TOXICOLOGICAL AND ENTOMOLOGICAL FIELD EVALUATION[1] OF MOBAM®[2,3] AND ABATE®[2,4] POWDERS USED AS BODY LOUSE TOXICANTS (ANOPLURA: PEDICULIDAE)

By **M. Steinberg[5], M. M. Cole, T. A. Miller[6] and R. A. Godke[7]**

Abstract: Field tests were conducted at The Republic of Korea's Army Disciplinary Center, located at Pusan, from January to March 1970, to evaluate the louse toxicant properties of Mobam® (4-benzothienyl-N-methyl carbamate) and Abate® (0,0-dimethyl phosphorothioate 0,0 diester with 4,4′ thiodiphenol). Four hundred volunteers were divided into 4 groups of 100 men each, and the groups were subdivided into 2 units of 50 men. The test subjects in 1 unit of each group were treated with 56.7 g of appropriate material contained in plastic shaker-top cans while test subjects in the other unit were treated using a power dekuser which delivered an average of 33.9 g per man. The four 100-man groups received single applications, respectively, of formulations of 2% Mobam in pyrax powder, or 2% Abate in pyrax powder, or 1% malathion in inert powder, or unformulated pyrax powder. Serum and whole blood cholinesterase as well as other clinical chemistry determinations were performed on the units treated with Abate, malathion, and untreated pyrax dispensed from shaker cans. Each of the formulated insecticides tested, whether dispensed from shaker cans or power dekuser, gave 25 days protection. Reductions in louse populations averaged 98.2% for Mobam, 91.9% for Abate, and 92.6% for malathion. Lice removed from volunteers' clothing were susceptible in laboratory tests to Mobam, Abate, and malathion, but were resistant to DDT and slightly tolerant to lindane. Evaluation of clinical chemistry data indicated no physiological abnormalities attributable to the Abate or malathion treatments.

The effectiveness of louse control through the use of insecticides, and the subsequent development of resistance to many of the materials used, has been extensively reviewed (Steinberg et al. 1971). Malathion [S-(1,2-bis (ethoxycarbonyl) ethyl) 0,0-dimethyl phosphorodithioate], formulated as 1% active ingredient in inert dust, is a standard military item[9] used to control body lice. To date, malathion resistance has not been reported in natural body lice populations, and intensive laboratory selection of body lice strains from Africa, Korea, and the United States has failed to develop resistance (Cole et al. 1969b). Nevertheless, malathion has not been completely aesthetically acceptable to military personnel due to its undesirable odor. Under provisions of an agreement between the Department of Defense and the Department of Agriculture, the U. S. Army Environmental Hygiene Agency (USAEHA) toxicologically evaluated 2% and 5% formulations of Mobam® (4-benzothienyl-N-methylcarbamate) in pyrax powder (Steinberg et al. 1968) and recommended that either of the formulations could be field tested as louse toxicants. The 5% formulation was field tested in the Republic of Korea in 1969 (Steinberg et al. 1971). Results showed that a single application of 5% Mobam® provided 4 weeks of nearly 100% control of louse populations with no apparent physiologic abnormalities in human test subjects. Based on the effectiveness of the 5% formulation, it was decided to conduct a similar field test using a formulation of 2% Mobam® in pyrax powder. The decision to evaluate a second candidate material, a formulation of 2% Abate (0,0-dimethyl phosphorothioate 0,0 diester with 4,4′ thiodiphenol) in pyrax powder, was based on comprehensive tests reported by Cole et al. (1969a) and Steinberg et al. (1970).

This paper presents results of field tests using pyrax formulations of 2% Mobam and 2% Abate against a natural louse population in the Republic of Korea in 1970.

MATERIALS AND METHODS

Four-hundred inmates at the Republic of Korea's Army (ROKA) Disciplinary Center, located in Pusan, volunteered to participate in the test conducted from 30 January to 7 March 1970. The inmates were divided into 4 groups of 100 men each. Each group was subdivided into 2 units of 50 men to compare treatment with material

[1]The Armed Forces Pest Control Board of the Department of Defense directed the U. S. Army Environmental Hygiene Agency (USAEHA) to conduct a field evaluation of Mobam® and Abate® as candidate louse toxicants.

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

[3]Registered trade name of the Mobil Chemical Company, Richmond, Virginia 23208, U.S.A.

[4]Registered trade name of the American Cyanamid Company, Princeton, New Jersey 08540, U.S.A.

[5]Lieutenant Colonel, MSC, Toxicology Division, USAEHA, Edgewood Arsenal, Maryland 21010, U.S.A.

[6]Entomology Research Division, ARS, USDA, Gainesville, Florida 32601, U.S.A.

[7]Captain, MSC, Entomology Division, USAEHA, Edgewood Arsenal, Maryland 21010, U.S.A.

[8]Formerly Captain, MSC, Toxicology Division, USAEHA, Edgewood Arsenal, Maryland 21010, U.S.A. Presently at University of Missouri, Columbia, Missouri, U.S.A.

[9]Insecticide, Malathion, 1% Dust, FSN 6840-823-7945

dispensed from shaker-top cans and from a standard U. S. Army power delouser.[10] These 2 methods of application were compared, since they are most likely to be used under field conditions.

All test participants were segregated from the rest of the Disciplinary Center population during the test, and were medically approved for participation in the test by the senior ROKA medical officer at the Disciplinary Center. The 4 test groups were treated, respectively, with formulations of 2% Mobam in pyrax powder, 2% Abate in pyrax powder, 1% malathion in inert powder, or untreated pyrax powder. Test subjects treated with material dispensed from shaker cans (Shaker Can Units) were dusted 50 men at a time in their barracks, under strict supervision, using shaker cans containing preweighed amounts (56.7 g) of appropriate material. All clothing was removed and thoroughly dusted by each individual. Most of the material was applied to clothing, but some was applied to individual bedding. Test subjects treated with material dispensed from power delousers (Power Delouser Units) were dusted fully clothed outside their barracks. The clothing on each individual was treated at 16 standard points (Department of the Army Technical Manual 1965), exclusive of the hat and head. Each dusting point was given an estimated 3-second burst from the dust gun. Bedding was not dusted. To determine the average amount of dust per man for the power delouser units, the total amount of bulk insecticide or pyrax powder on hand for delousing was weighed before and at the completion of dusting. The differences in weight constituted the total amount used and allowed for the calculation of the average dose per man. Test subjects treated with material dispensed from shaker cans were considered to have received a 56.7-g dose per man.

Louse populations were monitored 1 day pretreatment and 8, 15, 20 and 25 days post treatment. The number of lice on upper and lower undergarments (shirt/pants) of the test subjects was counted for 1 min. each, after which the number of adult and nymphal lice was recorded. Nits were not counted but their presence was recorded. The percentage reduction in louse populations was determined for each test group on each post treatment date. Data were subjected to analysis of variance, and the statistical significance of differences in percentage reduction was determined by calculating a least significant difference at the .01 level of probability.

The susceptibility of the natural louse population to Mobam, Abate, malathion, lindane, and DDT was determined by the filter paper method (Armed Forces Pest Control Board 1968) using lice collected from inmates other than those in the 4 test groups.

Venous blood samples were collected from certain selected test subjects in the shaker can units on 10, 6, and 1 day pretreatment and 1, 3, 7, 14, and 24 days post treatment. Venous blood was collected only from shaker can units, since these volunteers received a known dose per man rather than an average dose as in the case of the units dusted with power delousers. All serum specimens were returned to USAEHA for determination of blood urea nitrogen (BUN), lactic acid dehydrogenase (LDH), serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), and serum cholinesterase (ChE). These determinations were conducted on venous blood samples from 30 test subjects in the Abate shaker can unit, 15 from the malathion shaker can unit, and 15 from the untreated pyrax shaker can unit. Since no evidence of toxicologic effects was noted when testing the formulation containing 5% Mobam (Steinberg et al. 1971), it was felt that there was no need for further toxicologic evaluation of Mobam with the exception of whole blood ChE activity.

In vitro laboratory tests conducted prior to the field test indicated that any ChE inhibition caused by either Mobam or Abate could be evaluated with equal sensitivity by measuring either serum or erythrocyte ChE activity. Furthermore, liver homogenate studies indicated the same to be true of the metabolites of these 2 insecticides. Indications were that a ChE-inhibiting dose of either insecticide significantly inhibited serum ChE activity before the erythrocyte ChE activity was similarly affected. In addition to the clinical chemistry determinations, a "screen" of whole blood ChE using blood obtained from a fingerstick was performed at the test site on all test subjects 6 days pretreatment and 1, 3, 7, 14, and 24 days post treatment. A commercially available kit[11] for screening whole blood ChE was utilized.

The 4 test groups were characterized by determining average height (cm), average weight (kg), average age (yrs), and average hematocrit (% volume) on the last post treatment day.

Post treatment clinical chemistry results for

[10]Duster, Insecticide, Mass Delousing, FSN 4230-078-5455

[11]BD Unopette Cholinesterase Kits, Becton-Dickenson Company.

TABLE 1. Comparative susceptibilities* of wild Korean (R) and laboratory (S) body lice to insecticides.

Insecticide	Lethal concentration	Wild Korean (R)	Laboratory (S)	R:S**
DDT	50	0.0155	0.0157	2.90
	90	1.3980	.2397	7.92
lindane	50	.0055	.0025	2.20
	90	.0119	.0047	2.53
malathion	50	.0120	.0230	.78
	90	.0369	.0295	1.25
Mobam	50	.0034	.0111	.31
	90	.0106	.0263	.40
Abate	50	.0691	.2640	.26
	90	.8097	.6220	1.30

*In terms of percentage concentrations.
**R—Field-collected at Pusan, Korea. 1970. S= Gainesville standard colony. F_{51} generation.

groups exposed to Abate, malathion, and untreated pyrax were compared to pretreatment values. Additionally, values for groups exposed to Abate and malathion were compared on a daily basis to the pyrax treated units values to insure that any changes found were not due to non-test related conditions such as weather, specimen collection, handling and laboratory analysis. Commercially available standards and controls were used in the clinical chemistry laboratory studies conducted at USAEHA. Results of the clinical chemistry studies were expressed as mean, plus or minus 1 standard deviation. Statistical evaluation of clinical chemistry and physiologic data were conducted using the Student's "t" test with p at the .01 level.

RESULTS AND DISCUSSION

The susceptibility of wild Korean (R) and Laboratory (L) lice to DDT, lindane, malathion, Abate, and Mobam is shown in TABLE 1. The wild strain showed a 3–8 fold resistance to DDT and an approximate 2-fold resistance to lindane when compared to the laboratory strain. The wild strain was more susceptible than the laboratory strain to malathion and Abate at the LC-50 level and about equal at the LC-90 level. The wild strain was more susceptible to Mobam at both levels.

As mentioned earlier, test subjects in the shaker can units were issued, and considered to have received, 56.7 g of appropriate formulation. Based on calculations of the total amount of formulation dispensed, the test subjects treated by the power delousers received an average dose of 31.1 g of the Mobam and Abate formulations, and 36.8 g of the malathion and untreated pyrax formulations.

All insecticide formulations were effective in reducing louse populations on the test participants (TABLE 2). The single applications of Mobam, Abate, or malathion gave the same approximate levels of control for 25 days. Dispensing of materials from shaker cans or power delousers did not influence control effectiveness. Average percentage control for 25 days, regardless of means of application, was 98.2% for the Mobam formulation, 91.9% for the Abate formulation, and 92.6% for the malathion formulation.

No significant differences were noted between any of the groups in evaluating heights, weights, ages or hematocrit values. Hematocrits measured in this study were found to be similar to those of the population tested in 1969 (Steinberg et al. 1971).

The commercial whole blood ChE screening kits were checked for accuracy by Toxicology Division, USAEHA, prior to use in Korea. The suitability of these kits was established in laboratory studies and reaffirmed by the data collected from their use during field tests in Korea in 1969 (Steinberg et al. 1971).

During the test the attending physician found no test subjects who manifested symptoms which could be attributed to the treatments. There were no reports of skin irritation from the test

TABLE 2. Percentage control of adult and nymphal body lice on subjects treated with insecticides.

Treatment	Means of application	% Control* on post treatment day 8	15	20	25	Average**
2% Abate	Can	97.5	88.0	99.2	89.7	93.6
	Power	97.0	97.5	97.2	93.6	96.3
2% Mobam	Can	99.5	91.8	99.0	100.0	97.5
	Power	99.1	98.7	99.5	98.9	99.0
1% malathion	Can	97.4	95.0	89.6	86.7	92.1
	Power	93.0	86.3	94.8	98.6	93.1

*Percentage control = $\frac{A-C}{A} + \frac{B-C}{B} \times \frac{100}{2}$, where: A = Average number of pretreatment lice, B = Average number of post treatment lice on controls, and C = Average number of post treatment lice on treatments.
**Averages do not differ significantly at .01 level of probability.

TABLE 3. Summary of average pretreatment and post treatment BUN, LDH, SGOT, and SGPT for test participants dusted with Abate, malathion, and untreated pyrax powder dispensed from shaker-top cans.

	BUN*		LDH**		SGOT***		SGPT***	
TEST UNIT	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Untreated Pyrax	13.96	14.73	167.86	141.24	29.56	26.28	27.15	26.75
2% Abate	15.10	15.36	156.66	142.20	31.46	29.65	31.83	33.56
1% malathion	14.10	14.44	136.00	131.10	27.35	26.75	27.45	30.42

*mg percentage.
**Wacker Units.
***Karmen Units.

TABLE 4. Summary of serum cholinesterase activity* of test participants dusted with Abate, malathion, and untreated pyrax powder dispensed from shaker-top cans.

	PRETREATMENT DAY			POST TREATMENT DAY				
TEST UNIT	10	6	1	1	3	7	14	24
Untreated Pyrax	15.98 ±2.72	18.16 ±3.35	18.68 ±3.97	18.54 ±3.16	16.54 ±3.90	18.10 ±3.33	17.62 ±1.89	18.28 ±1.97
2% Abate	17.30 ±4.50	18.20 ±4.40	19.50 ±3.60	18.60 ±4.00	17.20 ±3.50	18.70 ±3.70	18.40 ±3.80	19.80 ±4.00
1% malathion	17.00 ±1.90	18.80 ±2.20	**	17.60 ±2.30	16.30 ±2.00	17.40 ±1.90	18.00 ±1.60	17.60 ±1.30

*Reported in the units of Garry & Routh (1965).
**Administrative considerations precluded the collection of venous blood on this day.

subjects. The screening evaluation of whole blood ChE indicated no pre- or post treatment depression of ChE activity. Evaluation of LDH, SGOT, and SGPT results (TABLE 3) indicated that no changes in liver function as measured by these tests occurred in the test groups. The SGOT results provide evidence that no damage to skeletal muscle or myocardium occurred. BUN results (TABLE 3) provide evidence that no changes in kidney function were experienced during the test.

Post treatment serum ChE results for units exposed to Abate and untreated pyrax were not significantly different when compared statistically to pretreatment values. Post treatment day 3 serum ChE results in the malathion unit were significantly lower (at the .05 level but not .01 level of probability) than pretreatment values for the same unit (TABLE 4). However, comparison with controls on the same day showed no significant difference.

Abate does not appear to be absorbed through the intact skin of man when applied in a pyrax formulation to the skin for 24 days and serum ChE activity is used as an indicator of absorption. There were no statistically significant differences in ChE activity measured between subjects dusted with 56.7 g of a formulation of 2% Abate in pyrax powder and the subjects in the control group dusted with 56.7 g of pyrax powder. The decrease in serum ChE activity 3 days post treatment, noted in those personnel dusted with 1% malathion, did not produce symptoms and the values were within this laboratory's normal activity range.

CONCLUSIONS

Mobam, Abate, and malathion are equally effective in controlling louse populations for at least 25 days. Single applications of the insecticides with either shaker cans or power delousers produces the same level of control. Susceptibility studies showed that the lice are highly susceptible to Mobam, Abate, and malathion, but were resistant to DDT and slightly tolerant to lindane.

Evaluation of the data indicates that there are no medical contra-indications to the single application of 56.7 g of 2% Abate, 1% malathion or 2% Mobam for 25 days. The parameters measured indicate that Abate in the proposed formulation presents no greater hazard than the Army medical standard item, 1% malathion, when used as a louse toxicant.

Acknowledgments: We wish to acknowledge the assistance and cooperation of the officers and enlisted men of ROKA in the joint study conducted by the U. S. Army Medical Department and ROKA. Special mention is made of, but not limited to, COL Chong, Commander, ROKA Disciplinary Center, his staff, LTC Kim, Vice Commander; MAJ Kim, S. -- S.; MAJ Park, Public Health Officer and CPT Lee, Medical Officer. CPT Yum, Project Officer, ROKA Surgeon General's Office, provided significant contributions to the study. We would also like to acknowledge the support given by The Surgeon's Office, Eighth U. S. Army and the 5th Preventive Medicine Unit of the 65th Medical Group, Eighth U. S. Army. Thanks are also due to Dr Roger E. Boldt, who checked the cholinesterase

screening kits and performed the clinical chemistry studies at USAEHA.

LITERATURE CITED

Armed Forces Pest Control Board. 1968. Methods for determining susceptibility or resistance of insects to insecticides. Tech. Inform. Memo. 3. 40 p.

Cole, M. M., P. H. Clark & D. E. Weidhaas. 1969a. Failure of laboratory colonies of body lice to develop resistance to malathion. *J. Econ. Ent.* **62:** 568–70.

Cole, M. M., J. M. Hirst, J. G. McWilliams & I. H. Gilbert. 1969b. Sleeve tests of insecticidal powders for control of body lice. *J. Econ. Ent.* **61:** 198–200.

Department of the Army. 1965. Military Entomology Operational Handbook. Technical Manual 5-632.

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

Steinberg, M., M. M. Cole, E. S. Evans, J. T. Whitlaw & J. J. Yoon. 1971. Toxicological and entomological field evaluation of effects of Mobam® powder against body lice (Anoplura: Pediculidae). *J. Med. Ent.* **8:** 68–72.

Steinberg, M., S. E. Rowe & R. E. Boldt. 1970. Assessment of relative toxicity of candidate louse toxicant ENT-27165, 0,0,0′,0′-tetramethyl 0,0′-thiodi-p-phenylene phosphorothioate (Abate®), Evaluation of animal and human exposure data and recommendation concerning a field test program. Project No. 33-001-70. USAEHA Report. Defense Documentation No. AD-869-265L.

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 human and animal exposures with recommendations regarding field test program: Project No. 33-27-67/69. USAEHA Report, Defense Documentation Center No. AD-845-601L.

J. Med. Ent. Vol. 9, no. 1: 77–80 **15 March 1972**

TERMINATION OF PUPAL DIAPAUSE IN *CUTEREBRA TENEBROSA* (DIPTERA: CUTEREBRIDAE) WITH INJECTIONS OF ECDYSTERONE

By **Craig R. Baird**[1]

Abstract: Pupal diapause in *Cuterebra tenebrosa* Coquillett was terminated by injections of 0.1 to 0.6 mg of ecdysterone per pupa. Treated pupae resumed development 2–3 days after injection and emerged as adults in 14 days independent of prior time in diapause. Controls remained in diapause. Reproductive capability of the resulting flies was normal. This technique is practical and useful in shortening the long pupal diapause and serves to coordinate development of pupae of different ages so adults emerge within a limited time range.

One of the difficulties encountered in studying *Cuterebra* bot flies is the extended pupal diapause that often lasts from 6 to 12 months. This has delayed the investigation of life histories, host-parasite relationships, and ultimate solution of the confused taxonomic situation within the genus. Colonization of bot flies in the laboratory has helped to provide much information on the biology of *Cuterebra;* however, the long pupal diapause has remained a problem. Investigators must often wait many months for adults to emerge from puparia, and even then males and females may not emerge synchronously.

In a recent paper, Fraenkel & Hsiao (1968) described the use of synthetic ecdysone in terminating diapause in *Sarcophaga* pupae. The present study was initiated to determine if similar treatments would be useful in terminating diapause in *Cuterebra* pupae.

[1]Department of Entomology, Washington State University, Pullman, Washington 99163, U.S.A.

MATERIALS AND METHODS

Diapausing *Cuterebra tenebrosa* Coquillett pupae were obtained from a laboratory colony in which larvae were reared on bushy-tailed woodrats (*Neotoma cinerea* Ord) and from larvae reared from natural infections in the same host.

Pupae were considered to be in diapause when the following characteristics were constant for 2 weeks: (1) Fat body globules were well defined in small spherical masses in head and thorax, (2) Eyes and an "open spot" or "window" in the frontal region of the head were free of fat body globules (FIG. 1). Diapausing pupae remain in this condition for months.

The operculum of each puparium was removed to determine the state of diapause of the pupa. Injections into the frontal clear area of the head were then possible without further removal of the puparium; however, thoracic injections above the wing pad required that the puparium be removed until the dorsal aspect of the head and