# A COMPARISON BETWEEN THE AREA SAMPLER AND THE TWO OTHER SAMPLING DEVICES FOR AQUATIC FAUNA IN RICE FIELDS

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ABSTRACT. The relative merits of 3 aquatic sampling instruments for rice fields were compared. A 0.1 $m^2$ area sampler was compared with a 400 ml dipper in terms of organisms per volume of water sampled. In addition, an unbaited and unlit minnow trap was compared to the other 2 devices, but on a qualitative basis only.

The area sampler collected more than the dipper in terms of numbers of organisms and numbers of taxa. It also collected more taxa than the trap. The dipper is easy to use and is adequate for the quantitative sampling of mosquito larvae or qualitative sampling of plankton and slow moving microorganisms close to the surface; but not benthos. The trap collected adult Coleoptera and other nekton, including *Gambusia*; some of which were barely represented by the other 2 methods.

The area sampler required the most work, in terms of man-hours spent to collect and process samples and the trap required the least.

## INTRODUCTION

Critical to the evaluation of integrated control of rice field mosquitoes is the development of standardized sampling strategies. Efficient methods which employ the least amount of equipment and work are important to develop in order to meet budget constraints of many researchers. Little is available in the literature that addresses devices which can sample entire aquatic invertebrate communities in rice fields. Most were designed to sample specific invertebrates and/or subhabitats. Service (1976) reviewed the voluminous mosquito sampling methods available, many of which can sample other invertebrates as well. Merritt et al. (1978) offered drawings of various collection devices for aquatic invertebrates, their uses and references.

A static, quadrate area sampler (Fig. 1) was selected for this study because of its potential to quantitatively collect entire aquatic invertebrate communities in rice fields, using a single sample method. An early quadrate sampler described by Knight (1964) and used by Cambournac (1939) was designed to sample mosquito larvae per unit area. More recent mosquito investigators continued to use quadrate samplers essentially similar in design and purpose (Hagstrum 1971, Roberts and Scanlon 1974, Ikemoto 1976).

The standard 400 ml mosquito dipper can be used to quantitatively (Hagstrum 1971) or semi-quantitatively (Merritt et al. 1978) sample plankton (Miura and Takahashi 1975) and small nekton (Washino and Hokama 1968, Legner et al. 1975) as well as mosquito larvae. The unit was light, easy to use and collections were made fairly quickly (Table 2). The dipper was not designed to directly measure absolute organism populations with respect to surface area but has been used to measure relative populations by the use of appropriate computational techniques (Knight 1964).

The minnow trap is primarily a qualitative sampling device but can provide estimates of absolute population by mark-and-recapture methods (Knight 1964). With modification it can sample nekton and spiders.

This study is to determine, by comparison, if the area sampler can singly provide adequate samples of the aquatic invertebrate community in rice fields. We will show comparisons of 3 sampling devices

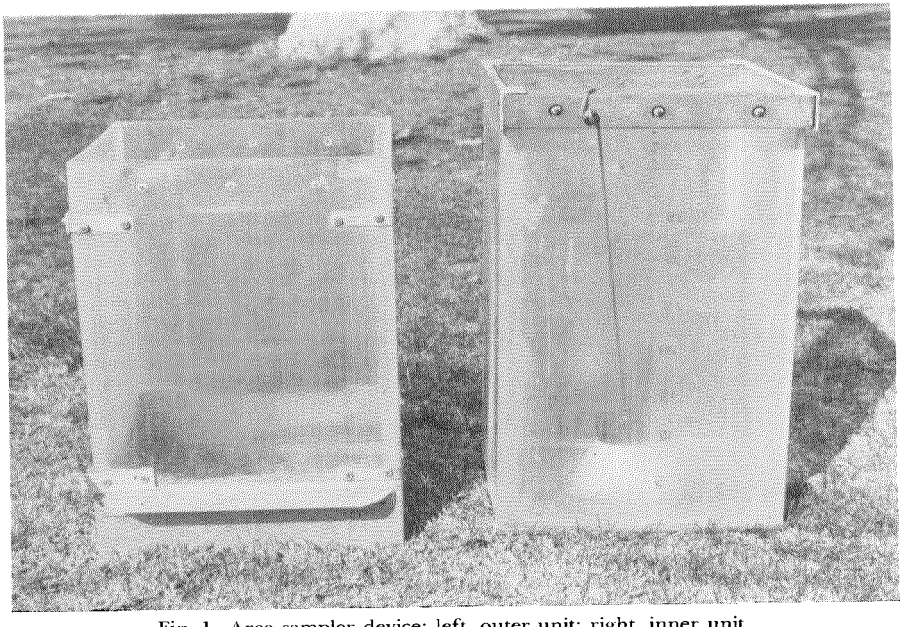

Fig. 1. Area sampler device; left, outer unit; right, inner unit.

with respect to: 1) relative numbers caught, 2) numbers and types of taxonomic groups captured, 3) limitations to their use and 4) cost in relation to man-hours of work.

## MATERIALS AND METHODS

The rice fields sampled were located south of Dos Palos, Fresno County, California. The area was flat, arid and nearly all under agriculture, predominantly row crops such as cotton, grains, vegetables and sugar beets.

Four fields were designated as: #4 (10.4 ha), #5 (8.2 ha), #8 (10.9 ha) and #9 (10.7 ha). They were arranged in a block design with contiguous borders. The fields were irrigated by water from the Delta-Mendota canal which was near the north border of the block. Fields 8 and 9 were stocked with 36.7 g/ha of mosquitofish, *Gambusia affinis* (Baird and Girard), approximately one month before sampling.

The area sampler consisted of 2 box-shaped units made of 6.53 mm acrylic plastic. The outer unit was open on both top and bottom and samples an area 0.1 $m^2$. The inner unit has an open top and a closed bottom with a stoppered hole and fits snugly inside the outer unit. Both units are 50 cm high. The inner unit is slightly higher for grasping and was graduated with volume marks. When sampling, the outer unit was plunged vertically into the water and immediately pushed down about 5 cm into the soil. Vegetation was then pulled and clinging organisms washed out into the unit. The inner unit was placed inside, with its hole opened, to flush in water containing most of the organisms, except benthos, while it was sinking. When at the bottom volume measurements were taken. Then the inner unit was plugged, its contents re-

moved and condensed through a 149 $\mu$ opening screen. Any remaining water in the outer unit was scooped out and filtered above. The condensed sample was then placed in a sample jar with alcohol to be processed in the laboratory later. Benthos were removed by scraping a 1–2 cm soil layer from the bottom, washed above a screen with 250 × 300 $\mu$ openings, and placed in another jar with alcohol.

The fractions were evaluated as a single sample. One sample was taken at each of the 10 stations at least 1 m away from the levees and in different paddies within the field. The 4 fields were sampled every week for 10 weeks starting June 1980. In the laboratory each sample was washed again and cleaned of soil and gross vegetation incorporating the same mesh screens as used in the field. Most samples were sized for counting convenience by running a sample through a gradient of sieves.

Organisms retained by sieves with 4 mm or larger openings were counted with a 2X magnifying glass, those retained by smaller openings were counted with stereomicroscopes at 4-20X. Large numbers of smaller organisms (Cladocera, Copepoda and Ostracoda, generally > 1000) were homogenously mixed in 50 ml of water and 2 ml aliquots were counted.

Dipper samples were taken with a standard 400 ml mosquito dipper (6 × 10 cm diam) along transects, sampling different paddies across the field. As the habitat is reasonably uniform throughout a paddy, except for bands very near levees, the dipper sampled essentially the same invertebrate community as the area sampler. Fifty dips were made, at about 2 m intervals, every week for 10 weeks. Each collection for a transect run was condensed through a concentrator (Husbands 1969) with a 149 $\mu$ opening screen, placed in alcohol and transported to the laboratory where all organisms were identified and counted. Quantitative comparisons between the dipper and area sampler were made only in terms of organisms per volume of sample water collected. The dipper concentrators did not accommodate large *Gambusia*, *Hyla* sp. or *Rana* sp. and therefore these organisms were omitted in dipper comparisons. As the dipper did not measure surface area, its comparisons with the area sampler were done on a volume basis (i.e. organisms/20 liters/wk).

The 40 × 22 cm diam minnow traps were modified by lining the interiors with 1200 to 1500 $\mu$ opening screen. These openings did not allow for the capture of the small crustacea so these organisms were omitted from trap comparisons. Both ends of the trap had funnel entrance openings about 2 cm diam. Eight unbaited and unlit traps were used in each field; 5 with openings beneath the water surface and 3 (for surface walkers) with openings above. The traps were operated from 1400 h till 1000 h the next day and positioned 1 to 5 m from where area samples were taken. Organisms were counted in the field and released. Those which could not be recognized were transported in alcohol to the laboratory for identification. Comparisons between the trap and the other two sampling devices (Table 1) are in qualitative terms and were not analyzed statistically.

## RESULTS

Throughout the 10-week sampling period there were 394 area (6 samples not taken), 40 dip and 320 trap samples collected in the 4 fields. Analysis of the numbers showed that the area sampler captured significantly ($p = 0.05$, analysis of variance) more organisms per volume unit than the dipper sampler in 12 taxa, whereas the dipper exceeded in only 2 taxa (Table 1; factor 1). The greater numbers collected by the area sampler were attributed in part to the vertical limitations of the dipper, i.e. the area sampler can sample benthos but the dipper samples only water near the surface. Most of the organisms which were missing or in significantly low numbers in dipper samples were benthos and/or fast swimming nekton. In the remaining taxa neither sampler captured significantly more than

Table 1. Relative numbers of organisms captured by the area sampler and the dipper (per 200 liters of sample water) or by 50 traps in 4 Dos Palos rice fields over a period of 10 weeks from June through August 1980. Factors 1 and 2 are relative indications of significant (analysis of variance, $p \leq .05$) differences between the area sampler and dipper only.

| Taxa | Avg. no./200 | | Factor | | Avg. no/ 50 traps |
|---|---|---|---|---|---|
| | Area | Dipper | 1[a] | 2[b] | Trap |
| Arthropoda | | | | | |
| Crustacea | | | | | |
| Cladocera | 20251.0 | 12578. | A | X | |
| Copepoda | 30734.0 | 11981 | A | | |
| Ostracoda | 60687.0 | 46206 | A | X | |
| Decapoda | 0.1 | 0 | | | |
| Insecta | | | | | |
| Ephemeroptera | 71.7 | 36 | A | | 4.3 |
| Odonata | | | | | |
| Zygoptera | 307.0 | 472 | D | X | 315.0 |
| Anisoptera | 36.6 | 12 | A | X | 121.0 |
| Hemiptera | | | | | |
| *Belostoma* | 2.3 | 4.5 | | | 47.8 |
| Corixidae | 17.0 | 5.5 | A | | 66.8 |
| Notonectidae | 7.4 | 7 | | X | 266.0 |
| Misc. Hemiptera | 0.5 | 0.5 | | | 0 |
| Coleoptera | | | | | |
| *Hygrotus* | 21.8 | 9.5 | A | | 93.0 |
| *Laccophilus* | 9.9 | 9 | | X | 394.0 |
| *Rhantus* | 0.0 | 0 | | | 5.5 |
| *Thermonectus* | 0.7 | 0 | | | 15.0 |
| *Cybister* | 0.1 | 0 | | | 107.0 |
| *Berosus* | 8.3 | 0.5 | A | | 4.5 |
| *Hydrophilus* | 0.5 | 0 | | | 13.5 |
| *Tropisternus* | 3.2 | 7.3 | | | 141.0 |
| Misc. Coleoptera | 4.6 | 7.0 | | | 0.8 |
| Diptera Chironomidae | 2854.0 | 270.0 | A | X | 0.5 |
| *Anopheles* & *Culex* | 1.3 | 37.5 | D | X | 0 |
| Misc. Diptera | 29.7 | 35.8 | | | 0 |
| Arachnida | | | | | |
| Araneida | 4.8 | 7.0 | | X | 23.8[c] |
| Ararina | 1.5 | 4.3 | | | 0 |
| Annelida | | | | | |
| Hirudinea-Leech | 2.3 | 2.5 | | X | 2.0 |
| Oligochaeta-Ag. earthworm | 4855.0 | 25.8 | A | X | 0 |
| Chordata | | | | | |
| Osteichthyes-*Gambusia* | 30.8 | | | | 2682.0 |
| Amphibia-*Hyla* & *Rana* | 4.8 | | | | 59.0 |

[a] The letter "A" (area sampler) or "D" (dipper) signifies which method captured more organisms of a particular taxon.

[b] The letter "X" indicates more organisms of that taxon were captured in the fields not planted with *Gambusia* mosquitofish.

[c] Avg. no. per 30 traps.

the other and in some instances the numbers for both were very low. The area sampler also captured a greater composition of organisms (Table 2) than either the dipper or trap.

Table 2. Average numbers of taxa (S) and average numbers of organisms collected by 3 devices over 10 weeks.

| Sampler | Field no. | S | Avg. no. organisms/ 20 liters/wk |
|---|---|---|---|
| Area | 4 | 21 | 16407 |
| | 5 | 19.2 | 17210 |
| | 8 | 19.1 | 9269 |
| | 9 | 21.1 | 5992 |
| Dipper | 4 | 12.5 | 11133 |
| | 5 | 11.8 | 7838 |
| | 8 | 10.2 | 7250 |
| | 9 | 10 | 5432 |
| | | | Avg. no. organisms/ 5 traps/wk |
| Trap | 4 | 15.3 | 229 |
| | 5 | 14.5 | 178 |
| | 8 | 14.9 | 415 |
| | 9 | 14.6 | 323 |

The traps yielded rather high numbers of organisms in taxa that are poorly represented by the other 2 sampling devices, especially some of the Coleoptera, Hemiptera and *Gambusia* mosquitofish. Therefore trapping may compensate for insufficient numbers collected by the other methods. The number of taxa collected by the trap was less than the area sampler but more than the dipper.

The man hours needed to complete the area sampling, including processing, was over 10 times greater than the time needed to complete the dipper and trap sampling together (Table 3). A single area sample from 1 station required 1.5 times more work than the dipper transect (50 dips across the entire field) and 60 times more than each trap. In addition the area sampler required more work than the dipper in terms of man-hours per liter of water sampled.

Factor 2 in Table 1 indicates which organisms were captured in significantly ($p = 0.05$ A.O.V.) lower numbers in *Gambusia* planted fields, regardless of the method used. Significantly, some of those were mosquito predators (Odonata, Notonectidae, *Laccophilus*). Equally important is that larval mosquitoes, *Anopheles freeborni* Aitken and *Culex tarsalis* Coquillett, were also reduced.

## DISCUSSION

We suspect that *Gambusia* preyed on, and/or competed with, the indigenous predators of the rice fields but still the net result was fewer mosquito larvae.

Washino (1968) observed that the invertebrate predator population in other California rice fields peaked in early summer; and this was somewhat supported by our data. He also reported that *Gambusia* predation on mosquitoes intensified during late summer when other

Table 3. Number of man-hours needed to collect and process samples from the 3 sampling devices used in this study.

| Sampler | Man-hrs devoted | | | No. samples collected | Man-hrs per sample[a] | No. liters collected | Man-hrs per liter |
|---|---|---|---|---|---|---|---|
| | Collection | Processing | Total | | | | |
| Area | 480 | 1664 | 2144 | 394 | 5.4[b] | 6669 | 0.32 |
| Dipper | 32 | 115 | 147 | 40 | 3.7[c] | 800 | 0.18 |
| Trap | 28 | | 28 | 320 | 0.1[d] | | |

[a] Includes processing time.
[b] A single area sampler. 10 samples were taken per field.
[c] 50 dips from transect crossing entire field.
[d] A single trap. 5 traps were used per field.

food items for the fish became scarce. Therefore, in order to achieve a further reduction of mosquitoes, an introduction of *Gambusia* during mid or late summer (if early thresholds are acceptable) would be a strategy to consider, but needs more testing.

Neither the area sampler nor the other 2 methods adequately sampled all the aquatic organisms in the riceland habitat. However, the area sampler was the most versatile of the devices tested as it quantitatively measured most of the aquatic invertebrates in this environ, per unit area and volume. It provided a greater composition and abundance of taxa than either the dipper or the trap. Yet the device was heavy and cumbersome, did not capture sufficient numbers of certain nekton, and the subsequent processing of its samples was tedious. In our study, it took more time to complete than the dipper and trap together and required more man-hours per sample.

The dipper was easy to use and the most efficient sampler of mosquito larvae and Zygoptera. It also captured plankton, a few benthos and nekton, but in smaller numbers than the area sampler. It yielded the smallest number of taxa but was the easiest to use because of its light weight.

The trap, in comparison, captured the most numbers of nekton, took the least man-hours to complete, but was the most limited with respect to ease in sampling design.

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