

AQUATIC INSECTS AS PREDATORS OF MOSQUITO LARVAE

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HISTORY OF AQUATIC PREDATORS AND THE BIOLOGICAL CONTROL OF MOSQUITOES

The appropriate use of mosquito control methods is the only means by which diseases transmitted by these insects can be prevented or controlled (WHO 1982). Since the middle of the 20th century, the primary strategies employed to combat these insects have involved the use of pesticides. After the appearance of DDT in the 1940s and after World War II, control was carried out with insecticides mainly of chlorinated or organophosphate origin (Quiroz et al. 2000b). This modality was used up to the 1990s in Latin American and other developing countries where control campaigns were based on the application of chemical products with larvicidal and/or adulticidal action. However, due to various criticisms and restrictions imposed on the use of pesticides, it has become increasingly necessary to seek more environmentally friendly alternatives for mosquito control.

In the search for alternatives in the fight against mosquitoes, biological control could provide ecologically acceptable reductions if suitable biocontrol agents become available. This option could help to resolve problems caused by hematophagous mosquitoes, albeit with some difficulty (WHO 1991). In addition, biological control can be included in an integrated pest management (IPM) program in its classical form through the introduction of entomophagous insects or by the cultivation and maintenance of these natural enemies.

Before the 1940s, control actions had been directed specifically at the aquatic ecosystem. The focus was on eliminating larvae, and there was a growing interest in applying biological strategies to reduce mosquito populations at the breeding sites. Researchers were concerned with identifying and evaluating the regulating capabilities of many aquatic predator organisms throughout the world. In the 1920s and 1930s, there appeared a series of studies of various biocontrol agents including the insectivorous

aquatic plant *Utricularia vulgaris* as a predator of mosquito larvae.

Various organisms were considered as effective predators of mosquitoes. Among them were mosquito fish *Gambusia affinis*, and invertebrates such as hydras, insects like *Muscidus scatophagoides* and *Lispa ulginosa*, various unidentified species of aquatic hemipterans, and the predaceous diving beetle *Eretes dytiscus*. Another important predator complex was the mosquito genus *Megarhinus*, one of the biological control agents most studied worldwide and now known as *Toxorhynchites*, including the species *M. inornatus* and *M. splendens*. Historic records even include bats for control of adult mosquitoes.

In the 1930s some studies were conducted with the aim of quantifying the potential of aquatic predators of mosquito larvae, but there was not always adequate identification of either the predator or the prey. These studies reported the number of larvae consumed as well as the quantity of adults that emerged. Clarke (1938) cited several of those laboratory studies; for example, of a total of 1800 larvae exposed to the insectivorous aquatic plant *U. vulgaris*, only 3 adults emerged. The backswimmer *Notonecta undulate* was shown to prey on 4000 larvae in 2 days. When the water scavenger beetle *Hydrophilus triangularis* and the predaceous diving beetle *Dytiscus hybridus* were exposed to 3500 larvae, only 20 adults emerged. Another arthropod, the whirligig beetle *Dineutus assimilis*, consumed 300 *Anopheles* larvae in 2 days. A combination of *Dineutus*, *Notonecta*, and dragonfly nymphs presented with 7500 mosquito larvae allowed the emergence of only 12 adults (Clarke 1938).

Worldwide there existed a special interest in applying biological control to mosquitoes, to the extent that the New Jersey Mosquito Extermination Association in 1939 invited two special guests to its annual meeting, Dr. J. L. King (King 1939), a specialist in strategic control in agriculture, and Dr. R. D. Glasgow (Glasgow 1939) who was particularly experienced in this field, to highlight current activities. At that time, there was a search for natural enemies of mosquito eggs, as well as an interest in using bats and birds to combat these vectors.

In 1939 the insecticidal properties of dichloro, diphenyl, trichloroethane (DDT) were discovered.

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