Chapter 8

BIOLOGICAL CONTROL OF MOSQUITOES

Biological control (BC) is the use of natural enemies to manage mosquito populations. There are several types of biological control including the direct introduction of parasites, pathogens and predators to target mosquitoes. These introductions are of two types: inoculative and inundative. Inoculative releases are single, relatively small introductions of natural enemies, followed by their semi-permanent establishment in the environment. Inundative releases are multiple releases of very large numbers (often millions of individuals). In most field trials, inundative releases have been more successful than inoculative ones.

Microbial pathogens of mosquitoes include **viruses**, bacteria, fungi, protozoa, nematodes, and microsporidia. Biological mosquito control methods have almost exclusively been directed against larvae.

Another type of BC is the management of habitats where mosquitoes develop in ways that tend to conserve natural enemies. Both introductions and conservation of natural enemies have a place in mosquito control operations.

If the definition of BC is expanded to include not only microorganisms, but also their toxins, then insecticides such as *Bacillus thuringiensis israelensis* (Bti) qualify as both a BC agent and a biorational insecticide.

Two other strategies have been developed that have many similarities to BC, but do not fit the classical definition of BC because natural enemies are not involved. One set of strategies comes under the broad term autocidal methods, the other genetic manipulation. Both of these strategies have been tried against mosquitoes, so far with only partial success. Both autocidal control and genetic control strategies feature using modified organisms of a given species to control populations of the same species.

BIOLOGICAL CONTROL BY INTRODUCTION OF NATURAL ENEMIES

FISH

Fish have been used as biological control agents for mosquitoes for many years. The most commonly-used species is *Gambusia affinis* (mosquitofish). This species is the most widely distributed fish in the world. Other fishes that have been used effectively are some species of carps and minnows. Fishes in the genus *Tilapia* have been studied as potential BC agents for mosquitoes, but some species tend to disruptive in some habitats because of their invasive qualities .

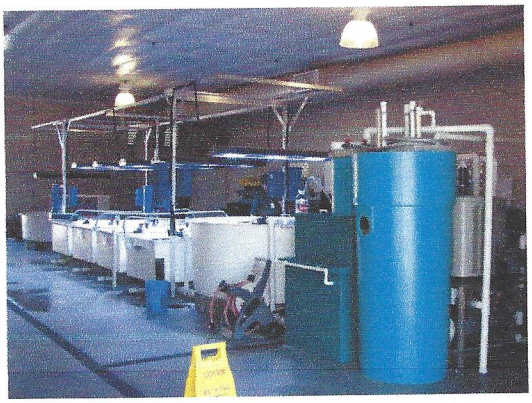
Fishes in the genera *Poecilia, Fundulus, Gasterosteus,* and *Lucania* have also been used for mosquito control in various parts of the world.

Gambusia affinis is not native to California; its natural geographic distribution is the southeastern USA. Because this species cannot survive the winter in many of the colder areas of the state, it must be re-introduced to mosquito habitats annually in areas with cold winters. Some mosquito abatement districts have developed large-scale rearing facilities for mosquitofish that are released as needed (Figs. 8.1, 8.2).

Gambusia affinis has been used with great success against mosquitoes that breed in swimming pools, bird baths, and similar types of artificial water structures. Most mosquito abatement agencies in California will provide mosquitofish to the public

free of charge for these kinds of uses (Fig. 8.3).

Because the mosquitofish is not native to California, their use is discouraged in some open freshwater situations because they tend to attack young individuals of native fish species. However, mosquitofish may be used in disturbed aquatic habitats for mosquito control because such habitats usually do not contain native fish.



Figs. 8.1 A laboratory facility for the rearing of mosquitofish

Proper use of mosquitofish for BC requires extensive knowledge of fish biology and local regulations concerning their transport and use. Used in appropriate habitats, they are one of the most effective biological control agents of mosquitoes known.

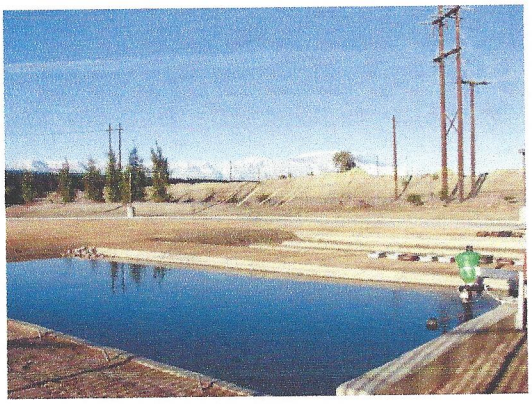


Fig. 8.2 An outdoor facility for the rearing of mosquitofish

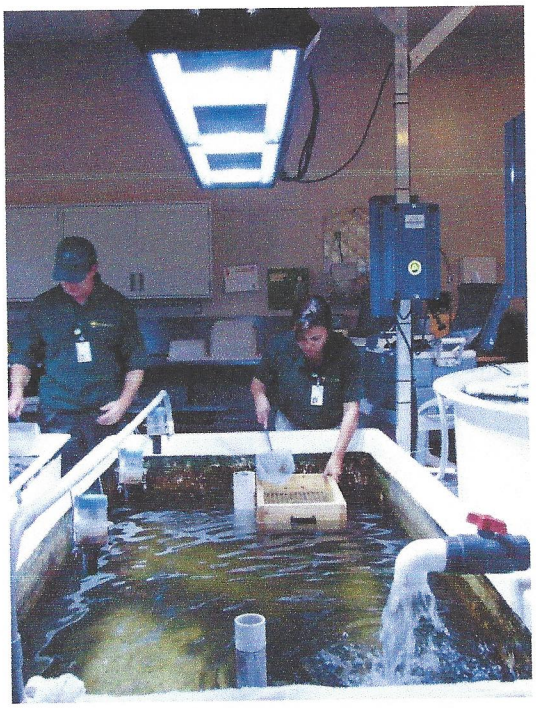


Fig. 8.3 Grading of mosquitofish in a rearing laboratory

Microbial Organisms For Mosquito Control

Microbial insecticides are widely used for mosquito control in a wide variety of situations. In almost all instances they are used as mosquito larvicides.

Microbial organisms such *as Bacillus thuringiensis isralensis* (Bti) and *Bacillus sphaericus* (Bs) have characteristics of both microbial insecticides and BC agents. Both are available as commercial formulations and can be applied with the same spray equipment as conventional insecticides. Bti kills mosquito larvae when they ingest crystalline toxins produced by the bacteria. The toxin interferes with larval digestion. Bs also produces toxins, but mosquito larvae can suffer lethal effects from infection.

The crystalline toxins of various species of *Bacillus* have been studied extensively and new experimental strains of these bacteria have been developed to find improved performance as mosquito control agents.

Some experimental strains of Bti and Bs have been created that have more toxic crystals that the wild strains. So far, commercial preparations have relied only on the natural bacteria.

Microbial insecticides can be dispersed by hand or dispersed using any equipment designed or modified for solid products. Bti is no longer effective after the larvae become pupae, because they stop eating.

Other Organisms Tested As BC Agents Against Mosquitoes

Copepods, fungi (genus *Coelomomyces*), and *Lagenidium* have been studied extensively as possible BC agents against mosquitoes. All of these organisms have been effective in reducing larval mosquito populations in laboratory trials, and even in limited field trials. None have been accepted for wide-scale use for a variety of reasons, most of them economic. The lack of reliable and economical mass rearing methods has been the bar to wide-spread use for most of these.

Other interesting organisms that have been studied include mermethid nematodes (parasitic roundworms), planaria, and tadpole shrimp. All have shown some promise at one time or another, but all had some drawbacks preventing their adoption for wide scale use. However, some California mosquito abatement districts with well established biological control programs do have successful rearing programs for some of these agents (Figs. 8.4, 8.5, 8.6).

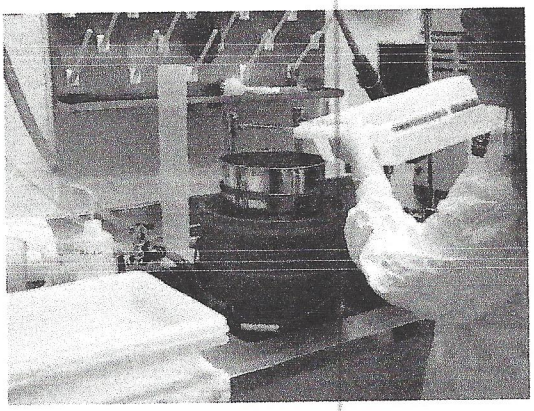


Fig. 8.4 Infecting Cx. quinquefasciatus with parasitic nematodes

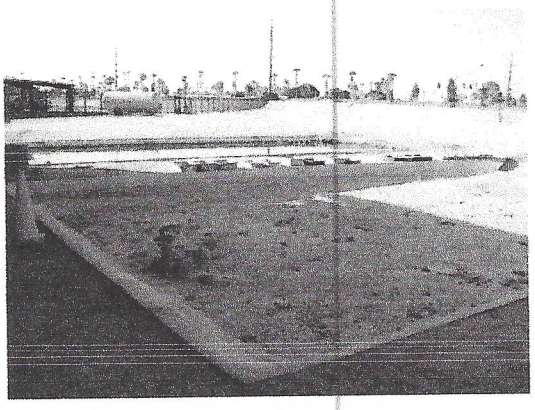


Fig. 8.5 An outdoor rearing facility for tadpole shrimp.

AUTOCIDAL CONTROL

Autocidal refers to methods by which organisms kill or otherwise harm themselves. As applied to pest control it means a method of pest control in which sterile or genetically altered insects of a given species are released to reduce the breeding success of the local insect population of the same species. This method gained world attention in the 1960s when scientists of the US Department of Agriculture used the method to virtually eradicate the screwworm fly from much of southern Texas.

The methods used for autocidal control involved the rearing of large numbers of male insects and their sterilization of male insects by radiation or use of chemosterilants. These male insects were introduced into natural (wild) populations using inundative releases. The sterilized males would mate with wild females, but no fertile offspring would result. Mathematical models upon which this method is based showed that over time and repeated releases the population level of