A COMPUTERIZED MOSQUITO INFORMATION AND COLLECTION MANAGEMENT SYSTEM FOR SYSTEMATIC RESEARCH AND MEDICAL ENTOMOLOGY (DIPTERA: CULICIDAE)[1]

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ABSTRACT. In 1979, the Mosquito Information Management Project (MIMP) was initiated to develop a computer-based system for storing and retrieving systematic, ecologic and distributional data on mosquitoes. The data base is being compiled from collection records accompanying approximately one million mosquito specimens in the National Museum of Natural History, Smithsonian Institution. To date, 15,500 collection forms pertaining to about 402,000 specimens have been entered into the computer. Using the set of programs SELf-GEnerating Master (SELGEM), any combination of data recorded on the forms can be extracted and associated and then transmitted to the user in the form of a report. The MIMP has acquired several mapping programs that permit computer generation of species distribution maps for any region of the world. This project is directed at supporting systematic research and providing easily accessible ecologic and distributional information to public health organizations and other scientific agencies concerned with vector species of mosquitoes.

INTRODUCTION

Knowledge of the systematics, bionomics and medical importance of mosquitoes is fundamental to the understanding and development of programs for vector control and disease eradication. Much of the information about the systematics of species comes from the study of museum specimens and associated collection data. The approximately one million specimens, with associated data, in the Smithsonian Institution (SI) constitute the largest and most

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complete mosquito collection in the world. The collection data and specimens have come primarily from 4 sources: the project Mosquitoes of Middle America (MOMA), University of California, Los Angeles; the Southeast Asia Mosquito Project (SEAMP) and the Medical Entomology Project (MEP), National Museum of Natural History (NMNH), SI; and the Walter Reed Biosystematics Unit (WRBU). For these collections, extensive ecologic data have been recorded on standardized forms. The information is detailed and specific, pertaining to the general environment and to the microhabitat.

Because of the large quantity of material and associated data in the National Mosquito Collection, it is extremely difficult to extract and synthesize information from the collection records as well as to manage the collection. There has been no easily accessible data base available to users. Questions concerning the distribution and ecology of species are difficult to answer and require considerable time. Belkin and Heinemann (1973-1976), Heinemann and Belkin (1977-1979), Heinemann et al. (1980) and Heinemann (1980) have published collection data on the MOMA collections. Although these data are available to workers, the utility of the records is severely restricted by the time required to manually permutate and associate the needed information.

A workshop entitled "Taxonomic and Ecological Services: Underdeveloped Resources" (Edwards and Grotta 1975) identified a number of problems regarding systematic collections: (1) inaccessible taxonomic and ecologic information, (2) lack of baseline information on species, (3) inability to make accurate predictions, and (4) insufficient time to process information. This workshop proposed the implementation of a computer-based systematic and ecologic data network to support federal agencies like the Environmental Protection Agency, U.S. Forest Service, and Department of Agriculture. Several programs have been developed in entomology to address these problems, including some specifically for assisting in mosquito control programs (White and Grodhaus 1972; Russo and McCain 1979). The Mosquito Information Management Project (MIMP) was designed to develop a computer data base especially for mosquito systematic research and for the support of medical research concerning vector species of mosquitoes.

The MIMP began in September 1979 as a collaborative venture between the Department of Entomology, SI, and the WRBU. Its purpose was to develop a systematic and ecologic data base from the National Mosquito Collection. The data are specimen-based rather than literature-based, and as such, possess some unique advantages. One is that the information obtained from specimens and their collection forms remains a constant, unchanging source of data that can be referred to regardless of taxonomic changes, such as the altering of the name or status of a taxon. This is particularly important when, for example, a former species is divided into several sibling species, some being sympatric, others allopatric, with one or more acting as a disease vector. Another characteristic of this kind of data base is that specific questions regarding the distribution and ecology of a species can be addressed. Details concerning faunal and floral associations, the immature habitat and distribution are often abbreviated or omitted in the literature.

OBJECTIVES

The primary objectives of the MIMP are (1) to enhance and support mosquito research; (2) to provide easily accessible, coordinated systematic, ecologic and distributional data on vector species to public health organizations, the military, and scientific and environmental agencies; (3) to provide knowledge of gaps in the collection and suggest new collection strategy; and (4) to alleviate managerial problems by providing a timely, cost-effective collection inventory.

Information for the data base will be extracted from (1) the collection records of MOMA, SEAMP, MEP and WRBU; (2) the collection data for the NMNH type specimens; (3) data on specimens in the NMNH world collection; and (4) data on specimens borrowed from other institutions and individuals. Because of the tremendous amount of information available to the project, priority for inclusion in the data base is given to mosquito groups currently under investigation or groups including medically important species.

SPECIMENS AND COLLECTION FORMS IN NMNH

Table 1 presents a summary of the specimens and collection forms that are currently available to MIMP. All of this material is located at the NMNH. The numbers and percentages in the table are conservative estimates based on a preliminary inventory of the collections and collection forms. For some regions abundant individually reared associated material is available, whereas other regions are very poorly represented in the collections. For example, despite the many mosquito workers in the region, the collection for the Nearctic Region is very small, with few detailed collection records and with only 3 percent of the collection represented by individually reared specimens.

COLLECTION FORM

The collection form (Fig. 1) that has been adopted by the project is essentially a composite of 2 previous forms (MOMA, MEP) with the addition of several new categories. The front of the form is divided into 5 sections: (1) locality, (2) general environment, (3) habitat of the immatures, (4) habitat of the adults, and (5) remarks. The back of the form lists mass and individual rearings (for description, see Belkin et al. 1965) for the various species in the collection, information on the medical importance of the species, museum data and type data (if collection includes a new taxon), and remarks. Because the collection form is different from previous forms, a brief description of the format is given with recommendations on completing each form.

The form is largely self-explanatory. For the locality section, the appropriate information is written immediately under each heading. Each collection, including borrowed material, is assigned a unique alphanumeric designator, which is formed by a 2- or 3-letter code specific for the country and the collection number. For general environment, habitat of the immatures and habitat of the adults, the main categories are numbered and the

subcategories lettered; often there are blanks adjacent to the categories and subcategories for entry of additional information. In completing the form, the appropriate categories and subcategories are circled, and any additional data are written in the blanks as in the completed sample form. Numbers are placed in the squares under the different stages[5] of mass rearings indicating the numbers of those individuals. Checks are made in the squares under the different stages of individual rearings specifying the presence of that developmental stage.

The portions of the form on locality, general environment, and habitats of the immatures and adults should be filled out as completely as possible in the field. Rearing data are added to the form in the laboratory as specimens are reared. The sections on species determination, medical importance, and museum and type data can be entered by the curator after the specimens have been examined.

DATA ENTRY

The information concerning the locality, environment, habitat and specimens is carefully checked before data from the collection forms are submitted to the computer. Correct locality names are determined from detailed maps and Official Standard Names Gazetteers of the United States Board on Geographic Names. The exact locality of the collection is recorded in either geographic coordinates (latitude, longitude), universal transverse mercator (UTM) coordinates or military grid reference coordinates.

Completed forms are entered into the computer via Nixdorf®[6,7] 600/55 minicomputer data entry system, a hardware-software system specifically designed for rapid data entry. This system consists of a central computer, remote terminals and remote printers. The system is programmed to display the collection form using 10 different formats: (1) locality, (2) locality number, (3) environment, (4) habitat of immatures, (5) habitat of adults, (6) general remarks, (7) mass and individual rearing remarks, (8) mass rearings, medical importance and museum data, (9) individual rearings, and (10) type data. Each format represents a record in the computer. These 10 records are composed of 78 categories and subcategories of information that are displayed in

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[5]L= whole larva(e), l= larval exuvia(e), P= whole pupa(e), p= pupal exuvia(e), M= male(s), F= female(s), E= egg(s) and G= genitalia mounted on slide(s).

[6]Nixdorf® data entry system is a product of the Nixdorf Computer Corporation, Burlington, Massachusetts. The system consists of the following units: 1920 data terminal model 162A, model 062T keyboard, model 616A central transmission interface and model 617A terminal transmission interface.

[7]Use of commercial sources is for identification purposes only and does not constitute endorsement by supporting agencies.

consecutive order on the cathode ray tube (CRT) screen. As one record is completed, the next is shown automatically. Typically, 6 records are transcribed for each collection form: locality, locality number, general environment, habitat of immatures or adults, mass rearing and individual rearing. Included in the computer program are various indices that permit the entry of abbreviations that are automatically expanded by the system to the complete name in the record. Indices exist for countries of the world (same as country code), collectors and Holdridge life zones (Holdridge et al. 1971). Every currently recognized country in the world has been assigned a 2-letter country code according to the National Bureau of Standards (NBS 1976). These country codes can be modified by adding an additional letter or number to distinguish collections acquired from other institutions and/or individuals. For example, the MOMA has used the NBS code "MX" for Mexico. Future collections from Mexico may be assigned "MXA" beginning with locality number one (MXA 1).

Special editing subprograms check the data of certain categories as it is being entered to determine if it conforms to a prescribed format, including predetermined line lengths. These subprograms exist for all the indices, in addition to the following categories: date, latitude and longitude, mass and individual rearings, and depositories. If the code is not "recognized," the terminal gives both an audible and visual illegal entry signal. One subprogram, for example, checks if the month of the year is correctly spelled. Also, several of the categories are considered "mandatory," that is, data must be entered in that category or an error signal is given. Country code, country, locality number and at least one species number for mass rearings are mandatory entries. Another timesaving operation is the automatic duplication feature which enables the operator to duplicate entries in consecutive mass rearings for species name, determiner, life stages, medical importance, depositories, synonyms, species names and the bibliography.

When a "batch" of information (300-3000 records) is complete on the Nixdorf® minicomputer disk, it is transferred to magnetic tape in the Honeywell® Series 60 level 66/80 computer system for permanent storage. The information in the data base is then printed by a Xerox® 1200 Computer Printer in the form of an "update report," which can be corrected or modified using a specially designed subprogram SELMOSIN (SELgem MOSquito INput). Other subprograms allow reformatting of the data base and checking categories for their presence or absence and/or frequency of occurrence. The information in the completed data base is printed as a "master list." This report can be formatted to include category definitions that clearly explain the type of information in each category, and can be kept for future reference.

SELGEM

The combination of 25 programs (mainly written in standard COBOL 74), developed at the SI for storage, management and retrieval of data, is called SELGEM (SELf-GEnerating Master). SELGEM (Creighton and Crockett 1971; Creighton 1981), a generalized system specifically designed for museum collection management, has developed and matured over 15 consecutive years of

research and experience with museum data processing. The ability to handle either sequentially or hierarchically structured data, and additions and deletions without reprogramming, makes SELGEM an effective, although now, a somewhat outdated system for the manipulation of mosquito collection data.

For the MIMP, an auxillary program of SELGEM was designed to handle the hierarchically arranged data included in the collection form. In a hierarchical file, data are arranged in a pyramid fashion; that is, for any one category within a record, there may be several, independent subcategories. The file designed for the MIMP is divided into 3 levels (Fig. 2). Level one includes 2 records, locality data and locality number. At level two, the file divides into (1) general environment, (2) habitat of immatures, (3) habitat of adults, (4) general remarks, and (5) mass and individual rearing remarks. At level three, the file separates into as many branches as there are species in the collection. Within this level, all the information that pertains to the species, such as medical importance and museum data, is listed for each species, including numbers of the different stages for mass-reared specimens. This level expands to include the specimen's number, and the stages and genitalia (if mounted on slides) of every individual rearing. To gain maximal accessibility to the information stored in this file, SELGEM permits association of any of the categories or subcategories within and among collections, thus allowing extensive file querying capabilities.

COMPUTER-GENERATED MAPS

MIMP has the capability of producing computer-generated maps and plotting collection sites (Fig. 3, lettering added). Two programs were obtained from the U.S. Department of Commerce, World Data Bank II and the fifth edition of the Cartographic Automatic Mapping Program (CAM). World Data Bank II is a set of programs that permit digital representation of the world. It is divided into 5 individual areas or volumes: North America, South America, Europe, Africa and Asia. The maps were digitized at scales between 1:1 million to 1:4 million and consist of approximately 6 million points. Included in World Data Bank II are international boundaries, coastlines, islands, lakes and rivers. For some regions, such as the U.S., it is capable of plotting state boundaries and the existing railway systems. The CAM is used in conjunction with World Data Bank II in performing a variety of functions, such as connecting points with a straight line, plotting geographic or UTM coordinates, drawing various map symbols and transformation of latitude/longitude into several other map projections. Also, the project acquired 2 programs from the Defense Mapping Agency (DMA), MILREF-76 (MILitary REFerence) and an associated subroutine DMS (Degrees, Minutes, Seconds), developed to convert military grid reference coordinates and UTM coordinates, respectively, into geographic coordinates. With the combination of the above four programs interfaced with SELGEM, it is possible to produce detailed species distribution maps for any country in the world, with locality data given in any of the above coordinates.

DATA RETRIEVAL

We will not describe in detail the data retrieval procedure for SELGEM, because in the near future the SI intends to obtain a data base management system (DBMS). It is anticipated that the records currently in the MIMP data base will be converted to the DBMS. This updated system will operate in an interactive mode, which will permit "on-line" data entry and querying, thereby greatly increasing efficiency and capability of the project.

With SELGEM, each record in the data base is given an 8-digit serial number to identify and sequence records, a 3-digit category code to denote fields and sequence them within a record, and a 2-digit number to sequence the line that contains fields exceeding the 64 character limit. The category code identifies the data (for example, 010 is Country, 045 is the latitude/ longitude). A sample computer printout is shown in Fig. 4.

SELEXT is the subprogram within the SELGEM system that retrieves data. Briefly, the procedure for retrieval using SELEXT requires the following steps. Query statements are written and transferred to DATA EVALUATION control cards instructing the computer to search for a given word among the words in a particular category. An indicator is turned on if the word is found. In the second step, INDICATOR EVALUATION, the indicators are considered in conjunction with each other, and action is requested if various indicators have been turned on. The final step is to define the ACTIONS to the computer within the possible choices of print, tally, replace or output data to magnetic tape.

INITIAL TEST AND SPECIALIZED SUBPROGRAMS

Early in the development of MIMP, we tested the capability of SELGEM in providing the kinds of associations of data that would be useful to mosquito research and collection management. For this, data from 61 collection forms, pertaining to about 3,600 specimens from Ecuador, were submitted to the computer. Below are the questions used in our initial test:

1. What species have been collected in Ecuador in association with *Culex (Melanoconion) bastagarius* Dyar and Knab ?
2. Where has *Anopheles (Nyssorhynchus) rangeli* Gabaldon, Cova Garcia and Lopez been collected in Ecuador ? Plot on map.
3. How many larval-pupal-female and larval-pupal-male individual rearings are there of *An. (Nys.) rangeli* from Ecuador ?
4. What months of the year has *An. (Nys.) rangeli* been collected in Ecuador?
5. Has *An. (Nys.) albimanus* Wiedemann been collected above 250 meters elevation in Ecuador? In what type of habitat ?

Three subprograms were written (MOSMAT, MOSCOM, MOSQTL) that, in conjunction with SELEXT, address these questions and arrange the responses in the form of simple reports. In addition, 3 other subprograms (MOSDX1,2,3) were designed for MIMP to produce a "species summary sheet" (Fig. 5).

PRESENT STATUS OF MIMP

The data base presently consists of 8 separate files based on geographic groupings of countries or islands: Mexico and Central America, Western South America, Northeastern South America, Southeastern South America, Greater Antilles, Lesser Antilles, Eastern Africa, and the Middle East. Files are expected to be created for the United States, Europe, other parts of Africa, and the Near, Middle and Far East.

The rationale behind the establishment of separate files for particular geographic regions is the ease and economy in querying these files. If there is a request for the distribution of a species, for example, in Colombia, it is not necessary to search through every collection for every country, but only search through the file on western South America.

Approximately 15,500 collection forms representing 402,000 specimens have been entered into the data base. New collection records are being entered at the rate of approximately 17 per working day, with a yearly total of about 4,550, representing approximately 115,000 specimens. It requires an average of 27 minutes to enter a completed collection record: 5 minutes to check coordinates, 9 minutes to enter information, 10 minutes to examine and correct, and 3 minutes to recheck.

SUPPORT OF SYSTEMATIC RESEARCH

The MIMP supports mosquito systematic research of the SI and the WRBU. For specific taxonomic studies, specimen identifications are made and entered on the original collection form by the taxonomist. When specimens are examined from other institutions, separate collection forms may be completed with the data accompanying the specimens. This information can be entered in the computer by MIMP staff. Lists of the specimens examined and environmental data are available to the taxonomist upon request. Projects currently supported include studies of *Aedes (Stegomyia)* and *Aedes (Neomelaniconion)* of Africa, *Culex (Culex)* of southwestern Asia and northern Africa, the genus *Trichoprosopon* and the Balabacensis Complex of *Anopheles (Cellia)*.

Another major function of the MIMP is assisting in the management of the National Mosquito Collection, to include activities such as (1) providing summarized, sequenced listings of fauna, (2) preparation of mailing lists, and (3) inventory of the collection. These functions are all within the present capabilities of the project.

USER REQUESTS

The project has received over 100 requests from agencies concerned with disease vectors and systematics. About half of these requests were for information on specific collection forms not requiring computer output. Many requests were for computer-generated, species distribution maps. Numerous others have required computer processing, in most cases, to provide a summary of habitats and distribution for a vector species within a particular

geographic area. Currently requests are handled without charge to users. The average cost to process a computer query, including plotting of maps, is estimated by the SI Office of Information Resource Management (OIRM) to range from $2 to $50.

LIMITATIONS

The current, relatively small size of the data base is the primary short-term limitation for the project. Of long-term importance is the fact that the available collections and forms are fairly complete only for certain regions. For the Nearctic, Palearctic, Afrotropical and parts of the Oriental regions the collections are incomplete or, in many instances, nonexistent.

For the collections that are available, the distribution of collections and, therefore, species is dependent upon the areas of interest and areas logistically feasible to collectors. The mosquito fauna of some regions such as that of the Canal Zone of Panama, is well represented in the collections, whereas the fauna of other regions, such as that of Amazonia or Patagonia, are very poorly represented. Similarly, the habitats from which collections are taken are dependent on the collector. If a collector samples only ground pools, obviously only those species that occur in that habitat will be included. The latter is usually not a serious problem, as most collectors attempt to collect from all available habitats. Yet, in most cases, no attempt is made nor does time permit collectors to collect from all habitats in a uniform or standardized fashion. Often one or several habitats receive preference over others, because certain medically important species have been previously collected in these. Also, the sampling techniques followed by various collectors differ, so that even if collections are from the same habitat, the collected species may vary. The same is true for adult collections. The species that come to light traps may not come to Magoon traps, or human and animal biting collections.

The result of these biases is that no concrete statistical inferences (e.g., proportions of a species collected in different habitats) can be drawn from the habitat data in the collection forms unless the collections are for a specific, controlled ecological study. However, the collection records do give information on where mosquitoes have been collected, and this can be used to gain insight into species distribution and bionomics. With the SELGEM system, these data are readily accessible and can be compiled in various forms to bring together a tremendous amount of information that would otherwise be unavailable or require considerable time, cost and effort to obtain.

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TABLE 1

APPROXIMATE NUMBER OF MOSQUITO SPECIMENS IN NATIONAL MUSEUM OF NATURAL HISTORY, SMITHSONIAN INSTITUTION

Geographic Regions	Adults	Slides	% Reared Individually	Collection Forms
Nearctic	91,500	20,400	3.0	71
Neotropical	289,000	110,000	28.0	13,100
Palearctic	11,650	2,600	18.0	28
Afrotropical	9,800	1,300	22.0	770
Oriental	146,000	166,000	30.0	26,600
Australian	5,900	1,000	5.5	800
Pacific	55,600	17,400	20.0	329
TOTAL	609,450	318,700	24.8	41,698

Total specimens = 609,450 adults + 1.25* (318,700 slides) = 1,007,825.
Error estimated ± 10%

*Approximately a quarter of the slides include both a pupal and a larval exuviae; therefore, there is an average of about 1.25 specimens per slide.

FIGURE 1

COLLECTION FORM ADOPTED BY THE MIMP, FRONT OF FORM

LOCALITY

Country Code: GUA	Nearest Town: CHAMPERICO	Elevation: NEAR SEA LEVEL
Number: 21	Specific Locality: ALONG RD. INTO CHAMPERICO; NATL. RT 9S, KM 222.5 FROM GUATEMALA CITY; 1 KM FROM CENTER	Date: 2 JULY 1964
Country: GUATEMALA	Map Designation: 1301XND15	Time:
State, Province or Department: RETALHULEU	Grid Coordinates: 15PXF1800081000	Photo: #1
Second Administrative Division:	Latitude and Longitude: 14° 18'--N. 091° 55'--W	Collector: C. BURNETT

GENERAL ENVIRONMENT

1. Air temp
   a. Wet ____ °C
   b. Dry ____ °C
2. % RH ____
3. Water temp 19 °C
4. Wind ____ kph
   a. none
   (b. light)
   c. medium
   d. strong
   e. gale
5. Sky
   a. clear
   (b. partially cloudy)
   c. overcast
   d. fog
   e. mist
   f. light rain
   g. heavy rain
6. Annual rainfall ____ mm
7. Rainy season months
   JFMAMJJASONDJFM
8. Topography
   a. mountain
   b. hill
   c. valley
   d. plateau
   e. plain
9. Latitudinal regions
   a. subpolar
   b. boreal
   c. cool temperate
   d. warm temp/subtropical
   (e. tropical)
10. Altitudinal belt
    a. alpine
    b. subalpine
    c. montane
    (d. lower montane)
    e. near sea level
11. Life zone
    a. Holdridge ____
    ____
    b. other ____
    ____
12. Vegetation types
    (a.) gymnosperms
    (b.) angiosperms
       1. monocots
       2. dicots
    (c.) deciduous
    d. nondeciduous
    (e.) broad leafed
    f. needle leafed
    g. bryophytes
    h. fungi
    i. other
13. Woody plants ____
    ____
    a. height range
       (0-2-8-15) 30 m
    b. density
       1. 0 total absence
       2. 1 low
       (3.) 2 medium
       4. 3 high
14. Herbs and (grasses) ____
    ____
    a. height range
       (0-0.5) 1-2-5-8 m
    b. density
       1. 0
       (2.) 1
       3. 2
       4. 3
15. Epiphytes ____
    ____
    a. density
       1. 0
       2. 1
       3. 2
       4. 3
16. Edge effect, edge or interior of
    a. vegetation
    b. swamp
    (c. road)
    d. dike
    e. bank
    f. other ____
17. Water effect, shore or margin of
    a. sea
    b. lake
    c. stream
    d. river
    e. swamp
    f. salt marsh
    g. other ____
18. Human influence
    a. clearing
    b. grazing
    c. plantation
    d. cultivation
    (e. domestic)
    f. pollution
    g. other ____

HABITAT OF IMMATURES

1. Modifiers of breeding site
   (a. large)
   b. medium
   c. small
   d. natural
   e. artificial
   f. other ____
2. Breeding site
   a. pond ____
   b. lake ____
   (c. ground pool) 2X5 M
   d. flooded pool ____
   e. animal track ____
   f. anim. container ____
   g. swamp, marshy depression
   h. marsh
      1. fresh 2. tidal
   i. flooded forest
   j. seepage, spring
   k. well
   l. stream
      1. margin 2. tidal
      3. pool
   m. ditch, drain, canal
   n. pit
   o. fountain
   p. gutter
   q. road rut; wheel track
   r. crabhole ____
   s. rockhole ____
      1. volcanic
      2. coral
      3. boulder at stream margin
      4. seaside
   t. rockpool ____
   u. stumphole ____
   v. treehole ____
   w. bamboo
      1. cut or broken
      2. stump
      3. split
      4. uncut internode
   x. flower bract, spathe
   y. attached fruit, nut or pod ____
   z. leaf axil ____
      1. epiphytic
      2. terrestrial
   aa. pitcher plant ____
   bb. fallen plant part
      1. tree ____
      2. leaf ____
      3. frond ____
      4. spathe ____
      5. fruit ____
      6. nut ____
      7. rind ____
   cc. artif. container ____
   ____
   dd. trap, bamboo pot ____
   ____
   ee. other ____
3. Light
   a. deep shade
   b. partial shade
   (c. full sun)
4. Height of site above ground 0 m
5. Dist. collection from nearest home ____ m
6. Water
   a. permanence
      1. permanent
      2. semipermanent
      (3. temporary)
   b. movement
      (1. stagnant)
      2. slow
      3. moderate
      4. strong
   c. turbidity
      1. clear
      2. turbid ____
   d. color REDDISH BROWN
   e. pH ____
   f. hardness ____
   g. salinity
      (1. fresh)
      2. brackish ____
      3. salty ____
   h. pollution
      1. anaerobic
      2. other ____
   i. bottom
      (1. mud)
      2. sand
      3. gravel
      4. rock
      5. organic matter
         a. plant ____
         ____
         b. animal ____
         ____
7. Collection method ____
   DIPPER
8. Aquatic vegetation
   a. quantity
      1. none
      (2. scarce)
      3. some
      4. abundant
   b. location
      1. submerged ____
      (2. floating) ____
      3. emergent ____
   c. type
      (1. grassy) ____
      (2. herbaceous) ____
      3. woody ____
      4. algae
         a. green
         b. brown
         c. blue-green
         d. other ____
         ____
      5. other ____

HABITAT OF ADULTS

1. Specific site ____
   ____
2. Dist. collection from nearest home ____ m
3. Ht. above ground ____ m
4. Collection method
   a. light trap ____
   b. bait trap ____
   c. sweeping ____
   d. aspirator ____
   e. other ____
5. Behavior
   a. resting
      1. house
      2. animal shelter
      3. cave
      4. treehole
      5. vegetation
      6. other ____
   b. biting
      1. animal ____
      2. human ____
   c. landing
      1. animal ____
      2. human ____
   d. swarming ____
   e. mating ____
   f. flying ____
   g. attracted to ____
   h. other ____

REMARKS:

MANY SMALL CULEX AND ANOPHELES, MOST OF WHICH DIED.

SI-17, Rev. 2-24-82

FIGURE 1

COLLECTION FORM ADOPTED BY THE MIMP, BACK OF FORM

MUSEUM DATA No. 21

MASS REARINGS

	Species	L	l	P	p	M	F	E	♂G	♀G	Det.	Medical Importance	Spa. Code	Depository	Original Depository	Next Sequential Depository	Synonyms	Bibliography
-1	CX. CORONATOR	6	3	2	4		2			1	SJH			USNM	UCLA			
-2	AN. ALBIMANUS	1									MEF	MALARIA	1	USNM	UCLA			
-3	CX QUINQUEFASCIATUS										SJH			USNM	UCLA			
-4	CX. SP													USNM	UCLA			
-5																		
-6																		
-7																		
-8																		
-9																		

INDIVIDUAL REARINGS ✓present 0 lost + dead, preserved in alcohol

Ind	Species	p	M	F	G	Ind	Species	l	p	M	F	G	Ind	Species	l	p	M	F	G	Ind	Species	l	p	M	F	G
-100	CX. CORONATOR	✓		✓		-10	CX. CORONATOR	✓	✓		✓		-40							-70						
-101	CX. SP	✓	✓			-11	" "	✓	✓	+			-41							-71						
-102	CX. CORONATOR	✓	✓		✓	-12	" "	✓	✓	+			-42							-72						
-103	" "	✓		✓		-13	" "	✓	✓		+		-43							-73						
-104	CX. QUINQ.?	✓	✓			-14	" "	✓	✓	+			-44							-74						
-105	CX. CORONATOR	✓	✓			-15	" "	✓	✓		✓		-45							-75						
-106						-16	" "	✓	✓	+			-46							-76						
-107						-17	" "	✓	+				-47							-77						
-108						-18	" "	✓	✓	✓			-48							-78						
-109						-19	" "	✓	✓		✓		-49							-79						
-110						-20	AN. ALBIMANUS	✓	+				-50							-80						
-111						-21							-51							-81						
-112						-22							-52							-82						
-113						-23							-53							-83						
-114						-24							-54							-84						
-115						-25							-55							-85						
-116						-26							-56							-86						
-117						-27							-57							-87						
-118						-28							-58							-88						
-119						-29							-59							-89						
-120						-30							-60							-90						
-121						-31							-61							-91						
-122						-32							-62							-92						
-123						-33							-63							-93						
-124						-34							-64							-94						
-125						-35							-65							-95						
-126						-36							-66							-96						
-127						-37							-67							-97						
-128						-38							-68							-98						
-129						-39							-69							-99						
-130																										

REMARKS

TYPE DATA

1. Species: _____
2. Kind of type(s), life stages, type numbers: _____
3. Method of preparation: _____
4. Type designator: _____
5. Date of designation: _____
6. Type name: _____
7. Original type name: _____
8. Type publication: _____

FIGURE 2

HIERARCHICAL FILE STRUCTURE

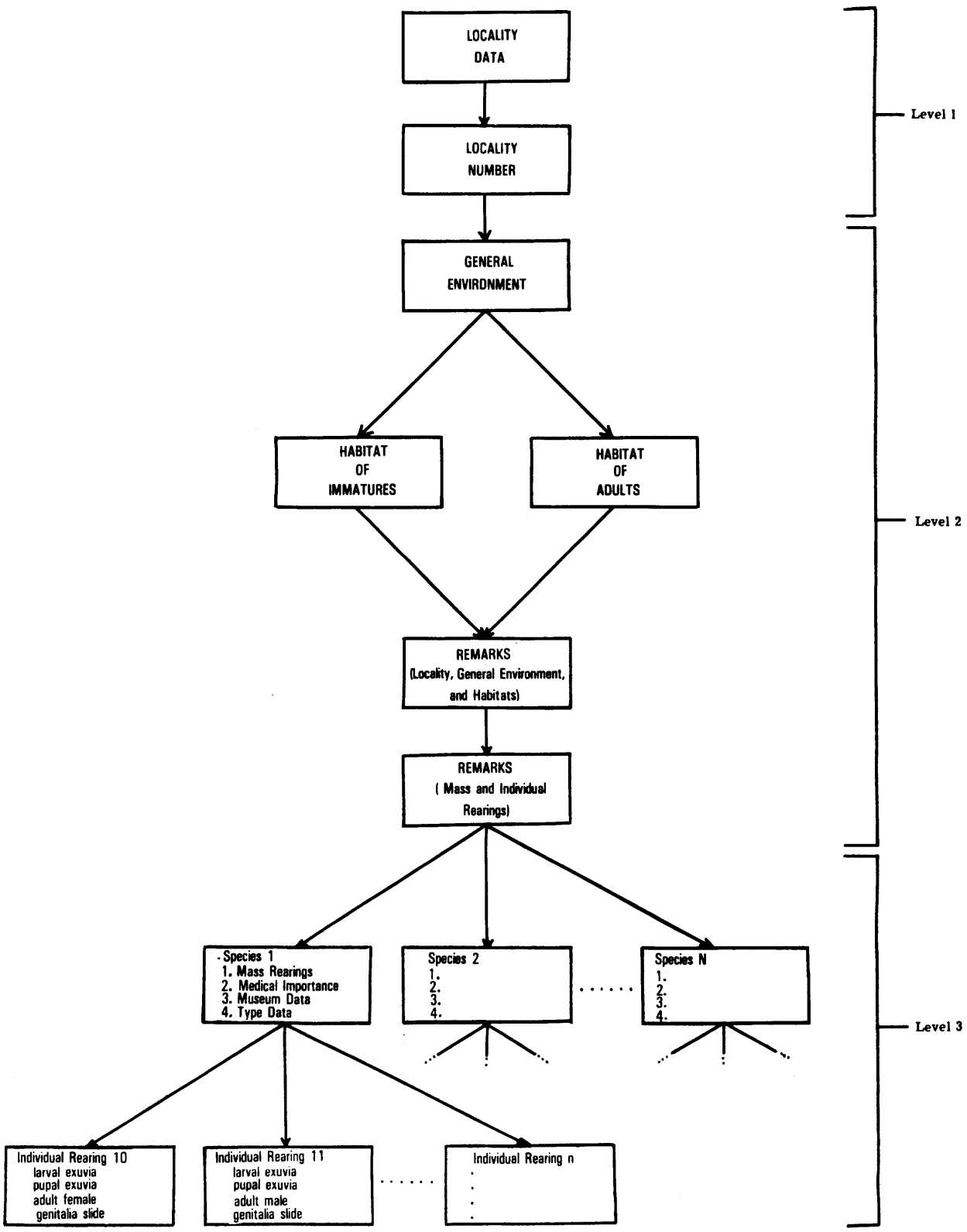

FIGURE 3

COMPUTER-GENERATED MAP OF *An. (Nys.) albimanus* AND *pseudopunctipennis* IN GUATEMALA

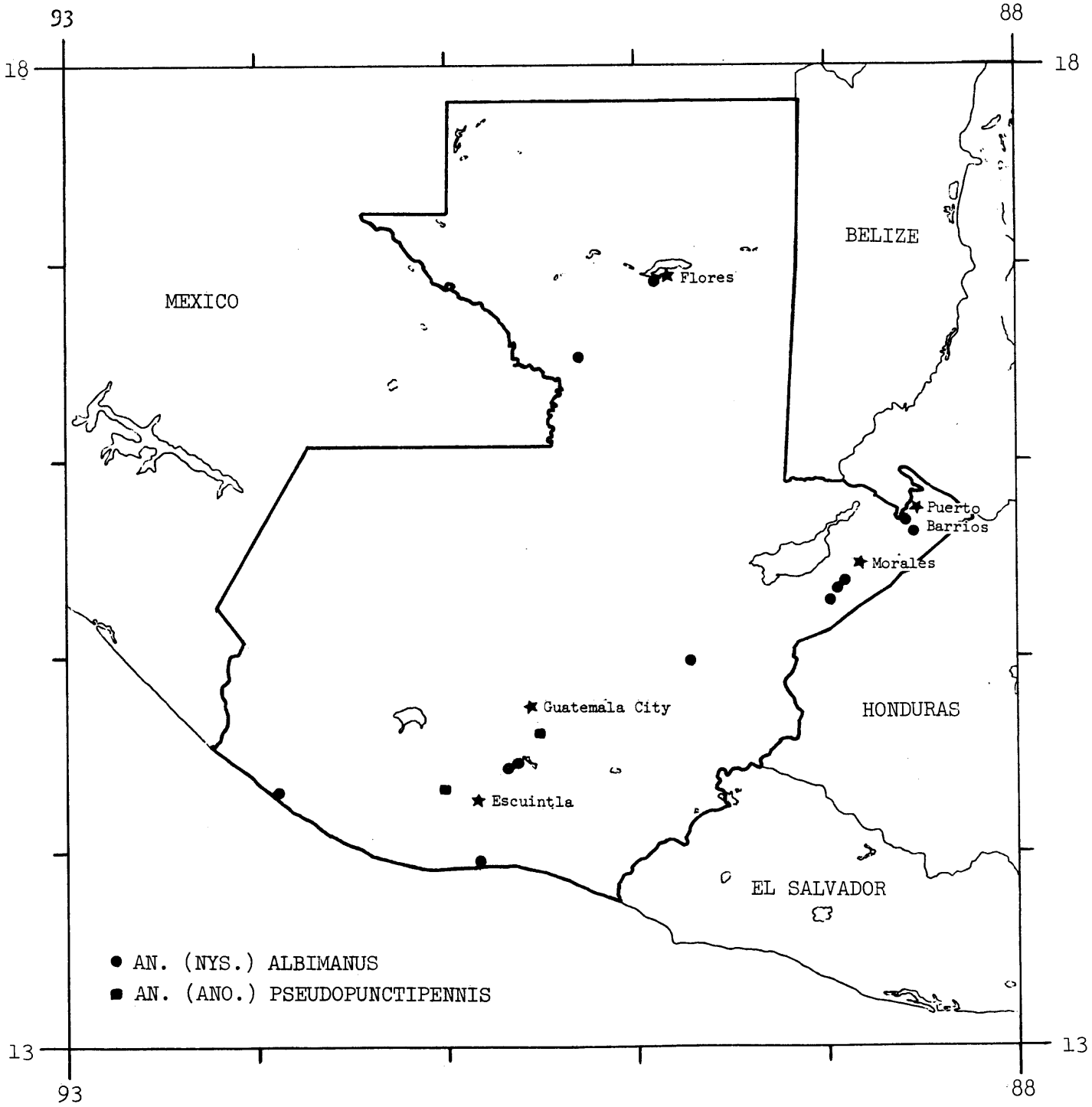

FIGURE 4

COMPUTER PRINTOUT OF *Anopheles (Nyssorhynchus) albimanus* COLLECTED IN GUATEMALA

SERIAL	CATEG	LINE	CAT-DEFINITION	....2....V....3....V....4....V....5....V....6....V....7....V....
20715130	005	01	COUNTRY CODE:	GUA
	010	01	COUNTRY:	GUATEMALA
	015	01	STATE/PROVINCE/DEPT:	RETALHULEU
	025	01	NEAREST TOWN:	CHAMPERICO
	030	01	SPECIFIC LOCALITY:	NATL. RT. 9S, KM 222.5, 1 KM N OF CHAMPERICO
	040	01	GRID COORDINATES:	15PXF1800081000
	050	01	ELEVATION (M):	000000
	055	01	DATE:	12 JUL 1964
	065	01	PHOTO:	YES; NO. 1
20715140	090	01	COLLECTION NO:	21
	140	02	VEGETATION TYPES:	GRASSY AREA
	170	01	HUMAN INFLUENCE:	DOMESTIC
	200	01	MODIFIERS:	LARGE
	205	01	BREEDING SITE:	GROUND POOL; IN GRASSY AREA
	210	01	LIGHT, DESCRIPTION:	FULL SUN
	215	01	HEIGHT ABOVE GROUND (M):	0000
	220	01	WATER PERMANENCE:	TEMPORARY
	225	01	WATER MOVEMENT:	STAGNANT
	230	01	WATER TURBIDITY:	COLORED
	235	01	WATER COLOR:	RED BROWN
	250	01	WATER SALINITY:	FRESH
	255	01	WATER POLLUTION:	FLOTAGE
	260	01	HABITAT BOTTOM:	MUD
	270	01	AQUATIC VEGETATION QUANTITY:	SCANTY
	275	01	AQUATIC VEGETATION LOCATION:	FLOATING
	280	01	AQUATIC VEGETATION TYPES:	GRASSY
	500	01	REMARKS:	MR: MANY SMALL CULEX & ANOPHELES, MOST OF WHICH DIED.
20715160	600	01	MASS REARING:	MR
	605	01	SPECIES:	2 AN. (NYS.) ALBIMANUS
	610	01	L I P p M F E G:	001 *** *** *** *** *** *** ***
	612	01	DETERMINER:	M. E. FARAN
	625	01	DEPOSITORY:	USNM UCLA
20715350	600	01	INDIVIDUAL REARING:	IR
	605	01	SPECIES:	020 AN. (NYS.) ALBIMANUS
	610	01	I p M F G:	X + * * *

FIGURE 5

DATA SUMMARY SHEET FOR *An. (Nys.) albimanus* IN GUATEMALA

1. TOTAL NUMBER OF COLLECTIONS - 12

2. COLLECTION NUMBERS and GEOGRAPHIC COORDINATES -

GUA 14	14 59 --N. 089 16 --W
GUA 21	14 18 --N. 091 55 --W
GUA 35	13 55 --N. 090 49 --W
GUA 45	14 27 --N. 090 34 --W
GUA 46	14 27 --N. 090 34 --W
GUA 49	14 29 --N. 090 37 --W
GUA 75	15 29 --N. 088 49 --W
GUA 92	15 19 --N. 088 58 --W
GUA 94	15 28 --N. 088 50 --W
GUA 95	15 28 --N. 088 50 --W
GUA 104	15 38 --N. 088 32 --W
GUA 126	14 18 --N. 091 55 --W

3. TOTAL NUMBER OF DEPARTMENTS - 4

4. DEPARTMENT NAMES and FREQUENCY OF OCCURRENCE -

ESCUINTLA	4
IZABAL	5
RETALHULEU	2
ZACAPA	1

5. ELEVATION RANGE - LOW 0
HIGH 1200

6. COLLECTION TYPES -

A. TOTAL NUMBER OF LARVAL HABITATS - 12

B. TOTAL NUMBER OF ADULT HABITATS - 0

C. HABITAT DESCRIPTIONS FOR LARVAL COLLECTIONS -

HUMAN INFLUENCE: DOMESTIC
MODIFIERS: LARGE
BREEDING SITE: GROUND POOL
COLLECTION NUMBERS:
GUA 21
GUA 49
GUA 126

HUMAN INFLUENCE: CULTIVATED FIELD
MODIFIERS:
BREEDING SITE: DITCH
COLLECTION NUMBERS:
GUA 92
GUA 95
GUA 104