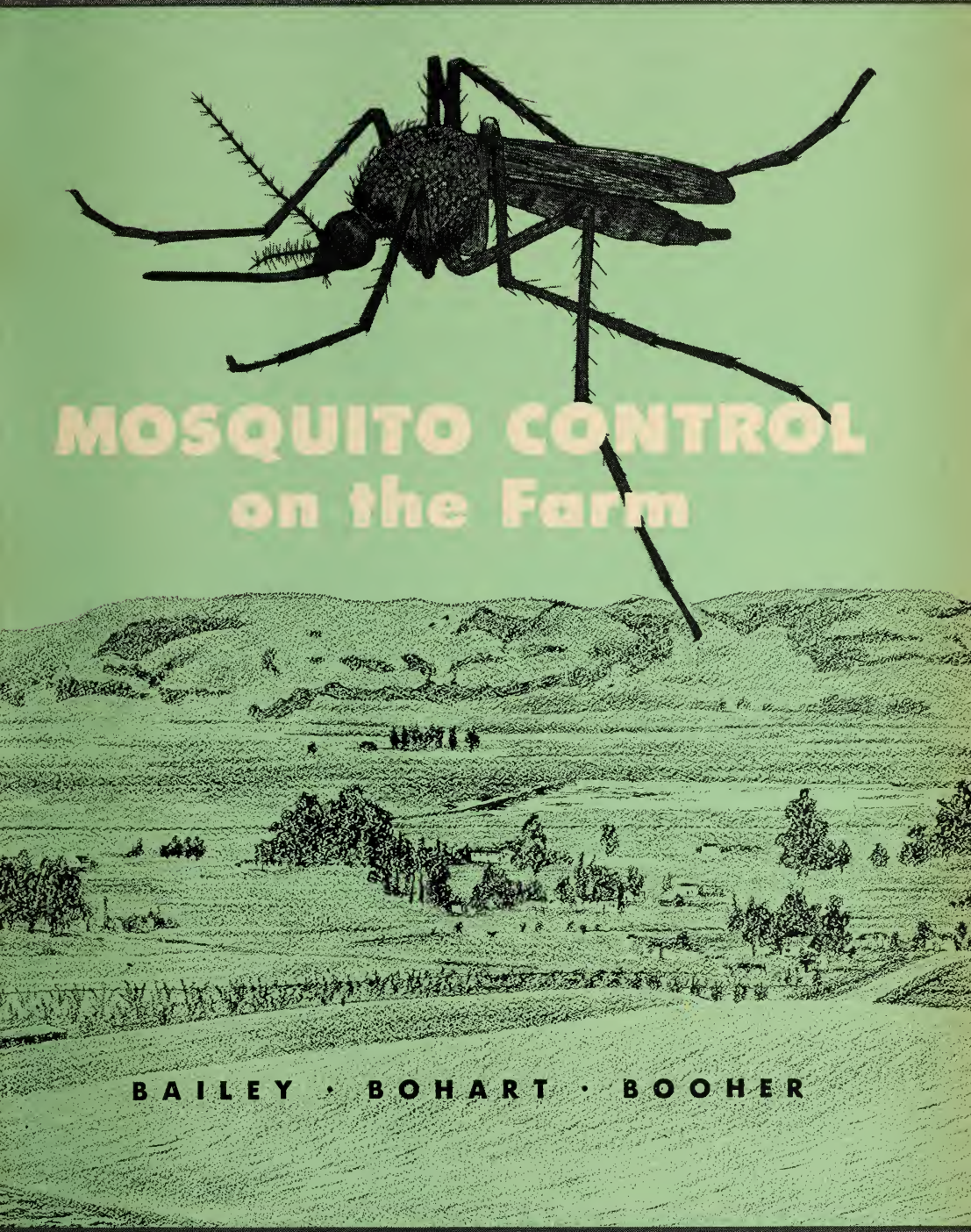
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA



MOSQUITO CONTROL on the Farm

BAILEY · BOHART · BOOHER

CALIFORNIA AGRICULTURAL
Experiment Station
Extension Service

CIRCULAR 439

Mosquitoes should be controlled because . . .

THEY AFFECT LIVESTOCK

If annoyed by mosquitoes, cows on irrigated pastures and near salt marshes will give less milk, and beef cattle, sheep, and poultry may suffer losses in weight.

THEY CREATE A LABOR PROBLEM

Farm help often refuses to work and reside in localities having a serious mosquito problem.

THEY CAUSE DISEASES

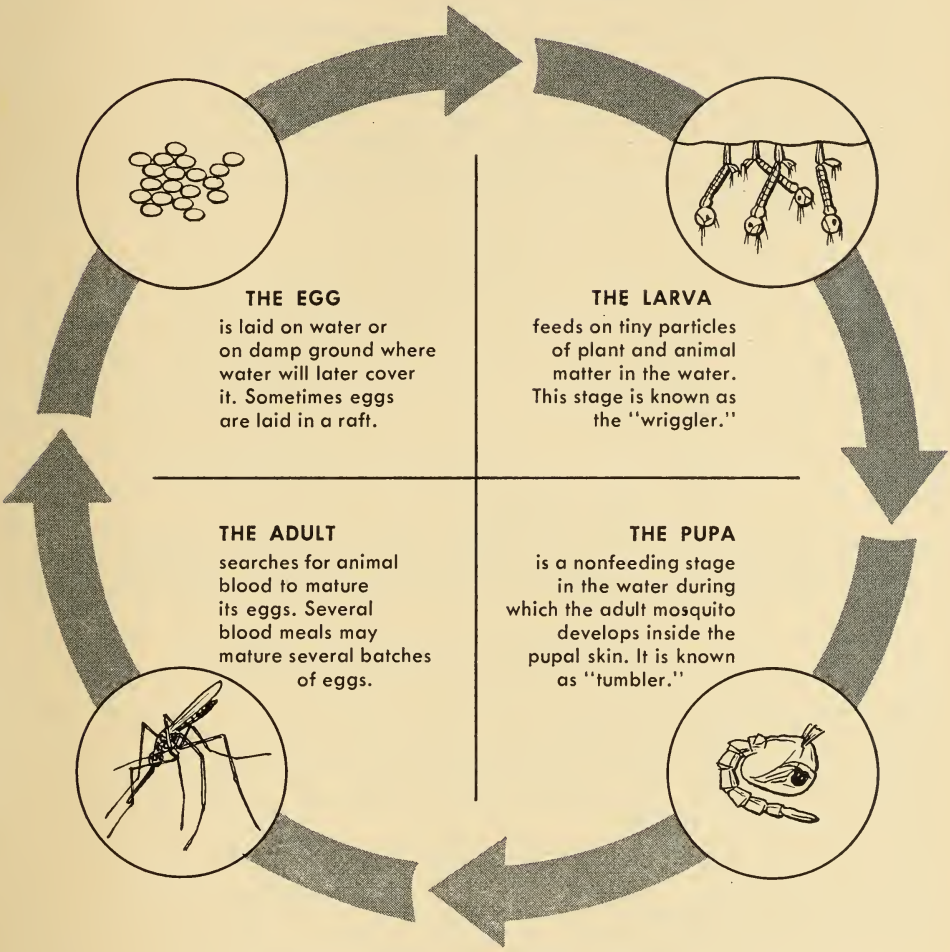
The farmer's family is particularly susceptible to mosquito-borne diseases such as sleeping sickness and malaria because the farm is often close to mosquito sources. Horses also are frequently affected.

THEY REDUCE FARM VALUE

Disadvantages caused by the presence of mosquito swarms may reduce the market value of a farm.

Your principal problems are

1. To break this cycle



All mosquitoes go through these four stages. However, the different kinds have their own peculiarities which must be understood if control efforts are to be efficient. For a detailed discussion on the most important kinds of mosquitoes in California, turn to pages 21–27.

and

2. To provide ample water for your crops and animals WITHOUT providing water for mosquito breeding grounds.

Irrigation water is the lifeblood of California agriculture. But water is also essential for the development of the younger stages of all mosquitoes. Methods of increasing irrigation without increasing mosquitoes are discussed on pages 10–15.

This circular answers some of the questions raised by this dilemma.

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MOSQUITO CONTROL ON THE FARM

In a semi-arid irrigated country such as California the use of water is the most important part of crop production. Good agriculture results from the efficient use of water. At the same time, efficient use of water means a reduction of mosquitoes to a minimum. While adult mosquitoes often rest in the grass or bushes, the larval and pupal stages of all mosquitoes require water for their development. It is here that you can break their life cycle most effectively. Most mosquito sources in our agricultural districts are man-made and can be reduced or eliminated by man.

As a farmer or rural resident you can do much to help rid your community of mosquito sources:

Eliminate stagnant water

Eliminate temporary and seasonal mosquito sources by filling depressions, improving stream channels, draining land. Reliable sources have computed that, on marsh land, mosquitoes can produce more than six million larvae per acre.

Use proper water management

Prepare the land properly; correct poor irrigation practices; and provide for adequate surface drainage.

Restrict chemical control

to instances where it will supplement preventive measures. Apply chemicals carefully according to recommendations and instructions.

Cooperate

with neighbors and public agencies in controlling mosquitoes in your area.

How to eliminate stagnant water on your farm as a source

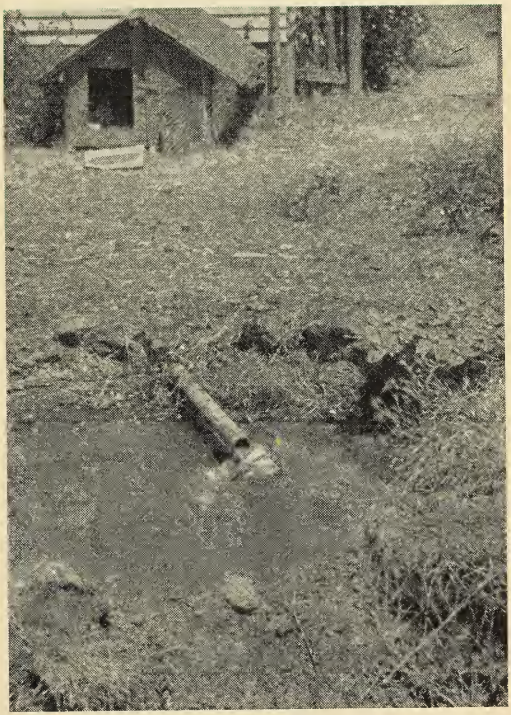
THE MERE FACT that water is closed in, dammed up, or otherwise impounded does not mean that it is a source of mosquitoes. A reservoir, for instance, will not produce mosquitoes if its sides and bottom are properly graded, and if it is stocked with mosquito fish. In general, a rather steep-sided pond of at least three feet in depth to cover bottom-growing weeds will offer the least problem. You can reduce the hiding places of the wrigglers by regular destruction of the weeds around the margin of the pond. Sudden lowering of the water level often helps to bring the mosquito larvae within reach of fish. Local agencies will give you additional information and advice on the use of mosquito fish in the particular situation you face.

However, there are a number of stagnant ponds and ditches which often become sources of mosquitoes. Where they result from irrigation overflow, you can prevent them by improving your irrigation practices, as will be discussed on pages 10–15. Where stagnant waters arise from other causes, you have to take appropriate steps to eliminate them. Here are some examples of what possibilities are open to you.

Dairy drains and their overflow may result in hordes of mosquitoes. The overflow from a dairy, as shown in the picture on the left, should be properly drained and kept free of vegetation. Another method to eliminate this source of mosquitoes would be to install a pump to use the collected water in the irrigation system. As a general rule, drain dairies where you can. Where you have the space, you may run the drainage down the furrows to percolate into the soil. Use several furrows in rotation to avoid standing water. When this is impossible, keep dairies free from weeds and spray the ditch at least once a week with an oil such as kerosene or diesel fluid.

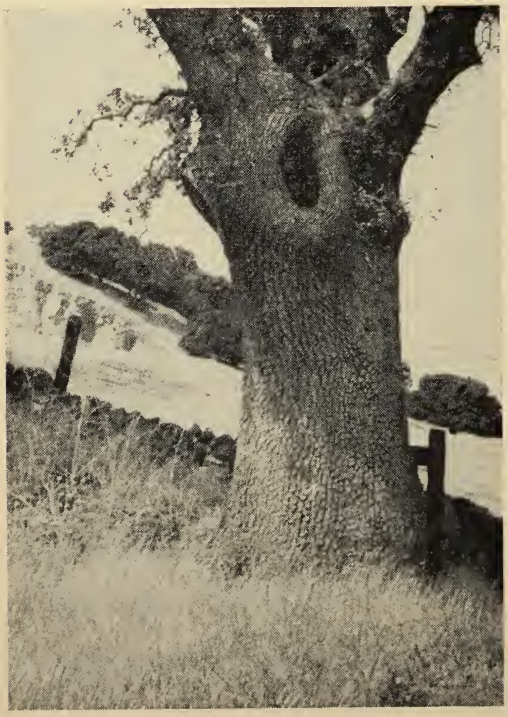
# of mosquitoes

In the picture above, hundreds of mosquito larvae show up as gray specks in a salt marsh pool. This is only one example of stagnant water becoming a major source of mosquitoes. Other examples are illustrated on these and the next two pages.

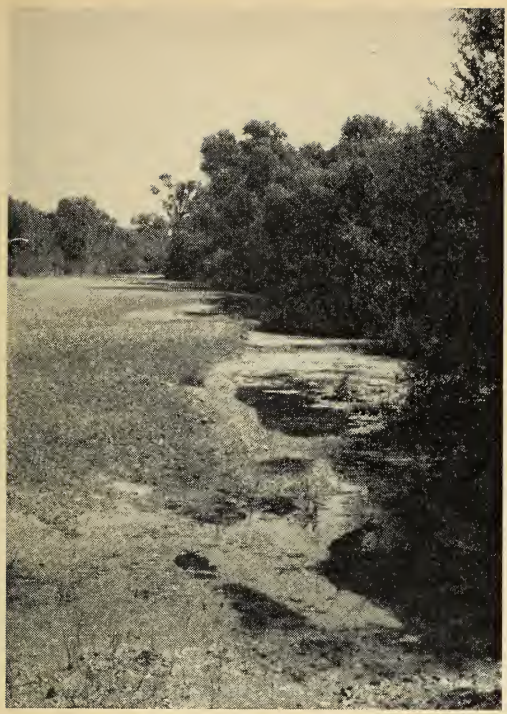


Cesspools and septic tanks are likely to produce droves of house mosquitoes. The septic drain on the right is constructed improperly and should be rebuilt to conform with approved sanitation and public health standards. It should have an adequate soakage pit, cover, vent, and overflow outlet. Overflow from septic tanks may create mosquito sources if heavy soils interfere with percolation. Proper construction of a septic tank drain field will remove this nuisance. Your local health department will advise you. Cesspool tops should be of concrete or tight-fitting boards covered with asphalt paper. Also, there should be a covering layer of two feet of earth.

Watering troughs such as the one pictured here may easily become a source of mosquitoes. The ground surface around the troughs often becomes roughened by the hooves of animals, and contains hundreds of small water pockets. This potential source of mosquitoes should be permanently corrected by providing drainage, paving, or the use of a mound of gravel. Otherwise the area should be sprayed regularly. Even if watering troughs do not overflow or leak, they may produce mosquitoes if they catch falling leaves or if they are not cleaned frequently. In these cases mosquito fish or top minnows are often useful. Most water-holding containers are unnecessary and should be overturned or destroyed.



Treeholes such as illustrated here may store rain water and provide an ideal place for the western treehole mosquito to develop its larvae and house its adults. You will find treeholes occasionally in oak, black walnut, cottonwood, and in old orchard trees such as cherry, English walnut, and olive. These tree holes may result from rot following disease, from fire injury or, in orchards, from a type of pruning which leaves a hollow at the center of the tree. Trees of particular value should be treated by a tree surgeon. Otherwise treat each hole with a cupful of 50 per cent wettable DDT powder. Or you may bore through the trunk with a brace and bit so the hole will drain.



Drying streams adjacent to farm lands are another source of mosquitoes because they create stagnant pools. They are particularly harmful where they provide breeding grounds for mosquitoes at a time when neither rain pools nor irrigation overflow pools are readily available. This happens in the late spring when the two disease-carrying mosquito types of California, the western malaria mosquito and the encephalitis mosquito (carrier of the sleeping sickness), find breeding grounds in the pools created by drying streams such as the one pictured here. You can eliminate this mosquito source by cleaning the shore line of vegetation, and by ditching to connect and drain the isolated pools.

Pools from high tides such as shown here sometimes cover an area of hundreds of acres. Farm lands in the coastal counties which are flooded by the tides and whose low spots retain the water, may become the breeding ground of the field mosquito and the California salt marsh mosquito. Sometimes this problem can be handled satisfactorily by constructing and maintaining ditches which will drain off the water when the tide falls. Or you may have to build a levee with a tide gate to prevent entrance of salt water during high tide but to allow fresh water to flow out at low tide. Spraying tidal pools with insecticide is expensive and only a temporary measure.

Here's how to have irrigated farms and

You can increase irrigation on your farm and at the same time decrease your mosquito problem by following some simple rules of water management. The rules evolve around three topics discussed in this section: land preparation, irrigation, drainage.

Land Preparation

Proper land preparation for both irrigation and drainage is the key to successful water management on your farm. Properly leveled fields not only help control mosquitoes but also produce higher yields at less cost. On good slopes you can apply irrigation water more efficiently, lowering your cost for water and irrigation labor. On such slopes you can grow more uniform crop stands which can be harvested more easily.

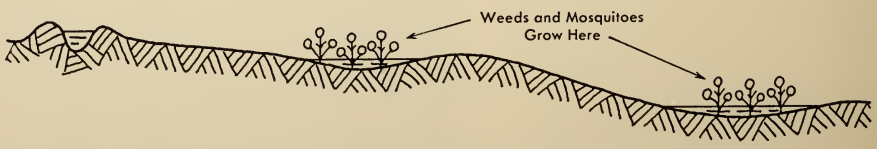
A field that is properly leveled will have a continuous slope in the direction of the irrigation runs. Slopes of at least 0.2 foot per 100 are desirable for most crops. Where flatter slopes must be used on soils which do not take water readily, extreme care should be taken that no low spots occur in the field. When available, a slope of 0.3 to 0.5 foot per 100 is preferable on pastures.

It is the practice in some areas to make the lower sections of the irrigation run perfectly flat. This permits spreading out the excess irrigation water which reaches the end of the field. This is desirable in areas where the soil takes water readily, but should *not* be used in soils where water penetration is slow. The crops in the lower ends of many fields are "drowned out" due to standing water. In such cases it is better to increase the slope rather than reduce it, and to include a small drain ditch at the ends of the irrigation runs. This reduces the area flooded and facilitates the collection of excess irrigation waters.

Where possible, level the land so there is a slight side fall across the field. This facilitates the delivery of irrigation water through the field ditches, and helps in collecting the waste water in the lower corner of the field.

Irrigation

Fortunately, irrigation practices which are desirable for the control of mosquitoes are also desirable for the production of crops. 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,



Bad Slope of Land: not continuous, water collecting in low spots, drainage impossible.

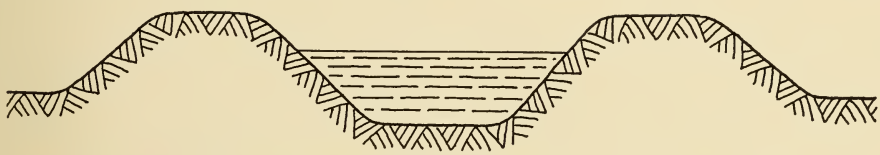
except in such specialized operations as rice growing. But water standing on fields for 24, and even 48 hours, will not produce mosquitoes. *Even the most rapidly developing mosquito types need three and one-half to four days in water to reach the adult stage.*

Field ditches. Temporary puddles, therefore, as formed by sprinklers on well-drained surfaces (as illustrated in the lower photo on page 13 do not remain long enough to produce mosquitoes. On the other hand, field ditches that hold water for a considerable time following irrigations may serve as a source of mosquitoes. Water may remain in a ditch constructed in heavy soil for a number of reasons: the ditch may have no drainage outlet, or it may not be constructed on a continuous grade, or it may not be properly maintained.

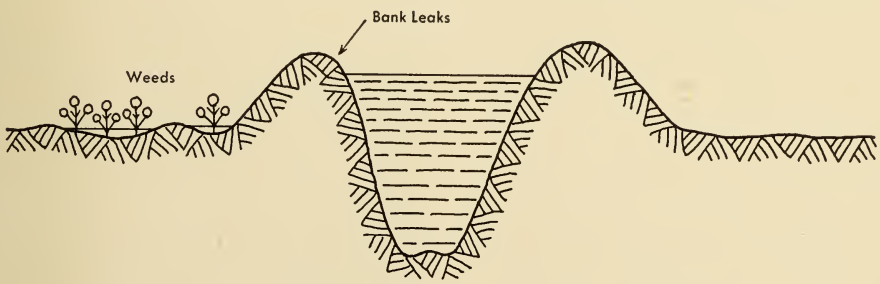
A properly constructed head ditch (see the diagram below) can be maintained more easily than one that is built poorly. You may want to place "ditch pads" along the line where the ditch is to be constructed. This should be done at the time the land is being leveled. A ditch pad is a mound of earth 8 to 12 inches high and 10 to 16 feet wide. This excess earth permits building strong ditches with well-shaped banks. The bottom of the ditch can be maintained near the elevation of the normal ground surface. This permits easy draining of the excess water from the ditch after the irrigation is completed.

Or you may try the practice of "plowing in" the field ditches following each irrigation. This permits easy turning of the cultivating equipment. The ditches are rebuilt prior to each irrigation. Where this practice is carried out, the field ditches do not propagate mosquitoes.

Leaky headgate and turnout structures may create small pools of standing water such as shown in the upper photo on page 12. Such leaks often contribute greatly to the mosquito problem. Care should be taken during construction to make sure that water cannot escape around or under these structures, and that the gates are fitting closely enough to hold the water.



Good: strong and well-shaped banks, broad and shallow, smooth bottom, easy to drain.



Bad: weak banks, narrow and deep, irregular bottom, difficult to drain.

Such precautions can often save sufficient water to pay for the cost of the structures.

Drainage

Irrigated farms which do not have adequate drainage facilities to take care of excess irrigation waters, produce most of the mosquitoes in many areas. As mentioned before, mosquitoes are no problem in areas where the water disappears from the ground surface within 48 hours after the irrigation.

Surface drains can be used for removing excess water that collects at the lower ends of irrigated fields. Often you may want to reduce the amount of waste water to a minimum, but will find it impractical to prevent the escape of at least some irrigation water from the fields. The amount of water wasted may be small compared to the total amount applied, but if not handled properly it can be the source of large numbers of mosquitoes.

In many irrigated areas drainage systems have been constructed to collect waste water from farms and remove storm water during rainy periods. The waste water can often be diverted into canals at lower elevations and re-used for irrigating other lands.

In areas where drainage outlets are not available, the farmers are formulating plans for the construction of a drainage system. Such developments should be a community undertaking because the health and welfare of a large area, as well as the reclamation of flooded land, may depend on the removal of surplus water.

A return-flow system, as illustrated by the upper photograph and the diagram on the opposite page, is another method to take care of your waste water. The excess irrigation water is collected in a sump at the low point in the field. A low-lift pump lifts the water into a pipeline which delivers the water into the farmer's own irrigation system. The water is sometimes re-used for irrigating other land more favorably located to the sump.

The main expense of a return-flow system is for the pump and pipelines. But because of the low lift, the cost of power to operate the pump is cheap.

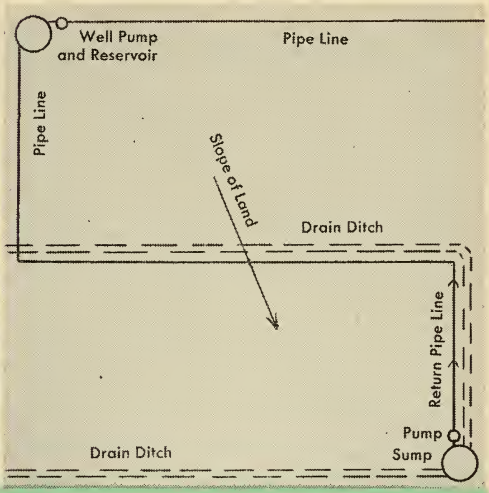
Waste water is usually of good quality

Leaks in pipelines, standpipes or ditches may cause stagnant water. Keep irrigation structures in good repair.

Dumping waste water provides a breeding place for mosquitoes. Water shown above should be collected and re-used.

for irrigating crops. It often contains fertilizers which can be saved by re-using the water. Also, its warm temperature is favorable to growing crops.

The practice of re-using waste water is one of the most effective means of controlling mosquitoes. It eliminates standing water from the lower end of the field which is frequently the trouble spot, particularly on irrigated pastures.



Left, sump and pump for a return flow system. Mosquito fish can be planted in the sump or in similar permanent ditches and sloughs, to control mosquito larvae. Right, diagram of a complete return flow irrigation system.

Temporary puddles formed by sprinklers on a well-drained surface, such as the one shown above, will dry out in less time than it takes to produce mosquitoes. There's no hazard here. If run-off water stands for several days, a rain ditch is needed.

Mosquito-free irrigated pastures?

Irrigated pastures inevitably tend to create an environment favorable for mosquitoes. Such pastures grow well on shallow, poorly drained soils where many other crops would not survive; or on heavy basin soils which normally occur where the land is relatively flat and difficult to drain. Many irrigated pasture plants, particularly Ladino clover, are shallow rooted and require frequent irrigations. These are some of the reasons why you have to give special attention to the management of irrigated pastures, to prevent them from becoming a source of mosquitoes. Luckily, the same practices which are likely to increase the production of pasture feed also help eliminate mosquitoes.

1. Have the land properly prepared for irrigation and drainage before the crop is planted. This is most important in the control of mosquitoes on the farm.

2. Apply only enough water at each irrigation to wet the soil to the depth of rooting; otherwise, nutrients will be leached from the soil and water wasted.

3. Irrigate only as frequently as is needed to maintain an available supply of moisture in the soil.

4. Remove all excess water from the pasture within 24 hours following each irrigation. This will prevent "scalding" and will reduce the number of water-loving, weedy plants in the pasture. Good check slope is needed to achieve this result in the field. A drain ditch should remove the water from the lower end.

5. *Do not graze the pasture when the soil is wet.* Much of the irrigated pasture mosquito problem results from hoof-prints of cattle being run on wet fields or even left in the field during irrigation. Avoidance of this practice will help prevent puddling of the soil which reduces water penetration. Also it will prevent cutting up of the planted crop.

Strip Check Versus Contour Check

The question often arises as to whether a farmer should use strip checks or contour checks for irrigating his crops—generally pastures. Each method has its place. In general, fields that are irrigated by contour checks are a greater source of mosquitoes than are fields that are irrigated by strip checks. From a mosquito control standpoint the contour check method may produce a new hatch of larvae in each check, part of which is carried along to the next check. This gives a population of mixed age and usually makes it necessary to spray larger areas.

The strip check or border method is widely used for irrigating orchard, grain and forage crops. When minimum slopes of 0.25 foot per 100 feet on soils with good vertical drainage or 0.5 foot per 100 feet on more impervious soils are available, this method is usually to be preferred. The essential factor is to have the land between the levees perfectly cross-leveled so that the water will spread uniformly across the checks as it moves down the field. Also, the slope must be continuous, although not necessarily uniform, throughout the length of the check in order to prevent water from ponding. The diagrams on page 15 show good and poor land for strip check irrigation.

Additional information on the strip check method can be obtained from "The Border Method of Irrigation," Circular 408 of the California Agricultural Extension Service.

Contour checks can be used to irrigate successfully if relatively large heads of water are available, the soil will take water slowly, and the land is fairly flat. This method is most often used where the general slope of the land is less than 0.1 foot per 100 feet. If the slope is greater than this amount, the strip check method of irrigation is preferred by most farmers.

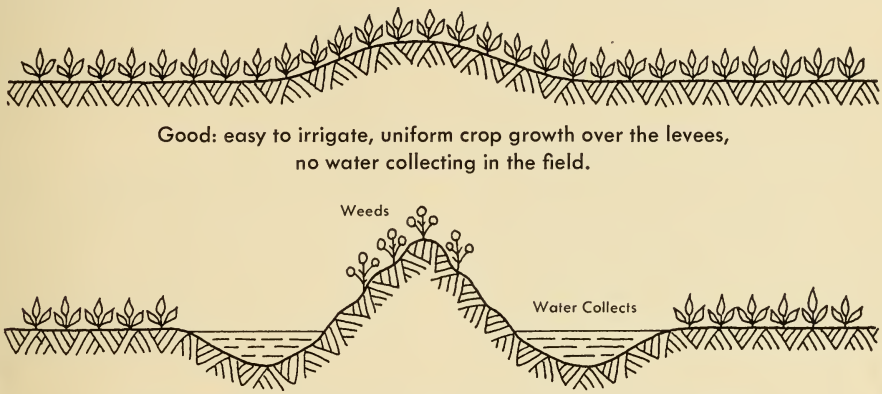
6. Break up your pasture into a number of smaller fields so that the animals can be rotated from one field to another.

7. Allow a sufficient regrowth period for each field between grazings so that healthy, vigorously growing plants will become established. This is an important factor in increasing the production from irrigated pastures, and helps to improve water penetration into the soil by establishing a better root system.

8. Fertilize as needed to supply the necessary plant nutrients to the soil.

9. Clip pasture occasionally to reduce weed growth and to control the rank growth of less palatable pasture plants.

Improperly prepared and managed pastures contribute to build-up of mosquito populations. Proper management of irrigated pastures will bring you greater returns and will help reduce your mosquito problem.



Good: easy to irrigate, uniform crop growth over the levees, no water collecting in the field.

Bad: difficult to irrigate, soil eroding, weeds reducing crop yields.

The contour method of irrigation consists of constructing levees on contour lines at vertical intervals of generally 0.2 or 0.3 foot. Control gates are placed in the levees to hold the water until the contour basins are irrigated, and to serve as a spillway to prevent water from over-topping the levee. The usual practice is to hold the water in each basin until the area is completely flooded and then open the control gates and release the water to the next lower check.

The main difficulty in using this method, both from a crop production and mosquito control standpoint, is removing the excess water from the field following each irrigation. A small amount of land leveling may be needed to fill in the natural depressions that occur in the field. Corrugations made in the direction of the slope of the land before the levees are constructed will help to drain the water into the borrow trench. A float is often used to smooth and partly to fill these trenches.

To eliminate mosquito problems created by waste water standing in contour checks, many farmers are using a broad, shallow ditch down the center of the field. This serves as a delivery ditch for the irrigation water, and as a drainage ditch for waste water. By constructing this ditch with a bucket scraper and removing the excavated soil, no spill banks will be left to dam the water. The fields are generally laid out so that ditches will occur at intervals of not over 660 feet, or so that the drainage water from the field will not have to travel over 330 feet to enter a ditch. Control gates are constructed at the points where the ditch crosses the levees. The crest of the control gates is on the same grade as the bottom of the ditch. Flash boards in the gates are used to check the flow of water during irrigations. When the flash boards are removed, the ditch will carry off most of the excess water.

When and how you can use chemicals in

Chemical control of mosquitoes has its place as a supplement to preventive measures. It does not replace them. The principal methods of chemical control are discussed here.

Chemicals are used in three principal ways to kill mosquitoes.

First, oils and other chemicals are sprayed on the surface of water to kill the immature or larval stages. Such chemicals are called larvicides.

Secondly, fine mist sprays, "smoke" or "fog," and the atomized particles or droplets from "bombs" kill the winged or adult mosquitoes that fly through the spray or are struck by it. Such a method creates a space spray or "aerosol."

Thirdly, poisonous materials are sprayed on the resting or hiding places of mosquitoes. The mosquito is killed by resting on these poisonous particles on wall surfaces, shrubbery, etc. This kind of application is called a residual spray deposit. Only certain specific chemical treatments, discussed below, are effective as residual sprays.

Types of Chemicals

The kinds of chemicals used today in mosquito control are petroleum products and various manufactured materials such as DDT, DDD, lindane, toxaphene, phosphate compounds, and pyrethrum. These are commonly used as "smoke," as finely atomized particles in mosquito "bombs," or as liquid solutions whether in concentrate form or diluted with water.

Petroleum products that are used in mosquito control are largely the stove or diesel oil types because they are cheap, spread easily, and do not evaporate too quickly. Kerosene evaporates rapidly and is not effective in killing the immature or larval stages; it is also more expensive. Waste oils such as crankcase drainings are sometimes used but are often difficult to find in quantity when needed, usually require dilution to pass readily through sprayers, and are less toxic to mosquitoes than diesel oil. Diesel and other oils together with other materials are generally used in fogging operations by abatement districts. Excessive use of oils, especially in warm weather, may cause some plant injury.

Manufactured chemicals (principally DDT) are compounded from various chemicals and sold as dusts (powders), spray (or wettable) powders, and liquid concentrates which must be diluted. Mosquito bombs contain a special form of one or more chemicals in solution under pressure.

Generally speaking, the dry powdered forms of these chemicals when placed on water or resting surfaces are less effective than the liquid sprays. Therefore, the dusting powders are not recommended.

Fogging and Pellets

Fogging is the application of an oil containing an insecticide in such a finely divided form (produced by pressure and heat) that it acts as a fog. This type of control should be employed by trained personnel primarily as an emergency method of handling invasions of adult mosquitoes. It has the following definite limitations: (1) Perfect atmospheric conditions with a minimum of wind are essential. (2) Results are temporary and winged mosquitoes may move into an area a short time after fogging. (3) Even with the best conditions some mosquitoes in secluded places will escape and a perfect kill cannot be expected.

Pellets and granules made of clay, impregnated with the toxic chemical, and pressed into small particles are on the market. This material is broadcast on the water by hand or from an airplane. By this method the amount of insecticide deposited on the foliage is reduced to a minimum.

Application

Correct application is necessary to obtain a satisfactory kill of the larval or adult mosquito. The chemical must (1) come in direct contact with the insect at the time of its application or (2) leave a deposit where the mosquito will contact it. In residual spraying a surface such as the walls of an out-building, well house, or similar favorite resting or hibernating place, apply the chemical until it begins to run off. Respraying may not be necessary for a month or more. Mosquito bombs do not leave a killing surface deposit. You also may apply the chemical by means of a paint brush outside the doors, windows, screens, vents etc. In painting on the solution, start at the top of the screen or door and proceed downward brushing from side to side. By doing so the runoff is not lost.

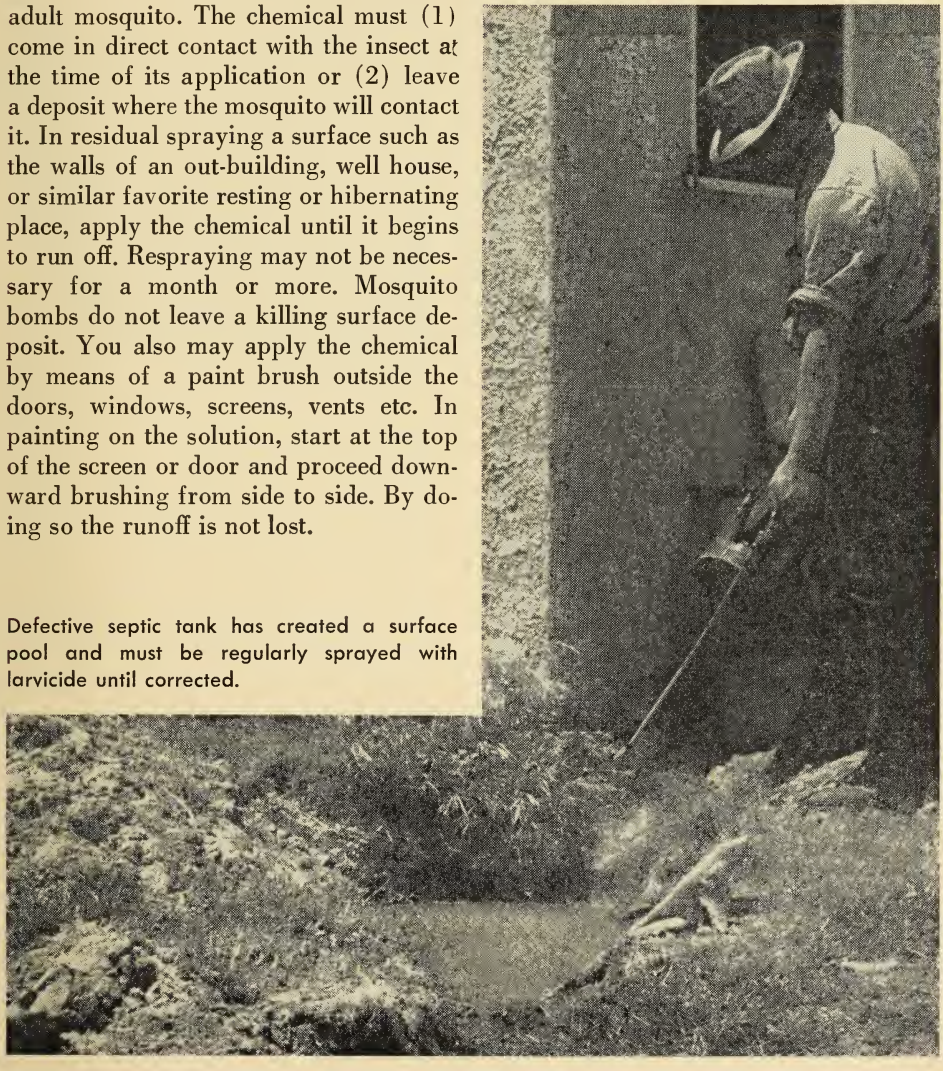
Before spraying be sure to:

Check the degree of concentration of the chemical. *Read the label.*

Dilute it to the correct amount in an open container where it can be thoroughly mixed.

Mix the spray powder into a thin paste or slurry to remove lumps, add to the sprayer with the full amount of water and agitate.

Add a small amount of water according to directions to liquid concentrates and thoroughly mix before using.



Defective septic tank has created a surface pool and must be regularly sprayed with larvicide until corrected.

Equipment

Equipment to use depends upon the size and location of the job. For space spraying in the home, the bomb is the handiest. A hand fly-sprayer of the continuous pressure type has an all-purpose use.

CAUTION

If you use chemicals on your farm for mosquito control, always keep in mind the possibility of poisoning livestock and injuring crop plants.

Use the correct chemical, in the proper dilution, and distribute it uniformly for maximum control at minimum expense. If you have any doubts as to what or how much to apply, ask the advice of experienced mosquito control personnel. This is necessary because you have a choice of many different chemicals; because local conditions (involving kinds of plants present) vary greatly; and because you ought to know the biology of the particular mosquito that troubles you, as well as the degree of its possible resistance to chemicals.

If you use chemicals yourself, follow the instructions printed on the label of the container. In general, follow these precautions:

Avoid or at least minimize inhaling chemicals. Particularly avoid spilling concentrates on skin or clothing.

Wash your hands, and other portions of your body directly exposed, with soap immediately after the job is finished.

Store the chemicals, including left-overs, properly marked, in a safe place, preferably locked, and out of reach of children and pets.

Avoid spraying directly on fruit and vegetables which are nearing maturity. Do not apply chemicals directly to animals and birds unless the manufacturer's instructions on the container suggest it.

Do not spray ponds or streams containing fish.

Burn, bury, or otherwise destroy empty containers. Discard broken containers.

Thoroughly clean all equipment immediately after using as someone else may use it for a different purpose later. This applies to sprayers, mixing cans, containers, and spoons.

A common garden pressure sprayer of 1 to 3 gallons capacity is most satisfactory for spraying in and about small farm buildings, small areas of standing water, shrubbery, and under the porch.

Fogging attachments, called venturi-tubes, may be added to the exhaust pipe of a jeep or truck to fog barns, warehouses, and packing sheds. Small portable smoke generators are available for use in greenhouses, grain elevators, stock yards, and pavilions where an investment in such equipment is justified. A number of mist blowers are now on the market and these can be used in similar fashion. As the name indicates, a fine drifting mist can be produced by such machines.

Cost

The cost of chemical mosquito control cannot be figured on the basis of a producing unit acre as the cost of plant pest control is estimated. Furthermore, the individual farmer usually cannot afford to purchase specialized equipment and must make maximum use of what he has. The expense of the chemicals is rather high per unit but the amount used is normally small and use is seasonal.

Large-scale operations, such as airplane spraying of rice fields and pastures, are beyond the scope of the smaller farmer's facilities. Some rice growers have applied DDT by plane when seeding. It may also be feasible to include an insecticide with a weed spray or fertilizer application later in the season. Licensed aircraft operators charge by the pound, gallon, or acre, to apply chemicals.

***UNSATISFACTORY RESULTS* may be caused by: (1) over-dilution of the chemical, (2) an insufficient quantity per acre treated, (3) uneven coverage, (4) a resistance of local mosquitoes to the chemical used, and (5) a large migration of mosquitoes after spraying from nearby uncontrolled areas.**

How to get help from public agencies

If your problem of mosquito control appears to be larger than you can handle or is particularly persistent, get in touch with your local Mosquito Abatement District, your Farm Advisor, or your local Public Health Department.

Mosquito Abatement Districts

In California, mosquito abatement districts have been formed in many areas to carry out local mosquito control. The area may be a county or a smaller political subdivision. The mosquito abatement districts are governed by a board of trustees, consisting of representatives from each city and from unincorporated areas in the district.

You should know whether you live within an organized mosquito abatement district. If you do, you can get free advice from it on local mosquito control problems. If you have a serious problem, you can get the coöperation of the district with its equipment and technically trained personnel.

The district's entomologist keeps careful records on trend of abundance of the species of mosquitoes in your area and the current cases of human and animal diseases carried by them. These records have a bearing on the nature and amount of control activities going on in your community.

New chemicals, new machinery, and methods of control are continually being tested to give you the benefit of the latest scientific information. In coöperation with the specialists of the State Department of Public Health, Bureau of Vector Control, the U. S. Public Health Service, the U. S. Department of Agriculture, and the University of California, experi-

mental work is being carried on to learn more about the habits of mosquitoes and their control. Such investigations are necessary to continually improve the control measures employed and make them more efficient and economical.

If you are interested in forming a district, or in such matters as its organization, duties, powers, and financing, consult the California Health and Safety Code. You can get actual assistance in forming a district from the Bureau of Vector Control, the State Department of Public Health, Berkeley.

Coöperating Agencies

The elimination of mosquito sources frequently becomes rather complex and may involve such problems as public and private property, rights of way, drainage, and sanitation. In these cases the mosquito abatement district must coöperate with other agencies to make control successful. Among these agencies are the following:

City, County, and State Department of Public Health;

Irrigation, Sanitation, Drainage, Reclamation, Soil Conservation and Flood Control Districts;

County Engineer, Road and Highway, Agricultural Commissioner (weed control), and Labor Camp Departments;

Agricultural Extension Service;

Federal Production and Marketing Administration, U. S. Army Engineers, Bureau of Reclamation, Soil Conservation Service; and adjoining Mosquito Abatement Districts.

> Paragraph (f) of Section 2270 of Article 4 of the California Health and Safety Code gives abatement district employees the right to "...enter upon without hindrance any lands, within or without the district, for the purpose of inspection to ascertain whether breeding places of mosquitoes, flies, or other insects exist upon such lands; or to abate nuisances in accordance with this article; or to ascertain if notices to abate the breeding of mosquitoes, flies, or other insects upon such lands have been complied with; or to treat with oil or other larvicidal material any breeding places of mosquitoes, flies, or other insects upon such lands."

Community Coöperation

Public agencies can never control all the mosquitoes on every individual property. Community coöperation is also necessary. The mosquito that bites you may have been raised on your own or your neighbor's property.

One of the most important steps in this coöperative mosquito control work is to establish a master drainage plan for the area. All new construction such as land leveling, roads, canals, housing projects, and industrial developments using water and producing waste water should be tied into the master plan. Frequently, this may appear impractical in rapidly growing communities. However, there is hardly a section of the state in which more community coöperation would not be in order.

Many examples could be cited for such needed coöperation. A few are: new housing projects are authorized with no stipulations as to adequate storm drainage. Cuts and fills are made in leveling industrial sites resulting in the blocking of natural drainage channels. Land is irrigated without being adequately prepared and drained. Culverts are often observed that have been installed above or below grade or are not maintained. Industrial wastes and irrigation tailwater are emptied into a convenient ditch or dumped on adjoining property.

These and larger problems are not concerns of individual farmers but, as progressive and interested citizens of the community, all can profit by intelligent planning, coöperation, and civic awareness of the necessity for mosquito control. Your Civic Improvement League, Farm Bureau, or other organizations can do much to prevent mosquito problems by the right kind of publicity.

What are our major mosquito types?

Mosquito larvae and pupae dangling from a water surface is characteristic of all mosquito types. But beyond the fact that all larvae and pupae require water, there are great differences in the habits of the various mosquito types. Knowledge of these habits is a prerequisite of effective control.

The mosquito life cycle must be understood before control can become efficient. The life cycle of all mosquito types consists of four parts—eggs, larva or "wriggler," pupa or "tumbler," and adult. However, each different kind has its own peculiarities as to where the egg is laid, how long the larva feeds, and what happens to the adult in the winter. It is essential for mosquito control specialists to know these details so that control efforts can be directed with certainty at the sources of the offending species.

Here are brief descriptions of the nine major types of mosquitoes that occur in California.

The Encephalitis Mosquito (*Culex tarsalis*) is probably our most important type. As its name indicates it is the vector of encephalitis (sleeping sickness) which can be transmitted to humans and horses. Great numbers of larvae are found in rice fields, irrigation ditches, barn drains, and roadside pools, especially when growing plants are present in the water. Sometimes larvae can be found where no vegetation is apparent. For example, they may develop in the standing water in irrigation valves where the valve is below the top of the pipe, allowing a small amount of water to remain after the valve is closed. Pools in alkali waste ground and oil-field skimming basins are two other situations where larvae may be found in the absence of plant growth. Newly flooded rice fields or irrigation

ditches free of plant growth do not harbor this species. Much of the roadside spraying and ditch maintenance carried on by mosquito control agencies is directed at this species.

The adult encephalitis mosquito overwinters in barns, sheds, deep culverts, caves, and similar dark, protected places. After hibernation, the female seeks to obtain a blood meal from a warm blooded animal, and returns to a sheltered place to mature her eggs. She prefers feeding at dusk but may bite at any time during the night or during the day in deep shade. She then flies out seeking some temporary or semi-permanent rain pool on which to lay her eggs. A preferred spot is the grassy edge of a ditch or pond, especially if there is green algae on the surface. However, later in the season larvae can sometimes be found in horse troughs or other artificial containers. There are successive broods throughout the summer and, after the rains stop, the larvae will be found in clogged irrigation ditches, in drying stream pools and other places where water remains long enough. Rice fields may produce tremendous numbers of this dangerous insect.

The larvae practically disappear after the first frosts, normally about the first of November, and the adults seek hibernation quarters.

The Western Malaria Mosquito (*Anopheles freeborni*) is next in importance. It was once greatly feared as a carrier of malaria in California, but as medical science has eliminated most of the human sources of infection, it is primarily a pest. The name "rice-field mosquito" might be more appropriate because the insect can develop in immense numbers in rice fields.

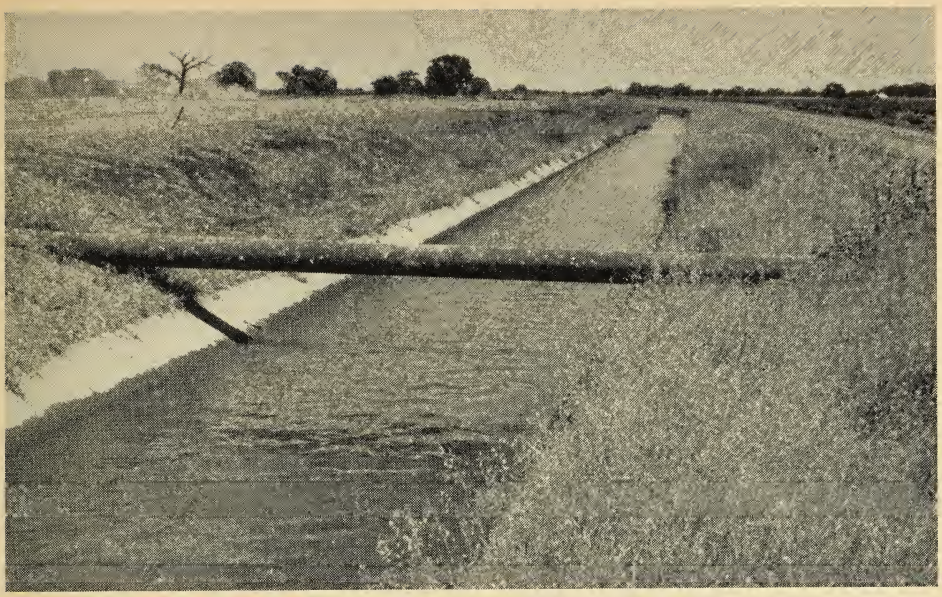
The seasonal cycle is similar to that of the encephalitis mosquito except that more adults survive the hibernation period and some of them come out during warm periods in the winter. These bloodthirsty individuals emerge from hiding in force on the first warm days of early spring to make life miserable for farmers and townspeople alike. In fact, the number coming out of hibernation is frequently so great that people mistakenly think that a new crop has hatched from the fields.

As soon as the female mosquito succeeds in getting a meal of blood from man or animal, she goes into the seclusion of a barn, culvert, or other protected place to mature the eggs within her body. A few weeks later she deposits them on available rain-water collections along roadsides, in old irrigation ditches, in road ruts, and on any ground pool where green algae is likely to form at this time of year. However, this mosquito does not lay eggs in running water. The first summer brood of adults is relatively small

THE TWO DISEASES which mosquitoes carry in California are encephalitis and malaria. To become a carrier of disease a mosquito must feed upon an infected man or animal, and the disease taken into the mosquito along with the blood. Then, after a definite lapse of time during which the disease organisms multiply within the body of the insects, the female mosquito transmits the disease by biting a susceptible man or animal. Actually, the chance of contacting the disease from any single mosquito bite is small, since not all mosquitoes are infected. It is only when there are many bites, and when an infective source exists nearby, that the situation becomes dangerous. Unfortunately, with the farm usually close to the most prolific mosquito sources, the farmer and his family are particularly liable to attack by disease-carrying or pest mosquitoes.

ENCEPHALITIS of man is also known as "sleeping sickness" or "brain fever." Outbreaks in California have been much more explosive and erratic than those of malaria. An equine form of encephalitis affects horses and has caused the deaths of thousands of farm animals across the country.

MALARIA is not as prevalent as it used to be but at least a few cases are recorded every year. Yellow fever, dengue fever, and elephantiasis are also mosquito-borne but do not occur in California.



Encephalitis mosquito, transmitter of sleeping sickness to man and horse, will not develop in a properly maintained ditch (above), free of vegetation, but when weeds clog a ditch (below), mosquito larvae thrive.

and lays its eggs largely in late rain pools, drainage ditches, or swamp areas. Succeeding broods with their increased numbers move into the ricefields if these are available. By the time these fields are drained in September, a succession of generations will have built up an enormous population of mosquitoes. If no control efforts have been made, the populace for miles around will be assailed at

The western malaria mosquito does not lay its eggs in running water but prefers standing water along country roads. Puddles such as shown here create many miles of mosquito sources which need to be sprayed. Proper drainage systems will permanently eliminate such sources.

This picture shows an ideal breeding ground for the irrigated-pasture mosquito. Swarms of these mosquitoes may emerge from irrigated fields where water stands four or more days after irrigation. Drainage at the low end of the field will eliminate this source and also increase yields.

all hours by frightening swarms of hungry insects. Only a small percentage of female mosquitoes will live to enter hibernation after the first frost but there always seems to be enough to make a good showing in early spring.

The Irrigated-Pasture Mosquito (*Aedes nigromaculis*) swarms out in hordes to annoy stock and dairy ranchers. The eggs are laid on damp soil and a new brood hatches with each irrigation. The development is extremely rapid, with adults sometimes emerging in less than four days after the eggs are wetted. This type of mosquito is rather widely distributed in California but is predominant in the San Joaquin Valley. Here, it is a common experience to walk across an irrigated pasture and to be literally covered by mosquitoes. Naturally, beef and dairy animals can be seriously affected. With such a short life cycle and a brood emerging with each irrigation, there may be ten or more broods during the summer. However, this mosquito is especially sensitive to temperature and the development is slow in the spring, tapers off in the fall, and stops in the winter. The winter is passed in the egg stage in the soil of pastures. The irrigated-pasture mosquito is a vicious day-biter and in general does not migrate far. It is not considered a disease carrier.

The Field Mosquito (*Aedes dorsalis*) was the main pasture mosquito before 1938 when the irrigated-pasture mosquito was first noticed in California. Since that time it has been eclipsed by the latter species. However, in some areas and at certain times of the year the field mosquito is still of prime importance. Its habits and life cycle are similar to those of the irrigated-pasture mosquito, but it develops somewhat more slowly and will

The field mosquito finds good breeding grounds in natural pastures near the coast. In this field the water rose with high tides, and left brackish areas—ideal conditions for the mosquitoes. Leveling, ditching, and installation of tide gates are desirable in the control of this mosquito.

tolerate salt water. You can recognize the adult as the straw-colored, day-biting species, differing in color from the darker irrigated-pasture mosquito. Although essentially a pest, there is some suspicion, backed by experimental evidence, that it may occasionally transmit encephalitis.

The California Salt Marsh Mosquito (*Aedes squamiger*) is found along the coast. Contrary to the habits of most other California species, development of the early stages of this form starts with the first fall rains and continues through the winter. It ranges from Sonoma County southward but only in coastal areas as the presence of salt in the water is a requirement for development. Adults emerge from January to May and invade

House mosquitoes often develop in one of the many containers holding water on a farm yard (above). These containers should be eliminated, covered, or turned upside down. Watering troughs can be stocked with top minnows. Poorly drained corrals (below) also are prolific producers of house mosquitoes. A concrete slab should replace dirt floor.

wooded canyons and residential districts many miles from the breeding grounds. Eggs are laid on the marsh and even though flooded by high tides, they do not hatch until fall. Sometimes the larvae concentrate in water in deep mudcracks. In late spring the adults fly in company with the field mosquito but can be distinguished from it by the large size, dark color and speckled wings.

The House Mosquitoes (*Culex quinquefasciatus* and *C. pipiens*) usually occur in artificial containers such as tin cans and horse troughs as well as in open cesspools, dairy drains, and standing water under dwellings. The adults enter houses readily through defective screens, cracks around ill-fitting doors, floor furnaces, or by way of the fireplace flue. They can usually be recognized by their dull brownish or yellowish appearance.

The Western Treehole Mosquito (*Aedes varipalpus*) often develops in dooryard trees. This black and white spotted mosquito may be a severe pest during the warm days of late spring. The larvae live during the winter and early spring in rain-filled treeholes. They are found most often in oak but also in black walnut, maple, sycamore, eucalyptus, and occasionally in orchard or other trees.

The Coachella Valley Mosquito (*Psorophora confinnis*) is restricted to the South and presents a special problem in the Coachella and Imperial Valleys. It occurs in the irrigation overflow along roads, and in pools created by occasional summer rains. With the prevailing high temperatures its larval growth is rapid and adults can be expected to show up within four days after an irrigation if there is residual water. Naturally, control is closely associated with proper irrigation practice.

The California salt marsh mosquito sometimes develops in apparently dry places such as this cracked soil. Standing water in the cracks of alkali soil may be found as much as a foot or more below the surface where it will escape notice. Disking or spraying eliminates this source.

The Snow Mosquitoes (*Aedes* species) are restricted to the mountainous areas of California. They occur at altitudes as low as 4,000 feet in Modoc and Shasta counties and at gradually increasing elevations to the southward. In eastern Tulare County, for example, their lowest limit is about 7,000 feet. These mosquitoes are a nuisance to farmers who pasture their cattle in mountain valleys. The affected areas are mostly outside mosquito abatement districts and control is the responsibility of the farmer, resort owner, and other residents. When the sources can be located, such as flooded meadows and pine-needle filled pools of melting snow, drainage of these areas will bring relief.

The Photos on pages 7, 17, 19, 21, 23, and 24 were furnished by the State of California Bureau of Vector Control, by various California mosquito abatement districts, and by the Water Projects Section of the Public Health Service.

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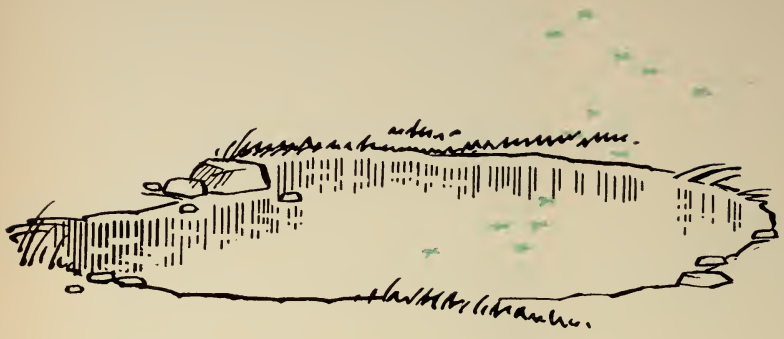
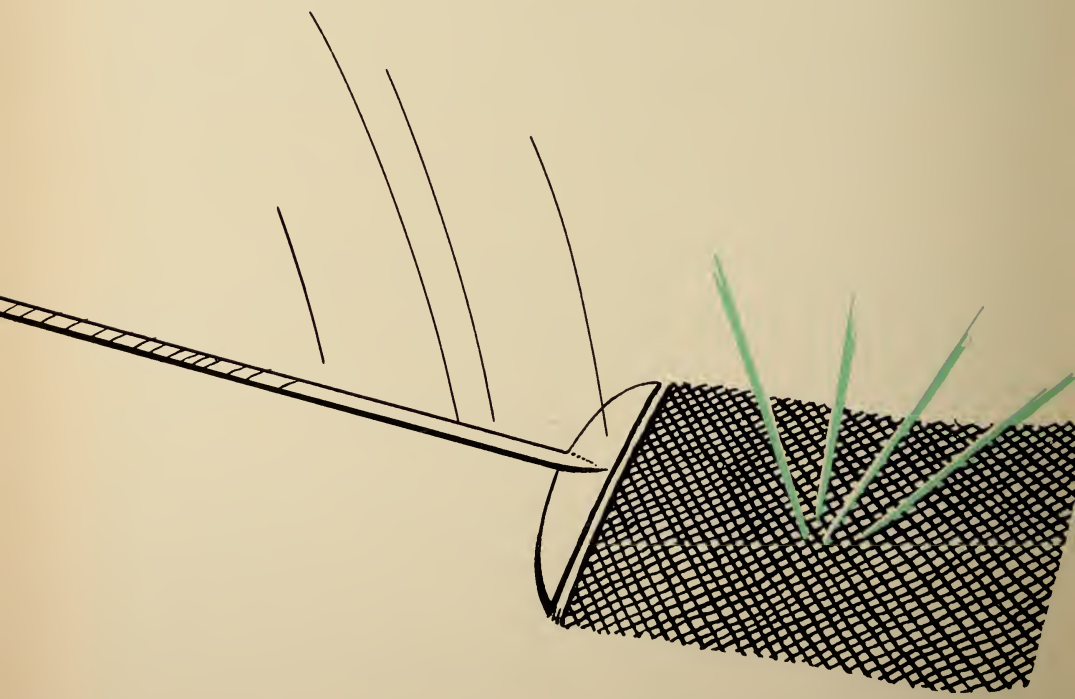
REMEMBER...



You may be raising

the mosquito you are

SWATTING!



Check all water sources,

and eliminate or treat them.