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DISCUSSION

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 Capitol Reef National Park

The Rock Pool Habitat

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To the potential colonizer, the desert rock pool habitat presents an exceptionally stressful, unstable environment, manifest in physical extremes of drought and recurrent flooding. Selective pressures are intense. Such environmental instability is not conducive to the development of habitat restrictions characteristic of endemism. In addition, there are extremes imposed upon all aquatic organisms, including variations in water chemistry and physical factors, with differing degrees of exposure, or formidable fluctuations in temperature. Changes in these categories evoke additional adaptive challenges in osmoregulation, respiration, energy fixation, etc. Regardless of a marked phylogenetic diversity, those biota isolated and identified from rock pools surveyed (14 phyla, 98 families, 237 species) have successfully invaded that habitat through the application of a diversity of behavioral and physiologic mechanisms, all resulting in a common enhanced adaptive potential for survival through periods of desiccation and other adversity. With a single exception, Aedes atropalpus nielsenii, all rock pool species encountered in southeastern Utah occur in other widely dispersed geographic ranges and in a great diversity of aquatic situations. Occupation then, of the rock pool habitat is essentially one of opportunity, as a function of great adaptive versatility.

The aquatic rock pool habitat is an oligotrophic one, with limiting factors in this consideration being a marked scarcity of available phosphorous and nitrogen. With those rock pools studied, contributing

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runoff from direct precipitation typically flowed over smooth sandstone surface areas which were barren, or only sparsely vegetated. In addition, all associated strata were composed entirely of sandstone, noted for reduced chemical solubilities. Accumulations of any one compound, or combination of materials in concentrations approaching possible toxic excesses were never evident in the analysis of water samples.

A wide range of physical values was recorded with those rock pools investigated. This was primarily a result of marked disparity in size, shape, depth and relative degree of exposure among those of a given region or series. For example, a selected, larger rock pool (10' X 13' X 2½'), originally filled to overflow and receiving upon its surface approximately 30% of maximum possible solar insolation per day demonstrated a 12 day average diurnal fluctuation in summer temperature of 20 degrees F. The diurnal fluctuation in water temperature of a smaller (2½' X 2½' X ½') similarly filled pool receiving 60% exposure per day typically approached 30 degrees F. The range of summer water temperatures for all pools surveyed varied from a 60 degree minimum to, in unusual instances, a maximal 100 degrees F. Through winter months, deeper pools accumulated surface ice of over three inches in thickness while smaller pools were commonly frozen solid. Summer temperatures at the surface of the substrate of dried rock pools often exceeded 130 degrees F. The pH values of pools monitored varied from 7.9 to 10.1. That for those more typical rock pools averaged a value of 8.45. The average monthly pH of any single pool rarely fluctuated in excess of .75% of one pH unit. Commonly encountered dissolved oxygen values varied from 3 ppm through 12 ppm. The water of the rock pools was

moderately soft when compared with that of other aquatic systems.

Unlike most aquatic systems, the physical, chemical and biotic profiles of filled rock pools were subject to sudden and potentially radical change. With those common, smaller rock pools in series, along sloping drainage lines, infrequent but often extremely heavy run-off would occasionally "flush" each given depression, resulting in the net loss and gain of disproportionate quantities of organic detritus and other nutrient materials. Contained phytoplankton and zooplankton populations were consequently decimated with the translocation of original volumes of water. Organisms including the strong-swimming nekton and those more benthic species avoided this action by seeking sheltered recesses at the pool bottom or walls, or by assuming an attached or clinging habit within the deeper confines of that container. The medium within a given pool was thus often transformed from a eutrophied (to the maximal limits allowed the primary producer by the least abundant essential nutrient, among other factors) condition to one approximating, in many respects, that of a rock pool having been recently filled from the dry state. These material interchanges not only resulted in sudden disparities in the organic and living biotic constituents of certain pools, but usually caused temporary reductions in water temperatures of flushed pools by as much as 25 degrees F. This often extensive exchange of organic and inorganic materials, accompanied by sudden depressions in water temperature occurred sometimes within a span of 10 minutes. In such cases and upon initial flooding of desiccated pools, a tremendous competitive advantage lies with those euryecious phytoplankton and zooplankton species with greater potentials

for immediate, renewed activity and accelerated reproduction and rapid increase in numbers.

As compared to most highly eutrophied aquatic systems, the rock pool habitat hosts a large number (54 families, 156 species) of algal species. This might best be explained in that the oligotrophic nature of the pools, while limiting in terms of availability of nutrient materials, and thus total biomass of primary producers, offers far more individual niches to an increased number of species. Presumably, this would occur in these shallow pools as a consequence of decreased competition for available space and light, in that due to limited nutrient materials, no single species or small complex of species (especially unicellular forms with reduced surface areas) could attain a mass sufficiently large to monopolize incoming energy supplies by effecting a generalized increase in turbidity and/or by forming an occluding surface scum. Also, many of the less abundant species may be able to utilize certain nutrient fractions, ions, light intensities, etc. which their more numerous, dominant competitors may not require.

Even with the diversity of algal species present within rock pools, only 10 or 12 species of the entire average algal complement could be termed truly abundant. This also is directly related to certain morphological or physiologic characters promoting enhanced competitive qualities in those forms. This phenomenon also applies to the overwhelming majority of rock pool zooplankters and many larger consumers and predators. In this regard, major taxonomic groups (Crustacea, Rotifera, etc.) were usually represented by one dominant species for each family or genus, plus a few associated species present in most

instances in diminutive numbers only.

Aquatic vascular plants do not occur within those rock pool types investigated.

TABLE 1
 REPRESENTATIVE WATER CHEMISTRY FOR
 SIX TYPICAL ROCK POOLS

LOCATION	P ₁	P ₂	A ₁	A ₂	C ₁	N-Dunes
Alkalinity, total	4.0	4.0	4.75	4.25	3.25	3.25
Alk. Phenylphthalein	0.0	0.0	0.0	0.0	0.0	0.0
Aluminum	0.02	0.05	0.02	0.06	0.1	0.01
Barium	0.40	0.55	0.80	0.75	0.55	0.12
Ca Bicarbonate	4.10	5.10	3.40	5.90	6.00	5.80
Ca Carbonate	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium, Hexavalent	0.018	0.025	0.006	0.006	0.006	0.012
Copper	0.17	0.34	0.13	0.15	0.15	0.13
Hardness, total	116.00	80.00	97.00	54.00	104.00	86.00
Hardness (Ca)	70.00	52.00	60.00	24.00	72.00	60.00
Hardness (Mg)	36.00	28.00	37.00	30.00	32.00	26.00
Fe (Ferric)	0.06	0.08	0.07	0.00	0.08	0.33
Fe, total	0.12	0.10	0.10	0.02	0.08	0.33
Fe (Ferrous)	0.06	0.02	0.03	0.02	0.00	0.00
Manganese	<0.05	0.20	<0.05	0.05	0.09	0.35
Nitrogen, Nitrate	0.35	0.48	0.31	0.26	0.35	0.52
Nitrate Nitrogen	0.08	0.11	0.07	0.06	0.08	0.12
Nitrogen Nitrite	0.006	0.005	0.006	0.005	0.005	0.019
Oxygen, Dissolved	6.00	6.25	6.50	6.75	7.10	7.25
pH Value	8.20	8.40	8.00	8.50	8.40	8.70
Phosphate, Ortho	0.028	0.027	0.027	0.036	0.040	0.034
Selenium	trace	trace	trace	trace	trace	trace
Silica	2.30	0.90	1.00	0.90	1.80	0.70
Sulphate	18.00	10.00	9.00	8.00	11.00	9.00
Turbidity Jackson Units	20 J.U.	20 J.U.	12 J.U.	4 J.U.	12 J.U.	47 J.U.
Water temp, °F.	69°	64°	48°	54°	52°	56°

note: values were measured in parts per million except those indicated

TABLE 2

AVERAGE TEMPERATURES AND PRECIPITATION THROUGH THE
BREEDING SEASON OF AEDES ATROPALPUS NIELSENI
NEEDLES DISTRICT, CANYONLANDS NATIONAL PARK
1969-1970

<u>1969</u>	<u>Average Temperatures</u>		<u>Precipitation</u>
	<u>High</u>	<u>Low</u>	<u>Total # of Inches</u>
April	64.1	34.0	.11
May	79.3	43.7	.72
June	84.9	51.8	2.03
July	95.6	62.8	1.63
August	95.9	62.7	1.22
Sept.	85.4	52.9	.78
Oct.	61.7	33.9	.96

<u>1970</u>	<u>Average Temperatures</u>		<u>Precipitation</u>
	<u>High</u>	<u>Low</u>	<u>Total # of Inches</u>
April	62.6	32.7	1.27
May	80.8	44.8	trace
June	88.4	52.6	.70
July	96.4	64.0	1.17
August	95.0	64.0	1.57
Sept.	86.1	55.1	.90
Oct.	63.0	33.3	.81

Larval predation

Within the rock pool habitat, major taxa of second order consumers predaceous upon A. a. nielsenii and other aquatic associates were represented by three insect orders. These included one family each of the Odonata and Hemiptera, and two families of Coleoptera. Each major group of predators was typically dominated by species of one or two genera, and in the case of the Hemiptera, by a single species. The following is a summary of the total number of species of major predators of each insect order, with the dominant species listed in order of their frequency of occurrence within rock pools known to support A. a. nielsenii populations. Of the total number of species noted for each family, only those which were collected in 20% or more of the total of all collections is listed. Other species not specifically named (see biosurvey) were collected as irregularly occurring, transient individuals. Other Hemiptera of the families Corixidae and Gerridae, bearing species of minor significance as predators, are not considered below.

ORDER Odonata (3 species)

FAMILY Libellulidae

Pantala flavescens (Fabricius)

Pantala hymenaea (Say)

ORDER Hemiptera (2 species)

FAMILY Notonectidae

Notonecta kirbyi Hungerford

ORDER Coleoptera (15 species)

FAMILY Dytiscidae (8 species)

Rhantus gutticollis (Say)

Deronectis striatellus LeConte

FAMILY Hydrophilidae

Tropisternus ellipticus (LeConte)

Laccobius Erichson

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All aquatic entomologists are thoroughly acquainted with the efficiency of the above taxa as predators of mosquito larvae. For instance, Lee (1967) in a study of the feeding efficiency of mosquito predators noted a tremendous rate of destruction of larger instar larvae by individuals of the genera Rhantus and Notonecta when introduced into larval populations under laboratory conditions.

The greatest observed, proportionate frequency of destruction of larval A. a. nielsenii occurred in small, compartmentalized rock pools with average aperture diameters of less than two feet. The primary predators in such situations were larval Rhantus gutticollis. One example of an extreme predator-prey relationship was monitored which involved six observed larval R. gutticollis within a single small rock pool containing an associate population of approximately 125 2nd and 3rd instar A. a. nielsenii. A total of approximately 5% of the original A. a. nielsenii remained after a period of seven days. The larval population appeared to have been destroyed by the contained predators, as no other predators or parasites were present. The remaining 5% of the larval population had presumably been spared due to a lack of random encounters with those predators.