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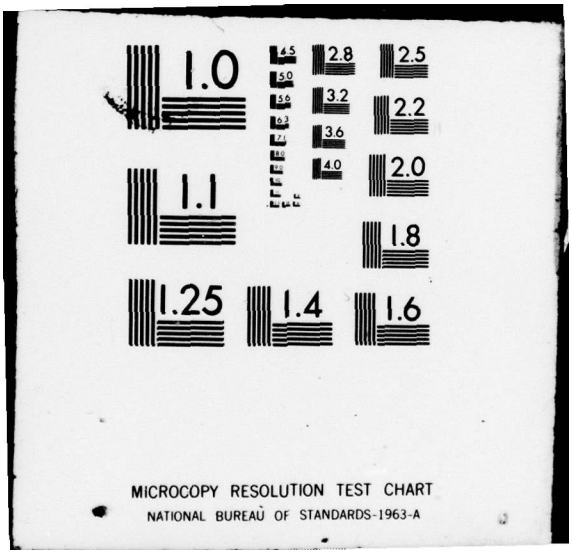
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INSTITUTE REPORT NO. 67

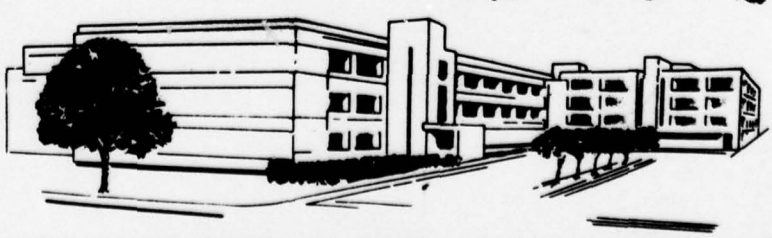
DATA STORAGE AND RETRIEVAL SYSTEM FOR A MOSQUITO REPELLENT TEST PROGRAM

Interim Report

THOMAS S. SPENCER, PhD, CPT MSC
KATHY L. ZELLER, BA, SP5
WILLIAM A. AKERS, MD, COL MC
and
WILLIAM H. LANGLEY, BS

DEPARTMENT OF DERMATOLOGY RESEARCH
and
DEPARTMENT OF INFORMATION SCIENCES

JULY 1979



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HUMAN SUBJECTS PARTICIPATED IN THESE STUDIES AFTER GIVING THEIR FREE AND INFORMED CONSENT. INVESTIGATORS ADHERED TO AR 70-25 and USAMRDC Reg 70-25 ON USE OF VOLUNTEERS IN RESEARCH.

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A computer data management system, Remote File Management System (RFMS), has been used to aid in storage and retrieval of mosquito repellent data collected as part of an insect repellent research program. The text covers three areas of program development: (1) initial organization of the data to define the problem, (2) definition of the data base and coding forms for computer keypunching, and (3) preliminary results from data analysis. Three findings concerning repellent protection time against mosquitoes illustrate the

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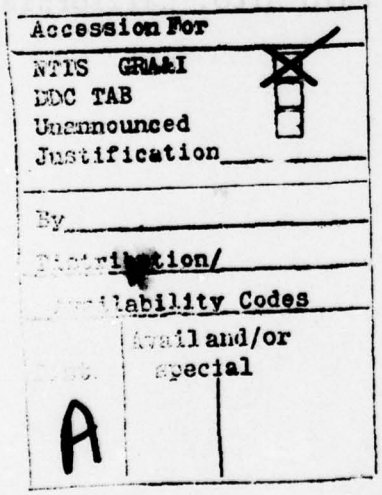
use of the data base: (1) no seasonal variation was observed in protection times, (2) no variation was observed among the protection times measured on each of the four application sites used in the four-site test method, and (3) no difference was found between the protection times determined by using the four-site or the two-site methods for repellent testing. RFMS provides a historical reference in a systematic format but lacks the capability for cross-correlation. The storage of data should continue and the present systems should be converted to another in which cross-correlation of variables can be carried out internally.

ABSTRACT

A computer data management system, Remote File Management System (RFMS), has been used to aid in storage and retrieval of mosquito repellent data collected as a part of an insect repellent research program. The text covers three areas of program development: (1) initial organization of the data to define the problem, (2) definition of the data base and coding forms for computer keypunching, and (3) preliminary results from data analysis. Three findings concerning repellent protection time against mosquitoes illustrate the use of the data base: (1) no seasonal variation was observed in protection times, (2) no variation was observed among the protection times measured on each of the four application sites used in the four-site test method, and (3) no difference was found between the protection times determined by using the four-site or the two-site methods for repellent testing. RFMS provides a historical reference in a systematic format but lacks the capability for cross-correlation. The storage of data should continue and the present systems should be converted to another in which cross-correlation of variables can be carried out internally.



PREFACE

The insect repellent research program at Letterman Army Institute of Research has been a joint effort of the Department of Tropical Medicine and the Department of Dermatology. The potential for producing a large volume of data in diverse fields of expertise is greatly enhanced by the departments' multidisciplinary approach. The current report presents the concept of an information storage and retrieval system for the repellent program and indicates how the program might be useful for comparison of current data, 1972 to 1977, to results obtained prior to the arrival of the authors. Information on program design and application is available through the Department of Information Sciences.

CPT Spencer's present address is: Commander/Director, Chemical Systems Laboratory, ATTN: DRDAR-CLL-MM/CPT Spencer, Aberdeen Proving Ground, Maryland 21010.

Colonel Akers is retired from the United States Army. His current address is Williams A. Akers, M.D., Syntex Research Corporation, 3401 Hillview Avenue, Palo Alto, California 94304.

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INTRODUCTION

The major objective of repellent research at Letterman Army Institute of Research is to develop means of protecting the soldier against vector-borne diseases such as malaria, encephalitis, dengue and chikungunya by finding a more effective topical mosquito repellent. Protection from mosquitoes for 24 hours under field conditions requires a repellent with good wash, sweat, and abrasion resistance as well as cosmetic acceptability to the soldier. Studies designed to find a better repellent have produced a great volume of data on repellents, repellent-mosquito interactions, and repellent-host interactions (with human subjects).

Since 1972, the Department of Dermatology has been using a standardized four-site method to determine the duration of protection against mosquitoes, water washing resistance, and resistance to sweating for promising new repellents and formulations (1-3). Historically, the repellent programs here and elsewhere have been designed to rank repellents or to study single variables of repellent efficacy (3-5). However, in our studies large differences were observed in protection afforded different individuals by a given repellent. For example, the standard military repellent, N, N-diethyl-m-toluamide (deet), offered from 2.5 to 11 hours of protection from mosquitoes when a group of 32 individuals was tested under the same conditions (3). In addition, differences have been observed among individuals in the amount of repellent necessary to protect against mosquitoes (3,4,6) in water loss from the skin (7) and in lipid content of the skin surface (8).

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1. Brodel C.G., et al. Evaluation of three mosquito repellent screening methods. Report No. 18, LAIR, 1974.

2. Shimmin R.K., et al. Four-site method for mosquito repellent field trials. Forty-second Annual Conference of the California Mosquito Control Association, 1974.

3. Spencer T.S., et al. Interactions between mosquito repellents and human skin. Ninth Army Science Conference, 1974.

4. Smith C.N., et al. Factors affecting the protection method of mosquito repellents. TB 1284, USDA, 1963.

5. Gabel, et al., Mosq News 36:141-146, 1976.

6. Maibach H.I., et al. JAMA 196:263-266, 1966.

7. Rietschel R.L., and T.S. Spencer. J Invest Dermatol 65:385-387, 1975.

8. Skinner W.A., et al. J. Pharm. Sci. 66:1764-1766, 1977.

In four years of testing many studies were performed on hundreds of volunteers using a large number of repellents or repellent formulations. It became nearly impossible to manipulate the data necessary to evaluate statistically the effectiveness of one repellent in relation to another and to determine the factors important in the observed differences in repellents on different volunteers. The current report describes the selection and use of a data base storage and retrieval system for management and analysis of data concerning repellents, test techniques, volunteers and insects. From this report the reader should gain an awareness of the background of the data system and the rationale for development of the system. The text covers three areas of program development: (1) initial organization of the data to define the problem, (2) definition of the data base and coding forms for computer keypunching, and (3) preliminary results from data analysis.

Initial Organization

Several questions were addressed before a data storage and retrieval system was established. The size of the data base was estimated; all variables that were thought important were listed; a workable hierarchy was designed; and the most frequent anticipated questions were stated. Minimal and maximal values for all variables also were cited. We knew that after the data base was designed, there would be little flexibility in entering new variables, even though new factors in repellents or human volunteers might be recognized later as important.

The size of the data base was originally estimated as follows: number of tests, dry protection time, 42; wash protection time, 54; sweat protection time, 5; other, 40; number of repellents, 121; and number of volunteers, 92. Under the entry "other tests" experiments were included such as guinea pig testing, mosquito photoperiod testing, mosquito circadian rhythm testing, mosquito harassment testing, and volunteer attractiveness testing. Some estimates were quite erroneous. For example, the number of volunteers tested is currently 260 although the 92 individuals in the original estimate participated in repeated tests while the remainder were tested only once or twice.

Several organizations were contacted and listed variables that were thought to be important. The Department of Tropical Medicine, Stanford Institute of Research, and the University of California San Francisco Medical Center all suggested data which should be included in the system.

A tentative hierarchy was established that allowed four main bodies of information: test data, volunteer data, repellent data, and insect data. Test data included variables such as type of test, location or laboratory doing testing, and atmospheric conditions during the test day. Volunteer data listed personal and biological

four-sites on each of eight volunteers. The dry protection time average for deet (the standard reference repellent used in testing) in each test technique shows virtually no difference between the two test techniques (Table 1). This also implies that there was no significant change due to the area of treated skin exposed to mosquitoes, since 7 x 10 cm sites were exposed in the two-site and 5 x 8 cm sites were exposed in the four-site method.

There was some concern that variation among protection times would occur between sites as determined by the four-site method. The mean protection times against mosquitoes for each site were retrieved from the data base, (Table 2), and no site dependence was found. Furthermore, since each test formulation was paired with every other formulation at least twice in a block of eight volunteers, any interaction between repellents on the same arm could be detected. No interactions have been observed up to this time.

Averages for deet at 0.32 mg/cm^2 were also calculated for quarterly intervals to see if there was any cyclic variation in mosquito avidity. Table 3 indicates that no significant variation occurred.

The means of individual volunteer dry protection times were retrieved for comparison with various individual characteristics which were studied at different times. One observation was that the range of protection times observed for any single volunteer was narrow compared to the differences observed between individuals. This confirmed observations reported previously. Another use of individual protection times revealed a correlation between the protection time afforded by a repellent and the quantity of skin lipids in an acetone extract from the individual's arm (8).

The repellent data system provides a technique for extracting summary data from a large block of data for use in long-term, statistical comparisons. Moreover, a method now exists for data to be stored in a systematic format, available as a historical reference for subsequent investigators.

CONCLUSION

Although the current RFMS systems lacks the capability for cross-correlation, the concept of a data base management system has proved to be a powerful tool in organizing and analyzing mosquito repellent data collected over years of testing.

RECOMMENDATION

The storage of repellent data in a computerized data base should be continued. Future work should be directed toward conversion of the Remote File Management System to an alternate system in which statistical cross-correlations of variables can be carried out internally.

characteristics of that individual. Repellent data included physical and chemical characteristics of the specific repellent. Insect information was confined to species and population density.

Questions that would routinely be asked were means of volunteer's dry protection time for specific repellents and overall means for repellents at specific concentrations. Ultimate analysis of the data, however, would be multivariant correlations of volunteer data with specific repellents to ascertain which combination of human characteristics could be used to establish repellent characteristics that are most important in prolonging repellent duration.

Data Base Definition

After collecting initial estimates and questions, the Department of Information Sciences suggested the use of a readily available pre-written storage and retrieval system, Remote File Management System (RFMS) (9). This program had three advantages for our data base: (1) repeating groups, items of data entry that could be iterated to accommodate variable size data sets, (2) open-ended files , data files which can accept more data on a regular basis, and (3) direct access to stored data for simplicity of editing.

Repeating groups allow one variable or a block of variables such as Volunteer or Lipid Information to be repeated an undetermined and virtually limitless number of times (Figure 1). From the terminology for our data base, Mosquito Repellent Effectiveness Data Base (MRE), which is listed in Appendix C, each test defines a logical entry. Three primary level repeating groups are used to define the insect, repellent, and volunteer information groups. Information regarding skin extracts from volunteers and repellent effectiveness is defined in a secondary repeating group descendant from the higher level volunteer information group.

An example of importance of the repeating group is seen in coding field trial test information (Appendix C). When testing repellent in the field, the number of different species of insects tested against is unknown; therefore, INSECTS (BGS) was made a repeating group. Those elements in the repeating group, namely SPECIES (SPC) and POPULATION DENSITY (PD), are entered over and over until all types of insects collected in the field during testing are entered.

The same rationale is inherent in the REPELLENTS (RPS) and VOLUNTEER (VOL) repeating groups. Our standard laboratory method

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9. University of Texas: Remote file management system (RFMS). 1968.

for determining repellent duration tested four repellents simultaneously on eight volunteers. Therefore, REPELLENTS (RPS) was entered four times—once for each specific repellent and its physical and chemical characteristics; VOLUNTEERS (VOL) was entered eight times with each entry corresponding to a specific volunteer and his personal and biological information. A flowchart for a typical repellent duration test is shown in Figure 1.

The other major advantage to the RFMS system is that it is open-ended such that data can be added as it becomes available. This is important because certain trends among the volunteers may not become apparent until many individuals have been tested. For example, if persons with AB negative blood type have natural repellent characteristics, this would not be recognized until testing is completed on a large number of volunteers. This open-endedness will also enable future investigators to have immediate access to data accumulated years before their arrival.

To prepare repellent data for keypunching, three separate coding forms (LAIR Forms 79, 80, 81) are used. These appear in Appendix C. LAIR Form 79 is used to collect volunteer information. LAIR Form 80 is general test information and contains the repeating group INSECTS (BGS). LAIR Form 81 lists repellent information. This block of variables is repeated four times since our standardized methods test four repellents simultaneously. If more than four repellents are tested, additional sheets could be added. In a typical repellent duration test, eight separate sheets would be coded since eight volunteers are tested at the same time. Information for this coding form is obtained under the guidelines of the Privacy Act.

RESULTS AND DISCUSSION

Statistical analysis is limited when the RFMS system is used. Output from our study includes count, minimum value, maximum value, sum, mean, standard deviation, and standard error of the mean. Although answers to recurring questions were obtained which were difficult to calculate by hand, no provision is available for cross-correlation of variables within the program. However, several observations were made possible by manipulation of the data base.

One major finding was that there was no significant difference between two standardized test methods used in determining repellent duration. Prior to 1972, the two-site dry protection time test was used to evaluate five repellents rotated in a partially balanced incomplete block design among two sites over four days on 20 volunteers. The current method, the four-site dry protection time test, tests four repellents applied in a Latin Square design by using

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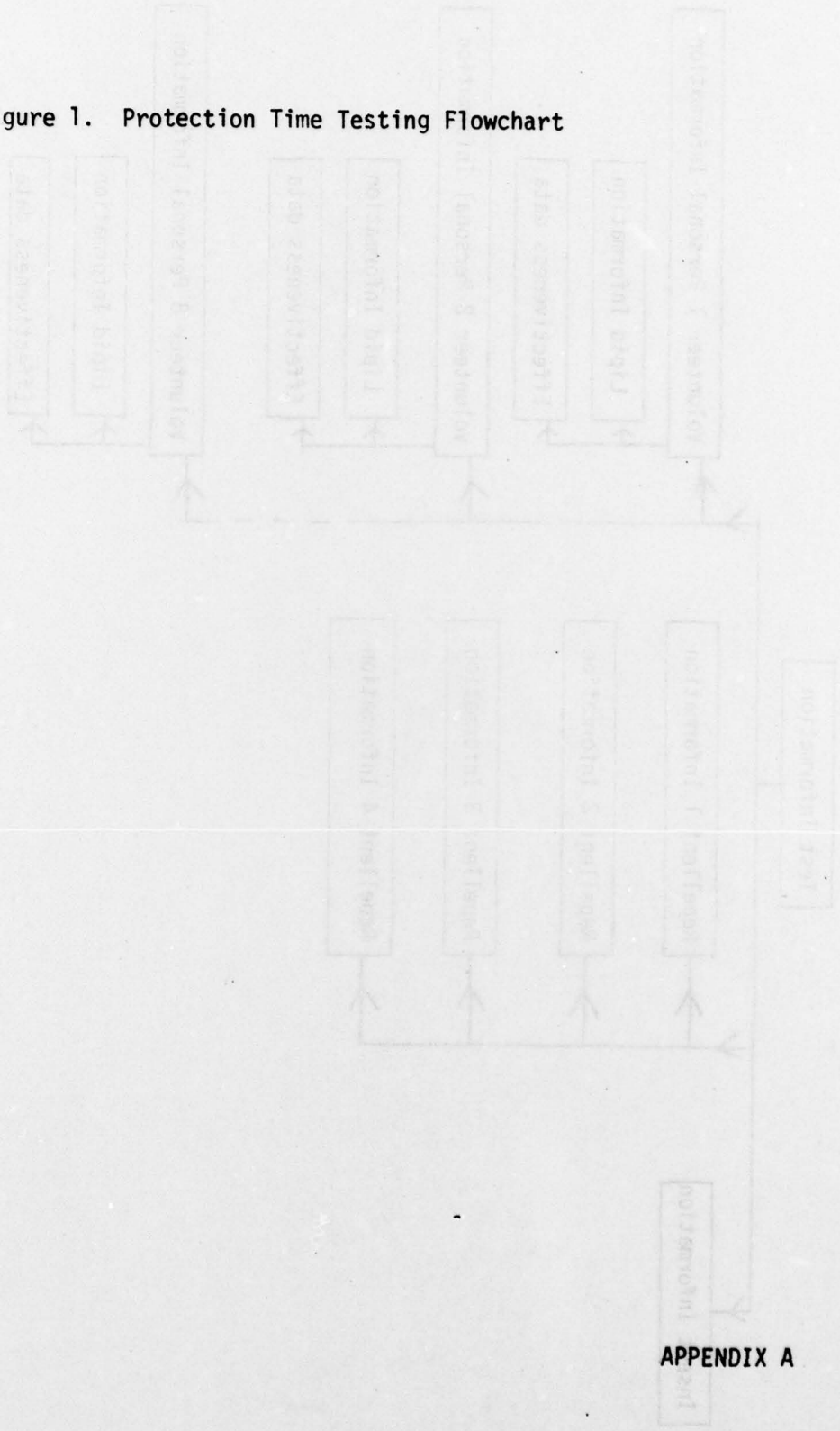
9. University of Texas. Remote file management system (RFMS), in Computation Center Technical Staff Documentation Publications. Vol O-14, Austin, Texas, University of Texas, 1968.

Figure 1. Protection Time Testing Flowchart



APPENDIX A

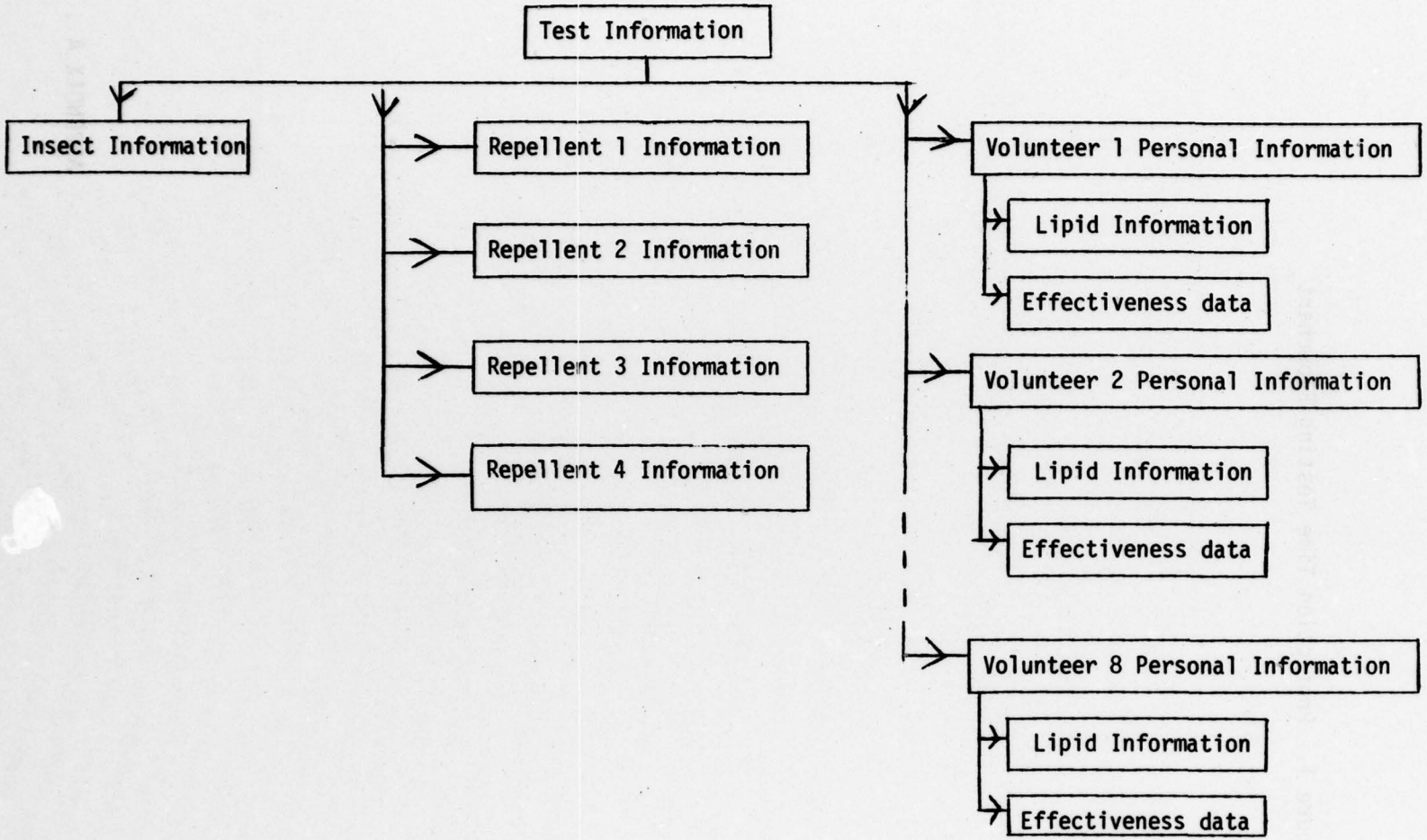


Figure 1. Protection Time Testing Flowchart

Table 1. Protection times against mosquitoes obtained by different test methods.

Table 2. Variation in protection time against mosquitoes according to the application site.

Table 3. Seasonal variation in protection time against mosquitoes

APPENDIX B

Table 1. Protection times against mosquitoes obtained by different test methods*

Method	N	Mean ± S.D.
		(hr)
4-site	195	6.8 ± 1.88
2-site	39	6.6 ± 2.35

*Repellent deet applied at 0.32 mg/cm^2

Table 2. Variation in protection time against mosquitoes according to the application site*

Site	Left Arm (Mean ± S.D.)	Right Arm (Mean ± S.D.)
	(hr)	(hr)
Wrist site	6.5 ± 1.73 (33)	6.9 ± 2.08 (33)
Elbow site	7.0 ± 1.81 (34)	6.4 ± 1.96 (32)

*Repellent deet applied at 0.32 mg/cm^2

Table 3. Seasonal variation in protection time against mosquitoes*

Time Interval	Mean (N)
	(hr)
Dec, Jan, Feb	6.91 (48)
Mar, Apr, May	6.42 (60)
Jun, Jul, Aug	6.20 (243)
Sep, Oct, Nov	6.32 (274)

*Repellent deet applied at 0.32 mg/cm^2

LAIR Form 79 Volunteer Information

LAIR Form 80 Test and Insect Information

LAIR Form 81 Information

Data Base Terminology

APPENDIX C

(MRE) **VOLUNTEER INFORMATION** TEST ______ PAGE ___ OF ___

(VOL) (ID) ______ (AG) ____ (SX) ___ (RC) ____ (DM) ___/___/___

(EO) ________ (MECD) ______ (BLD) _____ (HAR) ________

(EYE) ________ (SKN) ________ (SDT) ________

(SMK) ____ (FHD) _____ (HGT) _____ (WGT) _____ (TWL) ________

(ATT) ________ (SOP) ________________

- -

(EXT) (TOE) ________ (AMT) _____ (SFP) _____ (SFN) _____ (SFF) _____

(EXT) (TOE) ________ (AMT) _____ (SFP) _____ (SFN) _____ (SFF) _____

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(EFF) (IST) ________ (NAM) ________ (CNC) ________ (PSZ) _____

(LC) ________ (DPT) ________

(EFF) (IST) ________ (NAM) ________ (CNC) ________ (PSZ) _____

(LC) ________ (DPT) ________

(EFF) (IST) ________ (NAM) ________ (CNC) ________ (PSZ) _____

(LC) ________ (DPT) ________

(EFF) (IST) ________ (NAM) ________ (CNC) ________ (PSZ) _____

(LC) ________ (DPT) ________

LAIR FORM 79 DEPT. OF DERM. 20 JUNE 75

MOSQUITO REPELLENT EFFECTIVENESS (MRE)
DATA COLLECTION FORM

TEST AND INSECT INFORMATION

TEST ____________
PAGE 1 OF ______

KEYPUNCH INSTRUCTIONS:
FREE FORMAT, IGNORE PREFIX
IF DATA IS MISSING

(TST) ______________________ (LB) __________ (TDT) __/__/__ (TM) ____

(TMP) ________ (BPR) ________ (HM) ________ (ATM) ____________________

(SC) ____

(TCM) ____

- -

(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

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(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

(BGS) (SPC) ______________ (PD) ____ (BGS) (SPC) ______________ (PD) ____

LAIR FORM 80 DEPT. OF DERM. 20 JUNE 75

(MRE)

REPELLENT INFORMATION

TEST ________
PAGE 2 OF ______

(RPS) (RNM) __________ (SRC) ____________ (RCN) ______ (ML) __________
(BP) _____ (MP) _____ (WS) _____ (ES) _____ (FS) _____ (HS) _____ (MW) ________
(POL) _____ (PC) _____ (PSPR) _____ (PSES) _____ (ER) _____ (PR) __________
(TDH) ______ (TVP) ______ (GEXP) ______ (MEC) ________ (MED) __________

- -

(RPS) (RNM) __________ (SRC) ____________ (RCN) ______ (ML) __________
(BP) _____ (MP) _____ (WS) _____ (ES) _____ (FS) _____ (HS) _____ (MW) ________
(POL) _____ (PC) _____ (PSPR) _____ (PSES) _____ (ER) _____ (PR) __________
(TDH) ______ (TVP) ______ (GEXP) ______ (MEC) ________ (MED) __________

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(RPS) (RNM) __________ (SRC) ____________ (RCN) ______ (ML) __________
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(RPS) (RNM) __________ (SRC) ____________ (RCN) ______ (ML) __________
(BP) _____ (MP) _____ (WS) _____ (ES) _____ (FS) _____ (HS) _____ (MW) ________
(POL) _____ (PC) _____ (PSPR) _____ (PSES) _____ (ER) _____ (PR) __________
(TDH) ______ (TVP) ______ (GEXP) ______ (MEC) ________ (MED) __________

LAIR FORM 81 DEPT. OF DERM. 20 JUNE 75

DATA BASE TERMINOLOGY

(TST) TEST TYPE (CHAR):
(LB) INVESTIGATOR (CHAR):
(TDT) DATE OF TEST (DATE):
(TM) TIME OF TEST (INTEGER):
(TMP) TEMPERATURE (REAL):
(BPR) BAROMETRIC PRESSURE (REAL):
(HM) RELATIVE HUMIDITY (REAL):
(ATM) ATMOSPHERIC CONDITIONS (CHAR):
(SC) SPECIAL CONDITIONS (CHAR):
(TCM) TEST COMMENTS (CHAR):

(BGS) INSECTS (RG):
(SPC) SPECIES (CHAR IN BGS):
(PD) POPULATION DENSITY (INTEGER IN LBS):

(RPS) REPELLENTS (RG)

(RNM) REPELLENT NAME (CHAR IN RPS):
(SRC) SOURCE (CHAR IN RPS):
(RCN) REPELLENT CONCENTRATION (REAL IN RPS):
(ML) MOLECULAR STRUCTURE CLASS (REAL IN RPS):
(BP) BOILING POINT (REAL IN RPS):
(MP) MELTING POINT (REAL IN RPS):
(WS) WATER SOLUBILITY (REAL IN RPS):
(ES) ETHANOL SOLUBILITY (REAL IN RPS):
(FS) FREON SOLUBILITY (REAL IN RPS):
(HS) HEXANE SOLUBILITY (REAL IN RPS):
(MW) MOLECULAR WEIGHT (REAL IN RPS):
(POL) POLARITY (REAL IN RPS):
(PC) (PARITION COEFFICIENT (REAL IN RPS):
(PSPR) PLASTIC SOLUBILITY IN PURE REPELLENT (REAL IN RPS):
(PSES) PLASTIC SOLUBILITY IN 50PC ETHANOL SOLUTION (REAL IN RPS):
(ER) EVAPORATION RATE (REAL IN RPS):
(PR) PENETRATION RATE (REAL IN RPS):
(TDH) TEA DELTA H (REAL IN RPS):
(TVP) TEA VAPOR PRESSURE (REAL IN RPS):
(GEXP) GRAVIMETRIC EXPERIMENT (REAL IN RPS):
(MEC) MINIMUM EFFECTIVE CONCENTRATION (REAL IN RPS):
(MED) MINIMUM EFFECTIVE DOSAGE (REAL IN RPS):

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(VOL)    VOLUNTEERS (RG):
(ID)     IDENTIFICATION (INTEGER IN VOL):
(AG)     AGE (INTEGER IN VOL):
(SX)     SEX (CHAR IN VOL):
(RC)     RACE (CHAR IN VOL):
(DM)     DATE OF MARRIAGE (DATE IN VOL):
(EO)     ETHNIC ORIGIN (CHAR INVOL):
(MEDC)   MIN EFFECTIVE CONCENTRATION OF DEET (REAL IN VOL):
(BLD)    BLOOD TYPE (CHAR IN VOL):
(HAR)    HAIR COLOR (CHAR IN VOL):
(EYE)    EYE COLOR (CHAR IN VOL):
(SKN)    SKIN COLOR (CHAR IN VOL):
(SDT)    SURVEY DATE (DATE IN VOL):
(SMK)    SMOKING HABITS (CHAR IN VOL):
(FHD)    FOREARM HAIR DENSITY (REAL IN VOL):
(HGT)    HEIGHT (REAL IN VOL):
(WGT)    WEIGHT (REAL IN VOL):
(TWL)    TRANSEPIDERMAL WATER LOSS (REAL IN VOL):
(ATT)    ATTRACTIVENESS (REAL IN VOL):
(SOP)    SOAP (CHAR IN VOL):

(EXT)    EXTRACTS (RG IN VOL):
         (TOE)  TYPE OF EXTRACT (CHAR IN EXT):
         (AMT)  AMOUNT OF EXTRACT (REAL IN EXT):
         (SFP)  SKIN FLORA POSITIVE (REAL EXT):
         (SFN)  SKIN FLORA NEGATIVE (REAL IN EXT):
         (SFF)  SKIN FLORAL FUNGAL (REAL IN EXT):

(EFF)    REPELLENT EFFECTIVENESS (RG IN VOL):
         (IST)  INSECT TYPE (CHAR IN EFF):
         (NAM)  REP NAME (CHAR IN EFF):
         (CNC)  CONCENTRATION (REAL IN EFF):
         (PSZ)  PATCH SIZE (REAL IN EFF):
         (LC)   LOCATION (CHAR IN EFF):
         (DPT)  DRY PROTECTION TIME (REAL IN EFF):
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