestations are frequently very general over the entire body, especially on hairy individuals, any treatment should be applied not only to the pubic region and to the arm pits, but to the chest, back, legs, and other areas where coarse hair is present. It is a common occurrence to find lice and nits scattered on hair over the entire body. A few remaining lice or nits on untreated areas may serve to maintain the infestation, although it may take several weeks for the population to build up to the point where the infestation is again detected.

A. The use of Powders.

DDT louse powder can also be used to control crab louse infestations. As previously mentioned, the DDT powder has no ovicidal properties and a second treatment applied after 7 to 10 days is essential.

The powder should be sprinkled in the pubic and anal regions and under the arms. It should also be applied on all other areas where coarse hair is present. In hairy individuals the best policy is to apply the powder over the entire body from neck to foot. The powder should be distributed by rubbing the treated area so that it will sift down to the base of the hair where lice and eggs are attached. About 10 grams of powder will be required for the average infestation. The subject should be instructed not to bathe for 24 hours.

The powders have been used extensively at several army camps with excellent results. A powder treatment is ideal for the control of crab lice. It is easily applied, does not soil clothing, and causes no discomfort to the subject. Unfortunately no ovicide has been found that can

be relied upon to destroy all eggs when in powder form, and consequently a second application is necessary.

B. The Use of Liquid Preparations.

The two liquid preparations, SYLN or EEAY formulas, discussed in connection with the head louse treatment are effective in controlling the crab louse. One treatment with either of these two materials will generally control and infestation. The liquid should be applied to all infected regions of the body, which frequently means the entire body. Application can be made with a sponge or with a sprayer. As much as 30 cc. may be required for one application on hairy individuals. The treatment causes a rather intense burning sensation when applied to the scrotal region, which is due to the alcohol. The burning stops within a few minutes and causes no after effects.

Scabies

A limited amount of research has been done on treatments for scabies. The two liquid preparations used in connection with louse control contain 10 per cent benzyl benzoate, which has been found to be an effective scabicide by workers in England and other countries. This material also functions as a solvent for some of the other ingredients in the preparations, but is included in the formula purposely because of its scabidical properties. The presence of Benzocaine (which functions as an ovicide for lice and perhaps also for scabies) should (?) function as a local anesthetic to relieve itching.

The liquid should be applied over the entire body, paying particular attention to the infested areas. The material can be applied with a sponge or by means of a sprayer. One application will require about 50 cc. If a second treatment is necessary, it should be made 5 to 7 days after the first.