

PREDATION BY A CYPRINODONTID FISH, *APHANIUS MENTO*, ON *CULEX PIPIENS*: EFFECTS OF ALTERNATIVE PREY AND VEGETATION

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ABSTRACT. We assessed the effects of an alternative prey species (*Daphnia magna*) and a submergent plant (*Ceratophyllum demersum*) on the efficiency of the fish, *Aphanius mento*, to prey on mosquito (*Culex pipiens*) larvae in the laboratory. *Aphanius mento* is an untested biological control candidate of mosquitoes. When *D. magna* was introduced with equal numbers of *Cx. pipiens* larvae, there was a 50.7% reduction in predation by *A. mento* on the mosquito larvae. However, the more *D. magna* a fish ate, the more *Cx. pipiens* it consumed. *Ceratophyllum demersum* did not affect predation rates on *Cx. pipiens* larvae.

Fishes, particularly the mosquitofish, *Gambusia affinis* (Baird and Girard), have been used worldwide in various habitats for controlling mosquitoes (Gall et al. 1980). However, larvivorous fishes have proven inconsistent in controlling mosquitoes, even within the same habitat (Blaustein 1992).

Several biological components of aquatic habitats may contribute to this inconsistency. The impact of species sharing the same trophic level as mosquito larvae on mosquitoes has received little attention. They may compete with mosquito larvae (Blaustein and Karban 1990) and may modify the efficacy of larvicidal bacteria (Blaustein and Margalit 1991). They may also affect predation rates on mosquitoes by serving as alternative prey to introduced predators (Bence 1989, Blaustein 1990). Because alternative prey are often orders of magnitude greater in numbers than mosquito larvae (Blaustein 1992), their indirect effect on predation rates on mosquitoes deserves greater attention.

Another biological component, vegetation, may have different effects on predation rates depending on the particular predator, prey and vegetation species (Angerilli 1980, Linden and Cech 1990).

Because of the inconsistency of mosquitofish and their implication in disrupting communities (Hurlbert et al. 1972), there is interest in assessing native fishes for mosquito control. One candidate in Northern Israel is *Aphanius mento* (Heckel) (Cyprinodontidae). It is native to the Hula Valley (Goren 1983), an area proposed for a large wetlands restoration project. Before the area was drained, malaria was a major problem there. (Kliger 1930, Pener and Kitron 1985). *Aphanius mento* has not been assessed, but a conspecific, *Aphanius dispar*, proved to be a vor-

acious mosquito larvivore in laboratory experiments (Homski 1987³). Here, we compare predation rates by *A. mento* on mosquito larvae (*Culex pipiens* Linn.) in the laboratory in the presence or absence of the submergent aquatic plant, *Ceratophyllum demersum* Linn. and an alternative prey, *Daphnia magna* Straus. We hypothesized that both vegetation and alternative prey should reduce short-term predation rates on mosquito larvae.

We collected *A. mento* and *C. demersum* from Einan Pool (located in the Hula Valley). *Daphnia magna* and *Cx. pipiens* larvae were collected from local temporary pools. We conducted the experiment in a Haifa University laboratory during spring, 1992. We used 4 beige-colored plastic tubs (28 × 32 × 19 cm) containing 11.5 cm of aged tap water as experimental arenas. Into 2 randomly selected arenas, we added enough *C. demersum* for a stem length of 330 cm per tub. Approximately 20% of length of the plant intersected with the air-water interface. Sex of *A. mento*, indistinguishable from external morphology, was not determined in our experiment. One adult fish (2.5–2.6 cm standard length) was added to each arena 24 h prior to adding prey. Fish were deprived of food during this period to standardize hunger level. Each fish used had been in the laboratory for 1–4 wk and had been exposed to both prey types prior to the experiment.

We initiated all predation trials between 1500 and 1700 h and at temperatures ranging from 21 to 23°C. We tested the presence or absence of *D. magna* crossed with the presence or absence of *C. demersum*. Thus, during each trial, the 4 possible *Daphnia*-vegetation combinations were represented once. We randomized the treatments among tubs for each trial. At the start of each

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³ Homski, D. 1987. The potential of *Gambusia affinis* and *Aphanius dispar* as a biological control of mosquito larvae under diverse conditions of water quality as a basis for a new larvae control system by fishes. M.Sc. Thesis. Tel Aviv Univ. [In Hebrew.]

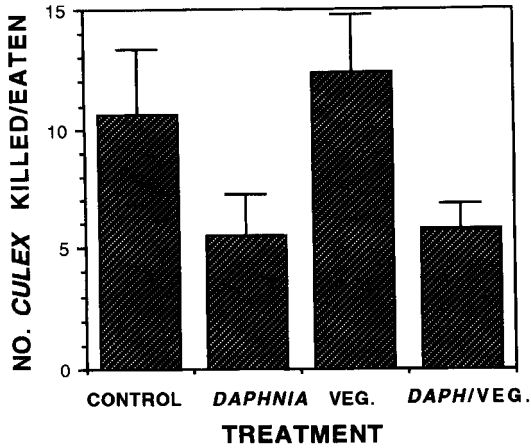


Fig. 1. Mean number of *Culex pipiens* larvae (late 3rd to early 4th instar) killed/eaten by a single *Aphanis mento* adult ($n = 36$) in the presence or absence of an alternative prey, *Daphnia magna*, and a submergent plant, *Ceratophyllum demersum*. "Control" signifies the absence of both alternative prey and vegetation in the presence of the fish. Error bars are standard errors.

trial, we added 30 *Culex* (late 3rd to early 4th instars) larvae to each arena and 30 *Daphnia* (length ca. 2.5 mm) to the appropriate arenas. After 60 min, we removed the fish and counted remaining larvae and *Daphnia*, both alive and dead. We replicated the experiment 10 times. If the fish did not eat/kill at least 2 prey items during the 60-min period (this occurred on 4 occasions), we discarded the results of that particular fish—an *a priori* decision. Each combination was also replicated 3 times without fish and there was 100% survival of the 2 prey species. Thus, we concluded that all dead prey not consumed by the fish (less than 5% of the total dead prey) were killed by the fish.

We analyzed data as a 2 factorial analysis of variance: 1) alternative prey (*Daphnia*) and 2) vegetation (*Ceratophyllum*). *Aphanis mento* predation upon mosquito larvae was reduced by 50.7% when alternative prey were present ($F_{1,31} = 7.62$, $P = 0.009$; Fig. 1). We hypothesized *a priori* that if a fish satiated on *Daphnia* in addition to mosquitoes, then the more *Daphnia* a particular fish ate, the fewer mosquitoes it would prey upon. In fact, we found the opposite ($r = 0.65$, $P < 0.01$; Fig. 2). Figure 2 indicates that most individuals did not satiate and regardless of how many total prey they ate, individuals tended to eat roughly the same fraction of the 2 species.

In our experiment, a mosquito: alternative prey ratio of 1:1 resulted in a ca. 50% reduction in predation on mosquitoes, indicating nonselective feeding. In many habitats, mosquitoes make

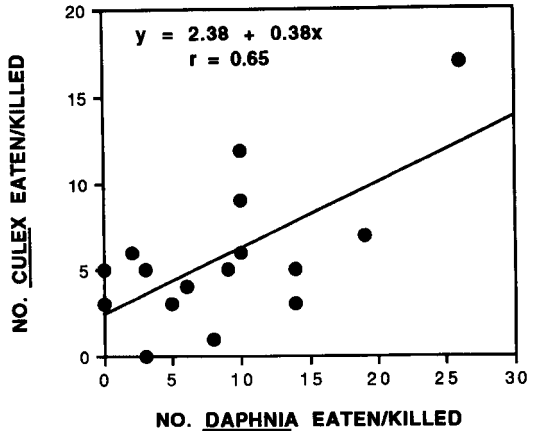


Fig. 2. The number of *Culex pipiens* larvae (late 3rd to early 4th instars) killed/eaten versus the number of *Daphnia magna* killed/eaten by a single *Aphanis mento* adult.

up a very small fraction of the prey available to larvivorous fishes (Blaustein 1992). Thus, with a normal mosquito: alternative prey ratio, we would expect alternative prey to cause a much larger, short-term reduction in predation intensity on mosquitoes. Longer term effects could be quite different; alternative prey could even cause an increase in predation on mosquitoes if apparent competition (*sensu* Holt 1977) occurs (i.e., predator populations increase in response to alternative prey and then prey more heavily on mosquito larvae).

The number of mosquitoes consumed by *A. mento* was not influenced by *C. demersum* ($F_{1,32} = 0.19$, $P = 0.67$; Fig. 1) nor was there an interactive effect of *Daphnia* and vegetation ($F_{1,32} = 0.29$, $P = 0.59$). An influence of vegetation on predation on *Daphnia* was not demonstrated either; *Aphanis* consumed an average \pm SE of 10.67 ± 2.47 and 7.22 ± 3.03 *Daphnia* in the absence and presence of vegetation, respectively ($t = 1.08$, $df = 16$, $P = 0.30$). The results are not surprising because neither *Daphnia* nor *Cx. pipiens* appeared to utilize the vegetation as cover from the predator. The efficiency of *A. mento* to prey upon other mosquitoes such as *Anopheles* species that utilize the meniscus at the plant-air-water interface may be heavily reduced in the presence of vegetation (Orr and Resh 1989). Moreover, *A. mento* prefers dense vegetation in nature (Goren 1983) and like other fishes (Angerilli 1980), may be more efficient at finding and capturing prey within vegetation.

The density of vegetation also influences its refuge capability (Crowder and Cooper 1982). In this study, the amount of vegetation intersecting the air-water interface was considerably lower

than some plant stands we observed in the field. Vegetation may have been important had we tested at greater plant densities.

The assessment of how many mosquito larvae a polyphagous predator will eat in a simple laboratory arena without consideration of other interacting biological components provides very little information in predicting whether this predator will be a successful biological control agent. Our results support the contention that alternative prey abundance is extremely important in how efficient a larvivorous fish will be in controlling mosquitoes. Greater emphasis should be placed on the importance of alternative prey when assessing polyphagous predators as biological control agents. Our study also suggests that *A. mento* should be assessed further as a potential biocontrol agent of mosquitoes, particularly in vegetated habitats.

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