

Canada
Department of Resources and Development

THE BIGHORN SHEEP
OF BANFF NATIONAL PARK

BY

HUBERT U. GREEN



NATIONAL PARKS AND HISTORIC SITES SERVICE
DEVELOPMENT SERVICES BRANCH
OTTAWA

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Introduction

The study presented in the following pages is an attempt to picture the life history and ecology of the bighorn sheep of Banff National Park, Alberta, Canada, a federal wildlife sanctuary.

The study was first undertaken as a personal project in 1938, and so continued until the autumn of 1943. From the spring of 1944 until the spring of 1949, the work was carried on as a project of the National Parks Service.

It is realized that this record of the work accomplished is little more than an outline, for many subjects discussed suggest the necessity of further field research. Deduction, too, plays a large part in the interpretation of evidence and events.

Since 1944, the carefully recorded data secured by members of the Park Warden Service regarding status, distribution, the occurrence of predators, etc. have been consulted and added to the data derived from personal study and investigation. In this respect, the interest and assistance of K.B. Mitchell, and Wardens U. LaCasse, J.E. Stenton, E.D. Young, A. McKechnie, and J.T.A. Miller are acknowledged and their contributions credited in the text.

All photographs are by the author.

Banff National Park,
Banff, Alberta. Canada.
April, 1949.

Hubert U. Green

PHYSIOGRAPHY

Banff National Park, Alberta, Canada, covers an area of 2,564 square miles lying entirely within the Rocky Mountains east of the Continental Divide.

Elevation above mean sea level varies from 4,362 feet at the southeastern entrance to the park to 11,902 feet at the summit of Mount Forbes.

Including the Continental Divide, six main ranges with a northwest-southeast trend are included in the park. These are transected by valleys down which flow, in an easterly direction, the waters of the North Saskatchewan, Clearwater, Red Deer, and Bow Rivers, all fed by numerous tributary streams.

There is a diversity of climatic conditions in the park area. Towards the western boundary, summer precipitation and snowfall are heavy while in the eastern portion summer precipitation is light and snowfall usually scanty. The latter conditions also prevail in the northern portion.

Three major plant communities are found in the park. These are alpine tundra or meadow, grassland or sub-alpine prairies, and forest; the latter may be sub-divided into foothill or valley forest, subalpine forest and alpine or timberline forest.

In valleys with a light to moderate annual precipitation, especially in those where the winter snowfall is light, white spruce (Picea glauca) and Douglas fir (Pseudotsuga taxifolia) are the dominant species except where, following cutting or fire, they are replaced by the fast growing and more aggressive lodgepole pine (Pinus contorta var. latifolia). Where the precipitation is heavy, Engelmann spruce (Picea Engelmanni) is dominant and finally, near treeline, alpine fir (Abies lasiocarpa) occurs in association with limber pine (Pinus flexilis), whitebark pine (Pinus albicaulis) and, in the southern parts of the park, alpine larch (Larix Lyallii). The valleys of the North Saskatchewan, Clearwater, Red Deer, and Bow Rivers support

scattered stands of aspen poplar (Populus tremuloides) in association with balsam poplar (Populus balsamifera).

There is some true prairie in the main valleys, especially the valley of the Bow. Alpine meadows occur on the western and southern exposures of many ranges as the aftermath of early fires. The open slopes of decomposed rock debris and loess support a variety of vegetation.

In addition to its rivers and streams, the park is well supplied with numerous lakes. Lake Minnewanka, seven miles long and about one mile wide at its greatest width, is the largest of these.

The outstanding feature of the park is the ruggedness of the terrain.

CLASSIFICATION

Class	Mammalia
sub-Class	Eutheria
Order	Artiodactyla
Family	Bovidae
Genus	Ovis

1758. Syst. Nat., ed. 10, Vol. I, p.70. Type, Ovis aries Linnaeus.

1804. Ovis canadensis Shaw.

1885. Ovis montana True.

1891. Ovis canadensis Merriam.

Rocky Mountain Bighorn. Canada Bighorn. Bighorn Sheep. Mountain Sheep.

Type locality: Mountains of Bow River valley, about Exshaw, Alberta, Canada, 15 miles east of the east boundary of Banff National Park, once included in park area.

RACES AND DISTRIBUTION OF BIGHORN OCCURRING IN CANADA

Ovis canadensis canadensis Shaw. Rocky Mountain Bighorn.

"Confined to the Rocky Mountains in which it ranges north to the vicinity of Wapiti Pass some 120 miles south of the Peace river."

(Cowan, 1940).

Ovis canadensis californiana Douglas. Northwestern Bighorn.

"Formerly from Chilcotin river, British Columbia, south through the Cascades of Washington and Oregon and the Sierra Nevada of California to the vicinity of Mount Whitney." (Cowan, 1940). "Still found in small numbers in parts of the Lillooet district, at north end of Okanagan lake, and in Ashnola creek region of lower Similkameen valley in southern British Columbia." (Anderson, 1946).

Ovis dalli dalli (Nelson). White Sheep. Dall's Sheep.

"Mountains of Alaska, Yukon Territory, Northwest Territories, west of the Mackenzie river, south in the main chain of the (Mackenzie Mountains) Rockies to the Nahanni river. In northern British Columbia and central Yukon intergrades broadly with O.d.stonei, but typical dalli is to be found in the St. Elias range in northwestern British Columbia bordering on the boundary of the Alaska panhandle." (Cowan, 1940). "Some specimens from the Nahanni Mountains, N.W.T. have blackish tails and dusky on legs, showing a faint intergradation with O.d.stonei." (Anderson, 1946).

Ovis dalli stonei Allen Stone's Sheep. Black Sheep

"The Omineca and Cassiar districts of British Columbia completely north of latitude 56°30'W. to the summit of the Coast Range and Lake Atlin, east to the Rocky Mountains, south to the Peace river along the slopes bordering the Nebesche river, Ingenika Range, Klappan Range, north in the Cassiar Mountains and adjacent ranges at least as far as the Pelly river but in the northern Cassiar and Pelly Mountains blending into dalli. In so far as can be discovered the range of stonei neither now nor formerly made contact with that of canadensis." (Cowan, 1940).

References

Cowan, I. McT. 1940. Distribution and variation in the native sheep of North America. The American Midland Naturalist, November, 1940.

Anderson, R.M. 1946. Catalogue of Canadian recent mammals, Bulletin No.102, Biological Series No. 31. National Museum of Canada.

PHYSICAL CHARACTERS

Description

Ovis canadensis canadensis is a large sheep, with robust body (especially the male), slender legs, short tail, narrow nose, beardless chin, and somewhat pointed well-haired ears. The pelage is short in late summer, longer in winter and composed of brittle hair, not wool. There are glands between the third and fourth hoofs (metatarsal) and below the eyes (anteorbital). There are four hoofs on each foot, black in color. The color of the iris is yellow to amber. Both sexes carry horns with well-marked brownish transverse ridges from base to tip. The horns of adult males are massive, curving backward from the base, which is immediately above the eyes, then outward, downward and forward in a majestic sweep. The horns of adult females are small and comparatively slender, with an upward and backward sweep, not curled.

Weights and measurements

As no sheep were destroyed and no carcasses were found in the field suitable for weight and measurement data during this study, the figures given by Anthony (1928) are quoted. These, it is believed, represent the average bighorn of the park.

Weights

Adult rams 200-300 lbs.
Adult ewes 125-175 lbs.

Measurements

Adult rams: Total length, 60-70 inches. Tail vertebrae, 5 inches.
Hind foot, 15-16 inches. Height at shoulder, 38-42 inches.

Adult ewes: Total length, 54-60 inches. Tail vertebrae, 4.75-5 inches. Hind foot, 15.5 inches.

Color

There is a seasonal variation in color, and there are variations between individuals at all times.

Late Summer after shedding

Ewes

Upperparts

Blackish-brown to greyish-brown, somewhat darker on throat, neck, and back; outside of legs and lower flanks paler than back; creamy-white rump patch; tail blackish to black, color extending two to three inches beyond base along middle line of back; face usually lighter than body.

Underparts

Belly whitish-yellow; inside of legs and chest whitish-yellow lightly washed with sooty-brown; distinct line of demarcation between color of outside and inside of legs; underside of tail bare; mammae sparsely haired.

Rams

Underparts

Similar to those of ewes but slightly darker.

Upperparts

Similar to those of ewes but somewhat darker.

Lambs

From birth to first shedding the overall color is creamy-white. There is no conspicuous rump patch. The tail is reddish, with an extension of color for about one inch along the middle line of back. After shedding the color is darker and the rump patch is conspicuous.

By mid-winter the color of the upperparts of all sheep has become subdued through bleaching of the hair tips. Rams, however, still remain

darker than ewes. On account of the bleaching of the upperparts the rump patch is less conspicuous than in late summer and early fall. Lambs are darker during the winter months than other sheep.

By spring, the late summer color of the upperparts is almost entirely bleached out and these are now whitish-grey, except about the head, which is darker. Rams, ewes, and lambs of the previous year are much the same color. The rump patch is even less conspicuous than in winter. The color of the tail is now rusty-black. This general coloration persists until shedding occurs.

Shedding

The shedding of winter pelage normally begins about the middle of June. It follows a more or less progressive pattern. Beginning in late May the long winter hair and "underfur" become matted before detachment. Shedding begins in the dorsal region followed by the neck, shoulders, flanks, and rump in more or less orderly sequence, the matted hair falling to the ground in patches. Shedding of the hair on legs and abdomen, which is neither as long nor as dense as that elsewhere on the body, is not noticeable. By the middle of July all sheep, except lambs and old and ill-conditioned animals, are slick-haired. No further shedding occurs; the winter pelage, which becomes apparent in late September, arises from the growth of summer hair, with the addition of newly-grown "underfur". The shedding by lambs of the woolly pelage of infancy in the early fall is followed by the growth of winter hair and "underfur". Old and ill-conditioned sheep may carry their winter pelage until about the middle of August.

Horn growth

Horn growth is evident at birth when soft "buttons" can be felt beneath the skin. By October the horns protrude slightly above the surrounding hair. Horn growth takes place at the base only, and is continued throughout life.

During the growth of the horns transverse ridges and wrinkles are laid down, these being more numerous on the horns of rams than on those of ewes, in accord with the more rapid growth of the former. Growth is accelerated during the summer months and is checked in winter. For this reason, the ridges and wrinkles laid down during successive summers are divided by rings marking the winter checks in growth thus providing an accurate method of ageing.

With age, the horn increases in circumference about the base, becoming massive in rams. After the first three years, the rate of growth gradually diminishes. The characteristic horn growth of rams is usually not evident in the field until the age of about two years, the horns of young rams having much the same appearance as those of mature ewes. There is considerable variation in the length and base circumference of horns at any given age. This is especially noticeable in rams, young rams sometimes carrying a heavier set of horns than older rams on the same range.

Horn measurements

Six pairs of adult ram horns and seven pairs of adult ewe horns, collected from park ranges, were measured and the age determined. Measurements were made of the length from base to tip, following the outside of the curve, and of the base circumference, and are given in inches in Table I.

TABLE I

Rams

<u>Right Horn</u>			<u>Left Horn</u>	
<u>Age</u>	<u>Length</u>	<u>Circumference</u>	<u>Length</u>	<u>Circumference</u>
6	37	14	36	14.2
7	36.5	14.5	37	14
5	36	11	35.5	11.5
4	33.8	12.5	30	11.5
3	28	10.2	26.6	29.3
4	31.6	11.5	32	12

Ewes

5	10	5	10.5	5.4
6	8.5	4.8	8	4.5
4	9	5.2	9.5	5
3	7	4	7.2	4.2
3	7.8	4	7.5	4.2
6	11	5.2	11.2	5.3
4	10	4.3	10.6	4.

Tracks

The tracks of adult bighorn are not difficult to identify in the field. They are larger than the tracks of mule deer and smaller than the tracks of the Rocky Mountain Goat. However, the tracks of the lower age groups of all three species are confusing and difficult to separate with any degree of accuracy. The difference between bighorn and mule deer tracks is photographically illustrated.

Feces

These are usually in the form of pellets but are sometimes compact, largely depending on the moisture content of the forage.

The presence of the bighorn in any given area cannot be definitely proved by the discovery of feces, because the compact droppings and pellets are identical in shape and size with those of the Rocky Mountain goat, as far as can be determined under field conditions.

The fecal pellets of the mule deer are larger than goat or bighorn pellets. Mule deer pellets are very similar to those of young elk.

The photograph of pellets, positively identified, illustrates the variation in shape and size.

Voice

Compared with domestic sheep the bighorn is almost mute. Except for occasional throaty rumblings the ram is silent. The voice of the ewe is like that of a domestic sheep, but deeper in tone. It is heard only when lambs are small, up to the time of weaning. At other times it is the same as the voice of the ram, but less throaty. The voice of the lamb is identical with that of the young of the domestic race, a plaintive ba-a-a-a. It is not often heard after weaning.

Hearing

The sense of hearing is acute. The bighorn is able to detect the crackling of twigs and rolling of small stones from a distance of about half a mile on a calm day or with a favourable wind.

Vision

The eyesight is remarkable. Sheep on summits have been observed watching others fully three-quarters of a mile away, with apparent interest and understanding. On one occasion three rams, standing on a high point in the Vermilion range, were seen to be intently watching the movements of two coyotes which were crossing the ice on the third Vermilion lake. The coyotes were estimated to be more than a mile away from the rams, at which distance they would appear to human eyes as mere moving specks.

GENERAL BEHAVIOUR

Social Aspects

The bighorn is gregarious and occurs in bands of varying sizes, from small groups of 15 or fewer up to large congregations numbering more than one hundred. Bands are loosely associated and may merge wholly or partly with others. On the other hand, large bands may split up into two or more smaller ones, which move away in different directions and remain separated until they merge with others encountered.

Except during the breeding season, mature rams are segregated from bands composed of other age and sex groups. However, they may occur in close association with the latter on the same range, but without mixing or any show of interest. Young rams remain with the ewes until about four years of age. Mature rams run together in numbers varying from two to fifteen, the latter being the highest number observed. Old and senile sheep of both sexes are usually solitary.

Relation to man

The most striking feature of behaviour of the Banff Park bighorn is its lack of fear of man, undoubtedly the result of protection over a period of years. On all park ranges the sheep can be closely approached. They frequent the yards of wardens' cabins and tourist camp grounds seeking food, which may be taken from the hand. Where the range is bordered by roads and highways, sheep pass between moving or parked automobiles without apprehension. The presence of dogs, too, unless they are aggressive or over-curious, is tolerated.

Time of activity

The bighorn is diurnal in activity. Activity begins shortly after daylight. Feeding periods alternate with periods of rest and loafing on open slopes and cliff summits. When the sheep are travelling from one place to another the same leisurely pattern is followed.

Beds

When resting, bighorns utilize a depression or bed in the shale slides or earth slopes. When they remain in one locality for any length of time, there is no evidence to indicate that the same bed is used from night to night. Any comfortable place is selected near where they happen to be at nightfall. Beds are usually in the open near protective cover.

Shelter

During storms of snow and heavy rain, sheep are seldom observed in the open. The tendency at such times is to seek shelter under the lee of cliffs or on the "edge" of timber. On some ranges where caves occur, there is evidence, in the form of fecal pellets, to suggest that the caves are used for shelter.

Feeding

The bighorn, unlike domestic sheep, scatters when grazing, leisurely picking here and there. It does not clip herbage closely, except in the spring, when it utilizes green shoots in preference to carryover. While essentially a grazing ungulate, it occasionally browses the leaves and tender twigs of certain shrubs.

Swimming

Sheep of all ages readily take to water. Stenton reports that sheep, including lambs, regularly swim across the Stewart canyon, Lake Minnewanka, when the water is high, without undue effort or discomfort. The distance is about 30 yards. Ashley states that a number of years ago he watched a band of sheep swim the Bow river below the Sawback range. The distance across the river at the place described would be about 50 yards, mostly deep water.

Climbing

The ease with which boulder-strewn terrain can be negotiated and almost vertical cliffs scaled is remarkable. Footholds little more than an inch in width, separated by vertical distances not much greater than body length, are all that is required for bighorn to reach the summit of rock faces 50 feet or more in height. Except when the distance is short, the route is usually oblique rather than vertical, with zig-zag changes of course being instantly selected should such be necessary. On only one occasion out of numerous observations was a sheep seen to miss its footing and fall. The distance fallen was about 20 feet; the animal was a young ewe. Young lambs are as agile as other sheep.

Fighting

Fighting is common to all age and sex groups, including lambs. Among ewes bouts are of short duration, with little show of aggressiveness, and consist of the bumping of heads from a distance of a few feet, with forelegs slightly raised a moment before contact. Young and old rams fight viciously, backing up for a distance of ten feet and more before clashing heads with forelegs raised high from the ground. Friendly jousts are not unusual in either sex, with pushing rather than clashing of heads, and both contestants kneeling at times. Breeding rams have never been observed in aggressive combat during the rutting season.

Playing

Bighorn, other than lambs and yearlings, are seldom observed at play. The favorite pastime of the young is chasing one another up and down loose shale slides.

BREEDING AND RELATED PHENOMENA

Breeding age

As maturity is reached at two and a half to three years (Spencer, 1943), the first breeding of ewes would occur at about two and a half years of age, the first lamb being born when the ewe is three years old. Judging from sexual behavior, rams are estimated as being sexually mature at three years of age.

Oestrus cycle

The bighorn is monoestrous, experiencing but one breeding cycle each year. Observation indicates that the onset of the rutting season is in mid-November. It reaches its climax in early December, and terminates in mid-December, covering a period of about 30 days. Whether or not more than one heat occurs is not known.

Period of gestation

The lambing period extends from about the end of May until late in June. The period of gestation is therefore about 180 days.

Birth records

The following are records of newborn lambs taken on the Vermilion range, with the estimated age at time of observation.

1939	June 1	One day
1941	June 5	One day
1942	May 31	Newborn
1943	June 2	Two days
1944	June 4	Newborn
1945	June 10	One day
1946	June 18	One day
1947	June 21	Two days
1948	May 30	Newborn

Number of young

All observations indicate that a single young at birth is the general rule. Definite evidence of twinning was observed on only two occasions, once in 1944 and once in 1948. Due to the loose association between ewes and lambs, the extent of twinning is difficult to determine accurately and may be much higher than indicated.

Period of lactation

Lambs are weaned when about 14 weeks old. None were observed nursing later than early October.

Reference

Spencer, C.C. 1943. Notes on the life history of the Rocky Mountain bighorn sheep in the Tarryall Mountains of Colorado. Jour. Mamm. 24(1): 1-11.

ENVIRONMENT

The environment requirements of the bighorn of Banff Park at all seasons of the year consist of open and semi-open mountain slope and alpine meadowland, irrespective of altitude. Localities with westerly or southerly exposure, where the vegetative cover is of greater density and variety and which experience longer hours of sunshine, are preferred. Sheep are seldom observed on terrain with a northern exposure unless travelling, or on terrain with easterly exposures unless the directional trend is well to the southeast. There appears to be no seasonal environment preference because, as a general rule, the ranges which are utilized during the summer, are swept almost bare of snow during the winter months by the prevailing westerly and southwesterly winds.

The nearness of escape cover such as rock slides, cliffs, and steep ledges, especially on or about grazing areas, appears to be a consideration where frequented terrain is more or less closely confined or enclosed by

forest growth. Where alpine meadowland of large extent is utilized, the presence of escape cover is apparently not a factor in choice of grazing areas, owing, no doubt, to unobscured vision of the surroundings which permits the detection of approaching enemies and decreases the hazard of surprise.

The presence or nearness of water is not a requirement, and water does not usually occur in the immediate vicinity of favoured range.

Bottom land, consisting of the floors of valleys at a distance from high country, is not utilized for grazing, although sources of water supply or mineral licks in such localities may be regularly visited.

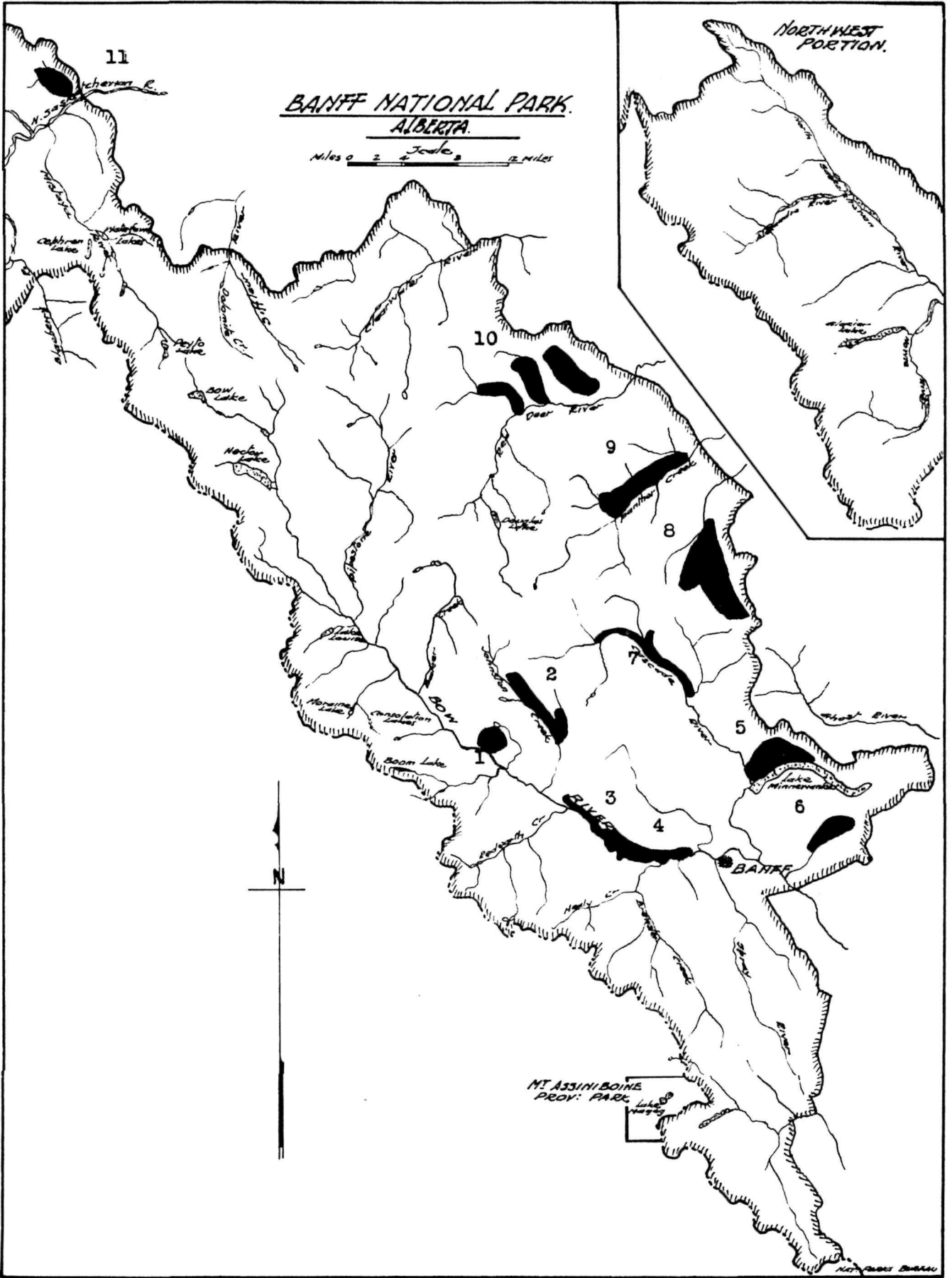
DISTRIBUTION

The bighorn does not occur in Banff Park west of the Bow, and Mistaya and North Saskatchewan Rivers, nor has its occurrence been noted in recent years south of the Bow River.

Within the remainder of the Park sheep occur in the following localities, which are outlined and numerically identified on the accompanying map:

- | | |
|------------------|------------------|
| 1. Eisenhower | 6. Carrot Creek |
| 2. Johnson Creek | 7. Palliser |
| 3. Sawback | 8. Dormer |
| 4. Vermilion | 9. Bare Mountain |
| 5. Aylmer | 10. Red Deer |
| 11. Mount Wilson | |

The Palliser includes the upper Cascade River valley to Flint's park; Bare Mountain includes the Panther River and Snow Creek; and Red Deer includes Tyrell, McConnell, and Divide Creeks.



DESCRIPTION OF RANGES

(Elevations are above mean sea level)

<u>Eisenhower</u>	Altitude approx. 7,000'. Well-grassed open mountain slope. Area, about two miles by half a mile.
<u>Johnson Creek</u>	Altitude approx. 6,000'. Open and semi-open alpine grassland. Area, about 3 miles by half to three-quarters of a mile.
<u>Sawback</u>	Altitude approx. 5,000'. Open, widely-separated narrow grassy ridges, with some alpine meadowland. Area undetermined.
<u>Vermilion</u>	Altitude approx. 5,000'. Separated small alpine meadows and semi-open mountain slope. Area, about 6 miles by one-quarter to half a mile.
<u>Aylmer</u>	Altitude approx. 6,500'. Open mountain slopes and alpine meadowland. Area undetermined but extensive.
<u>Carrot Creek</u>	Altitude approx. 5,000'. Open mountain slopes and alpine meadowland. Area undetermined but not extensive.
<u>Palliser</u>	Altitude approx. 7,500'. Open alpine meadowland. Area, about 10 miles by 1 mile. Range includes upper Cascade valley of lower elevation.
<u>Dormer</u>	Altitude approx. 7,000'. Open and semi-open mountain slope, with much rugged country. Area undetermined but extensive.
<u>Bare Mountain</u>	Altitude approx. 7,000'. Open and semi-open mountain slope, with alpine meadowland of limited extent. Area undetermined but extensive. Range includes Bare Mountain, Panther River and Snow Creek.
<u>Red Deer</u>	Altitude approx. 7,000'. Open and semi-open mountain slopes and alpine meadowland. Area undetermined but extensive. Range includes Tyrell, Divide, and McConnell creeks.
<u>Mount Wilson</u>	Altitude approx. 7,000'. Open mountain slope. Area about 4 miles by one-half to three-quarters of a mile.

MOVEMENTS

The bighorn of the ranges considered is not confined to any one area of occurrence. Observation indicates that bands of varying numbers are constantly on the move, seldom remaining in one locality for more than a few days. Well-travelled sheep trails connect all the ranges described, with the exception of Mount Wilson. The use of these trails may extend well into the winter or until deep snowfall on the intervening passes prevents free movement between the ranges. There are, therefore, no well defined seasonal movements to and from winter and summer ranges, as generally understood. The distance between ranges reaches a maximum of some 22 miles, with a minimum of from 5 to 10 miles, as closely as can be estimated.

There is much evidence to support the belief that sheep from as far east as Exshaw, 12 miles east of the park boundary, utilize the Carrot Creek and Aylmer ranges, following the continuous bench on the north side of the valley of the Bow from Exshaw to Carrot Creek, with a reverse movement in the opposite direction. It is also believed that the sheep of Mount Wilson come from a range outside the park.

In order to obtain specific data of local movements, 15 sheep were marked with numbered metal ear tags during the summer of 1948, 11 at Lake Minnewanka on the Aylmer range by Stenton, and 4 at Banff by the author. The result of this small experimental undertaking was encouraging. It will be extended in 1949, using colored plastic tags, with a different color assigned to each of several tagging stations at widely separated points.

Of the 11 sheep tagged at Minnewanka, seven were later observed on the Vermilion and Sawback ranges, the numbers on the tags being readable as the sheep were gentle. Of the four sheep tagged at Banff, one was later observed on the Sawback range; the number on the tag could not be read, but the sheep was otherwise identifiable. The details follow:

<u>Date Tagged.</u>	<u>Where Tagged</u>	<u>Later Observed</u>	<u>Date</u>
June 18	Lake Minnewanka	Vermilion range	July 6
June 19	"	"	July 5
Aug. 4	"	Sawback range	Sept. 6
Aug. 5	"	"	Sept. 6
Aug. 5	"	Vermilion range	Oct. 1
Aug. 16	"	"	Oct. 1
Aug. 24	"	Sawback range	Sept. 5
Sept. 8	Banff	"	Nov. 17

As there is no direct route used by sheep between Lake Minnewanka and the Vermilion and Sawback ranges, the route taken was probably via the south end of the Palliser range and the valley on the west side of Cascade Mountain, a distance of approximately 18 miles to the Vermilion and 22 miles to the Sawback at the points of observation. The sheep tagged at Banff had travelled approximately five miles.

Tagging operations on a more extensive scale are necessary for the management of park sheep, in order to learn the full extent of their movements and aid in the determination of population values, now difficult to appraise (See status).

FAUNAL ASSOCIATION

From 1944 to 1948 the faunal association of the Vermilion range between the 4,500' contour, the lowest elevation, and the 5,000' contour, where bighorn habitually occur, was studied. The work resulted in the observations listed. The occurrence of small mammals--shrews, mice, and voles--was determined by trapping. Species marked with an asterisk occurred as transients.

Mammals

<u>Sorex cinereus cinereus</u>	Common shrew
<u>Euarctos americanus americanus</u>	Black bear
<u>Ursus sp. x</u>	Grizzly bear
<u>Mustela erminea</u>	Weasel
<u>Taxidea taxus taxus x</u>	American badger
<u>Canis latrans lestes</u>	Mountain coyote
<u>Canis lupus</u>	Wolf
<u>Felis concolor missoulensis</u>	Rocky Mountain cougar
<u>Citellus lateralis tescorum</u>	Hollister's mantled ground squirrel
<u>Citellus columbianus columbianus</u>	Columbia ground squirrel
<u>Eutamias amoenus luteiventris</u>	Buff-bellied chipmunk
<u>Tamias ciurus hudsonicus columbiensis</u>	British Columbia red squirrel
<u>Glaucomys sabrinus</u>	Flying squirrel
<u>Peromyscus maniculatus</u>	White-footed mouse
<u>Neotoma cinerea drummondi</u>	Drummond's bushy- tailed wood rat
<u>Clethrionomys gapperi</u>	Red-backed mouse
<u>Microtus pennsylvanicus drummondi</u>	Drummond's meadow mouse
<u>Microtus longicaudus vellerosus</u>	Northern long-tailed meadow mouse
<u>Erethizon dorsatum bruneri x</u>	Yellow-haired porcupine
<u>Alces americana americana</u>	Eastern moose
<u>Cervus canadensis nelsoni</u>	Rocky Mountain elk
<u>Odocoileus hemionus hemionus</u>	Rocky Mountain mule deer
<u>Ovis canadensis canadensis</u>	Rocky Mountain bighorn
<u>Oreamnos americanus columbiae</u>	Rocky Mountain Goat

Birds

<u>Buteo borealis</u>	Red-tailed hawk
<u>Aquila chrysaetos</u>	Golden eagle
<u>Falco sparverius</u> x	American sparrow hawk
<u>Canachites franklini</u>	Franklin's grouse
<u>Stellula calliope</u>	Calliope humming-bird
<u>Colaptes cafer</u>	Red-shafted flicker
<u>Coephlloeus pileatus</u>	Pileated woodpecker
<u>Dryobates villosus</u>	Hairy woodpecker
<u>Riparia riparia</u>	Bank swallow
<u>Perisoreus canadensis</u>	Canada jay
<u>Pica pica</u>	Magpie
<u>Corvus corax</u> x	Raven
<u>Corvus brachyrhynchos</u>	American Crow
<u>Penthestes atricapillus</u>	Black-capped chickadee
<u>Penthestes gambeli</u>	Gambel's chickadee
<u>Sialia currucoides</u>	Arctic bluebird
<u>Bombycilla garrula</u>	Bohemian waxwing
<u>Euphagus cyanocephalus</u>	Brewer's blackbird
<u>Piranga ludoviciana</u>	Western tanager
<u>Leucosticte tephrocotis</u> x	Common rosy finch
<u>Spinus pinus</u>	Pine siskin
<u>Loxia leucoptera</u>	White-winged cross-bill

FLORAL ASSOCIATION

During 1946 and 1947 a study was made of the floral association of the Vermilion range between the 4,500' contour, the lowest elevation, and the 5,000' contour. Grasses, sedges, and forbs were collected in two representa-

tive plots of about 4 acres each at the central and east end of the range, in localities utilized by sheep. The trees and shrubs listed occur here and there over the entire range.

Grasses

<u>Agropyron trachycaulum</u>	Wheat grass
<u>Agropyron dasystachyum</u>	Northern wheat grass
<u>Agropyron repens</u>	Couch grass
<u>Bromus Dudleyi</u>	Brome grass
<u>Calamagrostis canadensis</u>	Bluejoint
<u>Calamagrostis montanensis</u>	Plains reed grass
<u>Elymus innovatus</u>	Hairy wild rye
<u>Elymus glaucus</u>	Smooth wild rye
<u>Festuca ovina</u>	Sheep's fescue
<u>Festuca saximontana</u>	Fescue
<u>Koeleria cristata</u>	June grass
<u>Poa sp.</u>	Bluegrass
<u>Poa glauca</u>	Bluegrass
<u>Poa pratensis</u>	Kentucky blue grass
<u>Stipa viridula</u>	Speargrass

Sedges

<u>Carex scirpiformis</u>	Sedge
<u>Carex rostrata</u>	Sedge

Herbaceous plants

<u>Achillea Millefolium</u>	Yarrow
<u>Allium cernuum</u>	Garlic
<u>Anemone multifida</u>	Windflower
<u>Anemone occidentalis</u>	Chalice cup
<u>Arctostaphylos Uva-ursi</u>	Bearberry

Arenaria lateriflora

Astragalus alpinus

Castilleja purpurascens

Epilobium angustifolium

Equisetum arvense

Erigeron sp.

Fragaria glauca

Oxytropis splendens

Oxytropis retrorsa

Senecio pseudo-aureus

Sisyrinchium sp.

Taraxacum officinale

Sandwort

Alpine milk vetch

Indian paintbrush

Willow herb

Field horsetail

Fleabane

Strawberry

Oxytropis

Oxytropis

Groundsel

Blue-eyed grass

Dandelion

Trees

Picea glauca

Pinus contorta

Juniperus scopulorum

Pseudotsuga taxifolia

Populus tacamahacca

Populus tremuloides

White spruce

Lodgepole pine

Rocky Mtn. juniper

Douglas fir

Balsam poplar

Aspen poplar

Shrubs

Elaeagnus argentea

Juniperus communis

Ribes sp.

Rosa Woodsii

Salix sp. (1)

Salix sp. (2)

Salix sp. (3)

Symphoricarpos sp.

Silverberry

Juniper

Gooseberry

Rose

Willow

Willow

Willow

Wolfberry

The floral pattern of the Vermilion range is not indicative of all highhorn ranges. Higher altitudes and varying soil conditions, while supporting some of the plants listed, exhibit a different overall association.

MINERAL LICKS

Mineral licks utilized by sheep are known to occur only at Mount McConnell, Red Deer range; Panther River, Bare Mountain range; Dormer Pass, Dormer range, and at the third Vermilion Lake and vicinity, Vermilion range.

One of the most utilized licks is on the north shore of the third Vermilion Lake, Vermilion range. This lick is frequented by sheep from a number of park ranges, and visits are a daily occurrence from early spring until late fall. Bands usually remain for a day or two in the vicinity, spending a number of hours each day taking "salt", and then depart elsewhere, with the probability of several return visits before the open season ends. The fact that visiting bands were not the same sheep was obvious from their varying numbers and different composition from time to time, and from their reaction to human presence, which varied from extreme tameness to extreme timidity.

The avidity with which the mineral soil was licked, and sometimes eaten, indicates a nutritional requirement undoubtedly lacking on neighbouring ranges. It was early determined that the soil about the lick at the third Vermilion Lake, known as the "big lick", was alkaline with a pH of 8. On several occasions salt, Sodium chloride, was placed about the lick to learn if it was preferred to the content of the soil. The salt was sparingly utilized, and often entirely neglected.

In 1948, a sample of the soil from the lick at the third Vermilion Lake was forwarded to Ottawa for qualitative and quantitative analysis. The sample was analysed by C. H. Robinson, Dominion Agricultural Chemist, Division of Chemistry, Department of Agriculture. The following data were obtained:

pH.....	8.3
Insoluble in acid.....	38.45
Oxides of iron and aluminum.....	4.74
(Fe ₂ O ₃ & Al ₂ O ₃)	
Calcium carbonate (CaCO ₃).....	40.98
Magnesium carbonate	3.01
Nitrogen.....	0.22

Water Extract

Calcium as CaO.....	0.05%
Magnesium as MgO.....	0.01%
Sulphates.....	trace
Chlorides.....	nil
Sodium.....	nil
Total phosphorus.....	0.29%
" cobalt.....	5.5 p.p.m.
" copper.....	8.3 "
" zinc.....	24.5 "
" manganese.....	317.0 "

Considering the data supplied, calcium carbonate appears to be the salt desired, with phosphorus (P₂O₅) and iron (Fe₂O₃) supplying further inorganic material of physiological value.

Population

The highest annual spot census counts taken on park ranges are tabled herewith:

TABLE II

<u>Range.</u>	<u>1942.</u>	<u>1943.</u>	<u>1944.</u>	<u>1945.</u>	<u>1946.</u>	<u>1947.</u>	<u>1948.</u>
<u>Eisenhower</u>	--	13	15	--	18	10	25
<u>Sawback- Vermilion</u>	147	105	74	87	85	61	78
<u>Johnson Cr.</u>	--	--	--	10	13	23	28
<u>Aylmer</u>	--	21	15	25	37	17	47
<u>Carrot Cr.</u>	--	60	--	--	--	--	11
<u>Palliser</u>	--	--	32	40	17	37	43
<u>Dormer</u>	--	--	--	41	18	13	32
<u>Bare Mtn.</u>	--	--	--	25	10	12	47
<u>Red Deer</u>	--	--	--	--	--	38	34
<u>Mt. Wilson</u>			38	36	--	--	15
Total:			<u>174</u>	<u>264</u>	<u>198</u>	<u>211</u>	<u>360</u>

Owing to the wide range of the bighorn of Banff park, the ruggedness of the terrain utilized, and the utilization of several often widely-separated localities by the same bands, the data derived are difficult to interpret. On the Sawback-Vermilion ranges, however, the highest count was the result of a large number of tallies taken from spring until autumn. The other counts, therefore, were subject to probable duplication, resulting from the tallying of bands in one location at one time and of the same bands, or parts of them, elsewhere at a later date.

Accurate interpretation is further complicated by occasions when no sheep were observed in frequented localities on account of the nature of the terrain, yet without doubt sheep were present but out of sight. No systematic census was undertaken before 1944, except on the Sawback-Vermilion range. For this reason the absence of records does not necessarily mean the absence of sheep.

The population trend has been generally downward in recent years. Some 20 years ago, it is said on reliable authority, bands of sheep numbering from 300 to 400 head were observed from year to year on the Sawback-Vermilion range; the highest count from 1942 to 1948 was 147, the number progressively declining since 1942. Stenton states that in company with James Simpson of Banff he counted between 600 and 700 sheep on the Palliser range in the summer of 1927 or 1928; the highest count from 1942 to 1948 on the Palliser was 43. Other reports of guides and outfitters who travel the park similarly indicate that the sheep population was substantially larger in the 1920's than it is today.

According to old park files of unknown authority, 100 sheep were counted south of the Bow River in 1914, presumably on the Goat Range, which is now taken over by elk. There are now no known sheep south of the Bow. In the same year 550 sheep were counted north of the Bow,

between the river and what is now the north park boundary. It is believed that the terrain covered by this count would include the same ranges at present considered.

COMPOSITION

Age and sex composition is derived from the aggregate of sheep tallied from April to September, 1944-48. The counts were made at the "Big lick" on the Vermilion range at the north shore of the third Vermilion Lake. As before explained this lick is visited by sheep from several park ranges, providing an unusual opportunity for determining composition from an aggregate sample which includes sheep from widely scattered bands. It is realized that possibly the aggregate method of sampling is not the best. On the other hand, the small bands in which sheep now occur are numerically insufficient for accurate sampling, too irregularly observed, and often seen at too great a distance to separate with any degree of accuracy.

In Table III below, as elsewhere in this paper, young sheep are considered to be "lambs" up to December 31 of the year of their birth; during the next calendar year they are called "yearlings", and during the following calendar year "two-year-olds".

Critical separation of the lower age groups was possible owing to opportunities of close approach. The separation of two-year-olds may be criticized. Nevertheless, the accurate ageing of this group, with a small margin of error, is not difficult following intimate association with the bighorn over a number of years.

Composition as indicated by the method employed shows what is considered a normal balance between sex and age groups, with almost persistent stability for a period of five years.

TABLE III
COMPOSITION OF AGGREGATE COUNT

<u>No. of counts</u>	<u>Male Over 2 yrs.</u>	<u>Female Over 2 yrs.</u>	<u>M & F 2 yrs.</u>	<u>M & F 1 yr.</u>	<u>Lambs</u>
		<u>1944</u>			
29	62 13.9%	258 58.1%	20 4.5%	28 6.3%	76 17.3%
		<u>1945</u>			
35	72 15.9%	243 54.8%	26 5.8%	33 7.4%	71 15.9%
		<u>1946</u>			
35	70 12.9%	288 53.3%	29 5.3%	64 11.8%	89 16.6%
		<u>1947</u>			
35	94 16.4%	353 61.8%	21 3.6%	25 4.3%	78 13.6%
		<u>1948</u>			
49	95 16.1%	357 60.8%	18 3.0%	20 3.4%	97 16.5%

MORTALITY

Twenty-three carcasses of sheep or their skeletal remains were discovered on the Vermilion range:

- 4 adult males
- 13 adult females
- 4 yearlings of undetermined sex
- and
- 2 lambs of undetermined sex

Of the four adult male remains, two skulls showed the lesions of actinomycosis, and one animal was killed by a cougar.

Of the 13 adult female remains the lesions of actinomycosis were evident in two skulls, and one animal was killed by a cougar.

The remains of one adult male and one adult female which had been infected by actinomycosis were found in rough, rocky terrain undisturbed. For this reason there was no doubt that death was due to malnutrition and starvation.

The cause of death of the remaining sheep (one adult male, 11 adult females, four yearlings, and two lambs) could not be determined.

Unless the remains found in the field are fresh, determination of the cause of death is generally difficult. Whether death results from predation or from other causes, carcasses on the range are, for the most part, quickly devoured as carrion or otherwise and the skeletal remains pulled apart and carried away.

No ranges other than the Vermilion were systematically worked for sheep remains. However, those discovered indicate the probability of similar losses on other park ranges.

The mortality incurred by lambs and yearlings from all decimating factors during the first two years of life is indicated by the composition percentages given in Table III above, and repeated here:

TABLE IV

<u>Year</u>	<u>Lambs</u>	<u>Yearlings</u>	<u>Two year olds</u>
1944	17.3%		
1945	15.0%	7.4%	
1946	16.6%	11.8%	5.3%
1947	13.6%	4.3%	3.6%
1948		3.4%	3.9%

A high mortality rate among the animals up to the age of two years is indicated. The rate is undoubtedly higher than the normal annual mortality of the older groups.

COMPETITION

All known areas of alpine meadowland in Banff National Park frequented by the bighorn, with the exception of Mount Wilson, are utilized by elk either seasonally or throughout the year. Because of this, range competition is a serious factor in the welfare of the bighorn.

The elk was not a permanent resident of Banff National Park before 1917. During the open months of the year small numbers may have drifted into the east-west valleys of the Bow, Red Deer, and Clearwater from the foothill country, where elk were abundant as late as 1880. Artificial stocking of the park with elk took place in 1917 and 1920, when 251 head, acquired from the Yellowstone National Park herd, were released in the lower Bow valley near Banff. Rigidly protected and largely immune from predation for a number of years, the released animals quickly adapted themselves to their new environment and multiplied to such a degree that by 1943 they had infiltrated into all good grazing areas irrespective of altitude. In 1943, the estimated elk population of the park, as determined by spot and strip census counts, was between 3,500 and 4,000 head. From 1943 to 1948 some 1,200 head were destroyed by rifle fire to relieve range pressure, and the meat and hides salvaged for use of the Department of Indian Affairs. This reduction has modified the pressure on some winter and summer sheep ranges north of the Bow. Excessive range utilization by elk still occurs on many bighorn ranges. This combined utilization may be beyond the carrying capacity of the ranges.

The degree of competition depends upon the number of elk involved in relation to range area and vegetative density. The Palliser range and its westward extension winter between 300 and 350 elk, with a summer population of about 250 head, determined by count. This range has reached the point of elk saturation and can no longer be considered suitable sheep range. The Eisenhower, Johnson creek, Sawback, and Vermilion ranges winter an estimated 250 to 300 elk all told, with a summer population of about 50 head. Compared with the Palliser range, the grazing area of these ranges is small and overall pressure is greater. Carrot Creek winters a large number of elk, to the detriment of summer sheep range. The Aylmer range

supports few elk during the winter months, but summer pressure is high. The Dormer, Bare Mountain and Red Deer ranges are, for the most part, utilized by elk during the summer. The elk pressure on all ranges, especially those of limited extent, has had the effect of confining sheep to range edges where forage is inferior, or driving them to less favourable localities nearby where elk do not occur. Some of the sheep which normally wintered on the Johnson Creek range now utilize inferior country between this range and the Sawback. A part of the Vermilion where sheep once wintered has likewise been abandoned under elk pressure for inferior country a few miles away. On the Palliser, sheep occur on both fringes of the terrain grazed by elk and are seldom observed between.

Elk pressure, it is believed, has had the further effect of breaking sheep up into small bands because ranges where they co-exist with elk cannot support the large numbers earlier evident on park ranges before increase of elk.

Another environmental factor derived from competition is the apparent intolerance of the bighorn to the presence of elk. This intolerance could largely, although not entirely, explain the utilization by sheep of the fringes of ranges where elk are found. Only on rare occasions have sheep been observed to mingle with elk. This may be due to the fouling of the range by elk, a condition apparently objectionable to sheep.

More range research than has heretofore been possible is necessary in order to present a complete picture of the potential of park sheep ranges. Moreover, fuller knowledge of the psychology of elk-sheep relationship is required for a better understanding of the situation. It is difficult, however, to escape the conclusion that the introduction of the elk to a region of which it was not previously a winter resident is a major factor responsible for the decline of the bighorn. The area of the park,

although vast, includes comparatively little terrain suitable for the support of herbivorous mammals during the winter months; and when two species of very similar food habits compete for limited range it is often noted that the larger and more abundant form will displace the smaller and less numerous. For this reason the welfare of the bighorn in the near future depends on elk management.

In this connection it may be stated that an elk reduction slaughter was undertaken on the Palliser range during the winter of 1948-49. Reduction will be continued annually until the number of elk frequenting the area is appreciably reduced, and further reductions elsewhere are expected to relieve range pressure; thus benefiting the sheep.

However, from a long term point of view, elk reduction alone cannot ensure the welfare of park bighorn. Some of the sheep-grazing areas of the park are essentially fire-made alpine meadowland. These areas are gradually reverting to forest in the natural order of events. In the primitive past, forest fires of natural origin would create new meadowland to replace areas taken over by forest. Fire protection and control, as practised, stressing the aesthetic value of park forests rather than considering the beneficial result of their natural destruction and replacement in orderly ecological sequence, prevents this phenomenon. The ultimate result, 100 years hence, may well be the virtual absence of range necessary for the support of the bighorn and other grazing mammals.

PREDATORS

Two known predators of sheep occur on or about the bighorn ranges of the park, the cougar (Felis concolor) and the wolf (Canis lupus), with the possibility that the grizzly bear (Ursus sp.), the golden eagle (Aquila chrysaetos); the coyote (Canis latrans) and the lynx (Lynx canadensis) may be involved.

Abundance

Cougar

The abundance or otherwise of the cougar is difficult to determine on account of the wide range of the species, (which may cover a route of 40 miles), and its habits of usually travelling alone and of passing through a locality without remaining in it for any length of time. For this reason it may occur in relative abundance and yet seldom be seen. In recent years, however, it has been more in evidence in the park for the reason, no doubt, that control measures have been dropped. During the study, 10 cougar observations were made on the Vermilion range, each involving a single animal; some of these might in fact have been separate observations of the same cougar. A female and 2 kittens were observed near the Aylmer range (Stenton, 1946), the tracks of 2 adults near the Eisenhower range (LaCasse, 1947), and the tracks of 1 adult near the Johnson Creek range (LaCasse, 1946). However, these observations denote only that the cougar frequents the localities where its presence was observed.

Wolf

After absence of about 30 years a wolf was observed at the west end of the Vermilion range (Woodworth, 1945). Since 1945, wolves have been observed in varying numbers about the Eisenhower, Johnson Creek, Vermilion, Palliser, and Aylmer ranges. The highest counts made in single observations about these ranges during the winters of 1946-47 and 1947-48 were: Johnson Creek, five (LaCasse); Eisenhower, one (LaCasse); Vermilion, 10 (LaCasse and Green); Palliser, seven (Young); and Aylmer, two (Stenton). The total suggests the existence of 25 wolves in and about the ranges mentioned. However, there may be fewer on account of the wide-ranging habits of the wolf which, in the park, are facilitated by the use of roads, especially

during the winter months. For this reason, the Johnson Creek and Vermilion counts probably involve the same animals. Thus the minimum number about these ranges may have been 10 during the period 1946-48. Similarly the Aylmer count might well be included in the Palliser tally, reducing the park minimum to 18.

Coyote

The coyote occurs on or about all Bighorn ranges. Observation suggests that it does not travel as far afield as the wolf, usually ranging over a comparatively small area occupied by a family group. The number frequenting a given area is difficult to determine, for a coyote, or coyotes, observed in one locality may well be the same seen a mile or more distant an hour later. Determination of numbers from tracks in snow is also confusing because one coyote investigating here and there and moving to and fro often leaves tracks suggesting that more than one is about. On the basis of observations, however, this predator could not be considered scarce in Banff National Park.

Lynx

Occasional observations of the lynx, or lynx tracks, were made about the Vermilion and Palliser ranges (LaCasse-Stenton-Young 1945-1948), but on account of the virtual absence of the varying hare (Lepus americanus) throughout the park during the study period, the lynx is believed to be scarce.

Grizzly bear

The grizzly bear is known to occur habitually about the Palliser range. One or two frequent this area at all times. Two observations were made on the Vermilion range (1945 and 1946), both of a single animal; and one observation was made from tracks below the Sawback range (LaCasse, 1948).

Golden eagle

The scarcity of the golden eagle in the park, apart from other considerations, precludes the possibility of its preying upon bighorn lambs to any appreciable extent. In any case, predation could occur only during early infancy of the lambs when they are of such weight that they can be carried away. Two pairs of golden eagles are known to nest from year to year, one on the Eisenhower range and one on the Vermilion range. The inaccessibility of their nesting sites prevented investigation of their food habits. On the Vermilion range eagles were observed soaring without apparent interest above bands of sheep containing young lambs; the sheep did not show any signs of alarm.

PREDATOR BEHAVIOR

Cougar

On June 30, 1939, a cougar was observed on the Vermilion range in pursuit of five ewes and three lambs, the lambs being in the lead. The distance of the ewes from the cougar when first seen was about 20 yards. The terrain was rugged, and the cougar was running in bounding leaps. The lambs, closely followed by the ewes took to the rough face of a cliff about 30 feet high on which were numerous rock shelves. When reaching the face of the cliff the cougar attempted to climb. It made three attempts but could not obtain a foothold. Upon reaching a small plateau at the summit of the cliff the sheep stopped for a moment and then continued their flight, passing out of sight in a small patch of timber. The cougar, with lashing tail, watched the sheep until they reached the summit of the cliff. When the sheep disappeared from view it slunk away at a right angle from their line of flight, its behavior indicating that it had given up the chase. The distance of observation was about 400 yards. Binoculars were used.

On August 30, 1942, a cougar was observed in pursuit of a band of seven ewes, two yearlings, and two lambs, on the slope above the big mineral lick on the Vermilion range. On this occasion the lambs were mixed with the sheep. The distance between sheep and cougar was about 50 yards. The sheep headed for a cliff face which they scaled on a narrow ledge sloping diagonally to the summit. By this time the cougar had gained about 10 yards. When the sheep reached the summit they continued their flight, almost completing a circle. The cougar followed to the top of the cliff, and then turned away from the direction taken by the sheep and climbed the mountain side along a dry wash, remaining visible for several minutes. A few minutes later the sheep were back where they were first observed. They were visibly exhausted, especially the lambs. After milling around, all bedded down as if nothing had occurred. The distance of observation was about 300 yards. Binoculars were not used.

On July 15, 1946, a cougar was observed hiding in a juniper bush on the Vermilion range. Only its head and the tip of a lashing tail were visible. Three lambs bedded together about 10 yards from the bush suddenly got on their feet and sped to the same cliff noted in the previous observation, which was about 50 yards away. The lambs on reaching the cliff did not climb to the top, but stopped halfway up the diagonal ledge, one behind the other. Five ewes near-by paid no attention to the sudden departure of the lambs other than to stare after them, as if wondering as to the cause of their alarm. The cougar made no attempt to follow the lambs. It backed out of its hiding place and disappeared under cover of rocks and timber. The lambs remained on the cliff for about 10 minutes after the cougar's departure and then joined the ewes. The distance of observation was about 50 yards. Binoculars were not used.

On April 15, 1946, the carcass of an adult ram was found on the Vermilion range. The carcass was quite fresh, with the hind quarters partly devoured, and the skin of the right shoulder torn from top to point, as if by claws. The left foreleg was broken below the knee. Cougar tracks were visible, leading from the summit of a cliff immediately above the carcass. The tracks ran first along a game path, through a wide crevice, and then to the carcass across a slide of sandy soil. Some cougar tracks were also observed on a small plateau above the cliff, but they were difficult to interpret accurately. It appeared, however, that the ram had been pursued for a short distance by the cougar before it plunged over the cliff, the shoulder wound being inflicted by the cougar during this pursuit, and the broken leg being sustained in the fall, which was over a distance of about 40 feet. As its neck was not broken, the ram had probably been killed by the cougar as it lay helpless at the foot of the cliff.

On April 16, there were more cougar tracks about the carcass. The thoracic and abdominal viscera had been devoured, with the exception of the stomach and intestines. More flesh had been torn from the carcass; the head and neck were still intact. An attempt had been made to cover what remained with debris scratched up from the ground. During the night of April 16-17 the head and neck were dragged away, probably by coyotes. The head was later found in a clump of bushes about 50 feet distant.

On June 5, 1948, the remains of a young ewe were discovered at the base of a steep cliff on the Vermilion range close beside the Banff-Louise highway. Cougar tracks were about the remains, which were fresh, and consisted only of head, neck, stomach, and intestines. There was no direct evidence to prove that the ewe had run over the cliff to escape from the cougar but there was little doubt that a cougar was in some way responsible. During the night of June 5-6 the skeletal remains with what little flesh adhered to the bones were torn apart and carried away by coyotes.

Wolf

On August 27, 1948, a wolf was seen in pursuit of a small band of sheep of undetermined number, on a semi-open mountain slope on the Vermilion range. The distance between the wolf and the rear of the sheep was about 50 yards. The sheep took refuge on a ledge or rimrock, where they stood with apparent knowledge of their safety. By the time they reached the ledge the wolf had gained about 30 yards. The wolf continued, without slacking pace, to the base of the ledge, the summit of which was about 12 feet above the surroundings. It looked up at the sheep for a few seconds and then walked away in the direction from which it had come, glancing over its shoulder at the sheep from time to time until it entered a poplar bluff near by and disappeared. The distance of observation was about half a mile. Binoculars were used.

Coyotes

In August, 1947, a coyote was observed harassing a band of nine sheep, including three lambs, on an open, grassy slope on the Vermilion range. After watching for a few minutes, the observer concluded that the coyote's behaviour suggested playful gestures rather than predatory intentions. The sheep were scattered, the lambs with the ewes. The coyote would run at them, now at one, now at another, retreating a few yards after each sally. The sheep showed no alarm; their reaction was rather one of annoyance. Steep, rocky terrain was distant about 100 yards, but there was no apparent inclination on the part of the sheep to seek its protection. This went on for about five minutes, after which the coyote leisurely walked away, investigating objects of interest here and there until it passed out of sight.

In August, 1948, two coyotes were seen in pursuit of an undetermined number of sheep on the Sawback range, running them through a semi-open stand of timber. The sheep emerged from this cover, ran up an open slope, and

disappeared over a shoulder. The coyotes, about 20 yards behind the sheep, stopped momentarily when they could no longer see them, and then continued in their direction at a fast trot until they were out of sight over the shoulder of the slope. About five minutes later, two coyotes were seen lying on the crest of the slope, their tongues lolling. Nothing more was seen of the sheep, nor was any evidence discovered that one was killed.

On a number of occasions, coyotes, single and in pairs, have been observed passing through bands of sheep without showing interest or any sign of aggression. The only reaction of the sheep was to give them the right of way. Sometimes an adult would stamp a foot. It seems that the coyote is not an important predator of bighorns in the park.

Such apparent indifference of carnivore and ruminant towards each other, however, is not confined to coyotes and sheep, for similar incidents have been observed involving coyotes and mule deer. Coyotes have also been observed following closely on the heels of cow moose with calves during the winter months, and milling about where these animals were feeding without even a show of aggression or annoyance on the part of the cows.

PREDATOR-PREY RELATIONSHIP

The hunting techniques and habitat preferences of cougar and wolf in the park, as elsewhere, indicate that each of these animals is adapted to hunt with maximum efficiency in specific terrain.

The maximum hunting efficiency of the cougar is attained in rocky, rugged or broken country with sparse or no forest cover, where ambush and the exercise of stealth is possible.

The wolf, on the other hand, hunts with greatest success in flat, open or semi-open terrain where comparatively long pursuit, the tiring of prey, and the exercise of team-work can be employed to maximum advantage. For this reason the wolf is out of its element in rough, rugged country.

Taking into consideration the hunting techniques and habitat preferences of the predators involved, it was found that each sheep range has its own predator-prey character.

The Eisenhower range is open mountain slope, with little escape cover, frequented by both cougar and wolf.

The Johnson creek range is open and semi-open alpine meadowland, with little escape cover. The cougar and the wolf occur.

The Sawback range consists of widely-separated narrow grassy ridges with some alpine meadowland. There is no escape cover other than forest. The wolf alone occurs.

The Vermilion range is largely a series of widely-separated, small alpine meadows, with much escape cover in localities frequented by sheep. The cougar and the wolf both occur.

The Aylmer range consists of open mountain slope and alpine meadowland, with much escape cover. It is frequented by the cougar, but it is doubtful if the wolf habitually occurs.

The Palliser range includes open alpine meadowland of large extent, with no escape cover. The wolf occurs.

Data from the Carrot creek, Dormer, Bare Mountain, Red Deer and Mount Wilson ranges regarding the occurrence of predators are insufficient for interpretation.

Considering the environment factors described in relation to predator hunting techniques, the order of vulnerability of the Bighorn to cougar and wolf on the ranges considered is: -

<u>Eisenhower</u>	1. Wolf.	2. Cougar.
<u>Johnson Creek</u>	1. Cougar.	2. Wolf.
<u>Sawback</u>	1. Wolf.	
<u>Vermilion</u>	1. Cougar.	2. Wolf.
<u>Aylmer</u>	1. Cougar	
<u>Palliser</u>	1. Wolf.	

As buffer prey occurs in one form or another on all the ranges considered, the local pressure on sheep by the predators involved would be conditioned by the abundance and seasonal occurrence of such buffer prey.

Eisenhower

Wolf pressure is relieved by the occurrence of elk, especially during the winter months. Cougar pressure is relieved by the presence of mule deer.

Johnson creek

Due to the virtual absence of mule deer, cougar pressure might be high. Wolf pressure is relieved by the occurrence of elk in both winter and summer.

Sawback

Wolf pressure is relieved during the winter months by the occurrence of elk.

Vermilion

The presence of mule deer at all seasons of the year relieves cougar pressure. The occurrence of moose and elk in the vicinity, in winter and summer, relieves wolf pressure.

Aylmer

With the exception of elk during the summer months, virtually no other large game species occur. Cougar pressure might therefore, be high unless smaller game were utilized.

Palliser

Wolf pressure is relieved by the occurrence of moose, elk, and mule deer.

On all these ranges, food such as small mammals, birds, berries and carrion would be available for predators mentioned. This food material would lessen the pressure on the bighorn sheep. If the sheep were protected by the

nearness of escape terrain it is probable that these wide-ranging predators would search elsewhere for their prey.

NATURAL CONTROL OF PREDATORS

Mange, infestation by either Sarcoptes scabiei or Demodex folliculorum, is exercising a measure of control upon the wolf and coyote populations occurring on park game ranges. It was observed that manifestations of the infestation were seasonal, making their appearance in the late fall and winter when infested animals become dehaired in varying degree. During the spring and summer the hair of surviving animals grows in, the condition again becoming active in the fall. When the infestation is heavy, death invariably results from exposure and starvation occasioned by physical weakness.

Mange was first observed in wolves in November, 1946, when Mitchell and the author encountered an adult wolf feeding on old elk bones at the west end of the Vermilion range. It was very weak and sparsely haired. It could not have survived the winter.

In December, 1946, LaCasse destroyed a mangy wolf, badly dehaired and in very poor condition, at the west end of the Vermilion range. It was autopsied by the author. Stomach and intestines were empty. All organs were normal. Sex: female. Weight: 54 lbs. Age: adult.

In January, 1947, LaCasse discovered a dead wolf in the same area near a winter den used by other wolves. On autopsy by the author it was found that stomach and intestines were empty. All organs were normal. Sex: female. Weight: 37 lbs. Age: about one and a half years. Death was attributed to exposure and starvation. It was almost completely dehaired.

In February, 1948, LaCasse destroyed an adult male wolf, badly infested with mange and very emaciated, in a cabin at the west end of the Vermilion range, in which it had sought shelter. This animal was almost dead from exposure and starvation when discovered.

The wolves occurring on the Palliser and Bare Mountain ranges were reported by Young (1947-48) to have several mangy individuals among them.

Mange was first observed affecting coyotes during the winter of 1939-40, when an occasional mangy individual was seen. Infestation progressively increased from that time until the winter of 1947-48, when few coyotes were seen which were not badly dehaired and in poor physical condition. Between 1944 and 1948, 10 mangy coyotes were destroyed, all in the advanced stage of infestation. None would have long survived. Two of these coyotes were destroyed in the town of Banff after they had found shelter in outbuildings.

Mange mortality in park wolves and coyotes is undoubtedly heavy, and would have the effect of reducing the predator pressure on the bighorn (and other park game).

Although the causative parasite has not been authoritatively identified it is believed to be Demodex folliculorum, the mite of follicular mange. This mite is parasitic in the sebaceous glands and hair follicles, causing loss of hair. The dehaired skin is left wrinkled, clean and shiny. Scab mange, infestation by Sarcoptes scabiei, is also characterized by loss of hair, but where the latter infestation occurs the skin is covered by many-layered scabs beneath which mites can be found. The dehaired skin of all infected wolves and coyotes examined was not scabby, but wrinkled, clean, and shiny, suggesting infestation by Demodex folliculorum.

EXTERNAL PARASITES

Ticks

Two ixodid ticks of the genus Dermacentor (D.andersoni Stiles, the rocky mountain fever tick, and D.albipictus Packard, the moose or winter tick) and one argasid tick (Otobius megnini (Duges), the spinous ear tick) occur on park game ranges. All are external parasites of the bighorn, but

the occurrence of D.andersoni and D.albipictus alone was noted during this study. O.megnini, however, has been collected from the ears of the rocky mountain goat.

The life cycle of the ticks described follows the same pattern of egg--seed--nymph--adult, with the exception that O.megnini experiences two nymphal stages, only the second of which is parasitic.

D.andersoni is a three-host tick requiring three separate mammal hosts, usually progressively increasing in size, to complete metamorphosis. The "seed" seeks a small mammal, such as a mouse or vole, as the first host. After attachment and ingestion of a blood meal it falls to the ground, undergoes ecdysis and becomes a nymph. The nymph selects a larger mammal, usually a ground or tree squirrel, as the second host, engorges itself with blood, falls to the ground, experiences ecdysis and becomes an adult. The adult adheres to a still larger mammal such as a sheep, goat or deer as the terminal host, and engorges itself with blood. Mating then takes place, the female deposits her eggs, and both sexes fall to the ground and die.

D.andersoni, in all its stages, infests the host only during the warm months of the year. Adults, nymphs and seeds which are unable to obtain the blood meal necessary for metamorphosis hibernate until the next warm season.

D.albipictus experiences the same life cycle as D.andersoni, but on a single host. In late summer or early fall the "seed" seeks an animal, usually a moose, elk, deer, or sheep, upon which it remains active throughout the winter, experiencing ecdysis on the host. By late spring the life cycle is complete and seasonal infestation is at an end.

The tick which chiefly infests the bighorn is D.andersoni. Infestation by D.albipictus was noted on only one occasion. A fresh carcass of an adult ewe, examined in January, 1946, harbored a few nymphs.

The preferred place of attachment of D.andersoni and D.albipictus is about the neck and shoulders. In the case of D.andersoni, the degree of irritation experienced by sheep during the study period appeared to be slight. Few sheep were seen rubbing, and rubbed hair was seldom observed. What blood was lost through tick engorgement apparently had no physical effect upon the host.

It was observed that magpies habitually feed on blood-filled ticks picked from infested sheep, especially in the spring, locating and following bands of sheep for that purpose. Six magpies collected after feeding on sheep contained 16, 11, 11, 9, 5, and 3 engorged ticks respectively. This relationship, which undoubtedly serves a useful purpose, is new, for the magpie (Pica pica) is a recent addition to the fauna of the park. Before 1920 its occurrence was only occasional.

The principal source of infestation of sheep by either D.andersoni or D.albipictus is the ground about mineral licks and well-travelled sheep trails. In early May of the five years 1944 to 1948, the author covered the same stretch of 90 paces of a well-used sheep trail leading to the mineral lick at the third Vermilion lake, dragging a piece of white blanket material, to which ticks readily attach themselves. On the same days, the ground about the mineral lick at the third Vermilion lake was similarly swept. The number of ticks collected in this manner was as follows:-

TABLE V

Sheep Trail

<u>Year</u>	<u>Total No. of Ticks</u>	<u>Adults</u>	<u>Nymphs</u>	<u>Seeds</u>
1944	41	39	2	-
1945	29	26	3	-
1946	18	17	-	1
1947	11	9	2	-
1948	13	11	2	-

Mineral Lick

1944	53	49	2	2
1945	21	18	3	-
1946	31	29	1	1
1947	17	15	1	1
1948	21	19	1	1

All adult specimens collected were identified as D.andersoni. The identity of nymphs and seeds was not determined, but these probably were of the same species.

Mites

A mite, Psoroptes ovis, has been noted as an external parasite of park sheep, infestation causing scabby dehaired patches on the skin. Stenton (1940) destroyed a scabby ewe at Lake Minnewanka, at the west end of the Aylmer range. The occurrence of this mite was not observed during the present study, and the condition is thought to be rare.

INTERNAL PARASITES

Cowan (1944) lists the following internal parasites recovered from the bighorn of the Banff and Jasper national parks;

Moniezia tapeworm	(<u>Moniezia benedini</u>)
Thin-necked bladderworm	(<u>Cysticercus tenuicollis</u>)
Hair lungworm	(<u>Protostrongylus stilesi</u>)
Medium stomach worms	(<u>Ostertagia circumcincta</u>)
	(<u>O.occidentalis</u>)
	(<u>O.marshalli</u>)
Thread-necked strongyle	(<u>Nematodirus filicollis</u>)

The thin-necked bladderworm was recovered on two occasions (1944 and 1947) by the author from 2 adult ewes accidentally killed on the Vermilion range,

and the hair lungworm from a lamb (1945) which died on the same range from an unknown cause.

The thin-necked bladderworm is a larval form of the tapeworm Taenia hydatagena which infests the colon of dogs and wild carnivora. It occurs as a cyst attached by a narrow neck to the mesenteries, **and, on occasion, to the lungs and liver.** When ingested by a carnivore, the scolex or head contained in the cyst develops into the adult worm, which often attains a length of 18 inches or more. A new life cycle is commenced when ripe segments of the worm containing eggs pass to the ground with the feces of the host and the eggs are ingested by a grazing mammal.

Three wolves and nine coyotes were autopsied (1946-1949). All the wolves and six of the coyotes examined were infested with Taenia hydatagena.

The hair lungworm occurs in the lung tissue and bronchioles. It is a very small hair-like worm less than one inch in length. Cowan (1944) states: "The life history of this species is unknown but in related species the adult worms deposit eggs in the lung, these hatch and the larvae make their way to the digestive tract and thence to the outside in the faeces. They are then either eaten by a slug or snail or burrow into the foot of one of these creatures. Within the snail they develop into the infective stage in a matter of about two weeks. The sheep becomes infected by accidentally or purposely eating the snail. On certain ranges it has been suggested that the sheep eat the small snails for the mineral content of their shells."

Reference

Cowan, I. McTaggart. 1944. Parasites, Diseases, and Injuries of game mammals in Banff, Jasper, and Kootenay national parks. Report National Parks Bureau, Department of Mines and Resources: (Canada) 32.

NON-PARASITIC DISEASE

Actinomycosis

The occurrence of actinomycosis was observed in bighorn frequenting the Vermilion range, and as this range is visited by sheep from a number of other park ranges the disease may be considered general.

The disease generally termed actinomycosis, which is commonly called lumpjaw when it occurs in domestic livestock, is of three types:- actinomycosis, which affects the bony structure of the maxilla and mandible, and necrotic stomatitis and actinobacillosis which affect the soft tissues of the mouth. Actinomycosis is invariably a chronic condition which ultimately results in death from malnutrition and starvation; necrotic stomatitis and actinobacillosis are acute.

The infective organisms (bacteria or fungi) gain entrance to the tissues by way of lesions caused by rough food particles, and possibly by sharp grit contained in mineral soil which may be eaten. During the progress of all three types of infection inflammation of the soft part of the mouth occurs, with attending suppurating abscesses which drain to the outside. In actinomycosis the inflammation induces exostosis of necrosed bone, and malocclusion of the maxilla and mandible results. The loss or maladjustment of molars and premolars is usual.

The infective organisms of actinomycosis, necrotic stomatitis, and actinobacillosis are of the genera Actinomyces and Actinobacillus. Actinomyces necrophorus is the infective organism of necrotic stomatitis and Actinobacillus lignierisi that of actinobacillosis. Cultures taken by Cowan (1944) from the jaws of infected bighorn in Jasper National Park have been tentatively identified by Dr. D.C.B. Duff of the University of British Columbia, Department of Bacteriology and Preventive Medicine, as Actinomyces bovis.

During the study, 13 sheep - five adult rams and eight adult ewes - were observed on the Vermilion range with suppurating abscesses in the region of either the right or the left side of the maxilla or mandible, and on the same range the skeletal remains of two adult rams and two adult ewes were discovered showing necrosis and exostosis of the maxilla or mandible, with malocclusion and loss of one or more premolars.

Cowan (1943) discovered the remains of 40 sheep at Sulphur Springs on the Bare Mountain range. Twenty eight of these were rams, 10 were ewes and two young animals. He states: "...the condition of these remains, many of them undisturbed skeletons, in several instances two animals close together, indicated that disease or climatic conditions rather than predation had been responsible for the loss. The evidence of disease (actinomycosis) was plainly visible in the distorted, ulcerated mandibles of many of the skeletons."

James Simpson, of Banff, who assisted Cowan in the above examination, informed him that in the spring of 1941 he found the remains of 20 mature rams, which had died during the previous winter, in a gully south of Sulphur Springs. Other skeletons were strewn along the bottoms of nearby gullies.

In 1948, Stenton discovered the skeletal remains of four adult rams on the Carrot Creek range. The skulls showed necrosis and exostosis of either the maxilla or the mandible.

Many reports have been received from guides and outfitters who travel the park concerning their discovery of sheep remains with the characteristic lesions of actinomycosis.

It is believed that actinomycosis infection may be largely spread at mineral licks where sheep congregate and at watering places, especially pools of still water, which are contaminated by the exudate from infected animals.

As it is clear that actinomycosis has occurred among park sheep over a considerable period of time, with evidence of major outbreaks punctuated by casual infections, its incidence is endemic and epidemic. When epidemic, losses are undoubtedly high. When endemic, the loss is low with little effect upon status. There has apparently been no epidemic in the park for several years.

No evidence of other non-parasitic disease was observed or suspected. However, haemorrhagic septicemia, according to Cowan (1944), decimated the bighorn of the neighbouring Kootenay Park in 1940. Cowan states: "There is some evidence to suggest that the Banff Park sheep suffered a similar epidemic about the same time and in it lost a large percentage of the population."

References

Cowan, I. McTaggart. 1943. Report on game conditions in Banff, Jasper, and Kootenay national parks. Report National Parks Bureau, Department of Mines and Resources: (Canada)

Cowan, I. McTaggart. 1944. Parasites, diseases, and injuries of game mammals in Banff, Jasper, and Kootenay national parks. Report National Parks Bureau, Department of Mines and Resources: (Canada) 32.

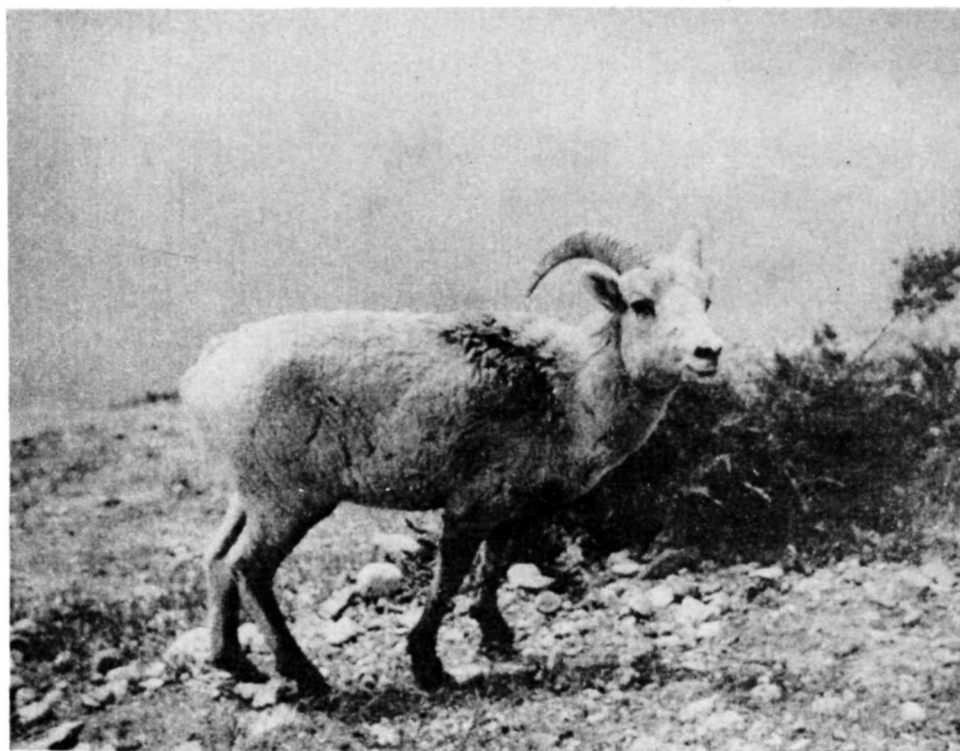
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PLATE I



Mature Ram



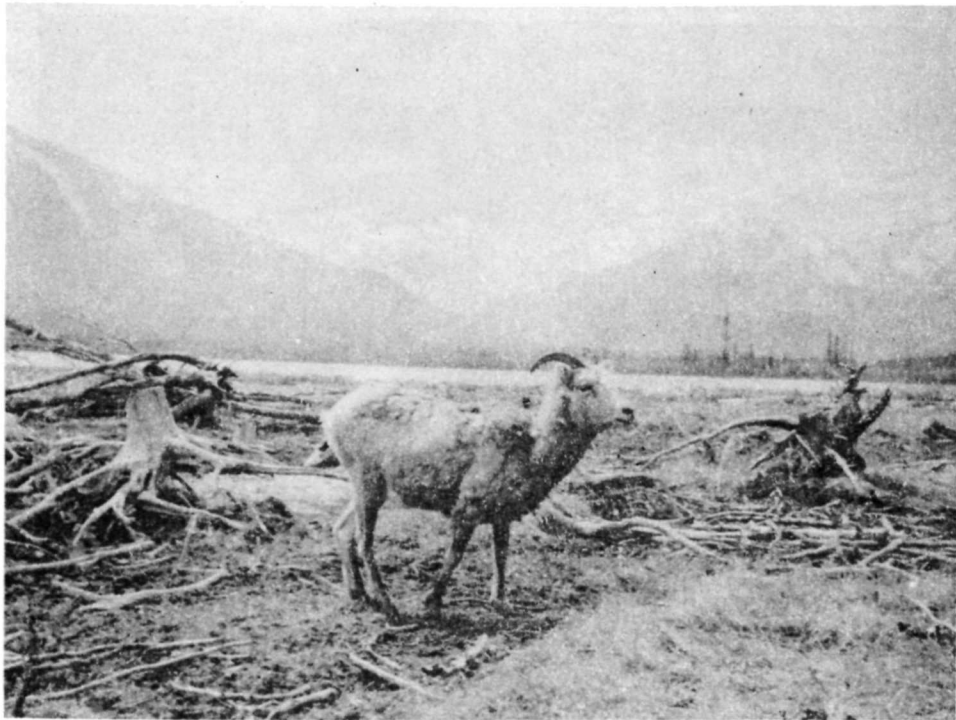
Three-year-old Ram

PLATE II



Rams

PLATE III



Ewes



Shedding winter pelage, June

PLATE V



After shedding, August



Horns of Ram showing annual growth

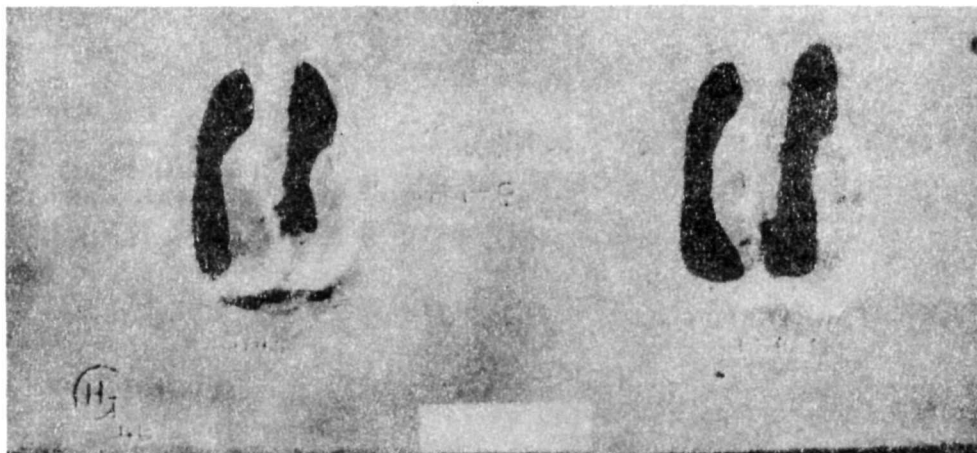


Ewe Horn

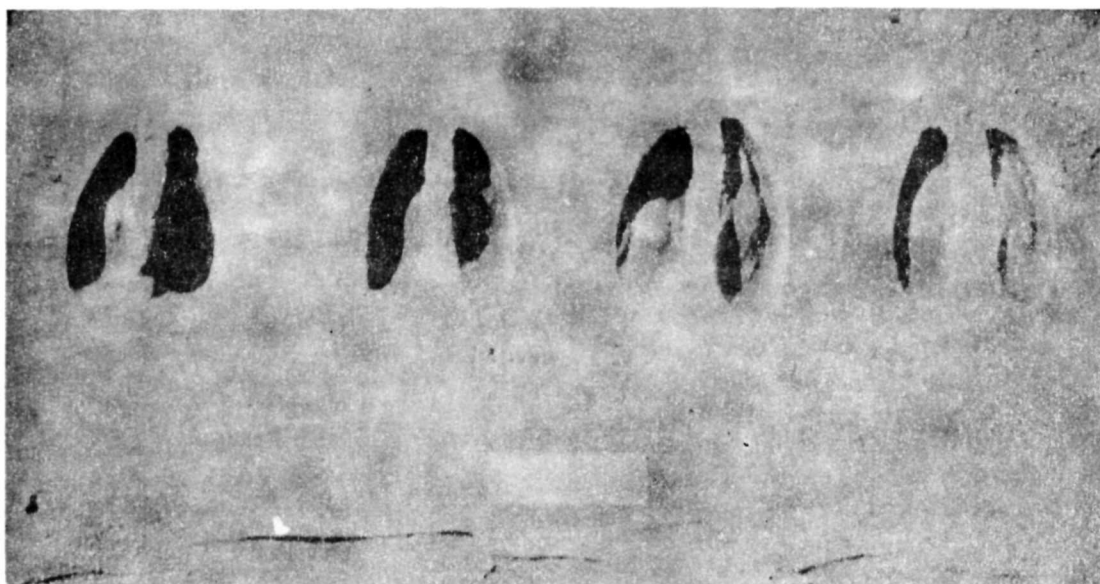
Horn of Rocky Mountain Goat

PLATE VII

COMPARATIVE TRACKS



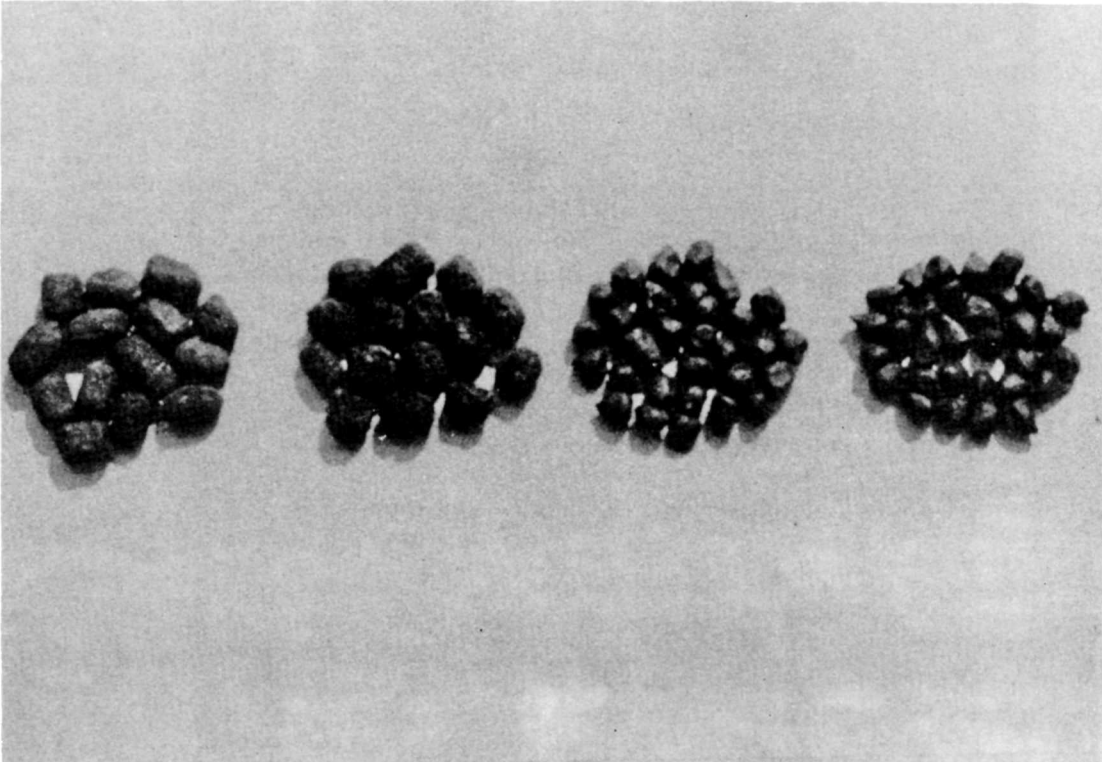
Bighorn Sheep



Mule Deer

PLATE VIII

COMPARATIVE FECAL PELLETS



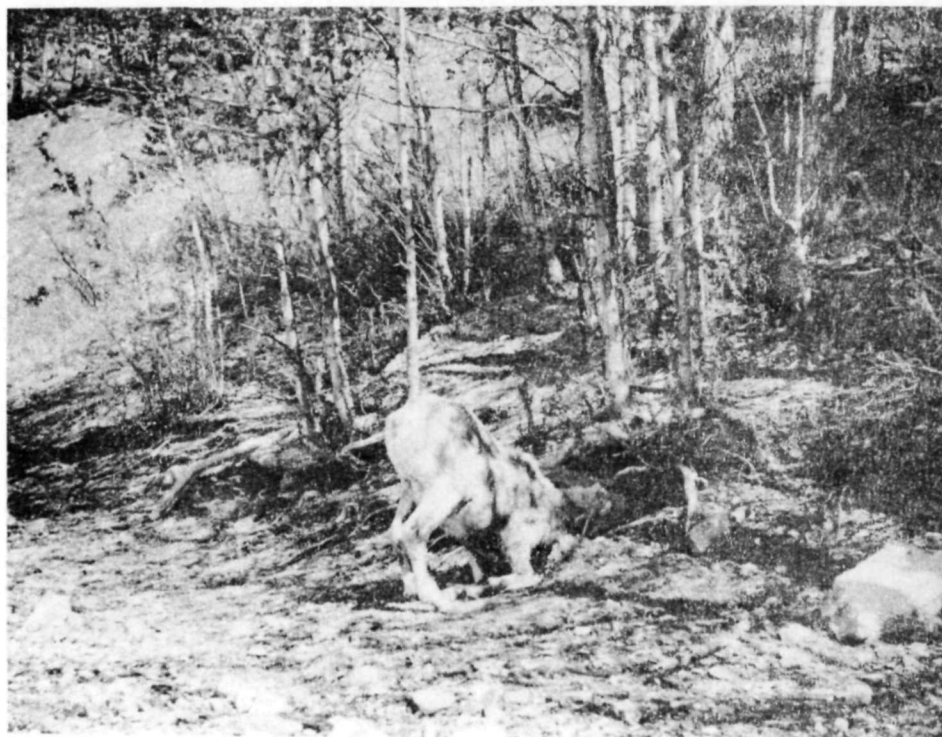
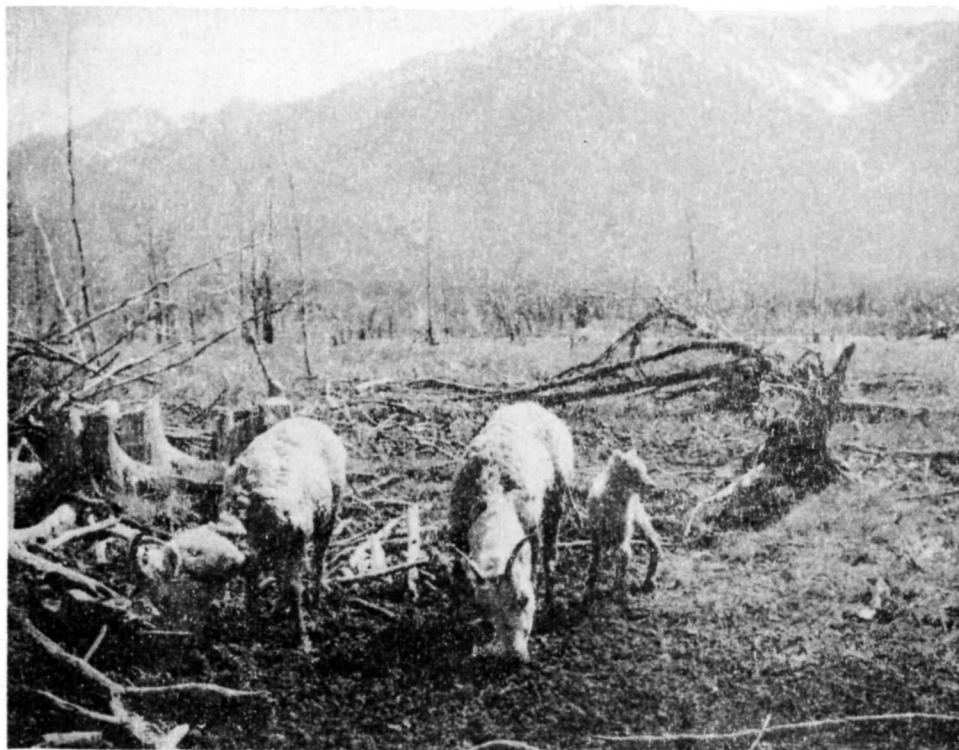
Young Elk

Mule Deer

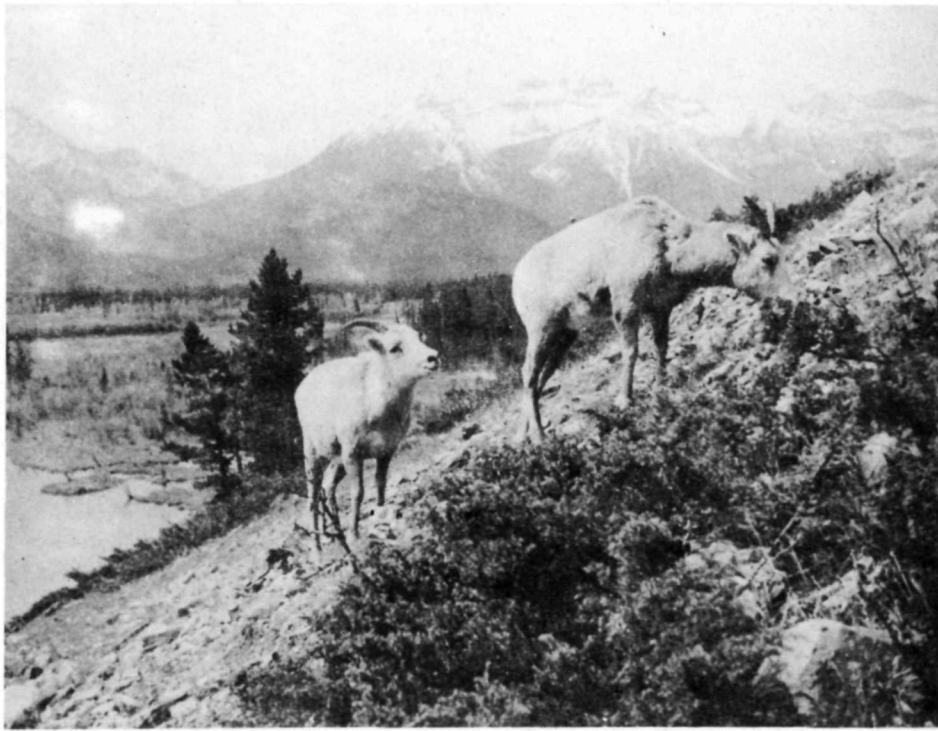
Goat

Bighorn

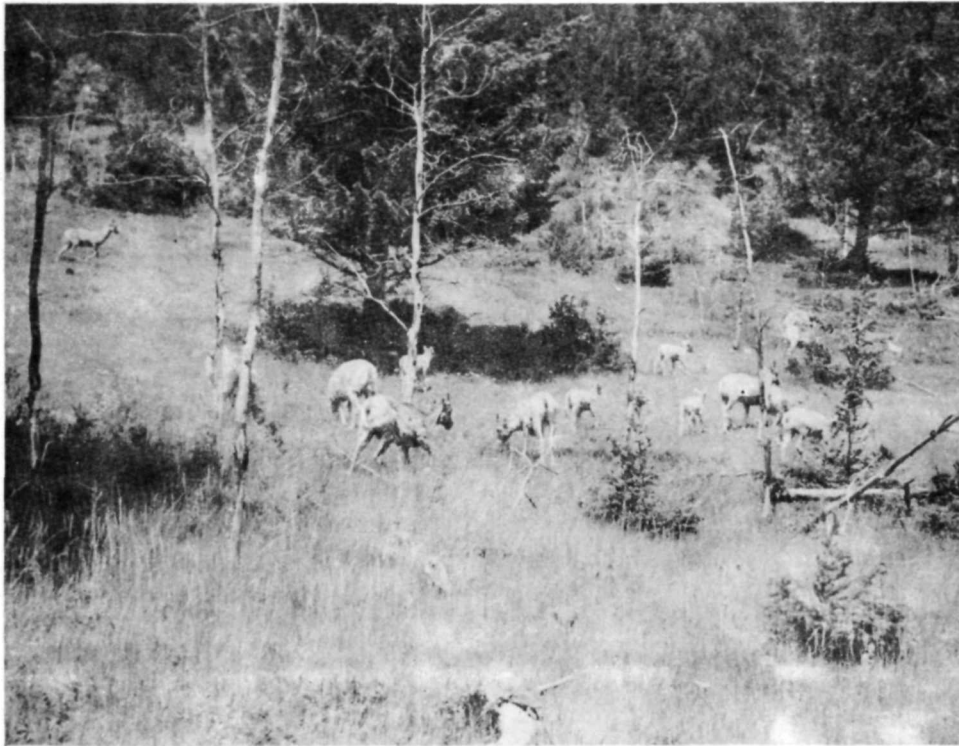
PLATE IX



Mineral Lick, Third Vermilion Lake, Vermilion Range



Open mountain slope, Vermilion Range



Semi-open meadow, Vermilion Range



Semi-open mountain slope, Sawback Range



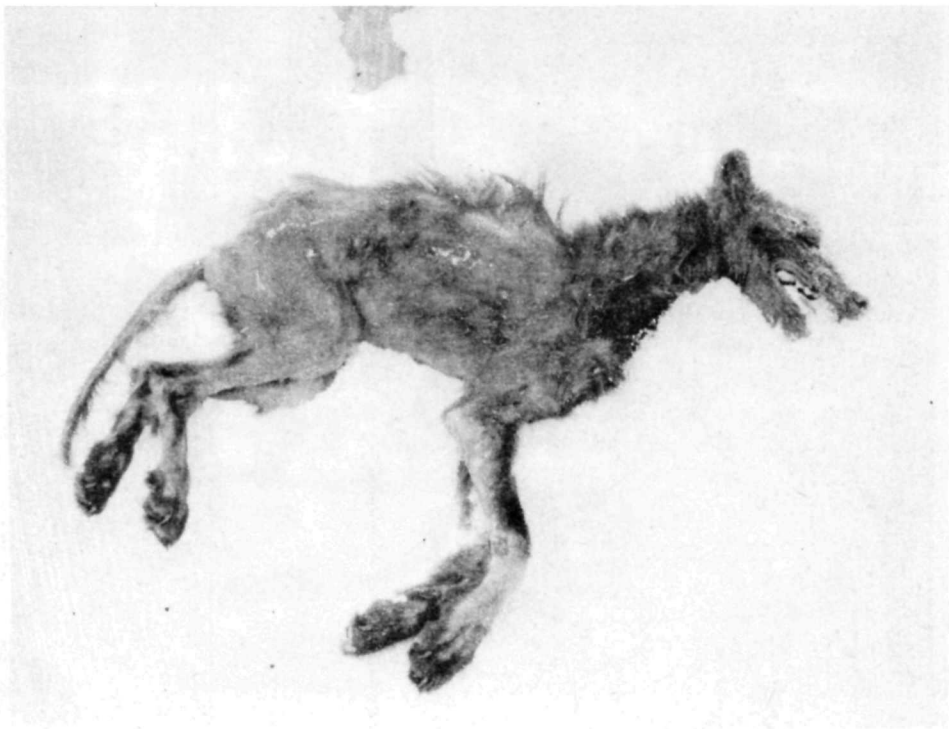
Alpine meadow, Vermilion Range



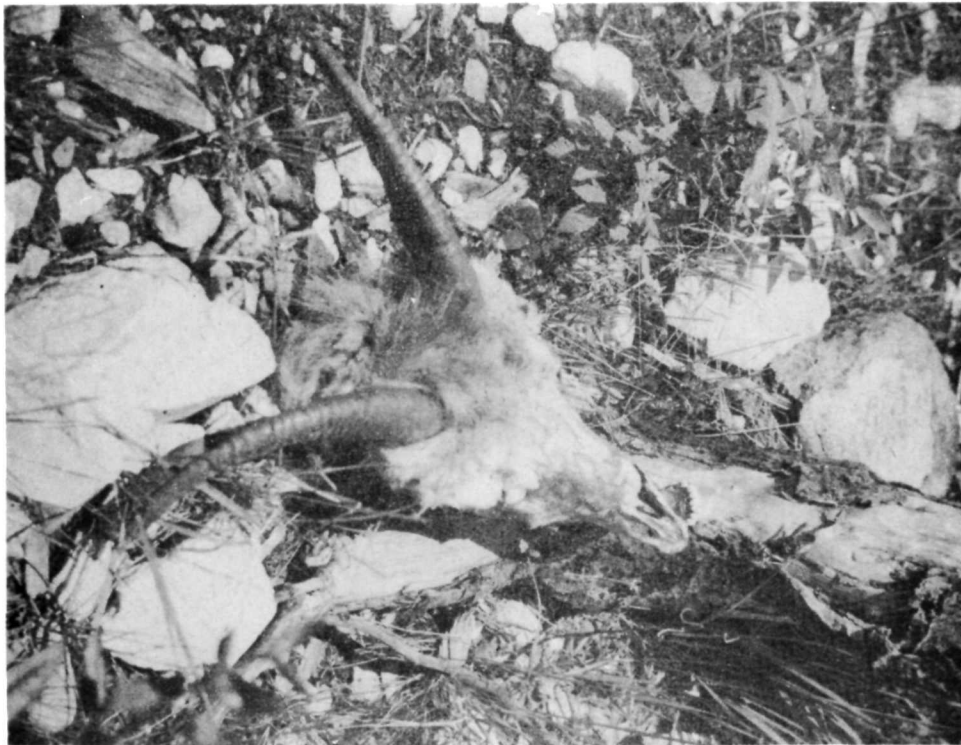
Typical escape cover, Vermilion Range



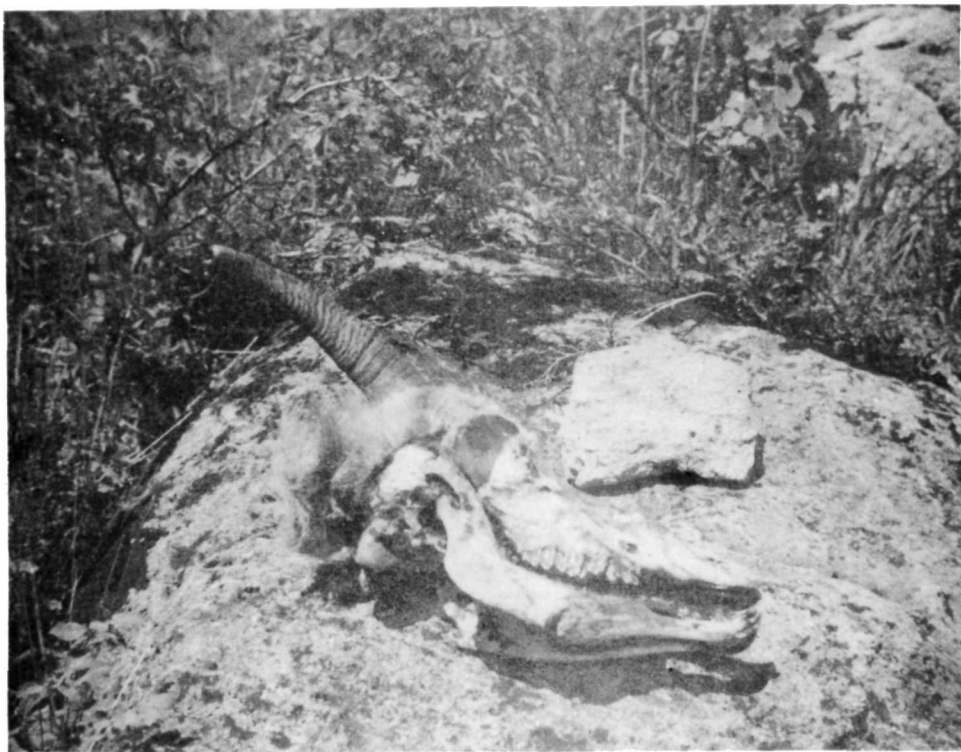
Wolf Den, Sawback Range



Mangy Wolf destroyed on Sawback Range



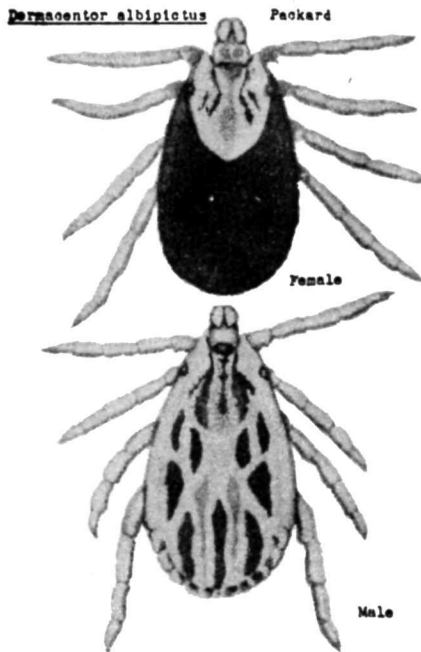
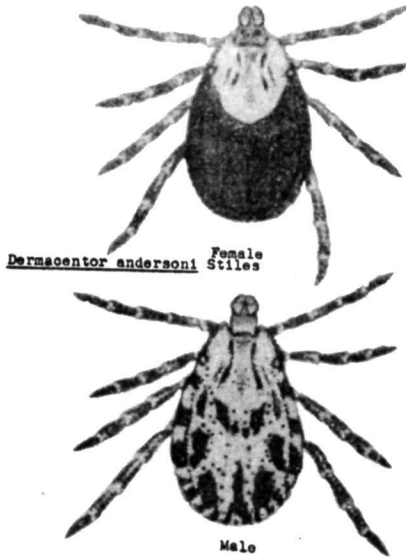
Actinomycosis with malocclusion of Mandible



Same skull showing necrosis and exostosis of Mandible

TICKS

Average length
3.5 mm.
Average width
2. mm.



Average length
5. mm.
Average width
3.5 mm.

