STRATEGIES OF COMPUTER USE IN MOSQUITO CONTROL[1]

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ABSTRACT. The major applications of the computer to mosquito control can be categorized into information processing, information storage, information retrieval, mosquito population modeling, routing optimization and small business applications. Each application is described and several references are provided for more detailed information. Some projections are made concerning the potential of future uses of the computer in mosquito control.

The most frequently received request of the Automated Data Processing Committee is for a description of the uses of a computer in mosquito control. The applications fall into the following categories: information processing, information storage or record keeping, information retrieval for reporting or increased efficiency of operation, mosquito population modeling, routing optimization and business applications. The purpose of this article is to describe and provide references where these applications are discussed in greater detail.

Before beginning, it is important to realize that only a well-run mosquito control program will benefit from computerization. A computer will not magically turn a shoddy operation into a shining one. Well-trained inspectors, experienced entomologists and effective managers provide the basis for an efficient mosquito control program. When combined with computer technology, these components may provide an unbeatable team.

INFORMATION PROCESSING

Information processing and storage are governed by the well-known GIGO rule (i.e, garbage in = garbage out). If the field inspectors do not submit accurate and detailed reports then the computer will supply inaccurate and/or useless information to the manager. Quality control of the information to be stored in the computer is an absolute necessity.

The ability of many computer programs to process information is directly related to the internal memory capacity of the particular machine chosen. Memory capacity is usually expressed in bytes with each byte storing one alphabetic character or number. Depending upon the type and size of computer used by an organization, internal memory capacity may range from 48,000 bytes (48K) on a small microcomputer to virtually unlimited memory capacity on the large maxicomputers.

Information processing is most easily accomplished by using one of the many electronic worksheet programs commercially available from software vendors. *Visicalc* (Visicorp, 2895 Zanker Road, San Jose, CA 95134) is perhaps the most popular of these electronic worksheets being currently utilized by an estimated million people. *Visicalc* appears on the screen of the computer monitor as a row of numbers down the side and a row of letters across the top. Using arrow controls on the keyboard, one can scroll down 254 rows and over 63 columns, giving one over 13,000 data entry points. At each of these points one can either enter a word (e.g., Jan, Feb, Mar, etc. for column headings, and mosquito species names for row labels), a number (e.g., how many *Culex pipiens* in Jan), or a formula (e.g., the sum of all number entries for a given month or a given species). The program will automatically fill in the points where one puts the formula. If one changes a numerical entry the program will utilize the formulas to recalculate the entire sheet within seconds. Fleugelman (1982) compares the major software packages which act as electronic worksheets.

Small memory microcomputers quickly reach their limit when one considers that one normal light trap weekly report takes over 9000 bytes. This means that even on the larger microcomputers (256K to 512K), less than 56 weekly light trap reports can be in memory at one time. This is ample if one has only two light traps whose data correlates with other data (e.g., weather, complaints, etc.) for a 6-month season. As a general rule, it is advisable when developing a computer hardware system to buy an expandable system with as much memory as

[1] The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the AMCA. Use of proprietary names does not constitute endorsement.

one can afford (The' 1982). If information processing is a major application that is envisioned, select carefully the software package which is needed for the agency's computer system and test it before buying.

INFORMATION STORAGE

Information storage does not require all the data to be in the internal memory of the computer at once. In this application, the Mosquito Abatement District is primarily interested in using the computer to permanently store inspection or light trap reports (or some other information) like an electronic filing cabinet. For example, breeding site data (the 20 questions asked about each breeding site by Kings Mosquito Abatement District inspectors) can be stored by a data base management system that utilizes external memory (i.e., a flexible disk, a magnetic tape or the new Winchester hard disk). These devices extend the external memory up to and beyond 5 million bytes (5 Mb), even with a microcomputer. This application was one of the first documented (White and Grodhaus 1972) and is explained in greater detail by Russo and McCain (1979). Most of these programs are flexible enough to allow the storage of all types of data in the multiple fields or parts of each record (a single inspection or observation). Coudal (1982) provides a detailed explanation of how data base management systems operate and their applications for managers.

It is not difficult to foresee the time when presently available technology will be more fully utilized in mosquito control. For example, a field inspector could enter all his inspection data (e.g., map number, site type, larvae/dip, larval stage, landing rate counts, etc.) on a hand held, battery-operated pocket computer (cost around $250) which would store the information on a cassette recorder (another $100). Later, this data would be transferred to the main computer by simply plugging the recorder into the computer. When used in conjunction with an error checking program, this procedure would bypass the time consuming manual entry of data via the main computer's keyboard.

INFORMATION RETRIEVAL

To the scientist, the production of information may be its own reward. In today's pragmatic and economically oriented world, it is usually necessary to utilize information to produce some recognizable benefit to the organization that pays for collecting that information. In other words, all of the data on weather parameters (e.g., precipitation, temperature, relative humidity, wind), breeding sites (site area, depth, habitat type, larval density), adult activity (resting sites, light traps, landing rates), and public relations (complaints) one stores in a computer should eventually help provide a better service at decreased real cost, thereby justifying the program.

The utilization of stored information depends on the computer's ability to retrieve the information in various formats. For example, one might want to know where in his territory heavy breeding was occurring in the last inspection cycle. Or one might want to know when the last time the public ditch in front of Ms.X's home was cleaned and/or larvicided. One would need to know the ADI (adult density index) in various areas on a daily basis to accurately schedule the ground adulticiding. On the other hand, one might only want a quick check on which of the district's 25 workers happen to be sick only on Mondays and/or Fridays. Previous breeding site inspection reports can even be used to prioritize the site inspection sequence so that the most likely or most productive breeding sites are visited sooner and more frequently. This application was the primary purpose of MIRS (the Mosquito Information Retrieval System) (Russo and McCain 1979).

With sufficient optimal equipment, the computer can generate various types of graphs and may even draw maps on which are indicated various interesting data (e.g., mosquito densities, mosquito-borne diseases, rainfall and temperature, etc.). Such visualizations of numerical data can be quite helpful in decision making. As more mosquito abatement programs begin to increase computer usage, specialized programs will be developed by mosquito control personnel. Eventually it should be possible to dial up the AMCA computer bulletin board with the microcomputer, examine their library of available programs, and download (i.e., load into the microcomputer) programs which are of interest, or conversely, add one's own programs or program modifications to their library.

Of course, information retrieval from one's own system will always be the most important type for running the agency's program. However, it is now possible with a small computer and a low cost ($150) modem (phone hook up) to access considerable information through such commercial data bases as The Source, CompuServe, and Micro-net. Although Notre Dame's MODABUND (Mosquito Biology Data Bank) (Crovello 1972) is no longer available, it provided the capability of searching through all the references collected by Helen Sollers-

Riedel. With the current communications technology, it would have been feasible to perform a search of MODABUND from a remote location. In the near future, a vast amount of information on pesticides and various pest control technologies will undoubtedly be available at the fingertips of the computer user.

MOSQUITO POPULATION MODELING

Although the prediction of the activity of specific mosquito populations through the monitoring of environmental parameters and use of a computer population model is highly desirable, such models are not generally available. The problem is not the handling of the immense amount of variable data nor the difficult mathematics involved. The problem is that in most cases the years of historical data necessary for a historical model and/or the majority of population pressures and their complex interrelationships are not sufficiently understood.

Current models of insect populations fall into two general categories: mechanistic and regression. Mechanistic models make their predictions based upon the suspected interrelationships among the components of the natural environment. The structure of these models attempts to mimic the interaction of the variables in the real world to predict when and where mosquitoes will occur. Such models are constructed using years of experimentation and observation of natural mosquito producing habitats. For example, rainfall or tide level data interact with temperature to provide the most important abiotic stimuli for the initiation and maintenance of larval populations. When combined with egg distribution data or adult population estimates of the preceding season, we have a generalized model which predicts larval population sizes. However, this type of model is by necessity general, describing large classes of breeding sites, at best, and thus is incapable of matching the subtle differences which make each breeding site unique. Examples of these attempts are described by Conway (1970), Haile and Weidhaas (1976), Weidhaas (1974) and Hagstrum (1971). Efforts have also been made to predict the interaction of biological control agents (e.g., *Toxorhynchites*) with pest mosquito populations (Focks et al. 1978) or genetically altered mosquitoes with wild populations (von Ende 1978).

The second approach to modeling mosquito populations is to use historical information to identify the relative importance of each causative factor. The relative importance values (regression coefficients) are then used in an equation, usually of a polynomial form ($Y = aX1 + bX2 + cX3$), to predict the number of mosquitoes which will result. This type of model does not try to mimic the mechanism which produces mosquitoes, but only acknowledges the relative importance of certain variables and then multiplies each coefficient by the current value of the parameter to make its prediction. While this type of model can be built for each breeding site, it requires the data from numerous site inspections over a wide range of environmental conditions to estimate the regression coefficients. And then the regression coefficients are averages which cannot predict stochastic environmental effects. Examples of this type of model are Hacker et al. (1973), Hacker et al. (1975) and Hayes and Downs (1980).

As field research defines these variables and their interrelationships, the computer will be ready to correlate them into a viable model that will be of great value in predicting mosquito populations and thus allow more precise allocation of limited resources. Because these powerful models will eventually be available and will require historical data, it is important to generate and store such data now.

ROUTING OPTIMIZATION

A standard problem faced in many industries involves the selection of the shortest route which passes through a set of intermediate locations before completion of the trip. This is called the transportation problem and can be solved by linear programming using the simplex algorithm developed during World War II. This type of problem is solved by several application packages available on both microcomputers and larger mainframes. Software Engineering Systems (3204 80th St., Lubbock, TX 79423) has developed a package called Mathematical Programming and Decision Science Software (865 Castle Ridge Road, Austin, TX 78746) has produced LP-80 (Douglass 1982) which can be used to solve routing optimization problems. Some localities already utilize such programs on their large computers to efficiently route their garbage trucks, making sure that on a given pickup route the truck makes as many right turns as possible and backtracks as little as possible. The optimization of standardized inspection and/or treatment routes would save time, gas, and money. Eventually, one should be able to type into the computer where in the city one wishes to go and where one is and have the computer generate a map with the shortest route indicated passing by the mosquito breeding sites which must be treated.

SMALL BUSINESS APPLICATIONS

Sufficient software and hardware are currently available to meet almost any small business application. Many mosquito control programs throughout the country are either local government entities tied to a large computer for purposes of payroll and personnel, or have contracted out their computing to a private business. Many other MADs are using the tremendous variety of business software packages available for microcomputers. Cubbedge (1982) reviews the best of the accounting application packages for microcomputers and Gabel (1982) presents an excellent comparison of word processors.

Manual accounting systems may be entirely sufficient for an outfit of three people, but they are wasteful of time when one is dealing with 15 to 30 people, 10 pieces of equipment and several thousand dollars of pesticides. Good, reliable programs for doing payroll, accounts receivable, and word processing are readily available on all but the smallest microcomputers. And, at a total cost (computer+ software) of less than $5000 (less than a pickup truck in many cases), it is only the smallest mosquito abatement districts that can afford to be without this capability.

CONCLUSIONS

In the future it is likely that separate programs within the same geographic boundaries will communicate and share data directly computer to computer. Such communication will, it is hoped, begin to obliterate the political boundaries that sometimes inhibit mosquito control without affecting mosquito movement.

We are certain that other applications will be found for computers in mosquito control as the number of agencies using the computer increases. Usually, the most innovative applications are developed by the workers within an area, not by the uninvolved computer programmer.

The computer by itself has yet to kill the first mosquito. It is a tool. One that can be utilized to great advantage by those willing to take the time to learn how to use it. The computer is no more a cure-all for mosquito problems than was DDT, the automobile, fuel oil, or the shovel. But it has the promise and potential of being no less useful a tool than any of these have been.

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