Preliminary Report on Feed Trials of Sacramento Perch (*Archoplites interruptus*)
by Chris Miller

Introduction

Interest in using native fish species for controlling mosquito populations has prompted research on California’s only native centrachid, the Sacramento perch (*Archoplites interruptus*). Although there are publications describing food habits of this species, the studies evaluated populations that originated from introductions (Moyle, P.B., S.B. Mathews, and N. Bonderson. 1974). Little is known about the feeding habits of Sacramento perch from Sacramento-San Joaquin Estuary because the Estuary was modified long before fishery scientists started studying this resource.

Historically the Sacramento-San Joaquin Estuary provided slow-moving rivers, sloughs, ponds, lakes and extensive flood plains during spring and early summer. The expansive shallow water of the flood plain would provide flooded vegetation for spawning substrate as well as food items for larval fish. Decomposing vegetation in the warmer shallow water starts the cycle by providing food for bacteria, algae and ciliates. These then provide food for rotifers, copepods and *Daphnia* sp. as well as mosquito larvae and other primary consumers. This group is then food for predatory insects as well as larval and juvenile fish. We believe that Sacramento perch used the flood plains to reproduce and co-evolved with various species of mosquitoes.

There are several facts that help to support this connection. 1) Sacramento perch spawn on vegetation.

Sacramento perch developing egg at 3 hours post fertilization 880 microns. 100x

In our experiments Sacramento perch preferred Spawn Tex™ (a rubber coated natural fiber—which may resemble matted grass or roots) over large cobble, gravel, garland and bottle brush material used for spawning Koi. The adhesive eggs attach to the fibers spacing the eggs out. 2) At hatch the larval perch are

Sacramento perch attached to Spawn Tex™ fiber. Four millimeters in length

attached to the egg shell by a thin filament. The filament is attached to the head of the larval perch and keeps that larvae attached to the spawning substrate for approximately 1-4 days (28-22°C). While the exact function of the filament can only be speculated, it may help to keep larvae from being swept out of the security of vegetation by wind generated waves or incoming tides. After the filament has dissolved, larvae cling to the substrate (Spawn Tex™ or vegetation) for 2-4 more days depending on the temperature (28-25°C.) 3) At swim-up larval perch are

Monostyla sp. at 80 microns in width. 400x

ready to start feeding. In our experiments larval perch first feed items are freshwater rotifers (*Monostyla* sp.)
that ranged in size from 75 to 95 microns in width. Other items of similar size (in width) such as copepod nauplii, paramecium and Philodina (a stationary rotifer) were offered. Although larvae attempted to capture these items they failed to feed. Larval perch will select larger prey items as they grow but without an abundance of rotifers (75 to 150 microns in width) at first feeding, larval survival will be poor. Flood plain habitat provides optimal conditions for rotifer production, providing food (decomposing vegetation) and elevated temperatures. 4) Although the exact cause of the elimination of Sacramento perch is difficult to determine reduction in flood plains (as well as introduction of non-native fish species) coincides with reduction of Sacramento perch populations. Systems that provide seasonally flooded shallow water may be important to larval survival. Two examples where perch are maintaining populations, Clear Lake and San Luis Reservoir have seasonal fluctuations in water levels. Water levels in Clear Lake fluctuate 5-9 feet annually with high water level generally occurring in May with lows in November. San Luis Reservoir water levels also fluctuate from 500,000 to 2,000,000 acre feet. In 1995 young-of-the-year Sacramento perch were found to be abundant in the Portuguese Cove Arm. The successful reproduction was believed to be related to the wet winter which allowed water levels to remained at over 2,000,000 acre feet from March thru June (IEP Newsletter Fall 1995, California Dept. Water Resources Data). 5) Sacramento perch are multiple spawners. In our experiments perch have spawned up to 18 times in 148 days (first spawn to last) averaging 14,112 larvae per spawn (seventeen spawns counted female 158mm standard length). With a range of 6,237 to 23,436 larvae per spawn. Larger females averaged larger numbers of larvae. A 162mm SL female averaged 14,680 larvae (8,732 to 21,924-seven spawns counted) and 168mm SL female averaged 20,383 larvae (15,309 to 26,271-six spawns counted). The time between spawns (inter-brood interval) averaged 9.6 days with a range of 5-14 days between spawns. Temperature ranged from 23-29°C. Given abundant food resources and warm temperatures Sacramento perch can produce large numbers of larvae in a relatively short period of time. Laying eggs in batches combined with the short interval between spawns is an effective way to quickly utilized beneficial conditions as well as insuring against total failure if conditions turn adverse.

If Sacramento perch did evolve in a flood plain environment or body of water that experienced large fluctuations in water levels, they would have also evolved with other organisms, both predator and prey. Because shallow warm water is important to various species of mosquitoes it may be that mosquito larvae were part of the diet of Sacramento perch during the early life history. We have observed Sacramento perch 17 days post hatch eat first instar larvae of Culex tarsalis. Perch were approximately eleven millimeters in length(TL). It is unclear if this predatory behavior was related to a reduction in Daphnia magna of the proper size or a switch to this recently introduced prey item (via egg raft introduction approximately 5 days previous). By 18 days post hatch all mosquito larvae (1st thru 3rd instars) were consumed.

A series of experiments were conducted in two gallon aquariums using Sacramento perch and mosquitofish. These experiments were conducted to answer two questions. 1) Numbers of mosquito larvae
consumed over time for each fish species and 2) Prey item preferences between mosquito larvae (Culex *tarsalis*) and *Daphnia magna*. This information will provide baseline data for larger experiments and may also resolve unforeseen problems.

**Methods & Material**

Mosquito larvae for this study were reared in 56.7 liter mortar mixing trays. Emulsified crustacean (blended cocktail shrimp) was added at approximately 150 grams per 37.8 liters of well water. Natural populations of female *Culex tarsalis* would lay eggs rafts on the surface and larvae grew well in the nutrient rich water. *Daphnia magna* were reared in 2000 gallon fiberglass tanks. Approximately 400 grams of alfalfa pellets, 20 grams of ammonium sulfate and 20 grams of Miracle Grow™ all purpose plant food (15-30-15) was added to well water. Once water turned green it was inoculated with *Daphnia magna*. This sequence was rotated between four tanks based on the density of *Daphnia magna*.

In the first study 7.56 liter aquariums, filled with 5.67 liters of well water were stocked with three Sacramento perch in each of three replicate aquariums. Mosquitofish were placed in three other replicate aquariums. Twenty-four hours after placing fish in the aquariums 200 *Culex tarsalis* larvae (ranging from 1st to 4th instar) were poured into each tank including the three control replicates. Within 23 minutes all mosquito larvae were consumed in Sacramento perch aquaria. Mosquitofish consumed mosquito larvae within 20 hours.

In experiment two we used the same tanks and number of larvae (200) but added 200 *Daphnia magna* to each tank. Mosquito Larvae were counted every hour during the first 5 hours and then intermittently until all larvae were consumed. Sacramento perch consumed all larvae in 5 hours while mosquitofish took up to 48 hours. *Daphnia magna* was still present in both Sacramento perch and mosquitofish aquaria after mosquito larvae had been consumed. Once mosquito larvae were consumed Sacramento perch consumed *Daphnia magna* within 24 hours while mosquitofish took 48 hours.

Experiment three was a duplicate of experiment two (200 mosquito larvae & 200 *Daphnia magna*) with a change in the data collection. We were going to count both mosquito larvae and *Daphnia magna* every hour until both prey items were consumed. In this study mosquito larvae were consumed in 25 minutes by Sacramento perch. It was extremely difficult to count *Daphnia magna* so the experiment was terminated.

In experiment four *Daphnia magna* were added to aquaria at high densities. One hour later mosquito larvae were added at high densities. No effort was
made to count either prey item. Both Sacramento perch and mosquitofish began feeding on *Daphnia magna* when added to aquaria. When mosquito larvae were added one hour later both species began feeding on the mosquito larvae. Within approximately 20 hours Sacramento perch consumed all mosquito larvae. Mosquitofish consumed larvae with in 72 hours. *Daphnia magna* was still present in Sacramento perch aquaria for another 48 hours after mosquito larvae were consumed. Temperatures during these experiments ranged from 20.1-21.0°C.

**Discussion**

These four experiments demonstrate that Sacramento perch will eat mosquito larvae and prefer mosquito larvae over *Daphnia magna* in experimental aquaria. Differences in time for all mosquito larvae to be consumed for Sacramento perch between experiments may be explained in two ways. 1) There were differences in average mosquito larval instar size between experiments. Production of mosquito larvae is affected by temperature, wind and attractive qualities in rearing water. Temperature too low will produce lower numbers of eggs rafts laid on the water and may prolong egg raft deposition. Prolonged eggs raft deposition results in a large range of sizes of mosquito larvae (1st instars thru pupae). Temperature too high can kill mosquito larvae. High winds reduce or even eliminate egg raft deposition. The attractive qualities of the rearing water may have differed as measurements were approximated, although all three conditions work in relation to each other. During counting of mosquito larvae we did not discriminate between sizes. A 1st instar larvae was counted the same as a pupae. Each batch of mosquito larvae were reared for a specific experiment and there were differences. 2) The period of “starvation” may have differed slightly as well as amount of feed offered during the pre-starvation period. *Daphnia magna* was fed to all treatments between experiment because it was available in quantity and remained alive until consumed. No effort was made to measure the amount fed to fish between experiment. This would effect the hunger level in both species and the consumption rates. Differences in consumption rates between Sacramento perch and mosquitofish can easily be explained by the size differences. Although some effort was used to select fish of approximate size there were differences. Sacramento perch averaged 580 milligrams and mosquitofish averaged 213 milligrams (wet wt. across replicates). The amount of food a fish can consume in a given time period is related to its’ weight. This was clearly demonstrated by observing replicate aquaria SP2. One individual perch was approximately 68% larger (in weight) than the other two individuals. This individual continued to aggressively feed on mosquito larvae and it was estimated that this larger individual ate more that 50% of the larvae in experiment two.

**Size Chart**

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<tr>
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<th>MF1</th>
<th>MF2</th>
<th>MF3</th>
<th>SP1</th>
<th>SP2</th>
<th>SP3</th>
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<tr>
<td>Len. TL</td>
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<td>1-27.5mm</td>
<td>1-24.5mm</td>
<td>1-32mm</td>
<td>1-31mm</td>
<td>1-32mm</td>
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<td>Ave Len</td>
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<td>23.4mm</td>
<td>25.8mm</td>
<td>32.5mm</td>
<td>35.5mm</td>
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<td>Wt. gm</td>
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<td>0.22</td>
<td>0.22</td>
<td>0.55</td>
<td>0.63</td>
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With information gathered from this series of experiments a larger experiment is planned. Depth of water will be increased as well as the color of the culture vessel. With encouraging results from this larger experiment, a replicate field experiment will be conducted. We are hoping that Sacramento perch will ultimately be used for mosquito control in specific areas. This species may prove to be useful in controlling mosquitoes in flood plain and wetland restoration projects. By using Sacramento perch in this manner we may help to reestablish this species to its’ original range.