GROUP ORGANIZATION AND ACTIVITY PATTERNS OF DESERT BIGHORN SHEEP

by

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ABSTRACT

Seasonal group organization and activity patterns of desert bighorn sheep (Ovis canadensis mexicana) were studied in the Harquahala and Little Harquahala Mountains in western Arizona during 1979 and 1980. There were 197 group observations made involving 759 bighorn sheep. Activity was recorded at 5 minute intervals, with 1,275 activity hours on 651 bighorn sheep. Average group size of bighorn sheep in the Harquahala Mountains, ranging from 2.5 to 4.5, was largest in the early summer. In the Little Harquahala Mountains, group averages varied from 6.1 to 16.2. Mixed groups were larger than ewe groups, with no significant size difference ($P<0.05$) between ram and ewe groups. Group type is related to season in the Harquahala population. Ewe groups were more numerous in the first half of the year. In late summer and fall, adult ram composition within mixed groups increased. Adult ewes were the primary leaders in mixed and ewe groups. Group integrity was not apparent for bighorns in the Harquahala Mountains. Daily activity patterns changed seasonally, primarily in bedding and feeding peaks. Breeding behavior peaked from August to October. Newborn lambs were observed from December 1979 to April 1980.

INTRODUCTION

This study is part of a long term movement and activity pattern study of desert bighorn sheep in western Arizona. The overall objective is to evaluate the impact the Granite Reef Aqueduct (part of the Central Arizona Project) has on wild ungulates. This study was concentrated in the Harquahala and Little Harquahala Mountains (Fig. 1), which provide habitat for most desert sheep near the Central Arizona Project. In 1978, Arizona Game and Fish estimated the Harquahala population to be between 39 and 45 sheep (Arizona Game and Fish Department 1978). No surveys are available for the Little Harquahala Mountains, but the maximum number of sheep we observed in this range was 20 in March 1980.

Research on seasonal activity patterns and specific alterations in the composition of desert bighorn bands is limited. Simmons (1969) studied social organization and behavior of O. c. mexicana on the Cabeza Prieta Game Range, Arizona. Welch (1969) and Augsburger (1970) delineated general activity patterns for O. c. mexicana in New Mexico. Golden and Ohmart (1976) and Olech (1979) studied summer activity patterns of O. c. mexicana and O. c. cremnobates respectively. This is a descriptive study to record the seasonal differences in group size and composition and to delineate the seasonal activity patterns of desert bighorn sheep. The study was

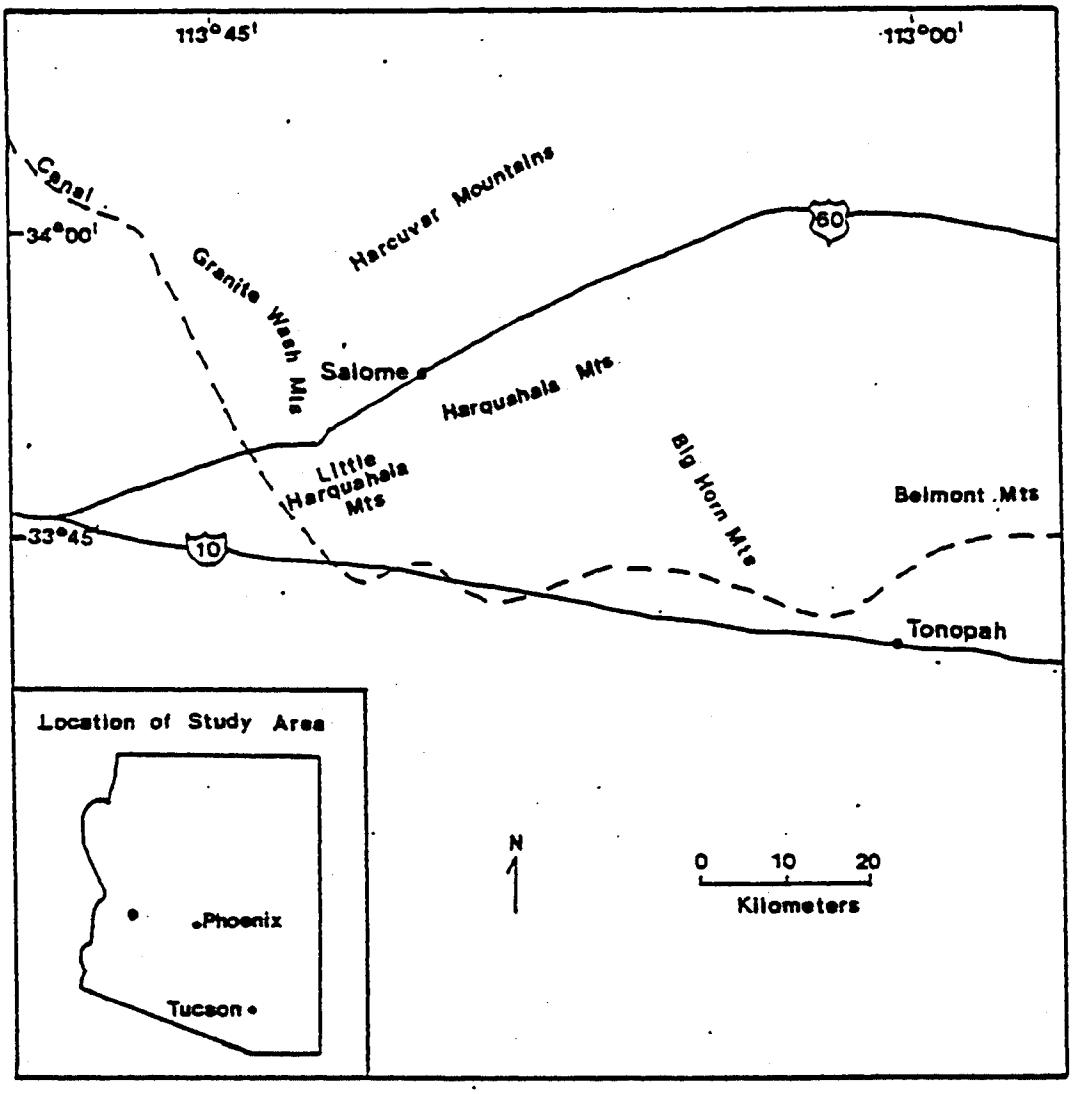

Fig. 1. Location of the Harquahala Mountains, Little Harquahala Mountains, and surrounding ranges in western Arizona.

conducted from May 1979 to December 1980. Intense field work began in January 1980.

STUDY AREA

Location and Physiography

The Harquahala and Little Harquahala Mountains lie in a northeast-southwest direction with the Little Harquahalas at the southwestern end. These ranges are approximately 147 km (91 mi) west of Phoenix (Fig. 1). The Harquahala Mountains cover approximately 311 km^2 (120 mi^2) and the Little Harquahala Mountains encompass 179 km^2 (69 mi^2).

In the Little Harquahalas, elevations vary from 427 m (1,400 ft) on the desert floor to 940 m (3,084 ft) at Harquar Peak (Fig. 2). Elevations in the Harquahala Mountains rise from 580 m (1,900 ft) to 1,732 m (5,681 ft) at Harquahala Mountain (Fig. 3). Topography ranges from rolling hills to very rugged cliffs.

Climate

Seasons were delineated using temperature and precipitation data from the Aguila station, elevation 695 m (2,280 ft) (U. S. Weather Bureau 1975-1979), from 1975 to 1979 (Fig. 4). Average annual precipitation was 21.80 cm (8.58 in) with April, May, and June (early summer) having the lowest average seasonal precipitation of 0.49 cm (0.19 in). January, February, and March (winter) had the highest seasonal average of 3.02 cm (1.19 in), and July, August, and

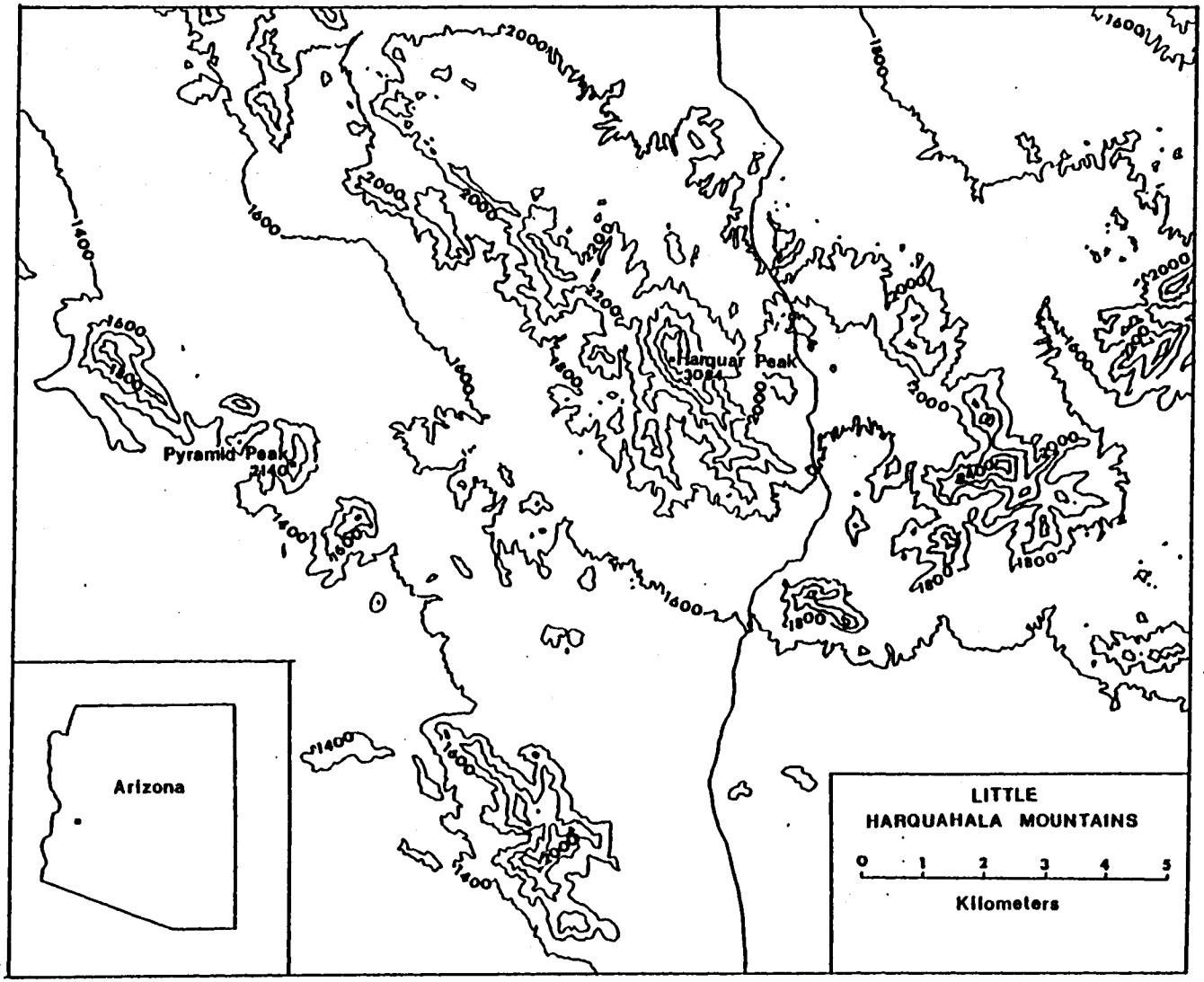

Fig. 2. Topographic map of the Little Harquahala Mountains, Arizona. Elevations are in feet.

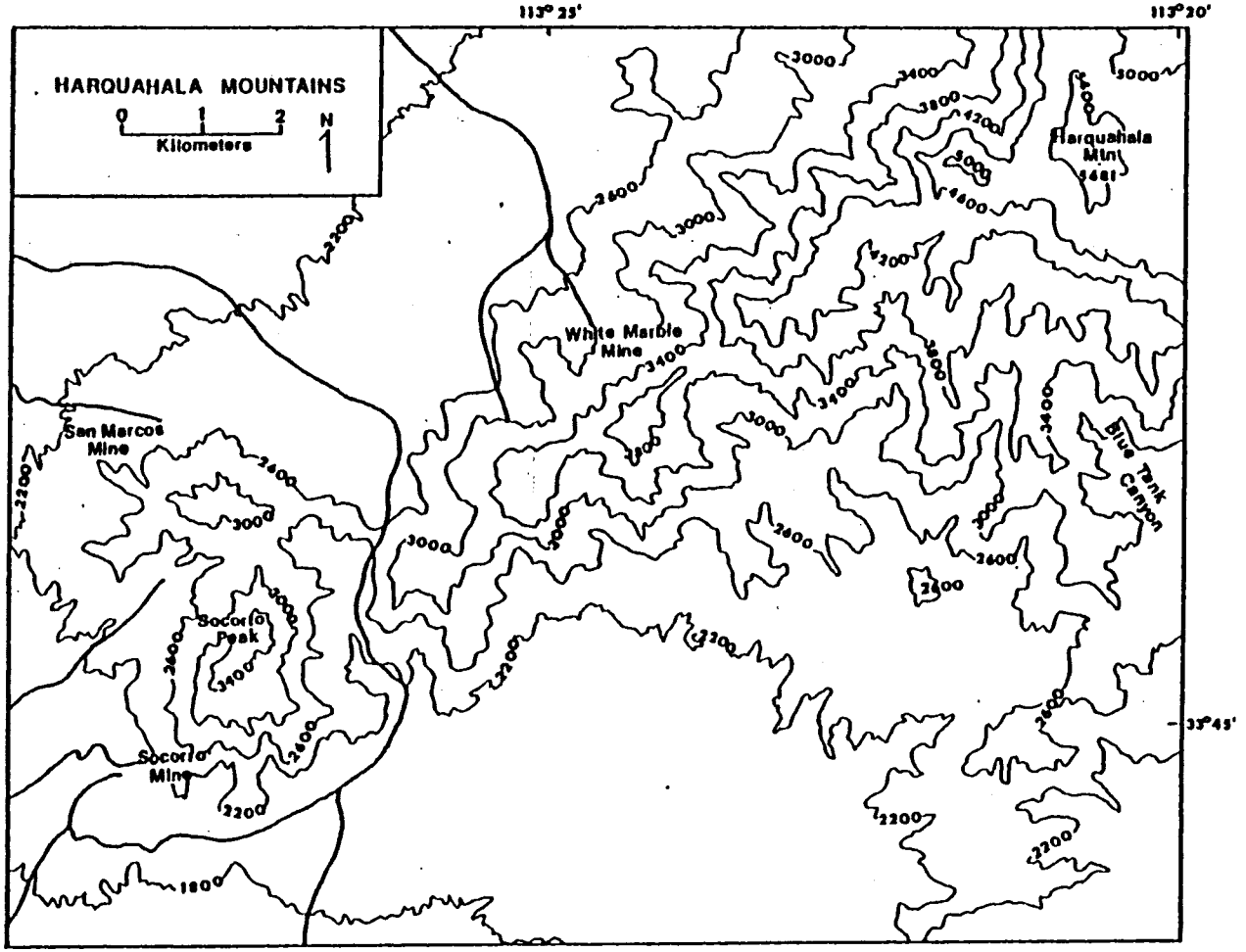

Fig. 3. Topographic map of the Harquahala Mountains, Arizona. Elevations are in feet.

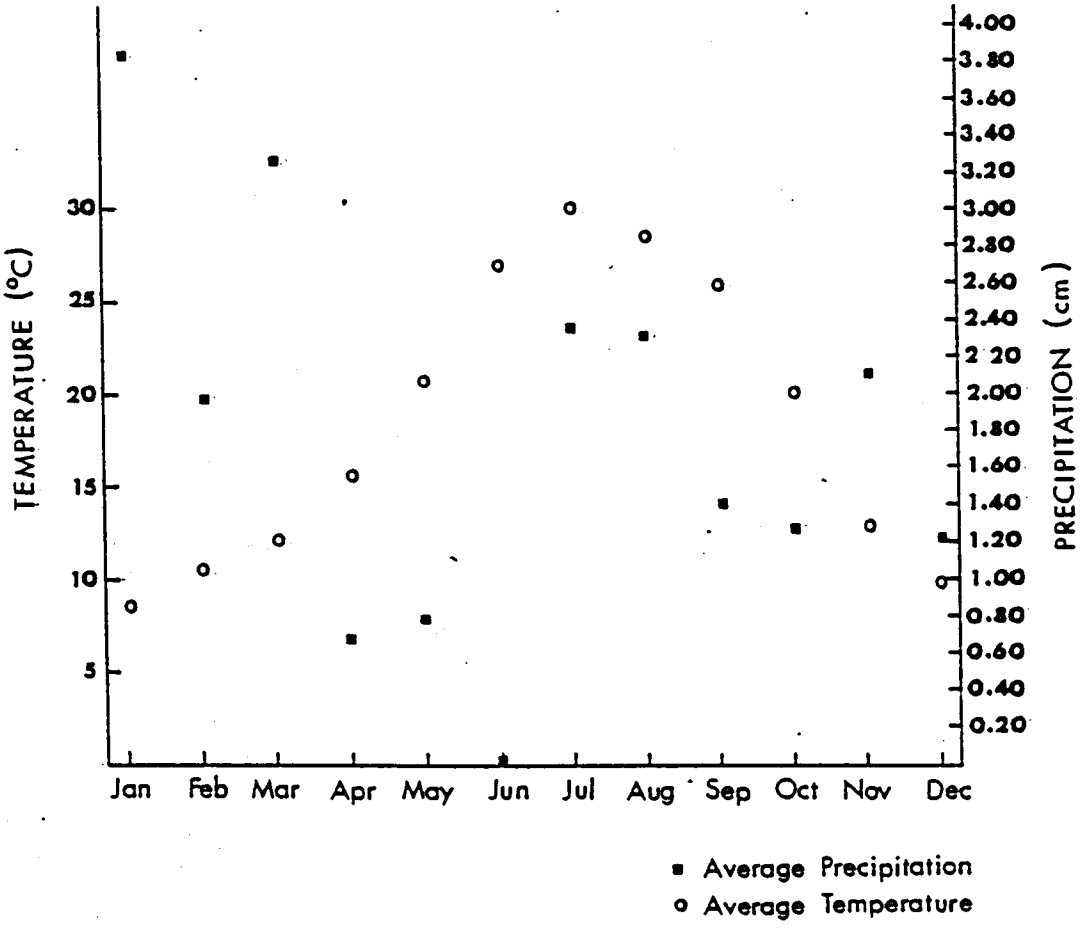

Fig. 4. Average monthly temperature and precipitation between 1975 and 1979, Aguila, Arizona.

September (late summer) and October, November, and December (fall) had respective precipitation averages of 2.02 cm (0.80 in) and 1.54 cm (0.61 in).

Winter had an average seasonal temperature of 10.3 C (50.5 F), early summer was 20.8 C (69.4 F), late summer was 28.1 C (82.6 F), and fall was 14.1 C (57.4 F). During the study, the highest temperature of 44.4 C (111.9 F) occurred on 30 June 1980 and the lowest of -6.7 C (19.9 F) on 17 November 1979.

Vegetation

The Harquahala Mountains contain 2 basic vegetative formations: the desertscrub formation, between 580 m (1,900 ft) and 1,646 m (5,400 ft) in elevation, and the chaparral formation, between 1,036 m (3,400 ft) and 1,732 m (5,681 ft), with an overlap between the two. Within the desertscrub formation there are 2 primary associations: creosote-bush, between 580 m (1,900 ft) and 792 m (2,600 ft), and palo-verde, from 580 m (1,900 ft) to 1,646 m (5,400 ft). The biotic communities are based on Lowe (1964) and a vegetational survey performed by the Bureau of Land Management in 1980 (S. Williams, pers. commun.).

The Little Harquahala Mountains lie entirely within the desertscrub formation. Creosote-bush/bur-sage and palo-verde/cholla cactus are the 2 dominate communities (Anonymous 1974).

During the study, flowering peaked in March and April. Fruits and seeds were common from June to August.

Land Use

Russo (1956) discussed the overgrazed condition of the Harquahala Mountains. There are numerous signs of previous cattle use in the upper elevations, particularly southwest of Harquahala Mountain. Presently, cattle and domestic sheep use of the mountain range is minimal.

Mining activity is increasing in the Harquahala Mountains. The most active mines include the Socorro, San Marcos, and White Marble Mines (Fig. 3). Development has recently begun on Harquahala Mountain.

In 1978, the first bighorn hunting permit was issued for the study area, and 1 ram was taken in the Harquahala Mountains. The second and third rams from this range were removed during the 1979 and 1980 bighorn hunting seasons.

MATERIALS AND METHODS

A total of 15 sheep was captured between 8 November 1979 and 5 November 1980: 2 yearling rams, 4 adult rams, 2 yearling ewes, and 7 adult ewes (Table 1). Desert bighorn sheep were located with a helicopter, immobilized with M-99, collared with color-coded radio telemetry collars, and released.

Sex and age classifications were made according to the methods of Hansen (1965) and Geist (1971). Adult rams were placed into horn size classes from I to IV. Group types follow Geist (1971): ewe groups consist of adult ewes, yearlings, and lambs; mixed groups are comprised of adult rams, adult ewes, yearlings, and lambs; and ram groups have only adult rams.

Radio collared sheep were systematically located by aerial and ground telemetry. Small fixed wing aircraft were used for aerial locations. Ground observations were made with 9 x 36 binoculars and a 20x spotting scope.

Ground surveys were concentrated in the Harquahala Mountains. Sheep movements from the Little Harquahala to the Harquahala Mountains were anticipated. We limited field activities in the former range to avoid disturbances of the sheep which could have caused a premature movement from the Little Harquahala Mountains.

For ground observations, sex and age composition of each group was recorded to determine if there were significant differences in the

Table 1. Desert bighorn sheep collared in western Arizona.

Code Number	Date of Capture	Sex	Age (years)	Mountain range
R1	16 Jan 1980	M	2	Harquahala
R2	8 Nov 1979	M	4	Harquahala
R3	16 Jan 1980	M	≤2	Harquahala
R4	13 Mar 1980	M	3	Harquahala
R5	29 Mar 1980	M	4	Little Harquahala
R6	5 Nov 1980	M	6	Harquahala
F2	8 Nov 1979	F	7	Harquahala
F4	28 Mar 1980	F	8	Granite Wash
F5	28 Mar 1980	F	7-8	Little Harquahala
F6	8 Nov 1979	F	7	Harquahala
F7	17 Jan 1980	F	1	Harquahala
F8	16 Jan 1980	F	≤2	Harquahala
F10	21 Nov 1979	F	7	Big Horn
F11	5 Nov 1980	F	3	Harquahala
F12	5 Nov 1980	F	4	Harquahala

average group size between seasons and mountain ranges and if the composition within ewe and mixed groups differed between seasons and mountain ranges (Bhapkar 1968). Changes in group composition and percentages of mixed and ewe groups were used in delineating the breeding season, when the number of rams among ewes increases. Group composition also was used to determine group integrity, limiting this analysis among the collared sheep where individual animals could be identified. Group integrity was analyzed using a 2-way frequency table (Dixon and Brown 1979) in a quasi-independence test (Bishop et al. 1975). Those individual sheep whose movement appear to influence other sheep to follow them were defined as leaders. Whenever observed, leaders of each group were recorded to determine which animals are leaders in the different group types (Goodman 1965). Statistical testing of data using Chi-square analysis was at the 0.05 level of significance, unless otherwise specified.

Observations of individual animals tend not to be independent due to the bighorn's gregarious nature. However, the basic assumption underlining the activity pattern research method was that the animals observed are representative of the population. Activity pattern data was collected to determine the daily activity patterns and how these patterns change between the seasons. Eleven main activity patterns were delineated, based upon Geist (1971), with definitions listed below.

Feeding activity includes browsing, chewing, and walking between food items. Watering activity is recorded when the animal's

head is lowered at a water source. Bedding occurs when the animal is lying down with head down or head up and animal is alert. Movement is a direct travel movement from one point to another, excluding feeding behavior. Standing activity is recorded whether or not the animal is alert, head up, and looking around. Sexual activity includes lipcurl, sniffing the rear or urine of another animal, courting, attempted and/or successful mounting. Resource competition is the act of pushing another bighorn away from shade, food, water, or other resources. Aggressive activity includes kicks, clashes, or butts towards other sheep. Attempted and successful suckling is recorded as nursing. Contact greeting includes rubbing, horning, and nuzzling of other sheep and the various horn displays described by Geist (1971) are recorded as dominance display.

During observations, activity patterns were recorded at 5 minute intervals (see data sheet, Appendix I). Detailed activity was noted for the period between the activity data points. An activity hour is defined as 12 activity data points on one desert bighorn. Frequency of occurrence of activity patterns for each hour during the day were derived for each season.

RESULTS AND DISCUSSIONS

Group Size

A total of 197 desert bighorn group observations (759 sheep) was recorded. Group sizes ranged from 1 to 22 (Fig. 5). Average group size was largest during the early summer in the Harquahala Mountains (Table 2); this seasonal group size is different from the fall average ($P<0.10$). Average group sizes in winter, late summer, and fall were not significantly different from each other. Simmons (1969) and Deming (1953, cited by Hansen 1980) frequently found group sizes from 1 to 3. Slightly larger group sizes of 3 to 5 were reported by Russo (1956), Welles and Welles (1961), Golden and Ohmart (1976), and Leslie and Douglas (1979).

Seasonal average group sizes in the Little Harquahala population varied from 6.1 to 16.2. Group size was larger in the Little Harquahala Mountains than in the Harquahala population (Table 2). The greater congregation of bighorn sheep in the Little Harquahalas may be partly attributed to the smaller area of this range reducing the size of suitable habitat and, thus, the dispersion of the bighorns.

In both populations, the largest seasonal group average occurred in early summer. McQuivey (1978) noted the highest average group size of 4.7 in spring 1970, and Welch (1969) similarly found the largest groups in late winter and early spring. The larger

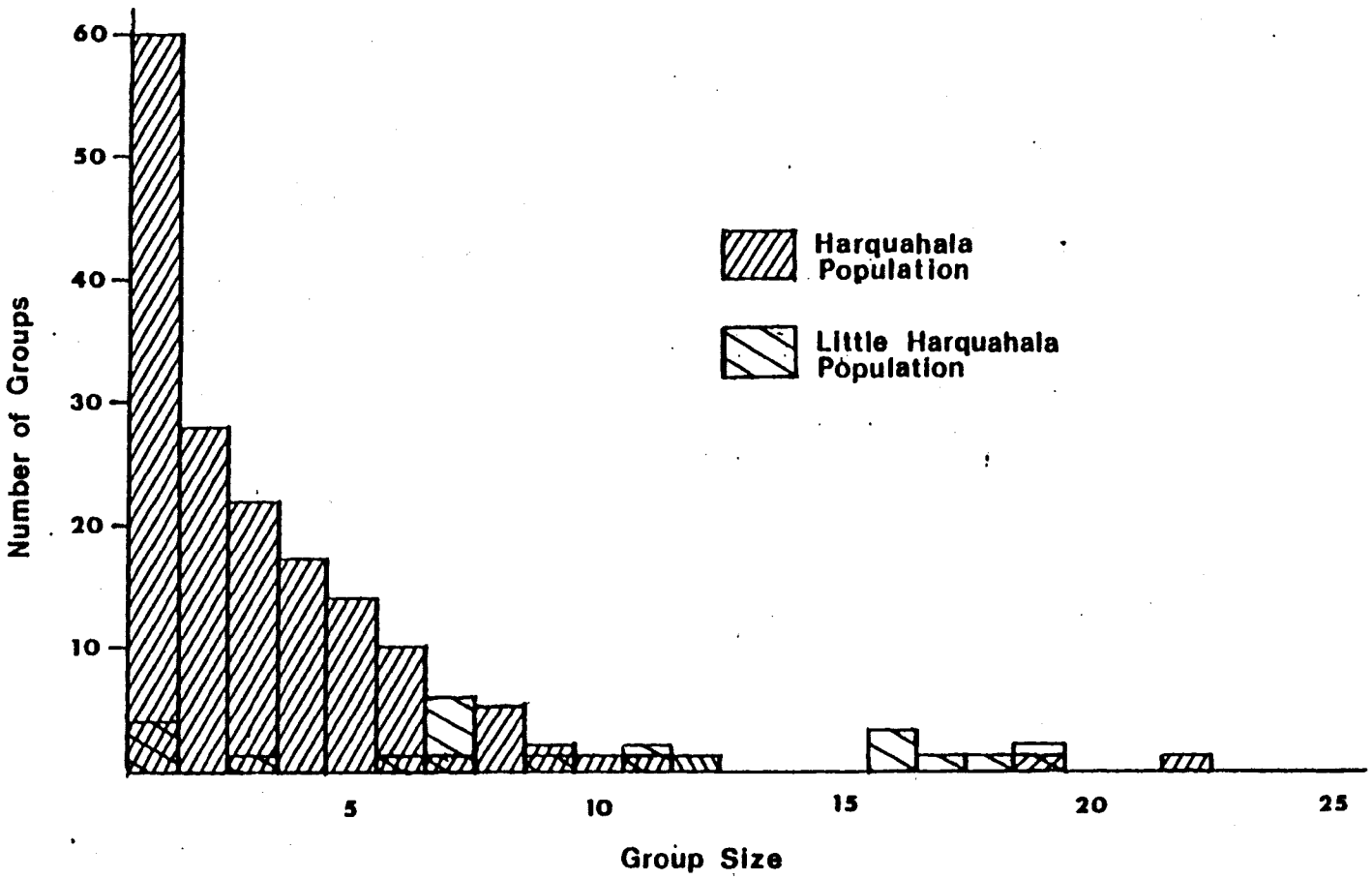

Fig. 5. Frequency of desert bighorn group sizes in the Harquahala and Little Harquahala Mountains from May 1979 to December 1980.

Table 2. Seasonal mean group sizes of desert bighorn sheep in the Harquahala (H) and Little Harquahala (LH) Mountains from May 1979 to December 1980.

Variances are in parentheses.

Season	Mean group size		Total sheep observed		No. groups	
	H	LH	H	LH	H	LH
Winter	2.9(0.15)		69		24	
Early Summer	4.5(0.49)	16.2(1.15)	207	81	46	5
Late Summer	2.5(0.05)	11.0(6.22)	161	33	65	3
Fall	3.1(0.15)	6.1(1.34)	89	86	29	14

groups found here and by other researchers may be attributed to the greater availability of food during this season; fresh vegetational growth was present during April and the first part of May, and fruits and seeds were available in June. Welles and Welles (1961) related the gregariousness of bighorns to the relative abundance of their food supply.

During the seasons in which mixed groups were observed in the Harquahalas, mixed groups were larger than ewe groups; this was also the case during fall in the Little Harquahala population (Table 3). No mixed groups were seen during winter. In the latter half of the year (late summer and fall), mixed groups in the Harquahala Mountains were also larger than ram groups. Only solitary rams were observed in the Harquahalas from January to June. There was no significant difference between ewe and ram group averages during the second half of the year (late summer and fall) in the Harquahala population. No ram groups were observed in the Little Harquahalas. Simmons (1969) in the Cabeza Prieta Game Range, Arizona and Blood (1963) in British Columbia found the mean group size of mixed groups were larger than ewe groups, which were larger than ram groups.

Whereas the overall group average in the Harquahalas was largest in early summer, ewe and mixed groups were significantly larger during winter and early summer than in the other 2 seasons (Table 3). Ewes were congregating in the Socorro Peak area in winter during lambing. The large mixed and ewe group sizes in early summer may be a response to food abundance; ewes with new lambs remained in

Table 3. Seasonal group type sizes of desert bighorn sheep in the Harquahala (H) and Little Harquahala (LH) Mountains from May 1979 to December 1980.

Variances are in parentheses.

Season	Group type	Mean group size		Total sheep observed		No. groups	
		H	LH	H	LH	H	LH
Winter	Mixed						
	Ewe	3.2(0.30)		64		20	
	Ram	1.0(0.00)		3		3	
Early Summer	Mixed	8.8(2.46)		132		15	
	Ewe	2.5(0.10)	15.3(2.07)	69	46	28	3
	Ram	1.0(0.00)		1		1	
Late Summer	Mixed	3.8(0.10)	9.0(0.00)	109	9	29	1
	Ewe	1.6(0.06)	12.0(12.50)	27	24	17	2
	Ram	1.3(0.04)		22		17	
Fall	Mixed	4.6(0.26)	8.8(1.06)	65	79	14	9
	Ewe	1.8(0.08)	1.0(0.00)	11	4	6	4
	Ram	1.4(0.10)		13		9	

the Socorro area during this season. There essentially was no seasonal change among Harquahala ram groups, with averages ranging from 1.0 to 1.4.

As in the general group averages, group type averages were generally larger in the Little Harquahala population (Table 3). One exception occurs in fall when the Harquahala and Little Harquahala ewe averages were 1.8 and 1.0, respectively.

Seasonal groups and mixed groups were largest in early summer, and ewe group sizes were greatest in winter. This finding conforms with the group sizes determined by Welch (1969) and McQuivey (1978). Harquahala mean group sizes fall in the range of sizes noted in other studies (Deming 1953, cited by Hansen 1980, Russo 1956, Welles and Welles 1961, Simmons 1969, Golden and Ohmart 1976, and Leslie and Douglas 1979). Group sizes in the Little Harquahala population were noticeably larger. The trend in group type sizes, mixed groups larger than ewe groups which were larger than ram groups, was noted here and by other researchers (Blood 1963 and Simmons 1969).

The group sizes in the Harquahala Mountains were smaller than those reported in more northern populations, with averages ranging from 5.3 to 16 (Smith 1954, Blood 1963, and Brown 1974). Berger (1978) suggested that the smaller groups in desert regions may be a response to the patchy food distribution. However, the Little Harquahala population had group averages as large as those reported in northern populations. The larger groups in the Little Harquahala population

may partly be a response to the smaller area in this range; however, further studies in these 2 areas may suggest explanations for these larger groups.

Group Composition

Desert bighorn sheep group type is related to season in the Harquahala Mountains. The seasonal percentages of mixed groups changed little in the Harquahalas; whereas, the proportion of ewe groups observed was greater in the first half of the year (winter and early summer) than the latter half (Fig. 6). The seasonal comparisons of the percentage of mixed to percentage of ewe groups show significantly more ewe groups present in the Harquahalas during winter and early summer; however, in late summer and fall the percentages of the 2 group types observed did not differ. In the Little Harquahalas, the percentage of ewe groups did decrease from April to December, with no significant difference in the percentages of mixed and ewe groups during fall (Fig. 6). Although no mixed groups were observed in winter during this study, several mixed groups have been observed in the Little Harquahalas during January 1981.

In the Harquahala population, adult ram composition of mixed groups was significantly greater in late summer and fall than in early summer. Adult ewe and yearling composition of mixed groups did not change seasonally. Mixed group lamb composition decreased from early to late summer, with no change in lamb composition during the latter half of the year (Table 4). In ewe groups, ewe and yearling seasonal

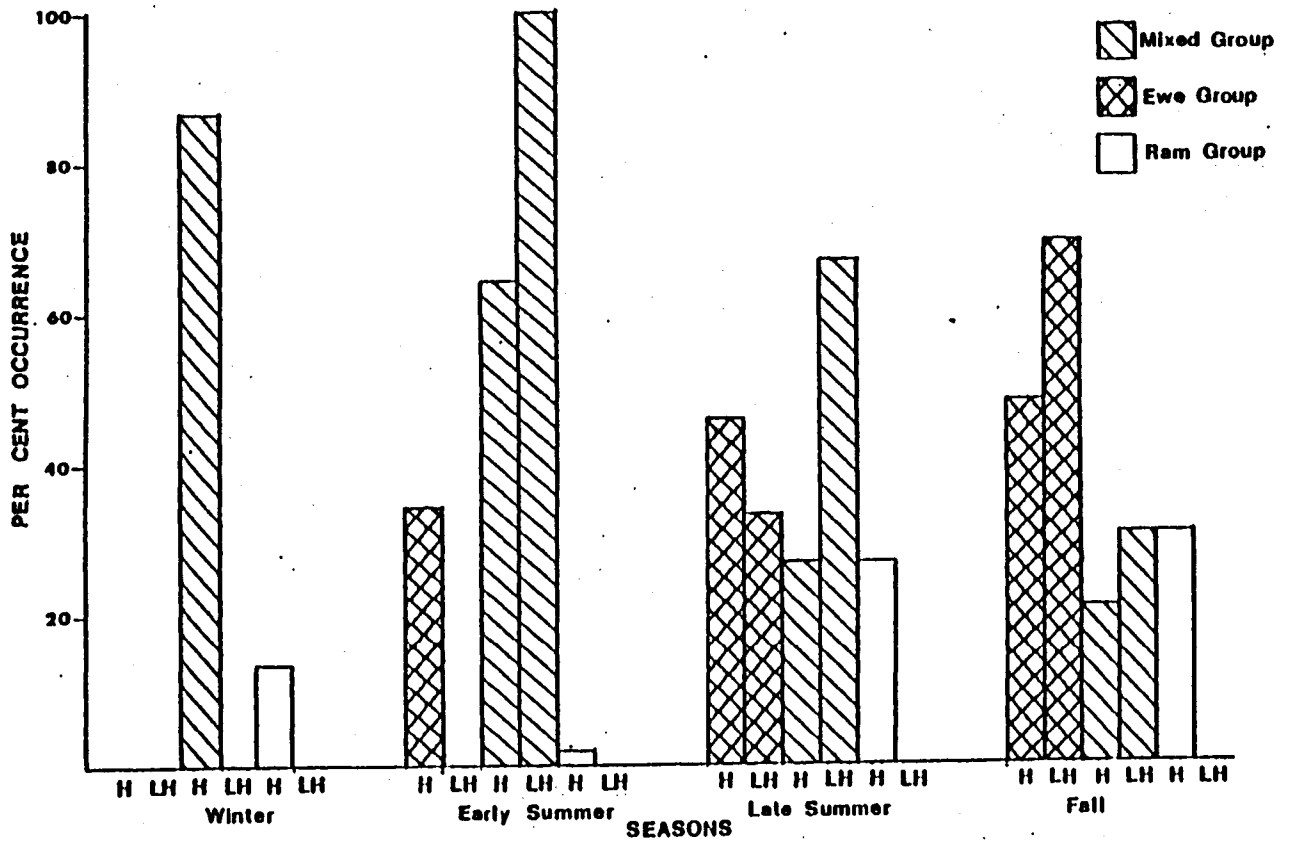

Fig. 6. Seasonal desert bighorn group composition in the Harquahala (H) and Little Harquahala (LH) Mountains from May 1979 to December 1980.

Table 4. Seasonal composition of desert bighorn sheep mixed and ewe groups in the Harquahala (H) and Little Harquahala (LH) Mountains from May 1979 to December 1980.

Season	Group type	Total No. groups		Per cent adult rams		Per cent adult ewes		Per cent yearlings		Per cent lambs		Per cent unclassified	
		H	LH	H	LH	H	LH	H	LH	H	LH	H	LH
Winter	Mixed	0	0										
	Ewe	20	0			56		16		28			
Early Summer	Mixed	15	0	25		51		4		13		7	
	Ewe	28	3			71	46	22	4	7	50		
Late Summer	Mixed	29	1	41	11	45	11	9	0	5	22		56
	Ewe	17	2			56	46	26	0	18	54		
Fall	Mixed	14	9	40	14	55	38	5	1	0	38		9
	Ewe	6	4			82	100	9	0	9	0		

composition did not change statistically; lamb composition decreased from winter to early summer, and then remained stable for the remainder of the year (Table 4). This decrease in the percentage of lambs in ewe and mixed groups during the first half of the year (winter and early summer) was expected due to newborn lamb mortality.

Adult ewes constituted a larger percentage of ewe groups than mixed groups in the Harquahalas during early summer; this difference was not noted in late summer or fall. In the Little Harquahalas during fall, ewe groups consisted solely of adult ewes, but the number of ewes was greater in mixed groups (Table 4).

Thus, not only was there a greater proportion of ewe groups in winter and early summer, a larger percentage of ewes were associated with this group type during these seasons. In late summer and fall, adult ram composition within mixed groups increased. These data indicate the greater association of rams with ewes during the latter half of the year (late summer and fall). Several researchers have also indicated that adult rams do mingle with ewes in late summer and fall during the rut and separate from ewes for the remainder of the year (Welles and Welles 1961, Simmons 1969, McQuivey 1978, and Leslie and Douglas 1979).

Due to small sample sizes in the Little Harquahalas, comparisons of sex and age composition of group types between the Harquahalas and Little Harquahalas generally could not be made. There was no significant difference in lamb composition in fall ewe groups between the 2 ranges. However, the number of lambs observed during the year

was greater in the Little Harquahalas than in the Harquahala Mountains. This aspect of bighorn sheep ecology needs to be investigated further. In fall, adult rams and ewes constituted a greater percentage of mixed groups in the Harquahalas than the Little Harquahalas, which may be accounted for by the larger percentage of lambs in the Little Harquahalas. Ewe group composition during this season did not differ between the 2 ranges.

Leadership and Group Integrity

Generally, adult ewes were the primary leaders in mixed and ewe groups. In mixed groups, adult ewes were leaders in 81.8% of the observations (CI=61.3-92.2%). Although Geist (1971) never observed large rams following ewes, several researchers (Welles and Welles 1961, Simmons 1969, and Woolf et al. 1970) noted that ewes generally lead rams. Since adult rams primarily associate with ewes only during the breeding season, ewe leadership within mixed groups may be due to the sexual attraction of rams to ewes. Adult ewes were also the primary leaders in ewe groups, comprising 92.8% of the observations (CI=73.1-98.4%). Ram groups were small and leadership changed among the adult rams. In the majority of all leadership cases, adult animals were the leaders; however, leadership is not considered permanent but rather alternates among adult sheep.

In the Harquahalas, association was analyzed using those animals which were collared for at least 9 months in 1980 (R1, R2, R3, R4, F2, F6, F7, and F8, see Table 1). Group integrity was not apparent in these bighorn groups. Leslie and Douglas (1979) suggested

that group integrity may be density dependent, with cohesion enhanced at lower densities. They found very flexible intraspecific associations in the River Mountain herd in Nevada, with 2.84 bighorn sheep/km^2 (7.36 bighorn sheep/mi^2). Our results do not conform to the density dependence pattern. In the Little Harquahala Mountains there were 0.11 bighorn sheep/km^2 (0.29 bighorn sheep/mi^2). The Harquahala Mountains had 0.13 to 0.14 bighorns/km^2 (0.32 to 0.38 bighorns/mi^2). The densities in these 2 ranges were less than in the River Mountains and still no group integrity was noticed.

Activity Patterns

There were 1,275 activity hours recorded on 651 desert bighorn sheep from 2 September 1979 to 31 December 1980. Sheep were observed in all seasons from 0545 to 2005h, except in fall when observations did not exceed 1900h. The mean number of activity data points per hour are 90 for winter, 425 for early summer, 248 for late summer, and 356 for fall. All daylight hours are represented, with 75% of the observations occurring between 0905 and 1655h. Early morning hours were spent in locating sheep. As a result, the period from 0545 to 0905h is not represented as much as other hours. The daily activity pattern changed seasonally, primarily in bedding and feeding peaks. During the active periods, when bedding constituted less than 50% of the activity, feeding was the primary behavior from 0545 to 0755h and 1600 to 2005h in all seasons. Differences between the seasons are discussed below.

Winter

There were 2 periods in which bedding comprised over 50% of the activity, 0900 to 1055h and 1200 to 1355h, during winter (Fig. 7). During the active periods, feeding was the primary activity from 0545 to 0755h and 1400 to 2005h. Standing was the main non-bedding activity from 0800 to 0855h; and from 1100 to 1155h, standing and feeding had nearly equal occurrences. Movement became more apparent after 1800h. Nursing was observed periodically during the day.

Early Summer

For the early summer daily activity pattern data (Fig. 8), bedding occurred at least 50% of the time from 0800 to 1155h and 1400 to 1555h. During the remainder of the day, there were 3 main feeding periods: 0545 to 0755h, 1200 to 1355h, and 1600 to 2005h. The majority of feeding occurred prior to 0800 and after 1600h. Behaviors seen less than 1% of the time include aggression, contact greeting, and dominance displays.

Late Summer

In late summer daily activity patterns (Fig. 9), bedding was the main activity from 0900 to 0955h and 1200 to 1455h. During the active periods, feeding was the primary activity from 0545 to 0755h and 1500 to 2005h, standing was the main activity from 0800 to 0855h and 1000 to 1055h, and from 1100 to 1155h feeding and standing had nearly the same occurrence. Thus, from 0800 to 1455h, when sheep were not primarily bedding, their main activity was standing; both

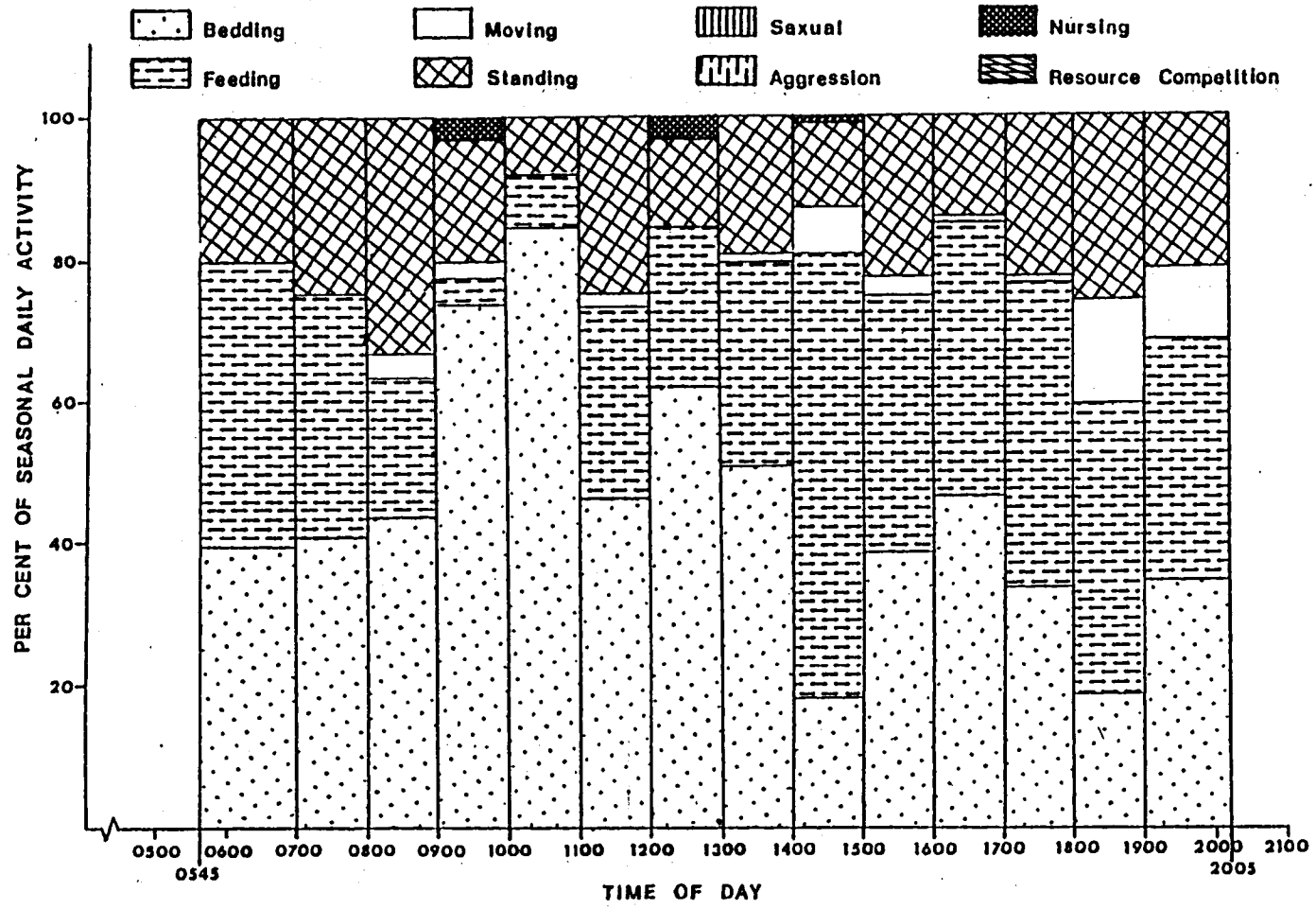

Fig. 7. Daily activity pattern for desert bighorn sheep in western Arizona, winter 1980.

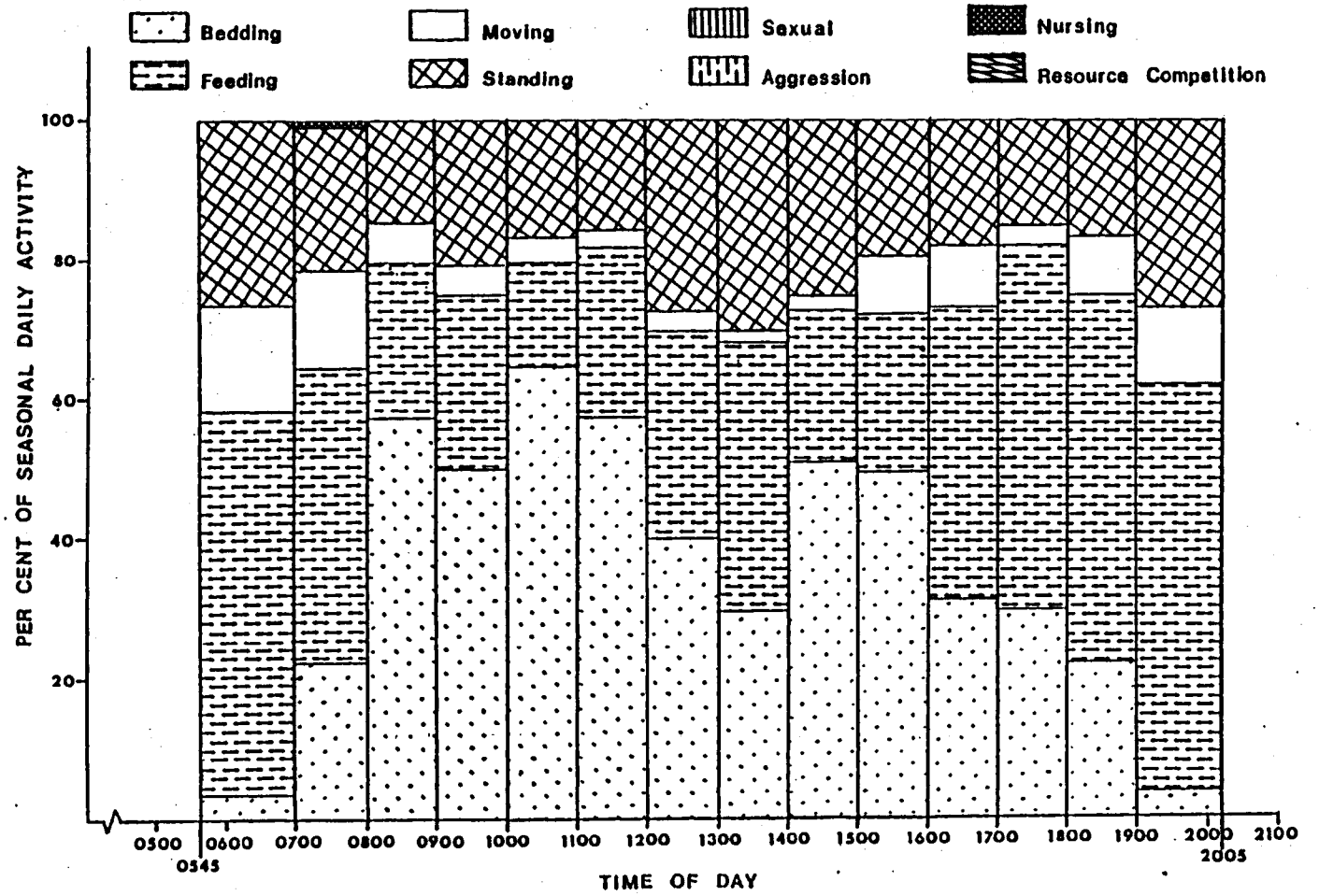

Fig. 8. Daily activity pattern for desert bighorn sheep in western Arizona, early summer 1980.

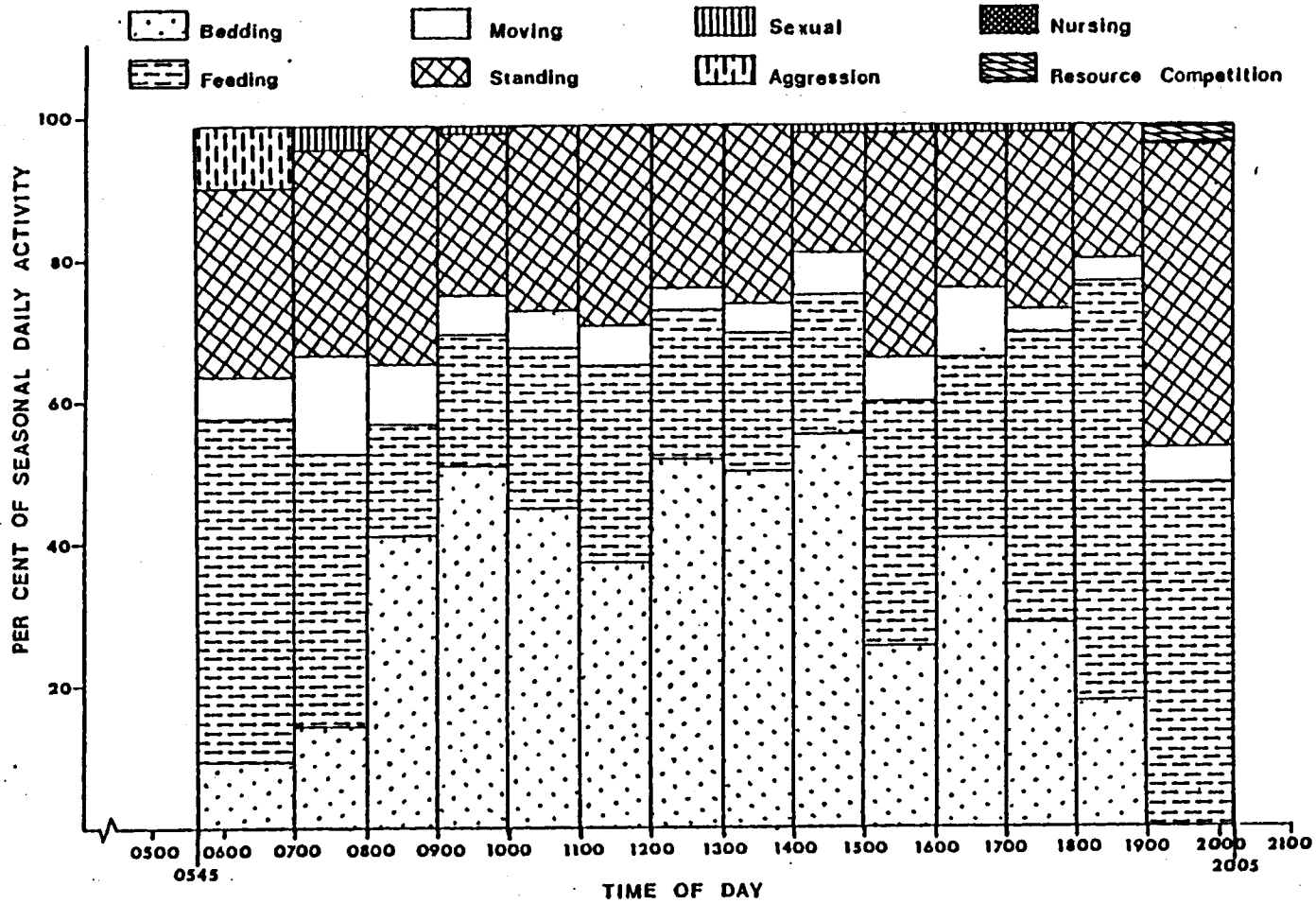

Fig. 9. Daily activity pattern for desert bighorn sheep in western Arizona, late summer 1979 and 1980.

behaviors aid in conserving energy during the heat of the warmest season. Olech (1979) observed activity patterns of peninsular bighorn sheep (O. c. cremnobates) during the summer around waterholes. Her results indicate greater than 50% activity in mixed groups from 1100 to 1330h. This activity includes interacting, moving, standing, drinking, and feeding. The greater midday activity of mixed groups observed by Olech than found in sheep during late summer in this study may be a result of the peninsular sheep being close to water.

The majority of feeding occurred prior to 0800 and after 1500h in this study. Welles and Welles (1961) noted sheep, during hot weather, to browse in early morning and late afternoon and evening. Sexual and aggressive behaviors occurred most frequently during late summer. Contact greeting and dominance displays constituted less than 1% of the activity.

Fall

During the fall (Fig. 10) there was only one peak in which bedding constituted over 50% of the activity, 0900 to 1055h. During the other periods, feeding was the primary activity, except from 1500 to 1555h in which feeding and standing had identical occurrences. Feeding was observed primarily prior to 0900 and after 1400h, increasing to dusk. Second to late summer, sexual behavior was frequent during the fall; resource competition had less than 1% occurrence.

In warm and cold seasons, Welch (1969) found similar activity patterns, with activity peaks approximately from 0900 to 1100h and in

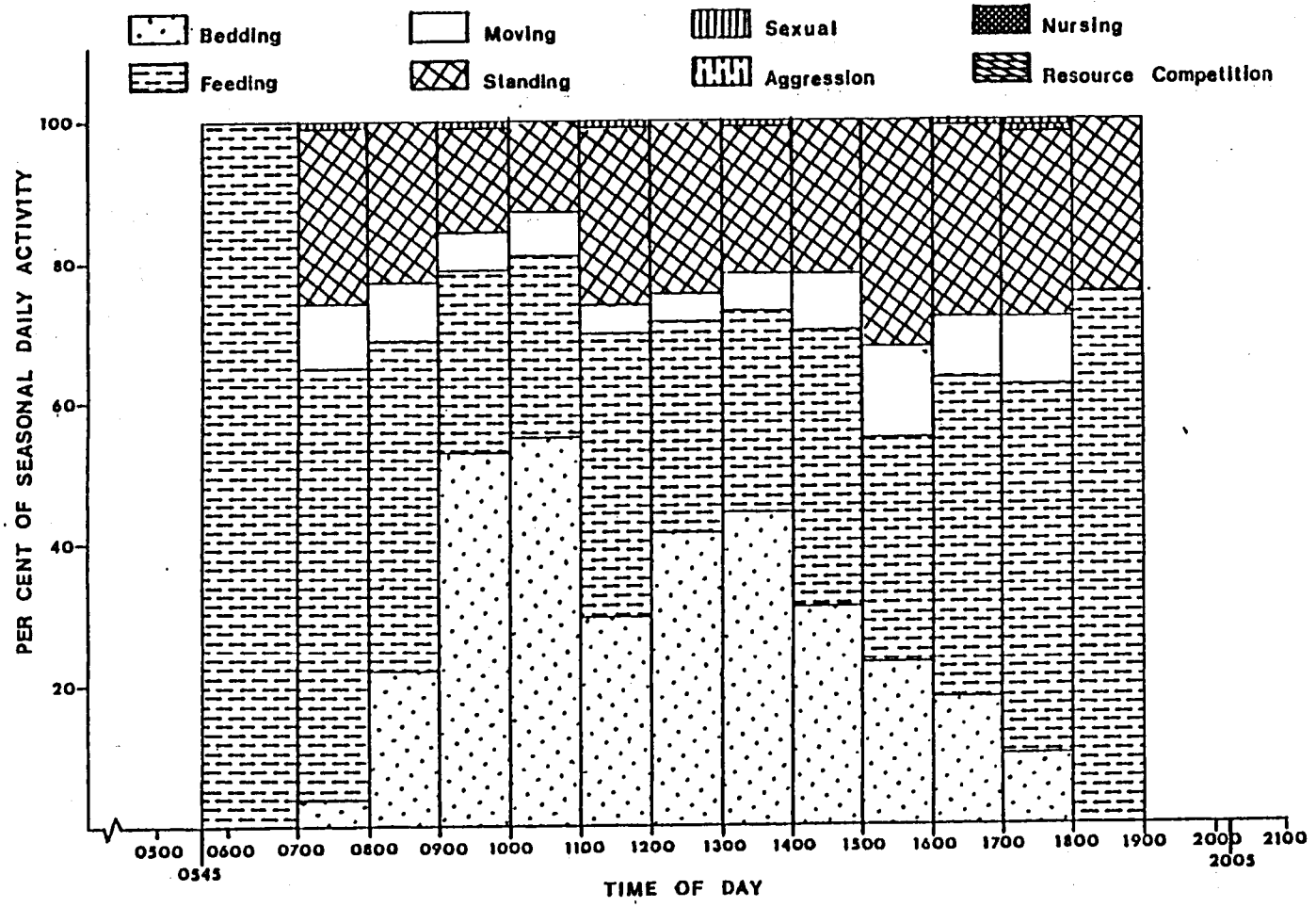

Fig. 10. Daily activity pattern for desert bighorn sheep in western Arizona, fall 1979 and 1980.

early and late afternoon. Augsburger (1970) observed bighorns feeding from before dawn to noon, with midday bedding of 1 hour in the cool season and 2 hours in the warm season. Sheep then fed and bedded periodically during the afternoon and evening until they bedded after dark.

The social interactions observed among bighorn sheep in the Harquahala and Little Harquahala Mountains are less intense than those described by Geist (1971) in northern populations. Sexual, aggressive, contact greetings, dominance displays, and resource competition behaviors generally constituted 1% or less of the activity within each hour. Berger (1978) found desert bighorn sheep had a lower behavioral diversity than northern populations; he attributed this simpler repertoire to smaller group sizes, less social facilitation, and reduced play among lambs in desert bighorn populations.

Reproduction

Sexual activity was observed whenever rams were in the company of ewes from April to December. However, breeding behavior became more apparent in June, increased in July, peaked from August to October, and decreased through December. In July 1980, a period of pre-rut was noted, when adult rams were seen in dominance displays and fights. Russo (1956) found the breeding season for Arizona bighorns ran from July to October. In the Cabeza Prieta Game Range, the breeding season peaked in July through August (Simmons 1969), and in New Mexico the breeding season for O. c. mexicana went from August to late October (Augsburger 1970).

Newborn lambs were observed during this study from December 1979 through April 1980. A lamb less than 1 week old was seen on 23 April 1980. At least 3 lambs, 1 to 2 months of age, were observed in February. The sighting of newborn lambs in the Harquahala Mountains places the lambing season one month earlier and later than that described by Russo (1956) for Arizona. Simmons (1969) found the peak lambing to be in December and January, and Augsburger (1970) delineated the lambing season from late December to mid-February. Nursing occurred in the study area from December 1979 through June 1980. Some nursing attempts were noted through September 1980, but none appeared to be successful.

APPENDIX I

DAILY ACTIVITY PATTERN DATA SHEET

Group Size and Structure:

_____

_____

Date _____

Distance sheep to observer _____

Reaction sheep to observer _____

_____

Sex & Age Class of Selected Bighorn Sheep	Time Intervals (min.)											
	00	05	10	15	20	25	30	35	40	45	50	55

Activity Codes

1 Feeding
2 Watering
3 Bedding w/ head up *
" " head down *
5 Group Movement - 25 m
6 " " - 50 m
7 " " - 75 m
8 " " -100 m
9 Movement away from group - 25 m
10 " " " " - 50 m
11 " " " " - 75 m
12 " " " " -100 m
13 Movement towards group - 25 m
14 " " " - 50 m
15 " " " - 75 m
16 Movement towards group -100 m
17 Single animal movement - 25 m
18 " " " - 50 m
19 " " " - 75 m
20 " " " -100 m
21 Standing

Social Interactions

22 Sexual
23 Resource Competition
24 Aggression
25 Nursing
26 Contact Greeting
27 Dominance Display

*Record head position with ↑ or ↓
If the head is not visible, record activity as a 3

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