A Field Evaluation of Malathion Dust for the Control of Body Lice

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ABSTRACT

During the period January 9 through March 6, 1961, a field evaluation was conducted at a Republic of Korea Army prison farm near Seoul, Korea, to determine the efficacy and safety of 1% malathion dust used to control body lice (Pediculus humanus humanus L.). One ounce of dust applied either semimonthly by hand or monthly by power duster gave virtually 100% control, while monthly applications of the same dosage of 1% lindane powder gave poor control. The responsible to DDT but susceptible to lindane and malathion as determined by laboratory tests. Physical examination and weekly red blood cell cholinesterase determinations revealed no adverse effects from malathion dust used on 200 test subjects. The discrepancy between laboratory and field results as they apply to lindane is discussed.

Chlorinated hydrocarbons have been used extensively to control body lice (Pediculus humanus humanus L.) since World War II when 10% DDT dust was used to control a typhus epidemic in Naples, Italy (Simmons & Upholt 1951). DDT is still effective in some parts of the world but in many areas DDT-resistant strains of body lice are prevalent. DDT was found to be completely ineffective in controlling louse infestations of Korean military personnel during the Korean War (Hurlbut et al. 1952). Investigation at Koje Island, Korea, revealed that the lice collected from North Korean and Chinese prisoners and South Korean soldiers were resistant to 10% DDT and methochlor, but highly susceptible to lindane, dieldrin, aldrin, chlordane, toxaphene and pyrethrins (Eddy 1954). Consequently, 1% lindane powder was substituted for DDT, and satisfactory control was obtained. DDT resistance has been reported in many other areas of the world since that time (Brown 1958). One-per cent lindane powder is currently the insecticide of choice for use in areas where DDT resistance in the local louse population has been established.

In 1954, lindane-resistant body lice were discovered in Egypt (Hurlbut et al. 1954). Reports of BHC-resistant body lice in Sierra Leone, Iran, Japan, French West Africa, France, Norway, and Yugoslavia followed in subsequent years (Brown 1958). Reports of increasing resistance of body lice to chlorinated hydrocarbons in widely separated areas of the world led to the development of a louse powder containing an insecticide outside the family of chlorinated hydrocarbons. One-per cent malathion powder was shown to have low mammalian toxicity (Hayes et al. 1960) but high toxicity for lice under laboratory conditions (Cole & Burden 1956). In 1959, plans were made by the U. S. Army to perform a controlled field evaluation of the effectiveness of 1% malathion powder in controlling louse infestations and its safety to individuals being decontrolled and to those performing the decontrolling operations. The field evaluation was begun in January 1961, and was of 57 days' duration.

The site of the evaluation was a Republic of Korea Army prison farm about 14 miles southeast of Seoul, Korea. The prison inmates were housed in corrugated sheet-metal buildings with 1,500 square feet of floor space. Approximately 100 inmates were housed in each building. The buildings were heated by two tent stoves, but fuel was scarce and frequently no fires were lit during the day. The inmates slept on a raised platform of compact earth, each using two wool blankets as a mattress and two as a cover. Their clothing consisted of two-piece long underwear, fatigue clothing, and field coats. About 90% of the prisoners wore stockings but shoes were worn for outdoor activities only. None of the clothing was removed for sleeping. The prisoners were in average physical condition although some had diarrhea and approximately 10% to 20% were in moderately poor nutritional condition.

METHODS.—The test subjects were selected from the entire prison population of 657 inmates by choosing those who would be confined for the duration of the evaluation and who were not acutely ill. A few of those chosen were given administrative releases prior to the completion of the evaluation. The test subjects were divided into four groups of 100 each, which were designated by the letters, A, B, C and D. Each subject was assigned an identification number consisting of the group letter and a sequence number which was written on his forearm in indelible ink. The subjects in the four test groups were housed in four separate barracks so as to insure segregation of the groups as much as possible and thereby prevent transfer of insecticide from one group to another. This also resulted in the prevention of reinfestation of the treated groups by untreated groups, or from infested prisoners not included in the evaluation. Group A subjects were each dusted with 1 ounce of 1% malathion; application was by siever can on test days 1, 15, 29 and 46. Subjects in Groups B, C, and D were dusted on test days 1 and 29 by gasoline-engine-driven power dusters. Each subject received approximately 1 oz. of dust by this method. Group B received 1% malathion; group C, 1% lindane, and Group D, an inert powder.

Four months before commencement of the evaluation, lice were collected randomly from the subjects to determine susceptibility of the lice to various insecticides. The testing method used was that recommended by the

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Air Force Pest Control Board (1959), in which lice are exposed to filter papers impregnated with various concentrations of insecticides dissolved in acetone. After day 15 of the evaluation, lice were collected for susceptibility determinations to lindane both by the Armed Forces Pest Control Board method and by the World Health Organization (WHO) method utilizing a small (3" x 3") square of cloth treated with 1% lindane. Excess dust was removed by striking the cloth squares against a piece of 1-inch hardware cloth.

Each test subject was checked for louse infestation immediately prior to the initial dusting and at weekly intervals thereafter. The louse counts were made by six experienced persons. The underclothing of each subject was examined for 1 minute under bright illumination afforded by 150-watt electric lamps. The infestations were categorized as light, medium, and heavy using counts of 1-10, 11-100, and 100 plus, respectively. It was decided, however, to record each subject as either infested or not infested to minimize errors in counting procedures owing to replacement of counting personnel, fatigue, etc. Only those subjects who exhibited no lice after 1 minute of searching were considered lousefree. In order to determine possible ovicidal action, the presence or absence of viable eggs was also noted. The temperature in the building where counts were made varied from 38° F. to 51° F.

The prisoners in Group A removed all their clothing and applied the malathion powder to their underclothes, fatigues, and field coats, in that sequence. The head and cap of each prisoner were treated by dusting the cap, placing it on the head, and patting it gently to stir up the dust. The entire uniform of each test subject was patted vigorously after the prisoner dressed to assure maximum distribution of the powder. The excess powder was sprinkled over the blankets to cover all possible body louse habitats, although few lice were noted on the blankets prior to dusting. The dusting operation of this group was conducted in the building in which the test subjects were housed.

Groups B, C, and D were dusted outdoors by personnel experienced in applying louse powders with the power duster. The dusting personnel used the standard U. S. Army 16-position system (Department of the Army TMS-692, 1958). Respirators were not worn by these men but they took advantage of the wind to carry away the excess dust.

After the louse count was made on each subject, the subject dressed, warmed his hands to increase the peripheral blood circulation, and was bled by finger puncture before he left the building in which the counts were made. Blood was collected weekly in a 1.5 x 100-mm. capillary tube for RBC (red blood cell) cholinesterase determinations from each individual in test groups A, B, and D, as well as from the U. S. Army personnel involved in the test. Intoxication owing to organophosphorous compounds can be detected by a depression of the RBC cholinesterase level. A depression of 35% or more from the baseline cholinesterase level was considered indicative of possible intoxication. A microelectrometric technique (Stublos & Fales 1960) was used to make the erythrocyte cholinesterase determinations. A baseline for RBC cholinesterase activity was determined by taking the average of two samples from the same puncture prior to test-day 1.

Blood samples were collected prior to each dust treatment throughout the evaluation period.

In addition to weekly RBC cholinesterase determinations, the test subjects were examined 1 week after the initial dusting for other symptoms of organophosphorous intoxication, such as miosis, by a U. S. Army physician. Subsequently, all test subjects who complained of illness were observed by the Korean prison farm physician and those who had illness which might have resulted from the toxic effects of the insecticides were examined by the U. S. Army physician. Any of the test subjects, or other personnel engaged in the evaluation whose RBC cholinesterase levels were depressed 25% from their baseline, were examined by a U. S. Army physician even though they had no specific complaints.

Results.—The week following the initial dusting the louse infestations were reduced nearly 100% in groups A and B while the reduction in group C was only 61% (fig. 1). The louse infestation of group C was reduced 19% the week after dusting with inert powder, but the counts the following week showed an increase to within 5% of the pretreatment counts. From four to seven trusties were included in each test group at the outset, an arrangement which materially aided the handling of the groups. Without exception, however, the trusties had cleaner clothing, better sanitary facilities, and consequently fewer lice than the other members of the group. Seldom would a trusty have more than a light infestation, and in many cases, no lice at all.

Under the conditions of this test, a single treatment with 1% malathion dust applied by power duster was effective in controlling lice for at least 4 weeks. Hand dusting resulted in excellent control for 2 weeks, but was not tested for a longer period. In all cases of infestation noted in groups A and B, after the initial treatment, the number of lice present was no more than two, and upon being questioned, these subjects revealed they had washed or changed their clothing after the powder had been applied. The 1% lindane treatment gave little reduction in the louse population except the week following the initial application in spite of the fact that the laboratory sus-

![Graph showing weekly percentage of subjects infested with the body louse in a test with 1% malathion dust in Korea, January-March 1961.](https://example.com/graph.png)
ceptibility tests indicated that these lice were more susceptible to lindane than to malathion. The infestations in groups A and B were always of adult or late instar nymphs; while in group C all stages were present the week following the initial dusting and on subsequent weeks throughout the test.

A distinct ovicidal action was noted in the malathion-treated groups when counts were made on test-day 8. Clothing that had been heavily infested with viable eggs prior to a dust application had no live lice present, and the eggs present were all shrunken and dried. Microscopic examination revealed that the operculum had not opened on the eggs that were present. No lice emerged on two 0.95-inch-square patches of an undershirt, heavily infested with eggs, taken from a prisoner who had been dusted with 1% malathion 3 days before the sample was collected. The patches were examined daily for 14 days while maintained at 95° F. and approximately 45% relative humidity.

The laboratory susceptibility tests performed before commencement of the evaluation showed a high degree of susceptibility to low dilutions of lindane and malathion. The lice were found to be highly resistant to DDT. The LC₅₀ was determined to be approximately 0.002% lindane and 0.01% malathion and over 10% DDT. When 1% lindane failed to give satisfactory control by test day 15, lice were collected from group C and tested to determine a possible change in susceptibility. The results of this test compared favorably with those of the earlier tests. The insecticides used in the field evaluation were analyzed by infrared spectrophotometry at the U. S. Army Environmental Hygiene Agency to determine the actual content of active ingredient. The lindane samples contained 0.84% lindane, while the malathion samples contained 0.95% malathion.

To establish the biological potency of the actual lindane powder being used on subjects of group C and to obtain an explanation for the failure to control, the WHO method of susceptibility testing was employed. A series of twelve 3"x3" cloth patches hand-dusted with 0.5 mg. of the same 1% lindane dust used in the field test produced 100% mortality after 24 hours in the exposed lice. No significant mortality was noted on control patches dusted with inert powder. It should be pointed out that these were lice which had survived lindane treatment with the same powder.

No toxic effects were noted during the 57-day observation period among either the 200 test subjects who were dusted with 1% malathion powder or the U. S. Army personnel associated with the evaluation. Three individuals in group D experienced a 25% depression from their baseline RBC cholinesterase activity while receiving no direct exposure to organophosphorus insecticide. Three individuals in group B displayed a similar depression, yet no test subjects in group A, a group which was exposed to the maximum amount of malathion powder, showed a depression of 25% from their baseline. The cholinesterase activity level returned either to the baseline or above it the week following the depression in all cases. The subjects with lowered cholinesterase activity had no clinical signs or symptoms of organophosphorous poisoning when examined by a U. S. Army physician. No miosis was observed in the test population throughout the test. There were no cases of lowered cholinesterase activity in the U. S. Army personnel involved in the test even though respirators were not worn during the dusting operation.

**Discussion and Conclusions.**—One-per cent malathion is a safe, efficient insecticide for use against body lice. Under the conditions of this test, a monthly application of 1 ounce of 1% malathion was more effective than 1% lindane powder. Excellent control of body lice may be achieved by hand-dusting 1 ounce of 1% malathion powder over the underwear semimonthly. Malathion dust caused neither visible signs or symptoms of organophosphorus poisoning nor significant lowering of the erythrocyte cholinesterase activity when used under the conditions of this test.

The failure of 1% lindane to produce satisfactory control under the conditions of this test is difficult to explain. The louse population considered in this evaluation was found susceptible to lindane repeatedly by the standard laboratory methods. Four separate tests were conducted to ascertain the reliability of the test results. These tests substantiated themselves and furthermore were conducted by two of the authors (W. W. B. and B. F. E.) independently of each other. Paik (1960) tested lice from the Seoul area and determined an LC₅₀ of 0.0005% for lindane. In 1960 Field & Johnston (unpublished data) tested the susceptibility to lindane of a population of body lice from a mental institution in Seoul, Korea, during the winter of 1959–60. Their tests were conducted over a period of 4 months, and employed more than 500 individual lice at each dilution tested. They determined the LC₅₀ to be approximately 0.004% lindane. Results of all susceptibility tests done in conjunction with this evaluation, and the tests just cited are in accordance with results obtained at the U. S. Department of Agriculture Laboratory at Orlando, Florida, using a strain of Korean lice and a strain of susceptible lice (Armed Forces Pest Control Board 1969).

Although the lindane used assayed somewhat below the recommended 1% (0.84%), it is difficult to explain the failure to control on this basis alone. Cole et al. (1958) have shown by sleeve test that lindane dusting powder kills 99% of exposed lice 3 days after application, but only 55% 6 to 7 days after application. Perhaps further studies along these lines will yield an explanation of the discrepancy between laboratory and field results.

**References Cited**


Activation of Guthion by Tissue Preparations
From the American Cockroach

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ABSTRACT

Activation of Guthion® (0,0-dimethyl S-(4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl) phosphorodithioate) and degradation of its active metabolite and P(0)S Guthion by whole tissues and tissue homogenates of the adult, female American cockroach, Periplaneta americana (L.), were estimated manometrically by inhibition of house fly (Musca domestica L.) head cholinesterase. A Guthion-activating enzyme system is present in several tissues of the American cockroach. The most active whole tissues, in descending order, were: Malpighian tubules, fat body, heart, nerve cord, ovaries and cases. The fat body probably has the greatest capacity for anticholinesterase production per insect. Because P(0)S Guthion and the active metabolite of Guthion were degraded by tissue homogenates, the activation of Guthion by tissue homogenates was studied by blocking degradation of the active metabolite with 0.01M sodium fluoride. Under these conditions, homogenates of the midgut and caecae were most active, followed by Malpighian tubules, fat body, foregut, and hindgut. Activation with homogenates required oxygen and NADPH₂ or other nicotinamide nucleotides as cofactors.

When organophosphates are converted to potent anticholinesterases in mammals, the liver is the most active site for the process (Dubois et al. 1950, March et al. 1955, O'Brien 1956, Murphy & Dubois 1958). In insects, the fat body possesses some of the properties of mammalian liver (Kilby & Neville 1957, Candy & Kilby 1959, 1961, Trivelloni 1960). However, no single organ or tissue is distinctly responsible for the metabolism of insecticides. For example, tissues of the American cockroach, Periplaneta americana (L.), that are most effective, on a weight basis, in activating organophosphates vary with the substrates: Malpighian tubules for methylparathion (Metcalfe & March 1958, the original report that the foregut was the most active tissue has been corrected by March 1961), gastric caeca for schradan (Casida et al. 1954), and fat body for parathion (Kok & Walop 1954). These reports of anticholinesterase production by whole tissues do not distinguish between the effects of activating and degrading enzymes within the tissues.

Activation of organophosphates by cell-free preparations of insect tissue has been reported in two cases. O'Brien (1957) could restore slightly the capacity of a cockroach gut homogenate to activate malathion by adding NAD₃ nicotinamide, and magnesium. Fenwick (1958) reported that homogenates of locust fat body activated schradan without exogenous cofactors and that a particulate fraction required NADPH₂ as the cofactor for activation. The present investigation is concerned with the activation of Guthion by whole tissues and tissue homogenates of adult female American cockroaches.

MATERIALS AND METHODS.—Highly purified samples of Guthion® (0,0-dimethyl S-(4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl) phosphorodithioate) (m. p. 73–74° C.) and P(0)S Guthion, O,O-dimethyl S-(4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl) phosphorothiolate, (m. p. 69–73° C.) were obtained from the Chemagro Corporation, Kansas City, Missouri. Stock solutions were prepared by dissolving each chemical in absolute ethanol containing 1% (w/v) of Triton X-100, obtained from the Rohm & Haas Company, Philadelphia, Pennsylvania. The concentrations of the stock solutions were 10⁻²M for Guthion and 3×10⁻⁶M for P(0)S Guthion. Aqueous dilutions of these solutions were used for the experiments described below. NADPH₂ was type II, obtained from the Sigma Chemical Company, St. Louis, Missouri. NADH₃, NAD and NADP were obtained from the Pabst Laboratories, Milwaukee, Wisconsin.

The anticholinesterase assay was carried out manometrically at 37° C. in an atmosphere of 5% carbon dioxide and 95% nitrogen. Readings over a 1-hour period were used to calculate per cent inhibition of cholinesterase after correction for blanks. The Warburg flask contents were as follows: 0.3 ml. of the sample to be assayed, 1 ml. of fly head homogenate and 1.2 ml. of bicarbonate Ringer solution in the main compartment, and 0.5 ml. of 0.1M acetylcholine iodide in the side arm. The cholinesterase preparation was made by homogenizing heads of house flies, Musca domestica L., in 0.25M sucrose solution in the proportion of three heads per ml., filtering the homogenate through a cotton plug and centrifuging it at approximately 3,000×g (gravity) for 10 minutes. The supernatant fluid...