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by
Jack B. Helvie and Donald D. Smith, DVM
Radiological Research
Western Environmental Research Laboratory

ENVIRONMENTAL PROTECTION AGENCY

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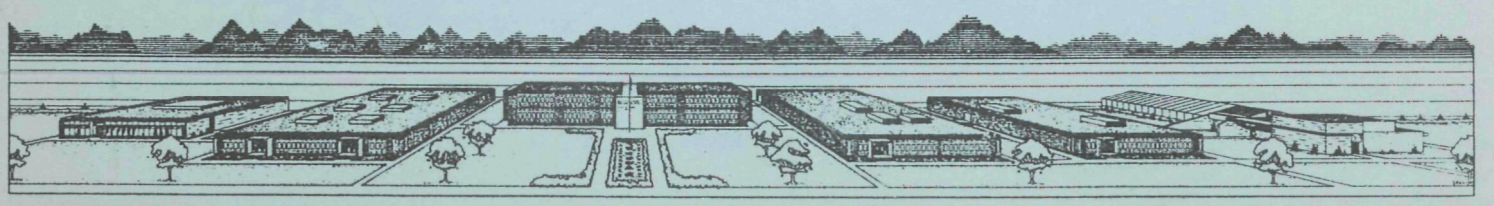

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ABSTRACT

A review of 49 necropsies performed on desert bighorn sheep in the southern Nevada area is presented. The Appendix shows a condensed version of all necropsies listing information on sex, age, diagnoses, and specific pathogens. Incidence of pulmonary pathology was high for all age classes of sheep: young (0-3 years) 78%; prime (4-9 years) 74%; old (10+ years) 92%. The data suggest that lung lesions may be more prevalent in old animals. There was little difference in the occurrence of pulmonary pathology between sexes (females 79%, males 83%). The major cause of death when determined was pneumonia. The data presented will provide reference material for wildlife biologists working with desert bighorn sheep in the wild and in captivity.

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INTRODUCTION

Mortality in bighorn sheep has been a topic of discussion for many years. Some questions concerning the maladies that occur in sheep have been answered, but there are many more yet unanswered. Allen (1960, 1962, 1964) has documented his findings of parasites in bighorn sheep. Johnson (1957) and Engel (1967) have described in detail some of the necropsies performed by them. The first case of scabies (*Psoroptes cervinus* and *P. ovus*) in bighorn sheep from Nevada was described by Cater (1968) and Allred and Bradley (1965, 1966) have commented on necrosis of teeth and skulls.

The purpose of this paper is to summarize the findings of 49 necropsies performed on desert bighorn sheep during the period 1953-1969. Data concerning parasites and tooth and skull necrosis are not discussed because the information available was not complete. The Appendix is included for the purpose of documenting each case in some detail.

Thanks are extended to all of the personnel at Environmental Protection Agency, Las Vegas, who performed the necropsies since 1964 and made this report possible. Necropsies prior to 1964 were performed by an Army veterinarian on temporary assignment to the U. S. Atomic Energy Commission.

This report is the result of a cooperative effort between the Bureau of Sport Fisheries and Wildlife of the U. S. Department of the Interior and the Western Environmental Research Laboratory (WERL) of the Environmental Protection Agency. The WERL participation is a part of the Animal Investigation Program being performed for the U. S. Atomic Energy Commission under Memorandum of Understanding No. SF 54-373.

PROCEDURES

At the Desert National Wildlife Range our policy is to have necropsies performed on as many sheep as possible. It is a rare occurrence when we find a wild sheep carcass that is still fresh enough to be of value. But occasionally we do stumble upon one and rush it in for necropsy. Likewise when a "penned sheep" dies at Corn Creek, every effort is made to learn all we can from it. Most of the sheep from these two sources fall into the "natural death" category. Other sources of information are grouped into categories as follows: hunter kills, trap and capture mortalities, collections, and road kills. Information gleaned from hunter kills is often incomplete because we don't have the entire animal to work with. Most of the animals included in the trap and capture category die as a direct result of injuries or drugs, but the ensuing necropsy often reveals interesting and valuable information relative to "healthy sheep" in the wild. Similarly, road kills provide additional valuable data on the health of the wild population. Very few sheep have been "collected," but data from these are included to complete the picture.

Sources for the sheep included in this report are as follows: Desert National Wildlife Range-39, Nevada Fish and Game Department-six, National Park Service-two, Cabeza Prieta Game Range-one, and Arizona Game and Fish Department-one.

RESULTS

Natural Mortality

Death from natural causes accounted for 17 (35%) of the sheep examined. Serious lung conditions consisting of: pneumonia, adhesions, abscesses, atelectasis, emphysema, edema, bronchitis, hyperemia, and tumors were found in 14 (82%) of these sheep. The actual causes of death as determined by necropsies are as follows: pneumonia - 7, enterotoxemia - 2,

multiple abrasions and fractures - 2, endothelioma which resulted in amyloidosis - 1, multiple abscesses and adhesions - 1, malignant tumor of lung and ovary - 1, and three cases were inconclusive.

The two cases involving enterotoxemia were surprising and interesting. The pathogen that causes enterotoxemia is the bacterium, *Clostridium perfringens*, Type D, and is a natural soil inhabitant. When a dietary change or digestive upset causes intestinal stasis, this bacteria proliferates in the gut and produces a powerful toxin which is absorbed and causes death in a few hours. On June 2, 1968, a two-month-old lamb was found at the southwest end of the Panamint Range in California. When found, the animal was weak and unable to stand. Treatment was provided in California, and on June 8 it was delivered to the Desert National Wildlife Range. The lamb had a good appetite and appeared to be healthy until it died suddenly on June 17. On July 30, 1969, an apparently healthy and vigorous two-year-old penned ram at Corn Creek became sick, and penicillin and streptomycin were administered. The next morning blood was noted in the feces and treatment was provided by a veterinarian. The young ram died a few hours later. We cannot say that there is any connection between these two deaths, but so far as we know these are the only cases of enterotoxemia noted in bighorn sheep in southern Nevada.

Of three other lambs examined, one succumbed to injuries sustained in a fall, and two died of bacterial pneumonia. One of these, a one-month-old wild lamb, was found to have *Pasteurella* pneumonia. The other a 13-day-old penned lamb born at Corn Creek, had *Corynebacterium* pneumonia.

In this group of natural mortalities, the average age at death for females was 5.2 years (excluding two of unknown age), and ages ranged from two months to eleven years. Remarkably, the average age at death for males was also 5.2 years with a range in age of 13 days to eleven years. When lambs are discounted, average age at death was 7.2 years for females and 7.2 years for males. The sample includes seven animals of each sex where age could be accurately estimated by horn rings or tooth development.

Hunter Kills

Sixteen (35%) of the sheep examined were hunter kills. Lung conditions were noted in 12 (75%) of these rams, while no remarkable pathology of any kind was noted in three animals. Microscopic examination of the thyroid of one ram revealed a follicular hypertrophy (goiter). Ages of the rams in this sample ranged from 5 to 13 years with an average of 8.5 years.

Trap and Capture Mortalities

Eleven (22%) of the sheep examined had succumbed as a direct result of trapping or capturing activities. Quite often the diagnosis on the necropsy protocol reads as follows: "Cause of death: shock, fatigue, gross hemorrhage and asphyxiation." Some sheep met their demise suddenly--by falling over a high cliff after an injection of drugs via the "Cap-Chur Gun." Data gathered from this sort of investigation may not appear to be of value upon initial inspection, but we have formed some general conclusions regarding the trapping and capturing of sheep. With drugs that are currently available, successful use of the "Cap-Chur Gun" is quite limited in rough, precipitous terrain. It also occurred to us that some workers tend to handle sheep in much too rough a manner. The examination of several sheep disclosed dislocated joints on the legs and neck and fractured ribs. This supports the idea that captive sheep must be handled very carefully. Carrying or "packing" live sheep more than one-fourth mile from trap site to vehicle should be discouraged. One other observation is that sheep may suffer fatal injuries when they run headlong into the side of a wire mesh trap. The use of nylon netting should be considered in all sheep trapping operations, however, this is recommended only on a trap that is closely attended. On an unattended trap, nylon net may result in as many injuries as with wire mesh.

Nine (82%) of the sheep in this category were found to have lung conditions of one kind or another.

Collections

Only three of the animals examined had been collected purely for biological investigations. A 10-year-old ewe was found near death and was sacrificed by bleeding. The diagnosis revealed that she was about to succumb to an advanced lung condition involving bilateral pneumonia and fibrinous pleuritis. Almost no functional lung tissue was observed. Two other ewes, ages five and eight, were collected in November and December 1957. No remarkable pathology was noted in one, while the lungs of the other contained pneumonic tissue. Both were in the first trimester of pregnancy.

Road Kills

One three-year-old ewe and a yearling ram were killed by cars. The lungs and liver of the ewe contained granulomas. The lungs of the ram showed areas of solidification.

DISCUSSION

The data presented support the general opinion that bighorn sheep in southern Nevada commonly suffer from chronic lung disorders. Eighty percent (39) of all sheep necropsied were found to have lung pathology of varying degrees. Lung lesions were found in 82% of natural mortalities, and in 78% of deaths due to sudden trauma. This is a lower rate of incidence than reported in Arizona sheep by Russo (1956), where he found lung adhesions in all sheep examined. A high percentage of sheep in all age classes exhibited lung lesions of various forms. As shown in Figure 1, the rate of incidence for lung conditions was 78% for young animals (age 0-3 years), 74% for prime animals (age 4-9 years), and 92% for old animals (age 10 years and older). There was little difference in the occurrence of lung disorders between sexes as they were found in 79% of the females and 83% of the males examined. As was expected, the major cause of death when determined was pneumonia. Enterotoxemia was found to be the cause of death in one wild sheep and one penned sheep. This disease may be more prevalent in wild desert bighorn sheep than we had expected. A review of the necropsies indicates that more remains to be

learned relative to immobilizing, trapping, and handling sheep successfully. Abnormalities were often observed in kidneys, liver, heart and other organs, but no conclusions were reached. Further study is needed in this area. A condensed version of necropsies is appended and will serve as a documented reference for biologists working with desert bighorn sheep.

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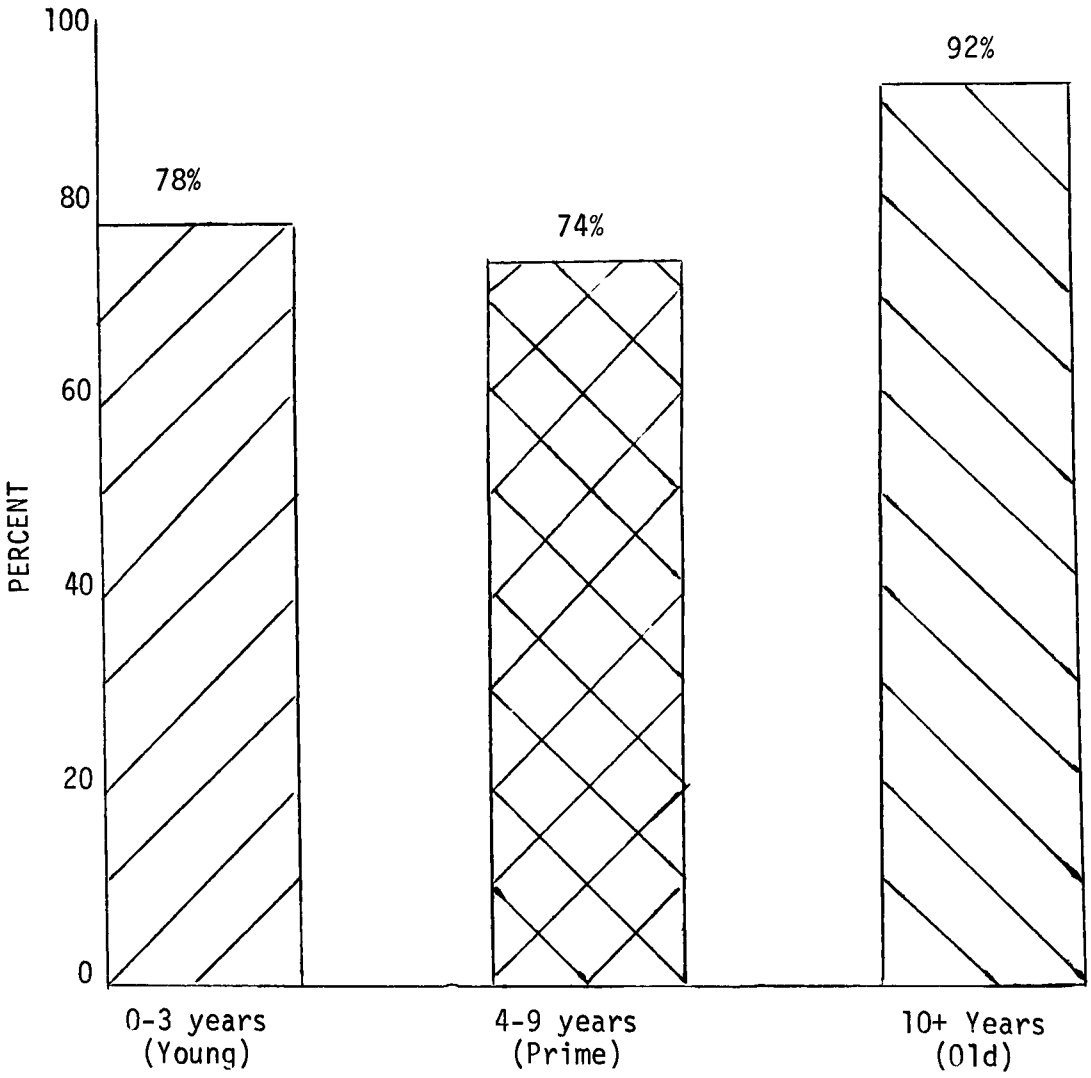

Figure 1. Incidence of lung lesions in three age classes of desert bighorn sheep.

APPENDIX

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
6326	3/53 Natural	Adult	F	Joe May, DNWR*	Malignant ovarian tumor, Adeno carcinoma; malignant lung tumor, Adeno carcinoma.	Heavily infested with lungworms. Protostrongylus stilesi ? Tapeworms, Thysanosoma actinoides.
NH-4	4/53 Hunter kill	Old	M	Muddy Mts.		Acute peribronchitis; sarcocysts in heart; tapeworm liver cyst.
OW-1-56	1/4/56 Natural	7	M	E. Sheep Range, DNWR	Chronic fibrinous pneumonia; lungs adhered to thoracic cage by extensive fibrinous pleuritis.	Myopathy, nutritional (?), panniculus muscle; hemorrhage, adrenal cortex.
OW-10a-56	1/21/56 Natural	7	F	DNWR	Unilateral pneumonia, grossly showing appearance of Corynebacterium pyogenes infection. Left lung completely pneumonic with adhesions involving 1/3 of pericardium. Very tightly adherent-lung to pericardial sac.	Multiple abcesses in lumbar area and pelvic cavity; petechial hemorrhages in kidneys; animal in late period of gestation, one lamb found in uterus.
OW-12-56	5/22/56 Hit by car	3	F	Boulder Beach, Lake Mead, Nevada	Death due to internal injuries as result of being hit by car.	No ectoparasites noted; one tapeworm, Wyominia tetoni, found in bile duct; another Wyominia tetoni found in small intestine; granulomas in lung and liver from undetermined cause

*Desert National Wildlife Range, Las Vegas, Nevada

APPENDIX (CONTINUED)

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
OW-10b-56	7/12/56 Trap injuries	10	M	DNWR	Died as a result of injuries sustained in trap. Considerable hemorrhage surrounding atlanto-axial articulation, and it appeared there had been major dislocation followed by partial healing.	Wt. 142 lbs. One tapeworm found in common bile duct; hemorrhages and adhesions in lungs; abnormal wear of all teeth with mottling suggestive of fluorine toxicity.
OW-10c-56	8/31/56 Natural	6	M	Cow Camp vic., DNWR	One small laceration and few abrasions might indicate fight with another ram.	Two tapeworms in common bile duct; both lungs hyperemic; two small growths in heart.
OW-15-56	11/8/56 Trap injuries	7	F	Corn Creek, DNWR	Died of injuries from trapping and handling--shock, fatigue, gross hemorrhage, asphyxiation. Anesthetised with 10cc Sodium Pentobarbitol i.v.	Wt. 114 lbs; condition good; five large tapeworms in bile ducts; in first trimester of pregnancy.
OW-16-56	11/8/56 Trap injuries	6	F	Corn Creek, DNWR	Died of injuries from trapping and handling--shock, fatigue, gross hemorrhage, asphyxiation.	Wt. 98 lbs; condition good; lungs congested with dark red blood, pleural adhesions.
OW-7-57	7/10/57 Found near death and sacrificed (collected)	10	F	Cow Camp DNWR	About to succumb to advanced lung condition when she sustained violent fall. Bilateral pneumonia, bilateral fibrinous pleuritis; almost no functional lung tissue observed.	Wt. 81 lbs; abnormal dentition; adenitis of salivary gland; interhepatic jaundice; hyperemia of kidney; fracture of mandibular symphysis; luxation of mandibular articulations; bilateral coxofemoral luxation; fecal exam positive for Protostrongylus sp.

APPENDIX (CONTINUED)

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
OW-8-57	7/14/57 Trap Injuries	6 mos	F	Corn Creek, DNWR	Animal suffered trauma from trapping operation. Debilitated condition resulted in bilateral bronchopneumonia which was inciting cause of death.	Wt. 40-50 lbs. est.; general condition good; luxation of atlanto-occipital articulation and coxo-femoral articulations.
OW-2057	11/7/57 Collected	5	F	Joe May Canyon, DNWR	No remarkable pathology.	Wt. 103 lbs; in first trimester of pregnancy.
OW-33-57	12/10/57 Collected	8	F	Joe May Canyon, DNWR		Wt. 112 lbs; in first trimester of pregnancy; nonactive foci of pneumonic tissue in lungs.
OW-18-58	7/11/58 Capture poisoning	7	F	DNWR	Acute nicotine poisoning.	Injected with 600 mgm nicotine salicylate i.m. with "Cap-Chur Gun." Ran 150 yards and died.
23-61	6/10/61 Natural	7	F	DNWR		Wt. 84 lbs; condition fair-poor; abscess at right elbow with tract thru thoracic wall and into right lung; reticulum and abomasum adherent to diaphragm with tracts thru diaphragm connecting to liver; subluxation of left scapula and humerus.
28406	1/25/65 Natural	Unk	Unk	DNWR	Hemangio-endothelioma; hepatic, renal and adrenal amyloidosis.	

APPENDIX (CONTINUED)

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
18-NEV-65	9/26/65 Natural	6	F	McCullough Mt., Nevada	Pyometra; cyst on right kidney; bilateral keratitis corneal ulcer; omental adhesions; ovarian abscesses; peritonitis, fibrinous; serious atrophy of heart.	Poorly nourished and emaciated; left lung dark red and non-air containing, evidence of pneumonia not observed.
19-DGR-65	12/28/65 Hunter kill	5	M	DNWR		Entire inside of left ear covered with dry scale; focal chronic thyroiditis; lung-atelectasis; focal perivascular lymphcytic accumulations.
20-DGR-65	12/28/65 Hunter kill	8	M	DNWR		No remarkable pathology.
21-DGR-65	12/30/65 Hunter kill	6	M	DNWR		Lung--focal hemorrhage and atelectasis; focal chronic pleuritis.
1-N17-66	1/9/66 Hunter kill	12	M	Boulder City, Nevada		Birefringent crystals in colloid follicles of thyroid; atelectasis of lung.
2-N17-66	1/10/66 Hunter kill	6	M	Muddy Mt., Nevada		Focal atelectasis of lung.
3-N17-66	1/16/66 Hunter kill	10	M	Mormon Mt., Nevada		Focal atelectasis of lung.
4-N17-66	1/22/66 Hunter kill	11	M	Nelson, Nevada		No remarkable pathology.

APPENDIX (CONTINUED)

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
8-DGR-66	1/30/66 Hunter kill	7	M	White Rock, DNWR		Lung--focal atelectasis.
1-C53-66	5/28/66 Hit by car	1	M	Joshua Tree Natl. Monument, California	Broken neck; no damage to interal organs noted during collection.	Lung--atelectasis, focal hemorrhage, slight edema. Spleen --acute congestion. Lymph node-- slight edema, poor follicle formation.
9-DGR-66	6/29/66 Natural	10+	F	Basin Spring Canyon, DNWR	Prolonged systemic infection and suppuration.	Wt. 72 lbs. Chronic supperative consolidated pneumonia; marked thickening of pleura. Edema of liver with suppuration and caseation necrosis. Caseation necrosis of spleen. Nearly full-term lamb in uterus.
10-DGR-66	7/20/66 Capture	7	F	Wamp Spring DNWR	Fell over 140 foot cliff after being injected with 96 mg Sernylan via "Cap-Chur Gun."	Wt. 145 lbs. Congestion and alveolar emphysema of lung.
12-DGR-66	7/25/66 Capture	4	M	DNWR	Injected with 186 mg Sernylan via "Cap-Chur Gun." Died 28 hours later.	Wt. 178 lbs. Lungs adhered to thoracic wall and diaphragm, congested; mucosal hemorrhage present in abomasum, entire intestional tract hemorrhagic, wall of duodenum dark red; several tapeworms, Moniezia, present.

APPENDIX (CONTINUED)

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
7-NT7-66	6/29/66 Natural	6 mos	F	6 miles upstream Willow Beach, Arizona	Injured (from fall?), alive when found; died two days later of traumatic shock and compounded insult by diuretics.	Multiple abrasions; fractured left femur; general shock and dehydration; possible CNS damage; temperature 104.5. Note: "...suggest that Diuretics are contra indicated in the desert sheep. If used, reduce dosage markedly."
1-DGR-66	1/16/66 Hunter kill	8	M	DNWR		Thyroid--generalized hypertrophy of follicular epithelium.
2-DGR-66	1/20/66 Hunter kill	13	M	3 miles northwest of Sawmill Canyon, DNWR		Lung--focal hemorrhage and atelectasis; lungs adhered to pleural sac.
3-DGR-66	1/18/66 Hunter kill	7	M	Sawmill Junction, DNWR		Lung--alveolar edema; focal atelectasis.
4-DGR-66	1/18/66 Hunter kill	10	M	Sawmill Junction DNWR		Lung--focal atelectasis; increased thickness of pleura. Striated muscle--Sarcosporidiosis.
5-DGR-66	1/22/66 Hunter kill	8	M	Lamb Spring, DNWR		Lung--atelectasis.
6-DGR-66	1/22/66 Hunter kill	7	M	Arrow Canyon Mts., DNWR		No remarkable pathology.
7-DGR-66	1/27/66 Hunter kill	10	M	DNWR		Lung--focal hemorrhage and atelectasis; focal chronic pleuritis.

APPENDIX (CONTINUED)

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
1-A5-67	4/9/67 Natural	Adult	F	Cabeza Prieta Game Range, Arizona	Animal observed in weakened condition. When capture was attempted, animal fell 20 feet to its death.	Wt. 93 lbs. Multiple abrasions and fractures; Cysticerus sp. cyst floating free in abdominal cavity; caseated necrotic lesions on liver; lungs adhered to parietal pleura and very congested.
10-DGR-67	7/27/67 Trap Injuries	11	F	Wamp Spring, DNWR	Apparently died from neck injuries.	Puncture in body wall, one-two weeks old; focal areas of atelectasis and emphysema in lungs--marked congestion; general pyemia prior to death resulted in numerous abscesses.
11-DGR-67	9/21/67 Capture	10	M	Cabin Spring DNWR	Injected with .36 mg/100 lbs. Succinylcholine chloride via "Cap-Chur Gun." Found dead two hours after injection. ...inferred that neither the drug nor the injury alone would cause the edema."	Wt. 167 lbs. Inguinal hernia with portions of small intestine protruding; all lobes of lung exhibit complete congestion; Adhesions--both diaphragmatic lobes to body wall, both apical lobes to diaphragm, both cardiac lobes to pericardium sac; cyst on liver; liver abscesses like Spherophorous necrophorous.
12-DGR-67	10/24/67 Capture	5	M	Sheep Spring, DNWR	Injected with .349 mg/100 lbs. Succinylcholine chloride via "Cap-Chur Gun." Ran 80 yards, fell over cliff and died. "...feel that the animal died of asphyxiation."	Wt. 167 lbs. Large tapeworm in bile duct; lung--right apical lobe adhered to rib cage, adhesions extend to pericardium; extensive pulmonary edema; petechial hemorrhages in epicardium and endocardium; left kidney congested.

APPENDIX (CONTINUED)

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
13-DGR-67	12/11/67 Natural	5	F	Corn Creek, DNWR		Wt. 70 lbs. est. Bilateral conjunctivitis and keratitis; corneal ulcer of left eye, corneal puncture of right eye; anterior 1/4 of small bowel dark green in color; liver with pale yellowish tinge; lungs--ecchymotic hemorrhages, atelectasis and emphysema, hemorrhage in left ventricle.
15-DGR-68	6/20/68 Capture	1	M	Sheep Spring, DNWR	Undetermined. Injected with M-99 and Aceproma-zine via "Cap-Chur Gun." Died eight hours after injection.	Wt. 95 lbs. Tapeworm in bile duct; petechial hemorrhage on kidneys; lungs--adhesions to pericardial sac and parietal pleura, mild peribronchial infiltrate of lymphocytes; petechial and ecchymotic hemorrhages on heart.
16-DGR-68	6/17/68 Natural	6-7 wks	F	Corn Creek, DNWR	Lamb found Panamint Range, California and transferred to DNWR. Tentative diagnosis: Clostridium perfringens, Type D. Enterotoxemia.	Wt. 20 lbs. Dark red hemorrhage throughout ventral abdominal musculature; kidneys swollen, dark red; right apical lobe of lung contains small, raised, yellowish necrotic areas.
17-DGR-68	12/15/68 Natural	10	M	Corn Creek, DNWR (penned sheep)	Geriatrics. Kidneys--nephritis.	Wt. 140 lbs. est. Kidneys--soft, cortex reduced in size, mild amyloidosis; severe bronchopneumonia with extensive pulmonary edema; animal emaciated.
1-DGR-69	1/10/69 Natural	11	M	Corn Creek, DNWR (penned sheep)	Pneumonia. Kidneys--nephritis.	Wt. 122 lbs. Apical lobes of lungs had fibrous adhesions between surface and thoracic pleura, congested, greenish colored indicating necrosis; renal pelves edematous.

APPENDIX (CONTINUED)

Ident. No.	Date of Death	Age	Sex	Location	Diagnoses or Comments	Miscellaneous Notes
2-DGR-69	3/26/69 Natural	1 mo	M	White Sage Res., DNWR	Bacterial pneumonia, suspect Pasteurella.	Wt. 15 lbs. Lower 1/3 of ileum hyperemic; 85% of lung area involved with pneumonic condition; fibrous adhesions between all lobes of lung and chest.
3-DGR-69	5/15/69 Natural	13 days	M	Corn Creek, DNWR (penned sheep)	Pneumonia, (Laboratory confirmed) organism was Corynebacterium sp.	Wt. 11 lbs. Lungs--adhesions on apical lobes; apical, cardiac and intermediate lobes hepatized with numerous abscesses.
5-DGR-69	7/31/69 Natural	2	M	Corn Creek, DNWR (penned sheep)	Enterotoxemia, Clostridium perfringens (Laboratory confirmed)	Wt. 150 lbs. est. Hemorrhagic areas in abomasum, small upper intestine and large bowel; clotted blood around anal area; smears of intestinal content negative for coccidia.

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76 Leo K. Bustad, University of California, Davis, California
77 Leonard A. Sagan, Palo Alto Medical Clinic, Palo Alto, California
78 Vincent Schultz, Washington State University, Pullman, Washington
79 Arthur Wallace, University of California, Los Angeles, California
80 Wesley E. Niles, University of Nevada, Las Vegas, Nevada
81 Robert C. Pendleton, University of Utah, Salt Lake City, Utah
82 William S. Twenhofel, U. S. Geological Survey, Denver, Colorado
83 Paul R. Fenske, Desert Research Institute, University of Nevada, Reno, Nevada
84 John M. Ward, President, Desert Research Institute, University of Nevada, Reno, Nevada
85 - 86 DTIE, USAEC, Oak Ridge, Tennessee (for public availability)