DESERT BIGHORN COUNCIL TRANSACTIONS

VOLUME 2 1958

Desert Bighorn Council

AGENDA

Desert Bighorn Sheep Council Meeting
April 8-11, 1958
Yuma, Arizona

Meeting opens at 9:00 a.m., April 8, 1958.

Welcome:	Gale Monson, U. S. Fish and Wildlife Service
Opening Remarks:	Gordon Fredine, Principal Naturalist, U. S. National Park Service.
Hunting:	Chairman Gale Monson.
9:30-10:00	Hunting in Nevada, Al Ray Jonez, District Supervisor, Nevada Fish and Game Commission.
10:00-10:30	Hunting in Arizona, John P. Russo, District Biologist, Arizona Game and Fish Dept.
10:30-11:00	Hunting in New Mexico, Herman Ogren, Biologist, New Mexico Game and Fish Dept.
11:00-11:30	Effect of Trophy Hunting on Big Game Herds, Dr. Wendell Swank, Project Leader, Arizona Game and Fish Dept.
11:30 1:00	Lunch
1:OO-2:00	Discussion of Hunting, Warren E. Kelly, Biologist, Arizona Game and Fish Dept.
Water Development:	Warren E. Kelly, Biologist, Arizona Game and Fish Dept.
2:00-2:30	Water Development in California, Richard Weaver, Game Mgr. I, Calif. Fish and Game Dept.
2:30-3:00	Water Development on the Kofa and Cabeza Game Ranges, Charles Kennedy, U. S. Fish and Wildlife Service, Refuge Manager, Kofa Game Ranges.
3:00-3:30	Water Development in Arizona, Dan Schadle, Project Leader, Arizona Game and Fish Dept.
3:30-4:30	Discussion, Bob Bendt, Park Naturalist, U. S. National Park Service.

Trapping, Tagging and Transplanting: Chairman Dick Weaver, Evening Session

7:00-7:30	Trapping and Tagging, Clair Aldous, Refuge Biologist, Desert Game Range, U. S. Fish and Wildlife Service.
7:30-8:00	Trapping on the Kofa Game Range, Paul Webb, Project Leader, Arizona Game and Fish Dept.

8:00-8:30 Transplanting and Observations of Transplanted Bighorn Sheep, Tom Moore, Texas Game and Fish Commission.

8:30 Discussion, Chairman Winston Banko, Refuge Manager, U. S. Fish and Wildlife Service.

Meeting Opens 9:00 a. m., April 9, 1958.

Chairman Joe Greenley, Chief of Game, Nevada Fish and Game Dept.

9:00-9:30 Physical and Mechanical Injuries, Dr. Edward Johnson, Capt., Veterinary Corps, U. S. Army.

9:30-10:00 Physical Disturbances Caused by Trapping, Dr. Benjamin Ham, D. V. M., Yuma, Arizona.

10:00-10:30 Lungworm Infections in Wild Sheep, Richard E. Pillmore, Biologist, Colorado Dept. Game and Fish.

10:30-11:30 Discussion, Joe Greenley

11:30-1:00 Lunch

Chairman Cecil Kennedy, U. S. Fish and Wildlife Service

1:00-1:30 Water Requirements, Gale Monson, Refuge Manager, U. S. Fish and Wildlife Service.

1:30-2:00 Daily Movements and Activities of Bighorn Sheep, Ged Devon, Refuge Biologist, Desert Game Range, U. S. Fish and Wildlife Service.

2:00-4:00 Discussion and Presentation of Other Topics, Chairman Gale Monson, U. S. Fish and Wildlife Service

Chairman John Russo

7:30 Evening session will be a business meeting and Dr. Wendell Swank will show slides and present a talk on African animals.

April 10, 1958

Group will meet at U. S. Fish and Wildlife Service office for start of two day field trip.

HUNTING THE DESERT BIGHORN SHEEP IN NEVADA

Al Jonez, District Supervisor
Nevada Fish and Game Commission
Reno, Nevada

INTRODUCTION:

The Nelson Bighorn Sheep had not been legally hunted in Nevada prior to 1952. It is common knowledge that illegal hunting has existed since the first man lived in Nevada. In the early days both Indians and white man utilized this animal as a source of food. With the advent of game laws and the feeling of preserving such species the Bighorn Sheep was protected by law from hunting. Until fairly recently, however, poaching has continued at a fairly consistent rate. Modern day law enforcement has probably reduced poaching to a low take and probably this take is way below the number harvested each year in the past.

In 1952, Nevada decided that their sheep population was apparently remaining fairly static or at least there was not any appreciable change in the numbers seen now as compared to the number seen say 10 years ago. With this thought in mind, coupled with an interest to find out more about the game animal, a legal season was proposed and the Commission accepted the proposal.

LEGAL HUNTING:

The first Bighorn Sheep season was a well controlled hunt with areas set aside as open to hunting and guides were required. The guides were local residents who know the various areas open to hunting and were expected to keep the hunters from shooting illegal rams. A legal ram as defined for hunting is a mature ram having at least 3/4 of a full curl. The guides proved to be of some benefit; however, some people objected to having to pay for a guide and complained that this restriction made the hunt available to those that had lots of money.

This first season was held only in Clark and Lincoln Counties, Nevada. The Desert Game Range was not included in the open area. The hunt was held in the Spring from April 12 to 29, 1952. Fifty tags were available and were awarded by drawing. The applications for this drawing were slightly over the number of tags available; therefore there was a drawing held. Another restriction that brought about much comment was that the successful applicants that received tags were not eligible to draw again for the next five years.

Hunters were fairly successful in that 48 out of the 50 hunters actually spent one or more days in the field hunting and they killed a total of 15 legal rams. The 33% success ratio was not bad considering the low density population that was being hunted. It is interesting to note that the average weight for 15 dressed rams was 145.6 pounds with the range from 122 to 175 pounds.

The second Bighorn Sheep season was also well controlled and was held in the Spring of 1953. The season was open from April 5 to 30, 1953 with sixty tags available for the hunt. A drawing was not necessary as there were not sufficient applicants and the tags were then sold on a first come basis. A total of 53 hunters went into the field and they killed 15 legal rams for a success of 28%. This hunt was held in a like manner to the.previous hunt with guides being mandatory. The combination of having the guide mandatory and the five year limitation on 1952 successful applicants from applying was felt to be the main cause for the lack of interest. All but one ram taken during the hunt came from the Muddy Mountains.

The fifteen animals averaged 135.6 pounds with the range from 109.0 to 168.5 pounds.

The third Bighorn Sheep season was held in the Spring of 1954. The season was heldfrom April 11 to 25, 1954. Sixtytags were awarded to resident hunters, out of 90 applicants, in a drawing. Only residents over 18 years of age are allowed to participate in these hunts. Guides were not required for this hunt; however, the five year limitation was still imposed. Three areas were opened for hunting and hunters were assigned to the three areas. Areas open for hunting in 1954 were: Desert Game Range, Muddy Mountains, and the Potosi Mountains.

Desert Game Range: 12 hunters killed five legal rams in the Las Vegas Range portion of the Desert Game Range for a success ratio of 42%. The five rams averaged 145 pounds with the range from 113 to 166 pounds.

Potosi Mountain: 19 hunters killed three legal rams in this area for a success ratio of 16%. Of interest was a pure white, full curl, ram killed on the west side of the Potosi Mountain. The hunter report also stated that another white ram of approximately the same size was seen.

Muddy Mountain: 29 hunters killed three legal rams in this area for a success ratio of 10%. Out of the six rams killed in the two county areas none were very large. They averaged 119 pounds with the smallest coming from the Potosi Mountains.

The fourth Bighorn Sheep season was held in December 1956. There was not any season recommendation for 1955. This time of the year was suggested and was tried for the first time. The hunt was held from December 1 to 22, 1956, with two areas open for hunting. The Sheep Range portion of the Desert Game Range was open and the Muddy Mountains. A variance from past hunts was noted in that guides were not required and the limitation of applying within five years after being successful in a prior drawing was eliminated. Forty tags were available with 25 for the Sheep Range and 15 for the Muddy Mountains. For the first time the number of applications exceeded 100 and a drawing was necessary to pick the successful applicants.

Information was sent to the hunters and they were instructed to check in and out of specified checking stations. The hunters were also supervised fairly close by personnel of the Nevada Fish and Game Commission and personnel of the Desert Game Range. Research information was gathered from both areas as the Nevada Fish and Game Commission was participating in a cooperative research project with the Desert Game Range.

Sheep Range: 25 hunters killed a total of 25 legal rams for a success ratio of 100%. It is interesting to note that the 25 rams averaged 104.6 pounds with a range of 85 to 124 pounds. This is the first time that this portion of the Desert Game Range has been hunted. It was felt that many large animals and nice heads would come from this ideal habitat. However, there were not any large rams taken and the largest head was 170-3/4 points on the Boone and Crockett score sheet.

Muddy Mountain: 12 hunters took to the hills and only killed one ram for a success ratio of 8%. The one ram that was killed weighed 128 pounds and had a Boone and Crockett score of 153-1/4 points. The 12 hunters in the Muddy Mountains hunted a total (combined) or 55 days for an average of 4.5 days per hunter.

The fifth Bighorn Sheep season was held from November 30 to December 15, 1957 with a total of 60 tags available. The hunt was set up somewhat like the 1956 hunt; however, all of Clark County and the southern portion of Lincoln County was opened. The Sheep Range portion of the Desert Game Range was again opened and a new area, the Pintwater Range of the Desert Game Range, was opened. Again there were over 100 applicants; therefore, a drawing was held and 30 tags were awarded to the Sheep Range, 10 tags to the Pintwater Range, and 20 tags to the county area.

Sheep Range: 30 hunters killed 19 legal rams for a success ratio of 38%. The 19 rams averaged 108.6 pounds with a range of 81 to 132 pounds. Again no large rams were taken and the largest ram taken was 168 points (head) on the Boone and Crockett score sheet.

Pintwater Range: This hunt was held from December 19 to 23, 1957 because it is in the Nellis Gunnery Range and access could be made during that period without conflict. Seven hunters killed two rams for a success ratio of 28%. One ram was weighed and it went 100 pounds.

Clark-Lincoln County: 20 hunters killed four legal rams for a success ratio of 20%. Three of the four rams were weighed and they averaged 131 pounds. The four rams all had scores over 150 points in the Boone and Crockett scoring system and the high was 179 points, a record for Nevada.

The Sheep Range and the Pintwater Range hunters were supervised by personnel of the Nevada Fish and Game Commission and U. S. Fish and Wildlife Service Desert Game Range. Although Nevada Fish and Game Commission does not have a technician working'with she'ep, assistance was given during the hunt with Charleston District personnel gathering research information on the game range.

The hunters in the county area were not supervised at all and were left to their own devices. They were required to turn in information after the hunt, but that is all.

OBSERVATIONS:

It is interesting to note that the rams killed in the lower elevations of southern Nevada have consistently averaged larger both in weight and head and horn size than have the animals taken from the higher elevations, such as Potosi and the Sheep Range. The only animals taken from the Desert Game Range that averaged larger were taken from the Las Vegas Range and this area is more like the lower elevation sheep range.

Why rams from what is considered low density population area, and what is considered by some to be marginal habitat for sheep, are consistently larger and have big trophy heads is still in question. There have been some ideas expressed as to why this exists; however, most of the ideas have not been worked out to determine their feasibility.

As to the effect of hunting on the Nelson Bighorn Sheep in southern Nevada, I do not feel that there is sufficient information to make any conclusions at this time.

On the Desert Game Range a total of 51 legal rams have been harvested out of a total of some 1,200 animals. The ram:ewe ratio for the past three years on the Desert Game Range has shown a definite spread.

Year	Ram		Ewe
1955	1	:	1.26
1956	1	:	1.53
1957	1	:	1.96

Another year's ratio should show the effect of the total removal of the 51 legal rams, as the 1957 sheep hunt was held so late that the 1957 ram: ewe ratio does not reflect the total decrease in rams.

During the five years that sheep have been hunted in the county areas a total of 41 legal rams have been killed in the following areas:

Muddy Mountains	26
McCullough Mountains	2
Potosi Mountains	5
Bird Spring Range	1
Meadow Valley Range	3
Mormon Mountain	3
Arrow Canyon Range	1
TOTAL	41

All seven areas have what is considered a low density population and the only area that might possibly have been hunted fairly heavily is the Muddy Mountain. When one looks at the number of areas hunted and the few taken from each area it is hard to believe that the total population has been harmed.

Area Hunted	Legal Rams Killed 1952	1953	1954	1956	1957	Total
Muddy Mountains	8	14	3	1		26
McCullough Mountains	1				1	2
Mormon Mountains	1	1			1	3
Meadow Valley Range	3					3
Potosi Mountain	2		3			5
Desert Game Range-Las Vegas Range			5			5
Desert Game Range-Sheep Range				25	19	44
Desert Game Range-Pintwater Range					2	2
Bird Spring Range					1	1
Arrow Canyon Range					1	1
TOTALS	15	15	11	26	25	92

Hunting success has shown an interesting yet unpredictable trend, as the following table shows:

Year	County Areas No. Hunters	Kill	%	Desert Game Range No. Hunters	Kill	%
1952	48	15	33			
1953	53	15	28			
1954	48	6	12	12	5	42
1956	12	1	8	25	25	100
1957	20	4	20	37	21	56
TOTALS	181	41	27	74	51	68

The total success taking in both areas would be 255 hunters killing 92 sheep for a success ratio of 36%.

During the hunts information was obtained on weights and measurements. The following table summarizes some of the information gained:

Weights and Measurements	1952 Hunt Average	1952 Hunt Range	1953 Hunt Average	1953 Hunt Range	1956 Hunt Average	1956 Hunt Range
Dressed Weight	145.6	122-175	135.6	109-168.5	104.6	85-124
Total Length	60. 5	52.5-68	55.8	52-60	57.1	52-63.5
Length of Ear	4.5	3.5-5.2	4.3	4-4.6	None	
Length of Hind Foot	14.75	11-16	13.5	12.5-15.2	14.6	12.5-16
Length of Tail	3.5	2.7-4	3.9	3.2-5.5	3.2	2.5-4.5
Height at Shoulder	38.3	36.0-41.0	36.6	34.0-40.0	36.2	31.0-39.0
Boone & Crockett Score	152	125-169	140	115-159	145.6	113.7-170-7

The 1952 and 1953 hunt information comes from sheep off the Desert Game Range. The 1956 information comes from animals either hunted or trapped from the Desert Game Range. Sample size: 1952-15, 1953-15 and 1956-25.

The dressed weight of the Nelson Bighorn Sheep was correlated with the live weight wherever possible and as a rule of the'thumb they will dress out about 2/3 of their live weight (M. Clair Aldous).

LITERATURE CITED:

1952 through 1957 Bighorn Sheep Hunt Reports and Material--Nevada Fish and Game Commission.

Some Weight and Measurements of Desert Bighorn Sheep, M. Clair Aldous, Frank C. Craighead, Jr., and George A. Devan--U. S. Fish and Wildlife Service.

Reports and Material on Bighorn Sheep Hunts--U. S. Fish and Wildlife Service, Desert Game Range.

AN EVALUATION OF HUNTING BIGHORN SHEEP IN ARIZONA

John P. Russo, District Biologist
Arizona Game and Fish Department
Phoenix, Arizona

In January 1953, for the first time in the history of its Statehood, Arizona opened bighorn sheep hunting. The initial seasons were established under a specific research and investigations project, then being conducted. Objectively, additional information was needed to contribute to an over-all study of the animal. In 1955, the bighorn project was directed under management and the hunt is now part of a state-wide big game management program.

Without entering into the entire research phase of the original program, hunting bighorn was more or less a "trial-and-error" study to determine primarily the results of hunting on the bighorn population. Understandably, the outcome of such a study would necessitate considerable time.

This topic will deal with an inconclusive evaluation of bighorn sheep hunting in Arizona to date, and no attempt will be made to formulate management procedures.

A comparative evaluation of six bighorn sheep seasons reveals several interesting diversities. Hunt regulations permit 20 hunters, a season of 10 days, a legal animal, as defined by commission order, and a specified area in which the sheep may be hunted. The above regulations have remained unchanged. Changes that did occur were not of a nature that would modify the hunt or alter any of the original objectives.

First, it was learned that a January season (first bighorn hunt) produced rams with poor capes. The hair was dry, brittle and often severely rubbed. Thereafter, the season was set a month earlier, in December. Subsequently, 1953 is recorded as having two sheep seasons, one in January and the second in December. An additional change was to provide three alternates, as replacements, in the event any of the first twenty could not participate in the hunt. The Game and Fish Department was to be notified in time to dispatch an alternate. One other change was made to modify the laws pertaining to weapon caliber, to allow the use of many good, light-weight, flat-shooting, high-speed calibers. Aside from the above mentioned alterations, no other changes have been made.

Before an evaluation of the hunts can be undertaken, several pertinent points should be mentioned to better understand the situation and obstacles confronting the hunter. The area opened to bighorn hunting is comprised of four mountain ranges, the Trigo Mountains, Dome Rock Mountains, Chocolate Mountains and Plomosa Mountains. These mountain ranges vary widely in geological formation, vegetative reproduction, topographical structure and accessibility. The latter plays an important role in hunter participation and preference. The four mountain ranges encompass an area of approximately 400 square miles.

The Trigos, Chocolates and Dome Rocks create an illusion of one mountain interrupted and segmented in juxtaposition, in a framework of disembodied upheavals and dispersions. The Plomosa Mountains are not directly joined to any of these three mountains and are separated by a relatively flat desert plain approximately five miles wide. Sheep have been known to drift from the Dome Rock Mountains to the Plomosa Mountains across this stretch of desert. The only obstacle in the line of travel is a state highway, which is unfenced. No other impediments exist to stop a free passage of bighorn in this area.

Largest and highest of the four ranges are the Trigo Mountains. The general composition of this range is of several individual mountains rising sharply from the desert floor. Arroyos, outwashes and eroded canyons create an escarpment of broken, rolling foothills and alluvial fans fringing the precipitous mountains.. Several'sheep have been taken from this range. However, all but one has come from the easily accessible areas of Mohave and Gould Washes.

With few exceptions, the majority of sheep have been taken from the Plomosa Mountains. It is not that this particular range has more sheep--rather, it is more easily accessible to vehicle travel and relatively easy to traverse on foot or horseback.

No sheep have been taken from the Dome Rock Mountains, although very fine trophy heads have been seen in this group. The Dome Rocks are situated on a geological fault and the upheaval creates difficult walking conditions. Those hunters who have spent a day of travel in this area are reluctant to repeat another day of the hardships experienced.

Smallest of the four mountain ranges are the Chocolate Mountains, which join the Trigo Mountains and display many of the topographical features of the Trigos. Foothills extend east to join the Castle Dame Mountains, which are located within the Kofa Game Range. There is an active exchange of sheep between the two areas. Several fine trophy rams have been taken from the Chocolate Mountains. The largest ram taken in any hunt has come from here.

Typical of the extensive bighorn habitat in Arizona, the four mountain ranges are commonly granitic with very small sedimentary pockets, widely dispersed and shallow in nature. Calcareous deposition is found along the fringe of the mountains and in the network of numerous outwashes.

Prior to recommending hunting of the Arizona bighorn, an extensive investigation was made to determine'the population level, reproduction potential and if sufficient trophies existed to make bighorn hunting worth the time, effort and expenditures required for such an undertaking. The investigation revealed that each mountain range supported an adequate trophy-class ram population to provide for several years' hunting, based on the twenty permit hunt. A trophy ram was so classed if it had full-curled horns or broomed tips. As a matter of interest, an animal five years old could fall into this category. A legal ram was specified as an animal with a three-quarter curl.

There is much to be desired in the definition of a legal ram when the purpose, and one of the objectives of the hunt, is to remove the larger horned, trophy animals. What then constitutes a trophy animal has to be left entirely to the discretion of the individual participating. Where one person hunts the animal as a trophy, another may hunt the horns.

No attempt is made to restrict hunters to areas or choice of ram. The Game and Fish Department does not have enough men familiar with the region to qualify as guides. Sheep movement is unrestricted and the exchange from one mountain range to another is unpredictable. Even a prehunt search and investigation to locate sheep is not a reliable conclusion for dispatching hunters. The nature of the terrain and the extensive unimpeded sheep movements can easily disrupt this control.

Whenever possible, Game and Fish Department personnel assisted in directing hunters to likely areas, or if requested a day or two was spent showing the participating sportsman how to hunt sheep. The desert bighorn hunt is extremely difficult. Many who have hunted sheep in Alaska, Canada, or in the Rocky Mountains of the United States have volunteered the opinion that the Arizona sheep hunt is the "roughest" they have experienced.

During the first three seasons, hunters were directed to likely areas where bighorns had been seen or known to visit. This method also enabled the checking station to keep the hunters dispersed among the four mountain ranges and apart from one another. However, in the following years, many of the hunters sought the advice and aid of those who had hunted sheep before. The result was that the distribution of hunters was to a great extent lost.

Experienced sheep hunting guides are not available in Arizona. As such, this remains a decided disadvantage to a hunter, especially to the nonresident hunter. Arizona requires a license of any individual who desires to be a guide. However, no qualifications are required for field experience or outfitting. Many nonresident, and several resident, hunters have hired guides from other states. One hunter had "his" guide from Canada. For legality reasons, these men are hired as "packers."

One point was brought out from this experience. A good sheep guide from another part of the country can enter a strange area with success. Knowing the habits of an animal is apparently more important than knowing the country.

In making a sincere evaluation of the past six seasons, several points must be kept in mind. Although the bighorn has been hunted for this length of time, it still remains a relatively "young" hunt. As a result, it is difficult to interpret the data to determine if a "leveling off" period has been reached. No two seasons have been the same from the standpoint of climatic conditions and general hunt participation. The majority of hunters in the past three years have been satisfied to hunt the animal as their trophy rather than pass up sheep in search of a big head.

During the first three hunts the success was 50.0%, 58.8% and 62.2%. The following year the hunt success dropped to its lowest figure of 25%, and was followed in 1956 with 31.6%, and 30.0% the last season. A comparative study of man-days in the field per successful and unsuccessful hunter, and calculated averages and percentages, reveals no correlation to date that would explain the large success change.

In the first three seasons hunters reported seeing 161, 95 and 96 sheep, respectively. In the following three seasons sight observations dropped to 57, 56 and 45, respectively. These sheep observations cannot be used as a correlative factor. Even if a depleted ram population did exist, the hunters should still have a large count of ewes, lambs and young rams. The hunters are not seeing the sheep; no mortality has been disclosed by technicians in the field, so the sheep must be there, and the hunters are failing to find them.

COMPARISON OF ARIZONA'S BIGHORN SHEEP HUNTS

Statistic	1953* First Hunt	1953 Second Hunt	1954 Third Hunt	1955 Fourth Hunt	1956 Fifth Hunt	1957 Sixth Hunt
Number of permits sold	20	17	20	20	20	20
Number of hunters checked in	20	17	19	20	19	20
Length of season (days)	10	10	10	10	10	10
Total possible hunter days	200	170	190	200	190	200
Total hunter days used	109	92	104	131	115	130
Percentage of days used	54.5	54.1	54.7	65.5	60.5	65.0
Average field days per hunter	5.4	5.4	5.4	6.5	6.0	6.5
Number of successful hunters	10	10	12	5	6	6
Hunter success (percent)	50.0	58.8	62.2	25.0	31.6	30.0
Successful hunter days (total)	55	35	55	22	16	18
Aver. no. days per successful hunter	5.5	3.5	4.5	4.4	2.7	3.0
Unsuccessful hunter days (total)	54	57	49	109	99	112
Aver. no. days per unsuccessful hunter	5.4	8.1	7.0	7.2	7.6	8.0
Tot. sheep observations hunters reported	161	95	96	57	56	45
Legal rams reported	36	35	29	19	15	13
Classed as full-curl rams (reported)	24	30	18	17	10	8

COMPARISON OF HORN MEASUREMENTS FOR ARIZONA'S BIGHORN SHEEP HUNTS

Statistic	First Hunt	Second Hunt	Third Hunt	Fourth Hunt	Fifth Hunt	Sixth Hunt
Largest trophy (total measurements)	102-1/8	100-2/8	99	93-6/8	93-4/8	90-6/8
Smallest trophy (total measurements)	56-2/8	72-3/8	65-3/8	85	65-2/8	60-2/8
Total measurements (of all heads)	825-2/8	878-6/8	1012	443-4/8	479-6/8	459-3/8
Average trophy head	82.5	87.9	84.3	88.7	79.9	76.6
Average outside curl (left horn)	28.4	29.9	29.0	30.5	27.0	25.7
Average outside curl (right horn)	28.1	30.2	28.5	30.1	27.8	25.7
Aver. basal circumference (left horn)	13.0	13.9	13.4	14.0	12.6	12.6
Aver. basal circumference (right horn)	13.0	13.9	13.3	14.0	12.6	12.5

*First hunt was in January; subsequent hunts in December.

BIGHORN CENSUS RECORDS--SUMMER SURVEYS

Year	Rams	Ewes	Yearlings	Lambs	Unclassified	Total
1951	56	46	13	30	9	154
1952	48	35	4	15	8	110
1953	59	48	8	24	17	156
1954				No Survey		
1955	159	129	2	29	41	360
1956	95	129	4	29	4	261
1957	53	54	1	9		117

BIGHORN SEX AND AGE DATA

Year	Rams:Ewes	% Ewes w/Lambs	% Yearlings*
1951	1:0.8	65%	12.4
1952	1:0.7	42%	3.9
1953	1:0.8	50%	5.8
1954		No Data	
1955	1:0.8	22%	0.6
1956	1:1.4	22%	1.6
1957	1:1.0	17%	0.9

*Based on those animals classified.

It can be said that a correlation does exist between the hunter observations and the hunter success, but statistically this would represent a poor sample, and a discrediting population figure.

It is worthy to note that each year, two to four nonresident hunters participate in the bighorn hunt. Of the fifteen nonresident hunters who have participated in the six hunts only two have been unsuccessful.

License fees for hunting sheep in Arizona for the first six seasons were $50.00 for a resident and $150.00 for a nonresident. The fee was established through a legislative act and is in no way part of the project study recommendations. The cost is high and many sportsmen have justifiably complained of it. However, when considering the expense of the hunt in time and equipment needed, the license fee can easily become a minor expenditure. The price of the license served a more important cause by practically eliminating the "novelty hunter" who would be more inclined to hunt for any animal rather than a large head. This is not meant to imply that only individuals who have means to undertake a hunt of this type are trophy hunters.

Possibly the answer to the noticeable drop in hunt success and sheep observations after the third season is that at this time Department personnel discontinued assisting hunters in the field. This practice was terminated because it was learned that many hunters were depending on Department personnel to "guide" them and to do everything short of shooting the animal for them. With only ten days to hunt in, it would be impossible to accommodate the desire of all participating sheep hunters. Many felt that they were being discriminated against and that favoritism was being shown to friends and influential people.

With the exception of the 1957 season, a definite pattern can be seen in the hunter take. Approximately one-half of the season kills were made on the first, second and third days. The following four days, with few exceptions, did not contribute toward the kill. However, on the eighth, ninth and tenth days, hunters brought in sheep. If we can follow the hunters' feelings, thoughts and reactions, the early kills typified most hunts. Enthusiasm, confidence and desire are strong factors in the initial drive. However, after three days of exhausting hunting, rough terrain and fruitless search, the participants are prone to fatigue, discouragement and doubt. The hunt progresses slowly. The hunters are starting later, quitting earlier, not traveling as far on foot, avoiding rough country, and not climbing quite as high.

About the middle of the season the checking station is active with hunters asking endless questions, closely examining maps and seeking advice about areas in desperation for any information that will lead them to a sheep--any sheep, quick. This has become more noticeable in the last three hunts. Generally, sights have been lowered from the big trophy head to any legal head. There is a quick shuffling about, changing of hunting areas, and a desire for assistance. Those hunters who drop out generally do so after the third day.

After the seventh day a "do-or-die" attitude prevails, with the realization that only three more days remain in which to procure their long-sought-for, and often expensive, trophy.

To many of the hunters this is a first experience with bighorn sheep--even to the the extent of seeing one. The method of hunting is unlike any they are familiar with, and they are not properly equipped physically, mentally or materially to undertake a ten day season of this kind.

Possibly a solution to this would be in the form of an information bulletin mailed to each person with a permit for bighorn sheep hunting. Along with regulations, restrictions and the permit the bulletin should include equipment needed, method of hunting bighorn, how to determine a legal-sized head, and an outline of difficulties to be expected on this type hunt. By educating the hunter and giving him an insight into what he may expect, a desired removal may be attained.

An evaluation of this type would not be complete without considering the invaluable information that has been obtained. Close examination of the animals has provided a study of internal and external parasites, disease, malnutrition and the general physical condition, weights and measurements, pelage condition and coloration, and dentition studies, to mention a few. All this information has been advantageous in the life history study of the Arizona bighorn and has contributed to a better understanding of the animal's demands and of proper management.

There is no indication that six years' hunting has had any damaging effect on the bighorn. Even in the Plomosa Mountains, whichhave received the greatest pressure and have produced approximately 75 per cent of the sheep, there is no evidence of decimation. In the early 1950s, it was not unusual to find carcasses of large, trophy rams in this range. This is not the case now; which may indicate that the hunter is hanging this trophy on the wall rather than finding it dead in the field.

In future years there will be more and more areas opened to hunting bighorn if for no other reason than to remove the old rams that are not herd potentials and that would die in the field. These old rams represent a desire of many sportsmen, additional revenue in the game and fish fund which in turn can be put back into continued study of the species, and an avenue toward making the people of the state sheep conscious.

SHEEP HUNTING IN NEW MEXICO

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Probably all of New Mexico, with the exception of the northeast corner, was inhabited by bighorn sheep when the white man came about 1650. Indiscriminate hunting and other factors reduced the species to very low numbers by 1886. At this date the territorial legislature provided legal protection for the remaining Mexican .bighorn sheep. The Rocky Mountain bighorn was probably extirpated from New Mexico by this date.

Two Mexican bighorn sheep seasons have since been held in New Mexico. These were held from January 15 through January 19, 1954 and from December 3 through December 7, 1955. Both seasons were held in the Big Hatchet Mountains in the southwest corner of the state. Only mature males having more than one-half of a complete horn curl were legal prey. Twelve public and three landowner permits were issued in 1954. Of the 15 permittees, 14 persons hunting and 11 persons, or 79%, took sheep. Twelve public permits were issued in 1955. All permittees hunted and six, or 50%, took sheep. Public permits were issued by chance drawing. Participants had to be residents of the state. Landowners were required to open their lands to public hunting to be eligible for a permit.

The primary purpose of the hunt was to provide information regarding the physical condition of bighorns, as well as to provide other biological data. Department biologists felt that a surplus of mature rams warranted both of the seasons. A checking station was maintained near the hunting area. Hunting regulations stipulated that successful hunters were to bring carcasses and the entire vicera to the checking station during 1954. During 1955 hunters were required to bring in the heart, lungs, liver and the last two feet of the colon, as well as the carcass. Blood samples and stomach samples were obtained in all cases. Body weights and measurements, as well as external parasites, were obtained at the checking station.

Analysis of the stomach samples revealed.that grasses, Opuntia, mountain mahogany, Garrya, sotol and agave were the most important foods in the winter diet. Stomachs of five mule deer collected from the same area in March showed Rhus trilobata to be the most important food item. Garrya, mountain mahogany, Opuntia and grasses were also present in the mule deer stomachs, but all were secondary to Rhus. Other workers (Halloran and Kennedy, 1949[1]) found silk tassel, mountain mahogany, sotol, Opuntia, big mellow yucca and agave to be the important food items and grasses of little importance for both deer and bighorn on the San Andres Mountain National Refuge in New Mexico.

All blood samples were negative for the brucellosis test.

All animals taken during the first hunt were in poor condition following drought. Heavy summer rains during the next two summers seemed to

[1] Halloran, Arthur F. and Cecil A. Kennedy, Bighorn-Deer Food Relationships in Southern New Mexico, The Journal of Wildlife Management, Vol. 13, No. 4, October 1949.

decrease the competition between cattle and sheep because of the increase in grass production. Sheep taken during 1955 averaged almost 20 pounds heavier than those taken during the first season. Browse failed to recover during this interim so that bighorn-deer competition remained high. Since the bighorn is a remnant species it was recommended that the Big Hatchet Refuge be abolished to make way for an any deer season.

Figures for the 1954 hunt ran as follows:

Average weight of rams	126 lbs.
Average height of rams	38.14 in.
Average length of rams	60.44 in.
Average age of rams	7.5 yrs.
Average horn length of rams	30.07 in.

Figures for the 1955 hunt ram as follows:

Average weight of rams	145 lbs.
Average height of rams	38.13 in.
Average length of rams	57.70 in.
Average age of rams	9.17 yrs.
Average horn length of rams	29.38 in.

The list of parasites for 1954:

1. Dermacentor albipictus
2. Otobius megnini
3. Cysticercus tenuicollis
4. Haemonchus placei
5. Pseudosterta ______ losa
6. Trichuris discolor
7. Skrjabinema ovis
8. Oesophagostomurn sp. (larva)

Only numbers 1, 3, 4 and 7 were collected from the 1955 sample.

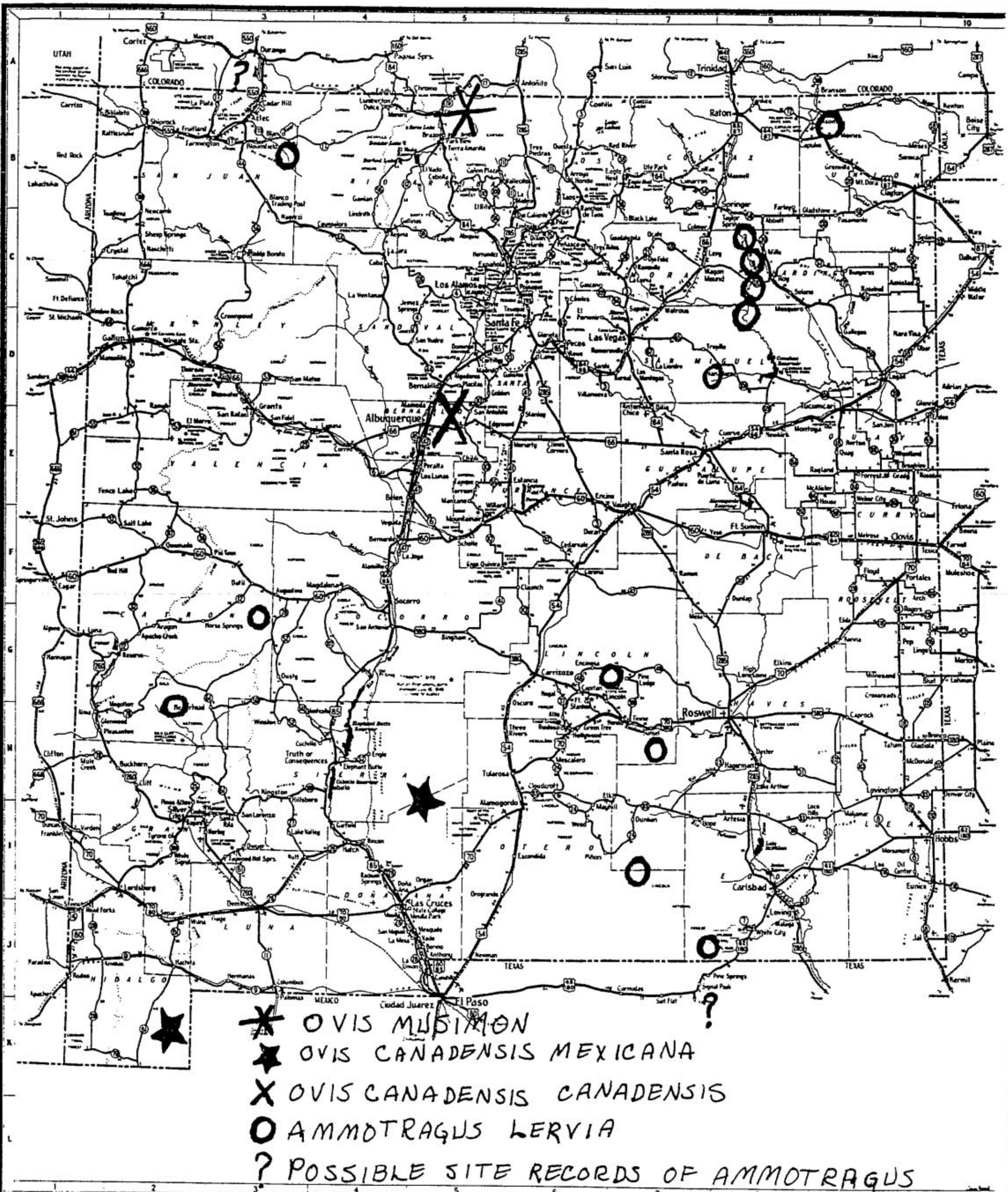
One factor accounting for the greater hunter success during the first hunt was the use of a Department of Game and Fish airplane. This was used repeatedly to locate legal rams.

Census of bighorn and deer of the Big Hatchet Mountains has never been very successful. However, 82 sheep were seen in March 1953. Only 60 were seen in February 1956. The ewe-lamb ratio was thought to be 1:62 in 1953 and 1:19 in 1956.

It is believed that there are about 100 sheep present on the San Andres Refuge. These are not being hunted.

During 1956, arrangements were initiated to obtain a group of Nelson's bighorn sheep from the Desert Game Range of Nevada. A suitable site was found for introducing this stock in the Caballo Mountains of southwestern New Mexico, which are ancestral Mexican bighorn sheep range. It was decided not to make the introduction when it was learned that the sheep of the Desert Game Range were infested with lungworm.

During 1938, arrangements were made with Banff National Park, Canada to obtain Rocky Mountain bighorns. Three groups, each consisting



OVIS MUSIMON
OVIS CAÑADENSIS MEXICANA
OVIS CANADENSIS CANADENSIS
AMMOTRAGUS LERVIA
? POSSIBLE SITE RECORDS OF AMMOTRAGUS
UTAH
COLORADO
ARIZONA
TEXAS
MEXICO
Albuquerque
Santa Fe
Las Vegas
Roswell
Carlsbad
Las Cruces
El Paso
Ciudad Juarez
Socorro
Gallup
Farmington
Raton
Trinidad
Durango
Clovis
Tucumcari
Santa Rosa
Alamogordo
Hobbs

of one male and two females, were received during 1939, 1940 and 1941. These nine animals were introduced into the Sangre de Cristo and the Sandia Mountains of New Mexico. The group in the Sandia Mountains is thought to have increased to several dozen head and has remained at that level. They are known to have crossed U. S. Highway 66 going south toward the Manzano Mountains. The state has no plans to hunt this subspecies. The Sangre de Cristo Mountains are believed to have been the southern limit of the Rocky Mountain bighorn sheep It is believed that the reintroduction to this area failed.

The mouflon sheep, Ovis musimon, has been introduced to north-central New Mexico by a private party. The New Mexico Department of Game and Fish has no official information on the present status of this group.

The Barbary sheep, Ammotragus lervia, a native of Morocco, was first introduced into New Mexico by a private rancher in 1941. From this group near Picacho, New Mexico, escapees have been known to egress through the southeast portion of the state. Introduction of Barbary sheep has been made by the State of New Mexico Department of Game and Fish to the northeast corner of the state. Fifty-two sheep were planted along the gorge of the Canadian River in 1950. Sportsmen's and other groups have introduced the Barbary throughout the northern, northwestern and western portions of the state. The Barbary sheep has not yet been recorded in the San Andres or Big Hatchet Mountains where remnant native bighorn are to be found.

The Barbary sheep was classified as a game animal by the state legislature in 1955. Hunting seasons were held for Barbary Sheep during 1955, 1956 and 1957 in the region of the Canadian River in northeast New Mexico. During December 1955, ten permits were given to landowners and 15 to New Mexico residents by chance drawing. Twenty-four participating hunters took 13 sheep for a 54% successful hunt. During 1956, 34 participating hunters took only six sheep for a hunter success of 18%. During 1957, 85 participating hunters took 43 Barbary sheep for a 51% successful hunt.

Hunters were required to check into and out of a checking station. All sheep carcasses were measured and examined here. The successful hunters were also required to bring in various parts of viscera.

Brucellosis tests were made during the first two years of hunting. There were negative for all animals taken.

Average dressed weights for mature Barbary sheep males ran about 170 lbs. Individuals of well over 300 lbs. have been recorded. Both sexes have horns. Female Barbary sheep, having much larger horns than female bighorns, are often mounted to make trophies. Male Barbarys usually have greater "spreads" than bighorn rams because the horns do not form as tight a curl as do the horns of bighorn. The extreme spread often approaches 30" in large rams. However, Barbary sheep ram horns are considerably smaller than those of bighorn. The largest we obtained usually measured about 30" long and 13-1/2" basal circumference.

Evidence obtained from stomach sample analysis and direct observations indicates that the Barbary sheep is primarily a grazing animal. This would indicate that the animal will compete directly with the Rocky Mountain bighorn and the desert bighorn in areas where the latter feed on grass.

The Barbary sheep's a remarkable animal in regard to productivity. Reproductive tracts were obtained from the 1957 hunter kill and from departmental collections. These have not been examined closely, but it is obvious that Barbary sheep drop lambs throughout much of the year. Multiple births are common. Almost all females are pregnant regardless of the time of collection.

Parasites of the Barbary sheep make an impressive list. These include:

Dermacentor albipictus
Haemonchus placei
Pseudostertagia bullosa
Trichostrongylus axei
Trichostrongylus colubriformis
Trichostrongylus vitrinus
Trichostrongylus longispicularis
Trichostrongylus probolurus
Cooperia oncophora
Nematodirus spathiger
Nematodirus helvetianus
Skrjabinema ovis
Thysanosoma actinioides
Ostertagia bisonis
Ostertagia spp.

A Barbary sheep has yet to be found which was noticeably suffering due to parasites. Practically nothing is known of disease in Barbary sheep at this time.

This animal seems to have the ability to adapt itself readily to several kinds of habitats.

THE INFLUENCE OF TROPHY HUNTING ON HORN SIZE OF BIGHORN POPULATIONS

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Introduction

There are three different factors that may influence horn size in bighorn populations: food, selective removal of the older animals, and heredity. The availability of food and selection and removal of the older animals would only affect the population temporarily, but could be brought about rather rapidly. Decreasing horn size by heredity, that is reducing the gene factor in the herd for big heads, if this could be done at all, would take many years but would have a lasting and perhaps a permanent effect.

The Effect of Food on Horn Size

Every organism is only as healthy and as robust as its food supply. Cold blooded animals, or indeterminate growers, are greatly influenced by the quantity and quality of food. Warm blooded animals, or determinate growers, are less influenced, but even in these animals we are coming to believe more every day that food has a greater influence than we formerly thought. The effect of quantity of food has long been demonstrated,-'but only recently, within the past ten years, has the effect of quality of foods available to game been studied. This can also be traced back to fertility of the soils. Our "bread basket" in the United States, the great plains, was the area that formerly supported our large herds of bison, antelope and elk. It has been demonstrated that animals on soils of high fertility have a higher productivity, are mare free of parasites, and are larger in body size than those on soils of low fertility (Denny, 1944).

In a recent study in Pennsylvania it has been shown that the size of antlers of white-tailed deer is a direct result of the quality of food ingested (French et al., 1955). For an animal to obtain large antlers the food must be of a high quality throughout the animal's growing period as well as during the current period of antler growth

On the basis of these data it then appears that bighorns on areas of either short food supply or producing food of low quality would small in body size as well as horn size. An area supporting many animals of trophy size could in a short period, due to competition with other herbivores or competition among themselves, become an area with few or no trophy animals. Once a range is heavily overutilized, particularly a desert range, it may take from 20 to 50 years of light utilization to restore it to a point where it can again support animals comparable to those originally found there. It took twenty years for the Kaibab deer herd to come back after the disastrous die-offs of the early and mid-thirties. A desert range recovers at a slower rate than one that receives more rainfall.

The Effect of Removing Old Animals on Horn Size

In bighorns it is the aged males that make the best trophies. The longevity of bighorn sheep is believed to be 12 to 14 years. Probably a ram would have to reach an age of six or more years before it would be considered an acceptable trophy, and an animal of eight years would be more highly desirable. On this basis the absolute maximum harvest of mature rams should not exceed one-eighth or 12 percent of the males present in the herd. Such a harvest would just permit young animals to replace those harvested and make no allowance for natural mortality.

In Arizona it appears that the harvest is considerably below this hypothetical maximum. In 1954, the last year listed in The Desert Bighorn Sheep in Arizona by Russo (1956) for census records, 44.2 percent of the bighorns counted were listed as rams. On the basis of 3,500 animals listed as the population of bighorns by the U. S. Fish and Wildlife Service report for that year, 1,547 rams were in the state. In the 1954 hunt 12 rams, or 0.77 percent of the rams present, were harvested. Most of these animals were taken from a relatively small portion of the range of the desert bighorn in Arizona, but even within the restricted area it is doubtful if hunting of this magnitude would have an appreciable influence on the number of trophy rams present for selection by the following year's hunters. It has been shown by several workers that bighorn rams wander considerably and sometimes cross from one mountain range to another (Honess and Frost, 1942; Jones, 1950; Russo, 1956; Smith, 1954). It is therefore probable that if a decrease of trophy rams occurred locally this condition would be corrected when the breeding season came around by mature rams spilling over into the country in search of receptive ewes.

In a state where hunting has been closed on a species for a long period, then this species is opened to hunting, the average size of trophies brought in by hunters in successive years may go down. On the surface this may appear to be due to a decrease in trophy rams available, but with such light hunting as had been shown to have occurred in Arizona it is doubtful if this is the case. There must then be other reasons. One apparent reason is the decreasing quality of hunters participating. Those persons participating in the first few hunts probably possess a great desire for a trophy animal. They may be local people who have a good knowledge of the country or experienced hunters wanting to complete their collection with a good head. Later the meat hunters and novelty seekers come in, and they kill an animal rather than pass up a shot hoping to get a better trophy later in the hunt or in another year.

Heredity

The size, body conformation, productivity and the increase of products (such as eggs and milk) have all been brought about in domestic animals by selecting those with the desired characteristics for breeding. This has led a few wildlife people and many sportsmen to believe that hunting, as well as inbreeding, eventually leads to smaller and smaller animals and heads. In most cases a decrease in body size and head size has been demonstrated as being due to crowding or competition either with other animals or with each other. The offspring of deer moved from the Edwards Plateau of Texas to the eastern portion of the state were considerably larger than their parents when reaching maturity. A search of the literature, even of the limited European literature, available to me reporting on animals that have been hunted for trophies for at least 500 years fails to show that hunting has permanently influenced a single characteristic that can be traced to heredity. Some of the Scandinavian countries have been attempting for about ten years to upgrade their wildlife species by selective hunting, but as yet little progress has been made.

The characteristics of wild game animals are the product of a long period of natural selection favoring those individuals that are better able to survive through to adulthood and produce their kind. These characteristics may favor the animals in obtain food, in escaping their enemies, including diseases andparasites, and in procuring mates. Such factors are not likely to be easily changed by hunting.

While hunting goes on and affects the population for a week or ten days those other factors shaping the characteristics of the animals go on throughout the year. Moreover, hunting bighorns, at least as now carried on in Arizona, affects a very small segment of the population.

To influence any population by changing the gene factor the normal gene flow must be either slowed down or stopped entirely. It then follows that it would be difficult to change the characteristic of a local population as long as animals drifted into and out of the area. As previously mentioned, bighorn rams, particularly during the rutting season, wander extensively. This may be one of those habits developed over the long period through which the bighorn has evolved favoring the dissemination of those characteristics equipping the animal for survival.

Undoubtedly the size of horns for rams has some survival significance. Even though there is little evidence that a victorious ram will chase the loser of a fight out of the herd, there is little doubt where each stands in the peck order. Everyone seems to agree that massive horns are an advantage to rams in combat, and young rams with small horns are successful in obtaining mates only when the mature rams are busy fighting.

Last, but probably of most importance in the influence of selective hunting on the gene factor, is that to affect any characteristic the animals must be heterozygous for that trait. We know that like breeds like, but only when the parents are homozygous. If we go back to our basic principles of heredity we can easily demonstrate this with a diagram. Let H equal the gamete for large horns which are dominant and h equal the gamete for small horns which are recessive. We know that every individual is the result of the union of two gametes, one from each parent.

A crossing of homozygous parents would result in offspring with all large horns, as demonstrated below.

	H	H
H	HH	HH
H	HH	HH

A crossing of heterozygous parents would result in the common three to one ratio, that is three offspring with large horns, two of which would be heterozygous, and one with small horns.

	H	h
H	HH	Hh
h	Hh	hh

We therefore see that to have any influence on the size of trophies, or any other characteristic, the parents must be heterazygous for that characteristic. If we assumed that bighorns are heterozygous for horn size hunting them for trophies would still affect the population very slowly for only by removing the homozygous (HH) males would the gene factor be changed. Only one out of the three males with large horns would be homozygous, and of course hunting would have no influence on the females, the parent contributing the other gamete to make up the characteristics of the offspring.

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GAME WATER DEVELOPMENT ON THE DESERT

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INTRODUCTION

It has been suggested that the exerpiences of the men an the State Department of Fish and Game's water development crew working on California's southeast desert be compiled far reference use, and this paper is an attempt to put their experiences into a usable form. No two water development projects are exactly alike, but individuals using this paper may find similar situations and it is hoped that the ideas contained here will prove adaptable to their specific needs.

It is an established fact that water, or the lack of it, is a major controlling factor on game populations in arid areas. Even in comparatively well-watered areas there are often dry localities where water development will enable game concentrations to spread out, and thus increase the carrying capacity of the range.

Spring development is not a complicated procedure. It consists mostly of hard, manual labor. To compensate for the sore muscles and blisters, one gains a sense of achievement and personal satisfaction from the visible benefits to wildlife.

Spring development consists of making water available to game, or of concentrating and conserving a small water supply. Most springs fall into one of two general groups. Either they are good and do not need development or they are merely wet-weather springs that dry up and can't be improved profitably because permanent water does not exist. The good springs, unless very remote, are usually appropriated by cattlemen, miners, or other residents. So it is the marginal spring that can be improved and developed for game. These are usually the small "bee seeps," moist places, or abandoned sources.

Seasonal or wet-weather springs that do not last the year around, or dry up during drought years, are important to game during the period when water is available, but do not usually warrant a great deal of expenditure of effort or money.

Unfortunately, anyone doing spring development will sooner or later have such a project go completely dry. Therefore, it is extremely important to check as many springs, seeps or other potential locations as possible during the fall of the year, before the winter rains begin, and during the driest years. These periods are best for locating the exact water source and for determining what development work would be necessary.

Summer rains are seldom of sufficient duration to restore or measurably increase the flow of a desert spring.

Prospecting for water is a gamble that must be carefully considered. Most spring development should be limited to locations where there is a permanent seep or sufficient other positive indication of water during the dry season.

A person wishing to prospect for water should learn as much as possible about the water-indicating plants that grow in the area. These will vary in different locations with the climate and elevation. The United States Department of Interior, Geological Survey Water Supply Paper No. 577, "Plants as Indicators of Ground Water," by Oscar Edward Meinzer, is a useful reference. Hydrophytes are discussed in U. S. Geological Survey Water Supply Papers No. 224 (page 20), No. 578 (pages 51-54), No. 497 (pages 112-117), and No. 499 (pages 156-157).

It is the author's belief that most water-indicating plants can survive some drought and exist for a period of time on only seasonal rainfall. Therefore, the plant itself is not necessarily an indicator of permanent water, and the condition of the plant becomes the important factor. If considerable deadwood is present it can be assumed that the water these plants normally depend on is seasonal. Conversely, if the plants are in good condition during the dry season, it is probable that their roots are in a permanent water supply at an undetermined depth.

The author has not determined any set rule for estimating the depth to water. In our opinion, water should be a depth not greater than 10 feet to be cansidered practical for game-use development.

Mesquite (Prosopis sp.) is a widespread tree of the desert and usually grows in areas of shallow water table. Many old-time desert residents firmly believe that a well can be dug in less than 40 feet at mesquite growths. The number of dry wells checked by our development crew has led us to the conclusion that mesquite will survive after the source of water dries up during long droughts and that mesquite, by itself, is not a positive indicator of water at any depth. In Water Supply Paper No. 497, "The Salton Sea Region," by John S. Brown, mesquite and its relation to depth to water is discussed at some length.

Arrow-weed (Pluchea sericea), which grows at low elevation in the warm southern deserts, is a good water indicator. Although we have not determined to what depth it will root, it is thought to be an indicator of permanent water if the plants are thrifty and without deadwood in a dry period.

Other plants to consider are wildrose (Rose sp.) and cane or carrizo (Phragmites communis), for we consider them to be good water indicators. Salt grass (Distichlis spicata) and some other grasses generally indicate favorable moisture conditions.

Some plants that favor moist conditions but are not positive water indicators are Forestiera neomexicana, Bacchoris sp., Atriplex sp., cottonwood (Populus sp.) and tamarisk.

Water that flows over bedrock usually can be considered seasonal and will dry up with prolonged drought. Permanent water, if dug out to its source, is almost always found to be coming from rock. These springs may fluctuate very little, either with the seasons or from year to year. An excellent example of this type is Mopah Spring in the Turtle Mountains, in southeastern San Bernardino County. The flow is small but constant near the head of a canyon in an extremely arid mountain range with an annual average of less than four inches of rainfall. These springs cannot be explained in the usual manner and are certainly not the result of local drainage.

In Water Supply Paper No. 224, Mendenhall states, "The greater permanent springs are deep-seated, and many of them probably lie along fault lines."

When searching for water in a new area, study the geological formations. Your chances of locating springs are best along faults and changes in the rock formation. Sometimes several springs or possible sources of water will be more or less in line along such a fault.

COMPETITION:

An important thing to take into consideration before developing a spring for wildlife is the other use it will receive, such as use by domestic livestock or feral animals. The development of water may have a very adverse effect on game if it results in greatly increased range use by competing animals. This is not intended to be a condemnation of domestic livestock grazing, but only to point out that this phase of the problem should be carefully considered and appraised.

Light or infrequent use of game water developments by livestock may be of little consequence, but where the supply is small a relatively few animals attracted to the development can completely usurp the available water. This is frequently the case with feral burros, if they are present in or adjacent to the area.

Our water development crew has never attempted to construct exclosures but they are worthy of consideration where the terrain permits practical application. (See U. S. Fish and Wildlife Service Leaflet No. 14, "Water Development for Desert Bighorn Sheep.")

We feel that ranchers have an obligation to develop the water on their ranges. Ranchers should clearly understand your purpose and policies before any waters are developed by your agency on their livestock range. Some form of legal agreement between the landowner and the agency doing the development may be needed.

TOOLS

The main tools of the water development trade are the pick, mattock and shovel. A portable hammer is necessary on many projects, and there are several kinds available. Rock drills of 2 and 3 foot lengths are necessary, as are chisels, spades, gads and mauls. If the location can be driven to, it is more efficient to use pneumatic tools with a compressor. Handwork is time consuming and can be costly.

Although the use of dynamite on springs is considered by some to be inadvisable, we believe that this explosive, when used by an experienced operator, can prove to be an efficient, indispensable tool.

The source of permanent water is frequently found in rock, and it is practically impossible to dig in hard rock without the aid of powder. Our crew used dynamite many times and has never lost a spring as the result. When springs are lost through the use of an explosive, it can usually be blamed on inexperience. Too heavy a charge may open a crack too deep, allowing the water to escape.

Since springs have been lost when they were blasted to increase the water flow, dynamite, should be used only on marginal seeps where there is insufficient water for game. In such a case there is much to be gained and nothing to lose.

Dynamite is also useful in clearing a storm channel to bypass and thus protect a spring, or to lay a pipe for gravity flow.

We wish to emphasize that extreme caution should be used when storing, handling or using dynamite and, particularly, the detonator caps.

The burning of plant life on a water development site is often employed where such burning can be safely controlled. It is much easier to determine the ground formation and probable source of water when the location has been cleared by fire. In one instance (Toro Spring, Santa Rosa Mts.) burning a dense arrow-weed thicket was all that was necessary to restore open water for game use. Periodic reburning may be necessary.

Spraying with a brush killer (2-4-D or 2-4-5-T) is often helpful (Figure No. 1). Plants such as willow waste a great amount of water through transpiration, and may cause a spring to go completely dry during the summer months. When the plants are killed the spring will often return to its normal flow. This has proved a very useful practice in instances of a small water supply. The possible loss of cover or shade is more than offset by making a permanent water supply available to game.

The use of an airplane has been employed successfully in locating remote springs, seeps and tanks. Green growth or converging game trails will reveal locations that can later be investigated on foot.

Back packs or pack horses are used to take materials into remote locations that can't be reached with four-wheel-drive vehicles.

MATERIALS USED

Materials most commonly used, as necessary, on spring development, include redwood lumber, galvanized or plastic pipe (plastic has the advantage of being light and easy to transport), Orangeburg asphalt pipe, rock masonry and cement.

TYPES OF DEVELOPMENT

Generally speaking, spring development falls into one, or a combination of three types--a ramp, a basin, or a spring dug out and piped to a suitable site.

RAMP

Young game birds and animals often drown in abandoned wells and flooded mine shafts, but these death traps can be converted into safe watering places for wildlife by ramping (Figures No. 2 and No. 3). That is, one side of the shaft is dug out and an incline extending below water level is constructed. In effect it becomes a walk-in well where birds and animals may drink without danger of drowning.

Such locations should be studied at the driest time of the year, as some will have a very high water table during wet seasons but drop a great deal, or go completely dry, during the dry seasons.

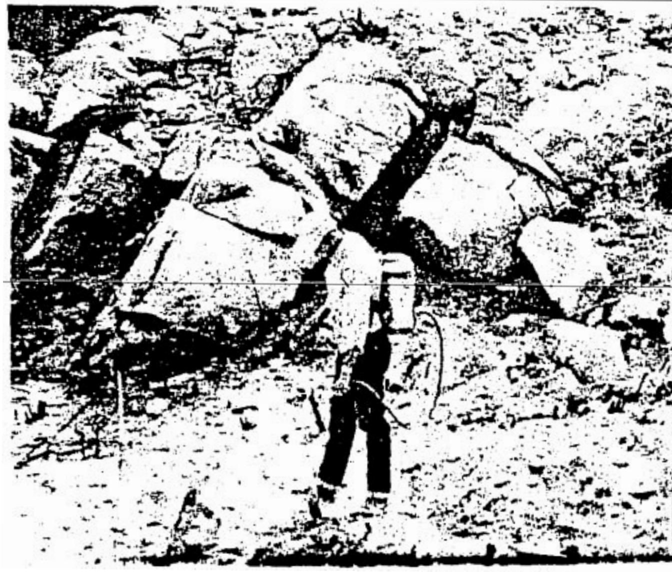

Figure No. 1. Butcher Knife Spring. Spraying new willow growth with **2-4-D** and **2-4-5-T,** using back tank.

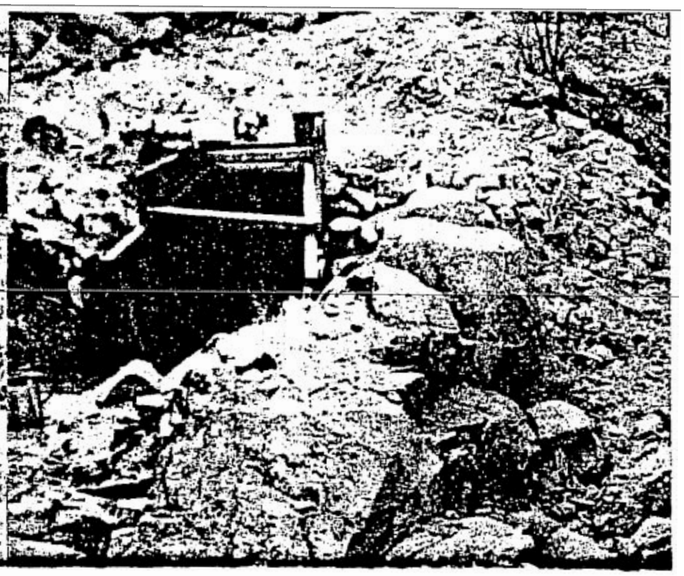

Figure No. 2. Butcher Knife Spring. **A** ramp or walk-in well constructed and cribbed with redwood. Channel at right of picture was blasted out with powder to allow storm water to bypass construction.

Figure No. **3.** Paramount Spring. **A** ramp was constructed here at a Coyote nose hole that contained water. The ramp was cribbed with redwood and a storm masonry wall constructed to keep storm water out.

The ramp should extend two or three feet below the low or static water level, giving an ample pool for the game to drink from. Although our crew has constructed a ramp 13 feet deep, in most cases 10 feet will be about a maximum depth that can be worked with ordinary tools. A slip scraper pulled by a truck is useful in removing material to form the ramp.

Unless the ramp is cut through rock it probably will be necessary to rock or board up the sides to hold them in place and keep material from falling into and filling the pool. If the shaft is much deeper than the ramp, the top of the shaft should be covered. The width of the ramp should be sufficient to allow livestock room to turn around, if there is livestock in the area. If the ramp is too narrow, stock may become trapped and die.

This ramp-type construction is also employed where there is no shaft, but where water has been located by prospecting, either on moisture seeps or where there are water-indicating plants.

Ramps or walk-in wells offer a simple, inexpensive method of making water available to game. They are used where it is impractical to gravity the water out in a pipe, either because the depth and length of the necessary trench would be prohibitive or because the water recharge rate of the shaft is so small it could not withstand constant drainage by means of a siphon. It may be necessary to construct masonry walls to keep storms from flooding this type of construction.

Mechanical devices such as float valves are to be avoided because they usually require frequent attention. For the same reason, siphons are not generally used in water development for game.

BASINS

Basins or pools may be constructed at the source of water to conserve the supply and make it available to game. They may be constructed in rock or of cement or masonry.

When small seeps are found to be coming from rock, pools may be constructed in the rock to catch and store water. One method used, when the location is remote and transporting tools is a problem, is to use a hammer and gad to gouge out a basin in the rock. This is slow and tedious work, wearing rock out the hard way (Figure No. 4).

If it is possible to get drill equipment to such a location, a considerably larger pool may be blasted out of the rock (Figure No. 5). Care must be taken not to shoot too hard and lose the water source, or crack the basin so it will not hold water.

Rock basins are practically indestructible and are not generally damaged by flood. If a flood does fill such a basin with sand and rock, coyotes and other animals will probably dig down in the saturated sand and make the water available again.

Cement, or cement and aggregate, may also be used to construct pools to catch and store water from seeps or springs, or may be used to enlarge either natural or created rock pools.

SPRINGS DUG OUT AND PIPED

Most springs are found in canyon bottoms, and it is often difficult to protect development work on them from damage by storms. A method found satisfactory in many cases is the burying of a short length of perforated "Orangeburg" asphalt soil pipe in packed gravel at the water source, and piping the water from that collection point into a basin or trough placed out of the canyon bottom (Figure No. 6). This allows storm water to flow over the buried source of the spring water without damage to the development work.

Plastic pipe is usually preferred because it is light and easy to transport and lay. Caution must be taken to insure that the pipe will not wash out during floods, freeze up, or be damaged by livestock. The pipe should be laid to grade to avoid air locks.

A redwood spring box and the simple perforation of the end of the plastic pipe in the spring has also been used successfully. The spring should be rocked up or cased in some manner, and a cement cover with a manhole should be used if possible. This permits the cutting out of roots that may grow into the spring, and allows storm water to flow over the development without damage.

If the spring is not located in a canyon bottom and is not subject to flood damage, a redwood spring box may be desired. This allows for the cleaning out of roots and other material. The trough or basin at the end of the pipe should be placed so as to be safe during cloudbursts and to minimize its becoming filled with detritus.

A cement or cement and rock basin or trough is preferred, although a metal trough, cylinder or barrel may be used if no aggregate is at hand. The metal should be galvanized or otherwise treated to prolong its life. If a deep trough is used, a ramp for birds is desirable to minimize the drowning hazard.

OTHER SPRINGS OR WELLS

Occasionally a location is found where simple digging out will produce a strong flow of water, and where no piping or storage basin is required. The discovery of such a location is a rare but gratifying experience.

There are locations where an adequate supply of water exists but does not make the surface because it is used and transpired by the dense growth of hydrophytes. Such water can be made available to game by opening up the source or sources (there may be more than one), usually found near the upper edge of the heavy growth.

Although seasonal springs that dry up do not warrant extensive work, the water they produce during the winter and spring might profitably be collected and stored for use by game during the dry season.

There is little that can be done to improve natural tanks or tenajas. They are important to wildlife when they contain water, and in some desert mountain ranges are the only source of water. It has been noted that deep and well-shaded tanks retain water the longest. Our crew has covered one large exposed tank (Figure No. 7) with a suspension roof built from salvaged cable, pipe and sheet metal. While it is hoped that this will make the water

Figure No. 4. Pickie Poke Spring. Basin created with a hammer and gad point in hard, volcanic conglomerate rock. Small seep normally wasted is stored and receives heavy game use.

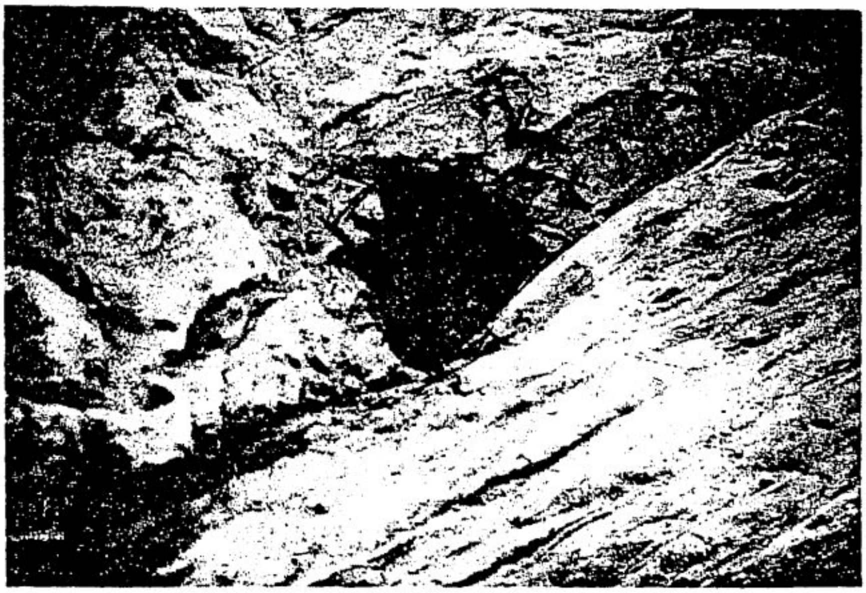

Figure No. 5. Magnesia Spring. **A** compressor and jack hammer were used to create this basin in solid rock. Storm water pours over development without damage.

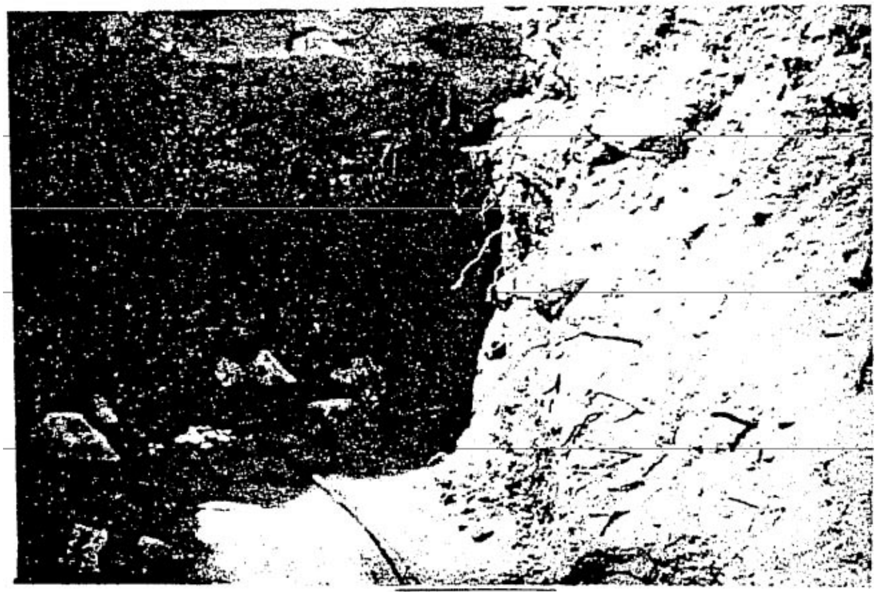

Figure No. *6*. Surveyor's Spring. Dug out and perforated Orangeburg asphalt pipe installed and gravel-packed. Plastic pipe installed to take water to basin out of canyon bottom.

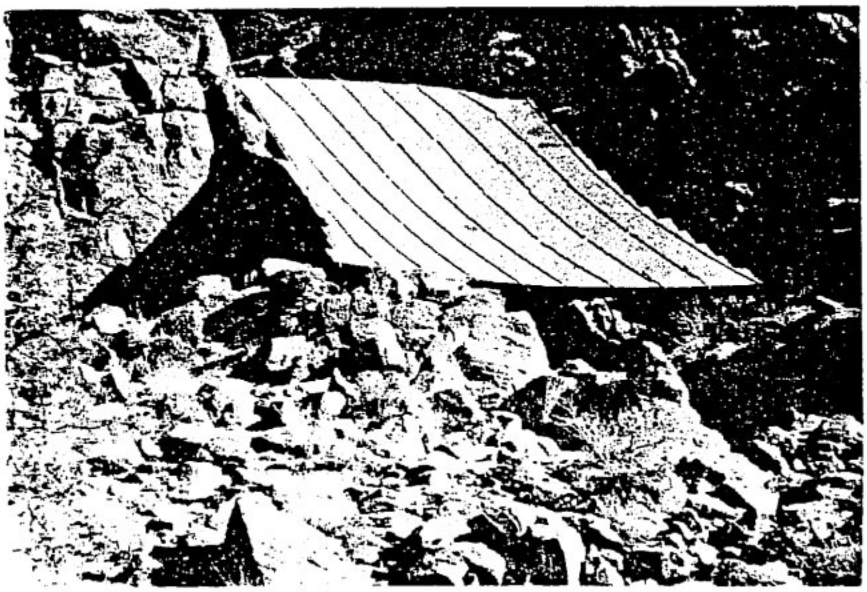

Figure No. 7. Black Tank. Experimental suspension roof built to shade natural tank or tenaja. Constructed from salvage material. Cable stretched with turnbuckle.

last a much longer time, the work has not been completed long enough to permit evaluation of its effectiveness.

Although California's Department of Fish and Game has installed over 2,000 gallinaceous guzzlers for birds and small game, only a few big game guzzlers have been tried and they have not been fully evaluated.

The guzzlers are mechanically sound and they certainly work well for small game. Rain water is collected by a large apron and stored in a large covered or underground tank or series of tanks. A ramp leading down into the tank makes the water available to game.

MAINTENANCE

Game water developments should be constructed so that a minimum amount of maintenance is necessary. Periodic rechecking is necessary since debris may accumulate in the basins or pipes, development work may be buried or destroyed by cloudbursts, diversion walls may need repairing, or water-dissipating plants may need respraying to effect control.

Periodic checking also permits evaluation of the development and its effectiveness. The experience gained on each site helps point the way to more effective and trouble-free watering sites for game in the future.

Mapping, so that persons other than those who did the development work can find the locations, is a must. If a location requiring periodic maintenance is lost and goes out of service as the result, all of the time, effort and money spent on its development has been wasted.

WATER DEVELOPMENT ON THE KOFA AND CABEZA PRIETA GAME RANGES

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The Kofa and Cabeza Prieta were both established by Executive Order in 1939. The Kofa is 660, 000 acres in extent, and the Cabeza Prieta is 880,000. Water development is still an important part of the management program.

It is not my intention to cover or even summarize the water development established by the Service since 1939; I have instead tried to select particular developments that emphasize or demonstrate particular techniques with which we have had some measure of success.

Both the Kofa and Cabeza Prieta are Game Ranges under joint jurisdiction of the Bureau of Sport Fisheries and Wildlife and the Bureau of Land Management. We have cattle allotments on the area and water developed by the cattlemen. Generally these water developments are of no benefit to sheep and I will not mention them again.

I have grouped the tanks I intend to cover into two groups: I. Natural, and II. Artificial.

I. Natural Tanks.

a. Tanks requiring no development. Under the first group, "Natural," I have selected types that ranged from natural waters needing no improvement, to those that needed substantial improvements.

We have at least one completely natural--near perfect--tank. I'm referring to Burnt Wagon Tank in the southeast end of the Castle Dome Mountains, on the Kofa Game Range.

It is situated in a drainage lying several hundred feet .above the desert floor. Above the tank is a plateau or mesa that is the drainage for the tank. This drainage is a large one and a good stream pours into the tank after a rain.

Water falls in a "steep" drop of 70 to 90 feet to gouge out the tank. I used the word "steep" because the fall is not perpendicular. The water falls from north to south (generally) and moves probably-20 to 25 feet horizontally in the fall, creating an overhang that shades the water. We have measured 12 feet of water by lowering a weight on a rope into the water, but we feel it is deeper yet since the overhang prevents lowering the weight into what appears to be the deepest part.

The force of the falling water causes the tank to clean itself. In spite of this, the bottom has a gradual slope so there is no death trap. And finally, it is probably not available to deer because of the rocky, narrow ledge leading to it. It is large, being a long 20 foot oval shape, and holds water through long dry periods. I personally have never seen it more than 24 inches below the full line.

One unfortunate features goes with this near perfect natural tank, and that is that the area which it serves is one of low carrying capacity.

b. Sites requiring minor development--Springs. Generally, springs, if they are substantial, require only slight improvements. This usually amounts to providing a storage trough. The best, most heavily used water on the Kofa, Tunnel Spring, is of this type. The spring lies at the back of a large cave or limestone cavern. The Service put a small concrete trough there catching and accumulating the flow. The flow of the spring is not large but there is virtually no loss of water. Only sheep and birds use the water due to the tricky footing coming into the cave or tunnel.

We also have other springs on the Kofa that have been boxed up and fed into troughs. There is also "one" spring on the Cabeza Prieta.

c. Tanks requiring substantial development. There are many natural tanks on our areas that are of some value in good years with no improvement, but require substantial improvements to provide water during poor years.

1. Pervious dividing wall type. One of these I wish to discuss is High Tank No. 8 on the Kofa. I'll not go into any detail of the history of the development of this tank but generally say that some of the first improvements were made by the C. C. C.

It was first of all a natural basin in a wash, formed by falling water. A dam was put in above the basin to catch sand, etc. and another dam was placed across the lower portion of the basin to increase the storage capacity. The final feature, that also proved of considerable value, was a pervious (to water) wall across the basin itself, roughly dividing it in half. This wall kept sand, rock, etc. on one side while on the deeper side free water was available. Large runoffs did however spill sand, etc. over into the water side. Last winter we undertook the rehabilitation of the tank which by that time was nearly full of sand on both sides of the pervious wall.

We retained the idea of the pervious wall and added one new feature. This was a deflection wall added on the upper silt dam that forces runoff into the sand side. We also raised the pervious dividing wall and of course cleaned out the tank side, providing a tank 10'6" in depth by 12' long by an average of 8' wide.

We have had several heavy rains since then and the system is working well.

2. 'Hydraulic force type development. McPherson Tank in the Castle Dome Mountains uses a different principle. Again this was a natural basin, formed in bedrock by falling water in a wash. This is an old, well-known tank going back to stage coach days. It was, however, a temporary tank because sand, rock, etc. made water unavailable. Various ideas were kicked around on how to overcome this problem. Stated very briefly the problem was solved by raising the height of the fall of the water by installing a dam so that the tank now cleans itself to a satisfactory degree.

This suggests clearly that generally the Service in its development program has tended to develop sites in such a way as to make them self-sustaining. We have attempted this in the natural sites, and also lean heavily toward this sort of perpetual tank in our artificial developments.

II. Artificial Tanks. The second part of my talk will deal with developments that are more artificial.

a. Dams. Of course, the most obvious water development is a dam on a wash. We have several. Two large dams built by the C. C. C. work reasonably well and store really large quantities of water. However, their cost is obviously prohibitive in nearly all cases. A long inflation ago, Four Peaks Dam was completed (in 1940) and at a cost of only $1, 516. 68.

Small dams soon fill with sand and rock. However, they will still store water in the sand. We have built a few small dams with drain pipe built into the dam and water piped to a trough. Generally this technique has been unsatisfactory.

b. Wells. The Kofa benefits from several wells developed and maintained by the holders of grazing allotments.

On the Cabeza Prieta, with its low rainfall, we have one Service-developed well. There are also several Government controlled wells.

We have just completed rehabilitation of Adams Well in the Castle Dome Mountains. We completed rehabilitation of De La Ossa Well in the Kofas last November. Generally with these three Service-owned wells we have used nearly the same technique on each.

This consists of a concrete collar around the top of the well in which the windmill tower is placed. A trough is placed at some distance with an underground line to the trough and a float valve arrangement to control water levels in the trough. An overflow return is attached to the column pipe whereby the water being pumped is returned to the well when the float valve at the trough closes. This system is superior to an overflow return from the trough in which it is possible to have a small animal die in the trough and then return this "sour" water to the well.

Other small details provided are: 1. A sloping wall inside the trough to enable small animals to get to water and out. 2. Concrete footing is usually provided around the trough. 3. A drain pipe is built in the trough to provide a good easy method of cleaning the trough. 4. The float valve is well protected (covered by boards) to prevent damage by animals or tampering by unauthorized persons.

c. Tunnel type development. The Service has three tanks using this technique on the Kofa and at feast twice that many on the Cabeza Prieta.

All of these have a man-made blasted out tunnel, adit or cave that is the water storage basin. All of them have generally a good drainage area; they are located with emphasis on the bare rock in the drainage so that on some of these if a gallon of water falls above the tank 99% of it will run into the tunnel.

The method of getting water into this sloping tunnel varies considerably. One of the best techniques is the placement of a small dam across the wash. This catches and raises the water level during periods of runoff. The elevation of the tunnel entrance is so located that water flows into it after the water level has come up. Gravel, sand, etc. is deposited in the wash and clear water flows back into the tunnel. A final refinement is the placing of a pervious wall across the entrance to the tunnel, protecting it from gullywashers, and screening out foreign matter.

There are several good features in this type development. One very important feature is that evaporation is very negligible due to such a small surface area of the water being exposed and also because air movement is retarded. They are placed so that they have generally a northerly exposure or at least an exposure protected from direct sun. This keeps the water temperature down, and helps discourage algae growth.

Actually this type of development can be located almost any place it is needed. All that is required is good rock and some rainfall. Even if the rock fractures badly and the tunnel leaks it can be lined with concrete.

The storage volume can be made to fit the needs of the location. . This brings up the problem of cost which in the final analysis is the factor that determines the size of the tunnel. These structures are expensive. Their biggest expense item is labor. Nearly always in our situation considerable time is taken in building a road to the site. Drilling, blasting and mucking follow, then lining if necessary, and finally construction of dams, pervious walls, etc. We have generally always used sand and rock at the site as aggregate for concrete, and with good success.

When it was stated that labor was the biggest item, this was assuming that a compressor, jackhammers, trucks, etc. are available.

The two tanks we just completed on the Cabeza Prieta--Eagle Tank and Sinita Tank--have not been broken down as to labor, supplies, etc. They cost approximately $4,000 each. Since no two tanks are the same, these items are not of much help.

SUMMARY:

Successful type developments we have used are: I. Natural Tanks-- a. Springs, b. Developed and c. Natural sites (using: 1. a pervious wall technique or 2. a technique employing the force of the falling water to clean the tank). II. Of Artificial types, we have used a. Dams, b. Wells and c. Tunnel type technique.

ARIZONA'S CATCHMENT THEN AND NOW

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In 1946 Thomas L. Kimball, a former biologist and director of the Arizona Game and Fish Department, was instrumental in constructing the first gallinaceous guzzler in Arizona for a quail research project. Under this project eight guzzlers were constructed by contract in the foothills of the Superstition Mountains and ten catchments were constructed within what is now the Paradise Valley Refuge located 22 miles north of Scottsdale, Arizona.

These first attempts to furnish permanent water for wildlife in a desert habitat met with outstanding success, but like most firsts, mistakes were made and the undesirable features soon became evident. Many of these undesirable features have been and are being eliminated.

These first catchments consisted of a four inch wall, concrete reinforced underground storage tank of 1,000 gallon capacity with a narrow ten inch ramp constructed at the front of the reservoir. This ramp ran diagonally from the top of one side of the reservoir to the bottom of the opposite side.

A concrete wall, with a three inch diameter pipe installed through the bottom separated the drinking ramp from the reservoir. This three inch pipe maintained hydrostatic water level throughout the reservoir and ramp and allowed game to utilize the last drop of stored water without actually entering the reservoir proper. The reservoir and ramp were covered with 2" x 12" lumber which was bolted down at the ramp end so that a six inch opening was left for quail and other small game. The entire reservoir top was then covered with six inches of earth to aid in lowering the evaporation.

An apron of sand sprayed with emulsified asphalt was constructed adjacent to and sloping toward the reservoir to collect and divert runoff. A six inch diameter inlet pipe was used to divert the water from the apron to the reservoir.

The undesirable features of these first efforts should be mentioned here:

1. The entrance to the drinking ramp proved too small; a wider ramp which would allow more game to water at once was preferred.

2. The asphalt-sprayed sand which was used for the apron soon deteriorated from weathering and became very costly to maintain.

3. Since isolated summer thunder showers produce a large quantity of rain in a short period, it was found that the small six inch diameter intake between the apron and reservoir was not sufficiently large enough to divert all the runoff from these showers into the reservoir, and thus a large percentage of this runoff was lost over the sides of the apron.

A second attempt to construct a more desirable catchment soon followed. Additional changes which were made are as follows:

1. The reservoirs were constructed so the ramp extended across the entire front of the reservoir and sloped 27° to the bottom.

2. The apron construction material was changed from asphalt-sprayed sand to concrete and a large screened sump 18" x 18" x 3" was constructed between the apron and the reservoir so that debris which fell upon the apron would not enter the reservoir.

3. A 4" x 4" concrete wall was constructed around the apron perimeter to prevent water loss and also aid in preventing debris from gathering on the apron.

4. Both intakes, into the reservoir and ramp, were enlarged sufficiently in order to receive all the runoff.

5. The small six inch ramp opening for small game was not adequate for deer and other large game which attempted to utilize these catchments and so a separate catchment with an open drinking ramp with three steps on the ramp floor was constructed for large game.

6. The wooden reservoir lids soon deteriorated, allowing dirt and other debris to fall into the reservoir. Small reinforced concrete lids 2' x 3' x4" were constructed to cover the reservoir. These lids were supported by 8" x 8"x36" reinforced concrete columns placed on end on the reservoir floor. Eight lids were required to cover this. catchment. However, it soon became evident that this small 1,000 gallon reservoir was not big enough to provide large game with permanent water, and so the length of the reservoir was doubled which increased the capacity to approximately 2,000 gallons. This increase in length necessitated adding four additional support columns and eight additional lids to cover the reservoir. The small rainwater catchment, with the open ramp, was still being constructed for quail and other small game.

The collecting aprons were first constructed in a 90° arc but later changed to a diamond shape to simplify construction. The size of the aprons is varied with the average rainfall in the areas where catchments are constructed. In areas where the average rainfall is from six to nine inches, an apron with a 50 foot radius is constructed. Areas where the average rainfall is from nine to eleven inches, an apron with a 40 foot radius is constructed. Areas where the average rainfall is from eleven to fourteen inches, an apron with a 35 foot radius is constructed. Where rainfall is fourteen inches and above, a 30 foot radius apron is constructed.

Since all game, both large and small, continued to use both large and small catchments the construction of the small rainwater catchment was discontinued and all stress was placed upon constructing the large, all-purpose catchment that would provide permanent water for all game.

The basic design of these first catchments is still being used and only a few minor additional changes have been made. These changes are as follows:

1. The walls of the reservoir were heavily reinforced and their width was increased from four to six inches.

2. Berm walls around the apron perimeter were increased from four to six inches.

3. Ten reinforced concrete lids 7' x 19.6" x 2.5" were constructed. These lids span the entire reservoir, from one side to the other, thus eliminating the seven concrete columns formerly needed to support the sixteen smaller lids.

4. The three steps in the drinking ramp were replaced with two inch V-shaped depressions constructed along the entire length of the ramp floor which allows both large and small game easy access to the water in the reservoir.

5. An additional prefabricated metal form 5' x 3' has been made to enlarge the reservoir and will add 561 gallons to its capacity. With this enlarged reservoir, an apron with a 60 foot radius containing 2, 546 square feet will be constructed. This large catchment will be constructed in areas where rainfall is less than six inches annually.

To date a total of 205 catchments, large and small, have been constructed by the Arizona Game and Fish Department.

The rainwater catchment, as it is now being constructed, is quite expensive with each 2, 000 gallon unit costing approximately $1, 500.

A total of eight men are permanently employed by the Department for the construction of these catchments.

The following is a list of equipment needed in constructing the rainwater catchment:

1. A two ton flatbed dump truck.
2. A "420" John Deere tractor with blade, ripper and 3/4 yard bucket.
3. A low bed tandem trailer for hauling the tractor.
4. A 3/4 ton pickup for hauling fuel.
5. Aflatbed semi-dump truck for hauling materials.
6. A 3/4 ton suburban for crew transportation.
7. Two house trailers for crew quarters.
8. A 1,200 gallon water tank truck.
9. A one sack "Trailsmith" cement mixer.
10. A 60 c.f.m. compressor with hammer and concrete vibrator.

Although the rainwater catchment is considered to be the most suitable development for supplying permanent water for wildlife, other developments such as springs, retention dams and windmills are also constructed by the Department.

Every resident game animal has either been observed utilizing or is known to have utilized the Arizona rainwater catchment.

Recently a New Mexico research project condemned their rainwater catchment as worthless and of no value to game. The construction of catchments within New Mexico has been discontinued upon recommendations based on the findings of this project.

Arizona now has an active research project in which the effect of the rainwater catchment on a known quail population is being carried out. The future of Arizona's catchment more or less rests with the findings of this study. Until these findings prove that the catchments are either worthless or of value to habitat improvement, we have only one alternative--that being to continue constructing catchments as in the past, using visual observations as our justification for catchment construction.

TRAPPING AND TAGGING OF BIGHORN SHEEP

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Trapping and tagging or marking go together, and since is is necessary to trap an animal before it can be marked, I will begin with the trapping.

Trapping can be broken into two types, mechanical trapping and drugging. First let us consider a few of the mechanical methods: padded steel traps, foot snares, corral type traps and Clover traps.

Now let's look at each of these mechanical methods in detail. Number 14 padded steel traps were used on the Desert Game Range with some success (Deming, 1949). In 1946 seven sheep were trapped; in 1947 four sheep were trapped, and in 1948 eight sheep were trapped. The cost per sheep trapped was $48. 86. This amount only covers salaries and per diem of trapping personnel. This method is not considered too effective. The traps were placed along trails and all around springs. Very few animals were caught as they came in, but as the numbers built up around a spring, they would often spook and in their blind flight an animal or two would often be caught. You can see this method depends largely on luck. These traps would hold ewes and young sheep, but often a large ram would bolt, and before he had gone far the trap would be smashed to pieces. Approximately 15 traps were sprung for every sheep caught.

Foot snares (Deming, 1949; Ashcroft and Reese, 1957) are of use only when you can find a trail or area used quite heavily and regularly by sheep. The cost per sheep to trap by this methodwouldbehigher than with the steel traps. A very close check would have to be maintained on the snares as an animal struggling in a snare would soon die in the summer heat. Because of the sheep's dependence on live water, it is only in the summer months that the animals' movements are well enough defined so that the method would have any chance of success on areas similar to the Desert Game Range. Both the steel traps and snares should be staked with ' a stout steel spring between the trap and the stake to absorb the shock, which in turn lessens the possibility of injury.

The corral type trap has been our most successful trapping technique to date. We have trapped, marked, and released a total of 45 sheep from two of the three corral type traps built on the Desert Game Range. The initial cost of a corral type trap is high but once built maintenance is very low, and a trap should last many years. The only bait that has been successful is live water, so the trapping season any year is a very variable and unpredictable thing. Through the end of the 1956 trapping season we had averaged 1.7 days per sheep caught, or $36.65 per sheep. Here again, this figure only covers salary and per diem of trapper. This figure is perhaps low as most trapping was done by one man. I would strongly recommend that the trapping operation be conducted as a two-man operation, first as a personal safety factor, and second the animals can be worked much faster, thus reducing the possibility of loss by shock (Aldous, 1957).

Our first corral type traps were constructed of woven-wire fencing. The second trap was made of cyclone fencing. The sheep injured themselves when struggling against this type of fencing. As a result, this fencing has been replaced with rope netting (Appendix 1). There is much "give" to the netting, and as a result the animals usually become entangled in it without injury to themselves.

The corral type trap utilizing water for bait should be 24 feet by 34 feet with 8 foot wide gates centered in either end. There is a reason for specifying the exact trap measurements. The netting comes in 50 foot panels, and these dimensions utilize a panel on either side. The side double gates allow the sheep to look through as the trap is approached and give them a sense of security that they don't have when there is only one gate. We have found that the sheep enter a trap with two gates more readily than they do a trap with one gate. Gates that hinge out give more room and are less likely to injure an animal than gates that are hinged from the inside. The trigger device can be a trip line from a fixed blind. Or, if you prefer to work from different locations, the gates can be dropped by detonating a blasting cap taped to a light piece of cotton cord holding the gates open (Sugden, 1956). There are several types of self-tripping devices that can be used, but as long as trapping has to be conducted during the heat of summer they are not recommended as sheep caught will fight the trap and unless worked immediately the loss would be high.

As mentioned this has been our most successful trap, but there are disadvantages. The trapping season lasts approximately two weeks to two months. If someone can find a bait of an ice cream nature, the trap could be operated any time. This would be a real step in the right direction. Incidentally, we put out feeders with several types of commercial feeds and supplements and alfalfa with molasses, but none of these were successful.

The Clover trap is a very nice compact trap developed by Mr. Clover of the California Department of Fish and Game (Clover, 1954). Warren Kelly and I set one up on the Desert Game Range utilizing water as bait, but we didn't have any luck. However, near Hoover Dam Warren used some of these traps baited with alfalfa and caught several sheep. This was an artificial situation, but in an area of low density vegetation during poor forage years perhaps this trap could be employed quite successfully by prebaiting with alfalfa until the sheep started using it and then moving in and setting up the traps. As mentioned, these traps are compact and easily transported in a pickup or even on a pack horse. The traps are easily built, and cost per unit is reasonable on those areas where scrap materials and shop facilities are available.

Chloral hydrate, the old-fashioned knock-out drops, was tried to a limited extent, but we were unable to get anything but a spotted skunk to try it. The chloral hydrate has a rather offensive odor and taste, so a few drops of oil of wintergreen were added to camouflage these undesirable features. Our experiments were inconclusive. However, Mr. B. J. Marlow of Australia (1956) has reported excellent results with chloral hydrate on kangaroos, reporting as follows:

> The optimum concentration was five ounces of chloral hydrate in eight gallons of water, which produced an anaesthesia of about four hours and did not result in any deaths.

This technique has several advantages. The capture, handling, and examination of large mammals is made possible without the use of heavy or bulky equipment, and the risk of mechanical damage to animals is obviated. The element of fright which accompanies most standard methods of trapping is absent, and animals, which are unaware that they have been caught and handled, continue to behave normally and do not shy clear of the place of capture. The solution is simple to prepare and administer.

Flaxedil, a synthetic curare (Hall et al., 1953), was one of the drugs many workers looked to as a promising anesthetizing agent, but tolerances were too critical, and to the best of my knowledge it has been dropped.

Nicotine salicylate is the drug that holds the most promise at present (Crockford et al., 1957). This drug has a wide tolerance, is fast acting, three to five minutes, and wears off very readily in 15 to 20 minutes. Of equal or greater importance is the development of a CO_2 gun which shoots a hypodermic syringe. The gun and drug were recently tried on moose in Alaska with good results.

The gun has a range of 200 feet with good accuracy. Our service in cooperation with the U. S. Public Health Service plans to test it on black bears. The progress on this drug and gun is so rapid that I am sure even the latest material I have cited here is already out of date. The gun and drug are being produced commercially (Appendix 2).

Now that we have successfully trapped our sheep, let's consider how we are going to mark them. First, why do we want to mark them? The answer to this question will determine what type of marking we use. For example on the Desert Game Range we wanted our marking to meet three requirements: mark each animal as a distinct individual, last the life of the animal, and be readily and easily identified in the field.

A marking technique that would meet these requirements would enable us to determine: summer and winter range, maximum and minimum movements, inter-relationships of individuals and groups, age activity relationships, and population figures by the application of Lincoln's Index (Aldous, 1957).

The fact that sheep do not shed their horns suggested the possibility of a horn brand similar to that used on cattle (Aldous and Craighead, 1958). An old cattle skull with the horns attached was experimentally branded. It was easily read some 500 yards away with a 30X spotting scope. A different brand number for each sheep solved the first two requirements. The next step was to devise something that would catch the eye, making a branded animal stand out in a group of sheep. For this we tried brightly colored plastic ear streamers (Appendix 3) similar to those Craighead and Stockstadt (1956) had used to mark geese in Montana. In addition, a stock-type ear tag was placed in the right ear of the animal for further identification.

When the sheep are trapped, they are quickly tied and blindfolded. The blindfold quiets the animal and make drugging unnecessary. The branding irons, 7/8 inch iron for ewes and a 2 inch iron for rams (Appendix 4), are heated in a fire or with a weed burner. It is very important to heat the iron until it is copper bright as an underheated iron doesn't make a good brand, while a hot iron burns a clean quick legible brand without any apparent pain to the animal.

Some of the other marking techniques that may be useful under different circumstances or in different combinations are: horn painting, pelage painting, belling, ear tagging (different shapes and colors), ear cropping and hide branding.

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Appendix

1. The Linen Thread Co., Inc., 116 New Montgomery Street, San Francisco 5, California.

2. Cap-Chur Equipment, Palmer Chemical & Equipment Company, Inc., 134 Houston Street, Northeast, Atlanta, Georgia.

3. The Gee-Bee Manufacturing Company, Inc., 76 North Fourth Street, Brooklyn 11, New York. Plastic available in following colors: black, white, red, orange, yellow, green. 20 yds. per pound. $1.20 per pound f. o. b. Brooklyn.

4. O. M. Franklin Serum Company, Livestock Exchange Building, Denver, Colorado. 2" irons - set of numerals 0 to 9 (6 and 9 interchangeable) - $24.50. Franklin Horn Branding Iron - 7/8" set of 9 irons - $8.50.

TRAPPING ON THE KOFA GAME RANGE

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Desert bighorn sheep trapping operations were initiated in Arizona in late spring, 1955. This trapping program was instigated by a desire of the state of Texas to re-establish the desert bighorn in historical range. Considerable planning and correspondence between various organizations were made before the trapping program could proceed. The organizations primarily involved were the respective game departments of Texas and Arizona. Other organizations evincing interest and contributing advice and financial aid were the U. S. Fish and Wildlife Service, the Wildlife Management Institute and the Boone and Crockett Club.

A plan was evolved where the state of Texas was to pay all expenses incurred for trapping and personnel of the state of Arizona were to do the actual trapping. Special legislation was enacted in Arizona to appropriate funds for this project to be made readily available with the stipulation that the state of Texas was to repay Arizona periodically as the expenses were incurred. This agreement ended on June 30, 1957.

Trapping of desert bighorn sheep began on the Kofa Game Range with very little knowledge of the techniques involved. For two summers attempts to trap sheep were unsuccessful before what was felt to be the "key to success" was revealed. With each summer's work the number of traps progressed from one in 1955, to three in 1956, to four in 1957. The original trap constructed in early June 1955, was patterned after a bighorn sheep trap on the Desert Game Range in Nevada. For the summers of 1955 and 1956, traps were constructed on a relatively flat surface near known sheep watering sites. Water was siphoned to a trough inside each trap and the original watering site was blocked by lumber and rock. The details of construction of these traps is relatively unimportant at this time for as explained in another portion of this paper these traps had to be torn down and rebuilt. It is sufficient to state that these traps resembled an antelope trap measuring approximately 35 feet wide, 50 feet long and 8 feet high. The sides and trap doors were of rope netting.

During 1955, the original trap was observed for a total of 28 days. Desert mule deer and smaller animals readily entered the trap but no sheep came in, although three were seen on several occasions in the vicinity. This trap is standing today and as far as is know very few sheep, if any, have entered it.

In 1956, the three traps were observed for a period of four days. Observations of sheep during this period were of particular importance. At one of the traps nine sheep were observed going toward the covered watering site, some passing within 100 yards of the trap. Once at the watering site, some of the sheep walked all over the lumber covering, pawing and butting in an attempt to get to the water. What should have been obvious before was now perfectly clear--the traps should have been constructed around the original watering sites!

Since it appeared that it would be highly improbable to trap sheep during the summer of 1956, attempts were made to snare the sheep near a watering site where trap construction was virtually impossible and where a comparatively large concentration of sheep was found. One sheep was snared but, unfortunately, the snare rope was inadequately fastened to a peg and the animal escaped. It is definitely believed by the writer that rope snares such as those described by Ashcraft and Reese (1957) have definite possibilities in areas where trap construction is difficult or impossible.

Throughout the trapping operations, the thought was that water would be the logical bait for desert bighorn sheep. Usually sheep only concentrate during the dry summer months and around water. Attempts were made to find a suitable bait other than water to aid in trapping. The baits offered were alfalfa hay, sahuaro, sahuaro fruits, sotol, natural rock salt and commercial sheep pellets. The only known utilization was of alfalfa hay during the latter part of the 1957 trapping operations. This phase of the program was unsatisfactory and further experimentation should be attempted.

With regard to past experiences, planning for the 1957 trapping operations began during the winter. Using the Kofa Game Range water hole counts as a basis, three of the watering sites showing the highest consistent counts of the previous three years were chosen as trap sites. Materials used were from the previously constructed traps. Size and shape of the traps were determined by the nature of the terrain around the water retention holes. In the original trap a heavy pipe frame trap door which swung down from a horizontal position was used. On the present traps a drop type trap door is used. This is simply an enlarged, slightly modified version of the type used on the Clover deer trap. In addition to the above traps an aluminum deer trap was placed at the entrance of a mine tunnel used as the water source for the original trap built in 1955.

Before trapping operations could begin in 1957 one more obstacle remained. Several known watering sites occurred in the vicinity of the traps. Since this could possibly defeat the whole program, these watering sites were drained by siphoning into a sand wash.

Trapping operations began in 1957 on June 10 and terminated on July 17. During this interim approximately 1, 081 hours were spent in blinds. A total of twelve sheep were trapped of which four were safely transplanted, four escaped and four died (one died shortly after release in Texas). In addition, two lambs were caught by hand, but each of these subsequently died. It is possible that some of the sheep that escaped were recaptured but since no identifying marks were noted on these animals, this is a matter for conjecture.

Usually the sheep were captured one at a time. The maximum number of sheep that entered the trap and were caught was three. Once captured, the problem of handling the animals remained. It is perhaps during this phase of the trapping program that the majority of the mortality occurred, apparently through a combination of shock, excessive heat and over-exertion.

In most instances when a sheep entered the trap, it was allowed to take a long drink before releasing the trap doors. Immediately after the doors dropped the sheep hit the nets very hard. There were no noticeable major injuries incurred when the sheep hit the nets. One ewe broke a horn completely off when thrown back into the trap after hitting the nets; however, this animal survived transplanting and apparently the wound healed.

Distances from the traps to the truck varied from approximately 50 yards to nearly 200 yards. One method used to get the sheep to the truck proved very satisfactory. A rope was tied to the animal's horns and with one handler holding the other end of the rope, the animal was driven in the desired direction. If the animal veered, a tug on the rope usually pulled it back. Once near the truck it was a simple matter to carry the sheep the comparatively short, remaining distance to the truck. This proved to be far easier on the animals as well as on the handlers.

We feel that a great deal has been learned about trapping the desert bighorn sheep and plan to continue this program this summer in cooperation with the game department of the state of Texas. Originally the plan was to trap fifty bighorn sheep of which twenty-five were to go to Texas and twenty-five to be transplanted in the state of Arizona. It is now apparent that this was a highly ambitious plan; however, with the present trapping techniques and favorable weather conditions, i. e., hot and dry, we may be able to realize our goal.

Acknowledgements

Eventual success in bighorn sheep trapping operations was due to the efforts of many individuals. Mr. Tom Moore, Texas Game and Fish Department, was primarily responsible for many of the bighorn captured in 1957. Mr. John P. Russo, Arizona Game and Fish Department, and Mr. Gale Monson and Mr. Jim Johnson, managers of the Kofa Game Range, gave assistance and technical advice whenever possible. Others, too numerous to mention, assisted in trap construction and spent many long hours in the blinds.

Summary

After three years, desert bighorn sheep trapping operations, done in cooperation with the state of Texas, were successfully undertaken. During the summer of 1957, twelve sheep were trapped of which four escaped, four died and four were released in Texas. In addition, two lambs were caught by hand but these subsequently died. It was found that traps should be constructed around known sheep watering sites to be successful. A satisfactory method of handling the animals was developed and it is hoped that this method will reduce mortality.

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TRANSPLANTING AND OBSERVATIONS OF TRANSPLANTED BIGHORN SHEEP

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History:

Renewed efforts to restore the bighorn sheep to its former range in Texas began in 1954 with the cooperation of the following agencies: Texas Game and Fish Commission, Arizona Game and Fish Department, Fish and Wildlife Service, Wildlife Management Institute, Boone and Crockett Club, and the National Park Service.

Negotiations were made with the Arizona Game and Fish Department for suitable broodstock and an agreement was worked out between the states of Texas and Arizona whereby Arizona would furnish the sheep and Texas would pay for trapping expenses.

Bighorn sheep have never been known to exist in large numbers in Texas; in fact, the hunting season has been closed since 1906. In 1940, approximately 200 sheep were estimated to be in the Sierra Diablo, Beach and Baylor Mountains of far west Texas. Today there are only a dozen or so known bighorns in the remote portions of this area. Historical range includes the major portion of the "Big Bend Area." The introduction of domestic sheep and goats probably was responsible for the decline in population more than any other factor.

A holding pasture of one section in size was constructed on the Black Gap Management Area. Within this rugged enclosure of mountains the broodstock trapped in Arizona (Kofa Game Range) were placed so that they might reproduce. The reproduction is to be released in the surrounding range and on the Sierra Diablo Mountain Sheep Area to furnish new blood to the small herd there.

The vegetation in the holding pasture is of the Yucca-Agave-Sot01 type. The elevation averages 2, 800 feet, with a rainfall of between 5 to 7 inches annually.

Principal plant species include:

Sotol	Dasylirion leiaphyllum
Lechuguilla	Agave lechuguilla
Purple sage	Leucophyllum frutescens
	Leucophyllum minus
Catsclaw	Acacia greggi
	Acacia constricta
	Acacia roemerina
Ephedra or Mormon tea	Ephedra trifurca
	Ephedra aspera
Brazil bush	Condalia apathulata
Littleleaf sumac	Rhus microphylla
Evergreen sumac	Rhus virens
Rockbrush	Eysenhardtia angustifolia
Krameria	Krameria glandulosa

Dalea	Dalea sp.
Guayacan	Porlieria angustifolia
Ash	Fraxinus sp.
Opuntia	Opuntia engelmannii (Pricklypear)
	Opuntia macrocentra (Pricklypear)
Yucca	Yucca elata
	Yucca torreyi
	Yucca thompsoniana
Pineapple Agave	Hechtia scariosa
Chino Gramma grass	Bouteloua breviseta
Side Oats Gramma	Bouteloua curtipendula
Bristle grass	Setaria sp.
Sprangletop	Leptochloa dubia
Three awn	Aristida sp.
Tabosa grass	Hilaria mutica

Transplanting of Bighorn Sheep:

It was decided to transport the sheep to the release site by airplane. A Cessna 180 airplane, capable of transporting a 700 pound cargo load was employed to make the five hour flight. The rear seat and baggage compartment were removed and a lightweight crate fitted into the space. The crate was rather small but could contain two average size sheep or possibly three. Infrequent catches involving only a few sheep made the use of a truck impractical. Also, the difficulties of heat, distance and time were overcome by using the plane.

Three flights to the release site were made. These trips are described separately as each shipment presented different problems, many of which were not foreseen.

Shipment No. 1. This load consisted of an old ewe (over 10 years) and a younger ewe estimated to be 4 or 5 years old. The old ewe was held in a small holding pen 10 days prior to shipment. She ate native browse, mainly Coffee berry' (Simmondsia chinensis), and took water readily and was in fair condition when transported to the airport. Both animals were given shots for shipping fever (Hemorrhagic septicemia), penicillin, and tranquilizer drugs (Thyrozine and Sparine). The plane took off at 5:30 a.m. and 5 hours later the plane landed two miles from the release site. The animals were immediately unloaded and placed in a large horse trailer having a tarpaulin for a top and a foot and one half of hay for bedding. Twenty minutes after landing they were released near a dirt surface water hole in the holding pasture. The younger ewe did not offer to run and evidently was suffering from injury and fright. The other ewe ran off immediately. Two days later the young ewe was found dead 300 yards from the point of release and in October the other ewe died. (She was not found until December, however.) No evidence of predation was found at either carcass. As a precaution against a shortage of food alfalfa hay and oats were placed near the major watering. Past experience in baiting with these feeds however led the observors to believe that the sheep probably would not take feed of any kind.

Shipment No. 2. On July 6, after summer temperatures had exceeded 120 degrees on several occasions, 5 bighorns were trapped. Events took place in the following sequence: At Horse Tank trap, about 60 miles from the Yuma airport, three sheep were caught. Two others were caught at No. 7 trap 75 miles from Yuma. Loading started at 4 p.m. at Horse Tank and two rams and one ewe were placed on the 1 ton hauling truck. Four men aided in loading. Because of the nature of the trap difficulty was experienced in capturing the sheep right away. In the center of the trap enclosure a large water hole is located with a short ledge between the water and the trap netting. Sheep would invariably run to the ledge and on one occasion the ewe fell into the water, went under and swam to the edge where she was quickly captured. Meanwhile two of the crew were trying to extract a 200 pound ram which had one horn caught firmly in the nylon netting. This animal quickly tired, as did the two men. The ram was placed in the shade and hobbled with one man kneeling down to hold its head. The two smaller sheep, a 3 year old ram and 5 year old ewe were quickly captured and loaded. All four men were required to load the large ram which sulked. This animal was carried to the truck and loaded. During the loading the ewe broke a horn off and seemed in a state of shock. The large ram was exhausted from the process and did not stand. The young ram was in excellent condition. The truck then proceeded to No. 7 trap where two large rams were caught. Two of the crew remained at the trap to reset and watch for other sheep.

As the trap was located over 100 yards away from the truck the sheep could not be carried by the crew. Excessive handling brought on fright and seemed to place the sheep in a state of shock. At one half hour before sunset the loading of the two rams began. This was accomplished by tying a 30 foot rope to the horns and by letting the animal lead the way down the trail to the truck. No undue trouble was had for the sheep did not sulk or offer to fight the handlers. The truck with the five sheep and four of the crew proceeded to the airport, arriving there at 10:00 p.m. Upon arrival the adult ram caught at Horse Tank was dead. The other sheep were in good condition.

At 3:00 a.m. the next day Dr. Walker and Dr. Ham of the Yuma Veterinary Clinic began administering tranquilizer drugs, shipping fever serum, and penicillin to the sheep. The sheep became lifeless within 20 minutes. In order to ship three of the sheep at one time the crate was removed and all but the large aged ram were loaded. This ram was placed in the Clinic until such time as it could be transported. The three sheep in the plane were blindfolded and a head harness placed on each which was tied by short length rope to the floor of the plane. During this operation the sheep remained tranquil. Because of a thunderstorm in the path of the flight, takeoff time was not until 6:20 a.m. The sheep at this time showed signs of reviving and the two rams were given another dosage of tranquilizer. About 20 minutes out of the airport the sheep became restless and strained at their hobbles with such violence that made flying hazardous. The plane turned back and landed. Upon landing the larger ram turned over in such a position that it choked to death by the short rope tied to the floor. The ram gave a dozen or so violent kicks with its hind legs narrowly missing one of the sheep that was lying down. The three sheep were unloaded as it was decided that the crate should be used for safer flying and to set the sheep free of their hobbles. Meanwhile the young ram making the flight showed symptoms of neck injury and was placed in the Veterinary Clinic for observation. The following morning the plane took off with the one horned ewe and the aged ram in the crate. Both were given tranquilizers. The trip was uneventful and the release was excellent. Both sheep ran off at a rapid pace. The one horned ewe is now in excellent condition in the holding pasture although the aged ram died sometime in November. It was observed with the two ewes in the pasture; however, none of the females were bred.

Shipment No. 3. At Horse Tank a 5 year old ewe was caught and shipped to the release site without trouble. Upon arrival at the airport at 8:00 p.m. it was discovered that the plane could not make the flight the next morning as the engine was being repaired. The ewe was held over at the airport in the shade and was flown out the next morning. While in the truck the ewe ate a considerable amount of Coffe berry browse collected for the purpose. This ewe is now alive and in good condition.

Mortality and Causes of. As had been expected, and as in dealing with deer and antelope, there is a nominal loss of individuals following release on new range. This is usually attributed to inability to adjust to the new environment. Injuries sustained during loading and hauling also are a factor. The loss of the two prime rams and the small lamb in the veterinary clinic can be attributed to unavoidable accidents. Two of the sheep, a ewe and a ram, were very old and probably should not have been moved. In view of the small number of sheep being caught, the investment, and the approaching rainy season, it was decided that all sheep should be taken unless they were injured or sick.

Observations of Trapped Sheep in the Holding Pasture. From the time the sheep were placed in the holding pasture they were under observation almost dailyfor the first month. With field glasses the sheep were observed to feed on chino gramma grass and catsclaw brush. During early spring sotol was cut and the two remaining ewes frequented the feed grounds to eat large amounts of this succulent plant. They have refused cottonseed cake (range cubes), oats, alfalfa hay and mineral salt. The sheep were observed on two occasions on top of the small cement header dam which impounds 20, 000 gallons of good drinking water. The sheep used this immediate area for their bed grounds. Many droppings were found under ledges and overhangs which are typical of the country. Bighorns fed on prickly pear (Opuntia engelmannii) in December and January. Plants 4 to 6 feet high were completely destroyed except for a small portion of their trunks. The sheep did not appear to suffer harmful effects as a result.

Stomach contents of the mature ram found three manths after it died indicated that it had eaten large amounts of grass, probably chino gramma which is abundant in the pasture and one of high food value. This animal died with its feet folded under it. There was no indication of predation.

Predator control. An important phase of the transplanting operation has been the predator control program which was undertaken two years before the sheep were received. This program is continuing. Since the sheep were released a total of 3 mountain lion, 6 bobcat, and 7 coyotes have been removed. The majority of these anirnals were caught either against the 7 foot net wire fence or within a few miles of the pasture. One lion and possibly another were repulsed by the charged wire which runs around the outside of the fence. No predator tracks have ever been found within the enclosure chiefly because of the constant check being made. While it is not the intention of the department to exterminate these animals entirely, certain measures of control are necessary. A golden eagle which had been living in the pasture was also removed.

PHYSICAL AND MECHANICAL INJURIES

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Certainly, physical and mechanical injuries can be one of the more intriguing aspects of wildlife study and take "top billing" as a campfire subject. The circumstances which would include all the possibilities for mechanical injuries are so varied that I shall not attempt to present an organized treatise on the subject but rather point out a few specific occurrences. The nine cases to which I will refer in the next several minutes are incidents which I have encountered in Southern Nevada during the past two years.

To me, the expression "mechanical injury" denotes physical trauma to the body as opposed to chemical or psychic trauma and may vary in degree of force exerted from the fine desert dust irritating the cornea of the eye to the automobile that breaks an animal's neck. The abnormally positioned leg of a fetus which ruptures his dam's uterus and the coarse browse which results in broken, loose and loss of teeth are, likewise, cases of mechanical injury. In the first four cases man was a cause of the injuries either directly or indirectly. The last five had natural causes of various kinds. Dental abnormalities will not be discussed.

The first case is that of a three year old, female, Desert Bighorn sheep showing the results of a rather typical automobile accident. There was much internal hemorrhage, the right horn was broken, both the right and the left pubic bones were fractured and the right hip joint was fractured. There were many ruptures of the intestinal tract with fecal contamination in the abdominal cavity. An interesting microscopic finding was the presence of granulomas in the lungs and liver but their cause could not be determined. Veterinary Pathology by Smith and Jones[1] states on this subject, "Fibrous proliferation occurs in the healing of wounds, where it may be either adequate or excessive in amount, in most local mechanical irritations and in long-standing pyogenic infectious processes." This is another (reference is made to paper "Lungworm - Protostrongylus stilesi" by E. L. Johnson presented at First Annual Bighorn Sheep Conference) of the findings indicating less than optimum lung health in the Desert Game Range sheep. It could be that the granulomas are the consequence of a previous lungworm infestation and it could also be the final stage of a strict bacterial pneumonia. Why the lungs of the Bighorn sheep seem to be the weakest link in their physiological chain on the Desert Game Range has not been answered yet.

The next case is of a six month old female Bighorn sheep and again illustrates the predisposition to pneumonias. At the postmortem examination there was an extensive pneumonia, partial dislocation of the joint at the head and first vertebrae of the neck and partial dislocation of the left hip joint. The right hip joint was completely dislocated and the joint ligaments ruptured. The cause of the various mechanical injuries was the pipe frame of a trap gate which had struck the animal as she was entering the trap. She lived nine days after the accident with the cause of death being pneumonia. The animal was apparently in good health prior to the accident.

Case number three is also a trap accident but this time the injury was self-inflicted. The specimen was a ten year old male Bighorn sheep.

As the ram approached and entered the trap it was noted that he held his head to one side. After the gate closed he made one lunge at the netting, fell to the ground and died within ten minutes showing very little struggling. There was a large amount of hemorrhage in the area of the first neck joint and the position of these two vertebrae indicated considerable pressure to the spinal cord. The spinal cord was intact, however. Because of an abnormal amount of connective tissue and bony projections from the joint surfaces it was concluded that there had been a previous neck injury resulting in a severe dislocation and tearing of the joint ligaments. It also seemed probable that venous sinuses had been formed because of the amount of hemorrhage found. The left wing of the first cervical vertebrae had been fractured. There is one other case similar to this reported on the Desert Game Range except that a pneumonia caused the animal's death and the old neck injury was found incidentally.

The last of my so-called "man caused" mechanical injury cases is one concerning a seven year old Bighorn ewe. Actually there were two ewes involved, but since their fates were the same details will be reported on one animal only. Two ewes had been trapped about 12:30 p. m. and were left in the trap while the trapper brought up "the reserves." "The reserves" did not arrive on the scene until 4:00 p. m., allowing the animals some three and a half hours in which to tire themselves pretty well and receive some bruises and cuts trying to escape from the trap. When the animals were anesthetized with intravenous sodium pentobarbitol at shortly past 4:00 p.m. the one ewe had a cut about two inches long, diagonally across her nose. Both animals were then loaded aboard a pack mule in panniers and care was taken to see that there was no excessive pressure on the trachea and esophagus to deter breathing and eructation. After the mile and a half pack trip the ewes were transferred into a carryall and 20 miles of rough road later they were bedded down with alfalfa hay. Both were resting easily, showed no respiratory difficulty and a strong pulse. The following morning at 6:00 a.m. the subject animal was found dead some four hundred feet from where she had been left the previous night. The other ewe was still down but within five minutes after an injection of adrenalin was up and running the fence of the enclosure. A mature Bighorn ram running in the same enclosure had some blood on his horns and it was thought that he had molested the ewe. On postmortem examination three ribs on the left side were fractured and the lobe of the lung which was immediately adjacent to the fractures was ruptured. There were many subcutaneous and muscle hemorrhages over the back and along the sides. The most interesting findings, however, were several small holes through the skin and large blood vessels along with large blood clots in the region of the larynx. I was quite concerned for this was the area in which I had injected the anesthetic but couldn't recall making so many holes. In addition, there were numerous small hemorrhages on the interior of the larynx and first few tracheal rings. The lungs were very dark in color. After completing the postmortem on this animal we went to check on the status of the other ewe and after some searching found her dead in a wash at one end of the pasture area. The only external signs were small drops of blood coming from holes in the skin near the larynx. The hair of this region was matted. Some fifteen feet away I saw a mature Bobcat, half asleep under a bush. My conclusions were that the immediate cause of death was asphyxiation by the Bobcat, with contributing causes being hemorrhage from teeth wounds, bruising and lung rupture, shock and general debilitation from the trapping, transporting and the anesthetic agent. It is doubtful to me that a Bobcat would attach a mature ewe unless she was weakened as this one or I should say, these, had been.

The next three cases were in deer but two could apply equally as well to sheep. The third, not so well with two rams but perhaps the results would be the same with one ram and a small tree, post or a wire fence.

The first is a case of complete blindness. There were three such animals found in a period of about a month. Local inhabitants, people that is, of the area called these animals "white eyes" and certainly the term was applicable for both corneas were a cloudy white as if milk had been injected into the eyes. The causes of the blindness were irritatinn and subsequent infection with healing by scar tissue formation. Dust, wind and bright sunshine are thought to be factors, low vitamin A levels could also contribute to the condition. In this particular case small pieces of vegetable matter were found in the layers of the cornea indicating that a small stick or piece of brush could also have been a cause Various writers give either bacteria or viruses as the infectious agents? & 3 probably both are involved. One of the three animals was taken to Reno alive where the Diagnostic Laboratory attempted to isolate the principal organism. Only a mixture of common skin inhabitants was found. The terms infectious keratitis, infectious ophthalmia, infectious conjunctivitis, pink eye, vascular keratitis and panophthalmitis have been given to the condition.

Quite similar to the teeth and gum infections associated with coarse forage was a situation in an emaciated yearling doe. Other deer in the area where this animal had been ranging were in relatively good condition. The range itself seemed quite adequate. When the animal was examined the rumen contained but a small amount of somewhat dry, packed ingesta and showed evidence of very little mastication. The small intestines were completely empty. There was a considerable amount of unchewed leaves and other browse in the oral cavity but the teeth were all in good condition. The animal would have shortly died from starvation. Further examination revealed two large abscesses on either side of the roof of the pharynx which undoubtedly caused such pain and mechanical obstruction that the animal would not chew. Had the abscesses involved the tonsils, the salivary glands or any of the lymph glands in this region it might seem likely that their cause had been a more generalized or systemic infection, but since these glands were not involved I am satisfied that some mechanical injury at least started the process. Most likely the coarse browse as I mentioned before.

The circumstance to which I was referring a few minutes ago was one in which two buck deer had locked antlers and died trying to separate themselves. I know this is nothing new and different but it was the first time I had found such animals and certainly constitutes another facet of mechanical injury. Nothing of significance was found at the examination and it was concluded that the animals died of exhaustion, trauma and thirst. I think that a ram might entangle a horn between or around small trees or a fence post and in woven wire fencing. I have seen several pictures of animals which entangled legs in barbed wire fences.

The next case concerns the mechanical injuries incurred from a fatal fall of a ten year old ewe. The significance is not in the nature of the injuries themselves but the circumstances under which they occurred. I seriously doubt that many such falls are encountered by normal sheep and that this animal made the untimely slip because she was very weak and incoordinated from her advanced pneumonia. The injuries were a fracture through the symphysis of the mandible, the mandible was completely disjointed from the head itself and both hip joints were complete dislocated. The lung condition was of long standing and involved the entirety of both lungs.

My last case is simply that of a broken leg in an eight year old Bighorn ewe. I think it interesting not because the leg was broken but because it healed. Honess and Winter in their publication, Diseases of Wildlife in Wyoming,[3] state, "Fractures of the leg bones in large mammals are difficult to repair, and few such animals sustaining this injury are restored to a normal existence." This particular case had been a complete fracture of both the left tibia and fibula with at least two inches of overriding of the opposing fragments. The skin showed no scarring so evidently had not been punctured by the jagged bone ends. How sufficient immobilization was effected to allow healing I do not know. The ewe did not favor the leg in any way and it appeared that the incident had occurred some years before.

A list of mechanical injuries could include perforations and irritations anywhere along the intestinal tract usually from foreign bodies, bone fractures and joint injuries anywhere in the skeleton, fractures of the penis, ruptures and lacerations of the uterus and vagina, ruptures of the skeletal muscles, rupture of the diaphragm, hernias, various injuries to the eyes, ears, nose, horns, hooves, hair, hide and what have you.

The cases that have been presented do not represent any given percentage of the total mechanical injuries in Southern Nevada and are therefore no more than a list of incidents and the findings that were made. I have the complete file on each case with me and anyone desiring more detailed information is certainly welcome to examine these files.

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PHYSICAL DISTURBANCES CAUSED BY TRAPPING

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For several years, the abstract concept of stress--at least as applied to medical science--was reserved for the ivory-tower theorist. Today, the subject of stress appears in all kinds of magazines. Although presented in elementary fashion for the general reading public, these articles treat the subject quite comprehensively and accurately.

Whether we consider stress from the practical or theoretical aspect, we must acknowledge its importance. In man it has been found that blood clotting is accelerated and blood cholesterol is elevated by psychic stress, accounting for some of the "coronaries" and "strokes." The speakers at a recent conference on stress presented varied individual concepts of the subject, but none could deny that it played an important part in several major diseases. It has been shown to produce a recognizable clinical syndrome in laboratory animals.

Definition--Stress is a physiological response. It may be defined as the sum of all nonspecific changes caused by malfunction or damage. These nonspecific changes are well defined in laboratory animals and probably accompany diseases in all animals. The obvious changes in laboratory animals involve the thyrnicolymphatic system, gastrintestinal tract and adrenal gland.

The causes of stress are known as stressors and for purposes of veterinary medicine may be considered as unfavorable influences on an animal's health. These stressors may be specific causes such as microbial pathogens and simple vitamin deficiency, or nonspecific such as psychic disturbance, exposure and malnutrition.

Systemic stress results in a sequence of general reactions first described by Dr. Hans Selve of the University of Montreal as the General Adaptation Syndrome. It is divided into three phases:

1. Alarm reaction
2. Stage of resistance
3. Stage of exhaustion

There is also local stress, described as the Local Adaptation Syndrome. Local stress is characterized by reactions occurring in the immediate vicinity of the stress.

Systemic and local stress may occur simultaneously, or one may predispose to the other.

The Alarm Reaction--In the alarm reaction, body defense mechanisms are alerted or "alarmed" to cope with the stress. In the case of stress due to excitement, the higher brain centers register the excitement and act through the hypothalmus and pituitary to stimulate the adrenal medulla to secrete epinephrine and the cortex to elaborate corticoids.

In the case of infection, the invading organisms alert inflammatory and other body defense mechanisms. For example, there is mobilization of phagocytic cells to destroy the invaders.

Where the stress is due to a nutritional deficiency, the body regulatory mechanisms are alerted to make ready to draw on body reserves and to conserve deficient substances.

The State of Resistance--After the alarm has mobilized the body defenses, the body becomes resistant to the stress.

In the case of excitement stress, epinephrine accelerates the heart, dilates the bronchioles, increases blood sugar, all of which enable the body to defend itself against stress.

In the case of infection, the outpouring of phagocytic cells overcomes the invading stressor, and antibodies are formed, thereby removing the stress.

When body reserves are liberated to replenish deficient nutrients and further loss prevented, the nutritional deficiency is corrected.

In these examples, and in many other ways, the body develops resistance to a stressing agent, and adapts itself to the unfavorable condition, permitting survival.

The State of Exhaustion--Repeated mobilization of body defenses or an overwhelming stressor will bring about the stage of exhaustion. When exhaustion occurs, the animal succumbs to the resulting stress, being unable to counter such unfavorable influences as excitement, infection, and nutritional deficiency. If the stress is severe or prolonged, death ensues.

When stress has forced the body to the point of exhaustion, other stressors that are latent in normal healthy animals become potent. For example, continued exposure to cold, damp environment frequently stresses an animal to a point where micro-organisms in the respiratory tract are able to cause pathological conditions and produce added stress. So, one stress may predispose to a second, and the second to a third, and so on. This multiplicity of stresses may eventually overwhelm an animal and cause its death. In other words, the body is unable to adapt itself and loses the fight for survival.

Fortunately, there are means to combat stress. Use of various therapeutics as supplements to body defense mechanisms serve as antistress factors. More important as antistress factors are preventive measures including good management practices, favorable environment, immunity to disease, and genetic selection.

Specific stresses are apparent because there is frequently a characteristic lesion associated with a particular stressor. For example, a vitamin D deficiency in young animals causing a nutritional stress usually results in rickets. Infection by anthrax organisms produces the characteristic anthrax syndrome.

So often are psychic factors such as anxiety, apprehension, excitement, and fear associated with stress in animals, that they may, indeed, be the most characteristic part of the clinical stress syndrome. Even where stress of psychic origin is not apparent, it may exist in a subclinical form, serving as a predisposing factor to infection or other insidious stresses.

At this point we can only theorize. But we can remind ourselves that in recent years medical scientists have shown psychic factors to be related to gastric ulcers. The indications are that more and more disease conditions will be related to stress of psychic origin.

Perhaps future investigators will pinpoint the factors that make up stress and fit together all the pieces of its intricate pattern.

When they do, we will develop specific preventives and therapeutic agents. Until that time, we must utilize the materials we have at hand if we are to combat stress.

Conventional therapeutic and immunizing procedures have been used successfully for a long time to combat specific stress, but only recently have we uncovered a specific drug to treat nonspecific stress. The new discovery is the tranquilizing drug.

The tranquilizer does not change unfavorable environment. It changes the animal's psychic attitude to that which it would display in a favorable environment. It removes stress due to unfavorable environment in this manner.

Nonspecific stresses resulting from a complex of causes such as undesirable psychic influences, exposure, disease, nutritional deficiency, inadequate shelter, and genetic abnormality and unsanitary housing are more difficult to demonstrate. However, in laboratory rats a characteristic pattern of nonspecific changes has been observed resulting from artificially imposed stresses brought about by extreme temperature, prolonged exercise, foreign protein injection and toxic drugs. In these rats there were consistent demonstrable lesions manifested as thymicolymphatic involution, gastric ulcers, and adrenocortical hypertrophy. Probably these same changes take place in other animals, but are less apparent or take a different form.

Because of adrenocortical hypertrophy and consequent increased corticoid output, it has been postulated that stress reactions are mediated through the pituitary-adrenocortical pathway. However, this appears to be only part of the story because stress reactions have been demonstrated in hypophysectomized and adrenalectomized laboratory animals. There are strong indications that the central nervous system and specific tissue responses play an important role.

Stress as we see it affecting our animals, therefore, must be considered as a result of a combination of nonspecific and specific causes. The nonspecific stresses are due to general environmental factors such as psychic influences and poor management practices. Specific stresses are due to more obvious causes such as disease, injury and parasitism. A nutritionally caused stress may be either type depending on whether or not it is a simple or complex abnormality.

Stress is due to the sum total of unfavorable environment influences affecting an animal's health.

When Tom Moore came back to us in about a month after we had first talked to him and we had received this answer from Dr. Booth, we decided to try the tranquilizing drug on the sheep. Theoretically, it was the ideal. I don't believe we got the results that we desired. I think we got the results that we could expect but not the desired results. You see, a tranquilizer even in humans does not work the same on each individual. What may, probably, put me to sleep may hop you up. There is an individual difference there and we just don't know what an individual animal will do. Yesterday I was down in the doctor's office and I saw a pamphlet there on Thoriazine, which was the principal tranquilizer which we used. It said that Thoriazine's desired results were not obtained sometimes in animals or in humans for weeks and even, possibly, a few months, and we have been wondering why we haven't gotten the desired results on all the animals that we used them on. We certainly haven't had them for months or even weeks. We give them one shot and if it doesn't work, we go to something else. What I had in mind there was that just because you use one tranquilizer in an animal, you can search around and change it and get another one which will do the desired job. In the Bighorn Sheep, it just wasn't possible to do that; we tried to make it a one-shot deal and it just didn't have the desired results.

The drugs we used on these animals to try to prevent this stress were shipping fever serum. Usually, we gave them about 25 cc's subcutaneously. We find that this not only helps in the prevention of respiratory ailments but, also, seems to give the animal a boost in order that he can combat other diseases as well as the respiratory forms. We gave them 5 cc's of districillin, which is a combination of penicillin and streptomycin injected into the muscle, and then we gave them the tranquilizing drug intravenously. We tried the intravenous route first and, frankly, in some of them we don't know where the tranquilization started or whether it actually did start or not -- or whether it was the peculiar habit of these animals to sulk. One thing at which I was amazed was how fast these animals actually tamed down. Now, I don't know whether it was a natural taming or whether it was a sulking, but it was very hard to tell right exactly where the tranquilization started and the sulking stopped. We have used the tranquilizing drugs in practically all of the normal species of animals. We have used them certainly in cats and dogs, cattle and horses. We have had very few bad results -- what you would call bad results. The worst results we have had were where they had been used in conjunction with a barbiturate or some other type of anaesthesia and there is a great prolongation of the anesthesia period. The other thing we find is that the male of the species, although it could be a castrated animal, has what we call a "fallout." The penis falls out and hangs out about a foot, and we have used it in cattle for surgery and examination of the penis, or examination of the washings of the prepuce. We have used it there very successfully. We've used it in horses; in fact, our best results we think have been with horses. We've used it in minor surgery. We've used it where they have roped and trapped wild horses; they were unable to even put a rope on an animal -- unable to walk up and put a hand on it, I should say. They four-foot the animal, we give it an intravenous injection, and in about five minutes we can just lead it up into the van and cart it on in to town. It does last quite a long time in the horses occasionally. We've seen it last 36 hours in horses. It does have quite a lasting effect. The tranquilizing drugs that we use are mostly phenothiazine derivatives; that is, the injectable forms are phenothiazine derivatives. Phenothiazine, you know, is a worming medicine for most of the animals that we have to do with.

My time is getting short here, and I want to quickly go over a couple of case reports, and then I'll try to answer any questions during the question and answer period.

We were brought a ewe lamb which, I think, they decided to be approximately four months old. We thought, possibly, that the lamb was a bum lamb inasmuch as they had been able to trap it so easily. Its hair coat was rough and it showed quite a pneumonic symptom. It had a temperature of 104 and was breathing rapidly. It showed some hunger, but it wouldn't eat very much. We treated it for the pneumonic symptom with the normal antibiotics and with serum, and the animal recovered from that very well. We checked the fecal examination and found that it was negative; we also checked it for brucellosis and it was negative. The interesting part of this case was that the animal calmed down and became very tame. In fact, within a few days, 5 or 6 days after its recovery from pneumonia -- my little daughter would go out there and the lamb would just jump and play and follow her like any other lamb. It was just as tame as it could be. However, this was in the heat of summer, so we kept it inside in one of our dog cages during the day and would turn it out at night in the back yard where there was some Bermuda grass in addition to other grasses. I believe that we actually killed the animal with kindness. We fed it canned goat milk and Vitamycin supplement, which is a vitamin and mineral supplement put out by Pittman Moore. The animal would eat weeds and just any part of the alfalfa, but it wouldn't eat the soft leaf. It would not eat Bermuda grass, but it would eat several types of browse. We went over in the field across from the office and picked out some distinct parts of the oats that were growing there, and the animal would eat that. However, after we had the animal approximately 12 days or so, she started eating hair. Now, we keep dogs there -- and there is a lot of hair. We would turn the little devil loose in the back room and we found that it would go over and eat the hair from the pushbroom that we had. It would even eat the pushbroom, so we started caging it up. We would put it out at night, and there is a drain right out at the back of my office that collects all of that hair. That is where we lost the animal, because at night when we would put the lamb out, it would go over, and it had a pica, an abnormal appetite for eating this hair. One cause for a pica appetite is a phosphorus deficiency; another cause is cobalt deficiency, or some of your other trace minerals. Now, we know that this area is a phosphorus deficient area, and we have found this pica appetite in lambs out on the mesa where there is alfalfa and where there was not a great amount of phosphorus put in it. These lambs had a pica appetite. This bum lamb actually killed itself by ingestion of, I would say, approximately 10 pounds of hair. I did an autopsy on the animal. All the tissue was absolutely normal except the paunch or rumen and it was completely packed with hair. I don't mean that it was just floating in there, but the paunch was approximately this big in a 3-month-old lamb, and it was packed with hair, so we considered a phosphorus deficiency, a cobalt deficiency, or any other of the trace mineral deficiencies.

The last problem is that of a 3-year-old ram which we had. It was brought to us following use of tranquilizing drugs. It was in a bloated condition and unable to stand, with a twisted neck. It was always twisted to the left, and we immediately thought of an injury and treated it as such. We immediately relieved the bloat, however, and the animal stayed in a condition of shock or stress the entire time that we had it. We took X-rays of the neck but could find no injury at all. The animal was conscious, but it just showed no interest in life at all. It could not balance itself when it stood up on its four feet. The first day it had no normal bowel movements -- no bowel movements at all. That is when I gave it an enema, and that's why I consider myself an expert. We gave it an enema and after that it started having normal bowel movements. We used a rumen transplant of a product called Boganox, which is actually for cattle, but we used that in that we used B-12. We used metacortent. We made a cast for the animal's neck; we put the neck in traction and made a sling for it. We fed it by stomach tube for the last four or five days of its life. The food was principally goat chow. However, for the first part of the time we had it the animal would eat, but you would have to put the food in its mouth and it would chew it. It periodically showed some bloat symptoms, which were relieved by stomach tube, and the last two days of its life the animal showed a very peculiar type of gangrene. I would call it just above the hoofs, especially the two hind legs. It looked like it was a complete circulatory collapse, possibly from not having enough exercise, enough movement, and not enough circulation. The hair would pull out, the area got purple, and about 48 hours later the animal died.

In summary, we are not satisfied with the results of the tranquilizing drugs as such. In the last couple of months there has been a new product come out called Diequill, put out by Jen-Sal.. I have not done enough work with it to know if it is any good or not. It needs further work and observation. It needs a standardized, effective therapeutic dose. Each species seems to act differently and each individual, possibly, within that species. I think you will notice in the reports that have been given most of our trouble was with rams. Possibly, there is even a sex characteristic there. I don't know. We, also, could possibly use the old anaesthetics, the barbiturates, in qualified hands and be able to take care of the unfortunate results.

In ending, it comes back to the old saying: "The animals die, and they die because they want to." They just seem to give up. I thank you. I have taken past my time and, also, some of Dr. Johnson's. I appreciate being here. Thank you very much.

PROBLEMS OF LUNGWORM INFECTION IN WILD SHEEP

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The problems of lungworm infection in wild sheep are brought into sharper focus when something is known about the history of the fluctuation of bighorn sheep populations and the lungworm which has been identified with them in recent years. The petroglyphs or pictographs depicting bighorn sheep are interpreted as evidence that these animals were present in the areas where they were pictured. The canyons of the Apishapa and Purgatoire Rivers and the Mesa de Maya of southeastern Colorado offer many such examples, yet there are no historic records of bighorn sheep in these areas. Why is this? Similar habitats have supported bighorn sheep populations in historic times. Most references to bighorn sheep are from the more mountainous areas of Colorado, and probably one of the best records exists for the area within a fifty-mile radius of Pikes Peak.

Lt. Zebulon Pike made the earliest reference to bighorn sheep in Colorado when he wrote in his journal for January 1, 1807, that the doctor and Brown had killed one of the mountain rams. Coyner (1847) writes about two trappers ascending the Arkansas River in 1809 and finding the flocks of bighorn increasing as they ascended the river. According to Edwin James, a member of the Long Expedition, game was neither abundant nor in good condition when the party reached the region in July of 1820; furthermore, bighorn sheep were not seen, only their skulls and horns about the licks and saline springs at the foot of the mountain and possibly their tracks near the summit of the peak. (Disease sheep have shown increased tendency to visit water and salt.) Rufus Sage (1857) reported that in September 1842 there was an abundance of game in the vicinity of Fountaine que Bouil (Manitou Springs) which included mountain sheep, elk, antelope, and buffalo. In 1846 when Ruxton (1861) visited the same area he saw several bighorn sheep and mentioned that bighorns were especially abundant about South Park. In the spring of 1858 Captain Marcy (1866) and his company spent thirty days camped near Manitou Springs and amused themselves hunting elk, mountain sheep, and mule deer, all of which were abundant. Tierney also in 1858 indicated that there were countless herds of elk and mountain sheep near the headwaters of the Platte River; but the prospectors in the South Park area did not find game especially abundant the following year. That disease may have been a factor is indicated by Seton (1927) citing an early resident of Breckenridge, Colorado, to the effect that scabies was present among the bighorn sheep when he came there in 1859. On the other hand Baille-Grohman (1883) mentions that scabies was unknown to Indians prior to the 1880's. Ute Indians camping in the vicinity of Manitou Springs in 1866-67 nearly starved, which they would not have done if game had been available. Game was in such short supply that the Territorial Government closed the hunting season during 1867 and 1868. By 1871 bighorns were reported common in the mountains about South Park by Brewer (Cary, 1911), and were generally abundant during the late 1870's and early 1880's when many sportsmen from foreign countries were attracted to the area. One hunting party reported killing twelve bighorns in one day, and the markets were well stocked with game (Weekly Gazette, 1880). Deer and bighorns were occasionally shot from hotel verandas in Manitou Springs, during the early 1880's (Hall, 1890). But in 1885 the Tarryall herd was severely decimated by scabies reportedly introduced by domestic sheep and about the same time the Pikes Peak herd as well. Certainly domestic sheep were increasing tremendously during this time. Brockett (1881) reports that in 1870 there were only about 2,000 head of domestic sheep, but by 1880 there were over two and a half million. Bighorn sheep decreased so drastically that the hunting season was closed in 1887. In the biennial report of the game commissioner for 1893 and 1894 it was stated that mountain sheep had increased a hundredfold as the result of the protection they had received over the past three years. It was felt by many of the early residents that the construction of the Short Line Railroad to Cripple Creek about 1900 stopped the annual migration of bighorn sheep between summer range on Pikes Peak and winter range in the Arkansas River Canyon. This fact apparently had a lot to do with restricting the future maximum size af the Pikes Peak herd. According to Mr. Frank Poley there were losses in the Pikes Peak herd in 1911, attributed to hemorrhagic septicemia by representatives of the Bureau of Animal Industry which went into the area. Information from the files of the Pike National Forest indicated that for 1911 bighorn sheep were increasing. The population estimated in 1912 on the Pike Forest, which at that time was larger than at present, was between 1,000 and 1,500 head, which dropped to between 500 and 600 by 1919. Mr. Poley thought that there was some loss in the Tarryall herd about 1911 as well, but the great decimation of the Tarryall herd came later. In 1921 to 1923 a few dead sheep were noted; then in 1923-1924 the herd was reported nearly exterminated by hemorrhagic septicemia (H. S.) as diagnosed by the B. A. I. laboratory in Denver (Case #3580). Mr. Poley said some of the sick bighorns were inoculated for H. S. but it was ineffective. Carhart (1940) states that there was an outbreak of hemorrhagic septicemia in cattle in the Tarryall area at the time of the bighorn mortality. This heavy mortality in the Tarryall herd focused attention on the Pikes Peak herd but no loss was experienced there until 1929 and 1930. On Pikes Peak the first evidence of illness in the herd is contained in the Colorado Springs Gazette for September 29, 1928, which reports that a bunch of 34 bighorns was seen, one of which was apparently sick and barely able to walk. Most of the mortality occurred the following year, and continued into 1930. Two sheep were taken to the laboratory of the Bureau of Animal Industry in Denver (Case #10414 and #10564) and apparently some were also examined at Colorado Springs. Lungworm larvae were first seen by Dr. Bossevain, of Colorado College. It was from the material taken to Denver that the lungworm, Protostrongylus stilesi, was recovered and described by Dr. G. Dikmans in 1931, being name r the Director of the Denver laboratory, George W. Stiles, who forwarded the material tb Dikmans. Dr. Hall was responsible for the idea that snail hosts were eaten intentionally by the sheep to satisfy some mineral deficiency; which would have been a most logical assumption if snails of the genus Oreohelix, which may be an inch or more in diameter, could serve as the intermediate host for the parasite (Hall, 1931). Penciled notations beside the Case #10414 and #10564 indicate that "strep" was cultured from the lungworm infected lungs.

The mountain sheep herds in Colorado remained at rather low levels or declined to some extent during the 1930's. As a result an interstate, interagency bighorn sheep study was initiated and gained some momentum before it disintegrated during World War II. An upward trend in the populations of bighorn sheep in the 1940's was largely responsible for a resident Colorado license for hunting of bighorn sheep being established by the legislature in 1945. The Tarryall herd became famous for its health and productive vigour; the lungworm was regarded at a very low level on the basis of the negative fecal sample analyses reported by Spencer (1943) from the Tarryall herd. Several successful transplants were made from the Tarryall herd in the 1940's and these transplants apparently have all done well since the decimation of the mother herd in 1952-1953.

Striving for a 1953 bighorn hunting season, game department personnel were explaining the need for such a season when it was learned that heavy mortality was taking place in the Pikes Peak herd as early as September 1952, and in the Tarryall herd about the latter part of December. Pathologist Lynn Griner and Parasitologist O. W. Olsen of Colorado State University concurred in the opinion that pneumonia, probably resulting from the heavy lungworm infection, had caused this mortality.

The obvious relationship between density of the population and the spread of disease prompted the Game and Fish Commission to go through with this plan and a bighorn hunting season was held in 1953, the first in Colorado since 1887.

With the historical information available it is certainly evident that disease and its control is of the greatest importance to the management of bighorn sheep. The lungs are consistently the most common site of gross pathology encountered on postmortem examination of bighorn sheep and unquestionably bighorns are particularly susceptible to respiratory infections.

Our work has demonstrated that several species of land snails belonging to the snail families Pupillidae and Valloniidae are essential intermediate hosts for lungworms of the genus Protostrongylus occurring in Colorado. This is confirmed for other species of Protostrongylus by investigators in Eurasia, especially Russia; however, in Eurasia other snail families are also implicated. We know the development which takes place after the larvae invade the snail's foot tissues and something of the conditions which affect the rate of this development. Larvae have reached the infective stage in as little as two weeks or have required as long as two months. Under natural conditions such development would require at least a month. Snails may remain infected for over a year, but at some time and under some conditions, infective-larvae may escape from the snail. Infection of the wild sheep is by accidental ingestion of the infected snails, but in some cases possibly by ingesting free infective larvae on the vegetation.

It is known that moisture is exceedingly important for the survival and activity of the snail hosts and the freelarvae, bothfirst and infective stages. Under natural conditions, the specific elements of weather favoring the completion of the life cycle have not been demonstrated but are indicated by field and laboratory observations. For instance, if the whole cycle takes place within a single year there must be a time during the winter or spring when the snails become infected. If the larvae reach the infective stage later in the summer, conditions must be favorable for the sheep to acquire infection in the late summer or early fall. Accumulation of infected fecal material must be deposited on the same range but some time before infection is acquired. If the only opportunity for infection of snail existed in the summer on a strictly summer range of the sheep then the only time the sheep could acquire the infection would be the following summer; however, if sheep wintered on the same range on which they summer, the cycle could be completed the same year. It should be possible to determine the hazards of infection by a knowledge of the weather, snail distribution, pattern of range use by the sheep, and densities of the population of both sheep and snail hosts.

The working out of specific techniques for determining the trend in the incidence and intensity of infection and when and where the infection is actually acquired presents a problem for which a solution is being sought by our present studies. Even if lungworm infection were found to be of little pathological significance in itself, which does not seem likely, then a measurement of the trend of infection could provide a useful tool for determining desirable bighorn densities. This is of course assuming that the disease epizootics are density dependent phenomena as the historical evidence suggests.

Experimental transmission of the lungworm in penned animals in which reinfection can be prevented, the intensity of the infection controlled, and complicating infections treated is the key to determining the pathological significance of lungworm infection.

Experimental transmission studies are full of pitfalls--results once obtained may be difficult to duplicate; techniques for measuring the results may be found inadequate; unforeseen complications may arise for which one is not prepared, which introduce more variables in an already complex problem. Each obstacle overcome is a step ahead; for example when snails naturally infected with larvae, apparently identical to the bighorn lungworm larvae, were found in areas without bighorns it became necessary to check on other species of Protostrongylus occurring in deer and rabbits. These species were found to have the same life cycle, involving the same snail intermediate hosts. Obviously, rabbits provide a better-and more easily obtainable experimental animal than is the case with bighorn sheep. Techniques can be perfected using rabbits which may provide general solutions to the problem of transmission, pathological significance, and treatment or control of lungworm infection. In order to use fecal analyses for lungworm larvae as a means of determining the trend of the infection, we must learn many things impossible to find out through field studies alone. We must know how much time elapses between infection and the first appearance of larvae in the feces. What is the duration of an infection when there is no reinfection? What is the pattern of larval output, and how is it related to the duration and intensity of the infection? From the wild herds we must know about seasonal fluctuations in the output of larvae, in order to be sure that comparison of samples from one herd with those of another represent the difference in level of infection and not just a difference in the time that infection is acquired. Furthermore, it would be most desirable to be able to check observations based on fecal samples with lungs from animals taken during hunting seasons. Obviously the possibilities of obtaining enough lungs from hunting seasons alone on which to base trends of the infection in the entire herd would be very difficult and possible only in areas having good populations and liberal seasons.

Certainly lungworm or protostrongylosis is an important disease but cannot always be demonstrated in animals dying of pneumonia; furthermore the epizootic pattern of mortality as it occurred in the Pikes Peak and Tarryall herds is not what would be expected from parasitism alone, but rather what would be expected from a more contagious disease.

The concept of complex infections as presented by Shope (1939) and his work in demonstrating that lungworms may be vectors of viruses (Shope, 1943 and 1947) certainly provides us with intriguing possibilities. Saito, 1954, reports heavy mortality in goats imported from the United States as the result of virus of the psittacosis-lymphogranuloma group (amenable to treatment with antibiotics) which can be transmitted, at least experimentally, to cattle, horses, sheep, dogs, cats, rabbits, pigs, and mice. Dunn and White, 1954, mention a possible relationship between lungworm and virus pneumonia in pigs. Underdahl and Kelly, 1957, demonstrate that clinical cases of pneumonia in pigs are the result of enhancement of virus pneumonia by the migration of ascaris larvae through the lungs. Carter and Rowsell, 1958, show that calves are subject to enzootic pneumonia, resembling virus pneumonia of swine and state that many cattle which develop shipping fever (same as hemorrhagic septicemia but a more acceptable name) are undoubtedly infected with enzootic pneumonia.

Actually determining the pathological significance of protostrongylosis and its relationship to other disease is the primary problem for which solutions must be found before any expensive programs are initiated to control the parasites. We must first learn how to produce the disease in experimental animals; then determine the pathological significance of various intensities of infection, and devise means of measuring the levels of infection in the wild herds. Then we may study the relationship of transmission to specific herd environments to determine what management measures are needed to control the infection in the herds. In the laboratory and with the penned experimental animals, methods of treatment can be investigated and other means of control investigated.

Finally there is the problem of trained personnel and adequate facilities and funds for attacking the solutions to the other problems mentioned above. Administrative interest is stimulated each time a devastating epizootic strikes or when the populations become so low that their future is threatened. When interest is high, projects are rapidly initiated and quickly supported, but may not have a very long life. Few state game departments have the laboratory or experimental facilities, the' personnel, or the funds for a complete, well-integrated and continuing study, and the available facilities cannot be restricted to the study of only bighorn diseases. The facilities available to game and fish departments are seldom more than diagnosis or identification services. Needed are studies or facilities to go beyond this point to the ecology or epizotiology of specific diseases.

I believe we are dealing with a situation in which we are concerned, not with lungworm alone, but with several disease factors, combinations of which are capable of causing epizootic mortality. Certainly the dynamics of bighorn sheep populations are complex; but several factors such as the activities of man, climate, and the general environmental construction can directly affect populations detrimentally as well as indirectly through disease. The concept of complex infections certainly provides a working basis on which to explain the action of disease in controlling the fluctuations of bighorn sheep. Is it not worthwhile to develop some long-range planning, realizing the financial and personnel limitations of the individual states or agencies, for solution of disease problems, to make some greater effort to cooperate and coordinate the research?

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WATER REQUIREMENTS

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This is a large subject, with direct application in management techniques. Our observations indicate a necessity for most, if not all, bighorns to drink at least during dry, hot periods. You will note my qualifying terms, "most, if not all," "at least," and "indicate." This doesn't mean I'm trying to beat around the bush, but it does mean we don't know much as yet about actual water requirements. In the absence of any specific scientific information where bighorn sheep are concerned, I am going to present some recent findings concerning another desert animal, that ship of the desert, the camel. It is possible that this particular research may give us some pointers on bighorn water requirements. I quote now from Natural History, Vol. 66, No. 5, May 1957, an article entitled "The Legend of the Camel" by Alonzo W. Pond:

"Legends of the camel and its water-drinking habits were the most recent to give way to facts. The Drs. Schmidt-Nielsen, husband-and-wife team of physiologists, have investigated these legends with results that only controlled scientific experiments can give. For several months they worked with camels in the Sahara, weighing them before and after feeding, before and after drinking. They kept records of body temperature, tested blood and body fluids, and finally dissected dead animals. Their findings explain the camel's way of life and account for the wide variation among the claims made about the beasts.

"Camels do not store up water. They only replace the quantity lost since the last drink. The Schmidt-Nielsens have records of one camel which drank over 27 gallons of water in ten minutes, nearly one-third of its own weight. In less than 48 hours, this water was evenly distributed to restore blood, body fluids, and cells to their normal water balance. The Schmidt-Nielsen studies also showed that unless it was dehydrated, the camel would not drink at all, even if it had gone for months without drinking.

"In Egypt the camel can go for three or four months without drinking between November and April if it is in lush pasture where the vegetation is kept green by dew and showers. If it is on dry feed, the camel will get thirsty in a couple of weeks, even during January. One animal which did not drink for 17 days in June was so dehydrated that its abdomen was drawn in, its muscles sunken, and its legs scrawny.

"It is evident, then, that the length of time a camel can go without drinking is much affected by the time of year, force of wind, heat in the air, intensity of the sunlight, amount of reflected heat from the desert floor, dryness of the feed, kind of feed, weight of the load carried, speed the animal travels, and the hours spent in travel each day. These same conditions bear on the need for water in human beings, horses, and donkeys. Nevertheless, it is the camel that can best adjust to the extremes of the desert.

"Like man, the camel must keep its body temperatures within certain bounds through perspiration, but for the camel there is more leeway. Its temperature in the morning may go as low as 93° and rise in the daytime heat to more than 104°, representing a daily range of 12 degrees. Man must keep his temperature within a degree or so of 98.6°. The camel has another advantage, too: it can tolerate dehydration to more than 30% of its body weight, while man is in trouble when he has lost water equal to 10% or 12% of his weight.

"Dehydration does not impair the camel's appetite, so it keeps eating and restoring its energy. Its woolly coat keeps out the heat of direct sunlight, reflected heat from the sand, and heat in the surrounding air. The wool also allows sweat to evaporate slowly and so cool its body more efficiently.

"Its wide temperature range is one of the camel's most important assets. This is because heat moves faster on a steep gradient then on a slow one. Air at 110° gives heat faster to a body at 98.6° than one at 104°. So, the camel doesn't get as much heat from its environment as man would because its body temperature is closer to the temperature of the desert air. Also, when its temperature is rising, the camel is storing heat for the cool night. Its body functions somewhat as do the new solar houses which store the sun's heat to warm the rooms after dark.

"So, it is not storage of extra water that allows the camel to go without drinking but rather its tolerance of great dehydration and its wide range of body temperature.

"The Schmidt-Nielsens found that the camel's stomach and rumen sacs, which desert legend credits with water storage, do contain liquid and sometimes solid food. This liquid, however, has as much salt in it as the blood or other body fluids. Furthermore, the capacity of the little sacs is insignificant compared to the amount of water the camel needs.

"No doubt there is some truth in the stories of drinking the contents of camel stomachs in desert emergencies. As recently as 1920 various Bedouins of Syria had done exactly this. Unappetizing as these normal digestive juices must have been, they did restore the energy and prolonged the lives of these dehydrated men. But they did not represent extra or stored water.

"There is no water in the camel's hump, either. It is fat, stored energy, like the hump on Brahma cattle now so common in the southern United States. Some students have reasoned that when the fat of the camel's hump is utilized it produces more than its weight in water and that the hump, therefore, does indirectly store water. The physiologists disproved this. They have shown that it takes a lot of oxygen to combine with fat and transform it into usable energy. Since oxygen comes through the lungs, this necessitates increased breathing and, consequently, more moisture evaporated in the exhaled breath. As a result, extra water produced from metabolized fat escapes from the body. Even though the hump isn't a water tank, it is quite a remarkable feature; a light, easily carried form of energy that keeps the camel supplied after the feed bag is empty or the pasture dried up.

"The camel has taught me the basic principles of desert living: keep out heat by wearing clothes that cover the body and still let sweat evaporate efficiently; travel slowly to keep down the production of body heat; drink water when you are thirsty to stay within safe water balance limits; take long vacations to fatten up and restore energy."

While we should hesitate about applying these findings to bighorns, we shouldn't overlook the possible correlations--there may be a great deal of similarity in the water needs of bighorns and camels. It may also serve to give direction to the type of research we need.

Field observations to this time are somewhat contradictory. We have seen bighorns come in to water during the dry summers obviously suffering from thirst. Others come to the same water at the same time and drink, but appear to be in no particular need for water. Bighorns seem to stay away from water in the desert winter, yet we have instances of them drinking even at that season. Then we.have cases where apparently the animals do entirely without water for a month or two at a time, during the hottest weather. We feel fairly certain that most of the bighorn sheep on the Cabeza Prieta Game Range in the summer of 1956 did not drink from July 1 until six months or more later. Dick Weaver of the California game department has told us about bighorns in a waterless mountain range on the California desert that apparently never drink water at all! This poses the question as to what extent water is a limiting factor, the answer to which of course would have important application in our management procedures.

I believe that is all I have to present on this very interesting matter.

DAILY MOVEMENT AND ACTIVITY OF THE BIGHORN

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My assigned topic, the daily movement and activity of the bighorn sheep, is as basic as the fact that daily movements occur and that their activity is divided between feeding, running, resting, drinking, playing, sexual activity, being born and dying. The variations in time, place and circumstances that these activities occur make the bighorn pattern of life highly unique and interesting, not fully predictable, and at times quite frustrating to the investigator.

I am a firm believer that men and animals follow patterns and routines, but also each man and each animal with a moderate amount of intelligence is an individual and acts accordingly - call it a personality if you will - and the sheep of the Desert Game Range in general and the Sheep Mountain range in particular seem quite highly gifted in this "I never read the textbook" attitude. The senior biologist at the Desert Game Range, Mr. M. Clair Aldous, and I have together a total of almost five years of studying the behavior and activity of Ovis canadensis nelsoni on the Desert Game Range in conjunction with our objective of establishing a sheep management policy and program for that area. Although we can as a rule predict or anticipate actions and occurrences of individuals and bands, there are still those times when unpatterned behavior has to be marked up as the unpredictability of nature's creatures.

I could go into quite a lengthy dissertation on the phenomena of this creature, his appearance symbolic of wilderness itself, the isolation in general of his habitat, and the difficulty and at times disappointment in finding, observing and studying the animal. However, we are all investigators to one degree or another of the desert bighorn and I am sure fully appreciate these points. Therefore, what I would like to use for the nucleus of my paper is highlight excerpts on daily movement and activity as witnessed by me, gathered by other investigators at the Desert Game Range, noted in my field diary, and above all recorded on our official observation forms that are on file at our Las Vegas office, which date from April 1955 and are still being collected.

A technique that we have been employing since the turn of this year to round out our information and which should be mentioned here is what we term "a 24-hour observation." One or preferable two men equipped with binoculars, spotting scope, writing material, bed roll and minimum food rations locate an individual or a group of sheep and attempt to stay concealed or under cover at a moderate distance and observe the subjects for a complete 24-hour period recording all behavior and activity, duration of activities, length of travel, etc. It is our plan to secure at least 12 of these observations this year with mixed groups, ram groups and ewe or ewe-lamb groups. Also, we hope to obtain some observations during periods of full-moon nights. Two men or even three have a decided advantage over a single observer in keeping contact on wandering groups as can be readily appreciated. Small portable 2-way radios would be a decided advantage when a group splits or is temporarily obscured from one observer. The work that has been done with this technique has proved most interesting and informative.

Now to get into this movement and behavior phase. Under the heading of movement I am safely under the wire for daily movement can pretty well be surmised. However, if it were movement in general or seasonal movement, then a vast and controversial subject of nomadic wandering, nonreturning drifts, food and/or moisture scarcities, population saturations, and unnatural or outside pressures would have to be delved into, and at present this is a hypothetical, debatable and speculative subject.

We have basically three life zones plus the transitional zones that our sheep utilize normally. They are the Joshua tree, pinon-juniper and the Ponderosa pine type. To find animals in any of these types at any time of the year would not be uncommon. However, as a rule the distribution seems to be generally that most animals use the Joshua and periphery of the pinon-juniper type most of the year with emphasis on the lower elevations during the spring and early summer and with at least a partial movement into the timber types in approximately July. Why there is this movement into a heavy pinon-juniper type and even higher into a Ponderosa type is not fully understood. One could jump to conclusions here and say "to beat the heat," but at this same period of time sheep have been observed in the lower Joshua tree zones lying in full exposure of the sun with a shade from a rock or tree or cave only a few feet or yards away. It is interesting, although expected, to note that all sheep observed in heavy timber types are quite nervous and will "stampede" when a horse whinnies or the observer in first seen, which is quite a contrast to the lack of concern they often show when seen in the open.

The longest undisturbed movement in a 24-hour period was approximately five miles, covering a route of about 300 degrees of a circle. As yet we do not have enough observations of this sort to determine if this could be considered an average.

The majority of daily movement would be better called daily wandering for the selective way of feeding allows them to cover much ground. It is very common to see a sheep feeding on stipa grass, for example, take several bites off the tip of the plant, see another identical plant while masticating these first bites and move on to it for further eating, passing up further identical plants along the way. Incidentally, this wandering-feeding pattern leads toward good range management practice for it is rare to find a forage plant that has been overutilized on our area. (We have no stock competition at present.)

Aside from the daily pattern of wandering-feeding a while, staring into the distance, feeding a while, pawing a bed and resting a while, and then feeding on, we also observed deliberate and persistent moves that seemed to be broken into these basic motivations, e.g. to indulge or pursue sexual activities, to join other sheep seen at some distance away or to travel to water (this is often done with frolic and play among the younger members of a band) and at times to seek known caves or other known shelter.

The habit of using shelter and protection from the elements is another controversial trait and one that is far from being a pattern. As previously mentioned, sheep have been seen in "tall timber" and open desert type both in the same day. One member of a band will insist on the shade of a rock or tree; others will merely lie wherever they are and in the broiling sun only a few feet from shelter. One very interesting observation that Mr. Aldous and I made during our February 24-hour observation was of three separate groups that were some distance apart, out of sight of each other, which we were able to observe during a brief snow squall accompanied by strong north winds. One group bedded in complete exposure to the storm with their backs towards the wind, one group went directly behind a large outcrop and bedded on the lee exposure, and the third continued to feed into the storm - yes, they do have an inconsistent nature.

The peculiarity of making a bed is an interesting thing. Sheep will often just lie down, particularly if they are interested in watching something, but as a rule they prepare a bed by pawing the rocks and soil with alternate forefeet to some degree and dropping to their fore knees and brisket lie down with their legs tucked under them. The head is often extended, chin resting on the ground with eyes closed. The animal will rest for several minutes at a time this way or even at times with the neck bowed and the head resting on its shoulder or flank.

Resting will last from only a few minutes duration to an hour or longer. As a rule a single animal will remain bedded longer than members of a group.

The method of lowering the rump last to lie down and raising it first to get up is of course typical of the sheep and always occurs. Bed pawing must be pure instinct for I have seen sheep paw away the relatively soft and thin litter and duff layers of the pinon type only to lie on hard ground or exposed rocks.

Playing is a small but integral part of the sheep's daily activity, and although jousts occur between older animals, the true playing as we think of it is primarily among lambs and yearlings. Quaint little butting tournaments with undeveloped horns and just prancing little gaits from feeding plant to feeding plant or from rock to rock are seen rather often in cooler weather. The little antic of jumping into the air and what appears to be clicking all four feet together with a tossing of the head is not uncommon among one-, two- and even three-year-old animals. The adults are much more sedate and seem to accept life in all its grim reality.

Drinking is an interesting phase of a sheep's activity. It is quite true that when feed is green or snow- or rain-soaked no live water is required, and when natural pools or puddles are to be found, they are used if further moisture is desired. However, during the critical scalding hot and dry summer months live water is sought, and our tanks - be they conventional stock tanks or cemented rock depressions, clear water or stagnant green water - are used. It is still unknown how far an animal will travel to water, how often and what is the average consumption, but we have hopes of working on some or all of this information at the Desert Game Range in the future. The longest duration of what appeared to be one continuous drink was for 20 minutes. The act of going to a spring is quite deliberate, but once at the spring animals may go directly to the water and use it (or directly into the fenced trap as is the case with three of our springs), or they may merely loiter around the water source, feed a bit, bed down or even just stand and stare around for several hours before using the water. If it is a group of animals, generally one animal will go to the water source or into the trap to drink, and the others will follow. Fights or passes at each other over possession rights at a water hole are quite common. No nursing lambs have ever been observed by a water hole.

During a very hot day last fall I trapped an old ram at our Cow Camp spring trap. He came deliberately to the trap, went in and immediately began drinking. He was trapped immediately, hogtied, blindfolded, measured, branded on the horns, tagged in an ear, hoisted upside down to a scale, mouth pried open for a tooth check and a fecal sample extracted from the other end, and in the final sweep was pushed out of the trap. I felt quite sorry for this poor old devil, who I found out later by tracking came about one and a half miles, almost all of it up hill with very few pauses on a very hot day, to get a drink, and ended up feeling as if he had gone through an army physical examination at a point of embarkation.

Sexual activity with sheep as with all creatures is quite interesting, but it is on this issue that the majestic symbol of wilderness, the ram, loses points with me, for here is the sadistical element of the animal world. It is rather common knowledge of the malicious way a ram or rams will chase and knock down a ewe, paw at her to get up, butt her repeatedly, and have classical slamming bouts among themselves. All this is the preliminary for copulation which occurs in practically seconds. No romantic pursuer of the lady's favor is our ram, but truly the rogue lover of the animal kingdom, and at times the rams will even take turns at mounting the ewe in oestrus.

Sexual impulses have been noted in the rams on the Sheep Mountain range at all times of the year with false mounting occurring not too uncommonly, but the mating season is considered to be from August to the latter part of November. It is during these months that the ram or group of rams seeks out the ewe bands and the individuals in oestrus.

It is rather apparent that the fights or blow matches are not over an objective but are stimulants of the rut. Several reports are to be had of two older rams doing battle royal while a third and generally younger ram does service to the ewe and then the trio leaving together in full brotherly spirit.

Our captive 10-year-old ram at our Corn Creek field station molests and persecutes the captive ewe in the normal manner, but he works off most of his steam by butting repeatedly and profusely at the well-scarred trunk of an almond tree in their pen. It doesn't take too much encouragement from a bystander at any time of the year to encourage the old boy to curl his upper lip, extend his neck, walk briskly to the tree, rear up and pop it a few good blows that sound like gun shots.

As a general rule the rams stay by themselves and the ewes, yearlings and lambs are by themselves with the exception of late summer and fall when mixed groups are seen; but once again there are exceptions for mixed groups, singles or paired sexes have been seen repeatedly at all seasons. The only exception to this is that yearlings and of course lambs are always with the ewes, and at times it is a bit difficult to tell a yearling ram from an adult ewe unless his genital organs are seen.

When a band of sheep are seen, it is generally an old ewe that leads the procession, is the last to lay her head down and close her eyes and the first to see the observer or sense some abnormality.

Butting bouts or just malicious bouts occur between rams, rams and ewes, ewes among themselves and their young, but I have yet to see a ram rough up a lamb or a short yearling. Instead the ram seems to be quite tolerant of them and at times even protective. An example is an incident that I saw during a July water hole count in the Pintwater Range where a belligerant ram literally cleared the first-arrived sheep from the water tank and defied any to disturb him while he drank although several tried and got a sharp blow for their troubles. Then a several-months-old weaned lamb went naively to the tank to drink. The big ram gently caressed the lamb across the back with his horn, and the two drank side by side, the ram still defying other sheep to approach.

Just a few lines on temperament now for phases and variations of temperament are observed daily in the field. I rate the animal on the whole as cautious but curious. Being caught in an open valley or at a lower elevation then a disturbance, say an observer, makes the creature quite nervous as does approaching the animal on a blind stalk of which the animal is aware. I have approached animals under favorable conditions very closely many times by walking slowly towards them and stopping often. Or I have stalked them quite successfully by dismounting my horse near a wash or cut and leaving the horse as a "decoy," and then working back, concealed, in the wash or cut to my desired position. I have also brought curious single sheep up to me by concealing myself in the rocks, peeking over from time to time to be seen, and then retracting very slowly.

I have tried calling sheep, too, for lambs, ewes and rams have very distinct calls at certain times of the year. I have bleated, blatted and made all sorts of adenoidal sounds, but only with the results of an occasional "cocked eyebrow and tilted head."

Contrary to what appears to be a very cooperative attitude in the above circumstances I might add that many observations were made of sheep one-half a mile or farther away and at a higher elevation with the result that they take off at full tilt as soon as the observer came into view.

Odor and noise seem of no consequence to our sheep. Sheep have been observed during the roaring sound of jet aircraft, during thunder storms and during gunfire with apparently no disturbance. However, buzzing helicopters or light planes will panic the animal as would be expected. More times than not when a sheep is shot the remainder of the group will bolt from the falling and thrashing body and not from the gun shot. The band will many times bolt a few hundred yards and continue to feed while the hunter examines and dresses their fallen comrade.

I believe that our bighorn sheep do have an acute sense of smell. However, they do not employ it as one would expect an animal to, which is in a defensive manner, but appear to rely solely on nimbleness and splendid eyesight. During a period last fall I was trapping sheep for our tagging program at one of our springs. A ram came right by my blind about 20 feet away and on the lee side. I had just finished boiling a pot of tea and was smoking a pipe. None of these odors even turned his head; he went to the trap that had odors of sheep blood from slitting an ear to accept a tag on an earlier caught ram and the odor of kerosene that I spilled from our branding iron heater. These odors were also ignored, but near one corner of the outside of the trap where there were tracks made by several ewes very early that morning he lowered his head and neck and sniffed out quite a few of the trails in hound dog fashion.

During the two hunts of 1956 and 1957 on the Desert Game Range I had quite a few hunters ask me, "What are their habits; what's the best way to stalk them?" I summarized it rather quickly for them by mentioning that the sheep are most nervous during windy or overcast days, when in a valley or wash, and if they see you, don't "sneak" but be slow and deliberate, playing on their curiosity. Ignore winds and odor drifts altogether, and if the quarry starts running, it would be very rare for him to stop for a second look back. They are non-conformists in many respects, and very few of them have read the book on proper behavior and etiquette in the face of a hunter.

These are only some of the highlights of the behavior of sheep on the Desert Game Range. Each item and trait could be expounded in great detail, but I believe these general points will serve as an outline and indicate the interesting and unusual behavior of our Ovis canadensis nelsoni.