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Paper No. 2

APPLICATION OF THE CONCEPT OF INTEGRATED PEST MANAGEMENT (IPM) TO MOSQUITO CONTROL PROGRAMS

J. K. OLSON

Dept. of Entomology, Texas Agricultural Experiment Station, Texas A & M University, College Station, Texas 77843

ABSTRACT. Integrated Pest Management (IPM), as it relates to mosquito control, is simply the proper and systematic execution of all the facets comprising an organized mosquito abatement program. Therefore, the various organized mosquito abatement programs in the United States which are being properly executed are primary examples of how the philosophy of IPM may be applied to solving mosquito-related problems. The TVA (Tennessee Valley Authority) mosquito management program stands as another example of the beneficial results which can be realized when a specific mosquito problem is approached in a systematic manner.

Scientists are now joining forces to develop management strategies for mosquito problems that have yet to be solved. An example of this is the Cooperative Research, USDA, Regional Project, S-122, designed specifically to begin developing strategies for the systematic management of mosquito populations emanating from riceland areas in the southern United States. Most recently, this concept and approach was expanded through the auspices of a research grant proposal to EPA to include nearly all rice producing areas in the United States. If funded, the latter research program will involve the coordinated scientific and educational input from a consortium of 6 universities in Texas, Louisiana, Mississippi, Arkansas and California.

As part of this panel, I was asked to explain how the concept of Integrated Pest Management (IPM) can be applied to mosquito control programs and to give examples of the application of this concept which are already in force. Dr. Axtell has already presented an excellent general overview of the concept; and, by the nature of his presentation, one can see that IPM means different things to different people. To me, IPM is a form of applied ecology and, in that context, is really a *philosophy* more than an exact science, since it guides one to systematize and interpret scientific knowledge concerning target pest populations (such as mosquitoes) using the basic concepts of reality, validity and value. Subscription to an applied ecological philosophy such as IPM dictates that one must first gain a basic understanding of the interrelationships of a target pest population with its environment, and then use that information to devise and implement means for systematically reducing the pest populations to sizes which can be tolerated in terms of human health and/or economy. As part of the overall philosophy of ecology, the philosophy of IPM further dictates that the management schemes devised for the suppression of pest insects take the environment into account and be as compatible with the environment as possible. This is no small task as many people involved in mosquito control already know.

In its application to mosquito control, IPM can be considered to be a new word for what used to be done to solve mosquito problems before the discovery of DDT. In Washington, D. C., IPM has become a beneficial "buzz word" that has stimulated a movement to take the information sandwiched between the covers of innumerable journals gathering dust on the shelves of our nation's libraries and to blend this information with new scientific discoveries and technologies in such a way that we can finally begin applying this information and technology in a systematic way to solve specific pest-related problems.

In the framework of my definition of IPM and my views on this concept of pest management as it relates to mosquitoes, I consider IPM from an operational standpoint as simply another term for "Organized Mosquito Control." However, an organized mosquito abatement program qualifies as an IPM program only if it is *properly* and *conscientiously* executed by each and every person involved in such a program. Also, an organized mosquito control program is IPM provided that the program takes the discovery of new effective mosquito control approaches and technologies into account and has the latitude, willingness, and means for applying these discoveries to the solution of its particular mosquito-related problems in such a manner that the total program is as compatible with the environment as possible.

An ad hoc panel co-chaired by Drs. Ernest C. Bay and David Pimental was charged by the National Academy of Sciences in 1972 to give their perspectives in mosquito control methods which were suitable for developing countries (National Academy of Sciences 1973). The criteria that this panel felt must be satisfied in an IPM or systems management approach to mosquito control are summarized as follows:

1. An understanding of the ecologies of the mosquitoes involved and of their relative importance to man.
2. A quantitative analysis of the costs and benefits that a program will impart to man and his environment.
3. Implementation of source reduction programs when possible.
4. Development and implementation of a supplemental program involving an integration of complementary control methods.
5. Development of a monitoring (surveillance) system that will detect changes in the effects of the mosquito control program.
6. A constant update of the control program to meet changes in the ecologies of the target mosquitoes.

Those knowledgeable in the applied and theoretical aspects of organized mosquito control will find little difference between these criteria and those set forth for many of the existing organized mosquito control programs and otherwise outlined for this approach to mosquito control in the Bureau of Vector Control Memorandum, dated April 30, 1948 (as quoted by Usinger 1956). The criteria for a systems approach to mosquito control have, therefore, been in existence for a long time. The problem has been in the failure of some mosquito control programs to satisfy certain of these criteria.

The primary basis for the success of any IPM program is the development of a surveillance system which initially supplies the data needed to gain the knowledge and understanding of the ecologies of the target pest species involved and which also supplies data on not only the environmental factors that serve to support the existence of the pest but also on the factors that may already be contributing to the suppression of the pest. This step in the process is usually accomplished by most organized mosquito control programs, at least to the level of collecting and identifying target mosquito species and identifying the sources of these mosquitoes; for, it is this information that is needed to begin developing the plan that will be used to abate the problem and to determine the cost for implementing the plan. However, in many instances, mosquito control surveillance programs fail to pay adequate attention to the assessment of the environmental factors that are already in force against the target mosquito populations.

Of even a more serious nature, many abatement programs reduce or, in many cases, eliminate surveillance efforts after a few years due to the cost in time, manpower, and funds needed for these efforts. This is unfortunate because when one looks to a successful management program, regardless of whether it is crop pest-oriented or mosquito control-oriented, the success of the program most often hinges on a strong surveillance system which continuously and accurately monitors the status of not only the target pest populations but also the natural controlling factors that are in force against these populations. Such surveillance systems provide the data needed to make accurate day to day operational decisions as to when, where and what strategies should be employed against target mosquito populations; and sometimes more importantly, deciding whether or not any additional abatement strategies should be employed over and above those already in force. A good surveillance system should also provide for a means to detect changes in the ecologies of the target mosquitoes and the naturally occurring control factors that might stand to reduce or even compromise the effectiveness of the program that is being followed. If such changes are detected, then, as already mentioned, the program should be reviewed and updated or modified so as to meet these changes.

Once the problem has been identified and assessed, IPM programs, as well as properly executed organized mosquito abatement programs, require the development and implementation of the strategies that will effectively reduce the problem. All too often the bulk of the strategies developed in recent years for insect pest control have begun and ended at the orifice of a spray nozzle. However, in the framework of the philosophies behind IPM and organized mosquito control, the chemical approach to insect control is but one of many strategies that should be looked to as to their suitability for use in a systematic, integrated scheme of approaches designed specifically for the type of insect pest problems that exist in a given area. At the same time, IPM programs should *not* in any way be considered as alternatives to the use of pesticides; but rather, they should be viewed as alternatives to the *indiscriminate and continuous use* of pesticides as was pointed out by Chasen (1979). In no way does IPM imply in its concept, or in its application, eliminating the need for or the use of pesticides as a means for reducing insect pest-related problems. Indeed, in many instances there are no other alternatives, particularly when one is concerned with suppressing outbreaks of vector-borne diseases such as St. Louis encephalitis (SLE). IPM in practice dictates only that, when the use of chemicals is indicated, all efforts be taken to insure that their use does not disrupt the other control measures that are in force—be they man-induced or ones that occur naturally. In other words, the chemical approach to mosquito control must be *integrated* with all the other approaches that have been incorporated into the overall management program.

Regardless of the philosophy on insect control that a given person might have, there are few people involved in mosquito control who would not agree that more care will have to be taken as to how and when chemicals should be employed in the future. This increased care in the use of chemicals is due not only to the desire to safeguard the environment but also due to the need to preserve the effectiveness of the already limited arsenal of chemicals which are effective against mosquitoes. These limitations have arisen as a result of (1) increased occurrence of insecticide resistance of mosquitoes to several key chemicals; (2) environmental hazards associated with some of the chemicals and the corresponding restrictions being placed on the use of these chemicals; and (3) reluctance on the part of chemical companies to develop new chemicals designed specifically for mosquito control due to development costs and the limited market. The integration of chemical approaches with non-chemical ones, in the manner advocated by the concepts of IPM and organized mosquito control, is certainly one way that effective chemicals may be preserved for the future.

One facet of IPM where a mosquito manager may have one up on the crop-pest manager is the former's appreciation for and attempts to implement source reduction as an integral part of a total pest management program. But even here, care must be taken to insure that efforts made to eliminate sources of mosquito problems do not result in the creation of worse ones. Again, an accurate in depth assessment of the need for such an approach as well as the impact that this approach will have on the environment must be taken into account just as is the case for any other approach to mosquito control.

In the mosquito control business, preventing source *production* is often as important as source reduction. Mosquito control people sometimes have the chance to perceive potential sources of mosquito breeding sites before they are ever created; and, if they are able to get involved in the early planning stages of such projects as the construction of dams and associated reservoirs, sewage treatment systems, and housing development projects while such projects are still in the planning stages, they often have the knowledge and means by which measures can be included in those plans which will prevent the production of mosquitoes or at least significantly reduce the problem. The mosquito control strategies developed by the Tennessee Valley Authority (TVA) during its planning phases stands as a monument to this approach (TVA and U.S. Publ. Hlth. Serv. 1947). Such an approach involves close cooperation and coordination between people representing a wide variety of professional disciplines and public service agencies; and most importantly, it requires strong public support. In fact, regardless of the strategies decided upon, an IPM program or organized mosquito control effort requires strong public support and acceptance in order for it to be effectively implemented. Such public support is gained through designing and executing effective public relations and educational programs. This aspect of a total IPM effort has been a central theme of organized mosquito control since its conception; but again, such programs are often overlooked or given low priority by many mosquito control agencies in the face of other activities which are considered to be more important. This is unfortunate since, from the standpoint of gaining public and political support for mosquito control efforts, public relations and educational programs are probably one of the most important facets of an organized mosquito control effort. It is important to remember that the human is the one species in any ecosystem which will probably finally prove to be the one most difficult to manage.

Thus, from an operational standpoint a person versed in the concepts of organized mosquito control should not be overawed by the philosophy of IPM; but rather, he or she should view it as a challenge to execute organized mosquito abatement properly. From the scientific standpoint, the challenge in true IPM programs is not so much the search for new scientific discoveries, although this is still required in order to seek out new and better means for manipulating pest populations. The real challenge to the scientists involved in IPM efforts is taking already existing scientific discoveries and refining these discoveries into a scheme of strategies that can be used specifically for and systematically against a target pest population residing in a given environmental system. So much of what is known about pests and their management has been left at the level of discovery and is fragmented over a wide variety of scientific and technological disciplines.

There is a need, therefore, to assemble this knowledge under the umbrella of interdisciplinary research and educational efforts and to develop this knowledge into operational packages which are in a form which can be presented to and implemented by those who need it so desperately. This tends to be the major theme of the federal and state supported IPM research and educational programs such as the USDA, SEA Cooperative Research supported Southern Regional Project S-122 referred to by Dr. Harold Chapman in his remarks at the AMCA meeting in Chicago in 1977. This particular project involves cooperative and coordinated input from scientists associated with Agricultural Research, SEA, USDA and the State Experiment Stations located in Texas, Mississippi, Louisiana and Arkansas and deals with the development of management strategies that will pertain to mosquito populations emanating from riceland areas of the southern region of the United States.

More recently, the concept of interdisciplinary and interinstitutional cooperative IPM research on riceland mosquito management was expanded through the auspices of a research grant proposal to the Environmental Protection Agency (EPA) so as to include those institutions and scientists involved in riceland mosquito management work in California. The proposed program is designed to bring together formally for the first time all major research efforts in the United States concerned specifically with riceland mosquito control and to unify these efforts into an organization of coordinated research which will draw upon the research strengths and disciplinary expertise within each participating institution to accomplish the overall program objectives with the intention of avoiding duplication of research effort whenever and wherever possible. The organization is such that each participating institution has developed specific research objectives designed toward providing packages of data and information revolving around the accomplishment of two major research tasks: (1) The Riceland Agroecosystems Analysis Research Task and (2) The Mosquito Management Methodology Research Task.

Research objectives under the Riceland Agroecosystem Analysis Task will supply the information necessary for ascertaining the biological and ecological nature of the riceland agroecosystems in the United States and man's present influence on these systems as it pertains to mosquito population dynamics, the occurrence and dynamics of nontarget, terrestrial and aquatic flora and fauna communities and means for accurately predicting changes in the biotic structure and dynamics of the riceland ecosystem which occur, or may occur, as the result of natural or man-induced changes in the environment. The specific research objectives accomplished as part of the Mosquito Management Methodology Task will supply the information key to assessing the efficacy, environmental impact, and economic feasibility of implementing individual approaches to suppressing riceland mosquito populations and information essential to integrating effectively these approaches into management schemes which will provide the answer to mosquito control problems inherent to riceland agroecosystems in the United States.

Both the regional project and the proposed expanded riceland mosquito IPM program were developed on the premise that mosquito populations breeding in riceland agroecosystems are among the most likely targets for the immediate application of IPM schemes since they have adapted themselves to habitats which are already largely under the control of man and have become rather dependent upon man and the schemes he has developed to manage his land for their continued existence in these agroecosystems. It is felt, therefore, that these particular mosquito populations can be effectively suppressed through a combination of altering riceland and livestock management practices to the disadvantage of the mosquitoes and augmenting these cultural approaches with ones designed specifically for mosquito suppression. The ultimate goal then will be to develop a total management plan which would render the riceland system unsuitable for mosquitoes yet highly productive from the standpoint of its agricultural intent.

Again, these 2 programs serve only as examples of the direction being taken by those involved in the research aspects of IPM as it relates to mosquito control. The future will no doubt see similar efforts being directed to other mosquito problems. One benefit that is usually realized immediately by those becoming involved in such programs is the establishment of good lines of communication, and the spirit of cooperation between the people and agencies upon whose shoulders rests the challenge of seeking out and implementing systematic schemes of solving mosquito-related problems.

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