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Saratoga Springs Validation Site

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1971 PROGRESS REPORT

SARATOGA SPRINGS VALIDATION SITE

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ABSTRACT

Biotic and abiotic parameters were measured monthly on Saratoga Springs and adjacent marsh during 1971. An inventory of plant and animal taxa is presented. The marsh presents a unique problem since it holds four major areas based on vegetation and soil types. These areas were sampled for soil invertebrates which were related to associated plant species and time of year collected. Most invertebrates collected were larval forms, and emergence was responsible for the reduction in biomass.

Data collected in 1966-67 for *Cyprinodon nevadensis* was used to construct a length-frequency histogram. These data suggest a growth rate for mature fish of 3 mm per month during the summer. Dramatic shifts in population structure during April and September indicate the influence by recruitment from hatches occurring in February, July and August. Spawning therefore probably occurs over an extended period of time. Life table information has been calculated from these data. This indicated that 50% of the fish of 15 mm live an additional 8-9 months, while the maximum life span after reaching 15 mm is approximately 16-18 months.

When comparing 1971-72 data to 1966-67 data, general trends appear to be the same with some differences in population peaks and sizes. In September, 1971, the population was estimated to be 1600 fish.

Separate sections of this report were devoted to descriptions of amphibia, reptiles, birds, and mammals recorded in the Spring area at various times. The most abundant reptiles appeared to be *Uta stansburiana, Cnemidphorus tigris, Callisauris draconides* and *Sceloporus magister*. Bird species reported close to the Spring and its vicinity numbered 90, but only 14 species were listed as abundant.

Collections were made in 1967 of small mammals and bats in the Spring and its vicinity. Six species of bats and ten species of rodents were recorded. Distribution, seasonal and reproductive activity, relative abundance, population structure, and food habits are briefly discussed. Most of the species collected were able to maintain maximum population densities in only the more mesic habitats because of the availability of water, food and shelter.

Plant production appeared to reach a peak in May at 47.6 g C/m^2/day with a low in October of 2.6 g C/m^2/day. Aquatic invertebrates except *Hyalella azteca* peak in June, with *Hyalella* peaking early in April.

INTRODUCTION

This report summarizes methods and findings of the investigation made during the first year (1971-1972) of the Saratoga Springs validation studies. Data gathered during previous years by the principal investigators and others are presented for comparative purposes.

OBJECTIVES

Major objectives of this study include:

1. Utilizing previously gathered and current data to construct an inventory of the ecosystem.

2. Periodical measurements of biotic and abiotic parameters of the ecosystem.

METHODS

The following paragraphs enumerate the methods used to collect data on the site.

Water input from adjacent spring and output of main spring into marsh area (DSCODE A3UDPC8)

Data recorded: Water volume flowing into main spring (gallons/week). Water volume out of main spring into marsh area (gallons/week).

Experimental methods: Water input determined weekly over a 24-hour period. Water output determined by a Leupoold water stage recorder.

Water temperature (DSCODE A3UDCP7)

Data recorded: Water temperature (in degrees Fahrenheit).

Experimental methods: Belford continuous, dual pen, and Ryan recorders placed at the water-substrate interface. Seven- and thirty-day clocks.

Air temperature (DSCODE A3UDCP6)

Data recorded: Air temperature (in degrees Fahrenheit).

Experimental methods: Weksler thermograph, single pen, continuous recording seven-day clock.

Experimental design: Most air temperatures taken in the marsh area among tall plants (mostly *Scirpus*) in order to avoid tampering by tourists.

Water level (DSCODE A3UDCP5)

Data recorded: Depth of water (in centimeters).

Experimental methods: A staff gauge placed at the deepest point of Black Lake, Marsh 1, Marsh 2 and Long Lake. A USGS water stage recorder activated in Long Lake.

Water level, main spring

Data recorded: Depth of water (in centimeters).

Experimental methods: A staff gauge placed near the east shore. A second staff gauge will be placed in the small feeder spring. Readings made approximately weekly.

Water chemical analyses (DSCODE A3UDCP1)

Data recorded: PH, alkalinity, sulfate, calcium, magnesium, sodium, potassium, chloride, nitrite, nitrate, total PO_4, ortho PO_4, conductivity, hardness.

Experimental methods: PH (APHA), Calcium-EDTA titrametric method (APHA), sodium-flame photometric method (APHA), potassium-flame photometric method (APHA), nitrate-brucine method (APHA), ortho PO_4-stannous chloride method (APHA), sulfate (Hach Chemical Co.), magnesium (Golterman, 1969 [APHA]), chloride-MOHR method (Hach Chemical Co.), total PO_4 (Hach Chemical Co.).

Experimental design: Water samples obtained from the middle of the spring with Kemmerer water sampler about midpoint in the water column. Some samples analyzed in the field (e.g., hardness). Others, to which chloroform is added, are returned to the lab for analyses (e.g., phosphates).

Length-weight measurements of Cyprinodon nevadensis (DSCODES A3UDCF3 and A3UDCF4)

Data recorded: Length (to the nearest mm) and weight (to the nearest gram).

Experimental methods: Minnow traps (1/16-inch mesh) used to obtain fish. Total length determined with the aid of calipers and a mm ruler, and weight taken with a triple-beam balance to the nearest tenth of a gram.

Experimental design: Stratified, random samples.

Mark and recapture of Cyprinodon nevadensis (DSCODES A3UDCF1 and A3UDCF2)

Data recorded: Length (to the nearest mm) and weight (to the nearest tenth of a gram).

Experimental methods: Minnow traps (1/16-inch mesh) used in main spring, Black Lake, Marsh 1, Marsh 2 and Long Lake. Temporary marks made by fin clipping and/or by using Bismark Brown Y as an immersion dye, whereas permanent marking utilizes a dye-spray technique (Rinne and Deacon, M.S.).

Experimental design: A stratified, random design will be employed.

Numbers and weights of benthic aquatic invertebrates (DSCODES A3UDCB1 and A3UDCB2)

Data recorded: Numbers of benthic invertebrates expressed as numbers or grams of a particular taxon in a particular size group/sample (44 cm^2). Weight (grams) of benthic invertebrates expressed as numbers or grams of a particular taxon in a particular size group/sample (44 cm^2).

Experimental methods: Benthic samples collected with modified Mecan core sampler in main spring. Eckman dredge used in marshes and Long Lake for middle samples. An open-end bucket used to sample in the shore vegetation. Samples washed through a sieve (0.354 mm openings) in the field, placed in glass container and 10 percent formalin and rodamine B dye added. In the lab, organisms are sorted into various taxa and 1-mm size groups, counted and weighed (to nearest 0.0001 gram). Each size group oven dried at 60°C until constant dry weight obtained. Samples ashed in a muffle furnace at 500°C and reweighed. The difference of the second weight from first gives ash-free dry weight.

Experimental design: Stratified, random samples taken in all areas.

Numbers and weights of soil and litter invertebrates (DSCODE A3UDCB8)

Data recorded: Numbers and weights of a particular taxon per square meter ground surface.

Experimental method: Soil care -- extraction of soil using casing 15.24 cm in diameter driven into the ground. Volume of soil extracted is approximately 1750 cm^3. Sample placed in plastic bag, returned to lab, placed in modified berlese funnels for 48 hours, examined under a microscope, then sugar floated. The taxa are sorted and numbers and dry weight recorded.

Experimental design: Stratified, random sampling.

Production rates of macrophytes in spring, using light-dark techniques (DSCODES A3UDC01)

Data recorded: Dissolved oxygen concentrations (ppm) in light and dark chambers per gram of biomass per plant species per unit of time.

Experimental methods: Metabolism of macrophytes measured by changes in dissolved oxygen in transparent and opaque 500 ml glass bottles with ground-glass stoppers. A blank containing water from the spring is also run.

Experimental design: Two light and two dark bottles are run for each producer for a period not exceeding two hours. Bottles are placed on the bottom in the middle of the spring situated so that they will not shade each other.

FINDINGS

Inventory of Taxa

The species composition of the main spring is well known now. Identification of a few taxa (Oligochaetes and Chironomids) is still being done. Data presented in Tables 1, 2, and 3 include work done in 1966 and 1967 (J.E. Deacon, indicated by *) and the current study (indicated by X). Programs for handling these data are being prepared by the central office.

Table 1. Periphyton, Macrophytes and associated vascular plants of Saratoga Springs.

Producers	Spring	Marsh
PERIPHYTON AND MACROPHYTES		
ALGAE		
Spirogyra	X	
MACROPHYTES		
Ceratophyllum demersum	X	
Ruppia maritima	X	
EMERGENT AQUATICS AND ASSOCIATED VASCULAR PLANTS		
Monocotyledonae		
Gramineae		
Distichlis spicta	X	
Phragmites communis	X	
Sporobolus airoides		X
Arundo donax (Not positively identified)		
Juncaginaceae		
Triglochin maritima		X
Cyperaceae		
Scirpus robustus		X
S. olneyi	X	
Juncaceae		
Juncus cooperi		X
Dicotyledoneae		
Saururaceae		
Anemopsis californica		X
Convolvulaceae		
Cressa truxillensis		X
Chenopodeaceae		X
Nitrophila occidentalis		
Suaeda fruticosa		
Atriplex parryi		
Atriplex hymenletyra		
Frankeniceceae		
Frankenia grandifolia		X
Aizoaceae		
Sesuvium verrucosum		X
Tamaricaceae (removed by NPS Jan. 1972)		
Tamerix aphylla		X
Tamerix gallica		X

X: noted in current study

Table 2. Invertebrates of Saratoga Springs. X: noted in current study; *: noted by Deacon, 1966, 1967.

Taxa	Springs	Marsh
NEMATODA		
PLANARIA DUGESIA		
MOLLUSCA		
GASTRAPODA		
BALIMIDAE		
Assaminea		*
Ponticella	*X	
Tryonia	*X	
ANNELIDA		
HIRUDINEA	*X	
OLIGOCHAETA	*X	
ARTHROPODA		
CHILOPODA		X
ARACHNIDA		X
SCORPIONIDA		X
ACARINA	*X	
SOLPUGIDA		X
ARANEIDA		
Salticidae		
Lycosidae		
CRUSTACEA		
AMPHIPOD	*X	
Hylella azteca		
COPEPODA	*	
INSECTA		
DIPTERA		
Tendipedidae		
Tanypus neopunctipennis		
Tanypus grodhausi		
Chironomus californicus		
Chironomus plumosus		
Paratendipes thermophilus		
Simuliidae		
Simulium tescorum		
Tabanidae		
Chrysops latifrons		
Tabanus punctifer		
Apatolestes villosulus		
Apatolestes hinei		
Silvius abdominalis		
Heleidae		
Culicoides variipennis		
Culicoides mojave		
Culicoides luteovenus		
Culicoides cockerelli cockerelli		
Culicoides weesei		
Culicoides salihi		
Atrichopogon websteri		
Forcipomyia squamipes		
Forcipomyia colemani		
Forcipomyia calcarata		
Stilobezziini fuscula		
Stilobezziini pruinosa		
Bezzia bivittata		
Dasyhelea tristyla		
Dasyhelea festiva		
Dasyhelea mutabilis		
Forcipomyia sp.		
Alluaudomyia needhami		

Table 2 (Continued)

Taxa	Spring	Marsh
Delichopodidae		
Asyndetus spinitarsis		
Asyndetus cornuta		
Asyndetus texanus		
Hydrophorus praecox		
Thrypticus fraterculus		
Tachytrechus granditarsus		
Dolichopus afflictus		
Stratiomyidae		
Eulalia communis		
Eulalia arcuata		
Myxosargus knowltoni		
Menotelus sp.		
Culicidae		
Uranotaenia anhydor		
HEMIPTERA		
Corixidae		
Trichocorixa reticulata		
Trichocorixa verticalis saltoni		
Notonectidae		
Notonecta unifasciata		
Saldidae		
Pentacora sphacelata		
Hebridae		
Hebrus sobrinus		
Merragata brevis		
Naucoridae		
Ambrysus sp.		
Pelocoris shoshone amargosus		
Hydrometridae		
Hydrometra australis		
Belostomatidae		
Lethocerus angustipes		
Belostoma saratogae		
Buenoa scimitra		
DERMAPTERA		
Labidruidae		
Euborellia annulipes		
Tricoptera		
Linnephilus assimilis		
COLEOPTERA		
Dytiscidae		
Cybister explanatus		
Cybister ellipitious		
Dytiscus marginicollis		
Rhantus anisonychus		
Rhantus hoppingi		
Hydrophilidae		
Hydrophilus triangularis		
Paracymus elegans		
Helochares noxmertus		
ODONATA		
Libellulidae		
Tarnetrum corruptum		
Pantala hymenaea		
Agrionidae		
Ischnura sp.		

Table 2 (Continued)

Taxa	Spring	Marsh
DIPTERA		
Pelastoneurus aldrichi		
Pelastoneurus cyareas		
Chrysotus argentatus		
Syntornion bisinuatum		
Parasyntormon utahnum		
Parasyntormon sp.		
Micromorphus albibes		
Sympycnus sp.		
Gymnosoma fuliginosa		
Mesogriapta marginata		
Occemyia propinqua		
Eupeodes volucris		
Siaeva pyrastri		
Metrasyrphus verabhesi		
Polydontomyia curvipes		
Asemosyrphus hieroslyphicus		
Callitroga macellaria		
Eucalliphora lilaea		
Phormia resina		
Microchaeta vallida		
Phorocera sp.		
Gonia sequa		
Sphenophorus sp.		
ORTHOPTERA		
Litareutra minor		
Conocephalus fasciatus vicinus		
Anconia integra		
Encoptolophus pallidus		
Toimerotropus pallidipennis pallidipennis		
HYMENOPTERA		
Melissodes (Eumelissodes) sp.		
Colletes spp.		
Hesperapis (Xeralictoides) laticeps		
Lasioglossum sisymbrii		
Lasioglossum (Dialictus) spp.		
Agapostemon melliventris		
Osmia (Diceratosmia) sp.		
Ashmediella spp.		
Hylaeus cressoni mesillae		
Epeolus sp.		
Andrena (Schizandrena) sp.		
Formica sp.		
Apherenogaster megommatus		
Hypoponera opacior		
Aroplius cylindricus		

Table 3. Vertebrates of Saratoga Springs. X: noted in current study.

Taxa	Spring	Marsh
FISH		
Cyprinodon nevadensis	X	X
AMPHIBIANS		
Hyla regilla	X	X
REPTILES		
Sauria		
Callisaurus draconoides		X
Cnemidophorus tigris		X
Sceleoporous magister		X
Sauromalus obusus		X
Uta stansburiana		X
Serpentes		
Crotalus cerastes		X
Leptotypholops humulis		X
BIRDS		
MAMMALS		
Chiroptera		
Antrozous pallidus		
Pipistrellus hesperus		
Tadarida brasiliensis		
Myotis californicus		
Lasionycteris noctivagans		
Lasiurus cinerea		
Rodents		
Spermophilus tereticaudus		X
Perognathus formosus		X
Dipodomys merriami		X
Dipodomys deserti		X
Onychomys torridus		X
Reithrodontomys megalotis		X
Peromyscus crinitus		X
Peromyscus eremicus		X
Peromyscus maniculatus		X
Neotoma lepida		X

Periodical Measurements

Abiotic - Chemical

Water chemical parameters have been measured monthly since May, 1971. Earlier measurements are presented for comparison to show the relative stability of the spring. These data are presented monthly in Table 4a and b.

Abiotic - Physical

Continuous measurements of the physical parameters have been hindered by a variety of factors: human interference, delays in the receipt of equipment and great difficulty with the flow pens because of the extremes in temperature fluctuations. One Weskler continuous temperature recorder and two Ryan thermographs (month) have been installed periodically in the area. None proved satisfactory and frequent breakdowns occurred. Air and water temperatures recorded during 1971 and 1972 are in the data bank. Previous temperature records (1966-1967) are presented in Table 5a and b. Additional temperature and solar radiation records from nearby (11 miles) USWB Station at Shoshone will be made available. Present data and additional data will be stored in the central office. Water levels are given in Table 5c.

Table 4a. Chemical characteristics of the main spring (1971-1972). (Values in ppm unless otherwise indicated.)

Date	HCO_3	Nitrates	Sulphates	Phosphates	Hardness	Silicates	TDS
May, 1971	356				236		
June, 1971	336				235	42.0	3088
July, 1971	338				245	42.0	3088
August, 1971	301			0.1	239	42.0	3088
September, 1971	600				233	42.0	3088
October, 1971	644	12.5	2450	0.12	250	42.0	3088
November, 1971	564	6.1	650	0.12	260	42.0	3088
December, 1971		0.79	4500	1.29		42.0	3088
January, 1972	532	0.15	2450	0.50	279	42.0	3088
February, 1972	256	2.77	2230	0.62	245	42.0	3088
March, 1972	618	5.60	1900	0.51	324	42.0	3088
April, 1972	534				260	42.0	3088

Table 4b. Chemical characteristics of the water in the main pool at Saratoga Springs, Death Valley National Monument, over a number of years.

Date	Ca ppm	Mg ppm	Na ppm	K ppm	CO_3 ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	NO_3 ppm	NO_2 ppm	M.R. Alk. ppm	Phenol. Alk. ppm	pH	Total Hard-ness	Sal. Salts	Ec x 10^3	Si O_2 ppm	Boron ppm	Ca hard-ness	Total alk.	Conductance k x 10^5 @ 25°C
1932 (R.R. Miller	3.7	6.7	87.7	1.8*		15.0	43.7	41	0.3				8.2		tds 3041			9.96			465
USGS 1106 (Hunt, et al) 19?	33	34	970	30	0	420	1040	680	4.7				8.1	222	tds 180°C 3080		44				4640 = sp. cond. @ 25°C umhos
9 Oct., 1965											410 427	0	8.0 7.5	274							
6-7 Nov., 1965											342 445	0	8.5 7.5	205 256							
25 Nov., 65											308	0	8.0								
13 Feb., 66								770	5.0				7.9	250							
5 Mar., 66	48.0	60.0									420		8.0								
8 Apr., 66	68.1	15.8					1250	340			137		8.3								
17 Aug., 66	27.0	34.0					600	350					8.5								
18 Dec., 66									26.4		220		8.2								
5 Nov., 66							1875	375						230					170		
24 Mar., 67 U.A.	37	39	969		0	430	980	700					7.7		3081	4.4	40	5.02			
24 Mar., 67. UCR	34	49	918	39	0	411	1032	696													
28 June, 67 U.A.	56	24	945		0	452	875	720					7.8		3072	4.5					
3 July, 67	30	33	660	55	0			610				14	7.5	210					23	250	
20 Sept., 67 U.A.	34	39	1016		0	434	1040	720					7.9		3283	4.6					
29 Dec., 67 U.A.	32	44	956		0	415	988	688					8.0		3123	4.4					

* in percent composition

Table 5a. Summary of ambient temperature at Saratoga Springs, Death Valley National Monument. Sample intervals represent first and last week in each month -- February, 1967 - May, 1968. The range is in parenthesis.

Sample Interval	$\bar{X}$ max. °C	$\bar{X}$ min. °C	$\bar{X}$ °C.
1-7 February, 1967	28.4 (26.7-30.0)	7.0 (4.4-8.9)	17.8 (4.4-30.0)
22-28 February, 1967[1]	21.6 (20.0-24.0)	4.2 (1.7-7.2)	13.0 (1.7-24.0)
1-7 March, 1967[1]	24.3 (16.6-28.9)	5.8 (2.2-9.4)	14.8 (2.2-28.9)
25-31 March, 1967[1]	23.4 (17.8-28.4)	8.9 (2.6-12.8)	16.3 (2.6-28.4)
1-7 April 1967[1]	21.8 (16.2-26.1)	7.5 (4.0-10.6)	14.7 (4.0-26.1)
21-27 April, 1967	34.1 (28.3-41.7)	11.5 (8.3-15.5)	24.4 (8.3-41.7)
28 April-4 May, 1967	34.3 (30.0-39.3)	14.1 (11.2-20.0)	25.2 (11.2-39.3)
23-31 May, 1967[1]	32.7 (27.3-37.3)	17.6 (11.1-20.0)	25.1 (11.1-37.3)
1-7 June 1967[1]	31.8 (26.0-35.0)	15.7 (11.7-17.8)	23.9 (11.7-35.0)
24-30 June, 1967[1]	42.4 (40.5-46.2)	24.0 (21.1-28.3)	33.0 (21.1-46.2)
1-7 July, 1967[1]	45.1 (41.1-48.4)	27.9 (23.3-31.6)	36.6 (23.3-48.4)
25-31 July, 1967[1]	43.0 (39.3-45.5)	28.6 (26.7-30.6)	35.2 (26.7-45.5)
1-7 August, 1967[1]	43.0 (40.6-45.0)	27.5 (24.4-30.6)	35.3 (24.4-45.0)
25-31 August, 1967[1]	41.8 (37.8-45.0)	25.5 (23.3-27.8)	32.8 (23.3-45.0)
2-6 September, 1967[2]	44.8 (41.1-48.8)	28.3 (24.5-32.2)	37.5 (24.5-48.8)
24-30 September, 1967	30.3 (16.0-37.3)	26.2 (23.8-28.8)	30.1 (16.0-37.3)
1-7 October, 1967	32.8 (30.4-34.4)	24.3 (21.1-26.7)	28.6 (21.1-34.4)
25-31 October, 1967	34.1 (27.8-37.3)	17.5 (12.8-18.3)	25.6 (12.8-37.3)
1-7 November 1967	32.9 (29.4-35.0)	17.2 (14.3-20.0)	24.8 (14.3-35.0)
24-30 November 1967	18.3 (12.7-21.1)	7.3 (4.4-10.0)	12.9 (4.4-21.1)
1-7 December 1967	17.0 (14.4-21.1)	5.6 (3.3-17.7)	11.4 (3.3-21.1)
25-31 December 1967[1]	18.3 (15.0-21.1)	1.3 (-2.2-15.6)	9.7 (-2.2-21.1)
1-7 January 1968[1]	14.0 (13.2-15.0)	-2.4 (-5.6-2.8)	5.8 (-5.6-15.0)
25-31 January 1968	22.1 (18.9-24.5)	7.3 (3.4-12.8)	14.6 (3.4-24.5)
1-7 February 1968	24.8 (21.6-27.6)	5.8 (4.0-8.3)	15.2 (4.0-27.6)
24-29 February 1968[2]	34.3 (32.2-36.2)	15.0 (10.6-16.6)	25.3 (10.6-36.2)
1-7 March 1968	31.6 (24.4-35.5)	12.7 (9.6-15.5)	21.4 (9.6-35.5)
25-31 March 1968[1]	29.4 (27.8-32.1)	10.8 (7.2-14.4)	20.3 (7.2-32.1)
1-7 April 1968	37.0 (35.0-39.4)	15.2 (13.7-21.1)	26.2 (13.7-39.4)
24-30 April 1968	45.5 (43.2-49.4)	17.6 (15.5-20.4)	31.6 (15.5-49.4)
1-7 May 1968	46.2 (41.6-50.4)	22.0 (18.3-25.0)	34.4 (18.3-50.4)

[1]Records from U.S. Weather Bureau station, Baker, San Bernadino County, California.

[2]One day's minimum temperature missing.

Table 5b. Water temperature in open water at Big Lake, Saratoga Springs, Death Valley National Monument.

1967		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
April	max.																						64	65	65	66	69	69	69
	min																						63	62	62	62	66	68	65
May	max.	67	68	70	71	71	71	74	76	76	74	70	70	70	69	71	75	78	80	80	81	81	83	83	81				
	min.	65	64	68	71	67	70	70	73	74	67	66	66	66	66	66	69	74	75	76	76	78	78	78	80				
June	max.		82	82	82	78	81	80	82	82	81	81	81	80	83	85	86	87	83	82	87	87	85	86	87	87	88	85	88
	min.		74	75	71	72	75	73	74	73	74	74	71	75	77	80	81	78	77	77	81	80	72	80	80	80	79	78	78
July	max.	92	91	91	83	92	94	94	91	93	94	96	94	93	95	94	96	91	93	95	95	92	82	96	98	96	93	96	98
	min.	84	84	84	91	80	78	79	78	79	81	84	83	84	85	82	82	79	80	80	81	81	80	79	82	80	82	80	81
Aug.	max.	87	95	91	95	93	92	92	93	95	95	95	97	96	94	93	93	92	93	94	92	92	88	90	90	90	91	93	90
	min.	83	80	82	82	82	82	78	80	80	84	83	84	85	85	83	82	82	84	85	83	84	84	80	80	80	83	84	81
Sept.	max.																						87	87	82	83	84	85	80
	min.																						71	74	74	73	75	75	77
Oct.	max.	82	79	79	81	76	73	75	76	76	75	75	75	77	76	71	73	72	73	73	72	71	73	72	72	73	73	72	70
	min.	75	72	72	72	73	67	66	67	67	68	67	69	68	70	60	62	62	60	63	63	62	64	63	64	65	66	63	61
Nov.	max.	67	70	69	62	64	65	69	68	66	68	67	66	66	66	65				67	66	65	67	63	62	62	62	60	57
	min.	60	61	60	59	59	60	63	62	60	61	61	60	60	60	60				63	62	62	60	55	54	55	55	51	52
Dec.	max.	54	54	54	53	55	56	56	54	55	50	50	51	48	40	38	40	46	49	45	45								
	min.	47	47	47	74	50	50	50	50	50	45	45	45	37	35	36	37	40	44	43	43								

Table 5c. Water level records from Long Lake, Saratoga Springs, DVNM.

Records from USGS Recorder

Date	cm
1966	
Dec.	27
1967	
Jan.	35
Mar.	35
Apr. 20	29
Apr. 26	27
May 6	24
May 16	20
May 26	16
Jun. 5	16
Jun. 28	15
Jul. 5	15
Jul. 15	14
Jul. 25	12
Jul. 29	13
Aug. 4	11.
Aug. 14	10
Aug. 24	9
Sep. 2	9
Sep. 13	11
Sep. 23	12
Oct. 3	15
Oct. 13	16
Oct. 23	17
Nov. 2	18
Nov. 12	19

Staff in middle of Long Lake

Date	Inches
1971	
Mar.	--
Apr.	13
May.	10
Jun.	5
Jul.	5
Aug.	4
Sep.	4
Oct.	4
Nov.	7
Dec.	10
1972	
Jan.	12
Feb.	14
Mar.	14
Apr.	11

Biotic - Periphyton and Macrophytes

Quantitative sampling of the floral aquatics achieved little success. Sampling tools developed on the basis of previous descriptions of the spring were discarded when it was found that *Spirogyra* was extremely abundant. Attempts at quantitative sampling *Ceratophylum* within a mat of *Spirogyra* did not yield results in which any confidence could be placed. Due to the small, fragile area involved and public relations problems, we were extremely reluctant to do any large-scale harvesting. Percent cover and volume estimates were made periodically. A total harvest of all vascular plants from the main spring was made in 1967. Percent cover was estimated and dry weight determined. From these data, an estimation of biomass in g/m^2 of all macrophytes in the spring can be calculated. These data correlate well with primary production data obtained from 24 diurnal O_2 curves presented in Table 6.

Table 6. Primary production as determined with 24 diurnal O_2 curves.

Date	O_2 prod./ 24 hrs.	O_2 resp./ 24 hrs.	Net prod./ 24 hrs.	dry wt. gr O_2/m^2/24 hrs.	g/m^2/24 hrs. C	N	P
1971							
7 May	70.25	3.4	66.85	119.0	47.6	2.4	0.35
6 Jun.	66.55	3.8	62.7	111.6	44.6	2.2	0.33
9 Jul.	63.55	4.65	58.9	104.6	41.8	2.1	0.31
7 Aug.	61.2	2.6	58.6	104.3	41.7	2.1	0.31
10 Sep.	20.4	6.0	13.6	24.25	9.7	0.49	0.07
16 Oct.	5.7	3.7	2.0	6.4	2.6	0.1	0.02
12 Nov.	6.25	1.95	4.3	7.6	3.0	0.1	0.02
21 Dec.	22.4	2.55	19.85	35.33	14.1	0.7	0.1
1972							
12 Jan.	7.35	2.6	4.75	8.4	3.4	0.2	0.02
18 Feb.	29.5	1.4	28.1	50.0	20.0	1.0	0.15
17 Mar.	13.1	5.0	8.1	14.4	5.8	0.3	0.04
21 Apr.	17.6	1.8	15.8	28.1	11.2	0.6	0.08

Light-dark bottles were utilized to provide information on production /g dry weight of important macrophytes. Whereas this technique has some obvious disadvantages, relative values of production may be constructed. Raw data for calculating production values for O_2/g dry weight of macrophytes are presented in Table 7.

Table 7. Production values for macrophytes in Saratoga Spring.

	O_2 (ppm)	Dry Weight
Sample Light		
Ceratophylum	7.6	.2235
Ceratophylum	7.0	.1347
Spirogyra	6.4	.0843
Spirogyra	5.4	.0985
Ruppia	7.2	.3234
Ruppia	8.2	.4680
Sample Dark		
Ceratophylum	5.8	.1846
Ceratophylum	5.8	.1673
Spirogyra	4.0	.0484
Spirogyra	4.0	.0612
Ruppia	6.0	.2391
Ruppia	5.4	.2193
O_2 content of water in the spring	6.2	

Volume of sample container equals 3950 ml.

Biotic - Consumers

Benthic - Invertebrates

Eight benthic samples were collected each month from the main spring, utilizing a modified Macan sampler. These were picked, sorted, counted, measured and weighed.

Dying the samples with Rhodamine B helped immeasurably in picking out benthos; however, an average of 24 man hours were spent in processing each sample. This situation has caused a shortage of manpower for other invertebrate studies of interest: e.g., emergence, insect blacklight collections and benthos collections in the marsh. Monthly collections of insect blacklight traps and benthos samples from the marsh are available but have not been processed. Insect-emergence traps, however, were not installed. Table 8 presents completed data on dry weight of benthos organisms /m^2 by sampling period.

Table 8. Numbers and dry weights (grams) of benthic organisms each sampling period. Cross-section of area sampled equals 0.003536 square meters.

	Tryonia		Fonticella		Oligochaeta		Amphipoda		Hirudinea		Chironomidae		Other Benthos	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
1971														
Apr.	1560	1.5276	276	.2244	177	.0691	1642	.1894	--	--	14	.0032	6	.0012
May	1696	1.4109	267	.1910	44	.0110	763	.0772	--	--	6	.0016	-	--
Jun.	2202	1.7521	822	.4979	405	.3390	395	.0482	--	--	2	.0007	6	.0251
Jul.	934	.7840	178	.1345	17	.0066	291	.0535	1	.0076	--	--	-	--
Aug.	1223	.5918	242	.2045	-	--	59	--	2	.0048	1	.0007	-	--
Sep.	615	.6539	57	.0465	79	--	117	--	3	--	--	--	-	--
Oct.	854	.6702	113	.0793	110	.0153	84	.0145	--	--	--	--	-	--

Productivity and Biomass of Marsh Vegetation

Seasonal trends in biomass of live, standing dead and below-ground plant parts were determined by the harvest method (Penfound, 1956; Westlake, 1963). Samples were randomly located in particular vegetation types within the marsh. Mat-like plants (*Distichlis* and *Cressa*) were removed from 182.4 cm^2 circular plots. Emergent aquatics with extensive root systems (*Phragmites* and *Scirpus*) were removed from 4069 cm^2 circular plots. In contrast, individual plants or clones of *Juncus, Anemopsis, Nitrophila* and *Sporobolus* were harvested and later converted to area estimates by use of density data for individuals or clones for each species.

Biomass data are given for approximately monthly intervals. Sample sizes varied widely and were small to allow for minimal damage to the study area. Biomass estimates are given for M^2 of either salt grass complex of bulrush vegetation type (see Table 9). In addition biomass estimates are given for the whole marsh area.

Table 9. Seasonal trends in standing crop biomass (Kg/ha) at Saratoga Springs marsh for the period March, 1971 - February, 1972.

Species and Plant Parts	23 May	8 May	3 Jun.	7 Aug.	11 Sep.	16 Oct.	12 Nov.	22 Dec.	13 Jan.	29 Feb.
Cressa truxillensis										
Green living	-	895.7	-	1,559.0	715.2	1,053.9	814.3	156.3	145.8	-
Standing dead & litter	-	567.7	-	7,586.0	4,636.6	1,859.4	5,320.8	1,376.8	5,765.2	-
Underground	-	196.3	-	-	263.9	283.1	536.6	763.9	363.0	-
TOTAL	-	1,659.7	-	9,145.0*	5,615.7	3,196.4	6,671.7	2,297.0	6,279.0	-
Distichlis spicata										
Green living	167.5	395.8	-	660.4	-	239.4	933.8	298.6	84.7	258.6
Standing dead & litter	1,083.0	1,935.7	-	5,521.1	-	2,460.9	3,212.9	3,106.9	2,021.8	1,880.2
Underground	1,383.6	1.027.4	-	-	-	1,021.8	1,710.9	1,266.3	1.099.3	334.6
TOTAL	2,634.1	3,358.9	-	6,181.5*	-	3,722.1	5,857.6	4,672.0	3,205.8	3,473.4
Phragmites communis										
Green living	-	99.5	-	236.9	168.0	103.3	66.3	135.3	-	-
Standing dead	-	268.2	-	470.6	287.5	428.3	247.5	550.0	-	-
Underground	-	-	-	-	-	-	-	-	-	-
TOTAL	-	367.7*	-	707.5*	455.5*	531.6*	313.8*	685.3*	-	-
Scirpus olneyi										
Green living	-	-	66.7	31.0	62.7	13.3	12.0	23.5	13.3	40.8
Standing dead	-	-	133.9	219.1	232.9	32.8	137.7	113.8	73.9	79.2
Underground	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	200.6*	250.1*	295.6*	46.1*	149.7*	137.3*	87.2*	120.0*
Juncus cooperi										
Green living	9.3	14.3	-	15.4	18.9	20.3	9.5	3.1	9.6	12.7
Standing dead	10.6	4.0	-	25.2	16.6	16.8	13.7	8.6	15.2	15.9
Underground	18.4	19.4	-	58.2	34.6	25.5	22.2	15.7	26.9	28.4
TOTAL	38.3	37.7	-	98.8	70.1	62.6	45.4	27.4	51.7	
Nitrophila occidentalis										
Green living	-	0.4	-	3.0	3.3	2.0	-	-	-	-
Standing dead	-	0.1	-	1.0	2.6	1.9	-	-	-	-
Underground	-	0.3	-	-	1.8	0.6	-	-	-	-
TOTAL	-	0.8	-	4.0*	7.7	4.5	-	-	-	-
Scirpus robustus										
Green living	-	-	2.3	0.5	-	-	-	-	-	-
Standing dead	-	-	1.1	4.2	-	-	-	-	-	-
Underground	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	3.4*	4.7*	-	-	-	-	-	-
Anemopsis californica										
Green living	0.2	0.9	-	0.8	0.7	-	-	-	-	-
Standing dead	1.0	1.1	-	2.4	0.5	-	-	-	-	-
Underground	1.1	1.8	-	1.4	0.9	-	-	-	-	-
TOTAL	2.3	3.8	-	4.6	2.1	-	-	-	-	-

- denotes sample being processed or no sample taken

* total above ground only

Results

An estimate of seasonal trends in standing crop biomass is given in Table 9 for the approximately 9.6 hectare marsh. Numerous samples are yet to be sorted and dried before a proper analysis can be made.

The mat-like *Distichlis* and *Cressa*, followed by *Phragmites*, *Scirpus olneyi* and *Juncus*, account for most of the standing crop biomass. Peaks in standing crop occur in June through September. Maximum standing crop was in excess of 16,441 Kg/ha. This estimate did not include below-ground parts for several major species. The peak in green living is a rough estimate of above-ground production. This peak was estimated for all species as 2833 Kg/ha.

Literature Cited

Penfound, W.T. 1956. Primary production of vascular aquatic plants. Limnol. Oceanog. 1:92-101.

Westlake, D.F. 1963. Comparisons of plant productivity. Biol. Rev. 38:285-425.

Soil Invertebrates

The purpose of the soil invertebrate study was to initially survey those organisms found in the soil and litter of the area. The marsh was stratified into four areas, based on vegetation and soil types.

Area 1 - South end of marsh in *Distichlis, Juncus* and *Phragmites*. Soil composed of 1 to 2-inch leaf litter, 3 to 4-inch humus and no subsurface water.

Area 2 - East edge of marsh in *Juncus, Anemopis* and *Sporobolus*. Soil has 1 to 2-inch salt crust, few litter, and subsurface water at 5 inches.

Area 3 - North edge of marsh in high *Cressa* and *Distichlis*. Soil sandy with 2 to 3 inches of root and vegetative litter. Subsurface water at 5 inches.

Area 4 - West edge of marsh in *Distichlis* and *Cressa*. Dry, sandy soil with 2 to 3 inches of roots and vegetative litter.

A total of 1576 individual invertebrate organisms were collected from the 105 samples. 53 individuals remain unidentified (7 from Area 1, 9 from Area 2, 30 from Area 3, and 7 from Area 4). 1523 organisms were identified into one of the following 12 categories:

1. Hymenoptera - ants and wasps
2. Coleoptera - Curculionidae - 5 other families
3. Isoptera - termites
4. Arachnida - greater than 10 species
5. Acarina - ticks and mites
6. Pseudoscorpionidae - 1 individual
7. Orthoptera - 1 small roach
8. Homoptera - Aphids
9. Diptera - Mosquitos - *Drosophila*
10. Dermoptera - earwigs
11. Gastropoda - snail shells only
12. Larvae - greater than 26 different forms

Table 10 represents the data obtained during this project. It is a block profile diagram. Each block is a cross reference between one category of organisms and one of the four plant complexes. Each block is further divided into 4 smaller units.

For example, the first block represents the Hymenoptera in the *Phragmites* complex. The first figure (180) represents the total number of Hymenoptera collected in Area 1. Since the number of samples varied from area to area, this first figure was corrected so that it could be compared with the others. For example, twice as many samples were collected from Area 2 than Area 1 so that the figure 180 must be doubled before it can be compared with Area 2. This second figure (360) represents the corrected value.

When all the Hymenoptera collected at Saratoga Springs are considered, the third number (66) represents the % of these collected in the first, or *Phragmites*, area.

With all the invertebrates collected from Area 1, the fourth figure (48) represents the % of these that were Hymenopterans.

Table 10. Block profile diagram of soil invertebrates of Saratoga Springs. [For explanation of diagram, see text.]

	Area 1 *Phragmites*		Area 2 *Distichlis Juncus*		Area 3 *Distichlis Cressa*		Area 4 *Distichlis-Cressa Nitrophila*	
Hymenoptera	180	360	66	66	108	108	9	10
	66	48	12	20	20	20	1	3.6
Coleoptera	15	30	14	14	18	18	8	9
	42	0.3	20.5	4.2	25	3.3	12.5	3.3
Isoptera	12	24	13	13	80	80	12	13
	18.5	3.2	10	3.8	61.5	14.5	10	4.8
Arachnida	4	8	6	6	8	8	12	13
	23	1	17	1.8	23	1.4	17	4.8
Acarina	46	92	165	165	78	78	189	201
	17	12	31	50	14.5	14	37.5	72.5
Homoptera	0	0	4	4	1	1	0	0
	0	0	66.5	1.2	33.5	0.4	0	0
Diptera	0	0	3	3	0	0	0	0
	0	0	100	0.8	0	0	0	0
Dermoptera	7	14	0	0	1	1	9	10
	56	1.9	0	0	4	0.2	40	3.6
Gastropoda	6	12	11	11	1	1	1	1
	48	1.6	44	3.2	4	0.2	4	0.4
Larvae	101	202	53	53	250	250	29	31
	37.2	27	10	10	47	45.6	5.8	11

Table 11 shows the data in a slightly different way. Invertebrate cateogories are cross-referenced with collecting times. The spring area was sampled three times during the project: March 20, April 17, and May 1. The first figure in each block represents the number of individuals of that category that were collected on that date.

Table 12 shows the invertebrate breakdown for all of Saratoga Springs sampled. Acarina, larvae, and Hymenoptera are clearly the largest represented groups.

Table 11. Numbers and percents of soil invertebrates of Saratoga Springs.

	Mar 20		Apr 17		May 1	
	No.	Percent	No.	Percent	No.	Percent
Hymenoptera	151	41	92	26	120	33
Coleoptera	33	60	16	29	6	11
Isoptera	71	60	43	37	3	3
Arachnida	4	14.5	13	43	13	43
Acarina	19	4	206	44	253	52
Dermoptera	0	0	10	59	7	41
Gastropoda	5	26	4	21	10	53
Larvae	304	71	80	18	49	11

Table 12. Percentage distribution of soil invertebrates from Saratoga Springs.

Category	Number	% of Total
Hymenoptera	363	23.9
Coleoptera	55	3.6
Isoptera	117	7.7
Arachnida	30	20.0
Acarina	478	31.0
Pseudoscorpionidae	1	0.05
Orthoptera	1	0.05
Homoptera	6	0.4
Diptera	3	0.2
Dermoptera	17	1.1
Gastropoda	19	1.2
Larvae	433	28.0

Discussion

Acarina, mites, appear to be the most well distributed soil invertebrates at Saratoga Springs. They appeared as immature forms in the first series of samples. Emergence was appearing sometime between March 20 and April 17. An increase in numbers was also observed in later samples.

Based on biomass estimates, it appears that Curculionidae (weevils) are the most important mature forms. They appear in considerably fewer numbers than the mites, but due to their large size contribute more to the biomass of the soil invertebrates sampled.

Larval forms contributed the most to total biomass in earlier samples. Emergence was responsible for the reduction in biomass.

Blacklight Collections

Blacklight insect traps were utilized at frequent intervals at the main spring. The purposes of this endeavor were to expand our invertebrate species inventory, to facilitate identification of larvae with adults, and to get an idea of seasonal relative abundance of flying insects. These data have not been processed and are considered third priority, following benthos and soil invertebrates.

Amphibians and Reptiles

During the course of field work on the ecology of Saratoga Springs, some data were gathered on the herpetofauna of the region. The records are based on miscellaneous collections and observations.

Species Accounts

Hyla regilla (Pacific Tree Frog). A total of 17 were collected from the marsh in November, March and April. Sizable populations are present in the marsh and attempts were not made to collect other specimens. Individuals were heard or observed during all months, except February and June, and no special attempt was made during those months.

Bufo punctatus. Although no specimens were collected, one was heard calling on one occasion.

Diposaurus dorsalis (Desert Creasted Lizard). Three were collected in April in the sand dunes adjacent to the marsh.

Crotaphytus wislizeni (Leopard Lizard). None were collected but several observations were made in the sand dunes adjacent to the marsh in July.

Callisaurus draconoides (Zebra Tailed Lizard). A total of five specimens was collected from the sand dunes near the marsh.

Sceloporus magister. (Desert Spiny Lizard). Single individuals were collected from reed grass and tamarisk near the marsh during January and April.

Uta stansburiana (Side Blotched Lizard). A total of 41 were collected from tamarisk, sand dunes, creosote bush and salt bush habitats. This species was observed more frequently than the other species and is probably active during every month of the year.

Cnemidophorus tigris (Whiptail Lizard). Seven were collected from the sand dune area adjacent to the marsh.

Leptotyphlops humilis (Worm Snake). Two specimens were collected at Saratoga Springs in April. Turner and Wauer (1963) reported this species from several other desert oases in Death Valley.

Crotalus cerastes (Desert Sidewinder). Two were collected in April from the sand dunes adjacent to the marsh. The species was observed frequently during the summer.

Discussion

Our data on herptiles were collected incidental to other studies and are presented here as preliminary only. Turner and Wauer (1963) reported six species from the floor of Death Valley that were not collected by us. Additional work specifically on the herptiles at Saratoga Springs will probably add most of these species to the list.

December is the only month in which no herptile was seen or collected. This probably suggests no more than reduced activity, since in December *Hyla* were heard calling loudly in the afternoon and evening and several *Uta stansburiana* were seen during the day. Numbers of species and individuals appear to be highest from March through August.

The most abundant species appear to be *Uta stansburiana*, *Cnemidophorus tigris*, *Callisaurus draconoides*, and *Sceloporus magister*. *Uta* appear to be active most frequently during the year, and *Cnemidophorus* appear most restricted to the summer months. Additional and more concentrated work will be undertaken to determine whether or not these relationships reflect reality.

Table 13. Records of the Herpetofauna of Saratoga Springs. (Numbers and X's indicate observations, and numbers within parentheses indicate collections,)

Species	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Hyla regilla	X	(4)		3		(4)	(9)			X	X	X
Dipsosaurus dorsalis							(3)				X	
Crotaphytus wislizeni										X		
Callisaurus draconoides	X	1				(2)	(3)	1		X	X	
Sceloporus magister				(1)	(1)		X (1)	1		X	X	
Uta stansburiana	(1)			4 (1)	14 (1)	(31)	X (7)	5	2	X	X	
Cnemidophorus tigris						(2)	(2)	8	2	X	X	
Leptotypholops humilis							(1)					
Crotalus cerastes							(2)	2		X	X	
No. of species	3	2	0	2	2	4	8	5	2	7	7	1
No. of individuals		5	0	6	16	39	36	17	4	-	-	-

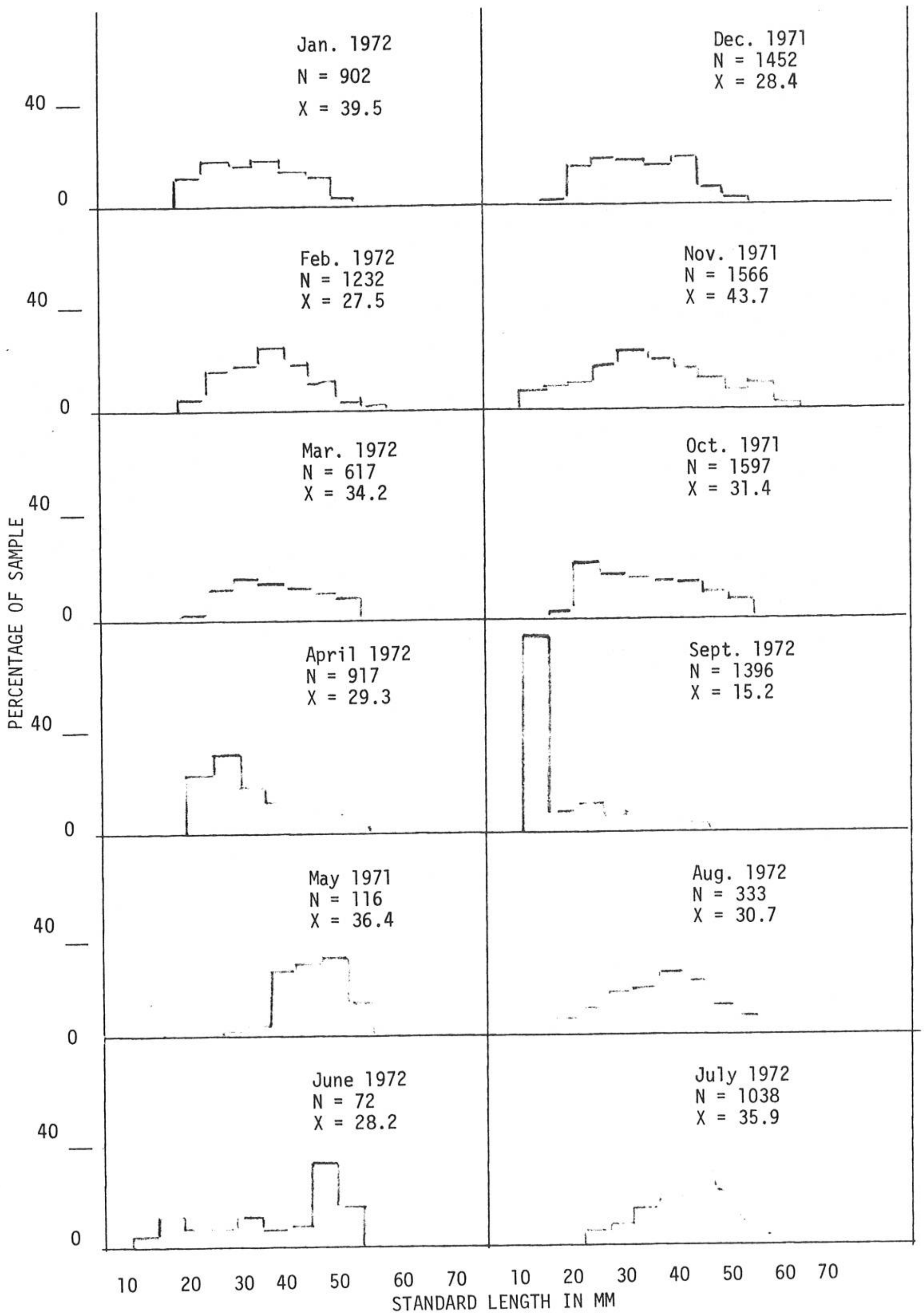

Figure 1. Length-frequency histogram for *C. nevadensis*.

Literature Cited

Turner, F.B., and R.H. Wauer. 1963. A survey of the herpetofauna of the Death Valley area. Great Basin Nat. 23:119-128.

Fish

Length-frequency

The length distribution of samples of the population is shown in Figure 1. This presentation permits a general impression of changes in population structure throughout the year. Greater detail can be achieved through the use of a smoothing technique, such as calculation of three-level moving averages that would permit preliminary judgments to be made regarding growth rates. Such analysis of data for 1966-67 suggested that mature fish grew about 3 mm per month during the summer. This is a low estimate since mortality was not adequately accounted for. The technique, of course, lacks precision. Since the data for 1971-72 have not been similarly analyzed we cannot compare the two sampling periods.

Evident from examination of Figure 1, however, are the following generalizations. In April the influence of recruitment from individuals that were probably hatched in February is clearly evident. Population structure shifted markedly in May through July, probably primarily as a result of growth of the large group of young that first appeared in April. In August, and more dramatically in September, the influence by recruitment of another strong size-class is responsible for shifting the population structure back to predominantly smaller individuals. The very large percentage of 10-15 mm fish shown in September was taken by seining. While the data from this month must not be considered directly comparable to data from other months, the presence of such a very large percentage of young is significant. These fish must have been hatched during July and August. From October through February growth is probably responsible for most of the shift in population structure. This interpretation suggests that a spring and summer spawning peak have a principal influence on the population structure of *C. nevadensis*. Spawning probably in fact occurs over an extended period of time; however, the combination of increased spawning intensity and differential survival of fry produces the changes noted.

It is possible by substituting size for age, to calculate life table information from the size-frequency distribution of the population. Using these methods for data obtained during 1966-67 resulted an estimation that about 50% of the population alive at 15 mm lives an additional 8-9 months, and further that maximum life span after reaching 15 mm is about 16-18 months. Whether or not this appears true for 1971-72 fish awaits analysis.

Life Tables

Using length-frequency information and assuming constant growth (because the spring is constant temperature), it is possible to calculate a life table for the populations of animals living in the spring. This is done by equating length with age and using the length-frequency distribution as an age distribution in calculating the life table. The method is instructive regarding changing patterns of mortality throughout the year. An example of the kind of results obtainable by this analysis is presented in Table 14 using data for *C. nevadensis*. These tables can be calculated for each collecting period or for any combination of collecting periods. A number of qualifying conditions must be recognized in order to use this information properly. These will probably be different for each species.

Table 14. Life table for *C. nevadensis* from Saratoga Springs. Data for 21 - 22 April, 1967.

Size (mm)	Size as % deviation from mean length	Number dying in length interval of 1000 alive at 16 mm	Number surviving to beginning of length interval of 1000 alive at 16 mm	Mortality rate per 1000 alive at beginning of length interval	Mean additional growth expected
16	-100.000	0.000	1000.000	0.000	22.602
17	- 95.475	0.000	1000.000	0.000	21.602
18	- 90.951	2.380	1000.000	2.380	20.626
19	- 86.426	0.000	997.619	0.000	19.650
20	- 81.902	0.000	997.619	0.000	18.650
21	- 77.378	0.000	997.619	0.000	17.650
22	- 72.853	7.142	997.619	7.159	16.710
23	- 68.329	0.000	990.476	0.000	15.766
24	- 63.804	7.142	990.476	7.211	14.820
25	- 59.280	19.047	983.333	19.370	14.006
26	- 54.756	11.904	964.285	12.345	13.216
27	- 50.231	14.285	952.380	15.000	12.385
28	- 45.707	23.809	938.095	25.380	11.619
29	- 41.182	26.190	914.285	28.645	10.914
30	- 36.658	26.190	888.095	29.490	10.210
31	- 32.134	52.380	861.904	60.773	9.643
32	- 27.609	30.952	809.523	38.235	9.097
33	- 23.085	42.857	778.571	55.045	8.492
34	- 18.560	28.571	735.714	38.834	7.863
35	- 14.036	64.285	707.142	90.909	7.335
36	- 9.512	45.238	642.857	70.370	6.894
37	- 4.987	42.857	597.619	71.713	6.345
38	- 0.463	85.714	554.761	154.506	6.016
39	4.061	59.523	469.047	125.903	5.845
40	8.585	54.761	409.523	133.720	5.470
41	13.109	59.523	354.761	167.785	5.373
42	17.634	42.857	295.238	145.161	5.191
43	22.158	47.619	252.380	188.679	5.020
44	26.683	19.047	205.761	93.023	4.707
45	31.207	28.571	185.714	153.846	4.222
46	35.732	38.095	157.142	242.424	3.999
47	40.256	30.952	119.047	360.000	3.999
48	44.780	19.047	88.095	216.216	3.954
49	49.305	16.666	69.047	241.379	3.823
50	53.829	14.285	52.380	272.727	3.789
51	58.353	4.761	38.095	125.000	3.533
52	62.878	2.380	33.333	71.428	2.814
53	67.402	9.523	30.952	307.692	2.227
54	71.927	14.285	21.428	666.666	2.250
55	76.451	2.380	7.142	333.333	3.000
56	80.975	2.380	4.761	500.000	3.333
57	85.500	0.000	2.380	0.000	3.499
58	90.024	0.000	2.380	0.000	2.500
59	94.549	0.000	2.380	0.000	1.500
60	99.073	2.380	2.380	1000.000	1.000
61	103.598	0.000	0.000	0.000	0.000

Population size

Fluctuations in population size were determined using mark-and-recapture techniques as previously described. Table 15 presents data obtained during 1971-72 while Table 16 presents data obtained during 1966-67. Comparative data from the two years are presented in Figure 2. It is apparent that general trends are similar with the annual low population occurring in March. The population peak arrived about two months later in 1972 than it had in 1967. In addition, the increase from the March low in 1971-72 involved a distinct rise of the population to May, followed by a decline and then a rise to November. In 1967 the population rose more or less steadily to September. The population size was higher for a longer period in 1971 than in 1967. These fluctuations appear to follow, with some lag, changes occurring in abundance of plants in the spring pool. It is important to keep in mind that the sampling method is selective for fish above 20 mm, a size at which the fish are older juveniles or mature. Therefore spawning, responsible for the increases in population indicated here, probably occurred 2-4 months before the increase is noted.

It will be noted that population estimates are not plotted for August and September, 1971. This is due in part to a change in personnel at that time necessitating a training period during which results were relatively less reliable. More important however was the fact that the population in August did not respond well to the standard collecting methods. Since other gear for alternative collecting methods was not available, the August sample was quite inadequate for a good population estimate (Table 15). In September seines were tried as an alternative collecting technique. While we were able to obtain important information in this way, the results are not easily comparable to results obtained during other collecting periods. For purposes of providing information that is better than a guess, we estimated that about 75% of the population was captured with the seine. This may be too high. Therefore, the estimate of population size in September of 1600 fish is probably conservative.

Diet and Food Utilization

Refer to the process study conducted by Deacon in 1971, entitled "Food utilization of *Cyprinodon nevadensis* as a function of availability, age, sex, habitat, temperature, and season."

Table 15. Estimated population size of *C. nevadensis*, Saratoga Springs.

Date		Total # Captured	Total # Marked	Total # Recaptured	Population Estimate	Standard Error
May	71	274	1246	171	1967	±153
June	71	926	840	224	1121	± 75
July	71	800	520	137	1495	±128
August	71	337	202	13	3276	±909
September	71	1399	--	---	1600	*
October	71	2628	1537	845	2137	± 73.5
November	71	1445	1063	141	3833	±323
December	71	2383	1063	521	1818	± 80
January	72	1841	980	657	1356	± 53
February	72	2171	964	954	1129	± 35
March	72	943	516	382	761	± 39
March	72	271	74.2% under 20 mm (seine sample)			
April	72	1423	598	426	999	± 48

* Seine sample % less than 20 mm

Table 16. Estimated population size of *C. nevadensis*, Saratoga Spring.

Date		Total # Captured	Total # Marked	Total # Recaptured	Population Estimate	Standard Error
July	66	2423	337	533	1327	59
January	67	776	497	168	1209	157
February	67	704	584	95	1006	413
March	67	640	424	138	795	148
April	67	500	404	88	804	222
May	67					
June	67	570	368	73	1265	314
July	67	1012	668	168	1368	75
September	67	1293	670	152	2746	434
October	67	340	183	13	2280	607
November	67	678	476	89	1752	358

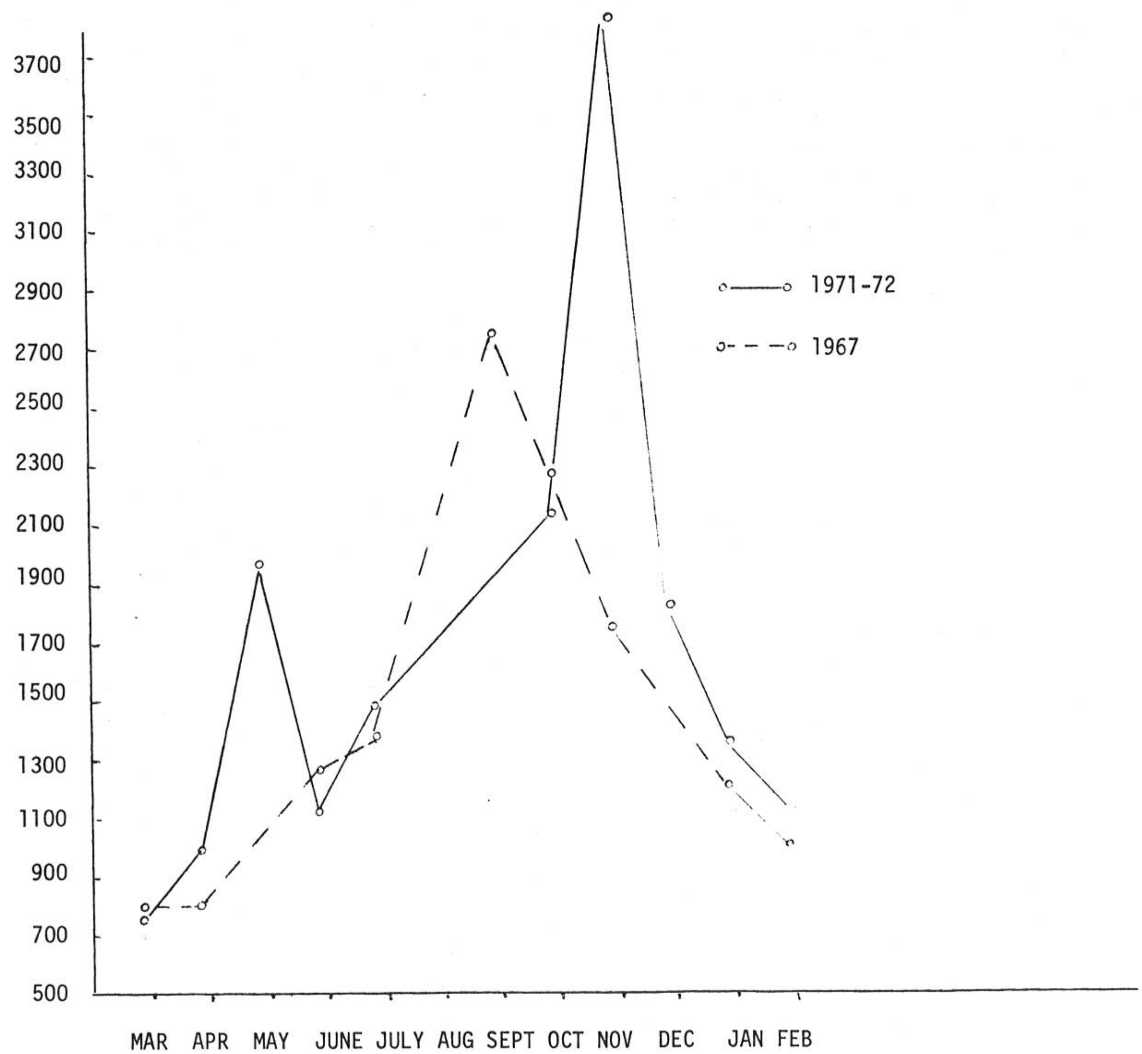

Figure 2. Population estimates for *C. Nevadensis*, Saratoga Springs, California.

Food habits.

A process study was conducted on food habits of *C. nevadensis*. Data are summarized in Tables 17 and 18. In general detritus and filamentous algae provided the great bulk of food during 1971-72. Filamentous algae appeared to be preferred since its occurrence in the gut dropped only when it became unavailable during fall and winter. Vascular plants (*Ceratophyllum* and others) were important in the diet during fall and winter. Gastropods became significant in the diet only during winter and other benthos showed significantly in spring, fall and winter. While detritus is important in the diet it appears to be relatively unpreferred and probably is an item used extensively as a "filler" when preferred items are relatively unavailable.

This general picture differs quite dramatically from that presented by fish collected in 1965-66. Here a pronounced difference was the near absence of *Spirogyra* from the spring pond. The estimated mean volume of *Spirogyra* in the diet during that period was maximum in the fall at 12.7%. Summer and winter showed 5.7% and 6.0%, respectively, and none occurred in the samples taken during the spring. By contrast detritus was dominant in the diet during every season, reaching a peak of 79.5% in the summer, a season of generally low availability of other alternative food sources. Some starvation was evident during that summer also. In addition, utilization of Gastropods and other benthos was considerably higher in 1965-66 than in 1971-72.

While this circumstance may well be due in part to differing abundance of benthic animals, it doubtless was markedly influenced by the major difference in algal abundance.

Information on feeding periodicity (Figure 3) suggests that feeding behavior is stimulated by increasing light intensity at sunrise and again by decreasing intensity after reaching a midafternoon peak.

Additional work useful for completing the modelling work would include measurements of daily food ration during reproductive and non-reproductive seasons. Measurements of conversions efficiency and growth rates should be coupled with intake studies. Other information on respiratory rates and rates of nitrogen elimination would also be useful.

Analyses of body composition in terms of water, total solids, protein, fat and ash, for *Cyprinodon nevadensis* are given in Table 19.

Table 17. Percent composition of major food items in the stomachs of *Cyrinodon nevadensis*, Saratoga Springs, 1965-1967. [N indicated in parenthesis.]

Date		Detritus	Filamentous Algae	Vascular Plants	Gastropods	Other Benthos
1965-66	Spring (20)	65.9	-	15.0	2.8	16.2
	March					
	April					
	May	15.4	52.6	9.3	0	22.7
1965-66	Summer (57)	79.5	5.7	4.1	1.6	9.0
	June	23.1	74.6	.5	0	1.9
	July	20.3	79.0	.1	0	.6
	August	51.7	45.1	.8	1.8	.6
1971-72	(58)	31.7	66.2	.5	.6	1.0
	Fall (30)	41.9	12.7	18.9	20.4	6.0
	September	56.4	22.7	13.8	0	7.1
	October	57.3	1.6	25.0	0	16.1
	November	49.6	2.4	26.3	4.2	17.5
1971-72	(59)	54.4	8.9	21.7	1.4	13.6
1965-66	Winter (34)	37.5	6.0	16.8	17.2	22.5
	December	55.3	.5	7.3	9.8	27.2
	January	46.7	.1	40.7	8.4	3.9
	February	77.8	0	15.6	0	6.3
1971-72	(76)	59.9	.2	21.2	6.1	12.5

Table 18. Estimated volume in percent (top row for each date) and percent frequency of occurrence (bottom row for each date) of food items in stomachs of *Cyprinodon nevadensis*, Saratoga Springs, 1971-1972. [N indicated in parenthesis.]

		Detritus	Filamentous Algae	Angiosperms	Cyprinodon nev.	Arthropods	Arachnids	Coleoptera	Diptera	Ostracods	Amphipods (Hyalella azteca)	Odonata	Tryonia	Fonticella	Other Benthos	Empty
May 71	vol.	15.4	52.6	9.3	5.0	1.0	5.0	6.2	.4	.2	5.0					
(20)	occurrence	80.0	80.0	25.0	5.0	20.0	5.0	10.0	10.0	5.0	10.0					
June		23.1	74.6	.5	1.7				.2							
(21)		85.7	100.0	4.8	14.3				4.8							
July		20.3	79.0	.1					.6							
(17)		100.0	100.0	5.9					5.9							
August		51.7	45.1	.8					.5			.1	.5	1.3		
(20)		100.0	100.0	20.0					10.0			5.0	5.0	5.0		
Sept.		56.4	22.7	13.8	2.5	.3			.5	.8	3.3					
(20)		100.0	90.0	65.0	5.0	5.0			5.0	10.0	10.0					
Oct.		57.3	1.6	25.0	6.3				9.0		.5					
(20)		100.0	50.0	40.0	20.0				20.0		5.0					
Nov.		49.6	2.4	26.3					2.1		15.4		4.2			1.0
(19)		84.2	63.2	63.2					5.0		15.0		15.0			
Dec.		55.3	.5	7.3			.3	2.2	22.3		2.4			9.8		
(12)		91.7	16.7	66.7			8.3	16.7	25.0		25.0			33.6		
Jan. 72		46.7	.1	40.7	2.3				.4		1.0	.2	8.1	.3		2.0
(39)		87.2	5.1	84.6	2.5				10.3		5.1	2.5	15.4	7.7		
Feb.		77.8		15.6	4.0				1.2	.2	.9					5.0
(25)		100.0		72.0	8.0				4.0	4.0	16.0					

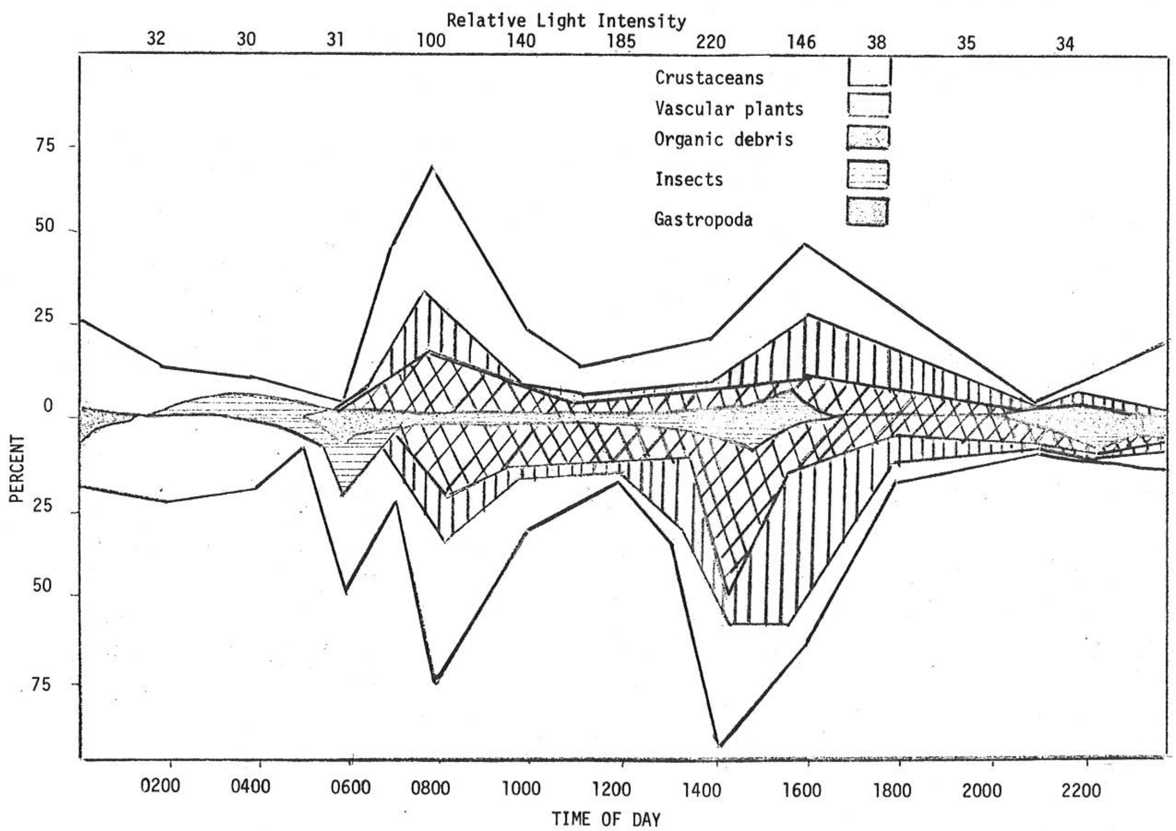

Figure 3. Diurnal feeding periodicity of *Cyprinodon nevadensis*.

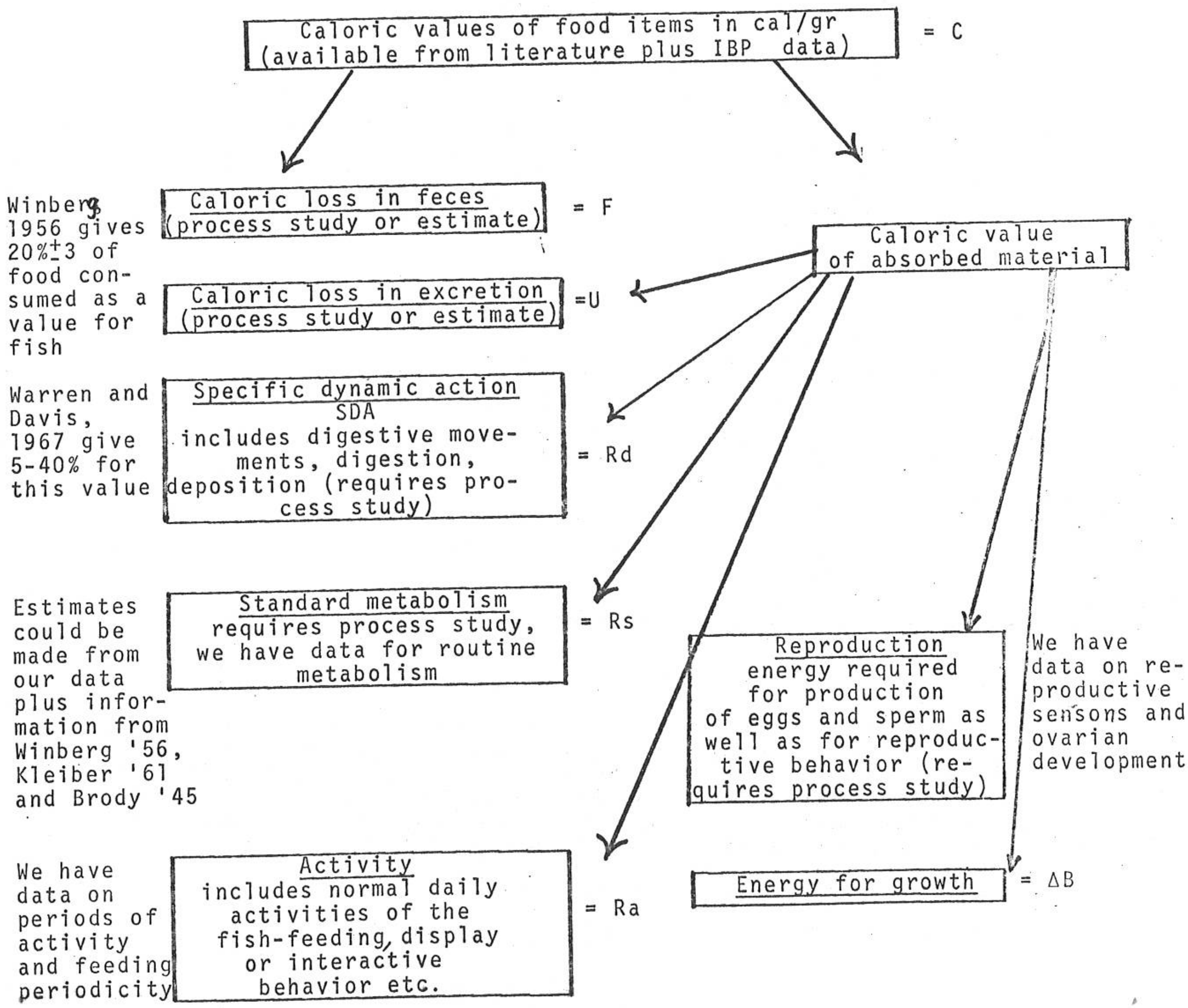

Figure 4. Energy relations in fish

Table 19. Body composition of *Cyprinodon nevadensis* from Saratoga Springs.

		PERCENT		
Water	Total Solids	Protein	Fat	Ash
80.4%	19.6%	12.83%	2.00%	7.9%
81.8	18.2	13.0.	1.56	7.2
76.7	23.3	14.67	1.24	6.2
73.6	26.4	17.09	1.33	6.5
75.8	24.2	14.94	4.07	6.7
76.0	24.0	14.20	4.20	6.8
79.7	20.3	15.02	1.58	5.8
81.5	18.5	14.74	1.78	4.9
76.6	23.4	14.59	6.76	5.9
78.2	21.8	15.87	1.67	6.1
77.6	22.4	16.60	1.99	6.6
78.7	21.3	16.55	2.71	6.7
76.2	23.7	16.18	2.31	7.6
75.5	24.5	16.51	1.87	6.7
71.2	28.8			
70.6	29.4			
74.6	25.4			
73.1	26.9			
73.2	26.8			
77.1	22.9			
75.5	24.5			
75.0	25.0			
78.0	22.0			
75.9	24.1			
72.0	28.0			
77.6	22.4			
76.2	23.8			
77.0	23.0			
74.8	25.2			
75.3	24.7			

Energy budget.

Energy requirements of the *C. nevadensis* population have been a consideration during this study. Figure 4 is presented as a first approach at organizing the data required to calculate energy requirements. Where appropriate we have indicated availability of information necessary for calculation of the parameters indicated. We also indicate those points at which data requires development or refinement. The following equations represent ways in which these relationships can be expressed. Refer to Figure 4 for definitions not given.

$$C = F + U + \Delta B + R$$

$$R = Rs + Rd + Ra$$

$$G + \frac{W_2 - W_1}{T}$$

where G = growth as increase in weight, W = weight, T = time. Energy coefficient of growth of 1st order (K) - $K = \Delta B/C$. Energy coefficient of growth of 2nd order (K_2) - $K_2 = \frac{\Delta B}{C - (F+U)}$.

Mammals

We investigated ecological distribution and relative abundance of small mammals in and adjacent to Saratoga Springs. Our records include 20 of the 25 species that Grinnell (1937) reported from the lower elevations in Death Valley. Habitats studied included open water, marsh and adjacent to the marsh, sand dunes, salt flat, rocky canyon and slope, and creosote bush desert.

Methods

Rodents were collected in snap traps (museum special and Victor rat traps) which were, whenever possible, set in lines of 60 traps, three traps per section, with stations at 50-foot intervals. Because of the small size of some habitats within or immediately adjacent to the marsh, fewer traps were occasionally used. Bats were collected by means of mist nets or by shooting.

Rodents were designated as young, subadult, or adult on the basis of size and pelage. Reproductive condition and food habits were determined by autopsy. Females with greatly enlarged uteri, visible embryos, recent placental scars, evidence of lactation, or a perforate vulva, were judged to be reproductively active. Males with enlarged or scrotal testes were considered reproductively active. Each stomach was removed and its contents placed on a glass plate marked off in one-millimeter squares. Food items were sorted into green vegetation, seeds, and insects (including other arthropods) and a visible estimate to the nearest five percent by volume was made. Comparisons with more precise volumetric measurements have shown this method to be reliable (Bradley, 1968).

Species Accounts

Collections of bats are summarized in Table 20 and rodents in Table 21. Additional observations and comments are recorded below. For a complete list of species captured refer to Tables 20 and 21.

Sylvilagus auduboni -- Desert cottontails were not collected or observed in the vicinity of Saratoga Springs. Grinnell (1937) reported their presence only near mesquite. This species may be expected in suitable habitat near the study area.

Lepus californica -- Black-tailed jackrabbits were commonly observed in creosote bush and sand dunes habitats. A male was collected from creosote bush vegetation 1.2 miles south of the spring in November. Rabbit droppings are abundant in salt grass vegetation and throughout the salt flats.

Spermophilus tereticaudus -- A total of 35 round-tailed ground squirrels were collected on the study area. All but two were trapped from the sand dunes immediately adjacent to the marsh. One of these was in reed grass in the marsh adjacent to the sand dunes. This species, which is known to hibernate and estivate, was active on the study area from December 5 through August 4 and was collected in every month except September and February (two months when effort may not have been sufficient to capture specimens even if they had been active). Many individuals were seen or heard in September. These data suggest that if hibernation and/or estivation occur at Saratoga Springs, it is not synchronous throughout the population. Grinnell (1937) considered this species rare in Death Valley and found only on loose soils covered by mesquite. They are quite common on the sand dunes at Saratoga Springs.

Ammospermophilus leucurus -- Antelope ground squirrels, which Grinnell (1937) considered common and widespread, were not found on the study area.

Perognathus formosus -- A total of 56 long-tailed pocket mice were collected from the study area. The majority (48) were collected from the rocky slopes east of Saratoga Springs. Small numbers were collected from creosote bush and marsh habitats. This species was not taken from middle October until late January.

Perognathus penicillatus -- Desert pocket mice were considered rare by Grinnell (1937) and were not found on the study area

Dipodomys deserti -- Twenty-seven desert kangaroo rats were trapped on the sand dunes adjacent to the marsh. The dependence of this species for deep sand is well known and it appears to be restricted to this habitat on the study area.

Reithrodontomys megalotis -- Fifty-three Western harvest mice were collected during the study. All but one individual was trapped from the marsh or adjacent sand dunes. This latter individual was taken in a small rocky canyon one mile southeast of the marsh.

Peromyscus crinitus -- Canyon mice were the most common mammal on the area with a total of 94 trapped. They were most abundant in the marsh and on rocky slopes adjacent to the marsh.

Neotoma lepida -- Sixty-three desert wood rats were collected from marsh, adjacent sand dunes, and rocky slopes.

Cantis latrans -- A coyote was observed on January 4 about one mile southeast of Saratoga Springs.

Vulpes macrotis -- A desert kit fox was observed near the marsh at dusk on July 5 and on December 17. Tracks and frequent reports of fox sightings by visitors indicate that this area is used heavily by one or more individuals.

Taxidea taxus -- Grinnell (1937) found badgers to be uncommon at Death Valley and we could obtain no evidence of their occurrence on the study area.

Lynx rufus -- Bobcats were not found on the study area, but probably occur in the nearby mountains and may visit Saratoga Springs infrequently.

Ovis canadensis -- No sign of desert sheep was found on the study area.

Table 20. The number of bats netted per mist net night (in parentheses) and total number of bats collected at Saratoga Springs, Death Valley National Monument. The number of nights netted is given below each month.

Species	Nov. (1)	Dec. (1)	Mar. (3)	Apr. (4)	May (1)	July (2)	Aug. (1)	Total Period (13)
Antrozous pallidus	1 (1.0)	--	5 (1.7)	17 (4.2)	4 (4.0)	9 (4.5)	--	36 (12.8)
Pipistrellus hesperus	3 (3.0)	--	3 (1.0)	5 (1.2)	2 (2.0)	6 (3.0)	--	19 (1.5)
Tadarida brasiliensis	--	--	1 (0.3)	5 (1.2)	--	4 (2.0)	--	10 (0.8)
Myotis californicus	--	--	1 (0.3)	--	--	--	2 (2.0)	3 (0.2)
Lasionycteris noctivagans	1 (1.0)	--	--	--	--	--	--	1 (0.1)
Lasiurus cinerea	1 (1.0)	--	--	--	--	---	--	1 (0.1)
TOTAL	6 (6.0)	--	10 (3.3)	27 (7.0)	6 (6.0)	19 (9.5)	2 (2.0)	70 (5.4)

Table 21. The numbers of rodents trapped in different habitats at Saratoga Springs, Death Valley National Monument. The number of trapnights in each habitat is given in parenthesis.

Species	Creosote Bush (1079)	Salt Flat (417)	Rocky Canyon and Slope (1075)	Sand Dunes (620)	Marsh (1131)	Total for all Habitats (4322)
Spermophilus tereticaudus	1	-	-	33	1	35
Perognathus formosus	5	-	48	-	3	56
Dipodomys merriami	5	-	-	2	-	7
Dipodomys deserti	-	-	-	27	-	27
Onychomys torridus	1	-	-	-	-	1
Reithrodontomys megalotis	-	-	1	5	47	53
Peromyscus crinitus	7	2	48	-	37	94
Peromyscus eremicus	-	-	4	-	3	7
Peromyscus maniculatus	-	3	5	2	8	18
Neotoma lepida	-	-	19	17	27	63
TOTAL	19	5	125	86	126	361

Ecological Distribution and Relative Abundance

Two species of bats, *Lasionycteris noctivagans* and *Lasiurus cinerea*, are present in the area only during migration. In addition to the one recorded in Table 20, two *Lasionycteris noctivagans* were observed at dusk on March 7 during the spring migration. *Myotis californicus* was found in low numbers, although it is common to abundant in other desert areas in southern California and Nevada. *Tadarida brasiliensis* was netted in moderate numbers during the spring and summer. It's migratory status is still in question for southern California. The two most abundant species, *Pipistrellus hesperus* and *Antrozous pallidus* were active in spring, summer and fall. Both species display year-round activity in nearby southern Nevada (O'Farrell and Bradley, 1970).

Number of rodents and relative abundance in the major habitats are given in Table 21 and Figure 3. These data indicate that *Peromyscus crinitus*, *Neotoma lepida*, *Perognathus formosus*, *Reithrodontomys megalotis*, *Spermophilus tereticaudus*, and *Dipodomys deserti* are common to abundant in suitable habitats.

Of the several species trapped in the creosote bush habitat, none appear to be abundant, although *Dipodomys merriami*, *Perognathus formosus*, *Peromyscus crinitus*, and to a lesser extent *Onychomys torridus* and *Spermophilus tereticaudus*, are found there.

Two species, *Peromyscus maniculatus* and *Peromyscus crinitus*, were taken from the salt flat near Saratoga springs in 117 trap nights during early November. These traps were placed about one-half mile from the eastern edge of the flat. Dispersal from the edge of the salt flat could account for the sparse populations of deer mice encountered in the fall. To further sample rodent populations in the salt flat, 300 trap nights were expended in February, 1967. No rodents were collected. Grinnell (1937) indicated the possibility that the Borax flat may be devoid of mammals. The salt flat near Saratoga Springs is at least crossed frequently by rabbits as indicated by the abundant droppings there. Our November records suggest that some rodents may disperse across this area and additional work is needed to determine whether or not resident populations exist.

On the rocky slopes and small canyons immediately east of Saratoga Springs, *Peromyscus crinitus* and *Perognathus formosus* reach their greatest abundance and *Neotoma lepida* is common.

The sand dunes contain abundant populations of *Spermophilus tereticaudus* and *Dipodomys deserti*. The latter species was not taken in the adjacent marsh area and the former was taken there only rarely. Individual round-tailed ground squirrels living in the sand dunes adjacent to the marsh probably wander into the marsh environment only briefly during the course of their daily movements. *Neotoma lepida* and *Reithrodonotomys megalotis* occur commonly in both sand dunes and marsh habitats, although the latter reaches its greatest abundance in the marsh. *Peromyscus crinitus*, the second most abundant rodent in the marsh, was not taken in the adjacent sand dunes. The same situation was observed for *Peromyscus eremicus* and *Perognathus formosus*. The marsh and sand dunes habitats thus show marked differences in species composition and abundance but at the same time share certain species.

A further measure of the suitability of habitats for rodent populations is shown in Figure 4. The rodent biomass (weight) for each community was obtained by totaling for all species the average number trapped per 100 trap nights multiplied by their respective average weights. With the exception of the salt flat, there is not a major difference in the total number of species trapped from the different habitats. However, there is a range of eight times in the numbers of individuals collected per equal trapping effort. Rocky slope, sand dunes and marsh contain many more individuals than creosote bush and salt flat habitats. Rodent biomass is three times higher in the sand dunes than in the rocky slopes and marsh. and these three habitats all contain much larger biomasses than the other habitats. The size of rodent populations generally can be correlated with the availability of food, shelter, and water. Plant cover is much higher in sand dunes and marsh areas than in the other habitats. Although there is not a major difference between vegetative cover in the rocky slope and lower desert habitats, this is compensated for by the great increase in shelter provided by large rocks and crevices on the rocky slopes. Sand dunes and marsh have not only an abundance of cover but, because of their spatial relationships, produce increased environmental heterogeneity or "edge effect". The major difference in biomass between these two communities is due to the sizable populations of two large species, *Spermophilus tereticaudus* and *Dipodomys deserti*, on the sand dunes.

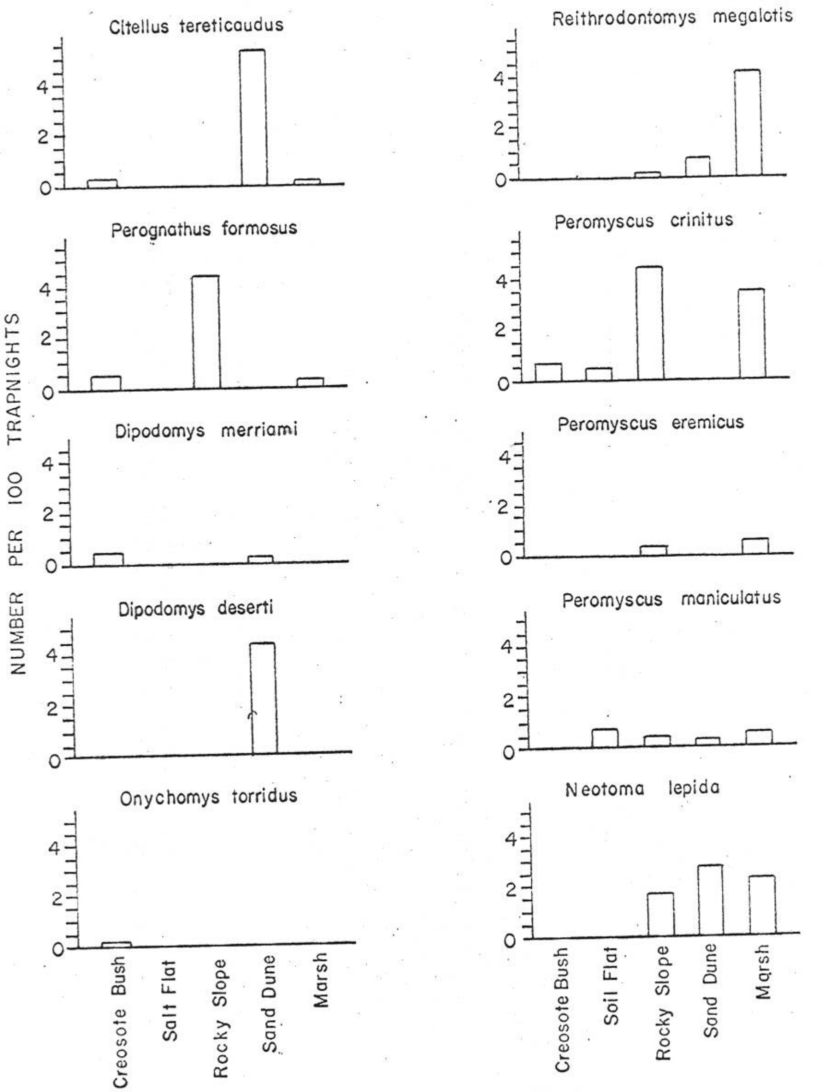

Figure 3. Relative abundance (number captured per 100 trap nights) of rodents in five habitats.

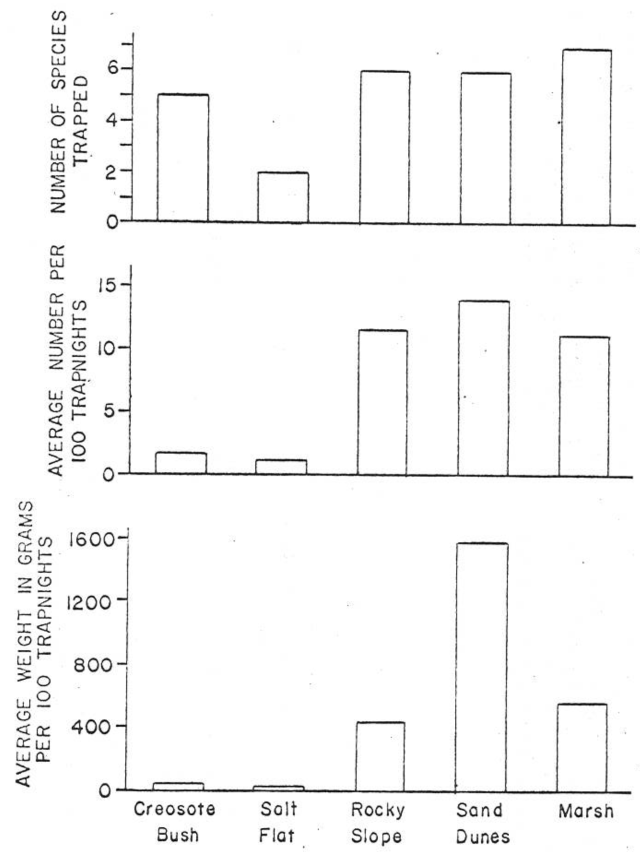

Figure 4. Number of species captured, average number, and average biomass per 100 trap nights of rodents in five habitats.

Seasonal Activity and Relative Abundance

The seasonal occurrence of bats has been discussed. The numbers of the more common rodents trapped per 100 trap nights for the four seasons are presented in Figure 5. Trapping success for each species is based on records from suitable habitats only. This permits the best possible assessment of seasonal activity and population denstiy. There is an indication for all species of an increase in population density by recruitment of young during the spring or summer months, followed by a decline in the fall and/or winter. *Perognathus formosus* is presumably in hibernation for most of the fall and part of the winter. Some *Spermophilus tereticaudus* appear to remain active, at least for brief periods during fall and winter. The four other species are known to be active the year around and the numbers trapped probably more nearly represent their seasonal abundance. On the basis of these limited data, it would appear that the seasonal density varies to a far greater extent in *Dipodomys deserti* than in the other three species, which are active throughout the year.

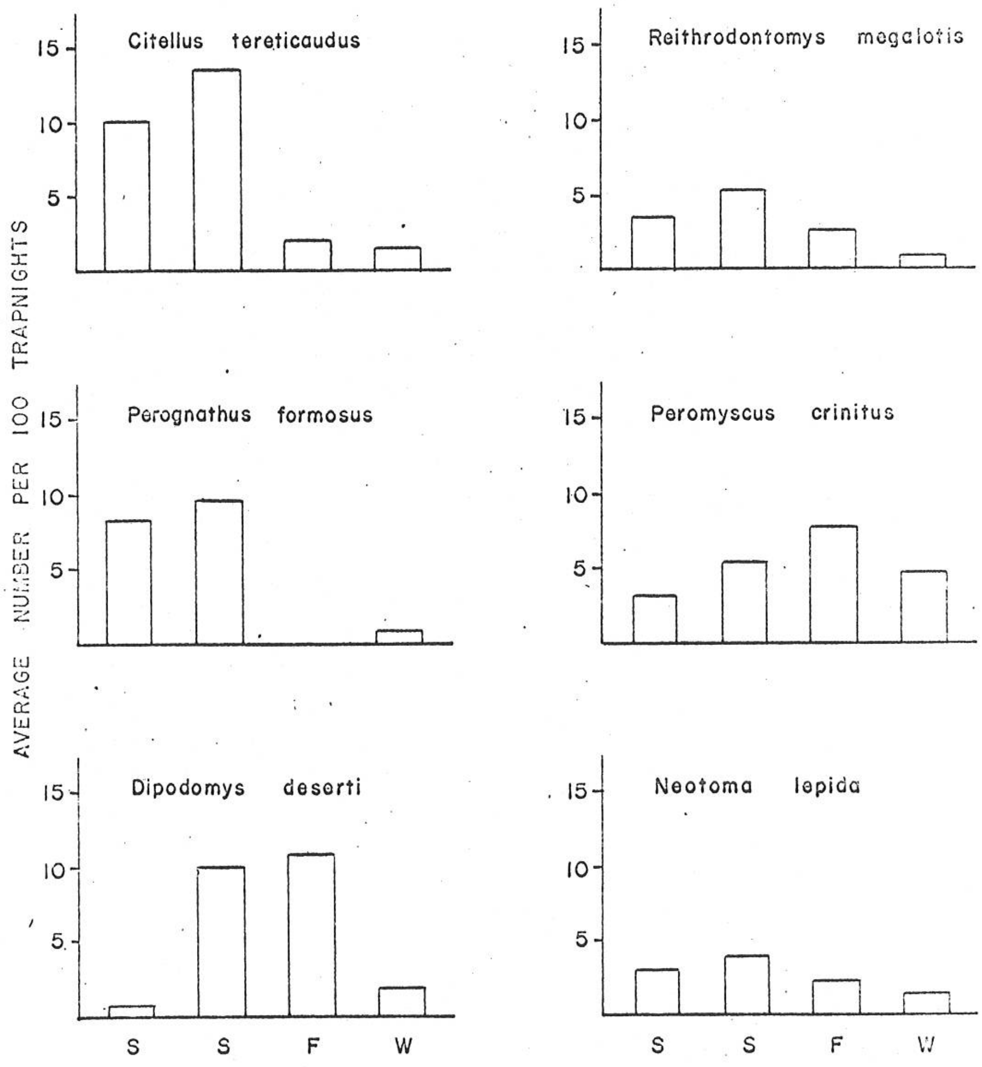

Figure 5. Relative abundance (number per 100 trap nights) of the more abundant species of rodents from suitable habitats for the four seasons.

Population Structure

Individuals of the more common rodent species were designated young, subadult, or adult. The percentage of each of these age categories in the total sample for the four seasons of the year is presented in Figure 6. Sample size is small in *Dipodomys deserti* for the spring and summer. The scarcity of young and subadults of *Reithrodontomys megalotis* may be attributable to difficulties of trapping small individuals. Changes in population structure are apparent for most species. These changes illustrate the recruitment of young and subadults, primarily in late spring, summer and fall. Winter populations consist almost exclusively of adults.

Reproduction

Seasonal reproductive activity for the common rodent species is shown in Figure 7. Although sample sizes are small, there is a clear indication of reproduction occurring in the spring and summer for all species except *Perognathus formosus*, which was reproductively active only in the spring. There is some indication that *Dipodomys deserti* may reproduce in the early fall and that two other species, *Neotoma lepida* and *Spermophilus tereticaudus*, are reproductively active from winter through summer. Reproductive activity in *Reithrodontomys megalotis*, and to a lesser extent in *Peromyscus crinitus*, occurs in all seasons, although it is greatly reduced in the fall months. On the basis of those species on which data are avialable, the reproductive peak for rodents is in the spring, but the season may be earlier or more prolonged in all species except *Perognathus formosus*.

Food Habits

An analysis by seasons of the stomachs of the more abundant species of rodents is given in Figure 8. Green vegetation has a high frequency and high volume for all species throughout the year. The dependence of *Neotoma lepida* upon green vegetation for its water requirements is well known (Schmidt-Nielsen, 1964). Species of *Perognathus* and *Dipodomys* are believed to be mainly seed eaters (Chew and Butterworth, 1964). Species of *Peromyscus* are usually considered to be primarily seed eaters, although they do ingest considerable green vegetation and insects. Ground squirrels are known to be highly omniverous. The high utilization of green vegetation is evident even in seasons when it is not abundant. *Dipodomys deserti*, *Spermophilus tereticaudus* and *Reithrodontomys megalotis* were trapped either in or immediately adjacent to the marsh, where more green vegetation is available than in the surrounding desert. The only species not abundant near the marsh was *Perognathus formosus*.

It has been shown for several rodents in the desert areas of southern California and Nevada that the reproductive season occurs when green vegetation is seasonally abundant (Chew and Butterworth, 1964; Bradley and Mauer, 1965). In desert areas increased utilization of green vegetation or other succulent foods may be necessary for a successful reproductive season (Beatley, 1969). Similarly, rodent populations from more mesic habitats, such as along rivers and desert marshes, may have a higher reproductive success when compared with populations of the same species from surround desert habitats.

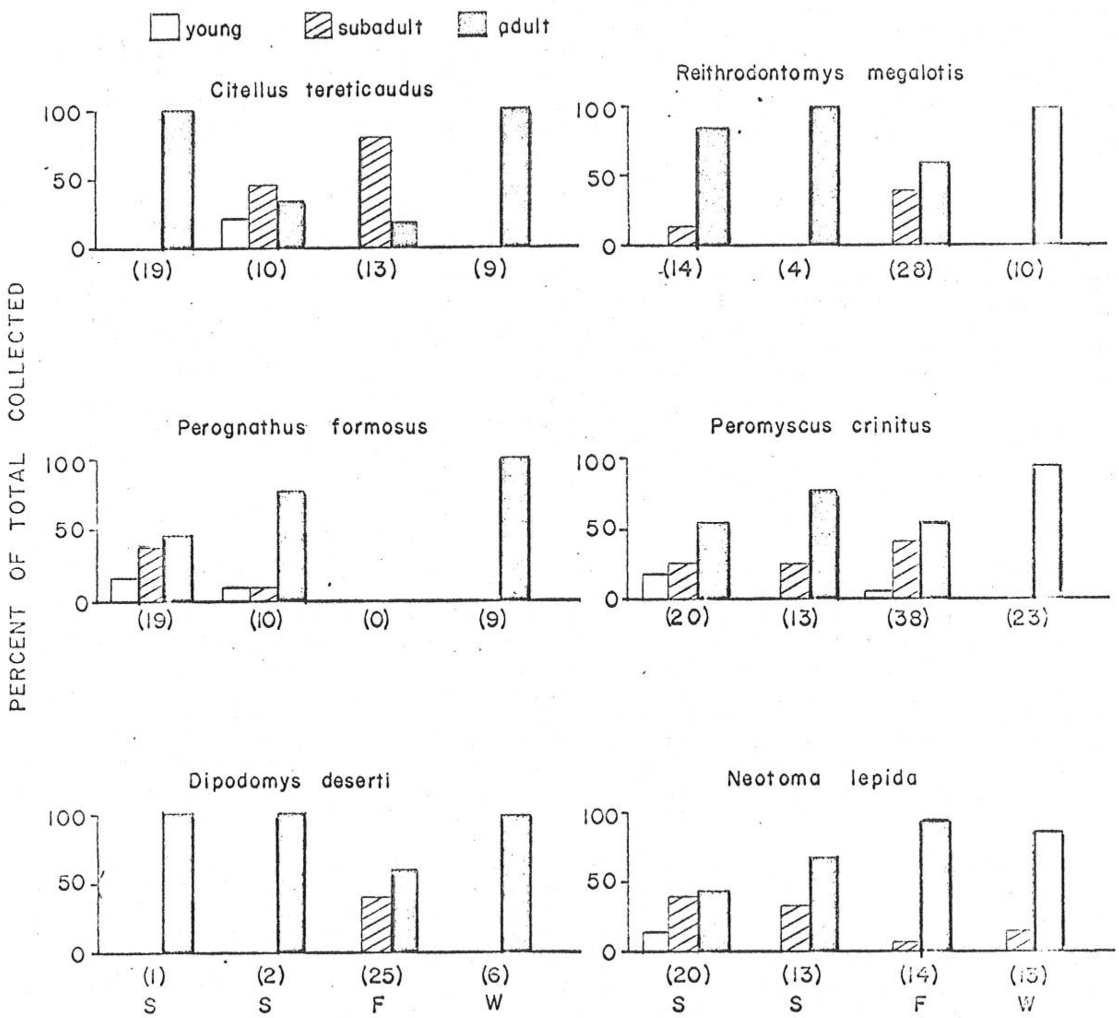

Figure 6. The percent of young, subadult, and adult individuals trapped during each of the four seasons. Total numbers of individuals examined during each season are given in parentheses.

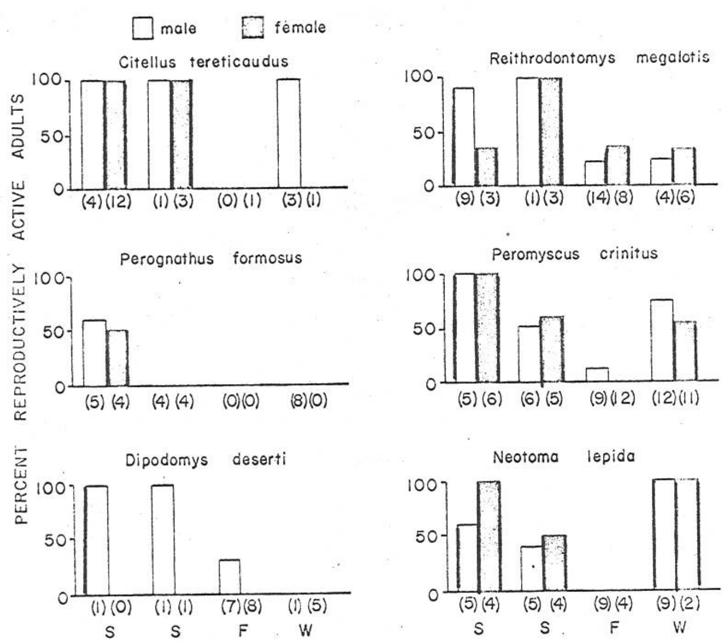

Figure 7. Percent of reproductively active adult rodents captured during each of the four seasons. Total numbers of adults examined for each season are given in parentheses.

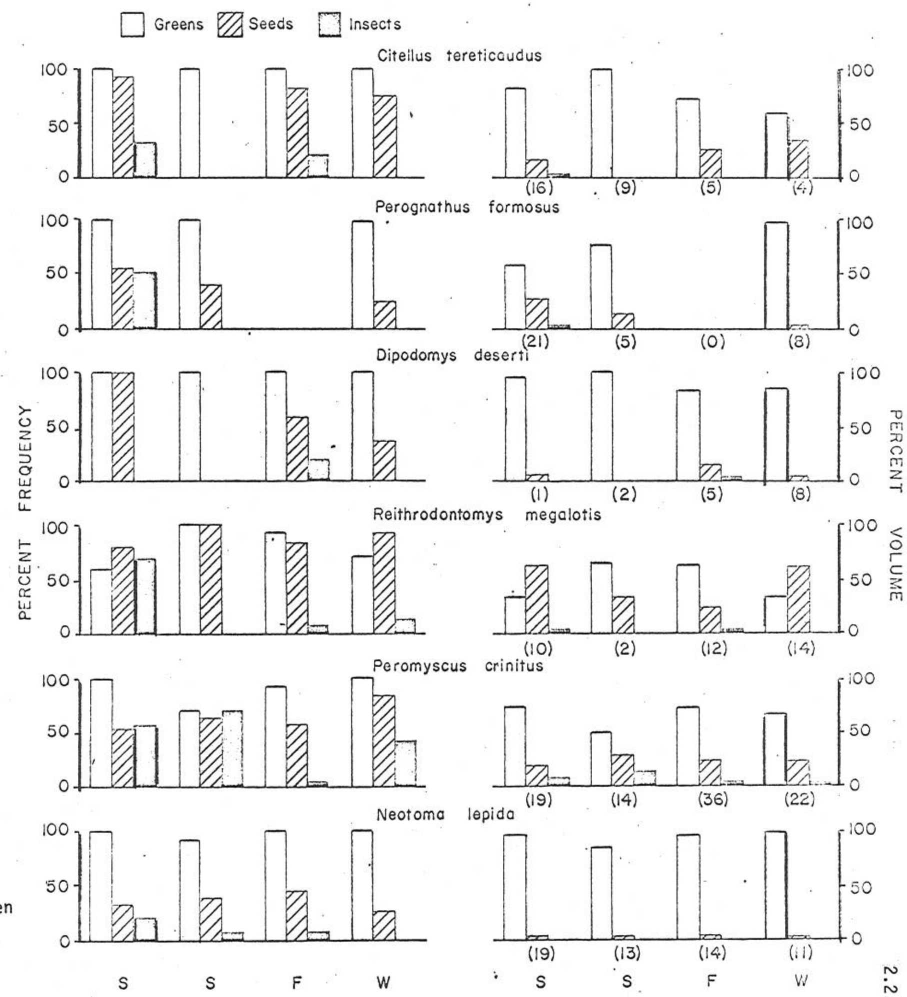

Figure 8. Frequency of occurrence and percent volume of green vegetation, seeds and insects in the seasonal diet of rodents.

Summary

Data on ecological distribution, relative and seasonal abundance, population structure, reproduction, and food habits are presented. Bats were collected in mist nets and observations were made of the larger mammalian species.

Of the six species of bats collected, two species, *Antrozous pallidus* and *Pipistrellus hesperus*, are abundant and active for most of the year. Ten species of rodents, all of which are found in desert habitats, were collected. Several of these, including *Spermophilus tereticaudus, Dipodomys deserti, Reithrodontomys megalotis,* and *Neotoma lepida,* had their greatest relative abundance within the more mesic sand dunes or marsh habitats. It appears that most species collected during this study are able to maintain maximum population density in the more mesic habitats where water, food (especially green vegetation) and shelter are more available. There is some evidence to suggest a more prolonged reproductive season correlated with increased utilization of green vegetation as food. Further investigations comparing reproduction and food habits between arid and mesic populations would be of value.

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Birds

Desert oases are especially inviting for the bird watcher since not only a wide variety but large numbers of birds are attracted to these habitats. The avifauna of Death Valley has received considerable attention and has been reported on by Fisher (1893), Grinnell (1919, 1923, 1934), Gilman (1935), Grinnell and Miller (1944), Wauer (1962), and others. Wauer (1962) lists a total of 232 species which have been reported at sea level or below in Death Valley.

The present study includes monthly observations of the avifauna of Saratoga Springs. Observations were made of 90 species of birds, five of which have not been reported from sea level or below in Death Valley. While Saratoga Springs is not below sea level, it is low enough that we suspect these birds could, and probably do, reach that level.

Methods

Saratoga Springs was visited at monthly intervals from October 9, 1965, through November 14, 1966. Observations and collections were made at random by various individuals. Rather complete observations of the avifauna were made on 39 days. These later observations include a total of 20 standard strip censuses during which a standard course, including all habitats, was covered. Due to the variety of habitats and the difficulty of observations in some portions of the marsh, a statistical analysis of this standard census was not attempted.

A total of 66 specimens of 44 species were collected and are deposited in the Biology Museum, Nevada Southern University.

Species Accounts

The following is a complete list of species of birds found at Saratoga Springs. Nomenclature is based on the fifth edition of the A.O.U. Checklist.

Podiceps caspicus. Eared Grebe -- A lone, apparently non-breeding individual was observed on open water on July 6 and 7.

Aechmophorus occidentalis. Western Grebe -- One specimen was collected on November 6, 1965, and single birds were observed on open water on May 7, August 5, and September 17.

Podilymbus podiceps. Pied-billed Grebe -- One male was collected on January 1. (1)

Ardea herodias. Great Blue Heron -- Observations of lone individuals in the marsh area (1) were made on March 25, April 2 and July 5-9.

Butorides virescens. Green Heron -- A single bird was regularly observed from November 7 through March 25. Two were observed together in the marsh on January 2.

Leucophorys thula. Snowy Egret -- A group of four was observed on July 7 and lone birds (2) on August 5 and 17. Two birds were observed on September 17.

Branta canadensis. Canada Goose -- A flock of approximately 70 individuals was observed (3) on open water on October 9.

Dendrocygna bicolor. Fulvous Tree Duck -- One specimen observed at close range swimming in open water on October 30 constitutes the first record of this species for Death Valley.

Anas platyrhynchos. Mallard -- Two specimens were observed regularly from February 13 (2)
through March 10, and a group of 4-5 were observed on August 4-5 and September 17. One was
collected on August 4, 1966.

Anas strepera. Gadwall -- Small groups of 1 to 6 individuals were observed February 13
through May 7. A flock of approximately 30 birds occupied the marsh on September 17.

Anas carolinensis. Green-winged Teal -- Observations of from two to twelve individuals (3)
were made from March 7 through April 8. Five were observed on August 17 and a lone individual
on September 17.

Anas discors. Blue-winged Teal -- Observations of one to three individuals were made (2)
from January 25 through March 26. A lone individual was observed on July 6.

Anas cyanoptera. Cinnamon Teal -- Two males were collected from open water in the
marsh on January 1, 1966, and a small group of from two to eight birds was observed regularly
until March 25. On this date, a large flock of 23 individuals occupied the open water at
the north end of the marsh. The last observation was of six seen on May 7.

Mareca americana. American Wideon -- Two were collected on November 11, 1965, and (2)
small groups of two to eight individuals were observed from November 6 until March 5. Two
individuals were observed on September 17.

Spatual clypeata. Shoveler -- A female was collected on January 1, 1966, and one or
two individuals were regularly observed from that date until July 9.

Aythya americana. Redhead -- Observations of one to three individuals were made from
March 5 until July 9.

Aythya valisineria. Canvasback -- A lone individual was observed swimming in the open (2)
water of the marsh on March 5.

Bucephala clangula. Common Goldeneye -- A single bird was observed in the marsh on
March 25.

Bucephala albeola. Bufflehead -- Small groups of two to four individuals were ob-
served on March 25 through May 7.

Oxyura jamaicensis. Ruddy Duck -- Observations were made of one to three individuals (3)
swimming in the marsh from March 7 through August 4. There was no evidence of breeding.

Mergus serrator. Red-breasted Merganser -- A male was collected on April 2, 1966, (1)
from a group of 21 birds occupying the marsh. A single non-breeder was observed regularly
from that date until August 14.

Cathartes aura. Turkey Vulture -- One bird was seen flying over the study area on
March 25.

Accipiter cooperi. Cooper Hawk -- A lone individual was observed flying near the area on (1)
October 10.

Buteo jamaicensis. Red-tailed Hawk -- This species was observed on numerous occasions (2)
soaring overhead in the late summer, fall and winter months.

Falco sparverius. Sparrow Hawk -- An individual was flushed from the marsh on September 17.

Rallus limicola. Virginia Rail -- A male was collected from marsh vegetation on March 5,
1966. This constitutes the second record for Death Valley from the lower elevations (Wauer, 1962).
Lone individuals were sighted regularly from that date until April 8, with additional observa-
tiosn of lone birds for July 7, August 5 and September 17.

Porzana carolina. Sora -- A male was collected in the marsh on March 25.

Fulica americana. American Coot -- This species was regularly observed utilizing the marsh area and may be considered a year-round resident. The resident group varied from about 30 to 50 individuals from September through March. During the remainder of the year, an average of six to twelve birds were observed each day. It is possible that Coots breed here, although no young were seen. Five were collected during the year. (3)

Charadrius alexandrinus. Snowy Plover -- Wauer (1962) reports a single observation of two individuals at Salt Creek in March. Our observation of four individuals on the edge of standing water on April 8 constitutes the second record for Death Valley.

Charadrius vociferus. Killdeer -- Observations were regularly made of one to three individuals from June 2 through September 17. (3)

Capella gallinago. Common Snipe -- One was collected on November 6, 1965, and observations were made of one to three individuals in the marsh during the months of January, March, April, and August. (1)

Numenius americanus. Long-billed Curlew -- Wauer (1962) reported observations of two or three individuals at Furnace Creek Ranch from August 18 to September 24, 1960. Our record of an individual sighted at close range at the main spring on August 10, 1966, constitutes the second locality record for Death Valley.

Actitis macularia. Spotted Sandpiper -- A group of four individuals was observed at the edge of the marsh on July 7 and 8. (2)

Limnodromus sp. Dowitcher -- Wauer (1962) observed dowitchers which he believed to be *L. scolopaceus* in March and again in September at Furnace Creek Ranch. Lone dowitchers observed on July 11 and August 4, wading at the edge of open water near the marsh, are probably also this species.

Recurvirostra americana. American Avocet -- A female was collected on July 5, 1966, and observations were made of lone individuals on November 25 and August 4. A flock of seven was sighted at the edge of the marsh on July 7. (2)

Himantopus mexicanus. Black-necked Stilt -- One was collected on August 4, 1966, from a group of four birds. Additional observations were made of single birds on April 8 and July 7. On July 8 a flock of 29 individuals was feeding at the edge of the marsh and a smaller flock of eight was sighted on August 5.

Larus delawareasis. Ring-billed Gull -- Gulls were sighted flying overhead on several occasions. The only positive identification is of four individuals of this species standing at the edge of the marsh on April 3. (1)

Zenaidura macroura. Mourning Dove -- Wauer (1962) reports this species as abundant during the spring migration, but does not include this species on his list of breeding birds in Death Valley. Our observations indicate that it is common to abundant from early April to early October and may breed here. (2)

Geococcyx californianus. Roadrunner -- A lone individual was observed in adjacent desert vegetation on January 1.

Asio otus. Long-eared Owl -- A specimen in mummified condition found in the mine on the hill immediately east of Saratoga Springs on November 14, 1966, constitutes the first record of this species from the lower elevations in Death Valley.

Phalaenoptilus nuttallii. Poor-Will -- Lone individuals were observed near the study area on March 7 and April 8.

Chordeiles acutipennis. Lesser Nighthawk -- Lone individuals were observed on June 1 and November 7 and 10, 1966, and four to ten were observed during July. Two were collected on July 6, 1966. (2)

Aeronautes saxatalis. White-throated Swift -- A male and female were collected from a group of five on January 1, 1966. Two or three individuals were observed on several other occasions in January. Additional observations were of ten individuals on March 5 and a lone individual on July 8 and 9. (2)

Calypte anna. Anna Hummingbird -- Wauer (1962) does not list this species as occurring in Death Valley. A female collected on March 10, 1966, from near the main spring constitutes the first record from the lower elevations in Death Valley.

Colaptes cafer. Red-shafted Flicker -- One was collected on October 9, 1965, and two additional specimens were collected on November 7, 1965. Observations of one to four individuals were made regularly from October through early April. The latest record for the year was of an individual found dead on June 1, 1966, in common reed grass near the main spring.

Tyrannus verticalis. Western Kingbird -- A male was collected from tamarisk on March 25, 1966, and two individuals were observed perching in tamarisk on June 1. (2)

Myiarchus cinerascens. Ash-throated Flycatcher -- Wauer (1962) does not include this species on his checklist for Death Valley, but does mention it as a summer visitant. One was collected on August 3, 1966, and two were seen on July 8 and August 5.

Sayornis nigricans. Black Phoebe -- Two females were collected from tamarisk near the main spring on March 10, 1966. Observations include lone individuals on March 8 and 25 and two individuals on September 17. (1)

Sayornis sayi. Say Phoebe -- One was collected on November 6, 1965, and observations of lone individuals were made on March 7 and 10.

Tachycineta thalassima. Violet-green Swallow - A lone individual was observed on September 17, 1966. (1)

Iridoprocne bicolor. Tree Swallow -- Two individuals were observed on September 17, 1966.

Stelgidopteryx ruficollis. Rough-winged Swallow -- A lone individual was observed on September 17, 1966.

Hirundo rustica. Barn Swallow -- A group of approximately 11 individuals was observed on September 17. (3)

Pterochelidon pyrrhonota. Cliff Swallow -- Three were observed on September 17.

Corvus corax. Common Raven -- One was collected on December 4, 1965. Observations were made regularly of one or two individuals for the period September through early June. (3)

Telmatodytes palustris. Long-billed Marsh Wren -- Wauer (1962) reports this species as commonly remaining in Death Valley throughout the winter. All of our records occurred in March, when this species was abundant (up to 25 sighted or heard per day). Males were collected on March 8 and 9, 1966. Due to the secretive habits of this species, it is probably passed up by observers not familiar with it's song. Species may be a resident at Saratoga Springs.

Mimus polyglottos. Mockingbird -- One was observed in a tamarisk thicket on July 5.

Turdus migratorius. Robin -- Two were collected from a total of five individuals ob- (3)
served on January 1, 1966. Observations were made of one or two individuals from the above date until early May.

Ixoreus naevius. Varied Thrush -- A male was collected from tamarisk on November 7, 1965.

Regulus calendula. Ruby-crowned Kinglet -- One was collected on November 6, 1965, and three on December 4, 1965. Observations were made of one or two individuals per day from either tamarisk or common reed grass from November until mid-March.

Anthus spinoletta. Water Pipit -- A male was collected from thick common reed grass (1)
on March 25, 1966. Two other individuals were observed on the same date in similar habitat. Lone individuals were observed on January 2 and March 8.

Bombycilla cedrorum. Cedar Waxwing -- A male was collected from near the main spring from common reed grass on November 7, 1965. Another was observed near the spring on January 1.

Phainopepla nitens. Phainopepla -- A female was collected on March 10, 1966.

Lanius codovicianus. Loggerhead Shrike -- One to three individuals were observed from early June through the middle of September.

Sturnus vulgaris. Starling -- One was collected on November 6, 1965. A flock of (2)
approximately 75 was in the marsh on November 11 and three to four individuals were observed monthly until March 7.

Vireo solitarius. Solitary Vireo -- A male (*V. s. cassini*) was collected on November 6, 1965.

Parula americana. Parula Warbler -- A male collected on the extremely early date of January 1, 1966, is the first record for Death Valley and appears to be the first California record away from coastal regions.

Dendrocia petechia. Yellow Warbler -- One was observed in a tamarisk thicket on September 17.

Dendrocia coronata. Myrtle Warbler -- One was collected on March 5, 1966.

Dendrocia auduboni. Audubon Warbler -- Five specimens were collected in November and (3)
March. Observations were made of one to twenty individuals from September through June, indicating that this is the most abundant warbler on the study area.

Geothlypis trichas. Yellowthroat -- Observations were made of lone individuals in (2)
tamarisk on March 8 and 10, 1966.

Wilsonia pusilla. Wilson Warbler -- A lone individual was sighted in tamarisk on August 17,
and large numbers were present in dense cover of common reed grass and tamarisk near the main (3)
spring on September 17.

Setophaga ruticilla. American Redstart -- A male was collected on September 18, 1966.

Passer domesticus. House Sparrow -- Two were observed in thick, common reed grass on (3)
April 8 and a total of 16 individuals was sighted on May 7 in similar habitat.

Sturnella neglecta. Western Meadowlark -- One was collected on November 6, 1966, and (1)
lone individuals were observed on February 13, March 5, and September 17.

Xanthocephalus xanthocephalus. Yellow-headed Blackbird -- Observations were made of a lone male on May 7 and a pair on September 17.

Agelaius phoeniceus. Redwinged Blackbird -- A male was collected on November 6, 1965, from a group of four individuals. Small numbers were observed in all months except December and January. A flock of 11 individuals on August 5 was the largest number observed on the study area. (3)

Euphagus cyanocephalus. Brewer Blackbird -- A male was collected on November 7. Observation were made of usually 10 or more individuals per day from August through March. The largest number observed was a flock of approximately 55 individuals on December 4. (2)

Molothrus ater. Brown-headed Cowbird -- A lone individual was observed on August 17.

Piranga ludoviciana. Western Tanager -- Two individuals were observed in tamarisk on the unexpectedly late date at this low an elevation of July 11. (1)

Carpodacus mexicanus. House Finch -- Observations were made of seven individuals on March 7 and of three individuals on March 8 and 10.

Spinus psaltria. Lesser Goldfinch -- Two were observed in tamarisk near the main spring on September 17.

Passerculus sandwichensis. Savannah Sparrow -- A pair was collected on March 25, 1962. One to four individuals were observed regularly in March and a lone individual was sighted on September 17.

Chondestes grammacus. Lark Sparrow -- A lone individual was observed on August 17.

Junco oreganus. Oregon Junco -- A lone bird was observed in tamarisk near the main spring in November.

Spizella breweri. Brewer Sparrow -- A male was collected on March 25, 1966,in desert vegetation about a mile northeast of the spring. (3)

Zonotrichia leucophrys. White-crowned Sparrow -- Individuals were collected on November 3, 1965, and March 5 and 10, 1966. Observations were regularly made of several individuals from September through March. (3)

Melospiza lincolnii. Lincoln Sparrow -- A male was collected on January 2, 1966. Observations were made on one to four individuals regularly through March.

Melospiza georgiana. Swamp Sparrow -- A lone individual easily observed and positively identified in a tamarisk tree near the main spring on March 8, 1966, is the first record of this species for Death Valley.

Melospiza melodia. Song Sparrow -- Observations were made of a lone individual in a tamarisk on March 8 and of four individuals in both tamarisk and desert shrub adjacent to the marsh on March 10. (2)

Numbers in margin of preceding list indicate rare (1), common (2), abundant (3).

Additional species observed at Saratoga Springs 1971-72 are listed below:

Chen hyperborea	Snow Goose
Totanus melanoleucus	Greater Yellowlegs
Lobipes lobatus	Northern Phalarope
Larus californicus	California Gull
Nyctea scandiaca	Snowy Owl
Megacergl alegon	Belted Kingfisher
Riparia riparia	Bank Swallow
Regulus satropa	Golden-Crowned Kinglet

Table 22. The average number of species and individuals observed per day at Saratoga Springs, Death Valley National Monument, based on 39 observation days.

Month	Average No. Species	Average No. Individuals
1965		
October*	9	115
November	20	112
December	13	162
1966		
January	15	130
February	13	72
March	23	102
April	17	58
May	15	57
June	13	23
July	16	72
August	19	108
September	28	145
Yearly Average	17	96

* Insufficient observations at the beginning of the study.

Analysis of Avifauna

Of the 232 species listed by Wauer (1962), as recorded from Death Valley during the period 1893 until 1962, we have records of 85 from Saratoga Springs based on a one-year study. In addition, five species are added to tha avifauna of Death Valley. Three species, Long-eared Owl, Anna Hummingbird and Parula Warbler, are represented by specimens. Positively identified sight records of species new for Death Valley include the Fulvous Tree Duck and Swamp Sparrow. During the study, unidentified species, including especially gulls, flycatchers, and swallows, were observed. Continued observations and collection at Saratoga Springs should result in numerous additions to this list.

A tabulation of the average number of species and individuals per observation day for monthly periods is given in Table 22. The month of October is not representative since the low number of species observed is based on inadequate observations for that month. The fewest numbers of individuals were observed in the summer months of April, May, and June, and probably attributable to the intense heat during these months. With the exception of February, with only one adequate observation day, these are the only months for which our estimate of individuals departs drastically from the yearly average. These data would strongly suggest that there is a heavy utilization of the study area by birds over much of the year.

Wauer (1962) has analyzed the seasonal changes in the avifauna of Death Valley. Our data, based on only one year of study, is not adequate to fully determine seasonal changes at Saratoga Springs. Where our data on a species is inadequate to determine seasonal status we have relied to some extent on Wauer's analyses.

Of the 90 species recorded from Saratoga Springs, only two, American Coot and Common Raven, have been recorded throughout the year. We consider these two, and probably the Roadrunner, Red-tailed Hawk, and possibly Long-billed Marsh Wren, year-round residents. Wauer (1962) includes these species, except the Long-billed Marsh Wren, among a total of 15 species of year-round residents in Death Valley. Further study may supplement the list for Saratoga Springs.

Transients and winter visitants appear at Saratoga Springs in late August or September. Species found on this area throughout the winter (September through April) include Mallard, Gadwall, Green-winged Teal, Ruddy Duck, Virginia Rail, Common Snipe, Red-shafted Flicker, Audubon Warbler, and Red-winged Blackbird. Winter visitants present on the study area for lesser periods of time include Green Heron, Blue-winged Teal, Cinnamon Teal, American Wigeon Shoveler, White-throated Swift, Western Flycatcher, Long-billed Marsh Wren, Robin, Ruby-crowned Kinglet, Water Pipit, Starling, Western Meadowlark, Brewer Blackbird, Savannah Sparrow, Oregon Junco, White-crowned Sparrow, and Lincoln Sparrow.

By the middle of March, many of the winter visitants move out and the first of the spring migrants appear on the study area. These include the Eared Grebe, Great Blue Heron, Snowy Egret, Cinnamon Teal, Redhead, Canvasback, Bufflehead, Common Goldeneye, Sora, Common Snipe, Black-necked Stilt, Mourning Dove, Myrtle Warbler, Yellowthroat, Red-winged Blackbird, House Finch, Brewer Sparrow, and Song Sparrow. Only a few of these migrants remain for the summer. Species which remain include the Mourning Dove, Red-winged Blackbird, and Brewer Blackbird.

In July and early August, bird populations are incrased by a number of summer visitants which remain in many instances throughout the remainder of the summer months. Summer visitants include Blue-winged Teal, Shoveler, Ruddy Duck, Killdeer, Spotted Sandpiper, Black-necked Stilt, Mourning Dove, Western Kingbird, Western Flycatcher, Audubon Warbler, and Mockingbird. Our rather limited data would also place the Loggerhead Shrike and House Sparrow in this category.

Wauer (1962) reports 15 species nesting below sea-level in Death Valley. At least three species from his list, Roadrunner, House Sparrow, and Red-winged Blackbird, probably nest at Saratoga Springs or in adjacent habitats.

Fall migrants appear in August and early September. In this category we have included the Western Grebe, Snowy Egret, Canada Goose, Sparrow Hawk, American Avocat, Mourning Dove, Barn Swallow, Wilson Warbler, Brown-headed Cowbird, and Savannah Sparrow.

Species which we consider of accidental or occasional occurrence include the Fulvous Tree Duck, Long-billed Curlew, Dowitcher, Anna Hummingbird, Flycatcher, Parula Warbler, American Redstart, and Swamp Sparrow.

Several of the above group could be easily placed in an unanalyzed group of uncertain status. At best, this later group includes a large number of species on which only limited data are available. This group, comprising at least 22 species, makes up a minimum of 22% of the known avifauna. Of the total recorded from Saratoga Springs, 5% are permanent residents, 28% are winter visitants, 14% are summer visitants, 29% are migrants, and 9% are transients or of accidental or occasional occurrence.

Wauer (1962) points out that the distribution of birds in Death Valley has been greatly altered by environmental changes due to the activities of man. He comments on the large numbers of birds which utilize the fields, orchards, ditches, ponds, and grasslands at Furnace Creek Ranch. Mesic habitats have been greatly reduced since the end of the Pleistocene. The marsh and open water area at Saratoga Springs has been little altered from its natural condition. An exception is the establishment of tamarisk near the spring and marsh areas. This has undoubtedly made the area more attractive for many species of birds. Since Saratoga Springs has not been greatly modified, it is somewhat representative of a desert oasis in Death Valley.

Continued study of such an environment, maintained in as natural a condition as possible, is desirable. For example, an analysis of the avifauna after several years of study should indicate the importance of natural oases in avian biology. At Saratoga Springs there are sizeable areas of bulrush, common reedgrass, tamarisk, open water, and salt grass, which form a vegetational mosaic. This mosaic results in increased heterogeneity of vegetation type and more edge area between vegetation types or habitats. This provides not only more diverse but more attractive habitats for a variety of birds.

An analysis of the preferred habitat of each of the 90 species recorded from the study area was attempted. Approximately 40% are waterfowl, shore, or marsh birds which find suitable or at least temporary habitat in the marsh (bulrush, common reed grass, salt grass) or open water. An additional 40 % are land birds which normally utilize thick cover such as trees, shrubs, or tall grass. This cover is provided by thickets and trees of tamarisk and common reed grass, as well as the more luxuriant desert shrubs that grow adjacent to the marsh. The remaining 20% are made up of birds with wider ecological tolerances that could inhabit, or at least spend some time in, the desert during the more favorable seasons without utilizing an oasis; most of the species and individual birds found at Saratoga Springs are present only because of the presence of water, cover, and diversified habitats not characteristic of the surrounding desert. This concentration of avifauna is striking to even the casual observer and continued study should result in additions to and a clearer picture of the seasonal pattern of the avifauna of the region.