MINIMIZING MOSQUITO BREEDING IN IRRIGATED PASTURES

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As a source of mosquitoes, water used for irrigation would seem, at first glance, to present a rather unique problem to the mosquito control worker. For example, most mosquito breeding places, such as the backyard tin can, the clogged eaves trough, the industrial by-product waste water, the sewage settling pond, the swamp or salt marsh, are also undesirable for other reasons. The simplest way to minimize mosquito breeding in them is to eliminate them, and allies can usually be found who are anxious to cooperate to that end.

Irrigation water, on the other hand, represents the livelihood of a large and important segment of our population, and the foodstuffs produced through its use feed much of the world. It is transported hundreds of miles and pumped up thousands of feet, arriving at its destination not by accident, but through concerted effort, and is deliberately placed in the field where it becomes a mosquito source. This might appear to be a variety of mosquito-breeding place about which little could be done in the way of minimization.

Fortunately, however, *water used for irrigation presents no mosquito problem.* Water actually in use for plant production, except in the case of rice, is below the surface of the soil, in the root zone of the crop, and can obviously produce no mosquitoes there. To quote from California Agricultural Experiment Station Circular

439, *Mosquito Control on the Farm,* "Water standing on fields for excessive periods of time reduces crop yields, encourages the growth of water-loving, weedy plants, presents an unhealthy environment for livestock, and may do injury to the soil. Water which stands on fields for more than 24 hours after irrigation is of no benefit to crops—but water standing for 24 or even 48 hours, will not produce mosquitoes."

It is the water *mis*-used and wasted which breeds mosquitoes, and this fact puts it right into the same category as the other sources mentioned above, as undesirable water which can and should be eliminated.

The foregoing statements, while referring to all irrigated lands in general, apply even more strongly to irrigated pastures in particular. With the possible exception of rice fields, pastures are the most prolific mosquito producers of all irrigated lands, and for a very simple economic reason. With most other crops, the plants grown are the direct means of livelihood of the farmer, pure stands pay best, and annual incomes are directly and obviously related to per-acre yields. Pasture grasses, on the other hand, are secondary crops. The farmer's income is derived from the sale of milk, meat, or animals, not plant materials, and the relationship between this income and the per-acre yield of the land is indirect and less obvious.

When, because of excess water standing on the surface of a field, a stand of cotton, alfalfa, tomatoes, or other money crop begins to drown out, the damage is immediately obvious, and so is the cure. The farmer quickly takes the necessary steps to get rid of the water, not to prevent mosquito production but to protect his pocketbook.

However, when the same thing occurs in an irrigated pasture, it is far less obvious, even to one as intimate with the land as the man who is operating it. Pastures are usually mixed stands to start with, and therefore present a heterogeneous appearance at best. When the original grasses drown out they are quickly replaced by water-loving weeds which, until a full-fledged swamp has developed, give the impression, to a hasty glance, that feed is being produced throughout the field. And most of the time a hasty glance is all they get, because the farmer is looking at the livestock in the field, not at the individual plants underfoot. Unfortunately, these animals do not reflect the low-grade quality of the feed too obviously, supplementary feeding often obscures the picture, and there seldom is a good direct comparison to be drawn between these animals and those produced on a field without standing water, other factors being equal. Where such comparisons have been possible, they almost invariably point up the economic value of eliminating the excess water. The Crocker-Huffman Land and Cattle Company of Merced, California, for instance, has been able to demonstrate a consistent fifty pound per head advantage at time of sale on beef cattle raised in pastures drained by the local Mosquito Abatement District, over those on undrained pastures.

So the allies necessary to cooperate with and help the mosquito control agency in reducing the mosquito breeding in irrigated pastures are potentially available. But they need to be cultivated and developed, and throughout the following discussion of the actual methods of achieving the minimization of pasture mosquito production, it should be constantly kept in mind that education is the best single tool which the mosquito worker has at his command. Most of the means of reducing mosquito sources in pastures are physically beyond the means, legally beyond the power, and ethically beyond the responsibility of the control agency. The only hope of accomplishing them lies in teaching their advantages, showing the individual farmer how they will directly benefit him, and making him want to cooperate in order to improve himself financially, and, maybe, incidentally, to get rid of the mosquitoes. He doesn't really like mosquitoes, but, in too many instances, has felt that they were just a necessary evil incident to his way of life.

Mosquito breeding in irrigated pastures may be minimized by care in planning of fields and their irrigation systems, by close and constant attention to the quantity of water applied and the method of applying it, by installation and use of a drainage system, or for greatest efficiency, by a combination of all three of these practices.

Careful preparation of pasture-land, prior to seeding, is the method likely to give longest-lasting results as far as both mosquito control and crop production are concerned. It is also the hardest program for a mosquito control agency to sell to the average farmer. Scientific planning and sound engineering in the design of the field's slope, checks, borders, and water delivery and spreading structures, based upon local soil characteristics and water supply factors, pay dividends in better yields and improvement of the land. But they represent a major capital outlay and the farmer who is hard-pressed for cash *because* his yields are low is frequently the most difficult to convince that such an expenditure is justified and will return in increased profits in a relatively short time. This is particularly true, of course, during periods of unsettled food prices, when the farmer is uncertain what his product will be worth over the next few years.

For these reasons, because few mosquito agencies are equipped or financed to perform such major construction work, and because it would be difficult to justify improving an individual's property to such an extent at the expense of the taxpayers, most agencies confine their efforts to improving pasture-land preparation, to pointing out its advantages to the owner, and to making recommendations as to the best means of carrying it out.

The second general method of minimizing mosquito production, the use of good irrigation practices, is also beyond the direct control of the mosquito agency. Historically, the development of irrigated agriculture has been a constant fight to obtain water and water rights. As a result of the fixed devotion to this cause over several generations, it is often difficult to convince the man who has acquired the right to put water on his arid land that it is possible to get too much of a good thing. Cooperative studies made by the California State Health Department's Bureau of Vector Control and the USDA Agricultural Research Service in Merced County, have shown over several years and with a variety of methods of irrigation that the degree of irrigation efficiency (i.e., achieving maximum plant use of available water) has a conspicuous inverse relationship to the numbers of mosquitoes produced. Fields in which maximum plant use was made of minimum quantities of water consistently produced fewer mosquitoes, and most of the water in the fields which produced mosquitoes was wasted as far as the crop was concerned.

Again, the agency's best approach to this aspect of the problem is education of the individual and demonstration that a little less water will produce greater crop yields at less cost.

The third general method of reducing sources of mosquitoes in pastures, and the one in which mosquito control agencies can participate most actively, is drainage of excess water from the fields before it can produce mosquitoes. The best-prepared pasture settles and deteriorates with time, creating water-holding low spots, and the most conscientious irrigator is capable of human error in estimating water flow or the current ability of the soil to take moisture. When these events occur the result is the production of mosquitoes unless some provision is made for removal of excess water.

Machinery used for construction of pasture drainage systems is within the financial capabilites of most agencies, and basically is the same earth-moving equipment used for draining or filling natural swamps or salt marshes. Simple cost accounting shows that expenditures made by the agency in constructing such systems are usually more than made up in savings in spray costs. A few examples of this, from

TABLE 1.—Comparative costs of larviciding before and after drainage in Merced County

	Pasture Area	Larviciding Cost for One Season	Cost of Drainage	Larviciding Cost Season Following Drainage
Case A	1200 acres	$1,275.00	$81.00	$295.00
Case B	100 acres	201.00	52.00	19.00
Case C	33 acres	29.00	11.00	———

the Merced County Mosquito Abatement District records, are given in table 1.

Because again we have the ethical problem of improving an individual's property at the cost of the taxpayers at large, and because under most legal codes, the responsibility for such work is the landowner's, most agencies require financial participation on the part of the owner, usually to the extent of re-paying the operating costs of the machinery used.

Two general methods of disposing of this excess water are widely employed; drainage of the water to a sump from which it is pumped back into the field's irrigation system, and drainage to a natural outlet. A third method, drainage to a so-called "upside-down-well" to put the water into the underground water-table, is sometimes employed, but is not too practical because of the danger of contamination of water supplies and the tendency of these drainage wells to clog with silt.

The re-circulation system, which has been most highly developed by the Kern and Delta Mosquito Abatement Districts of California, has its greatest application in areas where water is scarcest and therefore most valuable. Delta's source reduction program, supervised by a staff engineer, involves the design and engineering of complete systems, at District expense, and the rental, at cost and including operators, of heavy crawler tractors with bulldozers, scrapers, and graders, to construct them. This program has resulted in the minimizing of mosquito breeding on what were previously some of the most prolific mosquito-producing pastures in the area.

The system of drainage to an outlet has probably attained its greatest development in the Merced County Mosquito Abatement District. Because it has the widest general application, and because of the author's familiarity with it, a somewhat more detailed account of this operation will be given here. This system is relied upon in this area for two reasons: first, because water is fairly cheap and available, making it more economical to deliver new water and remove the excess than to pump back and re-use it; and second, because the alkali content of much of our soil and water is so high that it would reach dangerous levels if the drainage water were re-used repeatedly on the same fields.

The District maintains a full-time seven-man drainage department, headed by an engineer and operating three half-yard excavators, a dragline and two backhoes, as well as the tractor-lowbed trailer and other auxiliary equipment necessary to maintain them. In addition, all District personnel devote at least part of their time to this phase of the program.

To encourage the installation of adequate drainage systems, the District provides, at no cost to the landowner, the necessary legal and engineering services, does the leg-work involved in obtaining agreements and rights-of-way where several owners are involved, provides the minor hand-labor required for installation of culverts, flap-gates, and road-crossings, replacing fence, etc., and guides the owners in applying for Federal repayment under conservation provisions where indicated. If desired by the landowners, District excavators and operators are used for the actual construction, the cost of operating them being repaid to the District, with these costs divided among the participating landowners proportionally on the basis of individual acreage drained.

The charge to the owners is based upon $7.00 per operating hour of the excavator, which has averaged out, over the years, to be just about what it costs to run them and pay the operator, depreciation not being considered. This is from three to five dollars less than the current charge being made by local commercial operators, but no objection has been voiced by them for several reasons. They have all the work they can handle constructing irrigation ditches, which the District does not touch, many of the projects the District takes on would be uneconomical for the commercial operator because of size and location, and finally the District's educational program and engineering services have actually created more work for the commercial operators than existed previously.

The District attempts to assist in solving the drainage problems of anyone in the County who requests such help, while at the same time maintaining a priority list of the major mosquito producers. This practice has kept all of our men and equipment busy installing drain systems twelve months a year with the only time lost being that necessary for maintenance and repairs or moving.

To date it has been unnecessary in Merced County to invoke the legal provisions which may be used in California to force drainage where needed for mosquito control. Probably, however, such action will be necessary in the future to eliminate some of the major sources where owners have shown themselves to be immune to education or persuasion.

An average of approximately 6,000 acres of active mosquito sources have been eliminated or drastically reduced annually in Merced County during the past few years through the direct efforts of the Mosquito Abatement District. It would be difficult to estimate how many more have been reduced through the individual efforts of the landowners influenced by the District's constant educational program or by action taken by the landowner after he has seen the effect of District-installed drainage on his neighbor. The District has no illusions that it will ever be able to drain all of the county's mosquito sources through its own efforts, for the simple reason that more new source-areas are created each year than it can eliminate by direct action. Our ultimate aim is to have installed enough "demonstration" drainage systems, and by other means educated enough of our ranchers so that fewer new sources will be created, and more of the landowners will take the initiative in getting rid of existing mosquito-producing areas in their fields.

In California, with some 7½ million acres currently under irrigation, this is a tremendous problem to be solved, and it will undoubtedly get worse before it gets better, since the area expected ultimately to be under irrigation in the State is 21 million acres. But it is a problem we can view with hope and optimism, because we know that the solution lies in the three factors of better land preparation, improved irrigation practices, and the installation and use of drainage systems and because we are beginning to succeed in passing this knowledge along to the people most affected and best able to apply it, the irrigating ranchers. Such education has a habit of chain-reacting and it is not only our hope, but our belief, that when that ultimate irrigated area is reached, most of the water will be applied to it by people who have learned that mosquitoes are not a necessary by-product of irrigated agriculture, but rather a sign that fields are producing crops below peak efficiency.

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