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RESEARCH MEMORANDUM

RM 72-53

AQUATIC MACROINVERTEBRATES OF THE PLAYA

G. Richardson, C. R. Ward
and
E. W. Huddleston

DESERT BIOME
U.S. INTERNATIONAL BIOLOGICAL PROGRAM
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I.F.7. Aquatic Macroinvertebrates of the Playa

I.F.7.a. Introduction

I.F.7.a.1. Purpose and Scope

The stated objectives of the validation studies are as follows:

1. To conduct an initial inventory (standing-crop measurements) of energy, nitrogen, phosphorus, carbon, and water in as many as possible of the biotic (species) and abiotic components of the site.

2. To make periodic standing-crop estimates of the major biotic and abiotic components of the system.

3. To make periodical measurements of the physical factors and inputs in the sites.

4. To develop equipment and facilities to accomplish the above.

The study reported here is concerned with the macroinvertebrate populations in the playa lake located on the Jornada Site. Since the primary concern of this study is to supply initial values and periodic measurements with which to validate the predictions of a computer model of a desert ecosystem, in most cases these studies were not designed primarily for interpretation. However, discussions of the data are included herewith, as well as detailed descriptions of the equipment and procedures developed to collect these data.

I.F.7.a.2. Review of Previous Research

The study of astatic aquatic ecosystems presents unique problems to the researcher. The very fact that the system is ephemeral makes long-term studies difficult. Erratic rainfall makes studies of astatic desert aquatic systems even more difficult. The Jornada playa has been inundated only 8 of the last 16 years. These problems associated with astatic desert aquatic systems have resulted in relatively few reported studies of these systems.

Temporary waters are common features of many arid and semi-arid regions. The desert pans of Africa (Hutchinson, et al., 1932; Rzoska, 1961; and Weir, 1969) are analogous to the playas found in the American southwest (Hutchinson, 1937; Reeves, 1966; Sublette and Sublette, 1967; and Wendorf, 1961). In some areas, the temporary waters take the form of intermittent streams. The unusual habitats have been examined by Clifford (1966) and Harrel and Dorris (1968). Other temporary aquatic situations such as flood plains (Heuschele, 1969; Paloumpis and Starrett, 1960) and temporary ponds (Moore, 1970), even when located in regions less arid than this study reported here, often have a fauna and succession of populations similar to those found in desert playas. Hinton (1953) discusses some of the adaptations of insects to temporary aquatic environments.

Springs found in deserts vary considerably in fauna and total productivity. Teal (1957) and Odum (1957) indicate the great potential productivity of a spring environment.

Playa lakes, varying in size from a few hundred feet to several miles in diameter are the most common aquatic systems in large areas of the southwestern plains and the Chihuahuan Desert. These playas are mostly freshwater, but a considerable number are highly saline. These saline playas are scattered throughout the arid regions of the world (Broch, 1969; Brown, 1968; McLachlan and McLachlan, 1969) and have surprisingly uniform fauna of highly adapted organisms. Almost universally present in temporary saline environments is the brine shrimp, _Artemia salina_ (L.).
The typical desert playa lake is inhabited by one or several species of Entomostraca. These crustaceans have remarkable rates of development. Aegla, a tadpole shrimp (Notostraca), can appear as half-grown immatures within one week of inundation. The clam shrimp (Conchostraca) mature even faster, requiring as little as five days to reach the adult stage. Some of the planktonic Entomostraca have a generation time of only two days. This fauna of Entomostraca is increased in most cases by the presence of one or several species of fairy shrimp (Anostraca). These extremely common organisms have a generation time of 7 to 10 days and exceptional fecundity. In addition to the above-mentioned crustaceans, several species of insects are usually present. These include mosquitoes, the eggs of which have been known to remain dormant for many years, and various adult beetles and waterbugs which migrate to temporary waters and, if conditions remain conducive to their development, may pass one or several generations in ephemeral lakes. The various modes of colonization of temporary waters are discussed by Fernando (1959, 1960), Proctor and Malone (1965) and Maguire (1963).

I.F.7.b. Methods and Procedures

I.F.7.b.1. Site Description

The Jornada Playa is located approximately 20 miles north of the New Mexico State University campus at Las Cruces, New Mexico, on the New Mexico State University Ranch in the Jornada del Muerto Range of the Chihuahuan Desert. This playa was designated as a study site in the Jornada Site of the United States International Biological Program, Desert Biome Project.

The playa basin (Figure I.F.7.b.1) is approximately 400 meters in diameter, and at the time of the study was characterized by a large number of "potholes" (resulting primarily from collapsed animal burrows), and several well-defined mammal trails leading to an open-end earthen stock tank (approximately 50 x 20 m) which had been excavated on the south-western edge of the playa.

The basin was partially covered by an uneven growth of vine mesquite (Panicum obtusum H.B.K.) and small amounts of other grasses and forbs, with the area immediately surrounding the basin supporting a dense growth of mesquite (Prosopis glandulosa Terr.) and tobosa grass (Hilaria mutica Buckl. Benth.). An additional 3-5% of the basin area was covered by cattle dung piles as the playa, when dry, had been utilized as a pasture. In the south-central portion of the playa basin, there was a conspicuous accumulation of seeds of the cocklebur (Xanthium sp.).

At the time of this study, the vegetation in the playa was unevenly distributed. The central portion was primarily bare, the northern portion was very sparsely covered with clumps of Panicum, while the southern portion was more densely covered with clumps of Panicum. The fringe of the basin supported the greatest density of Hilaria. This substrate was further modified by the accumulated detritus (plant litter, feces, etc.) which was washed into the playa from surrounding areas by sheet flow from the watershed, primarily the northern and western slopes of Mt. Summerford of the Dona Ana Mountain Range.

Six fixed sampling stations were selected before the filling of the playa (Figure I.F.7.b.1.). These sampling stations were supplemented by the addition of station 7 in the northern portion of the playa and stations 8, 9, and 10 in the central portion of the playa. The playa filled only partially, leaving some stations dry but these stations were relocated at the nearest edge of the playa when flooded, and relocated inward on subsequent sampling dates as the playa dried.
2.2.2.4.-71

Figure I.F.7.b.1. A topographic map of the Jornada Playa (US/IBP Desert Biome Validation Site) showing the location of the ten fixed sampling sites, alternate site number 2', and the stock tank with depth shown in centimeters.

I.F.7.b.2. - Experimental Methods

I.F.7.b.2.1. - Sampling procedure*

The primary sampling device used in this study was a modification of the Bellville trap (Welch and James, 1960) designed to obtain quantitative samples of mosquito larvae. Galvanized steel metal was used to construct cylinders enclosing an area of one-fourth square meter. The traps were of five different heights, ranging from one to three feet with six inch intervals in order to minimize weight and to facilitate evacuation of water from the trap after positioning.

The trap was dropped from the end of a hand-carried boom which located the trap approximately eight feet in front of the person carrying the boom. The trap was suspended from the boom by a removable harness which was attached to the boom with a parachute release buckle triggered by a cord running the length of the boom.

After dropping, the trap was forced into the substrate until an adequate water seal was obtained. The water enclosed by the trap was then dipped out by hand and strained through a 120 mesh plankton net. The sample thus obtained was preserved in a 1:1 solution of 10% neutral buffered formalin and 95% ethanol.

* Data from sampling and weighing procedures are recorded under DSCODES A3UMDO1 and WD03.
A five m sweep with a 30.5 cm "D" frame aquatic sweep net was taken in conjunction with each trap sample and as supplementary samples taken between trap sampling dates.

All samples were taken at or as near as possible to the 10 selected sampling stations. The first samples were taken on July 27, 1970, after rainfall on the 25th and 26th filled the playa. Table I.F.7.b.2.1 indicates the number and type of samples taken on each sampling date. On August 6-7 a 24-hour study was undertaken with a series of three trap and five net samples being taken at two-hour intervals between 6 p.m. August 6 and 6 p.m. August 7. These samples were taken near sampling station 2. The first sample was taken at the margin of the playa, as near to the shoreline as possible, and the others were taken at 10-meter intervals toward the center of the playa. The trap samples were taken at the same location as net sweeps 1, 3, and 5. Each set of samples was taken at a slightly different position along the shoreline to reduce the effect of the disturbance caused by sampling during the preceding two hours.

By August 10, only six of the original 10 stations remained inundated. An additional station, designated 2' (Figure I.F.7.b.1.), was selected and seven samples were collected. Due to the very rapid drying of the lake only two additional trap samples were taken on August 12.

On August 14 only the tank contained water and two samples were collected from the tank at that date. Three samples were taken in the tank on August 19 and again on August 30. Sampling was continued at approximately two-week intervals through October 16.

Table I.F.7.b.2.1. Number and type of samples taken during sampling period July-October, 1970, Jornada Playa, Las Cruces, New Mexico.

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Trap Samples</th>
<th>Number of Net Samples</th>
<th>Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>27/07/70</td>
<td>10</td>
<td>10</td>
<td>1-10</td>
</tr>
<tr>
<td>31/07/70</td>
<td>0</td>
<td>20</td>
<td>1-10</td>
</tr>
<tr>
<td>03/08/70</td>
<td>10</td>
<td>10</td>
<td>1-10</td>
</tr>
<tr>
<td>05/08/70</td>
<td>0</td>
<td>20</td>
<td>1-10</td>
</tr>
<tr>
<td>06-07/08/70</td>
<td>39</td>
<td>64</td>
<td>Selected</td>
</tr>
<tr>
<td>(24-hr study)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/08/70</td>
<td>7</td>
<td>7</td>
<td>1,2,3,5,9,10,2'</td>
</tr>
<tr>
<td>12/08/70</td>
<td>3</td>
<td>5</td>
<td>1,2,3,5,9,10,2'</td>
</tr>
<tr>
<td>14/08/70</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>17/08/70</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>19/08/70</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>30/08/70</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>18/08/70</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>03/10/70</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>16/10/70</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Problems and possible sources of error. The difficulties encountered during sampling were numerous. The removal of all of the water and its associated inhabitants from the trap was sometimes difficult. Achieving an adequate seal around the bottom of the trap was often difficult, and at times impossible when the trap was dropped across the edge of a deep pothole. When sampling was attempted on July 31, and later, the separation of the numerous tadpoles from the samples to prevent destructive sampling of these vertebrates became a limiting complication. However, a series of soil sieves was employed to separate most of the tadpoles, which were counted and returned to the lake.

The problem of a shadow cast by the suspended trap was minimized by sampling in the early morning or late afternoon. The disturbance of the lake bottom by other researchers could be minimized by alternating sampling dates in future studies.

Probably the most limiting factor affecting the trap sampling was that of time. A time analysis showed a minimum of 30 minutes was required to take a set of one trap and one net sample. In addition, it took 1 1/2 to 2 hours to drop all ten traps prior to sampling. This procedure minimized the time-of-day effect in the trap samples. There was, however, a greater time-of-day effect in the "D" frame net samples, since they were taken as the traps were emptied in sequence.

I.F.7.b.2.2. - Traps versus net sampling

Due to the much shorter time required to collect and process net samples as opposed to trap samples, it would have been advantageous to restrict sampling to net sweeps with only occasional trap samples to calibrate the net data. If trap sampling could be reduced to some degree, the time saved would be considerable because of the great number of samples required.

A comparison of the trap and net samples collected in the 24 hour study (Table I.F.7.b.2.2.) indicated that net sampling may be a more efficient indicator of all species present. A total of 18 species were collected in 64 net sweeps while in 39 trap samples only 14 species were collected. Although this difference might be due in part to the greater number of net samples, theoretically all specimens enclosed by the trap are collected, so one would anticipate a more complete species representation by that method.

Most of the figures presented here will compare net and trap estimates. In most cases the net estimate is roughly equivalent to that of the trap. Thus, many net samples and a few trap samples could give a fairly accurate estimate of population density in future playa studies. Figures I.F.7.b.2.2.1. and I.F.7.b.2.2.2. compare the net and trap samples of the two major groups of invertebrates. The correlation of trap and net samples for Insecta is partially obscured by the presence of a large localized population of corixid nymphs.

I.F.7.b.2.3. - Sorting, counting, and weighing procedures

Samples taken in the field were returned to the laboratory and hand-sorted, using a dissecting microscope and white enamel pan. All macroinvertebrate organisms were removed from the associated debris, sorted to obvious species and measured to the nearest millimeter with an ocular grid. After recording species, body length, and sampling number, the specimens were stored in 95% ethanol in one-dram vials (or larger if necessary). A checklist of the macroinvertebrates encountered is given in Table I.F.7.b.2.3.

After a set of samples was recorded, a wide selection of specimens were dried at 70°C for 48 hours, removed from the oven, weighed, and the weights recorded to the nearest 0.01 mg. After a sufficient number of the specimens were weighed, a correlation between weight and length was calculated. This correlation was used to obtain an estimate of the weight of the specimens measured but not weighed.

To facilitate the assignment of estimated weights, each organism was assigned to a specific size group and an interval within that size group. Some groups, such as the Anostraca, may have up to 18 larval instars; however, most insects have a much smaller number of instars (4-6) and were much easier to group.
Table I.F.7.b.2.2. Number of species collected in each sample during the 24 hour study. Jornada Site, Las Cruces, New Mexico, August 6-7, 1970.

<table>
<thead>
<tr>
<th>Time</th>
<th>Trap Sample Number</th>
<th>Net Sample Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6 PM</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>8 PM</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>10 PM</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12 PM</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2 AM</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4 AM</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6 AM</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>8 AM</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>10 AM</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12 AM</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2 PM</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>4 PM</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6 PM</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

| TOTALS | 23 | 57 | 65 | 145 | 34 | 32 | 38 | 65 | 49 | 227 |
| X      | 1.8 | 4.3 | 5.0 | 11.2 | 2.5 | 2.5 | 2.9 | 5.0 | 4.1 | 17.5 |
Figure I.F.7.6.2.2.1. Total Eubranchipoda per trap sample —— and per 5m sweep sample ——. Las Cruces, New Mexico, July-August, 1970.

Figure I.F.7.b.2.2.2. Total Insecta per trap sample —— and per 5m sweep sample ——. Las Cruces, New Mexico, July-August, 1970.

<table>
<thead>
<tr>
<th>Class Eubranchipoda</th>
<th>Order Anostraca (Fairy Shrimp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Streptocoelidae</td>
<td>1. Streptocoelidae texanus Packard ?</td>
</tr>
<tr>
<td>Family Thamnocephalidae</td>
<td>2. Streptocoelidae sp. ?</td>
</tr>
<tr>
<td>Order Conchostraca (Clam Shrimp)</td>
<td>3. Thamnocephalidae packard ?</td>
</tr>
<tr>
<td>Family Laminidae</td>
<td>4. Bulimadia sp. ?</td>
</tr>
<tr>
<td>Order Notostraca (Tadpole Shrimp)</td>
<td>5. Apus (Triops) longicaudatus LeConte</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class Insecta</th>
<th>Order Ephemeroptera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Baetidae</td>
<td>6. CaZibaetis sp. ?</td>
</tr>
<tr>
<td>Order Hemiptera</td>
<td>7. Gerris sp. ?</td>
</tr>
<tr>
<td>Family Notonectidae</td>
<td>8. Buenoa margaritacea Bueno</td>
</tr>
<tr>
<td>Family Nepidae</td>
<td>9. Buenoa sp. #2 ?</td>
</tr>
<tr>
<td>Family Belostomatidae</td>
<td>10. Ranatra sp. ?</td>
</tr>
<tr>
<td>Family Hydrophilidae</td>
<td>11. Stenezimis sp. ?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Order Coleoptera</th>
<th>Family Dytiscidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. (One immature collected)</td>
<td>17. Eretes sticticus (L.)</td>
</tr>
<tr>
<td>13. Corisella edulis Champion</td>
<td>18. Thermoneca nigrofasciata (Aube)</td>
</tr>
<tr>
<td>14. Sigra (Vericorina) Alternata Say</td>
<td>19. Laccophilus fasciatus Aube</td>
</tr>
<tr>
<td>15. Sp. #3 ?</td>
<td>20. Laccophilus vacanania Young</td>
</tr>
<tr>
<td>22. Hygrota occidentalis (Fall) ?</td>
<td>23. Hydrophilus triangularis (Say)</td>
</tr>
<tr>
<td>24. Tropistemus lateralis Herbst</td>
<td>25. Tropistemus sp. ?</td>
</tr>
<tr>
<td>26. Beroe sp miles LeConte</td>
<td>27. Beroe sp. #2 ?</td>
</tr>
<tr>
<td>28. Beroe sp. #3 ?</td>
<td>29. Stenelmis sp. ?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Order Diptera</th>
<th>Family Culicidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>30. Aedes sp.</td>
<td>31. Paorophora signipennis (Coquillett)</td>
</tr>
<tr>
<td>32. Culex tarsalis Coquillett</td>
<td>33. Culex sp. #2 ?</td>
</tr>
</tbody>
</table>

| Family Chironomidae | 34. Sp. #1 ? |
| Family Ceratopogonidae | 35. Sp. #1 ? |
Problems and possible sources of error. As in taking the samples, the major problem encountered in sorting and measuring the organisms was the total time involved. The time required to sort the organisms from the debris in the sample varied greatly according to the total amount of debris and number and size of organisms in the sample. Generally a net sample could be sorted in 5-30 minutes, while trap samples, which usually contained much more detritus and even some soil, required from 15 minutes to as long as 6 hours in some extreme cases. The average time for sorting a net sample was about 20 minutes, while the same procedure for a trap sample required approximately 2 hours. This work could easily be delegated to laboratory technicians with minimal instructions; however, the separation of the organisms into species groups will usually require the personal attention of more highly-trained personnel.

The measuring, drying, and weighing of the sorted and identified specimens was also very time-consuming since literally thousands of specimens were involved.

I.F.7.b.2.4. - C-H-N Analysis

In the C-H-N analyses, the dried and weighed specimens were ground with a Wylie Mill equipped with a 40-mesh screen and the resulting powdered samples were pooled until sufficient quantities were accumulated for analyses (about 2.0 mg). The analyses were accomplished with a Hewlett-Packard model 185 C-H-N analyzer which has an accuracy of ±0.3 per cent absolute from the theoretical value.

I.F.7.c. Results and Discussion

I.F.7.c.1. - Population Trends in the Playa

The Jornada Playa's watershed received seasonal rainfall on July 25, 1970, partially filling the playa. Additional rainfall was received on July 26 and 28, which raised the water level to its maximum of approximately 25 cm. The lake had been invaded by a tremendous number of anurans the previous two nights and eggs were laid in great abundance. Tadpoles of at least one of the five species present (Bufo congnatus Say, B. debilis Girard, Scaphiopus couchi Baird, S. hammondi Baird, and S. bombifrons Cope) were taken in 2 of the 10 samples made July 27. Early instars of the tadpole shrimp (Apus longicaudatus LeConte), clam shrimp (Globomala sp. ?), and two species of fairy shrimp (Thamnocephalus platyurus Packard ? and Streptocephalus texanus Packard ?) were also found in samples on this date. Second and third instar mosquito larvae (Aedes sp.) and chironomid larvae were also encountered. A wide variety of terrestrial invertebrates that had been trapped by the sheet flow from the watershed also appeared in the samples on the first few dates. Numerous dragonfly and damselfly adults were observed flying over the lake on this date.

The first adult aquatic beetles were noted in the playa on the night of July 27. These beetles were Hydrophilus triangularis (Say) -- a large, black, water scavenger beetle. Following the rains on the night of July 28, numerous predaceous diving beetle adults (Eretes splendidus L. and Thermonectus nigrofuscatus (Aube)) were observed in the playa, in addition to H. triangularis adults. Even greater numbers of adult Odonata were observed and oviposition was noted; however, immatures were never taken from the playa or tank.

By August 3, a maximum of 328 clam shrimp, 108 tadpole shrimp, 24 T. platyurus, and 236 S. texanus per m² were found in trap samples. Greater numbers of the adult beetles already mentioned were observed and adults of most of the other species of water beetles collected in the playa appeared (Laccophilus spp., Tropisternus spp., and Hygrotrichus spp.). Early instar larvae of some of these aquatic beetles also appeared in these samples. A maximum of 44 early instar Ephemeroptera nymphs were found per m² on this date. Adult Corixidae and Notonectidae were also present.

At this time an algal bloom occurred in the playa. The water appeared to very stagnant with most of the standing dead vegetation having been so decomposed that it was no longer evident except in thick clumps.
The water level dropped from a maximum staff gauge reading of 25 cm on July 29 to 15 cm on August 3, and this water drop, coupled with the unevenness of the playa basin and the presence of potholes, had a dramatic effect upon the invertebrate (and tadpole) populations. In those situations where there is a fairly uniform lake bed, one would expect a concentration of these invertebrates into a smaller surface area (and volume) of water. However, due to the habit of the tadpole and clam shrimp feeding in the more tepid shoreline areas, a tremendous number of these organisms were isolated each day as these potholes were separated from the main lake body; and the tadpoles and clam shrimp perished as the potholes dried.

The effect of the drying potholes on the population of the invertebrates is shown in the data from the trap samples taken on August 10. By this date, maxima of only 20 tadpole shrimp and 66 *S. texana* fairy shrimp per m² were taken in the samples. No clam shrimp were present in the trap samples on this date. However, there was a tremendous increase in the number of larval insects. The adult insects also were being concentrated in the water of the tank and playa. As many as 260 corixid nymphs, 40 dytiscid larvae, 28 hydrophilid larvae, and 104 Ephemeroptera nymphs per m² were found in the trap samples taken on August 10.

Further concentration of the insect adults had occurred by August 12, but a reduction in larval numbers was noted. Many of the larval Coleoptera were in the last instar and many probably pupated prior to the time that the few remaining puddles and potholes became dry on August 14 or August 15. Attempts to recover pupae from the soil in and surrounding a pothole were unsuccessful.

Several factors are thought to affect the population density of organisms in a given area of the playa. Among these factors are time (date), time of day, water depth, amount of vegetation, temperature of the water, and dissolved oxygen content of the water. Also important is the interaction of populations through predation and/or competition. Among the most important of these factors in any specific locality in the playa are vegetation density and depth of water, which is usually a function of distance from shoreline in playa lakes (Ward, 1968).

I.F.7.c.1.1. - Time (Temporal Fluctuations)

The temporal fluctuations of the major groups of invertebrates as detected in trap and sweep net samples are shown in Figures I.F.7.c.1.1.1. and I.F.7.c.1.1.2.

Populations of Anostraca and Conchostraca appeared to peak about July 31, while the Notostraca reached maximum abundance about August 3. The insects had a much slower rate of increase, reaching their maximum density on August 10, the last full day of sampling. The rapid drying of the playa had restricted sampling to one large pothole near station 1 and to the tank by August 12.

These population trends indicated that if the playa had held water for a longer period of time, insects would have become increasingly important components of the invertebrate fauna, while the Eubranchipoda decreased in both numbers and importance after reaching their early peaks.
Figure I.F.7.c.1.1.1. A comparison of the mean numbers of Eubranchipoda ——— and Insecta --- per square meter in tank and playa samples. Las Cruces, New Mexico, July-October, 1970.

Figure I.F.7.c.1.1.2. A comparison of the mean numbers of Eubranchipoda ——— and Insecta --- per 5m sweep in the tank and playa samples. Las Cruces, New Mexico, July-October, 1970.
I.F.7.c.1.2. - Vegetation density

In order to determine to some extent the importance of vegetation density, the samples were divided into three groups. The southermost samples (1, 2, and 4), located in the densest vegetation, the northern samples (5, 6, and 7), in lighter vegetation; the samples 8, 9, and 10, from the nearly barren central portion of the playa were grouped and analyzed. The results of the analyses according to these three major areas of the playa are shown in Figures I.F.7.c.1.2.1. - 6.

Figure I.F.7.c.1.2.1. shows the expected deep-water distribution of the fairy shrimp *S. texanus*. This supports the previous observation of greater *S. texanus* density in the tank. In the shallower water, with a denser vegetation, few *S. texanus* were found.

An inverted distribution of clam shrimp (Conchostraca) was found (Figure I.F.7.c.1.2.2.); the greatest density was correlated with the densest vegetation, while the least density was found in the deeper, barren center portion of the playa. Distribution of the tadpole shrimp, *Apus*, in sweep samples was more or less uniform. A slight indication of a deeper water preference was found in the trap samples (Figure I.F.7.c.1.2.3.). The 24-hour study showed a similar distribution for *Apus* in trap samples and a more or less uniform distribution in the sweep samples (Figure I.F.7.c.1.3.2.).

The most common insects, with the exception of the Corixidae, were most numerous in the densest vegetation of the southern margin of the playa (Figures I.F.7.c.1.2.4. - 6.). Figure I.F.7.c.1.2.6. gives the aggregate effect of these variations for all insect species. The large number of corixids in the middle portion of the playa almost completely obscured the effects of most insects concentrating in the denser vegetation found along the southern margin of the playa. The Corixidae had increased tremendously by the last sampling dates in the middle portion of the playa only (Figure I.F.7.c.1.2.5.). This agrees with the distributional data of the 24-hour study (Figure I.F.7.c.1.3.2.).

There is a conflict in the distribution of the Ephemeroptera as indicated by the 24-hour study and the analyses by area in Figure I.F.7.c.1.2.4. Although the samples taken in the 24 hour study indicate a deeper water distribution, the regular samples taken in the playa indicate the highest density at the southern margin of the playa.
Figure I.F.7.c.l.a.1. Population fluctuations of *Streptosoma* (Anostraca) in the three major areas of the playa. Las Cruces, New Mexico, July-August, 1970.

Figure I.F.7.c.l.a.a. Population fluctuations of Conchostraca in the three major areas of the playa. Las Cruces, New Mexico, July-August, 1970.
Figure I.F.7.c.1.2.3. Population fluctuations of *Apus Longicaudatus* in the three major areas of the lake. Las Cruces, New Mexico, July-August, 1970.

Figure I.F.7.c.1.2.4. Population fluctuations of *Thermonectus* and *Ephemeroptera* in the major areas of the playa. Las Cruces, New Mexico, 1970.
Figure I.F.7.c.1.2.5. Population fluctuations of Corixidae in the three major areas of the playa. Las Cruces, New Mexico, July-August, 1970.

Figure I.F.7.c.1.2.6. Population fluctuations of total Insecta in the three major areas of the playa. Las Cruces, New Mexico, July-August, 1970.
I.F.7.c.1.3. - Water Depth

The effects of water depth on the populations of several species of insects can be seen by inspecting Figures I.F.7.c.1.3.1.-5.2. Comparing the marginal samples with those taken in the central portion of the playa. The indicated trend is for greater density near the margin of the playa. This observation is further supported by the evidence collected in the 24-hour study (Figures I.F.7.c.1.3.1 and I.F.7.c.1.3.2.). Nearly all the organisms showed a definite distributional pattern with relation to the shoreline, and thus water depth. Overall, the total number of all organisms collected was greater as the water became shallower, this trend was attributed in part to the concentration effect and to the growth of the organisms remaining. The denser vegetation in the water also provided food, protection and oviposition sites for some species. This distribution also was probably influenced to a large degree by the higher temperature of the water near the shoreline.

I.F.7.c.1.4. - Time of day - 24 hour study

In addition to the distributional data already mentioned (Figures I.F.7.c.1.3.1. - 2.), the 24-hour study yielded little information except for the observation that more insects can be collected in the daylight hours than at night (Figures I.F.7.c.1.4.1. - 3.).
Figure I.F.7.c.1.3.2. Distribution of some of the major invertebrate taxa in relation to the shoreline; 24-hour study. August 6-7, 1970.

Figure I.F.7.c.1.4.1. Average number of aquatic invertebrate organisms captured by each sampling method; 24-hour study. August 6-7, 1970.
Figure I.F.7.c.1.4.2. Average number of insects and other invertebrates per 5m sweep; 24-hour study. August 6-7, 1970.

Figure I.F.7.c.1.4.3. Number of insects and other aquatic organisms per m² as estimated by trap samples; 24-hour study. August 6-7, 1970.
I.F.7.c.1.5. - Interaction of Species

The effects of the interaction of populations through predation are shown in Figures I.F.7.c.1.5.1. - 2. In Figure I.F.7.c.1.5.1., the fluctuations in the numbers of Hydrophilidae and Dytiscidae, the most active invertebrate predators, are compared to the fluctuations in the numbers of Corixidae and Ephemeroptera, probably prey organisms, as determined by the trap samples. Figure I.F.7.c.1.5.2. presents the same data from sweep net samples. The lower numbers of prey organisms collected is most probably due to the coarser mesh of the sweep net which allowed many of the small early instar larvae to escape; a large percentage of the corixids collected were very early instars (1st or 2nd).

I.F.7.c.2. - Population Trends in the Tank

Since the tank was a completely different type of environment from that found in the playa proper, it would be expected to have a different fauna; this proved to be the case. Although the species present were the same, the density of the population differed markedly.

The first samples, taken July 27, indicated extremely low populations of macroinvertebrate organisms in both the playa and the tank. The tank, however, had a tadpole population of 32 per ml as compared to 0.4 per m² in the playa.

By August 3, the second full sampling date, the differences were much more pronounced. The estimated populations per m² in the playa and the tank for the following groups were:

<table>
<thead>
<tr>
<th></th>
<th>Playa</th>
<th>Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anostraca</td>
<td>125</td>
<td>924</td>
</tr>
<tr>
<td>Conchostraca</td>
<td>62</td>
<td>4</td>
</tr>
<tr>
<td>Notostraca</td>
<td>51</td>
<td>4</td>
</tr>
<tr>
<td>Insecta</td>
<td>14</td>
<td>4</td>
</tr>
</tbody>
</table>

Although fairy shrimp were the most numerous organisms in the playa, their density in the tank was seven-fold higher than in the playa. The groups which composed 50% of the remaining population in the playa composed only 1% of the total tank population. Only one Conchostraca and four Notostraca were taken in the eleven trap samples from the tank, while as many as 33 Conchostraca and 27 Notostraca were taken in a single trap sample in the playa. The insect population remained about the same in the tank as in the playa, until the playa dried about August 15. The insect population in the tank increased after the drying of the playa, while the population of Eubranchipoda, which had peaked about the same time that the playa dried, dropped to virtually zero. The increase in insects was due primarily to the presence of about 40 Corixidae nymphs per m² on the three sampling dates following the drying of the playa. The highest population noted in the last two samples was the larvae of a small dipteran, probably Ceratopogonidae, which reached a density of more than 200 per m² on August 30.

The densities of insect herbivores and predators appeared to peak about a week earlier in the playa than in the tank (Figure I.F.7.c.1.4.1. and 2.).

The major ecological differences between the tank and playa were water depth and vegetation. The groups which were found most often in deep water in the 24-hour study (Figures I.F.7.c.1.3.1. and 2.) were also those groups found in the greatest numbers in the tank. The fairy shrimp were also most numerous in the central, barren portion of the playa (Figure I.F.7.c.1.2.1.).
Figure I.F.7.c.l.5.1. A comparison of the mean numbers of predaceous aquatic beetles (Coleoptera, Dytiscidae, and Hydrophilidae) and two probable prey groups (Hemiptera, Corixidae, Ephemeroptera, Baetidae) per square meter in the tank and playa. July-October, 1970.

Figure I.F.7.c.l.5.2. A comparison of the mean numbers of predaceous aquatic beetles (Coleoptera, Hydrophilidae and Dytiscidae) and two probable prey groups (Hemiptera, Corixidae; Ephemeroptera, Baetidae) per 5m sweep in tank and playa samples. July-October, 1970.
I.F.7.c.3. - Biomass Data

As a measure of ecological importance, biomass is frequently more important than total numbers. Dry weight is an indication of the amount of organic material contained in any group of organisms. Also, the respiration rate of organisms is proportional to their size (Olson and Rueger, 1968; Zeuthen, 1953). Edwards (1958) found the oxygen consumption of a chironomid larva to be proportional to the 0.7 power of the dry weight of 3rd and 4th instar larvae at both 10°C and 20°C. The biomasses of the major insect predators in the playa are given in Figure I.F.7.c.3.1 and 2. The net and trap estimates are fairly close by comparison. The biomass of *Hydrotlius* is approximately ten times that of *Thermoneatus*, but the biomass curves are very similar. *Hydrotlius* peaked two days later than *Thermoneatus*.

A comparison of the total biomasses of Insecta and Eubranchipoda collected in the playa is given in Figure I.F.7.c.3.3. Insect biomass was definitely increasing when the playa dried, while the populations of Eubranchipoda had dropped to zero on the last sampling date.

![Figure I.F.7.c.3.1. Dry weight in mg of *Hydrotlius* larvae per m² — and per 5 m sweep](image-url)
Figure I.F.7.c.3.2. Dry weight in mg of *Thermococca* larvae per m² —— and per 5 m sweep —— –. July-August, 1970.

Figure I.F.7.c.3.3. Estimated biomass in mg per m² of *Eubranchipoda* —— and *Insecta* —— – in the playa. July-August, 1970.
I.F.7.c.4. - C-H-N Analyses

The results of the C-H-N analyses of various specimens is given in Figures I.F.7.c.4.1. and 2. These data show that a distinct increase in the carbon (C) to nitrogen (N) ratio occurs in the progressively smaller Notostroca; due to an increased percentage of carbon. A similar pattern can be seen in the other Entomostracan, Thamnocephalus, and to a lesser degree in the limited samples of Streptocephalus (Figure I.F.7.c.4.2.).

This pattern is in contrast to the Insecta (Figure I.F.7.c.4.1.) in which there is a distinct decrease in carbon percentages with progressively smaller larvae. However, the carbon to nitrogen ratio remains fairly constant in larvae. The ratio is considerably lower in adult beetles but only slightly lower in the hemimetabolous Corixidae.

The C-H-N analyses indicate that a maximum of 70.4 mg of carbon, 19.3 mg of nitrogen, and 10.9 mg of hydrogen were contained in invertebrate populations for each square meter of playa surface.

The peak for Eubranchipoda populations was 68.8 mg C, 18.8 mg N, and 10.7 mg H per m². These peaks occurred on August 3. On August 10 the insect population peaked, and this biomass consisted of 11.0 mg C, 3.3 mg N, and 1.9 mg H per m².

Figure I.F.7.c.4.1. Nitrogen, carbon, and hydrogen content by percent weight composition of A. Corixidae adults, B. large nymphs, C. small and medium nymphs, D. Hydrophilus triangulifer adults, E. large larvae, F. medium larvae, G. small larvae, H. Thermocorixa adults, I. large larvae, J. medium larvae, July-August, 1970.
I.F.7.d. - Summary and Conclusions

The primary objectives of this study were: 1) to supply initial standing-crop measurements of nitrogen, carbon, and hydrogen in as many as possible of the macroinvertebrate populations in the playa, 2) to make periodic standing-crop estimates of macroinvertebrates, and 3) to develop equipment and facilities to accomplish the above objectives.

The equipment was developed after a literature search and experimentation. The primary sampling device decided upon was a modification of the Bellville mosquito larva sampler (Welch and James, 1960).

This trap was used to obtain periodic quantitative measurements of macroinvertebrate populations. The specimens were then processed and analyzed for carbon, hydrogen, and nitrogen content with a gas chromatograph-type analyser.

The population of invertebrates in the Jornada Playa was composed mainly of Eubranchipoda. The most numerous organism in the playa was the fairy shrimp, *Streptocephalus*, which reached population densities as high as 1200/m². The tadpole shrimp (*Notostraca*) comprised the major portion of the biomass, more than 50%, on two sampling dates.

The Insecta were a relatively minor portion of the invertebrate fauna but, significantly, the insect population was increasing when the playa dried while the Eubranchipoda were decreasing. If the playa had remained inundated for a longer period, the insects would probably have become the primary invertebrate inhabitants of the playa.

The playa, when considered as an ecosystem, had a production and turnover rate much higher than the surrounding desert. The input of nutrients by sheet flow in the form of plant litter and feces resulted in a tremendous concentration of organic material in the playa basin. The high day-time temperature accelerated the growth of decomposers, as witnessed by the rapid decomposition of standing dead vegetation in the inundated portion of the playa basin. An algal bloom also occurred shortly after the playa had filled. These decomposers and simple plants were then readily available as food for the filter-feeding Eubranchipoda and some insects and anurans. Complimentary populations of secondary consumers developed as the numbers of prey organisms increased.

As in the case in many closed or partially closed systems, there is much predation and cannibalism in the playa. This rapid turnover of nutrients was obvious in the complicated food web which was observed during sampling. The major outputs in the playa system were in the form of mature insects and anurans, and the eggs of Eubranchipoda and insects.

The distribution of invertebrates in the playa was influenced by vegetation density and water depth as well as temperature and competition. The areas of highest vegetation density and shallowest depths seemed most attractive to the Insecta and Conchostraca while the deeper and more barren portions of the lake were the main habitat of *Streptocephalus*. The 24-hour sampling study confirmed the above distributional observations.

The distribution of *Streptocephalus* in the stock tank added further evidence that the fairy shrimp preferred deeper water without emergent vegetation. The absence of most insects in the tank would appear to indicate the preferences of insects for shallower water with more vegetation.

The comparison of trap and net samples indicates that, while trap samples probably yield more accurate estimates of population densities, it probably would be possible to collect a large number of net samples and calibrate them with a few trap samples. This would result in a considerable saving of time in the field and laboratory.
LIST OF REFERENCES


