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STUDIES OF THE RELATIONSHIP BETWEEN DESERT BIGHORN AND FERAL BURRO IN THE BLACK MOUNTAINS OF NORTHWESTERN ARIZONA

by

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABSTRACT

This study of the relationships between desert bighorn sheep and feral burros was conducted in Warm Springs Canyon of the Black Mountains, Mohave County, Arizona from July 1962 to September 1963.

Sheep and burros were located and observed to determine their feeding and watering patterns, their daily movements, and their seasonal distribution. Samples of the contents of eight sheep stomachs were collected during the 1962 and 1963 sheep hunts through the cooperation of the hunters and the Arizona Game and Fish Department. The Arizona Livestock Sanitary Board issued the permit necessary for collecting nine burros for stomach contents samples. These samples were analyzed for comparative occurrence of food items.

Sheep and burros were frequently found near the springs during the summer months. Here they fed on the same plant species, drank at the same times of day, and used the same shade to avoid the heat.

Although no direct harm to the sheep could be attributed to the burros, it is felt that under limiting conditions they could have a negative effect.

INTRODUCTION

Since the Europeans came to the Southwest, there has been a decline in desert bighorn sheep populations. Many biologists who have studied the bighorn have cited the feral burro as a major competitor, and some believe that the burro seriously interferes with the welfare and increase of bighorn populations. Much has been said for and against the burro, but no studies have been conducted to gather quantitative information on its effects on the bighorn.

McKnight (1958) and others have encouraged a study to determine more precisely the role of the burro as it affects the bighorn. Wells and Wells (1961) made a four month study of the burro in conjunction with their study of the Death Valley bighorn. They reported no acute competition, but encouraged further investigation.

The objectives of this project were to study the relationships between the desert bighorn and the feral burro regarding food and water. Any other effects of the burro on the sheep, both direct and indirect, were also investigated.

Field observations were made to determine the daily activities of both species. Eight sheep stomachs were collected during the 1962 and 1963 hunts. Arrangements were made with the Livestock Sanitary

Board to collect feral burros for stomach samples. These samples were analyzed to determine if these feral burros and bighorn competed for particular food plants. Field work began in July, 1962, and was terminated in September, 1963.

STUDY AREA

Warm Springs Canyon of the Black Mountains, Mohave County, Arizona was used as a study area (Figure 1). This area lies within T 17 and 18 N, and R 19 and 20 W, Gila and Salt River Base and Meridian. The Black Mountains parallel the Colorado River from Hoover Dam to Topock. Russo (1956), McKnight (1958), and Buechner (1960) considered these mountains to have dense populations of both bighorn and burros.

The whole range is of volcanic origin, mostly basalt. The south end is cut off by a rhyolite formation. The Warm Springs is made up of a series of three artesian springs that are present along the contact zone of these two geologic formations. Except for three seeps on the rhyolite formation there are no other springs for 5 miles. This distance nearly isolates the bighorn and burro populations which use the Warm Springs area during the dry part of the year.

Topography

The basaltic area is characterized by flat mesas cut by deep, steep-sided canyons. The surface is covered with broken rubble. The rhyolite forms rugged cliffs and slopes that jut abruptly above the deep canyons. From the base of the mountain an alluvial fan drops off

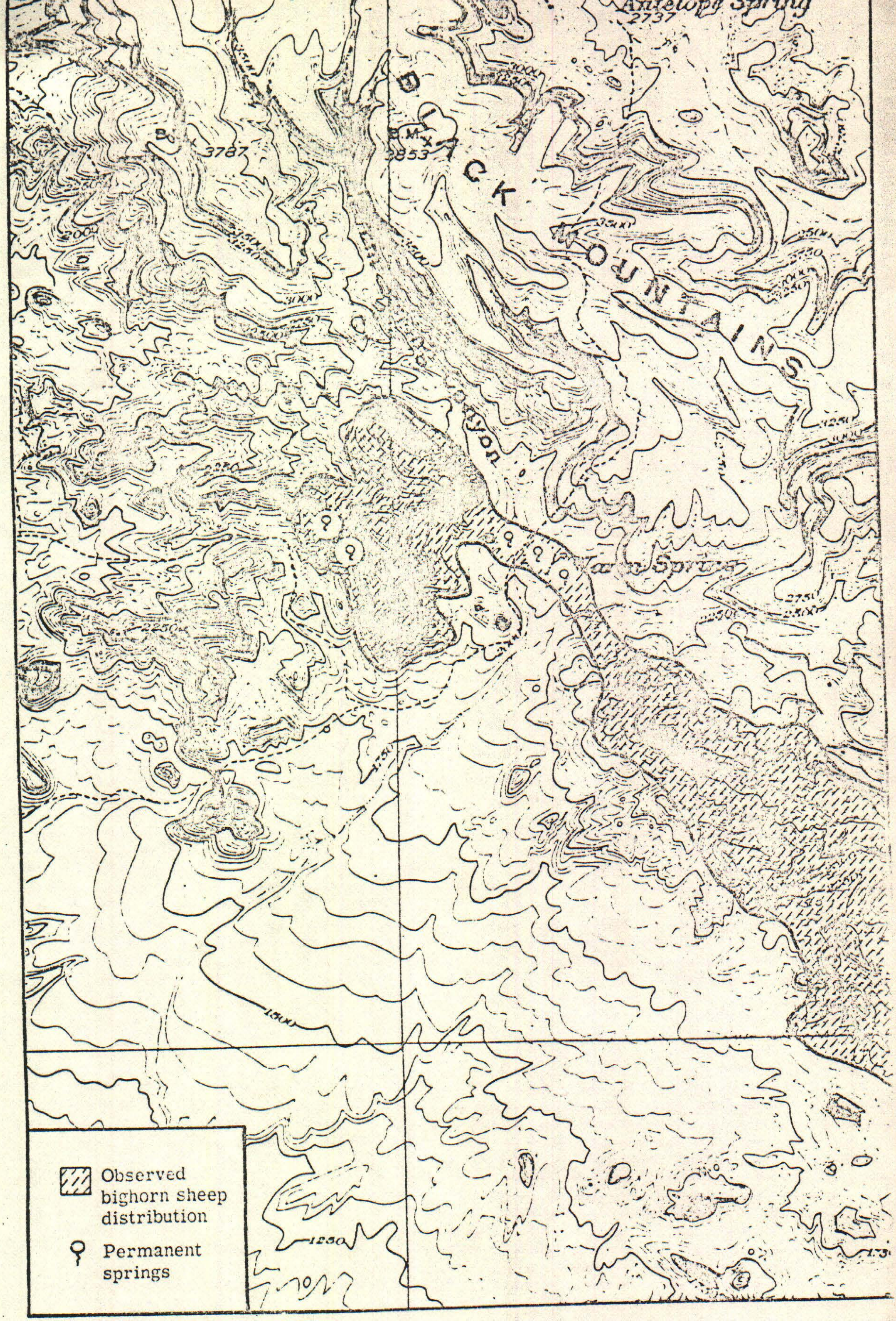

Figure 1. Map of the study area.

toward the Colorado River (Figure 2). This fan is about 12 miles wide at the narrowest place.

The elevations of the study area range from 1250 to 3853 feet above sea level. The springs are at an elevation of 2033 feet.

Climate

During the study maximum and minimum temperatures were recorded by a U-tubed Taylor thermometer, and precipitation was collected in an accumulating rain gauge (Hungerford, 1960). The extreme temperatures recorded between October 3, 1962, and September 3, 1963, were 114 and 26°F. Precipitation totaled 2.53 inches during the period from August, 1962, to September, 1963. There were no nearby weather stations that could be used as a source of climatalogical records.

Vegetation

The area includes both Sonoran and Mohave Desert vegetation. The alluvial fans, canyons, and south facing slopes are in the Sonoran Desert. Dominant plant species in the Sonoran desert area are foothill palo-verde (*Cercidium microphyllum*),[1] creosote-bush (*Larrea tridentata*), brittle-bush (*Encelia farinosa*), ocotillo (*Fouquieria splendens*), and white ratany (*Krameria Grayi*). The riparian communities

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1. Scientific names of plants in this thesis are from *Arizona Flora*, T. H. Kearney and R. H. Peebles, University of California Press, 1951.

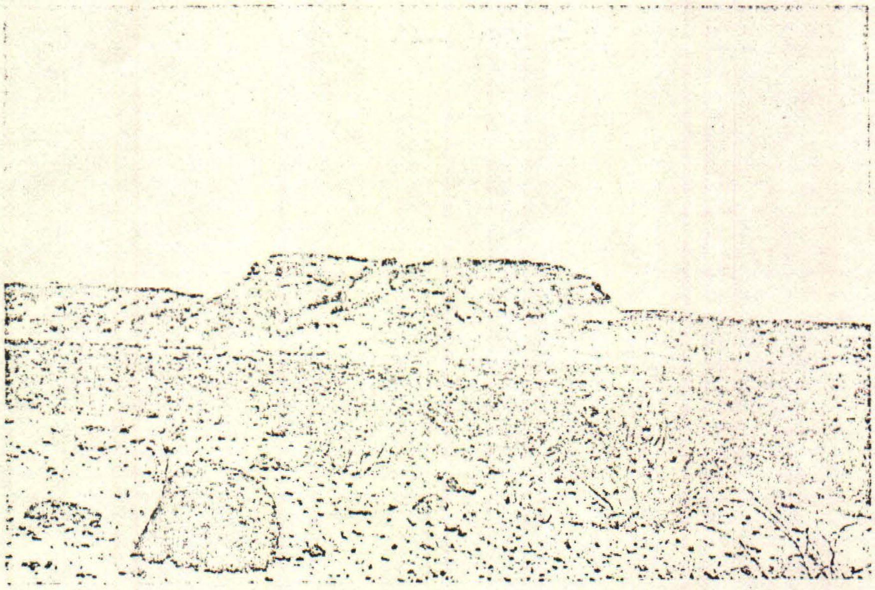


Figure 2. Topography of the study area.

In the foreground can be seen the alluvial fan; in the center, the rhyolite formation; and in the far background, the basalt mesas.

along the washes and around the springs are composed of willow (*Salix Gooddingii*), velvet mesquite (*Prosopis juliflora* var. *velutina*), screw-bean mesquite (*P. pubescens*), seep-willow (*Baccharis sarothroides*), gray-thorn (*Condalia lycioides*), and desert-willow (*Chilopsis linearis*).

The mountain and mesa tops and the north facing slopes have a vegetation representing the Mohave Desert. Dominant species there are Mohave yucca (*Yucca schidigera*), black-brush (*Coleogyne ramosissima*), bear-grass (*Nolina Bigelovii*), jointfir (*Ephedra* sp.), California buckwheat (*Eriogonum fasciculatum*), and golden-eye (*Vigueria deltoidea*). Other plants and their relative abundance are shown in the Appendix.

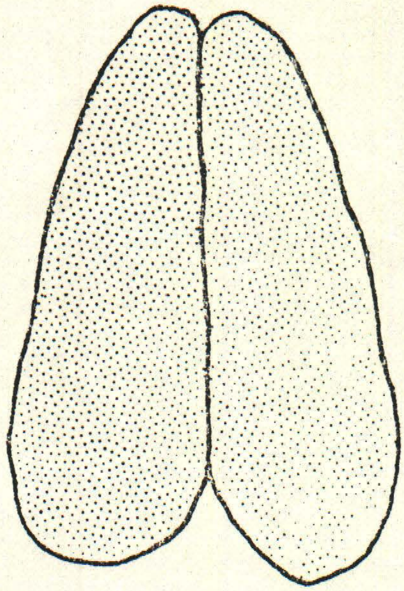
METHODS AND MATERIALS

Survey Techniques

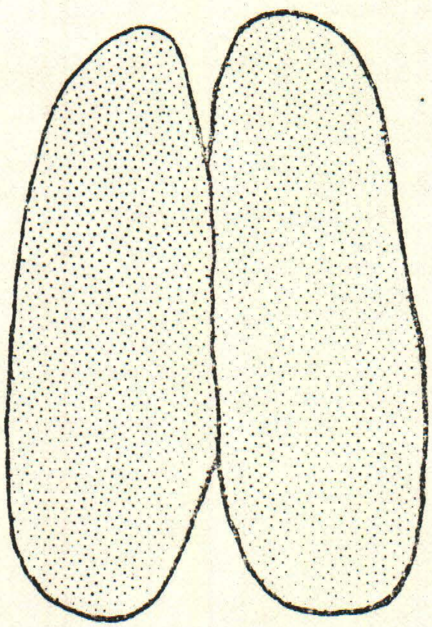
I covered the study area regularly by walking along predetermined survey routes. Observation points were used to search large areas where animals were likely to be found. When animals had not been located by mid-afternoon, I returned to the springs to observe animals coming in to water.

Tracks and sign that indicated recent use were also noted along these survey routes. When it was learned that desert mule deer used part of the area, a comparison of tracks was made in order to distinguish deer from sheep (Figure 3). After some practice clear tracks could be identified, but on rocky and gravelly soil positive identifications could not be made.

Animals were located and observed with the aid of 8 X 50 binoculars and a 27 X spotting scope. The short tripod base of the scope was modified by attaching extendible camera tripod legs with 1 inch hose clamps. This modification allowed me to use the scope from a sitting rather than a prone position. By using the pivot of the spotting scope base, areas could be searched in a horizontal grid pattern. Figure 4 shows the assembly in use.



Desert Mule Deer Buck
Front Foot



Desert Bighorn Sheep Ram
Front Foot

Figure 3. Comparison of desert mule deer and desert bighorn sheep tracks (actual size).

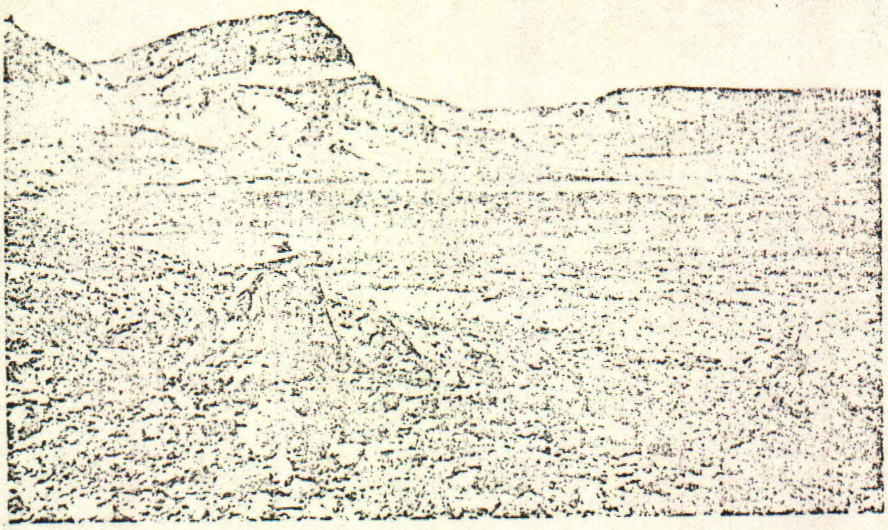


Figure 4. The spotting scope and modified tripod used for locating and observing animals.

When sheep were found, they could easily be approached as long as I remained in sight of them. Some animals appeared nervous when I was present and would not feed, but after a short period of time most animals resumed feeding. If I tried to conceal myself, the sheep became curious and approached closely or became frightened and took flight. When sheep started moving away, pursuit only made them move faster.

Like sheep, burros also have well developed eyesight and usually detect any movement. When they saw me they stopped feeding, stood, and watched. For this reason, it was necessary, when approaching them, to remain hidden or to make observations from established stations. Light colored clothing and shiny objects seemed to increase the chances of my being detected. Of the 17 sheep observations made, 64 percent provided feeding minutes, while only 18 percent of the 156 burro observations produced any results.

In addition to feeding minutes, notes were taken on distribution and movements, daily activities, sex and age composition of herds, and identifying characteristics of individuals. Sheep could be identified by their horn characteristics or by body scars (Figure 5). Burros could be identified by color, scars, and shoulder and leg markings.

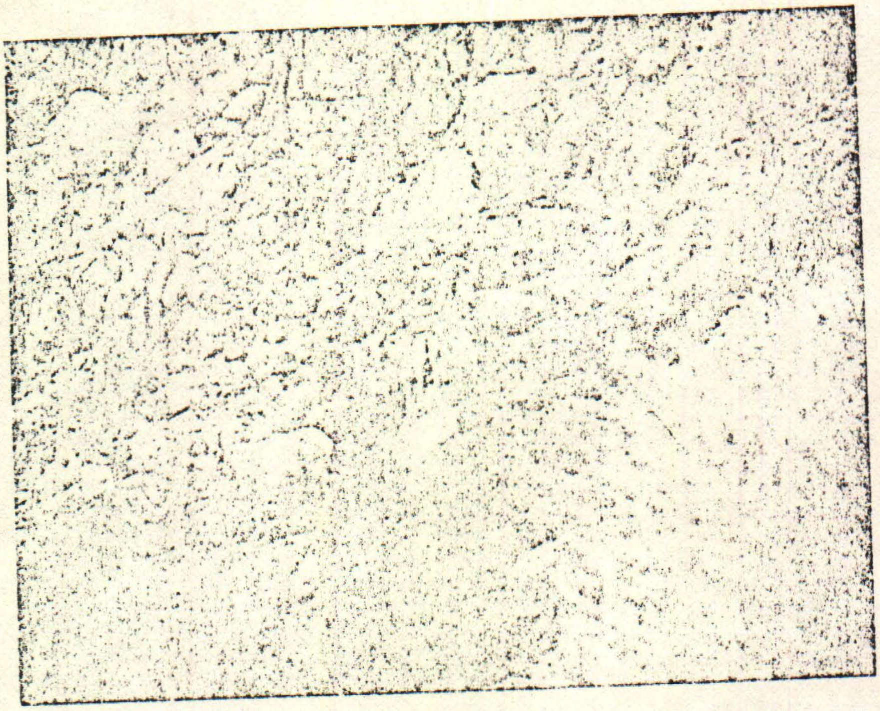


Figure 5. Identifying horn characteristics.

The ram to the right illustrates the use of horn characters to identify individuals.

Food Habits Determination

When animals were found and successfully approached the feeding minute technique as described by Buechner (1950) was used with the following modification. The time to the closest .05 of a minute or 3 seconds that an animal fed on each plant species was measured. A stop watch indicating minutes, tenths, and hundredths of a minute was used to facilitate computation. These data were totaled, and the percentages were computed to give the relative importance of the food item in the diets of both animals. The relative abundance of the plants was also considered. Burro observations were terminated when sheep were encountered because burro sightings were more frequent.

During the 1962 and 1963 sheep hunts, hunters were given kits consisting of plastic bags and formalin, and were asked to save samples of stomach contents from bighorn sheep (Figure 6). In 1962, hunters in Mohave County turned in three stomach samples from bighorn sheep. In 1963, Arizona Game and Fish Department personnel collected five stomach samples for me from successful hunters in this same area. A permit to collect feral burros for stomach samples was obtained from the Arizona Livestock Sanitary Board, and nine stomachs were collected. All of the sheep stomachs were collected in December; and burro stomachs were collected in February, April, May, and July.

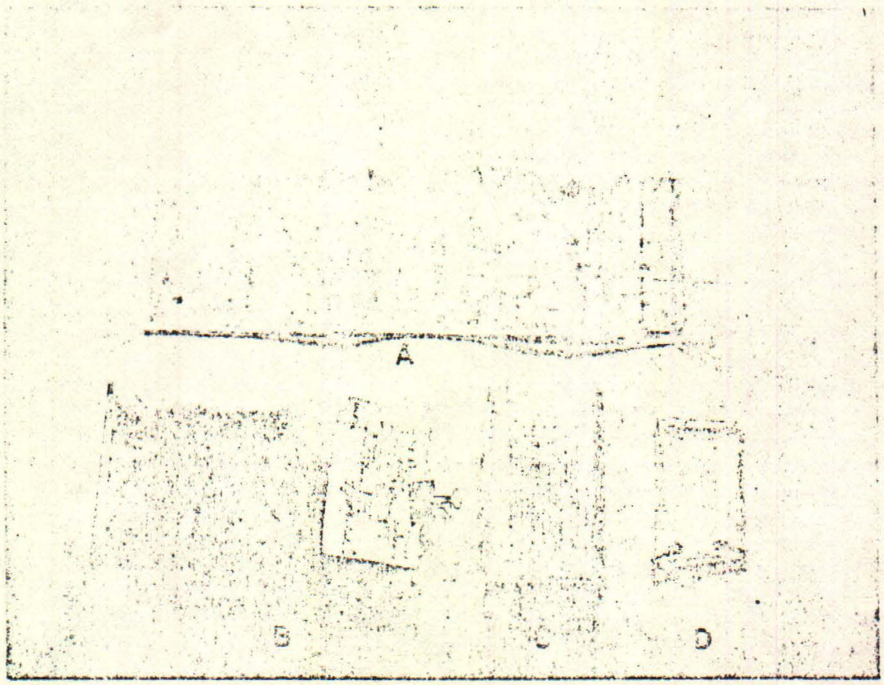


Figure 6. Kit distributed to hunters for the collection of sheep stomach samples.

A. Double plastic bag.
B. Kit with stomach contents sample.
C. Complete kit.
D. Plastic sample bag from Nasco Co. with formalin.

As soon as possible after collection the samples were washed and then preserved in 10 percent formalin solution. These were later analyzed to determine the percentage of forbs, grasses, and shrubs present. The occurrence of plants that could be identified as to species was also recorded. It was not possible to compute the percentages of individual species because of the masticated condition of the samples. Because of rumination there was a noticeable difference in particle sizes between samples taken from sheep killed early in the morning and those that had been killed later in the day. Because the burros so thoroughly masticate their food, stomach samples were hard to analyze regardless of the time of day they were collected.

Vegetation Determination

In order to determine the composition of the spring vegetation, three sampling methods were tested. Both the line intercept and strip mapping methods were too time consuming. The method finally adopted was a frequency method using a metal meter square drop frame with a one-tenth meter subdivision in one corner. Seven transects, each 50 chains long, were selected in the various vegetational types. At each chain the frequency of annual, perennial, and shrub and tree growths was recorded within 1/10, 1, and 10 meter squares respectively. All unknown plants were collected, pressed, and identified later. The data collected from these transects are presented in the Appendix. Other plants that did not occur on the transects but that were locally abundant were also collected.

Interviews and Additional Surveys

In addition to the surveys made in Warm Springs Canyon, several other areas of sheep range were visited. After the 1962 sheep hunt, trips were made to two areas where sheep had been killed and the stomach samples collected. Plants were collected to aid in analysis of the samples.

In June of 1963 one week was spent on the Cabeza Prieta Game Range aiding in the annual waterhole survey and obtaining additional observations of sheep watering.

Biologists that are familiar with the desert bighorn were interviewed both at their offices and at the annual Desert Bighorn Council meetings. Much was gained from talking to these experienced men.

RESULTS

Populations

The Warm Springs area shows signs of having been long inhabited by sheep. Petroglyphs of sheep have been carved upon rocks near the springs by prehistoric Indians. Arrowheads, percussion gun parts, and early cartridge cases also give evidence of hunting in the past. The latter were found around rock blinds that were placed in strategic passes, such as between isolated ridges and the main mountain range. Bill Musgrove of Kingman suggests that some hunters hid in these blinds while others drove the sheep off the ridges and back across the passes toward the main mountain range. Fred Harvey of Ensinitas, California, who has visited the area regularly for the past 30 years, states that he has found evidence of poaching in recent years.

Burros also have been reduced on the area. J. G. Waters, a retired Oatman mining engineer now living in Kingman, states that during the 1920's and 1930's the burro population in the Black Mountains was almost eliminated by trappers. There is still a trap and holding corral at Warm Springs. In more recent years ranchers, hunters, and others have shot large numbers of burros in the Black

Mountains, and many bleached skeletons were found during the study.

While these examples do not give any figures of harvest, they do indicate that the area has been at least fair sheep range and that it has withstood some harvest in the past. It is felt that under proper management the area could again become a productive sheep range.

On the Warm Springs study area 15 separate individual sheep were seen. It seems probable that there were an additional ten animals on the area. This gives an estimated population of 25 sheep. The observed sex ratio was .83 ram per ewe, and the observed lamb ratio after June 1, 1963, was one lamb per ewe.

It was more difficult to estimate the burro population. As many as 49 burros were seen on one side of the study area in one day. I believe that the number of burros using the study area throughout the year was about 100 head. The observed sex ratio was two jacks for each jenny. The departure from a more even sex ratio, which one would expect, may be because of the polyandrous mating habits of the burros. When jennies are in breeding condition they are attended by a herd of jacks, and when not they are found alone or in small groups with their colts. The large groups are more obvious; therefore, they are more frequently found. The observed colt ratio was .62 colt per jenny.

When comparing sheep and burros, it is necessary to consider biomass to arrive at valid estimations. The standard method for evaluating range use is the animal unit based on 1000 pounds of body weight. Russo (1956) found that sheep he collected averaged 150 pounds. Nishihawa (1959) found that five to eight year old Mongolian asses ranged from 566 to 647 pounds. No references could be found for the weights of western feral burros, but I would estimate it to be 500 pounds. Therefore two burros or six sheep would equal one animal unit.

Movements

The maximum distance moved by individual sheep was 6.5 miles. On February 14, 1963 a herd of two ewes with lambs and a yearling ram was seen bedding down. The next day they were found 2 miles away at 2:25 p.m. Assuming that they had not moved from their beds until dawn, they would have covered this distance in about seven hours. By 4:10 they had moved another mile, but this was under the stress of being pursued. One month later the same herd was seen on the far side of the study area. They were seen two other times during the study within a one-half mile radius of this second location. One mature ewe was seen six times within a radius of one-half mile.

Individual burros were observed moving a maximum distance of four miles. This movement, like that of the sheep, was also made during the cooler part of the year. Burros seem to return to the same areas summer after summer thus indicating a seasonal home range.

Several individuals were seen in the same vicinity during both summers.

Distribution

The summer rains which come in August and September break the annual drought and bring a change to the physical habitat of the study area. This precipitation is not evenly distributed. Narrow strips that are flooded produce new growth on dormant plants. In adjacent places which receive only slight precipitation, the plants remain dormant. Because of this green feed and cooler temperatures, the animals were widely distributed over the area and were extremely hard to find.

During the fall and winter sheep were not seen. Occasionally fresh sign was found in the mountainous areas although it was not nearly as abundant as it had been during the summer. During this same period Simmons (1963), studying bighorn on the Cabeza Prieta Game Range, found fresh sheep sign along the washes and in the lower foothills. Russo (personal communication, April 6, 1964) said he found sheep on the basaltic mesas of the Black Mountains during the cooler months.

Burros, also, were not located as frequently as they had been during the dry periods, but a few were seen and fresh sign was found. Their observed maximum daily range changed from 2 1/2 miles to 6 miles. The most frequent sightings were along the alluvial fans and basaltic mesas. The burros remained dispersed until March, when they began moving back into the areas around the springs.

In the spring ewes moved back onto the high mountain benches to have their lambs. Yearlings were with them, but no rams were found. The sheep bedded and fed during the day on the open slopes. As the temperatures rose they tended to feed earlier in the morning and later in the evening. They sought the shade of the cliffs and rocks during the daytime.

The higher temperatures also made the burros seek shade. They could be found standing under trees or in the shade of rocks and cliffs. It was during this period that the sheep and burro ranges seriously overlapped. Dung of both animals in the shady areas indicated that they used the same areas.

During this study I saw sheep in the presence of burros only once. On September 21, 1962, a ewe and a ram approached a herd of nine feeding burros in the high foothills. When the burros moved toward the sheep, the sheep moved away, thus maintaining a distance of about ten yards. After 20 minutes the sheep moved rapidly past the burros and on around the mountains. While there was no sign of outward aggression, the sheep did seem shy in the presence of the burros.

No evidence was found of the mule deer's range overlapping that of the bighorn. The mule deer were never seen more than a few hundred yards from the main washes. The burros use this area heavily, and they could compete directly with the deer. No evidence of this was collected during this study.

Feeding

During the study a total of 125 feeding minutes was recorded for sheep and 380 minutes for burro. Table 1 indicates the most prominent plant species used during each season. The relative abundance of the species is also indicated.

In the fall and winter sheep and burros were able to obtain a large amount of their water from the green vegetation. This allowed them to feed in areas that were beyond their range during other seasons. Forage was abundant in these areas, and there was no competition for food.

As the daily temperatures began to rise in the spring, the animals were restricted to the vicinity of the springs by their water requirement. At this time burros fed largely on winter annuals and sheep on green shrubs.

Table 2 lists the percent of time spent feeding on each plant that was eaten during the entire study. Those listed as traces were either not timed or were recorded as less than one percent. As can be seen from the table, ocotillo, catclaw, and forbs are important in both diets. Scientific and common names of plants mentioned are given in the Appendix. Sheep were never seen feeding on palo-verde, nor

Table 1. Comparison of the percent of observed feeding time spent on preferred plants by desert bighorn and feral burros during the four seasons.

Plant		Percent of Feeding Time	
Common Name	Relative Abundance	Sheep	Burro
June-August			
Perennial grasses	L	22	0
Catclaw	M	17	9
Golden-eye	M	13	0
Dry forbs	H	12	55
Brittle-bush	H	5	12
Ocotillo	M	0	12
Others		31	12
September-October*			
Palo-verde	H	-	81
Catclaw	M	-	18
Brittle-bush	H	-	Trace
Ocotillo	M	-	Trace
December-February**			
Brittle-bush	H	Trace	-
White bur-sage	H	Trace	-
Perennial grasses	L	Trace	-
Globe-mallow	M	Trace	-
March-May			
Ocotillo	M	78	7
Green forbs	H	9	64
California buckwheat	M	8	Trace
White bur-sage	H	5	0
Palo-verde	H	0	21
Catclaw	H	0	5
Others			3

*No feeding was observed for sheep

**No minutes could be recorded for either species, but sheep were seen feeding on these plants.

L = low; M = medium; H = high

Table 2. The percent of observed feeding time spent on various plants during the entire period of the study.

Plant		Percent of Feeding Time	
Common Name	Relative Abundance	Sheep	Burro
Ocotillo	M	18.5	7.7
Dry annuals	H	17.8	54.3
Perennial grasses	L	17.0	0
Catclaw	M	13.1	8.0
Golden-eye	M	10.0	0
Bear-grass	M	5.4	0
Brittle-bush	H	3.7	6.2
Sandpaper-plant	L	3.6	0
Jointfir	H	2.2	0.9
Bladder-stem	L	2.1	0
California buckwheat	M	2.0	Trace
White bur-sage	H	1.1	0
Palo-verde	H	0	19.6
Desert-lavender	H	0	0.9
Experimental feeding*			

*One male lamb was seen feeding on buzzard feathers and a bird's nest.

L = low; M = medium; H = high

were burros ever seen feeding on grasses; but both plants occurred in stomachs that were collected. Russo (1956) found that sheep took palo-verde, and Browning (1960) found that grass made up ten percent of the burros diet in Death Valley.

Laboratory analysis of the nine feral burro stomach samples revealed an average composition of 1 percent grasses, 11 percent shrubs, and 88 percent forbs. The high occurrence of forbs may be because the burros were collected during the spring and summer when these plants were most plentiful. Indian-wheat was the most abundant of these, and it was readily eaten. Collections should be made at other times of the year to indicate the seasonal change in diet.

The analysis of the eight sheep stomachs, collected in December, revealed 33 percent grasses, 39 percent shrubs, and 28 percent forbs. Table 3 shows the frequency of plants that occurred in the stomachs analyzed.

Table 3. The frequency of plants in stomach contents samples of eight sheep and nine burros.

Plant		Frequency	
Scientific	Common	Sheep	Burro
Acacia Greggii	Catclaw	2	0
Bebbia juncea	Bebbia	2	0
Boerhaavia Wrightii	Spiderling	2	0
Carnegiea gigantea	Saguaro	1.	0
Cercidium microphyllum	Palo-verde	2	1
Encelia farinosa	Brittle-bush	0	5
Ephedra sp.	Jointfir	3	2
Eriogonum fasciculatum	California-buckwheat	3	1
Fouquieria splendens	Ocotillo	1	4
Franseria dumosa	White bur-sage	0	1
Hyptis Emoryi	Desert-lavender	0	1
Opuntia sp.	Cholla	0	1
Peucephyllum Schotti	Pigmy-cedar	2	0
Physalis crassifolia	Ground-cherry	1	0
Sphaeralcia sp.	Globe-mallow	1	0
Tamarix pentandra	Tamarix	1	1
Annual grasses		1	3
Perennial grasses		5	0
Forbs		7	9

Of the two ways used to evaluate food habits, I believe that the feeding minutes method is the most reliable once the techniques of finding and observing animals are learned. After the data are collected, computations are easily made. It is impossible to collect an adequate sized sample of sheep stomachs to allow the investigation of the annual feeding cycle. Collection and analysis of burro stomachs is laborious and time consuming.

During the summer heat the plants either die or enter a dormant state. It is at this time that I believe acute competition for food exists. Both species feed on the same plants on a daily basis, but the burros have already removed much of the annual growth from the foothills and mountain slopes. These annuals might be necessary for lactating ewes and their lambs to survive the summer in good health.

The vegetation on areas near the springs and summer resting places showed damage by burro browsing. The palo-verde and mesquite trees were hedged to approximately 5 feet, and most branches less than 1/4 inch in diameter had been removed (Figure 7). The burros also fed on the terminal buds and bark of the dormant ocotillos. This gave the ocotillos a gnarled and branched aspect rather than the long slender form that they usually take (Figure 8). Catclaw and jointfir also showed hedging.

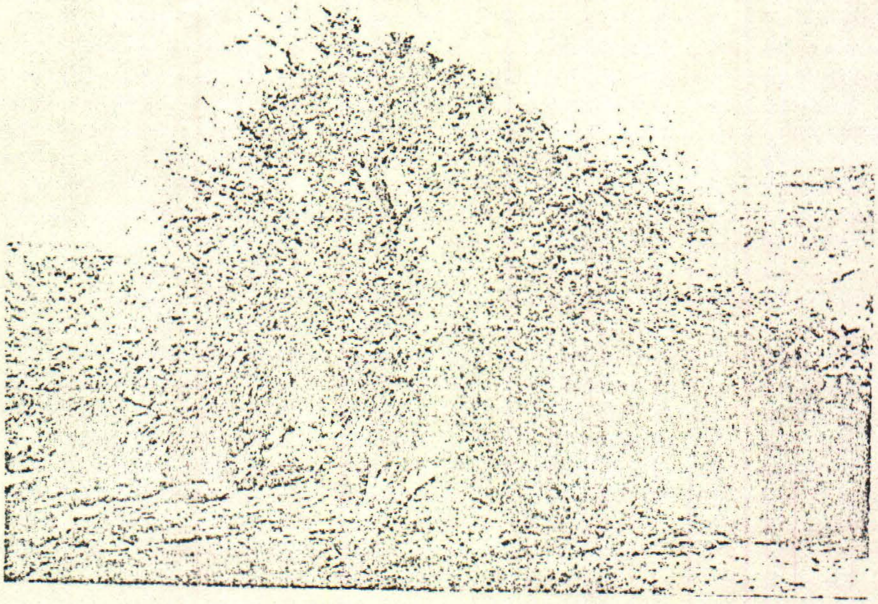


Figure 7. Mesquite tree at Warm Springs showing the browse line. Note the size of the twigs that are remaining.

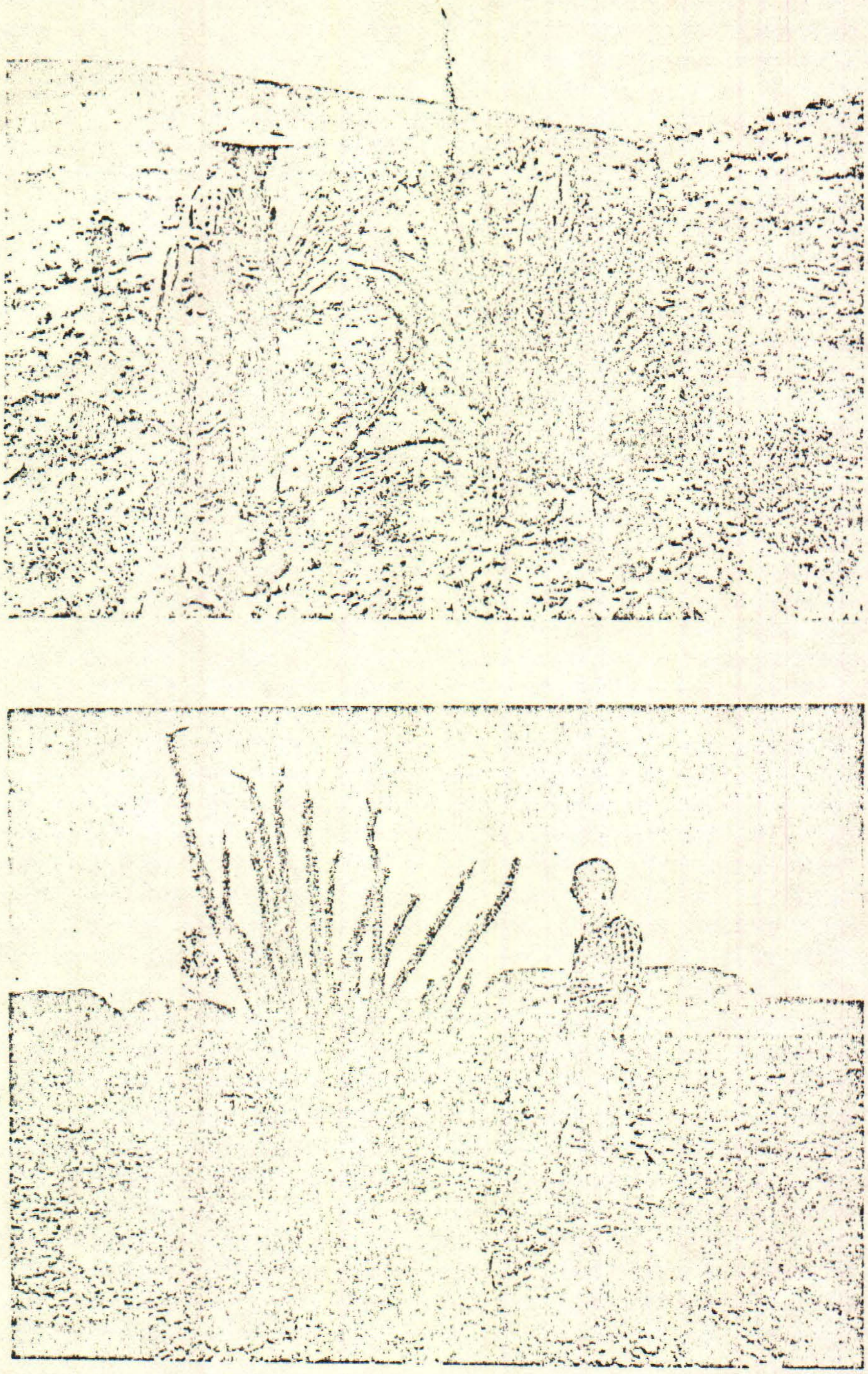


Figure 8. Comparison of ocotillo plants.

A. A heavily used ocotillo near Warm Spring.
B. A normal ocotillo away from the springs.

Watering

Burros were often seen coming to water on the study area, but sheep were seen only twice. It was, therefore, necessary to obtain additional observations from other sources. During the 1963 waterhole count on the Cabeza Prieta Game Range, I watched 15 sheep come in to water. John Russo of the Arizona Game and Fish Department, furnished me with times that he had seen sheep coming to water on various waterhole counts made throughout the state. These two sources were combined for comparison with the burro data collected on the study area.

The frequency of sheep and burros coming in to water during each daylight hour is shown in Figure 9. Sheep tend to water early in the morning or late in the afternoon, but they always return to the mountains before dark. Burros also come in to water later in the afternoon, but they remain in the vicinity of the springs until the following morning unless they are disturbed. They occasionally passed by my camp on dark moonless nights on their way to the springs. This watering schedule placed the sheep and burros at the watering areas during the same times of day.

Sheep were seen going 1 1/2 miles across rugged mountain terrain to a seep in the mountains rather than crossing a 1/2 mile flat to a spring in the open. The sheep came into the seep at a full run.

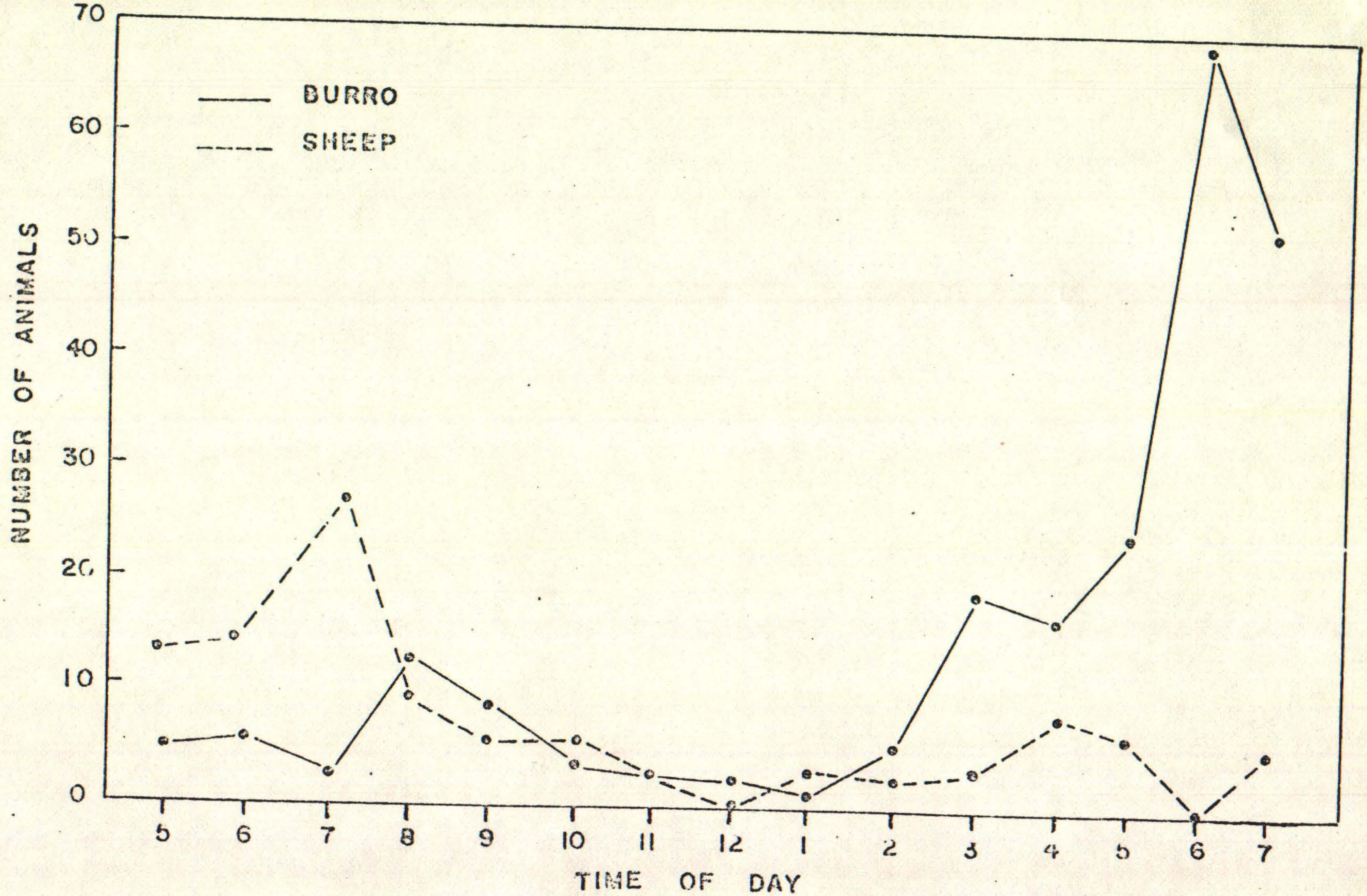


Figure 9. Observations of sheep and burros watering.

They covered 1/3 mile and dropped 1000 feet in elevation less than 5 minutes.

Several seeps were found where burros had pawed out the sand to form pools of water (Figure 10). Since one seep was less than 100 yards from a large spring, there appears to be some reason for their pawing other than a need for water.

Figure 10. Digging for water by burros.

The dark burro in the background is standing in a hole pawed in the sand to collect water. Photo by Arthur C. Risser.

CONCLUSIONS

In general it can be said that sheep inhabited the rocky mountainous areas and that the burros inhabited the flats and foothills. Burros were found, however, in all but the most inaccessible areas that were isolated by sheer bluffs. The area of highest overlap was in the upper foothills. During the summer months both sheep and burros stood in the shade of cliffs and large rocks to avoid the direct heat of the sun.

The browse plants in these areas were heavily hedged from overuse. Both species fed here during the summer, but during the rest of the year they were dispersed, and forage was abundant enough so that no competition existed.

In the Warm Springs area water was abundant, and there was no serious conflict for it. It was found that both species came to water most frequently during the same times of day. In areas where water is scarce, the burros could usurp the reserve that is necessary for the sheep to survive the drought periods.

There are two methods of controlling the burro in bighorn habitat. One would be to restrict their use of water, and the other would be direct control. If new water sources were developed in

...tions that were inaccessible to the burros, the sheep could use the areas around these developments for summer range while the burro could not. Present waterholes that receive use by both species could be enclosed by burro-proof fences or some other mechanical method to eliminate the burro from that area. This sort of ecological control would be more permanent than direct control.

Direct control is not advisable unless sufficient evidence of competition has been collected to convince the public of its need. Public sentiment is easily aroused, and laws completely protecting the burro could result. It is possible for burros to be controlled on special areas such as parks and game ranges. If such programs are carried out, studies should be made to measure the effect on the sheep populations. Such information could aid in more widespread control programs in the future.

APPENDIX

RELATIVE ABUNDANCE OF PLANTS ON THE WARM SPRINGS STUDY AREA DURING THE SPRING OF 1963

Mesa and Foothill Community		Abundance
Acacia Greggii	Catclaw	L
Asclepias subulata	Arizona milkweed	L
Astragalus Nuttallianus	Peavine	L
Bromus rubens	Foxtail brome	L
Carnegiea gigantea	Saguaro	VL
Cassia Covesii	Rattle-weed	L
Cercidium microphyllum	Palo-verde	M
Chorizanthe rigida	Rigid spiny-herb	L
Cryptantha sp.	Cryptantha	H
Cuscuta denticulata	Dodder	L
Dalea Fremontii	Fremont dalea	M
Delphinium scaposum	Larkspur	L
Encelia farinosa	Brittle-bush	H
Ephedra sp.	Jointfir	M
Eriogonum fasciculatum	California buckwheat	M
Eriogonum inflatum	Bladder-stem	L
Eriophyllum lanosum	Woolly eriophyllum	M
Erodium cicutarium	Filaree	L
Eschscholtzia glyptosperma	California poppy	L
Festuca octoflora	Six-weeks fescue	M
Fouquieria splendens	Ocotillo	M
Funastrum hirtellum	Climbing-milkweed	L
Gilia filiformis	Starflower	M
Hyptis Emoryi	Desert-lavender	L
Janusia gracilis	Janusia	L
Krameria Grayi	White ratany	H
Larrea tridentata	Creosote-bush	H
Lepidium lasiocarpum	Pepper-weed	M
Lycium californicum	Desert-thorn	L

H = high; M = medium; L = low; VL = very low

Mesa and Foothill Community (Continued)		Abundance
Mentzelia tricuspis	Stick-leaf	L
Oenothera sp.	Evening-primrose	M
Opuntia sp.	Cholla	H
Petalonyx nitidus	Sandpaper-plant	L
Plantago insularis	Indian-wheat	H
Salvia Columbariae	Chia	H
Sphaeralcia sp.	Globe-mallow	L
Viguieria deltoidea	Golden-eye	L
Cactaceae	Cactus	M

Riparian and Spring Community

Acacia Greggii	Catclaw	H
Baccharis sarothroides	Seep-willow	H
Boerhaavia Wrightii	Spiderling	L
Bromus rubens	Foxtail brome	L
Carex sp.	Sedge	M
Cercidium microphyllum	Palo-verde	H
Chilopsis linearis	Desert-willow	M
Condalia lycioides	Gray-thorn	M
Cryptantha sp.	Cryptantha	H
Cynodon dactylon	Bermuda grass	M
Datura meteloides	Indian-apple	L
Encelia farinosa	Brittle-bush	M
Ephedra sp.	Jointfir	L
Eriogonum deflexum	Skeleton-weed	L
Eriogonum fasciculatum	California buckwheat	L
Festuca octoflora	Six-weeks fescue	H
Hymenoclea Salsola	Burro-brush	H
Hyptis Emoryi	Desert-lavender	H
Krameria Grayi	White ratany	L
Lycium californicum	Desert-thorn	H
Oenotheria sp.	Evening-primrose	L
Phacelia sp.	Scorpion-weed	L
Plantago insularis	Indian-wheat	L
Prosopis juliflora velutina	Velvet mesquite	M
Prosopis pubescens	Screwbean mesquite	L
Salazaria mexicana	Bladder-pod	L
Salix Gooddingii	Dudley willow	M
Salvia Columbariae	Chia	L
Senicio monoensis	Groundsel	L

Riparian and Spring Community (Continued)

		Abundance
Sphaeralcia sp.	Globe-mallow	L
Wislizenia refracta	Jackass-clover	M

Mountain Community

Acacia Greggii	Catclaw	L
Agave desertii	Desert agave	M
Bromus rubens	Foxtail brome	H
Coleogyne ramosissima	Black-brush	H
Cryptantha sp.	Cryptantha	H
Encelia farinosa	Brittle-bush	L
Ephedra sp.	Jointfir	H
Eriogonum fasciculatum	California-buckwheat	M
Eriogonum inflatum	Bladder-stem	L
Erodium cicutarium	Filaree	L
Festuca octoflora	Six-weeks fescue	L
Fouquieria splendens	Ocotillo	L
Franseria dumosa	White bur-sage	M
Gutierrezia lucida	Snake-weed	L
Hyptis Emoryi	Desert-lavender	L
Krameria Grayi	White ratany	M
Larrea tridentata	Creosote-bush	M
Lepidium lasiocarpum	Pepper-weed	M
Lycium californicum	Desert-thorn	L
Nolina Bigelovii	Bear-grass	M
Opuntia sp.	Cholla	H
Petolonyx nitidus	Sandpaper-plant	L
Peucephyllum Schottii	Pygmy cedar	L
Phacelia sp.	Scorpion-weed	L
Plantago insularis	Indian-wheat	M
Quercus turbinella	Shrub live oak	L
Salvia Columbariae	Chia	L
Sphaeralcia sp.	Globe-mallow	M
Tridens pulchellus	Fluff grass	L
Viguieria deltoidea	Golden-eye	M
Yucca schidigera	Mohave yucca	M
Gramineae	Perennial grasses	L

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