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The Effects of Campgrounds on Small Mammals in Canyonlands and Arches National Parks, Utah

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THE EFFECT OF CAMPGROUNDS ON SMALL MAMMALS IN CANYONLANDS AND ARCHES NATIONAL PARKS, UTAH

by

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A thesis submitted in partial fulfillment of the requirements for the degree

of

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in

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Gregory A. Clevenger

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ABSTRACT

The Effect of Campgrounds on Small Mammals in Canyonlands
and Arches National Parks, Utah

by

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Campground use in our national parks is increasing yearly, but little quantitative data are available concerning the impact this use is having on the ecology of the campground and surrounding area. This paper reports on some of the effects of campgrounds on small mammal populations in Canyonlands and Arches National Parks, Utah. Data collection consisted of live-trapping from April to November, 1975 (12,337 trap-nights). The populations of Ord's kangaroo rat (*Dipodomys ordii*), antelope ground squirrels (*Ammospermophilus leucurus*), deer mice (*Peromyscus spp*.), woodrats (*Neotoma spp*.), Colorado chipmunks (*Eutamias quadrivittatus*), and desert cottontails (*Sylvilagus audubonii*) inhabiting campgrounds were compared with non-campground control areas. Squaw Flat campground in Canyonlands National Park contained significantly higher populations of woodrats and Colorado chipmunks than the control. Devil's Garden campground in Arches National Park exhibited significantly higher populations of deer mice, but a lower population of woodrats than the control. No significant difference was found between campgrounds and control areas for all other species.

Occurrence of species in the campground and control areas was identical.

(53 pages)

INTRODUCTION

The small mammals encountered in and around a campground are the only wildlife that many people will see during their visit to a national park. Such wildlife is of considerable interest to most campers and adds to the enjoyment of their camping experience. Subsequently, many questions are directed to National Park Service personnel concerning the types of "animals" found in and around campgrounds.

Rodents inhabiting a campground are generally considered interesting and desirable. However, little is known about the relationship between these species and campgrounds. Management plans concerning campgrounds need to consider the influence that campgrounds may have on the small mammal population of an area. The need for this type of information will become increasingly important as the demand for camping sites in our national parks increases and land managers become more involved in making decisions involving resource preservation and visitor use.

Since their establishment, Arches and Canyonlands National Parks in southeastern Utah have received an increasing number of visitors each year. Annual visitation for Arches National Park has increased from 1,835 persons in 1939 to over 237,000 in 1975. Visitation at adjacent Canyonlands National Park has grown from 19,000 in the year of its creation (1964) to nearly 72,000 in 1975. As the beauty of these national parks becomes better known, use of these areas should continue to increase.

Preliminary work has been done on small mammals in Arches and Canyonlands National Parks. For example, Durrant (1952) and Armstrong

(1972) covered the distribution of mammals in the area. Wadsworth (1969) studied the reproduction of Colorado chipmunks (Eutamias quadrivittatus) from Arches National Park. No information has been gathered, however, concerning the relationship of campgrounds and their use on the small-mammal community of an area.

Objectives

1. To study the effects of campgrounds on small-mammal populations of Arches and Canyonlands National Parks.
2. To obtain information on the occurrence of small-mammal species in Canyonlands and Arches National Parks.

STUDY AREA

Canyonlands and Arches National Parks, located in southeastern Utah (Figure 1), cover approximately 1,359 km^2 (525 $mi.^2$) and 295 km^2 (114 $mi.^2$), respectively. The two parks occupy the center of the Colorado Plateau with elevations ranging from 1,219 m (4,100 ft.) along the Green and Colorado Rivers to 1,860 m (6,100 ft.) on the Island in the Sky Plateau of Canyonlands National Park (Lohman 1974). Arches National Park does not contain any major rivers, but rather consists of rolling topography broken by rock formations and sand dunes.

This study was conducted at Squaw Flat campground in the Needles District of Canyonlands National Park and at Devil's Garden campground, Arches National Park. An area similar in topography and vegetation was selected near each campground to serve as a control for the study.

Climate

The climate of this area is characterized by hot summers and cold winters (Tables 1 and 2). Precipitation is low, generally ranging from 13 cm (5 in.) to 23 cm (9 in.) (Table 3). A substantial amount of this precipitation is derived from late summer thundershowers during some years.

Study Sites

Squaw Flat campground. The Squaw Flat campground is located in the Needles District of Canyonlands National Park at an elevation of 1,554 m (5,100 ft.). The campground contains 27 units and

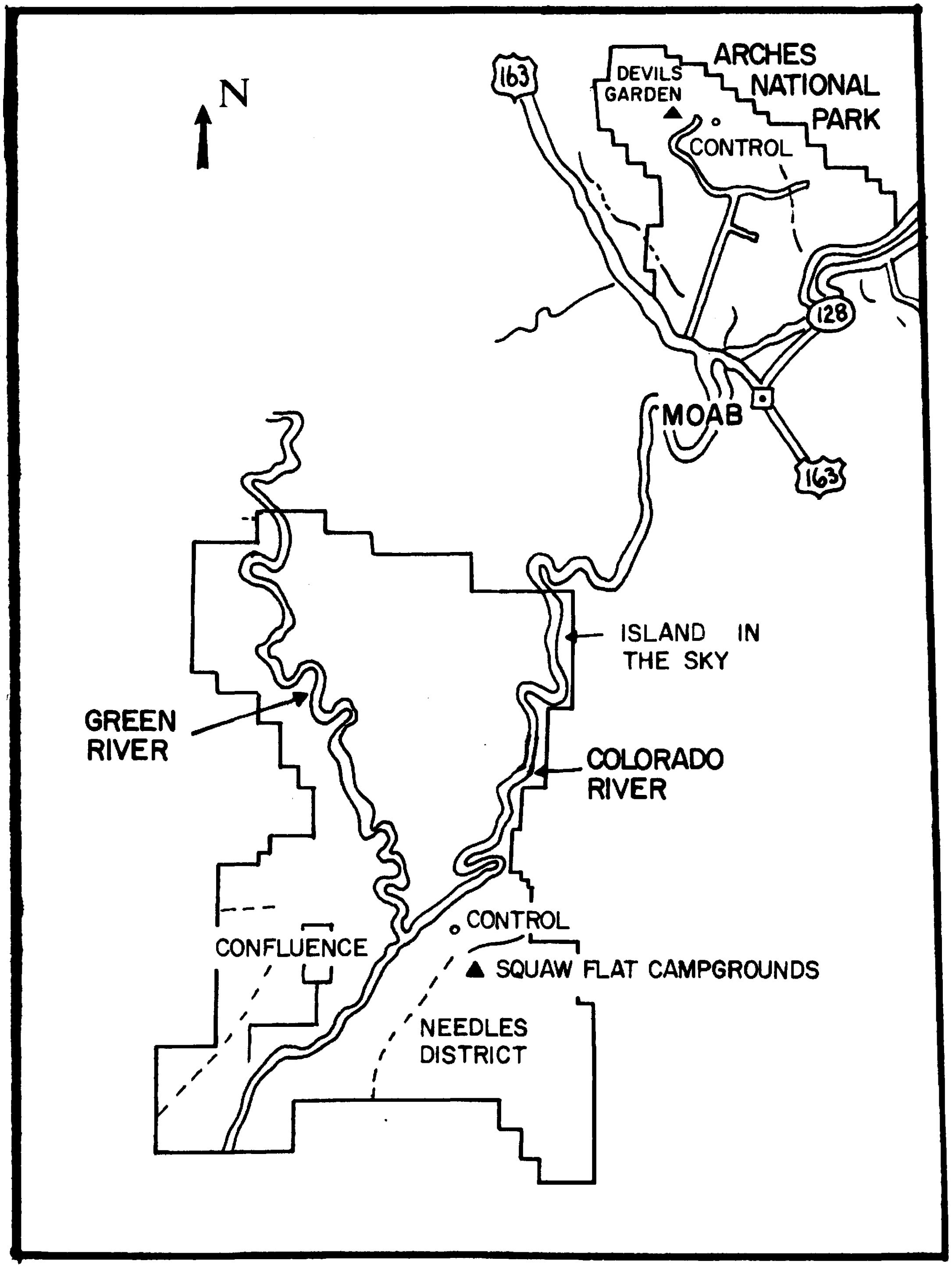

Figure 1. Canyonlands National Park and Arches National Park, Utah, showing campgrounds and control areas.

Table 1. Maximum and minimum mean temperatures by month for the Needles District, Canyonlands National Park, Utah (National Park Service data).

Month	Mean maximum temperatures (C°)		Mean minimum temperatures (C°)	
	Normal[1]	1975	Normal	1975
January	2.4 (36.4)[2]	4.9 (40.8)	- 9.3 (15.3)	11.4 (52.5)
February	9.1 (48.3)	8.7 (46.7)	- 6.2 (20.9)	- 6.6 (20.1)
March	14.9 (58.8)	12.7 (54.8)	- 1.9 (28.5)	- 1.7 (29.0)
April	18.7 (65.6)	15.3 (59.5)	1.0 (33.8)	.28(32.5)
May	26.8 (80.2)	22.1 (71.7)	7.5 (45.4)	5.2 (41.3)
June	31.3 (88.4)	31.3 (88.4)	16.9 (62.4)	10.7 (51.3)
July	34.9 (94.9)	34.4 (94.1)	16.6 (61.8)	16.9 (62.4)
August	31.9 (89.4)	33.4 (92.1)	15.5 (59.8)	13.9 (57.0)
September	27.8 (82.0)	28.5 (83.3)	9.3 (48.8)	9.1 (48.4)
October	19.6 (67.3)	21.5 (70.8)	3.4 (38.2)	1.1 (34.0)
November	11.2 (52.2)	11.3 (52.3)	- 2.7 (27.2)	- 4.8 (23.4)
December[3]	----	----	----	----

[1] 1968-1974
[2] Values in parenthesis expressed in degree fahrenheit
[3] Data not available

Table 2. Maximum and minimum mean temperatures by month for Arches National Park, Utah (1975)[1]. (Data from Atlas Chemical Co., Moab, Utah).

Month	Mean maximum temperatures (C°) 1975[2]	Mean minimum temperatures (C°) 1975
January	4.5 (40.3)[3]	- 8.6 (16.6)
February	9.7 (49.5)	- 3.0 (26.6)
March	14.7 (58.4)	1.4 (34.5)
April	18.3 (64.9)	3.7 (38.8)
May	25.1 (77.1)	8.6 (47.5)
June	31.4 (88.5)	11.2 (52.2)
July	36.3 (97.4)	18.4 (65.2)
August	35.2 (95.3)	15.2 (59.3)
September	31.2 (88.2)	10.9 (51.6)
October	23.3 (73.9)	2.8 (37.1)
November	13.5 (56.4)	- 2.6 (27.3)
December	7.05(14.7)	- 6.3 (20.7)

[1]Data recorded at Moab, Utah
[2]Long term data not available
[3]Values in parenthesis expressed in degrees fahrenheit

Table 3. Monthly precipitation for the Needles District, Canyonlands National Park, and Arches National Park, Utah (1975). (National Park Service data).

Month	Precipitation[1]	
	Needles	Arches[2]
January	1.8[3](72.0)	.5
February	9.9 (89.9)	.7
March	30.0 (84.7)	8.2
April	40.1 (62.1)	3.6
May	1.9 (00.0)	3.4
June	.7 (00.0)	1.7
July	3.9 (00.0)	.9
August	.1 (00.0)	.1
September	.8 (00.0)	1.3
October	1.2 (00.0)	2.4
November	7.3 (79.5)	.8
December	----	--

[1] Snowfall expressed in parenthesis as percent of total precipitation
[2] Snowfall data not available
[3] Data expressed in centimeters

receives moderate to heavy use from early spring through August (Table 4). Camping sites are located around a large formation of Cedar Mesa Sandstone (Lohman 1974). This large rock formation acts as an apron, collecting precipitation and concentrating it around its base. The underlying rock at a shallow depth also makes this moisture more available to vegetation by preventing rapid percolation through the soil. This additional amount of available moisture has resulted in the growth of large Utah juniper (*Juniperus osteosperma*) and pinyon pine (*Pinus edulis*).

Numerous potholes are scattered over the Cedar Mesa Sandstone. and act as catchment basins, holding water for several days after a storm. Water for camping use is provided by a water truck that is kept at the campground, but no free water is available to wildlife.

Associated with the juniper and pinyon pine around the campsites is four-wing saltbush (*Atriplex canescens*) and Fremont's bareberry (*Berberis fremontii*). Surrounding the campground is a flat covered by Russian thistle (*Salsola kali*), sunflower (*Helianthella uniflora*), and four-wing saltbush. Interspersed among this vegetation is cheatgrass (*Bromus tectorum*), dropseed (*Sporobolus cryptandrus*), and galleta (*Hilaria jamesii*).

The control site is located 0.5 km (0.3 mi.) north of the Squaw Flat campground. The topography of the area is nearly identical to that of the campground. Juniper and pinyon pine are found around the edge of a large formation of Cedar Mesa Sandstone. Surrounding this rock formation is a flat, similar in vegetative cover to that of the campground area (Table 5).

Table 4. Number of persons using Squaw Flat campground, Canyonlands National Park, and Devil's Garden campground, Arches National Park, Utah (1975). (National Park Service data).

Month	Campground	
	Squaw Flat	Devil's Garden
January	21	118
February	83	370
March	1,602	2,456
April	1,521	2,949
May	2,019	4,317
June	783	5,338
July	1,750	5,392
August	4,400	5,523
September	1,710	4,155
October	1,105	2,074
November	334	376
December[1]	---	---
Total	15,328	32,068

[1]Data not available

Table 5. Plant species composition for campground and control area, Needles District, Canyonlands National Park, Utah (1975).[1]

Species	Frequency[2]		Cover[3]	
	Campground	Control	Campground	Control
Trees (45)[4]				
Juniperus osteosperma	13[5]	49	6	5
Pinus edulis	8	29	3	2
Fraxinus anomala	1	14	--	--
Shrubs (45)				
Gutierrezia spp.	8	24	--	2
Berberis fremontii	4	2	1	--
Atriplex canescens	11	31	--	--
Artemisia filifolia	1	--	--	--
Echinocereus sp.	1	--	--	--
Opuntia spp.	1	9	--	--
Brickellia californica	1	1	--	--
Annual herbs (90)				
Salsola kali	40	53	4	30
Cleome lutea	14	11	--	--
Plantago purshii	21	17	--	--
Helianthella uniflora	38	18	--	--
Lappula redowskii	8	17	--	--
Descurainia pinnata	--	2	--	--
Senecio multilobatus	--	6	--	--
Grasses (90)				
Bromus tectorum	49	32	7	7
Sporobolus cryptandrus	42	10	2	6
Hilaria jamesii	39	50	1	2
Vulpia (Festuca) octoflora	7	7	--	--
Aristida longiseta	1	4	--	--
Oryzopsis hymenoides	3	7	--	--

[1]Sampling technique after Mueller-Dombois (1974)
[2]Number of times a particular plant species occurred in each plot
[3]Respective area of each plot covered by a particular plant species
[4]Number of plots sampled
[5]Values expressed as percentages

Devil's Garden campground. This campground contains 55 camping sites and is more developed than the Squaw Flat campground. Running water is provided for campers at three locations, but the water system provides no standing water that is available to wildlife. Devil's Garden receives substantial camping use from early spring through October (Table 4) and is generally full each night during the summer months.

Campsites are located adjacent to the base of a vertical rock formation of Entrada Sandstone where pinyon pine and juniper provide some shade. Scattered among the pinyon pine and juniper are cliffrose (Cowania mexicana), blackbrush (Coleogyne ramosissima), match weed (Gutierrezia spp.), and yucca (Yucca harrimanii). Common grasses include cheatgrass and Indian ricegrass (Oryzopsis hymenoides). Extending north from the campground are small sand dunes covered primarily with mormon tea (Ephedra viridis), false horsemint (Poliomentha incana), blackbrush, and sagebrush (Artemisia spp.).

The control area is located 0.25 km (0.15 mi.) east of Devil's Garden campground and 0.80 km (0.50 mi.) from the nearest trapping station within the campground. This area resembles the campground both topographically and vegetatively. A comparison of vegetational cover and species occurrence is found in Table 6.

Table 6. Plant species composition for campground and control area, Arches National Park, Utah (1975).[1]

Species	Frequency[2]		Cover[3]	
	Campground	Control	Campground	Control
Trees (20)[4]				
Juniperus osteosperma	20[5]	30	4	2
Pinus edulis	20	7	4	--
Shrubs (20)				
Ephedra viridis	15	17	--	3
Cowania mexicana	10	20	--	1
Gutierrezia spp.	33	43	1	1
Artemisia filifolia	13	3	1	--
Vanclevia stylosa	20	13	--	--
Yucca harrimaniae	20	10	--	--
Opuntia spp.	3	10	--	--
Poliomentha incana	8	3	--	--
Eriogonum smithii	3	10	--	--
Coleogyne ramosissima	8	7	--	--
Cercocarpus montanus	8	--	--	--
Atriplex canescens	5	--	--	--
Perennial herbs (40)				
Lepidium fremontii	10	27	--	--
Artemisia ludoviciana	5	30	--	--
Cryptantha flava	8	10	--	--
Abronia fragrans	--	3	--	--
Grasses (40)				
Bromus tectorum	58	30	3	--
Oryzopsis hymenoides	25	20	--	--
Vulpia (Festuca) octoflora	18	--	--	--
Muhlenbergia spp.	10	3	--	--
Sporobolus cryptandrus	3	7	--	--

[1] Sampling technique after Mueller-Dombois (1974)
[2] Number of times a particular plant species occurred in each plot
[3] Respective area of each plot covered by a particular plant species
[4] Number of plots sampled
[5] Values expressed as percentage

METHODS

Sampling Approach

Two different approaches can be taken in assessing the effect of a campground, or any other disturbance, on the ecology of a given area. The area to be affected can be sampled before the campground is constructed and then again afterwards to allow a before and after comparison. The problem with this method is that different population levels that exist after the campground is established may be the result of seasonal or yearly population cycles that occur independently of any effect(s) the campground may have. This problem is accentuated when dealing with small mammal species that are subject to large seasonal and yearly fluctuations in population.

The second approach is to select an undisturbed area as similar as possible to the campground and sample it simultaneously using the same sampling method as used in the campground. This method allows the study to be conducted over a shorter period of time and eliminates the problems associated with population fluctuations. The disadvantage of this method is that differences in population exhibited between the campground and control area could be the result of habitat or sampling differences, and not because of the effects of the campground.

The simultaneous sampling method was used in this study because the campgrounds were already established, precluding the use of the before and after method. It was also felt that the problems associated with using a control area were much less limiting than the problems involved with sampling before and after a campground was constructed.

Live-trapping techniques

Live-trapping was conducted to collect information on species occurrence and relative population size in campgrounds and control areas. Each campground and respective control area was trapped once a month for five consecutive days (weather permitting) beginning in April, 1975. This schedule was continued until trapping success declined in the fall of 1975 (Table 7).

The occurrence of several species of small mammals of varying size required the use of three sizes of live-traps. Sherman live-traps (9 x 8 x 25 cm; or 3 x 5 x 10 in.) were used to capture the smallest species, such as deer mice (*Peromyscus spp.*), Colorado chipmunks, woodrats (*Neotoma spp.*), Ord's kangaroo rat (*Dipodomys ordii*), and antelope ground squirrels (*Ammospermophilus leucurus*). National brand traps (17 x 18 x 48 cm; or 7 x 7 x 19 in.) were used to capture desert cottontails (*Sylvilagus audubonii*), woodrats, and antelope ground squirrels. Collapsible, double-door Tomahawk traps (23 x 23 x 104 cm; or 9 x 9 x 42 in.) captured adult desert cottontails and rock squirrels (*Spermophilus variegatus*). Apple slices were used for bait in traps of the two largest sizes, and bird seed was used in the small Sherman traps. The traps were placed 10-12 meters apart.

Transect design. One trap line was located in each campground adjacent to campsites with a second trap line bisecting it and extending into the area surrounding the campground (Figure 2). Permanent trapping stations were located along these transects and three traps of different sizes placed at each location. Ten trapping stations were placed in the campground at Squaw Flat (30 traps) and ten stations were located on the transect bisecting the campground

(30 traps) for a total of 60 traps located in and adjacent to these campgrounds. Distance between trap stations (three traps per station) ranged between 20 and 25 m (22 - 27.5 yds.), depending upon topography and vegetation of a particular site.

Table 7. Combined number of mammal trap nights for campground and control areas in Canyonlands and Arches National Parks, Utah (1975).

Month	Campground	
	Squaw Flat	Devil's Garden
April	1200[1]	672
May	1080	768
June	1200	480
July	840	672
August	1320	672
September	960	768
October	840	384
November	480	---
Total	7920	4416

[1] Differences in number of trap nights result of inclement weather.

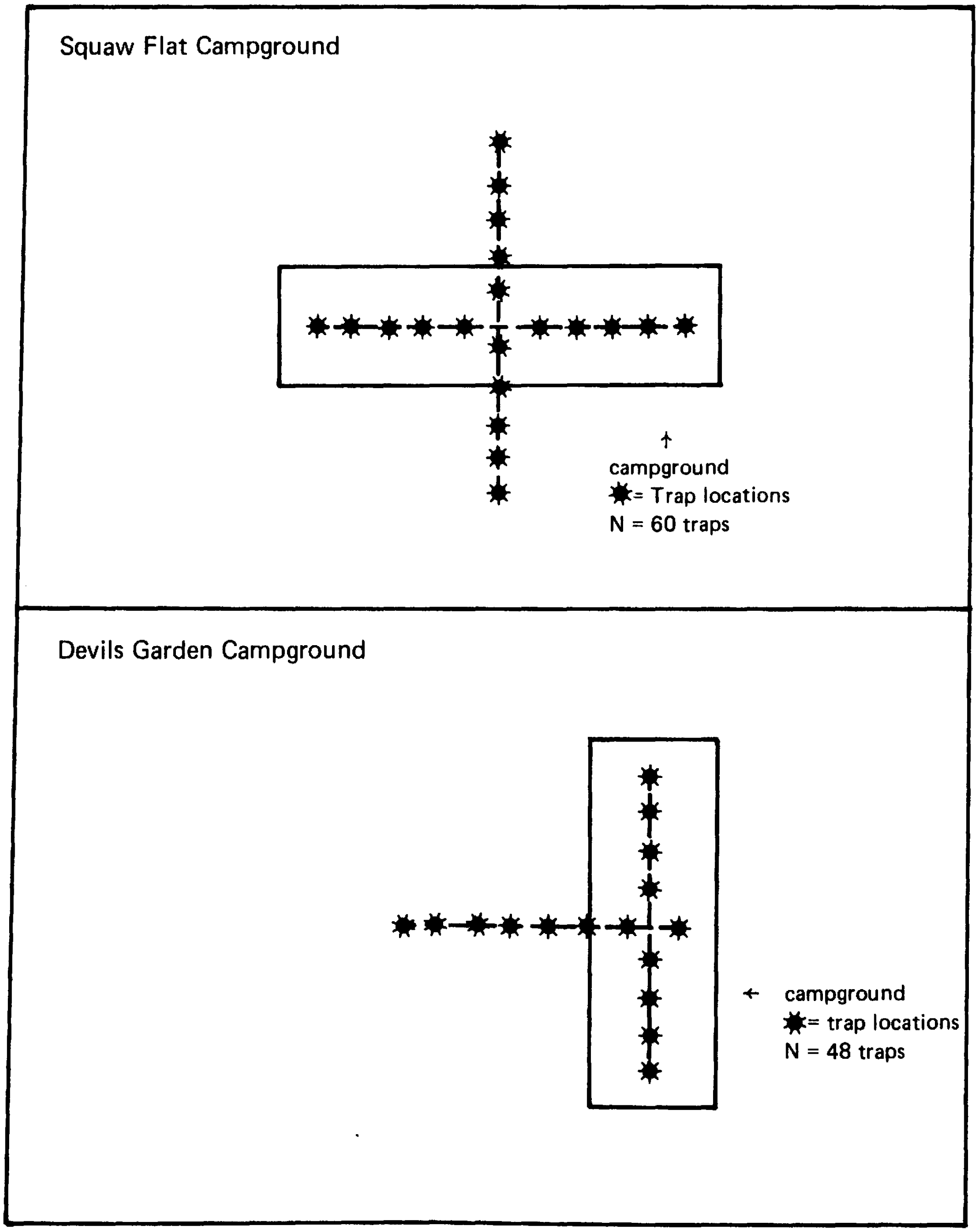

Figure 2. Schematic representation of trap transect design for Squaw Flat Campground and Willow Flat Campground, Canyonlands National Park and Devil's Garden Campground, Arches National Park, Utah.

The Devil's Garden campground was bordered on the south by a series of steep rock walls which prevented extending the transect to the south (Figure 2). The trap line located in the campground contained eight trapping stations (24 traps). The second trap line was perpendicular to the first and extended north from the campground. This line also contained eight trapping stations (24 traps), resulting in a total of 48 traps in the campground and the area surrounding it.

The design of the trap lines was the same in each of the respective control areas. Transects were the same length, contained the same number of traps, and were the same distance apart as those transects located in the campground.

Trapping procedure. The different behavioral patterns of the small mammals inhabiting the campgrounds and control areas necessitated the establishment of two trapping periods per day. Species such as the deer mice, woodrats, and kangaroo rats are almost strictly nocturnal. Desert cottontails and rock squirrels are, for the most part, crepuscular, whereas antelope ground squirrels and Colorado chipmunks are diurnal.

Traps were baited each evening just before dark, a procedure which took approximately two hours to complete. Traps were checked beginning at daylight, and animals captured were identified as to species, sex, reproductive condition, then toe-clipped and released. Immediately after a trap station was checked in the morning, the traps were re-baited and set again. When all of the traps in the campground and control area had been checked and re-baited, they were checked again and then closed for the day. This method allowed sampling of nocturnal and crepuscular species during the first trapping period and crepuscular and diurnal species during the second period.

The sequence of baiting and checking the traps was alternated between the campground and control area daily. One evening the campground would be baited first and checked first the next morning. This same procedure would be followed the next day for the control area. This method prevented sampling bias that might have resulted from having the traps in either the campground or control area consistently open and baited for a longer interval than the traps in the other area.

Vegetational analysis

Methods. Vegetational analysis of the campsite and control areas followed the method described in Mueller-Dombois (1974). Transect lines 50 m (55 yds.) in length were established in the campgrounds and corresponding locations in the control areas. One square meter (1.1 sq. yds.) plots were located every 5 m (5.5 yds.) along the transect to sample grasses and herbs. Five x five m (5.5 sq. yds.) plots were used to sample shrubs and ten x ten m (11 sq. yds.) plots to sample trees.

Nine of these transect lines were located at the Squaw Flat campground, and seven at Devil's Garden. The same number of transects were located in each respective control area. The number of times a particular plant species occurred in each plot (frequency), and the percent of the plot it covered (cover) was recorded for each plot. A summary of the data from all plots is recorded in Table 5 and 6.

Statistical analysis

The problem of accurately determining the size of populations of small-mammals has received considerable attention. The most common means of estimating the size of populations involves the mark-recapture method whereby individuals are live-trapped, marked, and then released. The subsequent capture history of these individuals is then treated by one or more statistical methods to generate a population estimate. Numerous assumptions must be met for most of the recapture methods involved. In many studies where numerous recaptures are not obtained and/or the requisite assumptions are not met, estimates of actual population size using the capture-recapture method must be viewed with some skepticism. These assumptions include: (1) No "trap shy" or "trap happy" individuals, (2) No immigration or emigration from the population, and (3) No mortality or natality during the sampling period. In actuality, few if any of these assumptions are ever met.

There have been studies, working with a known population size in an enclosure and obtaining a large number of recaptures, where a respectable degree of accuracy has been obtained in estimating actual population levels (Edwards and Eberhardt, 1967). However, in many studies where numerous recaptures are not obtained and/or the requisite assumptions were not met, estimates of actual population size must be viewed with some skepticism.

Two types of data were available from this study that allowed a comparison of the campground and control areas. One was the number of first-time captures (base-line estimate), and the other was the total number of captures for all individuals of a particular species.

Examination of the data indicated that the ratio between the total number of captures and the base-line captures was consistent. Consequently, the total number of captures was used as an index to compare the populations of the two areas because of the larger sample size provided by these data.

A statistical method was chosen that tested the hypothesis that there was a one-to-one ratio ($\mu = 0.5$) between the number of captures of small-mammals obtained in the campground and that recorded in the control area. A "z" value was computed using the formula:

$$z = \frac{\hat{P} - \mu}{\sqrt{P(1 - P)/N}}$$

where: $\hat{P}$ = observed ratio between the captures of the two areas.

P = expected ratio between the captures of the two areas (.5).

μ = expected mean (1:1 ratio = μ = .5).

N = total number of captures for the campground and control area.

This "z" value was then compared to a critical value of "z", which was 1.96 ($\alpha = 0.05$ level) in all cases in this study (Steel and Torrie 1960).

A test was also run on each month's data for each species to determine if the differences between each set of data from the two areas were consistently proportional (Freund 1962). Data that were consistent from month to month were pooled, and a "z" value was computed for all the data. Where monthly differences were not consistent, a "z" value was computed for each month's data.

RESULTS

Colorado chipmunk

Squaw Flat. A significantly higher number of captures was obtained in the campground than in the control area for this species (88 vs. 25, z = 5.93, Table 8). This "z" value was the largest found in the study with the exception of the value calculated for woodrats at the Squaw Flat campground.

Devil's Garden. There was no statistically significant difference in the number of captures between the campground and control area for this species (27 vs. 19, z = 1.18, Table 8), although the number of different individuals caught was significantly higher in the campground. The data suggest that continued sampling would result in a significantly higher number of captures in the campground.

Woodrats

Squaw Flat. The difference in the number of captures obtained in the campground and control was the largest of any found during this study. The fifty-two captures recorded in the campground, compared with three in the control were highly significant (z = 6.61, Table 9).

Devil's Garden. The number of captures was significantly higher in the control than the campground (24 vs. 11, z = -2.20), the only instance of this type found during the study (Table 9). It should be noted, however, that baseline values were similar between areas (8 vs. 7).

Table 8. Comparison of number of captures between campground and control for Eutamias quadrivittatus, Squaw Flat campground, Canyonlands National Park, and Devil's Garden campground, Arches National Park, Utah (1975).

Month	Campground			
	Squaw Flat		Devil's Garden	
	Campground	Control	Campground	Control
April	8	1	1	2
May	13	1	2	1
June	22	5	3	3
July	6	3	8	6
August	12	4	5	3
September	10	3	5	3
October	15	8	3	1
November	2	0	--	--
Total captures	88	25	27	19
Number of different individuals	44	11	28	10
z value[1]	5.93*		1.18	

[1]Based on total captures
*Significant at the 0.05 level

Table 9. Comparison of number of captures between campground and control for *Neotoma* spp., Squaw Flat campground, Canyonlands National Park, and Devil's Garden campground, Arches National Park, Utah (1975)

Month	Campground			
	Squaw Flat		Devil's Garden	
	Campground	Control	Campground	Control
April	1	0	1	1
May	3	0	1	3
June	9	0	1	2
July	4	0	1	7
August	10	0	4	3
September	12	1	2	8
October	12	2	1	0
November	1	0	--	--
Total captures	52	3	11	24
Number of different individuals	11	1	7	8
z value[1]	6.61*		-2.20*	

[1]Based on total captures.
*Significant at the 0.05 level

Deer mice

Squaw Flat. Comparison of capture rates showed no significant difference between the campground and control area when the captures for all months were pooled ($z = 0.95$). Because month-to-month differences were not proportional, however, a "z" value was also calculated for each month. Monthly comparisons indicated no significant differences, except during May when there were more captures in the campground than the control area (19 vs. 8), and in October when there were more captures recorded in the control than for the campground (19 vs. 7, Table 10).

Devil's Garden. Month-to-month differences in data for this campground and control area were also not consistent, therefore, a "z" value was computed for each month. Significantly more captures occurred in the campground during April (16 vs. 10) and May (19 vs. 8). No significant difference in the number of captures was found during the remaining five months of the study. Analysis of the pooled data, however, indicated a significantly higher number of captures in the campground (88 vs. 58, $z = 2.48$, Table 10).

Desert cottontail

Squaw Flat. This species exhibited no significant difference in the number of captures ($z = -0.34$) between the campground and control (Table 11). Total captures (16 vs. 18) and the number of different individuals captured (11 vs. 12) were quite similar.

The largest differences occurred in July, when six captures were recorded in the control area, compared to none in the campground, and during October when the campground had five more captures

Table 10. Comparison of number of captures between campground and control for *Peromyscus* spp., Squaw Flat campground, Canyonlands National Park, and Devil's Garden campground, Arches National Park, Utah (1975)

Month	Campground			
	Squaw Flat		Devil's Garden	
	Campground	Control	Campground	Control
April	16	10	18	3
May	19	8	16	5
June	22	15	19	11
July	5	9	17	21
August	16	19	11	9
September	11	6	2	7
October	7	19	5	2
November	5	2	--	--
Total captures	101	88	88	58
Number of different individuals	46	42	54	24
z value[1] (pooled data)	0.95		2.48*	

[1]Based on total captures
*Significant at the 0.05 level

Table 11. Comparison of number of captures between campground and control for *Sylvilagus audubonii*, Squaw Flat campground, Canyonlands National Park, and Devil's Garden campground, Arches National Park, Utah (1975)

Month	Campground			
	Squaw Flat		Devil's Garden	
	Campground	Control	Campground	Control
April	0	0	0	0
May	0	1	0	0
June	3	1	1	1
July	0	6	4	6
August	3	2	9	7
September	2	4	16	8
October	7	2	5	4
November	1	2	--	--
Total captures	16	18	35	26
Number of different individuals	11	12	14	7
z value[1]	-0.34		1.15*	

[1]Based on total captures
*Not significant at the 0.05 level

than the control (7 vs. 2). These sample sizes were too small, however, to be tested statistically.

Devil's Garden. No cottontails were captured until June, when one capture was recorded for each area (Table 11). There was a significantly higher number of captures in the campground during September (16 vs. 8). All other months had a sample size too small to be tested individually. The pooled data showed no significant difference in captures between the campground and control area (35 vs. 26, $z = 1.15$), although the data do suggest that a larger sample size might have indicated a significantly higher number of captures in the campground than the control area.

Antelope ground squirrel

Squaw Flat. Total captures for the campground and control were identical (67, $z = 0.00$, Table 12). The number of different individuals caught was also very similar (47 vs. 49).

Devil's Garden. There was no significant difference found in the number of captures between the campground and control area for this species (Table 12). Forty-six captures were recorded in the campground, and 43 in the control ($z = 0.32$), with the number of different individuals captured comparable (34 vs. 28).

Ord's kangaroo rat

Squaw Flat. The number of captures showed no significant difference between campground and control area for this species (79 vs. 87, $z = -0.62$, Table 13). Monthly comparisons also showed no significant difference between the two areas.

Table 12. Comparison of number of captures between campground and control for *Ammospermophilus leucurus*, Squaw Flat campground, Canyonlands National Park, and Devil's Garden campground, Arches National Park, Utah (1975)

Month	Campground			
	Squaw Flat		Devil's Garden	
	Campground	Control	Campground	Control
April	14	5	2	8
May	12	11	2	1
June	14	21	5	3
July	3	2	12	6
August	10	8	12	12
September	3	3	12	10
October	6	11	1	3
November	5	6	--	--
Total captures	67	67	46	43
Number of different individuals	47	49	34	28
z value [1]	0.00		0.32*	

[1]Based on total captures

*Not significant at the 0.05 level

Table 13. Comparison of number of captures between campground and control for <u>Dipodomys ordii</u>, Squaw Flat campground, Canyonlands National Park, and Devil's Garden campground, Arches National Park, Utah (1975)

Month	Campground			
	Squaw Flat		Devil's Garden	
	Campground	Control	Campground	Control
April	17	13	7	7
May	15	19	12	8
June	16	18	5	9
July	4	3	10	15
August	4	5	3	3
September	8	12	8	9
October	8	8	6	4
November	7	9	--	--
Total captures	79	87	51	55
Number of different individuals	36	26	15	16
z value[1]	-0.62*		-0.38*	

[1]Based on total captures
*Not significant at the 0.05 level

Devil's Garden. There was no significant difference in the number of captures obtained in the campground and control area (51 vs. 55, z = -0.38, Table 13). The number of different individuals captured was also quite similar between the campground and control area (15 vs. 16).

Rock squirrels

Rock squirrels were captured at the Squaw Flat campground adn the control area at Devil's Garden. The number of captures of these species, however, were too small to be tested statistically.

DISCUSSION

The results indicate that campgrounds do have some influence on the population of small mammals inhabiting them. Two species at Squaw Flat and two species at Devil's Garden exhibited significant differences in rates of captures between the campground and the control area (Table 14).

Food habits

It might be assumed that species exhibiting little or no difference in the number of captures between the campground and control area have a limited range of dietary adaptability that precludes utilization of the additional food resource provided by human camping activity. A review of the food habits of small mammals captured during this study, however, indicates that a variety of plant and some animal material are consumed.

Woodrats were found to utilize a wide range of plants and exhibit a degree of adaptability that enables this species to successfully exploit a wide spectrum of food plants (Cameron and Ramsey 1972). Meserve (1974) and Cameron (1971) studied competition and resource allocation between *Neotoma lepida* and *N. fuscipes*. They found that *N. lepida* was able to change diets when sharing habitat with the dominant *N. fuscipes*.

Three species of woodrats were caught during this study; *N. lepida*, *N. cinera*, and *N. albigula*. The interaction of these species is probably quite important in determining resource utilization

Table 14. Summary of small mammal captures at Squaw Flat campground and control, Canyonlands National Park, and Devil's Garden campground and control, Arches National Park, Utah (1975).

Species	Squaw Flat			Devil's Garden		
	Campground	Control	z value	Campground	Control	z value
Eutamias quadrivittatus	88	25	5.93**	27	19	1.18
Neotoma spp.	52	3	6.61**	11	24	-2.20*
Peromyscus spp.	101	88	0.95	88	58	2.48**
Sylvilagus audubonii	16	18	-0.34	35	26	1.15
Ammospermophilus leucurus	67	67	0.00	46	43	0.32
Dipodomys ordii	79	87	-0.62	51	55	-0.38

*Significant at the 0.05 confidence level
**Significant at the 0.01 confidence level

and needs to be examined in relation to the occurrence of these species at the Squaw Flat and Devil's Garden study sites.

A larger number of woodrats were captured in the Squaw Flat campground than in the respective control area, but at Devil's Garden there were more captures of woodrats in the control area than in the campground. This lack of a consistent difference could be the result of a lack of ground cover in the Devil's Garden campground that prohibited woodrats from exploiting the garbage found in the campground. Russian thistle was abundant in the Squaw Flat campground, occurring in 40 percent of the vegetation plots (Table 5). Although Stones and Hayward (1968) did not find _N. lepida_ using Russian thistle for food in central Utah, it formed an important component of the escape cover for woodrats at the Squaw Flat campground. Russian thistle did not occur at all, however, in the Devil's Garden campground (Table 6).

The heavy visitor use at Devil's Garden campground also resulted in a lack of small sticks and pieces of Utah juniper (collected by campers for firewood). This litter was important nest-building material for woodrats at the Squaw Flat campground, and the lack of this matieral may have depressed woodrat populations in the Devil's Garden campground.

Colorado chipmunks seemed quite adaptable to a campground situation and were often observed foraging for food around campsites seemingly oblivious to human activity. Foods other than garbage that chipmunks were observed eating included a variety of grasses and herbs in spring and early summer and large amounts of pinyon pine nuts when these seeds matured in late August. Chipmunks were not observed consuming animal matter, although Vaughan (1974) found least chipmunks (*Eutamias minimus*) consuming arthropods during June.

The difference in the number of chipmunk captures in the Devil's Garden campground was not significantly higher than the control (as it was in Squaw Flat, Table 8). The available data, however, suggest that a larger sample size would result in a statistically significant difference in the number of captures of chipmunks between the campground and control area. It is my impression that Colorado chipmunks are one of the most adaptable species of small mammals to campground situations.

Williams (1959) found that as a group, *Peromyscus* eat primarily seeds and leaves with some insects taken when they were available in the spring. A study by Jameson (1952) stressed the importance of seasonal availability of food. Seeds and fruits are consumed by *P. maniculatus* and *P. boylei* in summer and early fall and insects taken in the spring. Vaughan (1974) and Meserve (1976) also noted that *P. maniculatus* has a diverse diet, eating seeds in the spring (some arthropods in June) and switching to fruits and berries in September when seeds became less abundant.

The omnivorous nature of the four species of *Peromyscus* trapped during this study (*P. maniculatus*, *P. boylei*, *P. truei*, and *P. crinitus*) could enable them to utilize campground garbage. The reason for the lack of a significantly different number of captures between the campground and control at Squaw Flat is not clear. A better understanding of intraspecific competition among *Peromyscus* in this area is needed.

Studies by Johnson (1961) and Flake (1973) indicate that Ord's kangaroo rats consume large amounts of seeds, and some green vegetation. The similarity in the number of captures for this species between the campground and control area (Table 13) could result from the inability of Ord's kangaroo rats to switch from this specialized diet of seeds to garbage.

The desert cottontail consumes a variety of grasses, forbs, and shrubs (Turkowski 1975) and adjusts its diet to the availability of food throughout the year (Fitch 1947). This species was seen around the campgrounds, but never directly observed foraging for food around campsites. Cottontails were characteristically shy and would not tolerate human activity as much as Colorado chipmunks could. The low tolerance of human activity displayed by desert cottontails may have affected this species' ability to adapt to campground situations and utilize the food found there.

Antelope ground squirrels are diurnal herbivores that consume a variety of shrubs, grasses, and seeds (Chew and Butterworth 1964, Bradley 1967). This species is also tolerant of a wide range of temperatures (Kramm 1972) and does not hibernate or estivate (Hudson 1962), although some juveniles will decrease above-ground activity during extremely hot weather (Bradley 1967).

The number of captures of antelope ground squirrels in the campground and control area were very similar (Table 12). This species was not commonly observed in campgrounds, but preferred the open areas adjacent to the campgrounds, where it fed heavily on four-wing saltbush and annual grasses. This behavioral preference for an open, grass-shrub habitat type might minimize the effect of campgrounds on antelope ground squirrels because campsites are rarely located in such open, treeless areas.

Predation

Another factor that may influence population levels of small mammals in a campground and non-campground area is the difference in predator populations found in these two areas. Numerous signs of coyotes (*Canis latrans*) were observed around the control areas, particularly at the Squaw Flat control area where several desert cottontails that were in live traps were killed by coyotes. Swainson's hawks (*Buteo swainsoni*) were also frequently seen perching in pinyon pine and juniper trees in the Squaw Flat control area. These predators presumably did not hunt in the campgrounds because of the human activity in and immediately around the campgrounds. It is doubtful, however, that differential predation between campground and control areas by coyotes and raptors would have a significant effect on the smaller and more numerous species of small mammals, such as *Peromyscus* spp.

Trapping success

The number of captures obtained each week was divided by the total number of trap-nights for that week to determine trapping success values (one trap open for one night, or morning, considered one trap-night). Some species were vulnerable to more than one trap size. Desert cottontails, for example, were susceptible to capture in National and Tomahawk brand traps. Woodrats were captured in both the Sherman as well as National brand traps. These differences in trap susceptibility were considered when trapping success was computed (Figures 3-14).

Some of the work that has been done on trap susceptibility has indicated that many factors, or combinations thereof, may influence trapping success. Fitch (1954) stressed the importance that seasonal food availability has on trap susceptibility. He believed that during periods when food was abundant, trapping success would be low, even though populations of small mammals might be high. Smith and Blessing (1969) also thought food availability was important as well as the sex and reproductive condition of the individual.

Much work has been done concerning the effects that weather may have on small-mammal captures, with varied and sometimes conflicting results arising from this research. Gentry and Odum (1957) and Getz (1961) found that warm, cloudy nights resulted in the greatest activity for deer mice and a correspondingly higher rate of capture. Blair (1943), working with deer mice, and Jahoda (1973), studying *Onychomys leucogaster*, found that a clear, moonless night resulted in the highest number of captures. A study by Marten (1973) indicated that the activity of the pinyon mouse (*Peromyscus truei*) was positively correlated with high barometric pressure and the temperature at sundown. O'Farrell (1974) monitored several parameters throughout the night and found that time after sunset and the amount of moonlight were the most important factors influencing small-mammal activity in west-central Nevada. O'Farrell believed that ambient temperature, wind, cloud cover, precipitation, and barometric pressure had little effect on activity except under extreme conditions.

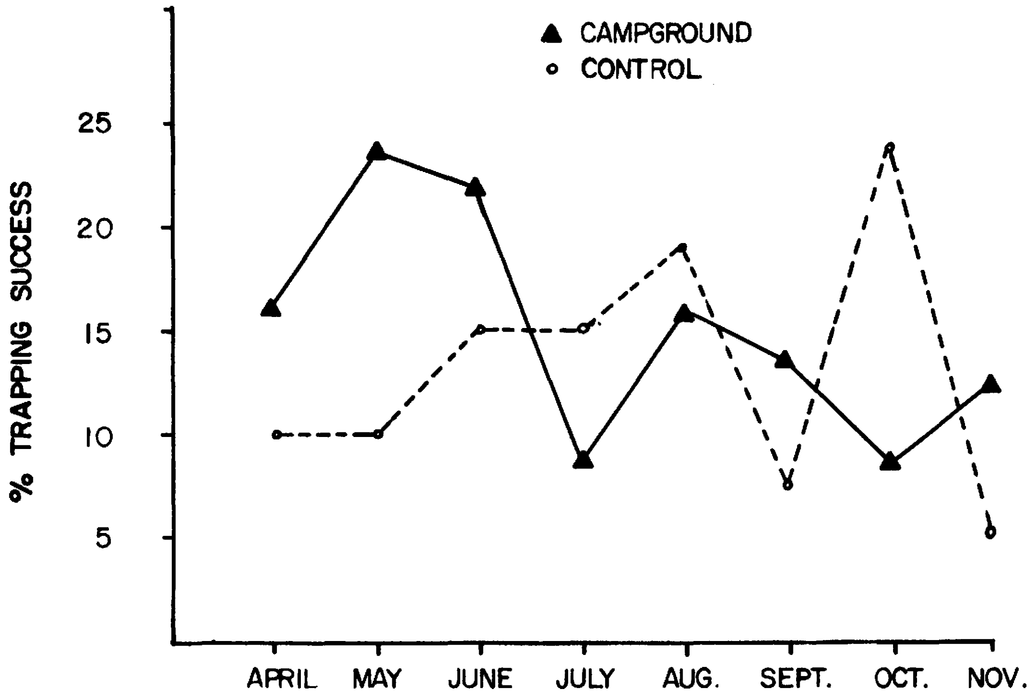

Figure 3. Trapping success for Peromyscus spp., Squaw Flat Campground, Canyonlands National Park, Utah (1975).

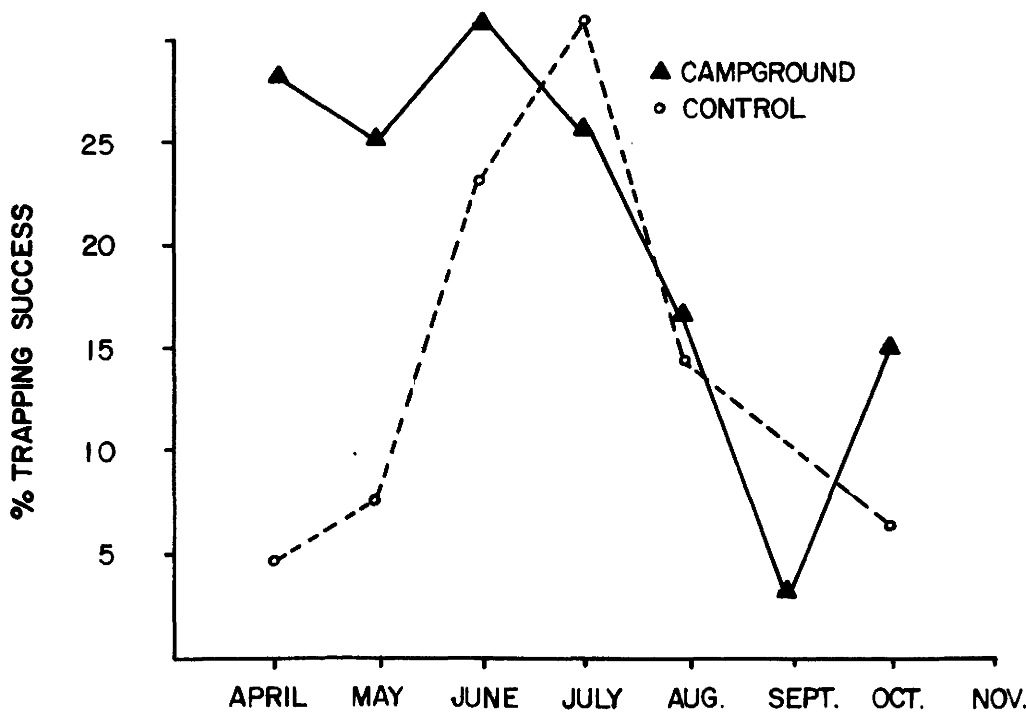

Figure 4. Trapping success for Peromyscus spp., Devil's Garden Campground, Arches National Park, Utah (1975).

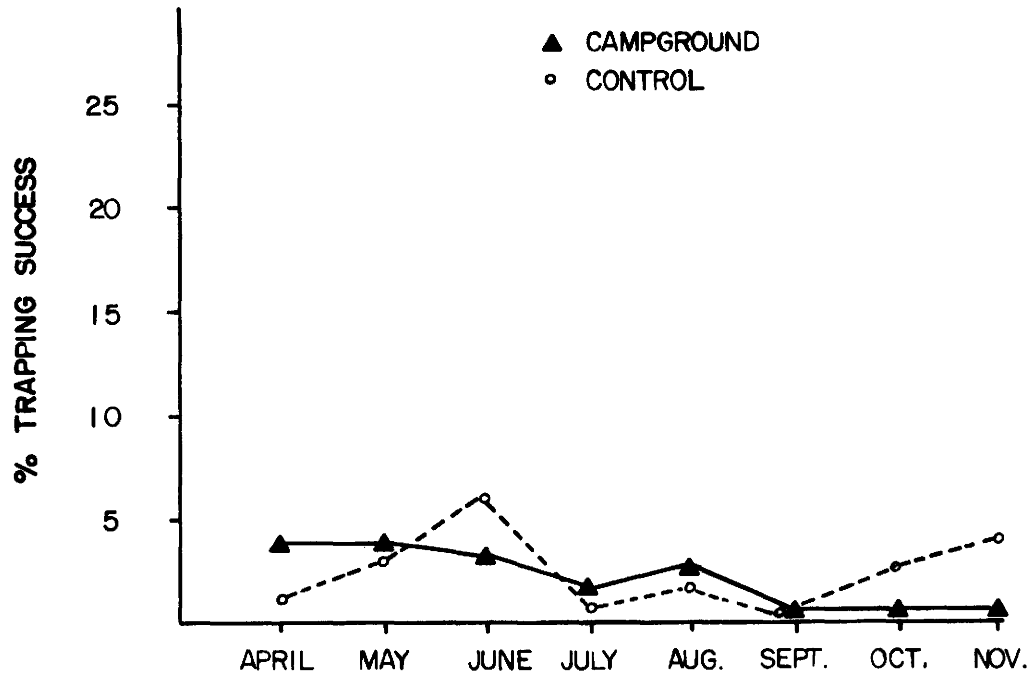

Figure 5. Trapping success for Ammospermophilus leucurus, Squaw Flat Campground, Canyonlands National Park, Utah (1975).

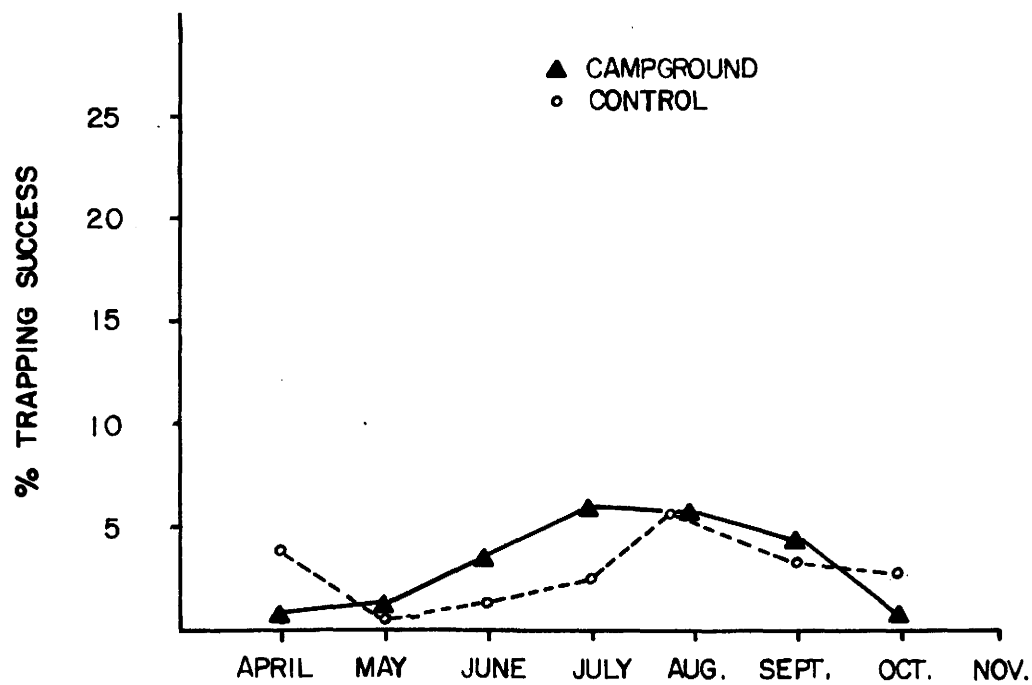

Figure 6. Trapping success for Ammospermophilus leucurus, Devil's Garden Campground, Arches National Park, Utah (1975).

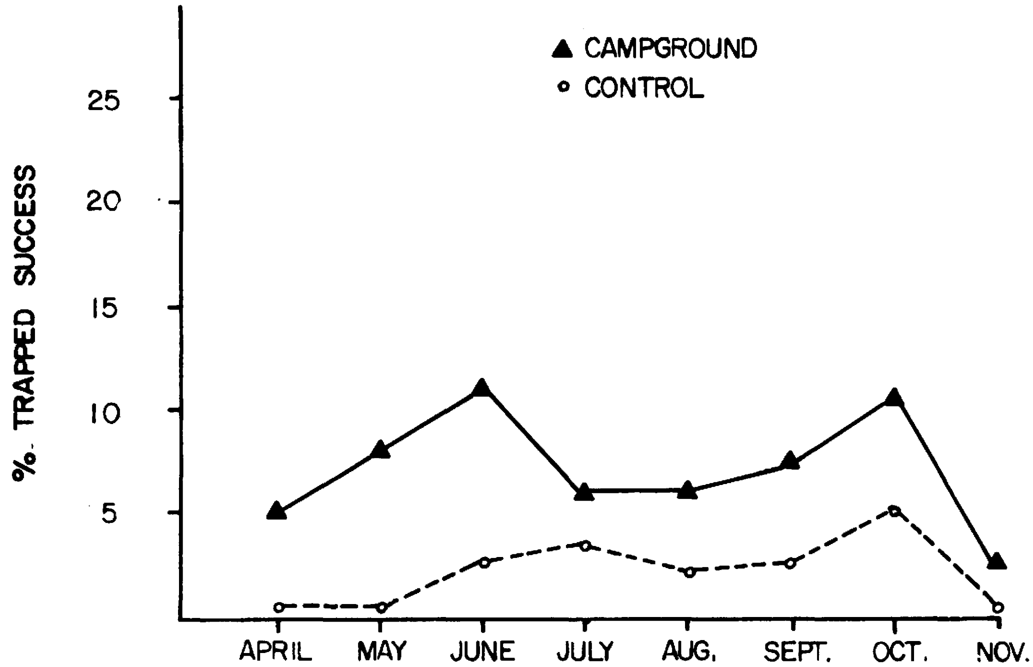

Figure 7. Trapping success for Eutamias quadrivittatus, Squaw Flat Campground, Canyonlands National Park, Utah (1975).

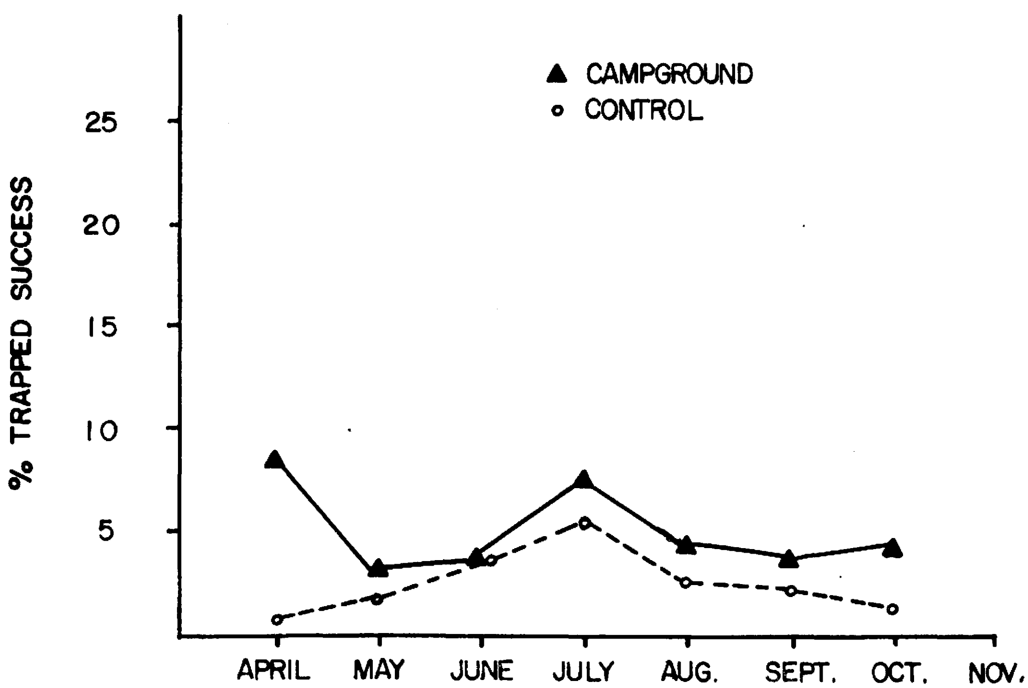

Figure 8. Trapping success for Eutamias quadrivittatus, Devil's Garden Campground, Arches National Park, Utah (1975).

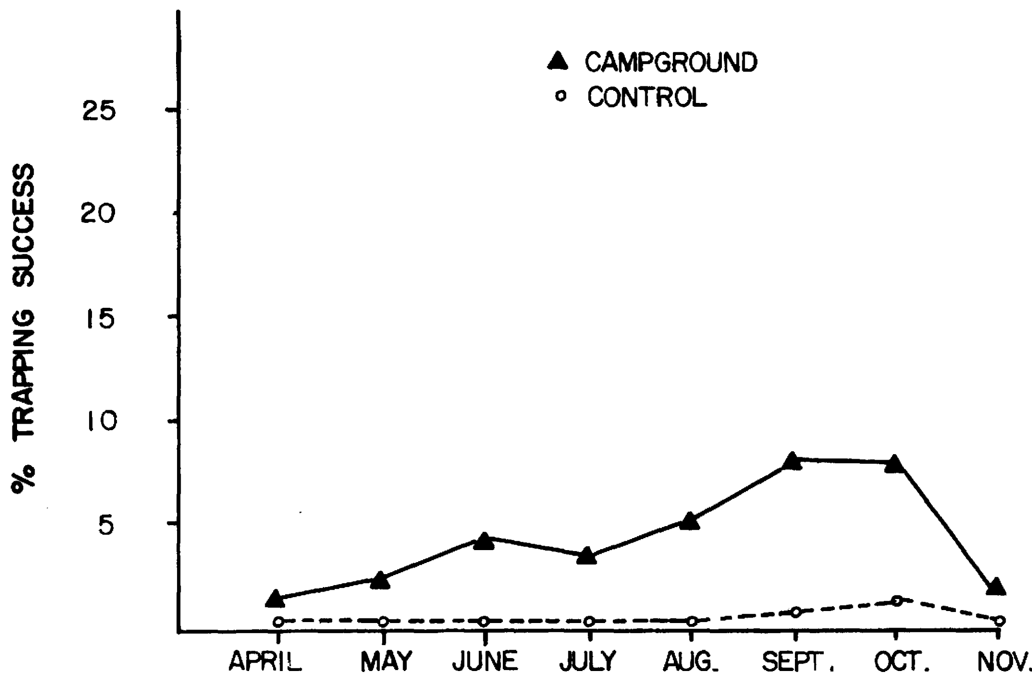

Figure 9. Trapping success for Neotoma spp., Squaw Flat Campground, Canyonlands National Park, Utah (1975).

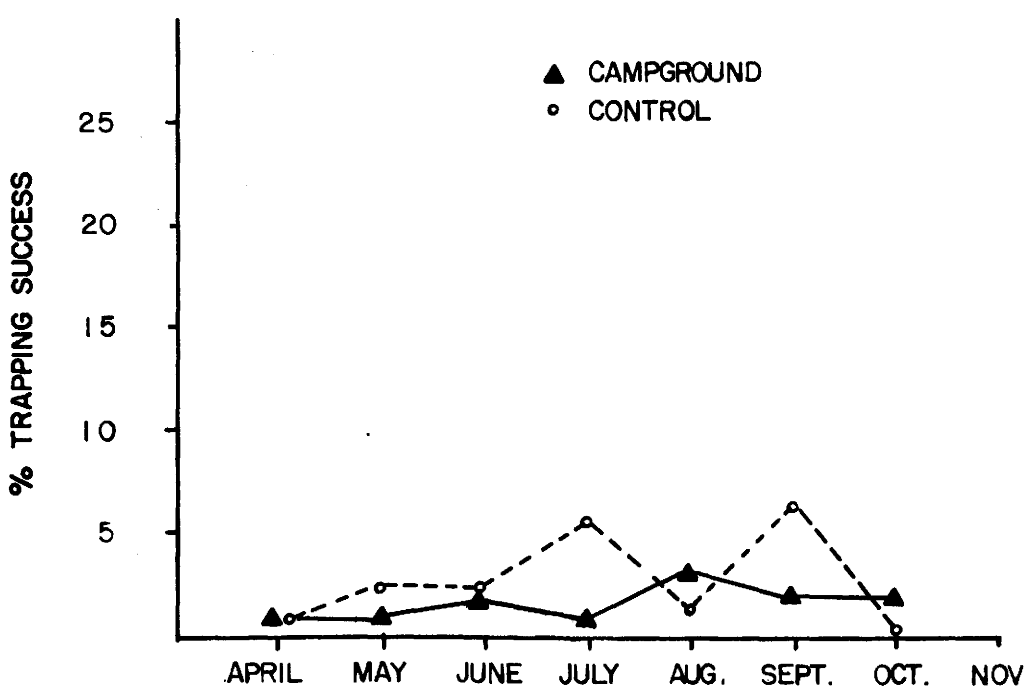

Figure 10. Trapping success for Neotoma spp., Devil's Garden Campground, Arches National Park, Utah (1975).

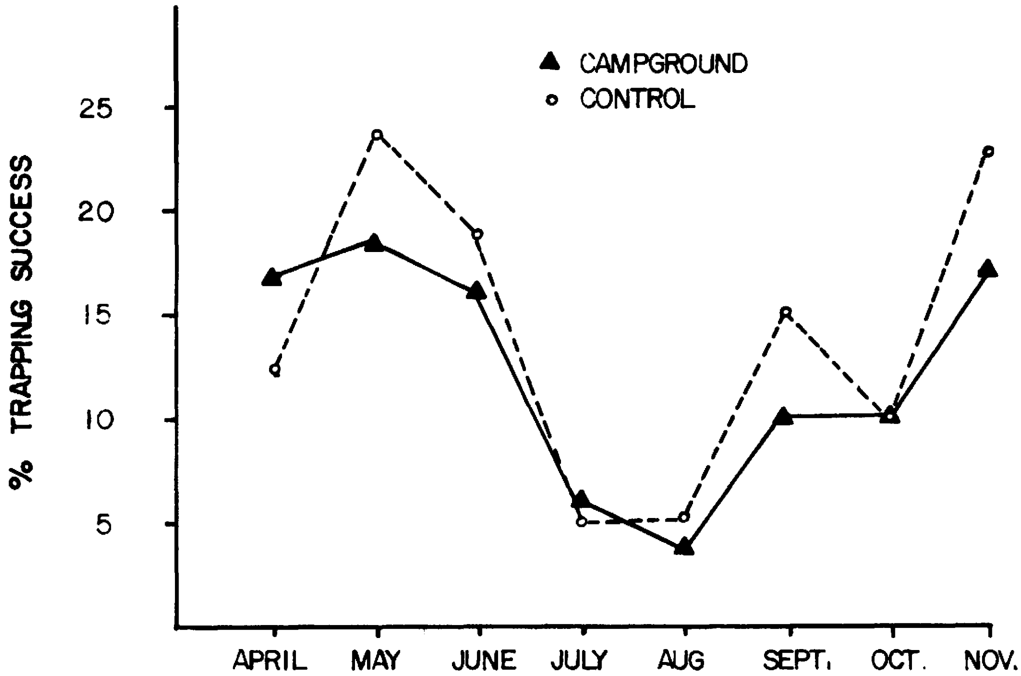

Figure 11. Trapping success for Dipodomys ordii., Squaw Flat Campground, Canyonlands National Park, Utah (1975).

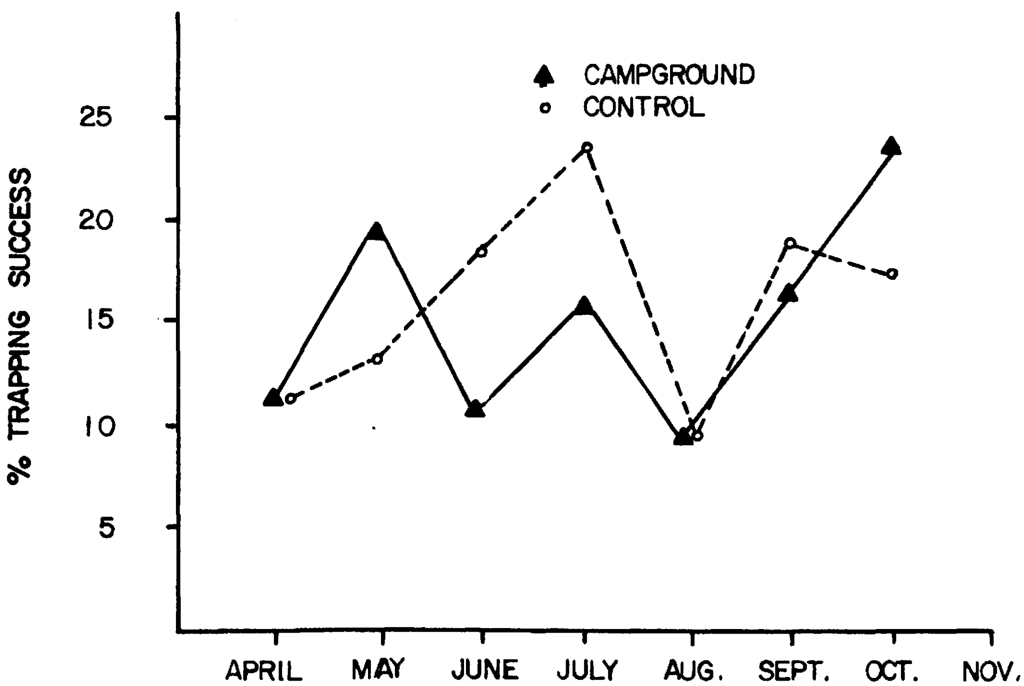

Figure 12. Trapping success for Dipodomys ordii, Devil's Garden Campground, Arches National Park, Utah (1975).

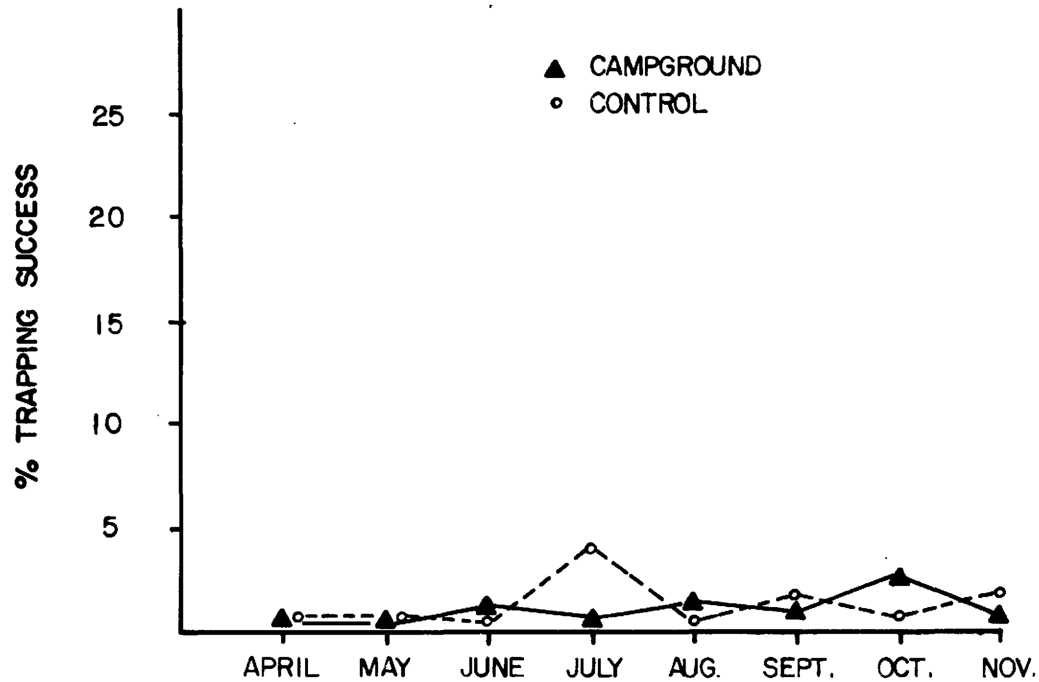

Figure 13. Trapping success for Sylvilagus audubonii, Squaw Flat Campground, Canyonlands National Park, Utah (1975).

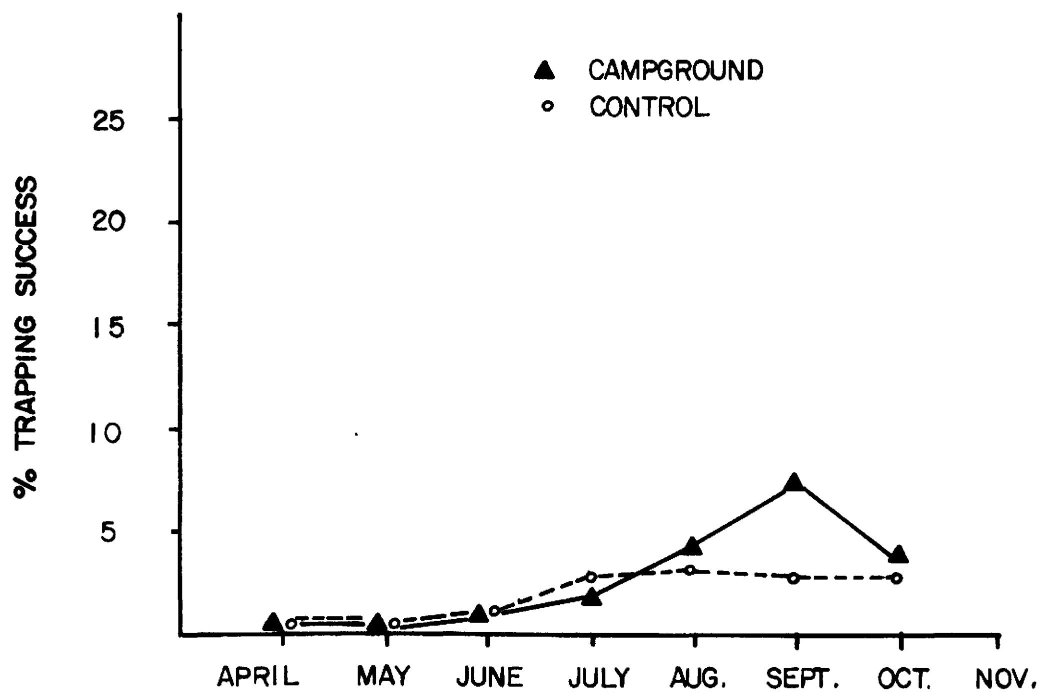

Figure 14. Trapping success for Sylvilagus audubonii, Devil's Garden Campground, Arches National Park, Utah (1975).

Hansson (1967) and Wiener and Smith (1972) demonstrated the importance of trap type (life vs. snap trap) and efficiency, and they concluded that these two factors were important to consider when evaluating results of small-mammal trapping studies. Additionally, Kenagy (1974) and O'Farrell (1974) pointed out that seasonal activity patterns of heteromyids can change and can have an effect on trapping results as well as can previous response to a trap by an individual Getz 1961).

Most, if not all, of the factors just reviewed were probably operative during this study at one time or another. Some of the factors such as weather (precipitation, temperature, wind, and barometric pressure), moon phase, and trap type were constant between the respective campgrounds and control areas. Other factors, such as food availability and human activity, were not the same for the campground as they were for the control area at any given time.

Some species, such as the antelope ground squirrel (Figures 5 and 6), Colorado chipmunk (Figures 7 and 8), and Ord's kangaroo rat (Figures 11 and 12) appear to show a general similarity in trapping success (within species) between the campground and control area. Other species, such as woodrats (Figures 9 and 10), and deer mice (Figures 3 and 4) seem to display little similarity in their response to live trapping.

Trapping success increased between June and August in 19 out of the 24 cases observed and declined during August and/or September in 17 out of 24 instances (Figures 3-14). The increase in trapping success between June and August can be attributed, at least in part, to recruitment, as many juveniles were caught during this period.

The decline in trapping success during August and September was followed by an increase in trapping success during September and/or October in 16 instances (Figures 3-14).

This general decline in trapping success followed by an increase in success in September and/or October could be the result of (1) a population decline during this period followed by an increased trap susceptibility of those individuals remaining in the population; (2) some internal or external influence that decreases trap susceptibility during the late summer period despite a relatively high population level; or (3) some interaction of these factors.

Weather. O'Farrell (1974) found that extreme weather conditions can depress trapping success. During the months of August and September, however, there were no cases of violent thunderstorms or abnormally hot or cold temperatures. Precipitation during August and September for Squaw Flat and Devil's Garden was 0.9 and 1.4 cm, respectively (Table 3). This precipitation was provided by a few scattered thundershowers, none of which was severe or of more than a few minutes' duration. Temperatures were close to the eight-year average for Squaw Flat (Table 1). Although no long-term temperature data are available for Devil's Garden, it can be assumed that the temperatures listed in Table 2 are representative for this area because of the lack of any abnormal temperatures in the adjacent Island in the Sky District of Canyonlands National Park.

Food availability. Increased food availability has also been mentioned as a possible cause of low trapping success. A situation of increased food availability occurred for some species during August and September. Four-wing saltbush matured in mid-August, and antelope ground squirrels were often seen climbing into saltbush plants and feeding on the seeds. Pinyon pine nuts also matured in late August, and Colorado chipmunks were observed gathering these nuts throughout the day.

Camping activity. Camping use at Squaw Flat increased from 1,750 persons in July to 4,400 persons in August (Table 4), and increase of 151 percent. It might be that increased camping use provided more food for small mammals, thereby lowering trap susceptibility. Devil's Garden camping use, however, increased only from 5,392 persons in July to 5,523 campers in August (Table 4), or only a two percent increase. Small mammals at the Devil's Garden campground still underwent decreased trap susceptibility. Additionally, small mammals inhabiting both of the respective control areas, which were subjected to relatively little human activity, also underwent a decline in captures.

SUMMARY

The purpose of this study was to compare the populations of small mammals inhabiting campgrounds and non-campground areas used as a control. The data collected are suggestive that campgrounds can have an effect on populations of some species of small mammals inhabiting them. There were four instances where a statistically significant difference in the number of captures of small mammals occurred between a campground and its respective control area. In three of the four instances where differences in capture rate existed, there were more captures in the campground than in the control area.

The factors responsible for the different populations of small mammals are not entirely clear. Additional food made available by camping activity could allow populations to increase to a higher level in campgrounds than in non-campground areas. A lower predation rate in campgrounds may also influence populations of small mammals.

Although campgrounds and their associated use appear to allow an increase in population levels of some species in some cases, a straight-line relationship between campground use and population levels of small mammals probably would not apply. Populations of woodrats might decline because of a lack of ground cover and nesting materials caused by intensive camping activity. Desert cottontails might be unable to tolerate continued high levels of human acitivity.

When evaluating the effects that a campground may have on a population of small mammals, it should be stressed that a very complex system is being dealt with. Interactions among and between species, innate and learned responses to human activity, weather, and food supply all may influence population levels and measurements of population levels to some extent.

Further investigation is needed to gain an understanding of how campgrounds actually effect populations of small mammals. Most basic to this research is a food habits study in which specimens are collected throughout the year in campgrounds and stomach contents analyzed. It is necessary to know to what extent various species of small mammals utilize the potential food resource provided by camping activity and the extent to which they are able to change between a diet of garbage and natural food during periods of intensive camping activity and periods of little or no camping use.

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Master of Science

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Major Field: Wildlife Science

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Honors: Xi Sigma Phi Scholastic Honorary Society; graduate research assistantship through Utah Cooperative Wildlife Research Unit.

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