Mosquito fish—
an established predator

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The mosquito fish, *Gambusia affinis,* is a small species native to the Gulf Coast and the Atlantic seaboard of the United States and Mexico. It has become widely distributed throughout the world since its use in mosquito control programs began in about 1905. It adapts to a wide range of environments and is found in fresh water, brackish water, and salt marshes with salinity concentrations above those of sea water. The mosquito fish also can withstand a wide range in temperature. It survives in freshwater ponds that freeze over at northern latitudes, and it has been found in hot springs at temperatures as high as 35° C. The mosquito fish also withstands very low oxygen levels in the water, since it has evolved the behavior of skimming the surface of the water where the levels are highest because of oxygen exchange from the air.

Mosquito fish feed on aquatic insects and insect larvae as well as terrestrial insects that fall into the water. They appear to favor insect larvae and show a preference for mosquito larvae when the density is high. The females are fertilized internally, and the young are born alive after a gestation period of 15 to 50 days, depending on water temperature. Once bred by a male, the female can retain sperm for an extended period of time and produce several broods without mating again. Fertility and number of young produced increase with increased feed intake and size of the female, but fertility decreases as the female becomes older. The number of young produced varies from 1 or 2 to as many as 30; an average of about 15 is typical in California.

The mosquito fish is used extensively for biological control of mosquitoes in California rice fields. Information provided by the Fresno Westside Mosquito Abatement District reveals a number of interesting population characteristics of the fish. Most fish stocked at a single location in a rice field do not move far from the original stocking site. However, progeny produced by the stocked fish spread throughout the field. Consequently, fish should be stocked initially at several sites in a field to reduce the lag time between stocking and effective reproduction to improve the population distribution in the field.

Further evidence of the dispersal behavior is the observed migration of young fish out of rice fields through outlet boxes. To study the nature of this migration and to find ways to reduce this behavior, an effective system of marking known groups of fish must be developed.

Salt marshes are notorious mosquito breeding habitats, but control in California salt marshes has been effective, partly because programs have taken advantage of the mosquito fish's dispersal behavior. Most mosquito breeding takes place in small potholes in the marshlands with few natural channels connecting them. Mosquito abatement districts have added circulation ditches in part to enhance the spread of the fish. For example, in a recent comparison of mosquito fish populations in ditched and unditched areas of a San Francisco Bay salt marsh, the density of mosquito fish was three times greater in the ditched areas. Also, many more young fish were found in the ditched areas than in the unditched, indicating that migration was occurring and that ditching had improved accessibility to potholes previously not inhabited by mosquito fish.

Because of significant changes in the field habitat throughout the growing season, the number of mosquito fish required for effective mosquito control changes with water temperature, oxygen levels, and available food. One approach to this problem is to assess the food energy requirements of the fish in relation to various environmental conditions. It may be possible to calculate how many mosquito fish will be needed for control under certain environmental conditions, based on the number of mosquito larvae the fish must eat to obtain an adequate supply of energy and on the expected density of larvae in the field.

The rate of oxygen consumption by individual fish is used to estimate the rate of metabolism; this provides a way to calculate the energy requirement of the fish. A multiple-chambered, flow-through respirometer measures oxygen consumption under various water temperatures and oxygen concentrations. Results to date show that the metabolic rate in both males and females increases as the temperature rises from 10° to 35° C. It is predicted that fish at 30° C would eat 5.5 times as many insect larvae as fish at 10° C. In contrast, oxygen concentrations in the water as low as 25 percent of saturation do not appear to affect the metabolic rate, so one would predict that fish would eat as many larvae in low-oxygen water as in oxygen-saturated water.

Large-scale use of mosquito fish in control programs will depend on our ability to produce large quantities of fish for release at the beginning of the mosquito season. Various mass-production systems have been conceived based primarily on pond culture. These systems have been only marginally successful because of low water temperatures in early spring, overwintering problems at northern latitudes, and predation by many animals, including the mosquito fish itself.

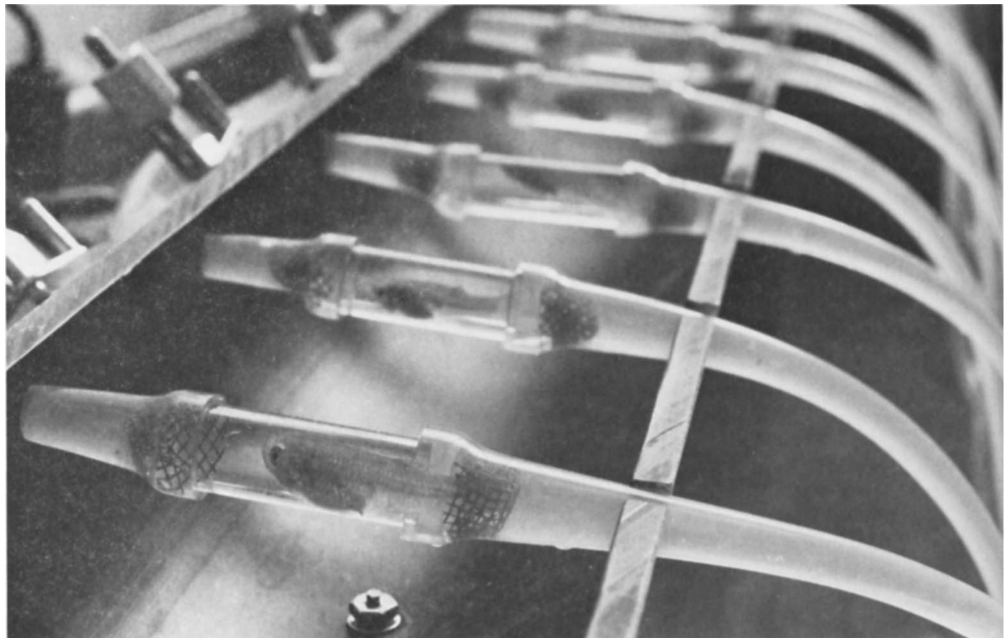
A long-term project has been initiated to develop new technology for mass-rearing mosquito fish. The first objective is to determine the genetic and environmental parameters important to mass-rearing. A recirculating culture system has been designed using 128 five-gallon aquaria divided into two sections to provide 256 separate containers. Progeny from individual females are reared in each aquarium to provide genetic information on growth and reproduction and to allow assessment of variability among containers.

A genetic evaluation of fecundity, growth rate, and age at sexual maturity is being made of three California stocks of mosquito fish: *Calistoga* was collected from a warm-water ditch on Talbs Lane, Calistoga; *Wheatland* was supplied by the Sutter-Yuba Mosquito Abatement District from oxidation ponds in Wheatland; and *Terra Bella* was supplied by Sequoia Fisheries in Terra Bella.

Considerable variability in length and weight has been observed. For example, in a sample of five brother-sister families from the Terra Bella stock at 60 days of age, females were about 50 percent longer than males and more than 2.5 times heavier than males from the same family. Large differences in both length and weight existed between families. Such differences reflect the level of genetic control and indicate that selection for large size will be an effective breeding method. It also can be assumed that larger, faster-growing fish will eat more insect larvae.

Early sexual maturity with high fecundity will improve the rate at which fish can be produced in a hatchery as well as the rate at which planted fish will populate a field. Significant genetic differences have been observed. Age at sexual maturity in a Terra Bella sample of five males from each of five families ranged from 29 days (rapid maturity) in one family to 54 days (slow maturity) in another.

The identification of biochemical-genetic markers, based on genetically controlled differences in tissue proteins, provides an effective method of assessing the dynamics and behavior of interbreeding populations of fish. To date, two highly variable enzyme systems have been identified. One involves the enzyme esterase and is characterized by fish that have one or both of two forms of the enzyme. The second system is phosphoglucose isomerase, which results in individual fish having either three or six forms of the enzyme. Stocks of fish can be bred that will express only one form of these enzymes. Their performance, after planting, can then be quantitated by determining the mixture of forms found during the mosquito season.



Multiple-chambered, flow-through respirometer measures metabolism of mosquito fish under various conditions.

Note: The mosquito fish is a close relative of the guppy, a common aquarium fish. A colleague informs me that the Latin word *gambusia* means *nothing* or *frustration.*

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