TOXICOLOGICAL AND ENTOMOLOGICAL FIELD EVALUATION[1] OF THE EFFECTS OF MOBAM®[2,3] POWDER AGAINST BODY LICE (ANOPLURA: PEDICULIDAE)

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Abstract: Human volunteers were exposed, under medical surveillance, to 34 g of a 3% formulation consisting of 3% Mobam® (4-benzothienyl-N-methylcarbamate) in pyrax powder (w/w) to evaluate the formulation's potential value as a louse toxicant. The test was conducted at the Republic of Korea's Army Disciplinary Center, at Kwang Ju, near Seoul, Korea from January to March 1969. The test participants were divided into 3 groups of 100 men each and dusted once in the following manner: the control group was dusted with an average of 17 g pyrax powder; the test group was treated with an average of 31 g of the test formulation; and a third positive control group was dusted with an average of 20 g of 1% malathion in inert powder. Applications of Mobam® dust using a power-dusting apparatus gave 4 weeks of nearly 100% protection, with apparently no greater degree of hazard than 1% malathion, which provided about 94% control. Lice removed from prisoners' clothing were not resistant in laboratory tests to low concentrations of Mobam® or malathion. Other lice from the same source were shown to be slightly resistant to lindane.

The effectiveness of louse control through the use of insecticides was dramatically illustrated in Naples, Italy late in 1943 when 10% DDT powder applied at the rate of 28 g per person completely controlled the body louse infestation of the population and halted an incipient typhus epidemic (Simmons & Upholt 1951). Spectacular control was obtained throughout the world in ensuing years by this new insecticide.

In the winter of 1950–1951, it was reported that the use of 10% DDT powder on Korean military personnel failed to provide satisfactory control of body lice (Hurlbut et al. 1952). Upon further investigation at a detention camp on Koje Island, Korea in 1951 it was observed that the lice collected from prisoners were resistant to 10% DDT and methoxychlor, but highly susceptible to lindane, dieldrin, aldrin, chlordane, toxaphene, and pyrethrins (Eddy 1952). Subsequent investigations in other parts of the world demonstrated a growing list of areas where body lice had become resistant to DDT, in some cases in as short a period as one year after its initial use.

In 1952 the U. S. Army began using 1% lindane to control body lice in Korea, obtaining excellent results. One percent lindane is currently the insecticide used in areas where DDT resistance in the local louse population has been established.

In 1954 lindane resistance in body lice was reported in Egypt (Hurlbut et al. 1954). Reports of resistance in Sierra Leone, Iran, Japan, French West Africa, France, Norway, and Yugoslavia followed in subsequent years (Brown 1958). The alarming fact that body lice in widely separated areas of the world were becoming resistant to both of these insecticides stimulated research to find a new insecticide for use against DDT and lindane-resistant lice. Malathion dust was selected for an extensive field test in Korea because of its low mammalian toxicity (Bruaux 1957, Hayes et al. 1960) and high toxicity for lice under laboratory conditions (Cole & Burden 1956, Cole et al. 1958).

Investigators (Barnes et al. 1962) conducting a field test in Korea during 1961 reported that the use of 1% malathion provided virtually 100% control when applied at 28 g per man on a semimonthly or monthly schedule. It was further stated by these investigators that monthly applications of 1% lindane at the same dose rate gave poor control.

To date, malathion resistance in body lice has not been reported in natural body lice populations. In addition 3 strains of lice from widely separate parts of the world, namely Africa, Korea, and the United States, failed to develop resistance under intensive selection in the laboratory (Cole, Clark & Weidhaas 1969). Nevertheless, malathion has not been completely aesthetically acceptable to military personnel due to its undesirable odor.

The possible use of several newer insecticides as lousicides for human lice was reported by Cole,

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[1]The Armed Forces Pest Control Board of the Department of Defense, directed the U.S. Army Environmental Hygiene Agency (USAEHA) to develop a protocol for and conduct a field study of Mobam® as a candidate louse toxicant in the winter of 1969.

[2]Mention of a proprietary product does not constitute indorsement by the USDA or the Department of Defense, but is used to assist in identification of a specific compound.

[3]Registered trade name of the Mobil Chemical Company, N.Y.

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Hirst, McWilliams & Gilbert (1969). Mobam®, MC-A-600, and ENT-27041 are the various designations for the single material 4-benzothienyl-N-methylcarbamate which has shown promise as a lousicide in laboratory and limited-use tests and was selected for further testing.

In 1968 under the provision of an agreement between the Department of Defense and the Department of Agriculture, U.S. Army Environmental Hygiene Agency (USAEHA) toxicologically evaluated 2 and 5% formulations of Mobam® in pyrax powder for their potential use as field lousicides. It was recommended (Steinberg et al. 1968) that either a 2 or 5% formulation in pyrax could be field tested.

This paper presents the results of field tests using a powder containing 5% of Mobam® against a natural louse population in the Republic of Korea. The test subjects were inmates of the Republic of Korea Army (ROKA) Disciplinary Center located at Kwang Ju near Seoul. This was the same location where previous tests were conducted with malathion (Barnes et al. 1962).

PROCEDURE

Three hundred inmates volunteered to participate in the test which lasted from January through March 1969. They were divided into 3 groups of 100 men each. Each group was further subdivided for administrative reasons into 2 units of 50 each. Each unit of 50 men was separated throughout the entire test from every other unit. All test participants were certified by the senior ROKA medical officer of the Disciplinary Center to be in good physical condition and were medically approved for test participation. The participants were randomly numbered and were not told that there was a difference in the treatments they received.

Three separate rosters were maintained. The first roster of 100 people was designated roster A or pyrax control group. The participants in each group were dusted once. Each man was dusted clothed, in a standing position, with an average of 17 g of untreated pyrax powder using a standard Army power duster. The second roster of 100 people was designated roster B and constituted the group which was dusted with an average of 34 g of 5% Mobam® in pyrax powder per man. The third group (roster C) of 100 people was dusted with an average of 20 g of 1% malathion in inert powder per man. The bedding materials used by the 300 test participants were not dusted. The difference in the amount of powder delivered to each group was unintentional and was a function of the physical characteristics of the powders and the method of application.

Two one-minute counts, one on each of 2 underwear garments (shirt and shorts) were made of all adult and nymphal lice, immediately before treatment and at weekly intervals for 4 weeks after treatment. Counts were recorded as number of nymphs and adults on the underclothes.

The susceptibility of the natural louse population to DDT, lindane, malathion, and Mobam® was determined by the filter paper method (Armed Forces Pest Control Board 1968).

Certain pre-selected clinical chemistry studies were performed at intervals prior to and after dusting. These chemistry studies involved the scheduled collection of venous blood from randomly-selected test participants, as described later in this report. Specimens for definitive clinical chemistry determinations consisting of blood urea nitrogen, alkaline phosphatase, lactic acid dehydrogenase, serum glutamic oxaloacetic transaminase, serum cholinesterase, and red blood cell cholinesterase were returned to the continental United States, where technicians accomplished the determinations using "blind" techniques. These determinations were not conducted on all test participants but only involved 15 men from Group A, 30 from Group B, and 15 from Group C. Blood collections were made 14, 7, and 1 day before treatment and 1, 3, 7 and 28 days after treatment.

In addition to the definitive studies, a "screen" of whole blood cholinesterase activity, using blood obtained from a fingerstick, was performed on site on all test participants using the same collection schedule. A commercially available kit (Unipette Disposable Cholinesterase Kit[9]) was used for this purpose.

All statistical evaluations of post treatment clinical chemistry results were made against pre-exposure values within the individual groups (A, B, or C), as well as pre-exposure values of 3 groups combined (A + B + C). An additional evaluation of the 2 groups exposed to insecticides (B and C) was made on a daily basis against the control group (A) to insure that any changes found were not due to specific conditions existing that day, such as: weather, specimen collection, handling and laboratory analysis. Chemistry results in this study are expressed as the mean, plus or minus one standard deviation. Significance of any change was determined using Student's "t" test and $p. \leqslant 05$.

[9]Registered trade name of Becton Dickinson and Company, Rutherford, N.J.

TABLE 1. Summary of red blood cell and serum cholinesterase activity data, reported in Garry & Routh (1956) Units.

Determination	Pretreatment Control Group A	Pretreatment Mobam® Group B	Pretreatment Malathion Group C	Post treatment Control Group A	Post treatment Mobam® Group B	Post treatment Malathion Group C
Serum Cholinesterase	17.0± 3.2	17.0± 2.4	15.2± 2.5	16.7± 3.9	15.8±2.5	13.9±2.0
Red Blood Cell Cholinesterase	42.9±15.1	46.5±17.2	41.8±14.5	41.2±11.1	41.2±9.8	43.2±8.2

RESULTS

It was found, when evaluating the Unipette Disposable Cholinesterase Kit® prior to use in Korea, that the whole blood cholinesterase activity results erred to the high side; that is, personnel having an activity of 85% as measured by using the method of Garry & Routh (1965) showed activity of 100% using the commercial screening kit. Subsequent investigation indicated that the acetylcholine substrate supplied by the manufacturer contributed to errors in excess of 15%. Therefore, a purer acetylcholine chloride substrate was provided by the Toxicology Division, USAEHA for use in the study. Based upon an evaluation performed on Toxicology Division personnel, it was determined that the test would be suitable for its intended purpose of "screening" to determine changes in whole blood cholinesterase activity that might reflect physiological changes.

During the course of the test exposure period no test participants evidenced any symptoms which were attributed by the attending ROKA physician to the treatments. The "screening" evaluation of whole blood cholinesterase activity indicated no physiologically significant depression of cholinesterase activity before or after treatment. Evaluation of lactic acid dehydrogenase, serum glutamic oxaloacetic transaminase (SGOT), and alkaline phosphatase results indicated that the treatment produced no changes in liver function as measured by these tests. The SGOT test results also indicated no damage to skeletal muscle or myocardium. Blood urea nitrogen results indicated that no changes in kidney function occurred. There were no physiologically significant changes in red blood cell cholinesterase in any of the groups.

Serum cholinesterase results in Groups A and B were not remarkable either before or after treatment. Post treatment serum cholinesterase results in the malathion treated group (Group C), though

TABLE 2. Total number of lice counted on test groups in 2 minutes with percent protection afforded by treatments expressed in terms of lice per man.

Treatment group*	Pretreatment	Post treatment 7 Days	14 Days	21 Days	28 Days
Control (Group A)					
Total Lice	1821	1367	1678	1223	1747
Number of men infested	96	96	97	98	100
Post treatment lice / Pretreatment count per man / lice per man infested	19.0**	14.2	17.5	12.7	18.2
Percent Protection***		25.3	7.9	33.2	4.2
Mobam® (Group B)					
Total Lice	1060	5	0	5	24
Number of men infested	85	3	0	1	13
Post treatment lice / Pretreatment count per man / lice per man infested	12.5**	0.1	0.0	0.1	0.3
Percent protection***		99.2	100.0	99.2	97.6
Malathion (Group C)					
Total Lice	1192	25	57	21	83
Number of men infested	82	13	15	13	37
Post treatment lice / Pretreatment count per man / lice per man infested	14.5**	0.1	0.7	0.3	1.0
Percent protection***		99.4	95.2	97.9	93.0

*100 men/group.

**Number of lice (adults and nymphs) per infested man for the group, before treatment.

***Percent control = $100 - 100 \frac{\text{Number of lice after treatment/infested man}}{\text{Number of lice before treatment/infested man}}$

within normal limits, were significantly lower than pretreatment values and post treatment control group values. Summarized cholinesterase activity data are found in TABLE 1. There were no reports of skin irritation from the test participants and the attending physician found none caused by the materials which were applied.

The relative numbers of lice per individual (0-117) noted at the onset of the test were not great. Disciplinary Center officials stated that all of the inmates had been dusted 2 months earlier with a powder made from formulations of 1% malathion and 1% lindane. The prisoners were requested not to wash their underwear during the test, but some disregarded this. TABLE 2 indicates the total number of adult and nymphal lice per test group on specific days in relation to the day and type of dusting procedure. It would appear from a brief examination of these data that a higher degree of control was afforded by Mobam® than malathion. This may not be so when one considers the amounts of insecticide delivered to the individuals by the duster, since on the average more Mobam® than malathion was delivered.

In the final calculations for effectiveness of the powders, adults and nymphs were combined. It was noted that in some instances several stages of lice were present on both garments.

The results of susceptibility tests performed using malathion, Mobam®, lindane, and untreated controls at various concentrations are shown in TABLE 3. DDT was used as a standard.

TABLE 3. Susceptibility of a natural population of body lice in Korea to 4 insecticides (3 to 11 replications, 20 lice/test at each concentration).

Insecticide	Percent concentration insecticide	Average percent mortality
DDT	1.0	92
	0.1	72
	0.05	54
Lindane	0.1	100
	0.05	100
	0.005	54
	0.001	49
Malathion	0.05	100
	0.025	78
	0.02	65
	0.015	43
Mobam®	0.1	100
	0.075	100
Untreated Control	0.0	6

Comparisons were made between the susceptibility of the wild Korean lice (R) and laboratory colonies (S) to selected insecticides. The comparative LC_{50}'s and LC_{90}'s and the ratio of R to S were as follows:

Insecticide	LC-	Wild Korean (R)	Laboratory Colony (S)	Ratio R to S
DDT	50	0.0293	0.0157	1.86
	90	0.7220	0.2397	3.01
Lindane	50	0.0012	0.0025	1.68
	90	0.0152	0.0047	3.23
Malathion	50	0.0139	0.0419	0.33
	90	0.0511	0.0112	1.16

The figures for DDT and lindane against the laboratory colony are according to the Armed Forces Pest Control Board (1968), and those for malathion are from more recent unpublished data (Cole). The ratio of R to S indicate that the natural wild Korean lice showed about a 2-fold resistance to DDT and lindane when compared to the laboratory lice. However, they appeared to be slightly more susceptible to malathion at the LC_{50} level than the laboratory colony and about equal in susceptibility at the LC_{90} level. Due to the difficulty of obtaining wild lice for tests, no comparisons of LC_{50}'s and LC_{90}'s were performed using Mobam® and only enough tests were conducted with Mobam® to establish that the wild Korean lice were susceptible to it. The results showed that the wild strain is as susceptible to Mobam® as the laboratory colony.

CONCLUSIONS

The formulation of 5% Mobam® in pyrax powder did not appear to be absorbed through the intact skin of man when an average of 34 g were applied per man for 28 days, and cholinesterase activity (RBC or serum) was used as an index of absorption. There were no physiologically significant differences as measured by the selected clinical chemistry determinations between subjects dusted with an average of 34 g of 5% Mobam® or an average of 17 g of pyrax powder. The decrease in serum cholinesterase activity noted in those dusted with the formulation of 1% malathion was not reflected by any symptoms and the values were within the normal activity range. However, the difference between pre and post treatment serum cholinesterase was significant at the $p < .05$ level.

It has been shown under field conditions that 5% Mobam® is an efficient insecticide for controlling human body lice. Four weeks of protection were provided by application of an average of 34 g of dust per person. Susceptibility tests of Korean lice indicate no resistance to malathion or Mobam® was present during the test period. Evaluation of the data obtained by applying 5% Mobam® in pyrax powder to humans indicates that there

are no medical contraindications to the single application of 28 g of the 5% formulation for 28 days. Some data collected suggest that malathion may be absorbed through the intact skin. It is planned to reexamine this possibility in the winter of 1970.

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BIBLIOGRAPHY

Armed Forces Pest Control Board. 1968. Methods for determining susceptibility or resistance of insects to insecticides. *Tech. Info. Mem.* **3:** 40.

Barnes, W. W., B. F. Eldridge, J. H. Greenburg & S. Vivona. 1962. A field evaluation of malathion dust for the control of body lice. *J. Econ. Ent.* **55**(5): 591–91.

Brown, A. W. A. 1958. The insecticide-resistance problem, a review of developments in 1956 and 1957. *Bull. Wld Hlth Org.* **18**(3): 309-21.

Bruaux, P. 1957. Toxicity of malathion to rats. *Ann. Soc. Belge Med. Trop.* **37:** 789.

Cole, M. M. & G. A. Burden. 1956. Phosphorus compounds as ovicides and adulticides against body lice. *J. Econ. Ent.* **49**(6): 747–50.

Cole, M. M., P. H. Clark & D. E. Weidhaas. 1958. Sleeve tests with malathion powders against DDT-resistant body lice. *J. Econ. Ent.* **51**(5): 741–42.

1969. Failure of laboratory colonies of body lice to develop resistance to malathion. *J. Econ. Ent.* **62**(3): 568–70.

Cole, M. M., J. M. Hirst, J. G. McWilliams & I. H. Gilbert. 1969. Sleeve tests of insecticidal powders for control of body lice. *J. Econ. Ent.* **62**(1): 198–200.

Eddy, G. W. 1952. The effectiveness of certain insecticides against DDT-resistant body lice in Korea. *J. Econ. Ent.* **45:** 1043.

Garry, R. V. & J. I. Routh. 1965. A micro method for serum cholinesterase. *Clinical Chem.* **11:** 91.

Hayes, W. J., A. M. Mattson, J. G. Short & R. F. Witter. 1960. Safety of malathion dusting powder for louse control. *Bull. Wld Hlth Org.* **22:** 503–14.

Hurlbut, H. S., R. M. Altman & C. Nibley, Jr. 1952. DDT-resistance in Korean body lice. *Science* **115**(2975): 11–12.

Hurlbut, H. S., R. L. Peffy & A. A. Salah. 1954. DDT-resistance in Egyptian body lice. *Amer. J. Trop. Med. Hyg.* **3**(5): 922–29.

Simmons, S. W. & W. M. Upholt. 1951. Disease control with insecticides, a review of the literature. *Bull. Wld Hlth Org.* **3:** 535–56.

Steinberg, M., M. Weeks, R. Boldt & R. A. Renne. 1968. Preliminary assessment of relative toxicity of ENT-27041 (4-benzothienyl-N-methylcarbamate) Part II, evaluation of data from animal and human exposures with recommendations regarding field test program: Project No. 33-27-67/69, USAEHA Report, Defense Documentation Center No. AD-845601L.

Steinberg, M. & J. T. Whitlaw. 1969. Toxicological and entomological special studies of human exposure to 5 percent ENT-27041 (4-benzothienyl-N-methylcarbamate) Mobam® in pyrax powder. Phase III, Evaluations of findings from volunteer use of louse toxicant with recommendations for standardization. Study No. 99-009-69/70, USAEHA report, Defense Documentation Center No. AD-859410L.