AN ECOLOGICAL STUDY OF THE MOOSE IN THE ROCK LAKE AREA OF ALBERTA

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AN ECOLOGICAL STUDY OF THE MOOSE IN THE ROCK LAKE AREA OF ALBERTA

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

FACULTY OF ARTS AND SCIENCE

DEPARTMENT OF ZOOLOGY

by

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Edmonton, Alberta.

April 1953

UNIVERSITY OF ALBERTA

SCHOOL OF GRADUATE STUDIES

The undersigned hereby certify that they have read and recommend to the School of Graduate Studies for acceptance, a thesis entitled "An Ecological Study of the Moose in the Rock Lake Area of Alberta", submitted by John Burton Millar, B.Sc., in partial fulfilment of the requirements for the degree of Master of Science.

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ABSTRACT

Concern over the declining moose population prompted the Alberta Game Branch and the University of Alberta to begin investigations in 1951 into possible solutions to the problem. It was felt that altering of the sex ratio by the shooting of cows might have a beneficial effect and the first studies were directed towards determining the feasibility of such a plan. The former Athabaska Forest Reserve was chosen as the study area by reason of its isolation and relatively good moose population. Later studies were expanded to cover the entire ecology of the moose in one portion of the Reserve - the Rock Lake area.

A series of 55 skulls was collected and measured in an effort to determine the exact taxonomic status of the moose in the area.

Observations were made whenever possible in an effort to determine the numbers of moose present, the sex ratio and rate of reproduction. These factors were considered vital in the consideration of the justification of opening the season on cows. The history of the moose in the area was considered briefly in order to relate the present conditions to the past.

Notes were made on behaviour, appearance and general life history etc., to supplement information already known about the animals.

Studies on feeding habits, browse plot analyses, fecal pellet and stomach analyses were all carried out in an effort to determine the major winter and summer food plants of the moose around Rock Lake.

Considerable work was done on the natural salt licks in an effort to determine the elements which were sought after by the moose. Soil and water from each of twelve licks were analysed for soluble salts and salt troughs containing 19 different chemicals were set up to see which salts were preferred by the animals. Results from this last experiment were rather inconclusive.

Three moose - two bulls and one cow-were shot in September and complete autopsies were performed on them. Specimens of all internal organs were submitted to the Provincial Veterinary Laboratory for pathological study. Stomach contents were analysed in connection with food studies.

The relationships of the moose to other species in the area, including predators, were studied and discussed at some length.

The effects of the open season in 1952 on the moose were also considered.

CONTENTS

	Page
INTRODUCTION	1
DESCRIPTION OF THE STUDY AREA	6
TAXONOMIC STATUS OF THE MOOSE	11
HISTORY OF THE MOOSE IN THE AREA	21
POPULATION & DISTRIBUTION	
Population Estimate	23
Distribution Within the Study Area	25
DATA ON AERIAL PHOTOGRAPHS	28
SEX RATIO & REPRODUCTION	
Calculated Sex Ratio	32
Rate of Reproduction	34
LIFE HISTORY	38
GENERAL APPEARANCE & PELAGE	45
GENERAL BEHAVIOUR & ACTIVITIES	
Senses	48
Movements	48
Social Habits	50
Reactions to Humans	51
HABITAT STUDIES	55
FOOD STUDIES	58
Feeding Habits	58
Stomach Analyses	62
Plot Studies	64
Pellet Analyses	73

Contents - cont'd

	Page
SALT LICK STUDIES	75
Soil Analyses	76
Water Analyses	79
Salting Experiments	83
General Lick Observations	87
ANATOMICAL STUDIES	89
DISEASES & PARASITES	91
PREDATION	93
RELATIONSHIPS TO OTHER ANIMALS	
Elk	98
Deer	99
Caribou	100
Domestic Stock	100
Beaver	100
Rabbits	101
HUNTING PRESSURE	102
CONCLUSIONS	105
ACKNOWLEDGEMENTS	110
REFERENCES	112
APPENDIX	115

AN ECOLOGICAL STUDY OF THE MOOSE IN THE ROCK LAKE AREA OF ALBERTA

INTRODUCTION

The decline in the moose population across Canada in recent years has aroused considerable interest and concern in wildlife circles. As a result, nearly every province, Alberta included, has embarked upon some research project in the effort to solve at least some of the factors involved in the decline of these majestic game animals.

In 1951 the Game Branch of the Alberta Provincial Government, in conjunction with the University of Alberta, decided to initiate a study of the moose in the western portion of this province. The original objective of the study was to determine whether or not the situation in the proposed study area was satisfactory for carrying on experiments in hunting of both bulls and cows.

On the basis of hunting data from Sweden (Skunke, 1950) where the killing of both sexes has been legal for many years, it is apparent that the Swedish moose population has been maintained at a high level in spite of the killing of females. It is this fact which inspired local game authorities to consider the possibility of instituting an open season on cow moose as a means of

increasing the population. Although this latter statement may, at first glance, appear rather absurd its significance becomes apparent when one considers that in a population where the sex ratio is disproportionate a large percentage of the cows will not be bred and hence are not contributing to the population increase.

It was generally felt that such a radical change in hunting practice should be preceded by a limited experiment to determine its effectiveness. Therefore it was decided to select a suitable area as a test hunting ground where all hunting activities could be rigidly regulated. The area chosen for the survey was that tract of land lying north of the Athabaska River and east of Jasper National Park which constituted the former Athabaska Forest Reserve. The wide diversity of terrain within the area was such that most of the normal habitats frequented by moose were available for study. These varied from subalpine swales to typical northland muskeg. As a secondary consideration, this same area possessed numbers of every other notable big game species, including sheep, goat, elk, deer and bear, which might have an effect on the ecology of the moose. The single means of entry into the Reserve through the Ranger Station at Entrance makes it ideal for a test hunting area since close to a hundred percent check can be made on all hunting activities with a minimum of effort.

The summer of 1951 was spent travelling throughout the Reserve in an effort to get a general idea of the game situation and to locate the most favorable location to carry on further possible studies. During the four months from May to September nearly 1000 miles were travelled by horseback and most of the Reserve south of the Smoky River was investigated. The results of the preliminary investigations were not such as to favor the institution of an open season on cows since reports received and personal observations indicated a fairly well balanced sex ratio. However, subsequent studies have indicated otherwise and at the present time such a project seems quite feasible.

Since the primary objective of the study had been, to all intents and purposes, achieved it was decided that further studies in the Reserve should take the form of an investigation into the general ecology of the moose in the area. On the basis of the 1951 investigations the Rock Lake region was selected as the most suitable site for making moose studies. This area lies forty miles north and slightly west of Jasper just outside the northeastern boundary of Jasper National Park. The summer of 1952, from May 25 to October 9, was spent in this location making the various investigations which

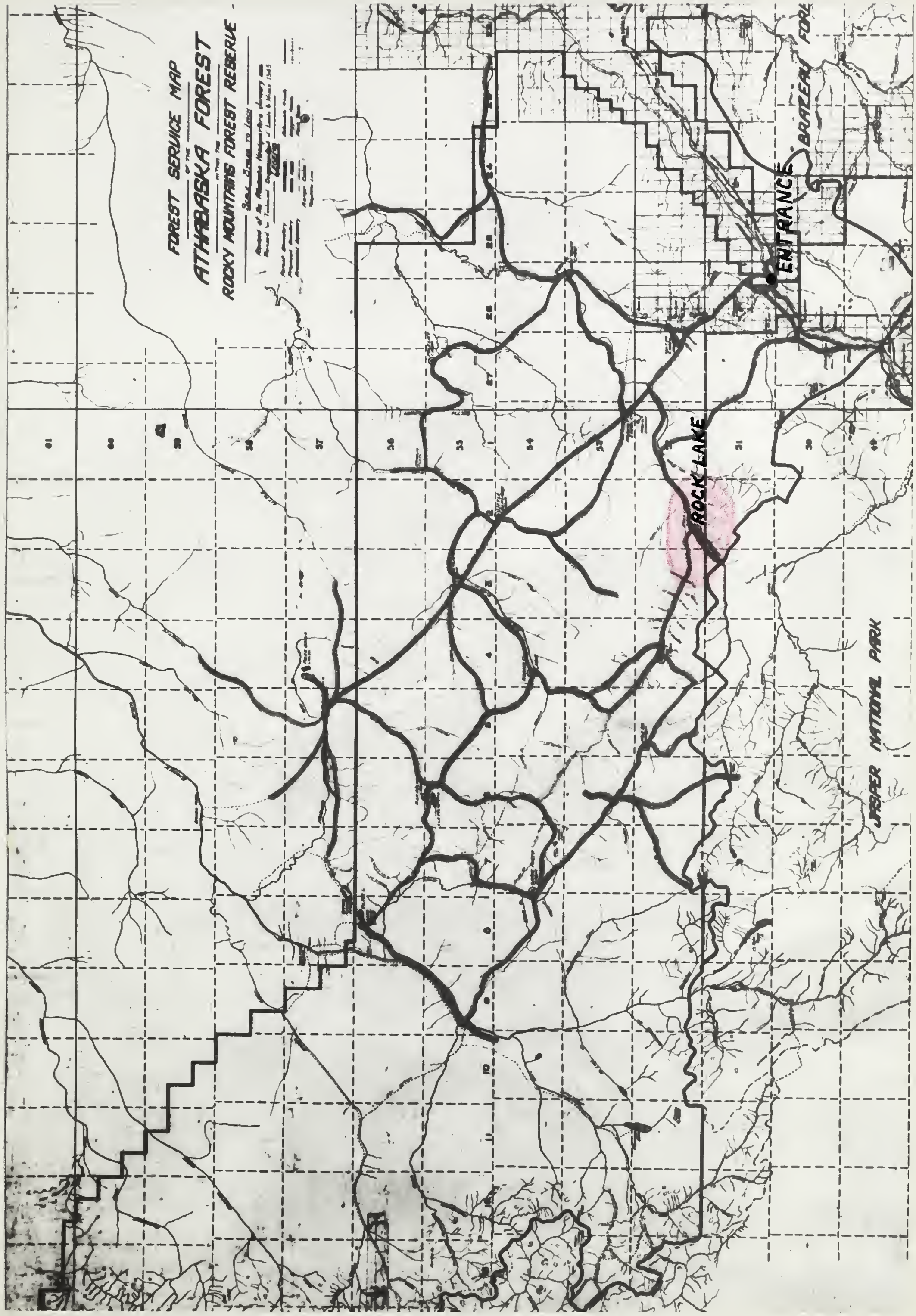
are the basis of this thesis. All field work was carried out on foot (an average of 10 miles a day and as high as 35) during the summer and considerable time and effort were expended in becoming as familiar as possible with the study area. Several lookout points, from which most of the observations were made, were set up but much of the time was spent investigating out-of-the-way corners of the terrain for possible points of interest.

Although all aspects of moose ecology are dealt with three facets - taxonomy, foods and salt licks - were found to be of particular interest and are therefore most strongly stressed. Technically speaking, taxonomy is not actually a part of ecology but it most certainly is basic to any general study of an animal in a new area and hence is given consideration in this thesis.

Unfortunately it was impossible to make any winter observations and the writer has had to rely upon the reports of trappers and forest rangers for information on the wintering habits of the moose in the area.

The map of the Athabaska Forest Reserve on page 5 will serve to give some impression of the location of the study area. Routes followed in 1951 are indicated by heavy black lines and the 1952 study area is set out by pink shading.

Fig. 1. Map of Athabaska Forest Reserve



DESCRIPTION OF THE STUDY AREA

The Reserve as a whole contains an extremely wide variety of terrain. In the east it is reminiscent of the northland with its low pine ridges and expanses of black spruce muskeg cut through by streams winding about in shallow park-like valleys. As one progresses westward into the foothills the pine and spruce-clad ridges become more prominent and the muskeg areas more restricted. The extreme western portion of the Reserve lies within the outlying ranges of the Rocky Mountains and presents in itself a range of habitat types such as only the Cordilleran regions are capable of producing. Narrow, rocky gorges suddenly blossom into wide, open subalpine valleys. Densely timbered slopes of Engelmann spruce, alpine fir, and lodgepole pine alternate with the more exposed grassy inclines.

Rock Lake, a body of water one and one half miles long and three quarters of a mile wide, lies about thirty five miles northwest of Entrance and just within the western fringes of the Reserve where it impinges on Jasper National Park. The study area lies wholly within the Wildhay River watershed and is drained by Rock Creek, which enters Rock Lake from the northwest, and the north fork of the Wildhay River which also flows from the north-west to join the center fork about three quarters of a

mile after it leaves Rock Lake.

The terrain around the lake is one of vegetation-covered ridges rising from the flat, glaciated valleys of Rock Creek and the Wildhay River to an altitude of 6000 to 7000 feet. The lake itself is at an elevation of 4500 feet. As one moves back from the lake the mountains become more and more rugged, rising to become 9-10,000 foot rocky bastions which encircle the lake as it lies within the first outlying ramparts of the Rocky Mountains.

The nearby ridges themselves offer a wide range of vegetational types. The north and east facing slopes are covered with heavy spruce-pine-fir canopies while the west and south slopes show a mixture of grassy meadows, poplar bluffs and lodgepole pine stands, depending on the particular "lay of the land". The bottom lands around the lake, formerly grassy meadows, are now growing up to willow pasture and poplar bluffs. Much of the country was burned over about the turn of the century and has grown up to lodgepole pine cover which is slowly giving way to Engelmann and white spruce in the more favorable locations. The last large fire in the region occurred in the early thirties and these burned tracts are now growing up in young pine, poplar and willow, interspersed with grassy patches.

Figs. 2-6 serve to give a rather comprehensive impression of the terrain immediately around Rock Lake.

Fig. 2. Rock Lake looking west.

Fig. 3. Lower end of Rock Lake looking southeast. Ranger station in the lower center.

Fig. 4. Rock Lake looking east.

Fig. 5. Typical mountain terrain south of Rock Lake. Busby lakes in the background.

Fig. 6. Open terrain along the upper north fork of the Wildhay River - typical of the higher valleys.

TAXONOMIC STATUS OF THE MOOSE

Dr. R. L. Peterson of the Royal Ontario Museum has, through his recent moose studies (1949), determined that an area of overlap between the geographical races *Alces americana andersoni* and *A. a. shirasi* exists in the region along the north central B.C. - Alberta boundary. As the proposed limits of the overlap region lie quite close to the present study area it was deemed advisable to determine, if possible, which race is present or if there has been an intergrading of the two. Since some of the basic differences in the two races occur in certain skull dimensions it was decided to collect all skulls noted during the summer in order to compile as large a series of measurements as possible. A collection of 52 skulls, 33 bulls and 19 cows, was obtained from over 70 moose skeletons located within a six mile radius of camp. In addition, measurements were also taken from the skulls of the three animals shot on special permit so that in all a total of 55 skulls was measured during the summer. Of these only 28 were complete but the vital measurements (width of palate and length of toothrow) were obtained from all 55.

Tables 3 and 4 contain the summarized measurements of all skulls, both male and female, collected in 1952.

In order that a comparison can be easily made Peterson's tables (Tables 1 and 2) on bull measurements for both A. a. andersoni and A. a. shirasi are included. In addition, a complete table of all skull measurements from the 55 specimens collected is to be found in the Appendix.

Mastoid breadth measurements in my tables should be ignored as incorrect interpretation of this measurement in the field has invalidated the figures. Since the mastoid measurements are incorrect the ratio of the height of the occiput to the mastoid breadth must also be disregarded. However, on the basis of three male skulls retained in the University of Alberta collections it appears that the correct measurement coincides closely with that given for A. a. andersoni.

Peterson (1951, 1952) considers the flare of the nasal aperture and the ratio of least palatal width to length of upper toothrow crowns (in bulls) to be the significant criteria for separating A. a. andersoni from A. a. shirasi. Figs. 8 & 9 (page 16) illustrate the exact nature of these measurements. Nearly all other measurements show some variation between the subspecies but the degree of overlap is such that it is impossible to use them as valid criteria for determining the taxonomy of the specimens.

It was found that most of the skull measurements, including percent nasal flare, coincided very closely with those given for *A. a. andersoni*. However, the ratio of the least palatal width to the length of upper toothrow crowns showed definite *shirasi* influence. The mean value given for *shirasi* is 41.4%, for *andersoni* 38.3%, while the value calculated from specimens collected in 1952 was 42.1% ± .69%. In the light of these data it seems logical to conclude that, while the population is predominantly *andersoni*, some *shirasi* influence is present. Therefore I believe that the range of overlap between the two subspecies can justifiably be extended north to include the Rock Lake area. This is some 60 miles north of the previously known limit of overlap at Southesk Lake, Jasper National Park.. Peterson (correspondence) concurs with the suggestion of extending the range of overlap to the Rock Lake area.

For all practical purposes the moose of the study area around Rock Lake may be considered to be intergrades between *A. a. andersoni* and *A. a. shirasi*.

In order to facilitate the interpretation of the tables of cranial measurements a list of the definitions of the various measurements (Peterson, 1951) is given on the following page.

DEFINITIONS OF CRANIAL MEASUREMENTS

Greatest Length. Anterior tip of premaxilla to posterior point of occiput.

Median Palatal Length. Anterior tip of premaxilla to the median posterior edge of palate.

Length of Rostrum. Anterior tip of premaxilla to the anterior rim of the orbit.

Nasal Aperture. Anterior tip of premaxilla to the junction of nasal and maxillary bones.

Mastoid Breadth. Greatest transverse dimension across mastoid process; outside of one to outside of other at the base.

Height of Occiput. Vertical dimension from inion to lower tip of foramen magnum.

Length of Upper Toothrow Crowns. Greatest distance from the anterior-most edge of crown of the first premolar to posterior-most edge of crown of last molar.

Greatest Width of Palate Between Toothrows. Greatest width between third upper molars at the margins of the alveolii.

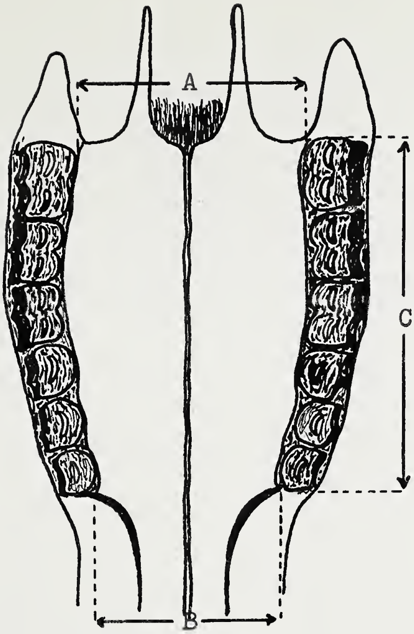
Least Width of Palate Between Toothrows. Least width between first upper premolars at marginal alveolii.

"Percent Flare" Nasal Aperture. An expression of the shape of the nasal aperture derived by subtracting

the measurement of the width of the nasal aperture at the junctions of the nasal and maxillary bones from the measurement of the greatest inside width of the nasal aperture (along dorsal rim) and calculating the difference in terms of its percentage of the length of the nasal aperture.

Fig. 7. Collection of skulls amassed for study during the summer of 1952.

Fig. 8. Palatal Measurements

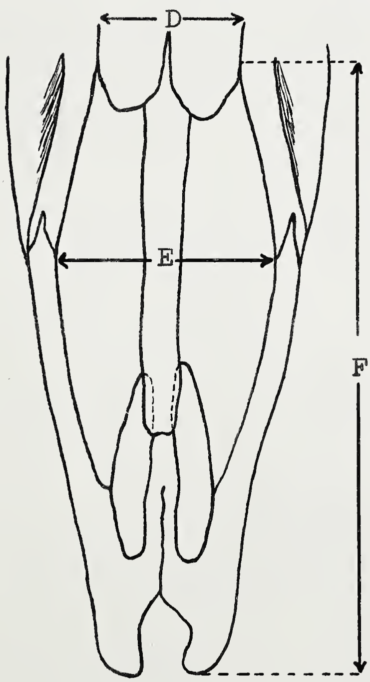


A - Greatest Palatal Width

B - Least Palatal Width

C - Length of Upper Toothrow

Fig. 9. Nasal Measurements



D-- Least Nasal Width

E - Greatest Nasal Width

F - Length of Nasal Aperture

Table 1. CRANIAL MEASUREMENTS OF MOOSE - Male

A. a. andersoni - Peterson, 1952.

	Young ad.	Mid-ad.	Old ad.
Greatest length	569.5 (11) (538-586)	591.7 (24) (559-621)	593.0 (8) (576-625)
Median palatal length	335.5 (11) (309-350)	349.7 (24) (331-368)	350.4 (9) (334-370)
Length of rostrum	347.5 (11) (326-363)	360.7 (25) (335-382)	360.7 (9) (346-380)
Length of nasal aperture	249.5 (11) (229-260)	265.0 (25) (248-292)	267.5 (8) (255-286)
Mastoid breadth	150.4 (11) (139-162)	164.0 (25) (157-176)	164.2 (11) (152-175)
Height of occiput	120.8 (9) (115-124)	125.2 (22) (115-134)	124.2 (11) (118-131)
Ratio of height of occiput to mastoid breadth (%)	80.0 (9) (72.5-86.3)	76.8 (22) (68.8-85.2)	75.7 (11) (72.0-79.8)
Length of upper toothrow crowns	152.9 (11) (149-156)	149.8 (24) (144-158)	146.3 (15) (140-151)
Greatest width of palate between toothrows.	83.4 (11) (78-88)	90.3 (25) (81-100)	90.3 (16) (84-99)
Ratio greatest width of palate between toothrows to length of upper toothrow crowns (%)	54.6 (11) (51.0-57.5)	60.3 (24) (55.5-66.4)	62.0 (15) (57.2-69.8)
Least width of palate between toothrows	54.5 (11) (51-60)	57.4 (25) (53-65)	58.1 (16) (52-66)
Ratio least width of palate between toothrows to length of upper toothrow crowns (%)	35.7 (11) (33.3-39.0)	38.3 (24) (33.6-43.0)	39.9 (15) (35.6-43.7)
"Percent flare" of nasal aperture	8.53 (11) (6.42-10.29)	9.25 (25) (6.24-13.25)	8.79 (8) (7.60-9.51)

Table 2. CRANIAL MEASUREMENTS OF MOOSE - Male

A. a. shirasi - Peterson, 1952.

	Young ad.	Mid-ad.	Old ad.
Greatest length	521 (1) ---	601.0 (7) (577-634)	579.2 (5) (569-594)
Median palatal length	320.0 (2) (297-343)	344.0 (7) (324-379)	333.8 (5) (322-344)
Length of Rostrum	329.0 (2) (306-352)	338.4 (9) (334-386)	349.5 (5) (333-359)
Length of nasal aperture	232.5 (2) (216-249)	267.4 (9) (251-293)	257.5 (5) (254-264)
Mastoid breadth	132 (1) ---	160.9 (10) (145-169)	164.7 (6) (160-174)
Height of occiput	115 (1) ---	122.8 (4) (118-127)	121.2 (6) (115-127)
Ratio of height of occiput to mastoid breadth (%)	--- ---	75.3 (4) (74.7-76.2)	73.5 (6) (69.6-76.6)
Length of upper toothrow crowns	143.5 (2) (143-144)	142.9 (11) (136-151)	140.8 (6) (138-145)
Greatest width of palate between toothrows.	80.5 (2) (75-86)	88.1 (9) (85-91)	90.3 (6) (85-94)
Ratio greatest width of palate between toothrows to length of upper toothrow crowns (%)	56.1 (2) (52.4-59.7)	61.2 (9) (57.3-66.9)	64.2 (6) (60.3-67.6)
Least width of palate between toothrows	53.5 (2) (48-59)	59.2 (9) (53-63)	61.5 (6) (56-67)
Ratio least width of palate between toothrows to length of upper toothrow crowns (%)	37.3 (2) (33.6-41.0)	41.4 (9) (37.3-44.8)	43.7 (6) (40.0-46.2)
"Percent flare" of nasal aperture	11.55 (2) (11.10-12.05)	11.11 (9) (10.10-12.36)	11.59 (4) (9.26-12.60)

Table 3. CRANIAL MEASUREMENTS OF MOOSE - Male

Specimens Collected in 1952

	Young ad.	Mid-ad.	Old ad.
Greatest length	---	591.3 (12) (637.5-528.3)	596.2 (8) (579.1-609.6)
Median palatal length	---	351.6 (12) (321.3-365.8)	350.5 (9) (340.4-360.7)
Length of rostrum	---	360.0 (12) (331.4-388.6)	359.6 (9) (340.8-370.8)
Length of nasal aperture	---	264.2 (12) (228.6-287.0)	266.7 (9) (256.5-287.0)
Mastoid breadth	125.1 (2) (110.5-139.7)	142.6 (19) (130.8-156.2)	145.0 (10) (139.7-152.4)
Height of occiput	110.5 (3) (101.6-119.4)	125.4 (19) (116.8-151.1)	123.4 (10) (116.8-129.5)
Ratio of height of occiput to mastoid breadth (%)	88.7 (2) (85.5-91.9)	86.9 (19) (81.6-97.1)	85.1 (10) (81.4-87.3)
Length of upper toothrow crowns	132.4 (4) (118.4-149.9)	144.8 (20) (134.6-153.7)	147.8 (11) (142.2-154.9)
Greatest width of palate between toothrows	75.2 (4) (65.0-83.5)	87.7 (20) (80.0-96.0)	88.6 (11) (58.0-94.0)
Ratio greatest width of palate between toothrows to length of upper toothrow crowns (%)	56.8 (4) (55.0-58.7)	60.6 (20) (53.8-68.1)	59.9 (11) (40.8-64.2)
Least width of palate between toothrows	54.2 (4) (50.0-58.0)	61.0 (20) (52.0-68.0)	60.0 (11) (51.0-64.5)
Ratio least width of palate between toothrows to length of upper toothrow crowns (%)	41.5 (4) (33.4-48.6)	42.1 (20) (36.2-48.2)	40.4 (11) (38.0-44.5)
"Percent flare" of nasal aperture	---	8.75 (13) (6.0-15.3)	9.7 (9) (7.8-13.2)

Table 4. CRANIAL MEASUREMENTS OF MOOSE - Female

Specimens Collected in 1952

	Young ad.	Mid-ad.	Old ad.
Greatest length	---	567.5 (8) (544.8-593.1)	561.3 (1) (561.3)
Median palatal length	---	340.1 (8) (320.0-368.3)	337.8 (1) (337.8)
Length of rostrum	---	348.1 (8) (327.0-367.7)	350.5 (1) (350.5)
Length of nasal aperture	---	251.9 (8) (236.2-269.2)	254.0 (1) (254.0)
Mastoid breadth	122.3 (3) (116.8-127.0)	130.6 (10) (124.5-137.2)	132.8 (3) (129.5-134.6)
Height of occiput	110.9 (3) (106.9-116.8)	117.5 (10) (108.0-124.5)	117.7 (4) (115.6-121.9)
Ratio of height of occiput to mastoid breadth (%)	90.6 (3) (88.6-92.0)	88.9 (10) (86.1-96.9)	86.5 (4) (78.5-90.6)
Length of upper toothrow crowns	142.2 (3) (134.6-152.4)	145.0 (11) (139.7-149.9)	142.2 (6) (138.4-144.8)
Greatest width of palate between toothrows	79.3 (3) (77.0-81.0)	87.0 (11) (82.5-95.0)	90.6 (6) (89.0-92.0)
Ratio greatest width of palate between toothrows to length of upper toothrow crowns (%)	55.8 (3) (53.1-57.3)	60.0 (11) (58.0-67.4)	62.9 (6) (61.5-65.1)
Least width of palate between toothrows.	52.0 (3) (51.0-55.0)	58.6 (11) (53.0-63.0)	60.2 (6) (58.5-62.0)
Ratio least width of palate between toothrows to length of upper toothrow crowns (%)	36.9 (3) (33.5-39.4)	40.4 (11) (38.0-44.9)	42.5 (6) (40.7-44.8)
"Percent flare" of nasal aperture.	---	9.75 (7) (7.8-12.1)	11.8 (1) (11.8)

HISTORY OF THE MOOSE IN THE AREA

Moberly (1929) records that moose were plentiful in the area north of Jasper House in the fall of 1855. Seventy-seven animals were killed on a hunting trip north from Lac Brule to the Smoky River, a distance of roughly 100 miles. Moose were still numerous when he left the area in 1860.

Stan Clark and other early residents of the area report that moose were absent from Rock Lake in 1913 and first appeared in 1919. At that time the Indians considered the moose to be drifting in from the northeast. In the early 1930's the moose reached a population peak and then declined to a low in the early 40's, At the present time most residents feel that the moose are on the upswing but have not regained the numbers known in the 30's.

Several writers have remarked on the fact that the moose appear to exhibit some cyclic behaviour with a periodicity of roughly thirty years. This phenomenon has also been noted in some other big game species but as yet no positive cycle has been determined.

The absence of moose from the area in 1913 could conceivably be attributed to the extensive forest fires which are reported to have ravaged the mountains and

foothills around the turn of the century. Observations made in 1951 indicated that vast tracts of the Reserve had been denuded about fifty years ago. If the denudation was as complete as supposed it seems safe to assume that the moose were driven from much of the Reserve at that time. If the animals were driven from a large enough area it is not inconceivable to assume that it might take them fifteen to twenty years to repopulate the entire tract.

POPULATION AND DISTRIBUTION

Population Estimate

One hundred and three observations totalling 1267 moose minutes (one moose minute is the unit of time describing the observation of one moose for one minute) were made in the course of the summer. It was possible to identify several individual animals through coat color peculiarities, presence of a calf or the size and shape of antlers. On this basis it was estimated that the 103 observations involved roughly 25 animals. Of these perhaps 20 were seen ranging in the immediate vicinity of Rock Lake.

With the limited amount of data available any proposed population estimate for the study area is bound to be open to considerable error. However, I believe that, by correlating several factors, it is possible to arrive at a reasonable estimate.

From my observations during the summer the sex ratio appeared to be one bull to three cows. Six separate bulls seen in one three hour period on June 24 would, on the basis of the observed sex ratio, represent one fourth of the adult population - in this case 24 animals. The observations were made at a salt lick during a particularly busy period of utilization. However, it is extremely unlikely that the entire bull population was congregated at that time and therefore the adult population would certainly be more than 24 animals. To this, of course, must be added the juvenile population of 6 or 8 animals.

Hosley (1949), in summarizing various population figures, states that over large areas one moose per square mile can be supported indefinitely without damage to the food supply. In my estimation it seems that this figure could be considered valid for the Rock Lake area. The valley floors form most excellent ranges and concent--rations of moose in these localities certainly exceed one per square mile. However, when one considers the extensive timber slopes which have no value as moose range I think the figure of one animal per square mile is quite within reason. Browse studies indicated that the basic food species were not being utilized as fully as they might and therefore it may be assumed that the population is well within the limit of one animal per square mile which the area can support. The area most intensively studied involved about fifty square miles so, on the basis of the above data, it is estimated that the moose population was between 30 and 40 animals.

Rangers who spent part of the winter at Rock Lake report that it was quite common to see from 12 to 15 animals daily on the flats below the lake. Considering

that equally good, and more extensive, feeding grounds lie above the lake and up the north fork of the Wildhay River, I should venture the opinion that the animals seen below the lake represented roughly one third of the population. Recent reports from Rock Lake indicate that fewer moose are using the lake flats this winter than at previous times. This could conceivably be the result of the extremely mild winter which has allowed the animals to move up to higher ranges normally made inaccessible at this time of year.

On the basis of the information presented above I have estimated that the moose population in the area around Rock Lake, prior to the 1952 hunting season, was between thirty and forty animals. At least six moose were known to have been killed in the area last fall. Three of these, two bulls and a cow, were taken personally on a special permit while the other three, two bulls and a cow, were shot during the regular season. The cow apparently was killed by mistake but no further data was available concerning it.

Distribution Within the Study Area

The largest proportion of the observations was made on or adjacent to the lowlying flats at either end of the lake and, while this might be attributed in part

to the open nature of the terrain, it seems to indicate that these constitute the most favored moose pastures in the area. It is also interesting to note that, of the 103 observations, all but fifteen were made prior to July 3rd and after September 1st. It is quite apparent then that during the hotter and more fly-infested months of July and August the moose leave the lower flats for the higher and more timbered areas. However, this is merely a generalized shift and occasional animals remain in their old haunts at least part of the time. The importance of natural salt licks to the moose can be judged by the fact that of the 15 observations made during July and August 10 were at the salt licks at lower levels.

The winter distribution of the moose was roughly determined through frequency of fecal droppings and shed antlers. As had been anticipated the animals concentrated on the lower flats but it was surprising to note the occurrence of winter pellets and shed antlers on mountain tops around timberline. This can be explained in part by the fondness of moose for alpine fir which grows more plentifully at higher altitudes and for which they undoubtedly range upward during mild spells. Hatter (1946, 1950) reports that several well defined migrations of forty to sixty miles from summer to winter range are

known in Central B.C.. To the best of my knowledge there is no such lengthy shift in the Rock Lake area. Certainly none of the local inhabitants has remarked on such a phenomenon.

The locations of the 70 or more moose skeletons discovered during the summer present an interesting point on distribution. With possibly five exceptions all carcasses were found along the fringes of, or in close proximity to, timber stands. Moose are by nature animals of the woodlands and it is therefore to be expected that they would seek cover in times of stress. However, only rarely was a carcass ever found any distance within a large timber tract. Lack of suitable browse normally keeps the moose from frequenting the interiors of large timber tracts and from the carcasses it would appear that even when hard pressed, either by predators or for other reasons, these animals will avoid penetrating heavy timber to any distance.

The locations of moose observed and carcasses noted are plotted on figs. 10 & 11, which occur on pages 30 and 31.

DATA ON AERIAL PHOTOGRAPHS

In view of the extreme diversity of terrain it was felt that aerial photos would provide a far clearer impression of the area than could be set forth on any outline maps. Therefore all data which would normally be recorded on maps are plotted on the two aerial photos which follow. In order to simplify study of the map it might be well to mention that the lightest areas represent grassy slopes or flats and the darker portions the timbered tracts. In general, the gradation from light to dark in the photos represents two stages of forest regeneration in addition to the mature stands which are the darkest portions.

Data Recorded

Figure 10.

Salt licks (numbered in accordance with the soil and water samples collected for analysis) ---------

Moose observed - undetermined ------- ○

- female ------------- ♀

- male --------------- ♂

- juvenile ----------- ●

Rock Lake Ranger Station ------------

Figure 11.

Moose skeletons - undetermined ----- O

- female ----------- ♀

- male ------------- ♂

- juvenile --------- ●

Browse transects ------------------ / / /

Figure 10.

Aerial photo of Rock Lake showing locations of natural salt licks and the moose observed during the summer.

Figure 11.

Aerial photo of Rock Lake showing locations of browse transects and moose skeletons.

SEX RATIO AND REPRODUCTION

Calculated Sex Ratio

Of the 103 observations made in 1952 the breakdown according to sex and age is as follows:

Unidentified ---- 20

Adult females --- 50

Adult males ----- 16

Calves ---------- 9

Yearlings ------- 8

Disregarding the unidentified animals the apparent sex ratio is one bull to three cows. The validity of this ratio may be altered by the fact that cows are more in evidence at certain times than bulls and vice versa. Cows will frequent dense cover when their calves are young (Hosley, 1949) and bulls are inclined to remain in thickets during antler formation. However, it can probably be assumed that over the entire season the variations will even out fairly well and the observed ratio may be considered reasonably accurate.

The problem of polygamy in moose has been a point of contention for some time now but the general concensus of opinion at present (Hosley, 1949;Pimlott, 1949) seems to be that limited polygamy does exist. On the basis of discussions with local trappers and personal observations

it would appear that a bull may spend several days with a cow waiting for her to come into heat. When one considers that the breeding season is only roughly four weeks long (September 18 to October 18 at Rock Lake) it becomes apparent that a bull could serve not more than three or four cows at best. In view of the fact that the breeding is tapering off by October 10th the chances of a bull serving three or four cows is extremely unlikely. Although cases of bull moose keeping small harems have been reported it would seem that this is not the common practice (Hatter, 1950). One young bull was seen to be in association with two cows just prior to the rut but in the one other case noted the bull had a single cow with him.

At this point I would like to mention a rather interesting fact brought to light during the course of my skull collecting activities. The living sex ratio was calculated to be three cows to one bull but the past sex ratio, as based on skeletons found, was 2.2 bulls to one cow - practically a direct reversal! In considering possible factors responsible for the heavy bull mortality sport hunting can be generally disregarded since, prior to the opening of the road into the lake three years ago, the area was used only by a small number of hunting parties packing in with horses. Hunting by local residents may be considered negligible since only one trapper winters at

Rock Lake and there are no Indians in the area. Also, on the basis of local information, I believe that natives etc., when hunting for meat are more inclined to take the female of the species since the meat is conceded to be of better quality. If, as many suppose, the bulls are more susceptible to predation some change between the living and dead sex ratios might be expected. However, it seems very unlikely that the bulls would be 2.5 times as vulnerable as the ratios indicate. Therefore, the only hypothesis I can offer for this unusual sex ratio in the skeletal remains is that in past years the sex ratio was on a much more even basis than it is at present.

The 3:1 sex ratio occurring at Rock Lake in 1952, while not critical, may be considered not entirely favorable. The opening of the hunting season on bull moose in the fall of 1952 will undoubtedly have resulted in the sex ratio becoming increasingly disproportionate. I believe that if hunting is to be carried out at all in the Reserve an open season on cows should also be declared in order to keep the sex ratio within reasonable proportions.

Rate of Reproduction

Although there is considerable variation it would appear that under normal circumstances not more than half of the cows produce calves each year (Peterson, 1949).

In 1952 at Rock Lake only 17.6% of the cows seen had calves with them. This represents an annual increment to the adult population of 10.4% - about half of the normally expected increase (Hosley, 1949). The eight yearling observations represent an increase of 9.3% for 1951, a figure which seems to correlate with the 1952 increase rather well considering that the 1951 offspring have undergone one winter of predation etc.. From the above figures it is apparent that the average population increase is around 10%. The 9.3% increase for 1951 may well be considered above average in view of the light degree of predation which occurred in the area during the winter of 1951-52. Cowan (1946) considered that a yearling crop of 6% of the adult herd in Jasper National Park was too low to sustain the herd. Therefore, on the basis of the data presented above it would appear that the moose around Rock Lake are reproducing at a rate sufficient to sustain the herd but not to allow any appreciable increase in the population. This agrees with the opinion expressed by most of the local residents that the moose are holding their own but not increasing to any great extent.

Peterson (1949) considers twinning to occur in roughly one quarter of the births in Ontario while other invest--igators (Hosley, 1949) make estimates of twinning

occurring in 10-50% of the births. However, in the two summers spent in the Athabaska Forest Reserve I did not at any time see a cow with twin calves. One report of a cow seen in 1951 with twin yearlings was received and a young cow and yearling bull seen together in July 1952 could possibly have been twins. Reports from Ranger Currat at Hay River Ranger Station indicated that he considered twinning in the Reserve to be far less common than in the Lac La Biche area where he had previously been stationed. All in all, it appears that the birth of twin moose calves in the Rock Lake area is rather uncommon.

The low rate of reproduction in the study area is likely the result of a number of factors. There is no doubt that predation by wolves and bears accounts for some calves and that still others are lost through disease and accident (see fig. 12). Many investigators (Hatter, 1950; Peterson, 1949) feel that the mortality rate among very young calves is extremely high. It is also quite possible that the extremely low rate of twinning in the area may partially account for the rate of reproduction being lower than in areas where the frequency of twins is higher. However, I feel that the critical factor in keeping the rate of reproduction at a low level is the adult sex ratio. Hatter (1946) found that in central

B.C. the calf crop was highest where the adult sex ratio approached 1:1. In Sweden where the moose population has been maintained at a high level for many years, the sex ratios in 1936-37 were roughly 1:1 (Skunke, 1949). Thus it appears that where maximum reproduction occurs the bulls and cows are in equal proportions.

Fig. 12. Stillborn female calf found in willows along Moberly Creek. Postmortem failed to reveal anything anatomically wrong. Found on June 9, 1951, had been dead 2-3 days.

LIFE HISTORY

Many aspects of the life history of the moose are still subject to much dispute. Therefore, I shall attempt to set forth the most generally accepted views, supplemented by such personal observations as I was able to make in the course of the past two summers.

Calves are born during the latter part of May and early June around Rock Lake. In 1951 the first calf was reported on May 25th. A calf seen on June 3, 1952, was evidently a week or so old. These dates fit in well with observations made over the years by other investigators (Hosley, 1949; Peterson, 1949). Though varying degrees of twinning have been recorded single calves appear to be the rule in the study area. The gestation period is about 240 days or eight months (Seton, 1929). Hatter (1950) suggests the possibility of two estral periods during the breeding season with the result that some calves are born much later than the others. All calves seen in 1952 appeared to be of a uniform age and therefore, insofar as the Rock Lake studies are concerned, the hypothesis is still open to question.

The fact that a cow moose will defend her young is indisputable (Hosley, 1949) but in most instances, if the calf is not too young, the cow will resort to flight rather

than stand her ground. In only one of the several personal encounters I had with cows and young calves did the cow show any indication of belligerence. This consisted of laying her ears back, bristling her mane and stamping her forefeet. As I circled her to draw closer through some sizeable timber she paced about nervously then broke and slowly trotted away with the calf following. In all other cases the cows merely trotted into the nearest cover when aroused. The reaction of cows with calves to humans appears to vary considerably. Though I personally had no difficulties the rangers informed me that in the spring of 1950 the cows were extremely belligerent for some time. A report from two local Indians concerning the killing of a calf moose by a grizzly seems to indicate that the cow will hesitate to actively fight this predator in defense of her calf.

The calves grow rapidly and by the end of July appeared to be about the size of a small mule deer. Yearlings are considered to weigh 400-600 pounds (Trippensee, 1948) but unless seen with adults or at close range it was found difficult to distinguish them.

The calf will remain with the cow through the winter and, unless another calf is born the following spring it may continue to accompany her for the second summer. If a new calf is born the yearling is driven off before the

birth occurs.(Trippensee, 1948). The fact that no cows were seen with yearlings after about midsummer suggests that the young are set on their own well before their second winter, even if a new calf is not born.

According to weight figures given by Trippensee, (1948) moose attain their full stature at about 3-4 years of age and reach their prime at 7 or 8 years. At least that is the age at which the bulls develop the finest sets of antlers. Sexual maturity is believed to be reached by both sexes at two years of age. The exact age to which moose will live is not certain but Skunke (1949) states that the Swedish moose attain an age of 17-18 years.

The pattern of antler development in bulls has been extensively described by many authors (Hosley, 1949; Peterson, 1949). Small nubbins are developed by the calves during their first summer but the first real set of spikes develop during the second summer. In general forked spikes develop in the second set of antlers (third summer) though in some cases they may occur in the first set. A skull bearing one single spike and one forked spike was found in 1952. The third set of antlers shows the beginning of palmation and the fourth set assumes adult conformation on a miniature scale. It is generally considered that the bulls attain full antler development

at an age of 7-10 years, after which they become smaller and heavier of beam. Undoubtedly there is considerable freakish development in the antler structure and in 1951 one instance of a double prong developing from the lower side of the palm was noted.

Antlers are progressively developed earlier and shed earlier as the animal grows older. In prime bulls development begins in April and the antlers are shed in December or early January. The 1952-53 season at Rock Lake appears to have been abnormal in that mature bulls were still seen with their antlers in early February.

The rubbing of the velvet from the antlers signals the onset of the reproductive cycle and in the Rock Lake area this seems to occur in late August or early September. A three year old bull was noted with clean antlers on September 9th and a mature bull with the velvet partially removed was reported several days prior to that.

During late September and early October a special effort was made to gather as much information as possible on the mating activities of the moose. A young bull was seen consorting with a cow as early as September 16 and likely had been doing so for several days but the rut in all probability did not begin in earnest till about the 22nd of the month. Local reports indicate that the rut in the area is past its height by October 10-th though

the younger cows may continue to come into heat as late as October 20. Two cows noted on the lake flats on October 7 were without consorting bulls and this seems to bear out the idea of the rut being on the decline by that time. Undoubtedly variations in the weather from year to year would cause a slight shift in the rutting period. Following the rut, in late October, it is reported that the moose will occasionally congregate in mixed groups.

The calling of moose during the rut and the fighting of bulls, as described by so many authors, were not noted during the course of the survey though a mature bull shot at the height of the rut bore numerous fresh scars from a recent skirmish. It is interesting to note that there are only two or three records of locked antlers being found in the Reserve. Notes on the polygamous status of the moose are discussed in the section on reproduction.

Particular interest was taken in the rutting wallows and other pawings which the bulls indulge in at breeding time. From the locations of these it became apparent that most of the mating activities were carried on either in the sheltered, willowgrown areas of abandoned stream beds or at higher altitudes at the heads of favorable draws. It was also noted that the pawings were of two types. The first and most common type consisted of a

shallow bowl-shaped depression varying from $1\frac{1}{2}$ to 3 feet in diameter (see fig. 13). These smelled strongly of urine and showed evidence of having been rolled in. It would appear that the practice of pawing up wallows, urinating and rolling in them, as described by Hosley (1949), is part of the premating activities of the animals. The second type of pawing depression is entirely different and, if local reports can be relied upon, is likely involved in the actual mating. These depressions are about 6-8 inches deep and 15-18 inches across with quite steep sides. According to local trappers bulls have been seen to paw out these depressions, whereupon the cow places her hind feet in them thus lowering her hind-quarters and facilitating the copulatory process which usually follows immediately. Such a freshly dug depression was found when a bull and cow were disturbed during the height of the rutting period and several older ones were observed from time to time during the summer.

In general the breeding studies were rather disappointing and the poor results can likely be attributed to a combination of two factors. Firstly, the open, warm fall encouraged the animals to range further and higher rather than to move down towards the lake flats. Secondly, the shooting of the three moose during September for anatomical study is believed to have

disturbed the animals in the area sufficiently to make them more wary and unapproachable.

Fig. 13. Moose wallow found near a salt lick at the head of a draw - September 23, 1952.

GENERAL APPEARANCE AND PELAGE

The moose is the largest, most ungainly looking of the deer family. The bulls may stand 6 feet high at the shoulder and measure 8-9 feet in length. The largest of the Alaska moose may weigh 1700-1800 pounds (Camp, 1948). The cows are generally about three quarters the size of the bulls.

The bulls are most distinctive with their huge sets of palmated antlers which are grown each year and shed after the breeding season. The exceedingly long head with its characteristic pendulous upper lip is borne on a short, thick muscular neck. From the high shoulders the animal's back slopes down to lower hindquarters. The tail is a short insignificant stub which is unnoticable to the casual observer. The long, ungainly-looking legs serve the creatures admirably for negotiating the boggy and brushy habitat which they frequent. The track of the moose is easily distinguished by the pointedness of the cloven hooves and the large size (up to 7" for bulls).

A distinctive feature is the bell or dewlap - a pendulous bag of skin which hangs from the neck at the base of the head. This is fairly long in young animals but decreases in size as the animal ages. A three year old bull shot at Rock Lake bore a bell 10 inches long.

The pelage of the moose, most commonly described as dark brown to brownish black, can be most variable. A buckskin female and males varying from medium brown to nearly black were noted just prior to the rut. The winter pelage which is quite dark usually becomes faded and greyish by the time of shedding in May or June (Peterson, 1949). It was noted that the greying was pronounced along the short mane of the neck and along the belly. The legs below the knee are greyish and on the inner portions of the hind legs above the knees a definite white area usually occurs which is particularly noticable when the animal is in motion. A reasonably accurate criterion for judging the sex of the animal when the antlers of the bulls have been shed seems to be the lighter brown face of the female.

The calves are born with a reddish brown coat which may be faded to nearly a fawn color by July. Peterson, (1949) states that the juvenile coat is shed after 2-3 months and the new coat is greyish brown, lighter beneath and the face is brown. Calves noted in September ranged from this greyish brown color to a blackish brown nearly comparable to the adult.

Fig. 14. Bull moose alerted in marsh June 24, 1952. Pelage rather pale - likely still shedding.

GENERAL BEHAVIOUR AND ACTIVITIES

Senses

Peterson (1949) considers that hearing serves to alert the moose, sight to investigate and smell to provide the stimulus for action. On the basis of certain observ--ations made in 1952 it would appear that eyesight may be of more importance than previously considered. On one occasion a cow and calf were disturbed by my movements on a hillside nearly three quarters of a mile across a flat. A strong crosswind sweeping down the valley minimized the chances of smell or sound reaching them so it must be assumed that the sight of my movements stimulated their flight. At times it seemed that smell provided no stimulus whatsoever since shifting by the observer to a position upwind from the animal resulted in no change in its behaviour. Evidently the reaction to stimulus depends on the animal's alertness. It was noted that the animals kept the wind to their rear while feeding. This fact was also noted by Skunke (1949).

Movements

The moose is not a wandering animal and its movements, whether daily or seasonal, are not inclined to be great. Seton (1929) considers that a cow moose spends her life within 10 miles of her birthplace.

Daily movements are usually short shifts between the browsing area and adequate cover. Often the animals bed down right where they were feeding. The bulk of the activity of the moose at Rock Lake occurred in the evening after five p.m. and in the early morning before 8 a.m.. However, a definite daytime feeding period was noted during the time aquatic vegetation was being utilized. This extended from 9:30 to 11 a.m. and continued until early July when feeding on aquatics in the shallow waters of the sloughs and bays ceased. Skunke (1949) considers that movement is less on windy days or in bad weather. This was substantiated by personal observations though it was noted that feeding often extended through most of the morning on cool cloudy days. It was also noted that activity increased at the licks following a prolonged period of bad weather and that it continued throughout the day. The longest single movement of a moose observed was a two mile trip by a bull to a salt lick. The swimming ability of moose is well known but at no time during the survey were the animals seen swimming in Rock Lake. Local residents reported seeing them swim the width of the lake on several occasions.

Seasonal movements in the study area consisted of generalized shifts to the higher ridges in the summer months and downward movements into the sheltered valleys

in the winter. During the course of the survey fresh tracks were found on the highest windswept ridges above timberline and at the same time shed antlers and winter pellets found in the same locations indicated that, under certain conditions the animals do not entirely forsake these higher areas in the winter. It is quite likely that during mild spells or in a winter of little snow the animals range upward in search of fir browse. There was no evidence to indicate the occurrence of lengthy migrations between summer and winter ranges as described by Hatter (1946).

Social Habits

The moose is not a gregarious animal and as a general rule lives in a solitary state. Loose aggregations may occur accidently at licks or in areas of excellent feed but these seem to be of little significance. The largest number of animals seen at a lick at one time was four bulls. Yarding of moose in the winter time seems to be quite variable according to most authors and generally doesn't occur unless conditions become severe. There were no reports from local residents of any yarding occurring in the Rock Lake area. Since the valley is in a light snow region (average 2-3 feet) it is unlikely that yarding would normally occur.

Reactions to Humans

It would seem that past experience is the major factor in determining the reaction of the animals to the presence of humans (Peterson, 1949). The moose in the Rock Lake area had not been hunted for two years and were therefore considerably more approachable than they would be now since the season has been opened. Cows with young calves would invariably depart in a hurry though it was possible to approach cows and their calves in the fall with little difficulty. In such cases the calf invariably proved to be the most nervous and would frequently trot off in alarm while the cow followed leisurely after (see fig. 15).

Bulls generally seemed less tolerant of humans than the cows and would beat a steady and not always dignified retreat when aroused. One particularly vigorous individual when disturbed during the rut departed with the air of one nursing a very bad headache but at no time did he or any other rutting bull show signs of belligerence. Where the two sexes were found consorting during the mating season the cows were noted to be much more nervous than the bulls in the presence of humans.

On several occasions I found it quite easy to approach dry cows and to follow them about without them becoming alarmed. The only sign of annoyance displayed at such

times was a flattening of the ears when one approached within 15-20 yards. Under these circumstances an immediate withdrawal was usually deemed advisable. In one particular instance no amount of shouting, whistling or waving of hats at a distance of thirty yards could interrupt the female in her feeding activities (see fig. 16.).

In general I found the moose to be a rather curious animal and even in cases where they were obviously alarmed they would invariably stop their flight one or more times to look back. When I speak of flight I refer to their loping trot for at no time did I ever see a moose in full panicky flight. Around the salt licks I found the moose to be rather persistent in their desire to get their salt requirements even in the presence of human intruders.

Fig. 15. Cow moose moving slowly into the brush. The calf had just preceded her.

Fig. 16. Cow feeding on willows - undisturbed by noise and movement.

Fig. 17. Bull pacing through marsh - this illustrates the gait through soft ground.

Fig. 18. Moose bed in semiopen pine-poplar hillside.

HABITAT STUDIES

Peterson (1949) states that mixed stands of young second growth vegetation are essential in the formation of ideal moose habitat. Such areas usually develop as a result of fire or lumbering.

In this respect the Rock Lake area is a perfect example of good moose habitat. In the natural state the valley bottoms are mixture of grassy meadow, willow pasture and poplar or spruce bluffs. Many of the south and west facing slopes are covered with bluffs of scrub poplar and scattered willow - perfect moose browse. This varied vegetational pattern extends up many of the narrow draws as well and all creek banks have their good stands of willow. The shaded slopes, of course, are covered with pine, spruce and fir and are therefore lost as moose habitat.

The last major fire to go through the area occurred in 1931 and burnt off large areas around the lake. At present these tracts support small pines, aspen, willows and buffaloberry - all of which form excellent moose forage. However, on the basis of studies made on older burns the regeneration within the next twenty years will eliminate the useful browse now growing there. Thus, barring future fires, the quality of large tracts of

useable moose range in the area will decrease steadily and the carrying capacity will be appeciably reduced. The logical solution to this appears to be controlled burning of selected areas at periodic intervals. The loss in timber values to the country would be negligible when one considers the extremely slow rate of regrowth of merchantable timber in higher alpine regions.

The presence of logging interests in the valley below the lake is bound to have a certain effect on the moose range. Some 5,720 acres on the Wildhay River and its tributaries have been or are being logged. As the timber is all overmature spruce a practice of clear cutting has been followed and generally the areas logged over were completely denuded. Operations began in 1946 and studies made in the area cut then show no appreciable development of useable browse species over the intervening six years. Herbaceous species occur in abundance but they have value only as summer foods. Undoubtedly the logging operations will prove beneficial to the moose over a long period of time but it will be some time yet before the cut-over areas will support vegetation enough to make them suitable as wintering grounds. The 5000 or 6000 acres logged are only a very minor portion of the area and as they had been lost to the moose as feeding grounds anyway I can forsee no detrimental effect to the wildlife

arising from them. The present status of the timber in the area is such that it is extremely unlikely that further extensive logging operations will be carried out in the vicinity of Rock Lake in the immediate future.

Fig. 19. Area on south fork logged in 1946. Heavy herbaceous growth has developed on old logging road.

Aquatic feeding possibilities are not as extensive as in eastern Canada but Rock Lake and the sloughs at its upper end provide considerable pondweed (Potamogeton) and mare's tail (Hippuris) for the moose during the summer months. Unfortunately four other small sloughs in the general vicinity have developed no appreciable aquatic growth and are therefore of no value as feeding grounds.

FOOD STUDIES

The food requirements of an animal constitute a very vital phase of its ecology and therefore considerable time and effort was devoted to an attempt to determine the plants utilized by the moose in the area and their relative importance. Summer foods were determined in part through observation and vegetational analysis and partly through examination of stomach contents of three animals shot on special permit. Winter feeding habits were determined through sample plot studies and pellet analyses.

Feeding Habits

Considerable time was spent during the summer observing the moose during their feeding periods in an effort to gain as much information about their eating habits as possible. Aquatic feeding was given particular consideration and several interesting facts were noted. Activity in the early part of the season was confined to one shallow bay of the lake and several adjoining sloughs in which the vegetation developed earliest. It was noted that the vegetation fed upon was almost entirely *Hippuris vulgaris* (mare's tail). Undoubtedly some *Potamogeton* (pondweed) was also taken. Waterlily (*Nymphaea*), a

favored food in some parts was totally absent from the area.

Fig. 20. Mare's tail (*Hippuris*) torn up by the moose during their feeding.

Aquatic feeding ceased about July 3rd and this was attributed to the increasing unpalatability of the plants as they matured. It was noted that feeding ceased just about the time the flowering stalks of the plants appeared above water and no further feeding occurred in these areas. Although moose are generally considered to feed in the early morning and evening hours it was noted that a definite midmorning feeding period from 9 to 11 a.m. existed until about the first of July when it ceased at the same time as the aquatic feeding. Aquatic feeding

was resumed about the middle of August along the lake shore and was still continuing when the survey terminated in October. However, feeding during late summer and fall was confined to the shores of the lake in somewhat deeper water than earlier in the season. However, at no time was a moose seen more than bellydeep in the water. Investigation of the plants in the areas frequented by the moose showed them to be chiefly Hippuris and Potamogeton, as in the shallower waters.

Observations with respect to summer browsing habits proved that, although some twigs were taken, the bulk of the feeding consisted of stripping the leaves of aspen poplar and willow off the branches by taking them crosswise in the mouth and jerking the head upward. Subsequent investigation revealed that, as a general rule, this feeding practice did little harm to the branches themselves and young buds were left intact. In all cases feeding was noted to be random i.e. the animals would feed here and there without browsing one single bush completely.

Examination of the browse plots discussed in the next section showed that fresh summer browsing occurred on willow in 31 plots, on aspen poplar in 4, on balsam poplar in 9, on bog birch in 2 and on buffaloberry and green alder in one each. Some utilization of the herbaceous plants, fireweed (Epilobium) and peavine

(Lathyrus) was also noted. These browse figures are, I think, indicative of the importance of willow and poplar as summer browse.

Stripping of bark from willows and aspen poplar apparently occurs in the spring as the sap is rising and several such instances were observed. One remarkable case is shown below. The exact reason for this barking is not too clear but likely the bark acts as some sort of a spring tonic. Salicin, a chemical found in willow and poplar bark, is known to have just such a tonic action.

Fig. 21. Aspens barked by moose in May 1951. This case is unique because the bark had been jerked off in large strips (some four feet long) and eaten up entirely.

Stomach Analyses

Two quart samples of the stomach contents from each of three animals shot during September were washed and dried for analysis during the winter. In all cases the animals were shot toward the end of their morning feeding periods and, with the exception of the mature bull, the material in the stomach was largely intact and quite decipherable. The mature bull was taken during the rut and, as might be expected, had little food in the paunch and what there was was quite watery.

In addition to the three fresh samples of stomach contents one sample from an animal killed the previous winter was collected.

The first sample from a cow shot on September 5 weighed 127 grams dry weight and was found to consist of roughly 75% aspen poplar leaves, 20% willow leaves and five percent small twigs. There were slight traces of peavine (Lathyrus) and bedstraw (Galium boreale).

The sample from the 3 year old bull shot on September 18 weighed 205 grams and consisted mainly of willow leaves. Twigs amounted to 7% of the dry weight of the sample and small amounts of bedstraw, peavine, grass and sedge, buffaloberry (Shepherdia) and rushes were present. The animal had been feeding in the lake shallows just prior

to being shot but no indications of aquatic species other than sedges and rushes were found in the sample.

A sample weighing 130 grams was collected from the paunch of the mature bull shot at the height of the rut on October 1st. The remarkable fact about the sample is that it was almost 100% graminaceous material! Very small traces of willow, fir needles and lungwort (Mertensia) were noted. At least part of the graminaceous matter was known to be rye grass (Elymus). One possible explanation for this unusual feeding behaviour could be that during periods of physiological disturbance when digestion is upset the bulls will seek the more easily digested food materials.

The stomach sample from the animal killed during the winter was found to contain principally twigs from yellow barked willows, some 5-10% graminaceous material and traces of fir needles.

Although the set of samples was too small to be significant I think one may justifiably consider that the diet of the moose during the summer and early fall consists principally of aspen and willow leaves with aquatic species and graminaceous material playing a secondary role.

Plot Studies

The assessment of winter browsing values was achieved through use of a system of sample plot analysis developed by Aldous (1948) and used by Peterson (1949) in his moose studies. Certain modifications were made in the original method but basically it remained the same. 1/100 acre plots (a circle with an 11.7 ft. radius) were laid out on compass-plotted transects at 100 yard intervals (paced). Various browse species within the plot were noted. Percent of the plot covered by each species and the percent of available browse on each species which had been utilized by moose were estimated and recorded. Aldous determined the occurrence of browse species and degree of browsing in terms of light, medium or heavy and then assigned arbitrary percentage figures to each category. During the 1952 studies an effort was made to estimate the actual percentage values for each individual plot. Four hundred and eighty five plots were laid out in June and early July. This was a bit late in the season for best results as new growth was obscuring the effects of winter browsing but fairly accurate results were obtained.

The entire flat below Rock Lake was chequered with plots taken every hundred yards on NW-SE transects which were spaced 100 yards apart. In addition, separate transects were made on the upper Rock Lake flats and

on various mountain slopes in an attempt to sample as many of the vegetational types as possible. Since there is considerable logging in the Wildhay River valley plots were taken in cutover areas of various ages in an attempt to ascertain what regrowth of suitable moose food could be expected. The transects, with the exception of those in the logged-over areas, are plotted on fig, 11, page 31.

Fig. 22. Typical moose pasture below Rock Lake showing the method of laying out browse plots.

The results of the plot analyses are summarized in table 5. Explanation of the significance of each of the six columns is given on the following page.

EXPLANATION OF COLUMNS IN BROWSE PLOT TABLE

Column 1 - % of plots present - This is obtained by totalling the number of plots in which each species occurred and dividing this by the total number of plots analysed.

Column 2 - Average density - This figure is obtained by adding up the total density figures for each species and dividing by the number of plots surveyed.

Column 3 - Average degree of browsing - column 3 is obtained in a similar manner as column 2 except the degree of browsing figures are totalled and divided by the number of plots in which each species occurred.

Column 4 - After columns 2&3 are completed for each species, the average density is multiplied by the average degree of browsing to obtain this column of values which represents usage. This column in itself is of little significance until its values are transposed to a percentage basis in the next column.

Column 5 - This column of figures is obtained by dividing the total of all usage values (Column 4) into the usage values of each species, These figures then represent the percent of total foods eaten by the moose that each species has provided.

Column 6 - Percent of browse available - to represent the percent of total browse that each species provides the total of all average densities (column 2) is divided into each species' average density.

Table 5: DATA ON BROWSE PLOTS

Species	% of Plots	Average Density	Average Browsing	Usage	% of Total Food Used	% of Available Browse
Willow spp.	79	.186	.076	.014	90.8	61.7
Lodgepole Pine	21.6	.033	.015	.0005	3.2	11.0
Aspen Poplar	17.1	.006	.043	.0003	1.9	2.0
Buffaloberry	43.7	.032	.006	.0002	1.3	10.6
Green Alder	3.1	.006	.024	.00014	.9	2.0
Balsam Poplar	23.1	.003	.036	.00011	.7	1.0
Alpine Fir	4.3	.003	.030	.0001	.6	1.0
Bog Birch	10.1	.0025	.021	.00005	.3	.8
Rhododendron	1.4	.0008	.027	.00002	.1	.26
Gooseberry	4.3	.0005	.003	trace	trace	.2
Currant	1.4	.0001	.01	trace	trace	trace
Rose	6.0	.0002	.006	trace	trace	trace
Juniper	.6	.0001	.007	trace	trace	trace
Black Spruce	2.5	.003	-	-	-	1.0
Wh. & Engel. Spruce	35.7	.016	-	-	-	5.3
Labrador Tea	13.8	.009	-	-	-	3.0
Vaccineum	.4	.0001	-	-	-	trace
Raspberry	.8	trace	.005	-	-	trace
Low Bush Cranberry	.2	-	-	-	-	trace
Shrubby Cinquefoil	.4	-	-	-	-	trace

Several points of considerable interest were noted as a result of the plot studies. The relative paucity of browse species in the study area was particularly striking. Peterson (1949) found 29 browse species in Ontario, of which 25 had been utilized and 12 of which formed 92.3% of all food eaten. Only 19 species were found in the Rock Lake area. Sixteen of them had been browsed to some extent and 3 species provided 94.6% of the total food eaten. Conspicuous by their absence from the area were such important moose food species as mountain ash (*Sorbus americana*), Douglas fir (*Pseudotsuga taxifolia*), paper birch (*Betula papyrifera*), and maples (*Acer* spp.). Hazelnut (*Corylus cornuta*), High bush cranberry (*Viburnum opulus*), shadbush (*Amelanchier* sp.) and red osier dogwood (*Cornus stolonifera*), though possibly of limited occurrence in the area, were not found in any of the plots studied.

Plots taken in logged-over areas revealed that, even after a lapse of five or six years no appreciable browse had developed. Summer foods such as peavine and grass were very abundant but winter foods were practically nonexistent thus making the year-round use of these areas impossible.

The status of the conifers as moose food was of special interest in view of the abundance of lodgepole pine (*Pinus contorta*) and relatively small amounts of

alpine fir (Abies lasiocarpa) which were available for winter browsing. Pine was found to rank second in percent of food eaten while fir ranked seventh. This is in direct contrast to the situation in Ontario where Peterson (1949) considered balsam fir to be the most commonly eaten winter food and vital in the winter economy of moose. Martin (1951) considered fir to constitute 5% of the winter diet and pine 1½ to 2%.

The ten most important winter browse species in the Rock Lake area, on a percentage basis of food eaten, are ranked as follows: (1) willow, (2) lodgepole pine, (3) aspen poplar, (4) buffaloberry, (5) green alder, (6) balsam poplar, (7) alpine fir, (8) bog birch, (9) rhododendron, (10) gooseberry.

As indicated by the average degree of browsing the ten most highly preferred winter foods were found to be in the following order: (1) willow, (2) aspen poplar, (3) balsam poplar, (4) alpine fir, (5) rhododendron, (6) green alder, (7) bog birch, (8) lodgepole pine, (9) currant, (10) juniper.

The reasonably large percentage of lodgepole pine taken seems to be related to its extreme abundance rather than to any great degree of palatability. The use of rhododendron, with its apparent high palatability, is curtailed by its limited occurrence in the area.

It was of considerable interest to note the marked preferences of the moose for certain species of willow. The more succulent yellow-barked willow (Salix macalliana) appeared to be the favorite, the red-barked S. arbusculoides ranked next while the coarser and more woody grey barked S. glauca was utilized but slightly. In several cases macalliana was noted to be browsed as high as 80% while adjacent bushes of glauca were untouched. Future study of this problem may reveal many interesting factors about relative palatability of closely related species.

Skunke (1949) considers spruce as an emergency moose food. Since there was no indication of any utilization of spruce around Rock Lake it may be assumed that the moose have been living well within the bounds of their food supply and have not had to resort to use of the emergency food species.

No instances of appreciable overbrowsing were noted in the area. Moose have a habit of straddling small trees and breaking them down to secure the upper foliage but few cases of this were observed during the course of the studies. However, the condition of much of the willow growth indicated that severe overbrowsing occurred some years ago.(see fig. 23).

Peterson (1949) considered that the presence of deer and elk in any numbers within areas frequented by

moose largely nullified the value of browse plot studies. Therefore, since both animals occur in the Rock Lake area the results obtained from the browse analyses must be considered somewhat inaccurate. Cowan (1945) considered willow highly palatable to black-tailed deer in summer but made no mention of it being browsed in winter. Therefore it is possible that the deer will not appreciably alter the winter browse figures on willow. Murie (1951) considered bog birch, aspen and willow the most favored browse species of elk in the mountain areas. Hence it is likely that the elk constitute the major factor in altering the true moose browse picture. In view of the relatively small numbers of both deer and elk in the area I do not feel that the data on moose browsing will be basically altered.

A number of plots were studied within the pasture at the Rock Lake Ranger Station in an attempt to determine the effect of fencing on moose movements. On the basis of the browse analyses and personal observation it appeared that a four foot fence, when topped by rails, provided no obstacle to the moose. However, it has been reported that the moose persistently blunder into wire fences which do not have a rail along the top. This appears to be the result of the animal's inability to recognize the fine wires as a barrier.

Fig. 23. Willow killed back by overbrowsing in the past but now in healthy condition.

Fig. 24. Lodgepole pine heavily browsed by moose or possibly elk.

Pellet Analyses

Moose faeces, in summer, are viscous masses due to the increased percentage of herbaceous material in the diet. With the onset of fall and the switch to a more woody diet the faeces become more consolidated and assume the shape of small elongated pellets roughly one inch in length. It would appear that pellet formation begins in September and ends in early June. The pellets have been found to contain many identifiable portions of woody plants and therefore may serve as another criterion upon which to base an adequate study of winter moose diet.

In the course of the above-mentioned plot studies 200 samples (5 pellets each) of winter pellets were collected for analysis. Two pellets from each sample were broken up with a mortar and pestle and were placed under a binocular microscope for study. In most cases it was found that portions of pine and fir needles, graminaceous material and willow twigs were readily identifiable under magnification. The results of the study are as follows: twigs in 100% of the samples, pine in 45.5%, fir in 19%, and graminaceous material in 85.5% of the samples. With few exceptions the percent of pine, fir and graminaceous material in each sample was found to be very small - generally less than 10%. From the above

figures it is evident that pine and graminaceous material form a consistent, though small, portion of the winter diet of the moose. Fir on the other hand appears to be of relatively minor importance.

SALT LICK STUDIES

Natural salt licks have long been an object of much interest to naturalists and even yet there is a great deal of uncertainty as to the actual value and importance of these much-frequented areas. Almost without exception the salt content of the soil and water has been found to be extremely low. However, the very fact that the animals persistently come to these spots indicates that there must be some element present which their bodies require. A series of studies begun in 1951 was expanded in 1952 in an effort to gain some idea of the compounds present which the moose seem to require.

A total of twelve licks in the general Rock Lake area were investigated and, of these, eleven were found within a five mile radius of the lake. The twelfth was located near Eagles Nest Pass thirteen miles from the lake. Five of the licks had areas of over 2000 square yards and could be considered of major importance while the rest were much smaller. Location of the licks appeared to follow no definite pattern - some occurred on river flats, others on boggy hillsides, still others at the bases of hillsides and three were found on or near the divides between creeks.

Fig. 25. Lick No. 3 at base of hillside. Note trails leading down to it from all angles.

Soil Analyses

A series of three soil samples were taken from each lick - sample A from the surface soil in the lick; sample B taken from 12-18" deep in the lick; and sample C from a 6" depth 20 yards back from the edge of the lick. It was felt that these three samples would give a fairly accurate picture of the occurrence of the salt concentrations.

The Soils Department at the University of Alberta carried out analyses on the soluble salt content of the soil samples and the resulting data are presented in table 6 on the following page.

Table 6. SOLUBLE SALT DATA ON SALT LICKS

Soil No.	pH	Conductivity mmhos per cm.	% of soil HCO_3	Cl	SO_4	Ca	Mg	Na
1a	8.5	.62	.069	.032	.080	.004	.009	.052
1b	8.4	.13	.033	0	.004	0	.010	.015
1c	8.0	.12	.031	0	.004	.012	.014	0
2a	7.8	.40	.054	0	.004	.012	.014	.025
2b	7.6	.74	.038	0	.050	.056	.011	.025
2c	7.8	.22	.056	0	.016	.016	.036	0
3a	1.6	11.4	0	0	3.20	.228	.150	.005
3b	5.6	1.98	0	0	.550	.148	.057	.002
3c	6.0	.57	.028	0	.110	.028	.025	0
4a	6.7	1.01	.038	0	.270	.040	.027	0
4b	7.3	.35	.033	0	.050	.012	.045	0
4c	7.3	.20	.051	0	.006	.016	.023	0
5a	7.8	.36	.054	0	.030	.012	.047	.020
5b	7.5	.15	.049	0	.010	.008	.038	.010
5c	6.9	.88	.051	0	.040	.048	.104	.005
6a	8.3	.74	.152	0	.020	.280	.045	.060
6b	8.0	.27	.051	0	.020	.004	.181	.015
6c	5.3	.03	.013	0	.004	.020	.027	0
7a	7.3	.98	.094	0	.160	.089	.043	.022
7b	6.2	1.52	.045	0	.410	.051	.020	.016
7c	6.5	.47	.110	0	.070	.038	0	.056
8a	7.4	.38	.150	0	.010	.016	0	.003
8b	8.2	.11	.040	0	0	.012	0	0
8c	6.9	.09	.030	0	0	.008	.007	0
9a	7.2	.45	.040	0	.06	.036	.007	.005
9b	7.6	.16	.040	0	.01	.016	.016	.003
9c	6.2	.09	.030	0	.002	.020	.014	0
10a	6.5	1.29	.040	0	.300	.073	.023	0
10b	4.8	4.46	.020	0	1.46	.450	.049	.015
10c	3.8	.10	.002	0	.003	.012	.016	0
11a	7.2	.20	.030	0	.012	.020	.009	0
11b	7.5	.11	.030	0	.008	.008	0	0
11c	5.4	.03	.040	0	.002	0	.002	0
12a	7.7	.21	.050	0	.010	.040	0	.017
12b	6.6	.32	.020	0	.040	0	.002	.012
12c	5.6	.06	.010	0	trace	0	0	0

Note: No carbonate present in samples.

With the exception of licks 3, 4 and 10 which contained much sulphur the soil of the licks was slightly alkaline. This fact becomes more significant when one notes that with but two exceptions the soil around the licks was slightly acid. This indicates that the licks contain accumulations of alkaline salts. Aside from two of the sulphur licks the total soluble salt content of the samples never exceeded .5% to .75%. Except for sodium which generally was most abundant in the surface soil of the licks no consistent correlation in the location of maximum abundance of the various salts could be determined. The amount of sodium present showed a rough correlation to the size of the lick but one or two notable exceptions where large licks were lacking in this element tend to make this invalid. It is rather interesting that chloride was almost universally absent from the samples. In all likelihood this is due to its extreme solubility which has resulted in it being leached from the soil.

The only significant points which seem to arise from the soil analyses are the general alkalinity of the lick soil and the relative abundance of sodium in the surface soil. This correlation indicates that in all likelihood sodium is responsible for much of the alkalinity of the licks and therefore may be one of the constituents attracting the animals.

Water Analyses

Water samples (24 fl. ozs.) were taken from the pools or seepages in the licks in an attempt to determine whether the salts present actually existed in the local soil or were brought in in the seepage flow. This is of particular interest in view of the fact that, while deer and sheep will eat the soil at the licks, moose seem to confine their activities to sipping the water lying about in the licks. As a matter of general interest, and for comparison, samples were also obtained from a sulphur spring which was not utilized as a lick and from the Hay River.

Analyses on the samples were carried out by Mr. J. A. Kelso, provincial analyst and his findings are contained in table 7 on the next page.

Analysis of the water samples, as with the soils, revealed little in the way of correlation between amount of usage and the amount of salts present or the degree of alkalinity. In general, the better patronized licks were those containing $NaHCO_3$ as one of the alkaline components. It was also noted that in the cases of the unutilized sulphur spring and one very poorly defined sulphur lick the sulphate concentration was at both places over 900 parts per million. It seems logical therefore that a very high concentration of sulphate may be

Table 7: SALT LICK WATER ANALYSES

Parts Per Million

Lick No.	Total Solids	Ignition Loss	Hardness	SO_4	Cl	Iron	NO_3	Alkalinity	Nature of Alkalinity
1	3026	334	140	440	316	30	-	1280	HCO_3 of Na, Ca, Mg
2	430	140	250	70	3	0.3	-	270	HCO_3 of Na, Ca, Mg
3	1166	172	800	470	53	-	-	125	HCO_3 of Ca, Mg
4	2014	250	1000	945	1	-	-	135	HCO_3 of Ca, Mg
5	662	136	185	30	7	0.5	-	430	HCO_3 of Na, Ca, Mg
6	360	110	115	50	13	-	-	185	HCO_3 of Na, Ca, Mg
7	464	160	250	80	27	0.1	-	200	HCO_3 of Ca, Mg
8	792	234	115	4	145	-	36	240	HCO_3 of Na, Ca, Mg.
9	470	184	270	85	2	-	-	220	HCO_3 of Ca, Mg
10	484	190	280	85	2	-	-	215	HCO_3 of Ca, Mg.
11	----------	----------	----------	Lick was dry	----------	----------	----------	----------	----------
12	1830	86	165	870	3	0.3	-	260	HCO_3 of Na, Ca, Mg
Stream	266	104	230	45	1	---	-	145	HCO_3 of Ca, Mg
Sulphur Spring	2152	316	1000	985	2	-	-	155	HCO_3 of Ca, Mg

unpalatable to the animals.

At this point I would like to make mention of certain observations made by Stan Clark, a longtime resident of the area, concerning sulphur licks. Over the years he has noted that moose frequenting areas rich in sulphur springs were found to be free of ticks. He advanced the hypothesis that perhaps the sulphides or some other agents in the water found their way to the epidermal tissues after the animal had consumed them. Conceivably then, these agents may have exerted a repellent effect upon the ticks. There is little concrete evidence to support this theory but I do feel that it is certainly worthy of further study. The fact that a rubbing tree (alpine fir) used by moose was found within 20 feet of a sulphur lick may or may not be of significance.

Fig. 26. Sulphur lick on the shore of Rock Lake.

Fig. 27. Rubbing tree used by moose at the sulphur lick above.

Salting Experiments

One of the major licks at the head of the Rock Creek flats was selected as the location for a series of salting experiments designed to determine, if possible, the salt preferences of moose. The experiments carried out were based on information received from the Idaho Department of Fish & Game and the Montana Cooperative Wildlife Research Unit concerning big game salting experiments carried out in those states.

After rather lengthy delays in obtaining the desired chemicals, a dual set of experiments were set up at the lick on July 26 and were carried on until the survey terminated in October. The nineteen chemicals used were as follows: $CoCl_2$, H_2SO_4, H_3PO_4, HI, $KHCO_3$, $CuSO_4$, $NaHCO_3$, $FeSO_4$, Na_3PO_4, $CaCl_2$, $MgCl_2$, NaCl, NH_4I, KH_2PO_4, $CaCO_3$, CaI, NaI, KCl, KI.

The first experiment consisted of dissolving as much of each salt as possible (up to ½ pound) in three pints of water and mixing it with seven pounds of sandy loam. These muddy mixtures were then placed in small troughs measuring 8"x 14"x 5" which were hollowed from logs and placed in the center of the lick area (see figs. 28 - 30).

Realizing that the animals would be rather cautious about any strange object at the lick it was decided to run a parallel experiment under as nearly natural conditions

as possible. A series of bowlshaped depressions 18" across and 6" deep were dug along the higher elevations of the lick. Into each of these three pints of salt solution (three pints of water saturated with salt - ½ pound maximum) were poured and then the depressions were filled with water (see fig. 31). The depressions and troughs in both experiments were checked for usage and refilled with water at weekly intervals during the summer while fresh salt solutions were added monthly to restore loss by leaching.

Results of the trough experiments were largely negative and it was felt that at least a year would be required before game would be sufficiently used to the troughs to make use of them. However, it was noted that stray outfitter's horses made ready use of the salt troughs and particularly the one containing NaCl. A study of the salt impregnated depressions revealed that the moose showed particular interest in Na_3PO_4 and NaCl though the phosphate was the more used of the two. These preferences agree closely with results obtained in similar experiments in the States (Cheatum, 1951).

Results of the salting experiments and soil and water analyses all indicate that the sodium ion is one of, if not the important, elements in natural salt licks.

Fig. 28. General view of lick No. 1 used for salting experiments. Troughs are shown in place.

Fig. 29. Closeup of one salting trough with samples placed in it.

Fig. 30. Salting trough under construction.

Fig. 31. Water-filled depressions used in the second salting experiment.

General Lick Observations

As a result of the summer's activities several points of interest in the lick activities of moose were noted. First, it was observed that activity at the licks was greatest immediately following prolonged periods of bad weather and that at such times the animals would frequent the lick throughout the day. Ordinarily the largest proportion of activity at the licks is nocturnal. Second, activity of the moose at the lick was confined to sipping water - there was no eating of soil. Stance of the moose while drinking was usually one foreleg back and the other slightly bent. Peterson,(1949) describes three stances. At no time was a moose seen to kneel as has been reported by some local trappers. Third, young calves were observed to make use of the lick at two months of age. Fourth, in general, lick activity was maintained through the summer and into the fall with only moderate fluctuation. Where-ever lick activity declined with the advancing season it was noted that the decline seemed to be correlated with a drying up of the lick. Thus it appears that apparent seasonal fluctuations in the use of licks may be due, in part anyway, to the availability of the salts rather than entirely to variations in the animal's metabolic require-ments as suggested by some investigators.

Fig. 32. Young cow moose alerted at salt lick No. 1.

Fig. 32a. Young bull alerted while feeding in lake shallows.

ANATOMICAL STUDIES

During the period September 5 to October 1 three moose were shot on a special biological permit for anatomical study. These animals were as follows: a mature cow, a three year old bull and a mature bull. Originally it was hoped that obviously diseased animals could be taken for study but since all animals seen appeared to be in reasonably healthy condition three specimens were finally picked at random. Taking of the animals was delayed until September in order that somewhat cooler weather could be used to advantage in the handling of meat from the carcasses. In accordance with the terms of the permit meat from all three animals was turned over to the local Forest Officer for distribution to charity. Mr. S. H. Clark gave me particularly valuable assistance in the butchering and transportation of the carcasses.

An extensive study of all internal organs was carried out on all three animals and fresh specimens of heart, liver, lung, spleen, kidney, and intestine were secured. In addition sterile swabs of heart and liver blood were taken and blood smears were made from all organs. In each case the specimen material was dispatched within 24 hours of collection to the Provincial Veterinary

Laboratory in Edmonton for detailed pathological study. Results of the laboratory analyses will be discussed in the section on diseases and parasites.

Samples of the stomach contents of each animal were washed to remove digestive juices and then dried and packed for food analysis which was conducted during the winter at the University of Alberta.

Other material secured from the animals for the University included:

1. the brain of the mature male
2. the genital tracts of the cow and young bull
3. samples of stomach wall tissue
4. cooked and raw samples of meat for microscopic study of muscle structure
5. the skull of the cow.

DISEASES AND PARASITES

Pathological investigation of tissues from the three animals shot failed to reveal any bacterial infections but parasitic tapeworms, either as adults or as cysts, occurred in all three. Hydatid cysts of *Echinococcus granulosus* occurred in the lungs of the cow and mature bull. Cysts of *Cysticercus tenuicollis* (intermediate stage of *Taenia hydatigena*) were found in the heart, liver and back muscles of the three year old bull and in the liver of the mature bull. Adult tapeworms of a *Monezia* species were found in the ilea of the cow and young bull. Infestation in the case of the cow was very light, there being but a single worm present; but the ileum of the young bull was partially blocked by 7 or 8 mature worms lying side by side. However, aside from being slightly thin the animal did not seem to be suffering any ill effects from this infestation.

None of the animals examined carried any ticks (*Dermacentor albipictus*) and at no time during the course of the survey were any picked up in the brush. The previous year (1951) a few ticks were collected involunt--arily from the brush around Rock Lake. The fact that horses coming in from winter range during the past two years have been relatively free of ticks seems to indicate

that tick infestations are at a low ebb at the present time.

Local Indians reported that the die-off of moose in the area some ten or fifteen years ago was accompanied by a particularly heavy infestation of ticks. Strickland (1938) reported on tick infestations on moose in Elk Island Park during the die-off of the animals in 1938. He believed that the die-off was due directly or indirectly to the ticks but was unable to obtain positive tests which might indicate that the fatal moose disease, which ticks are reported to carry, was responsible for the deaths.

Insect pests in the area are, I believe, of little real concern to the moose. Mosquitoes and the so-called bulldogs may become annoying in July and August but do not attain anywhere near the numbers common at lower elevations. If the flies do become too bothersome the moose have but to move out on the clear windswept ridges for complete relief.

PREDATION

The effect of wolves upon the moose population is perhaps one of the most hotly disputed wildlife problems today. Cowan (1945) considered that the wolves in Jasper National Park had little effect on the overall moose population. However, every investigator, whether pro or con, admits that the wolves do prey on the moose to some extent and therefore these predators must be considered a factor in the control of the moose population.

Predation during the past winter appeared to be quite light and of over 70 carcasses noted only 4 or 5 could be classed as the previous winter's kills. The patrolman stationed at Rock Lake during the winter reported that the wolves in the area were quite few and to the best of my knowledge only one pack of five or six animals ranged through the area at periodic intervals during the summer. However, evidence that they were exacting a year-round toll on game was noted in the case of the cow moose shot on September 5. Presence of milk in the udder of the animal indicated a calf but none was seen at the time of shooting or during an intensive search of the area soon afterward. Further examination of the carcass revealed weekold scars, which could only be interpreted as fangmarks, on the tendon of the left hind leg and hence it may

logically be assumed that the calf fell prey to the wolves at the time the cow was attacked. The bull whose remains are shown in fig. 33 was presumed to have been killed by wolves since the surrounding underbrush was badly crushed and broken as though a battle had occurred at the time of its demise.

The close proximity of Jasper National Park presents a possible problem in predator control. Within the Park the wolves may breed with immunity and then range out over the surrounding area. As long as these predators have a protected breeding ground no programme of trapping or poisoning can be completely effective. At present I do not think this problem is critical but I do feel it is worthy of further investigation. Cowan (1945) considered the area between Rock Creek and the Snake Indian River (in Jasper Park) to be one of the main wintering grounds of the wolves in the northern part of the Park. Therefore any pressure exerted by the animals is bound to be directed to the Rock Lake area.

Figure 34 of nineteen wolves poisoned out of a pack of twenty in the winter of 1950-51 shows rather well the color variation among wolves and indicates the size of packs which may range through the Reserve.

Most investigators (Hosley, 1949) are agreed that bears constitute a measurable factor in moose mortality,

particularly where their numbers are large. Black bears prey principally on the young calves and likely have little direct effect on the adult population. Grizzlies, on the other hand, are fully capable of downing fullgrown animals. During the summer of 1951 two cases of grizzlies killing moose were reported to me. The first incident occurred on the banks of the Wildhay River and was witnessed by two Indians. The bear was seen to pummel the calf to death and devour it while the cow stood off in the brush bawling. In the second case two fishermen observed a grizzly on the Muskeg River feeding on a fullgrown bull which had been killed just a few hours previously. Stan Clark also reported seeing a grizzly pursuing a cow and calf two or three years previously. Cowan (1947) reported that grizzlies commonly ran down elk and moose. In 1952 one report of a badly mauled cow moose was received and was investigated without success. As the bear population (both black and grizzly) in the Rock Lake area appears to be relatively small I do not think that these predators exert any serious effect on the moose population.

In all likelihood cougars are capable of killing moose but as these animals are reported to be rather uncommon in the area they may be disregarded as a factor in predation.

Coyotes are generally regarded (Hosley, 1949) as ineffective in killing moose. It is quite possible that they may pull down the occasional young calf which may have strayed from its mother but it is unlikely that they would face a grown animal in healthy condition. Most of the moose remains found in coyote scats are undoubtedly from carrion for the animals are great scavengers. Insofar as they may protect the moose food supply by keeping the rabbit population down coyotes may be considered of some benefit to the moose. The coyote population around Rock Lake appears to be within normal bounds and several animals were destroyed during the course of predator control activities last winter.

Fig. 33. A fullgrown bull presumed to have been killed by wolves during the winter of 1951-52.

Fig. 34. Nineteen wolves taken from a pack of twenty during the winter of 1950-51 by Ranger Smith (Berland District).

RELATIONSHIPS TO OTHER ANIMALS

Elk

Elk are generally considered to be the most aggressive of the deer family and where competition with other related species developes they invariably become the dominant animals. Cowan (1945) considers that the relatively low moose population in Jasper National Park may be due, in part at least, to competition with the elk for the food supply on a greatly overpopulated range. Murie (1951) considered that the pressure exerted on the food supply by elk is greater because they congregate in such large numbers.

On the basis of personal observations made in 1951 it would seem that the moose have some actual aversion to contact with the elk. While observing five bull elk feeding and resting on an open hillside the writer noted a bull moose moving uphill toward the elk. At a distance of 200-300 yards he apparently caught wind of them and stopped in his tracks. He then whirled about and trotted rapidly over the ridge at right angles to his original course.

According to local reports it is only within recent years that elk have appeared in the Rock Lake area from Jasper National Park. At present their numbers are not

large and seven animals were the most ever seen together at one time. The fact that no bugling was heard during the rutting season indicates that there is not much breeding occurring in the area.

Competition in the summer when abundant graze is available for the elk may be considered to be negligible. Severe winter conditions as experienced in 1951-52 when a rain and thaw in midwinter iced over the entire area, may make the graze inaccessible to elk. Under these circumstances the feeding pressure will be thrown entirely on browse species which the moose also utilize (see page 71). However, in view of the relatively small elk population I do not believe that they exert an appreciable competitive effect on the moose.

Deer

On the basis of animals seen and the utilization of licks I do not feel that the deer population around Rock Lake is large enough to produce a significant effect on the available browse supply even under the drastic winter conditions described in the above section on elk. From observations made at salt licks it appears that the moose and deer are quite compatible when in contact with one another.

Caribou

Mountain caribou once ranged right across the Rock Lake area in fair numbers but now only the odd animal drifts through the district in the winter. Small bands still occur to the north around the headwaters of the Wildhay River. Their effect on moose range can therefore be considered practically nil.

Domestic Stock

In the past the presence of outfitter's horses in the area has been rather sporadic as the region has never been highly rated as a wintering range. At present one small band of horses is being wintered at Rock Lake but their effect on the overall food supply will likely be negligible. There is no indication that the numbers of stock being grazed there will be increased in the near future.

Beaver

Peterson (1949) considered the beaver to exert considerable effect on moose habitat through their pond building practices. He felt that the new plant successions set up by their actions outweigh any loss of habitat or food supply (poplar). The beaver population in the Rock Lake area is not large and with one exception the animals are all bank dwellers. Therefore there is no altering of

habitat through pond development. The utilization of browse along the streams is not enough to reduce the available beaver food appreciably and the moose certainly have ample browse available which is out of reach of the beaver. In the light of these facts one may assume that the effect of beaver and moose upon each other is negligable in the Rock Lake area.

Rabbits

When the rabbits reach the peaks of their cycle it is quite possible that they might exert an adverse effect on the moose food supply through their habit of barking willow and other browse species. In extreme instances they may bring about a periodic plant kill of many of the browse plants. However, the rabbits in the Rock Lake area have never recovered their numbers since the cyclic "crash" in the twenties and at present are not overly abundant in the region even though the cycle is once more on the upswing. Most of the barking which was noted in the area occurred in young stands of lodgepole pine. No appreciable barking was ever noted on the willows. Thus, at the present time, rabbits can be disregarded as a factor of any consequence in the moose ecology of the area.

HUNTING PRESSURE

All hunters entering and leaving the Athabaska Forest Reserve by vehicle must register at the checking station at Entrance but nonresident hunters, in company with guides, usually enter and leave through Jasper Park. Therefore, while a complete check is not possible the bulk of the game passing out of the Reserve is recorded. Sheep, goat, caribou and grizzly are the chief animals hunted by non-residents so the figures on deer, elk, and moose at the checking station can be regarded as very close to the actual total killed.

Kill figures for 1952 from the Entrance Checking Station are as follows:

Deer	42
Caribou	2
Elk	3
Sheep	9
Goat	12
Moose	44
Bear (Grizzly)	6
Total	108

Four hundred and seventy hunters were checked into the Reserve in 1952 - making a game return of one animal per 4.4 hunters. Of the 108 animals taken 44 or 40.7%

were moose. This heavy kill of moose may be attributed to two basic factors. First, moose are among the easiest of the big game animals to kill at any time and two years protection through closed seasons has made them even less wary. Therefore they presented extremely easy targets for the sportsmen. Second, after the moose had been off the hunting lists for those years many nimrods undoubtedly wanted to try for the newly legalized trophies. It seems to be human nature for people to rush after something they've been deprived of for a while. From the practical hunter's standpoint moose provide the largest quantity, as well as some of the choicest, meat of any of the game species - therefore who will take 100 pounds of deer meat when they can just as easily bring in 500-600 pounds of equally good moose meat?

The moose have certainly borne the brunt of the hunting pressure this past season and if this condition continues for another year or two serious complications may arise through the reduction of the male population. In my estimation the opening of a full season on moose this year after protecting them for some time was an ill-advised move that should not be repeated. It seems to me that the animals have been subjected to greater slaughter through having become less wary during years

of protection. A season of restricted hunting would have given the animals a chance to become accustomed once more to being stalked without having the population shot to pieces. Fortunately only limited areas of the Reserve are accessible by road and therefore the hunting is largely confined to these regions. As long as only a small portion of the population is subjected to the heavy hunting pressure the overall effect on the population as a whole will be negligible since animals from the inaccessible areas will drift in to repopulate the decimated regions.

CONCLUSIONS

On the basis of the material presented in this thesis it is possible to draw several basic conclusions about the ecological status of the moose in the Rock Lake area of the former Athabaska Forest Reserve.

The Rock Lake area, with its wide range of veget--ational types, provides excellent moose habitat at the present time. However, regrowth of burned tracts will eliminate large areas of browse within the next twenty years and thus bring about a notable reduction in the carrying capacity of the range. The solution to this problem appears to be controlled burning of selected areas to set up new cycles of plant succession which are favorable to moose. The effect of logging on the habitat structure of the area may be considered negligible at present but beneficial over a prolonged period through new successions set up.

Data obtained from 55 skulls indicate that the moose in the area may be classified as intergrades between the Montana moose, _A. a. shirasi_, and the western Canadian subspecies _A. a. andersoni_.

Seasonal distribution of the animals indicates that a general movement to the higher ridges occurs in the spring and that a similar shift back to the valleys occurs in the fall. However, there is no indication of any

lengthy seasonal migrations.

Results of the food studies show that aspen poplar and willow leaves together with some aquatics and grasses constitute the major portion of the moose's summer diet. Willow, bog birch, pine, aspen and buffaloberry are the most important winter browse species.

Salt lick studies indicated that the sodium ion was the important element which drew the animals to the natural salt licks. The wide occurrence of licks throughout the area seems to indicate that game in general is fairly evenly distributed.

Browse studies and population estimates have shown that the area is capable of supporting a greater moose population than exists at present. Although the population is evidently holding its own the birth rate and survival of young is not sufficient to produce an appreciable increase in the near future. Predation, competition and disease do not appear to be critical factors in holding the population at its present level. In view of this, one possible factor which could conceivably be holding the population in check is an unsatisfactory sex ratio. Under present conditions, with cows outnumbering the bulls three to one, the chances of all females being serviced as they come into heat are greatly reduced. With an excess of cows present the selective breeding effect,

which acts through the competition of bulls for mates, is at a minimum. Thus every sexually mature male, regardless of his suitability as breeding stock, has ample opportunity to breed one or more cows. If the sex ratio were evenly balanced competition between bulls would be greatly increased and only the finest, most virile specimens would have the opportunity to breed. This in turn would mean that the calves produced would possess a better genetic heritage and a correspondingly greater chance of survival. Breeding for quality has proven highly successful with domestic stock and there seems little reason why the knowledge developed there should not be applicable in game management. In this matter, too, there arises the problem of the selective effect of hunting on the bull population. While it is true that the breeding is over before hunting commences there still remains the fact that the prime breeding stock of the next two or three years is being picked out for slaughter. No stock breeder in his right mind would ever consider killing off his prize bulls but this very policy is being followed year after year with big game species. Is it any wonder then that the hunters report smaller heads and more disease infestation!

On the basis of the information I have at my disposal at the present time I would recommend that, if the season

is to be opened on moose in 1953 in the Athabaska Forest Reserve, it be made legal to shoot cows in an effort to establish a more favorable sex ratio. Such a policy is bound to bring with it a number of problems that can only be solved through rigid control of hunting activities. When cows are hunted there is always the possibility that a number of calves will be orphaned and left to the mercy of predators. This situation can be minimized only if the persons doing the hunting are experienced and conscientious outdoorsmen. How this might be achieved without restricting the rights of every individual to hunt I am not prepared to say. There is also the problem of regulating the kill in order that excessive slaughter of either sex will not occur. One possible method of handling the hunting activity would be to carry out a short game census just prior to the opening of the season and then, on the basis of the data obtained, set the number of animals of each sex which could be taken without affecting the breeding stock. Once the prescribed number of animals had been shot the season would automatically be closed. Another alternative would be to carry out a draw for a set number of hunting permits. Undoubtedly there would be a great deal of public indignation over any set of regulations which might accompany such a change in hunting practise but no experiment, biological or otherwise, can validly

be carried out unless all possible factors are rigidly controlled.

The status of the moose in Alberta is far from satisfactory and, while it is unlikely that correction of a single factor can remedy the situation, no possibility should be overlooked. Therefore, I offer the suggestion that hunting of females be carried out on an experimental basis to ascertain the possible effects on population trends.

ACKNOWLEDGEMENTS

I am particularly indebted to Dr. Wm. Rowan for his direction, advice and especially his efforts in obtaining various essential reference material for me during the course of my studies.

I should like to express my appreciation to Mr. E. S. Huestis, Fish & Game Commissioner, Alberta Department of Lands and Forests, for the services he made available through his department; to Mr. T. D. Dalkin, Technical Division, Department of Lands and Forests, for his assistance in obtaining maps and photos of the area; to Mr. Bill Round who carried out the photographic enlargments for me; to the various rangers and forestry officials who gave much valuable assistance in the field; to Dr. R. L. Peterson of the Royal Ontario Museum who was most helpful in supplying information on skull measurements for the taxonomic studies and to Mr. E. L. Cheatum, Montana Cooperative Wildlife Research Unit and Mr. W. M. Shaw, Idaho Fish and Game Department for making available information on salt lick experiments being carried out by their respective organizations.

To Dr. E. H. Moss, Botany Department, University of Alberta, go my sincerest thanks for his invaluable assistance in making the various plant identifications.

The studies embodied in this thesis were financed, in part, through a grant of the Alberta Biological Station at Gorge Creek, made available through the courtesy of the

Director, Dr. R. B. Miller. In order that the problem of declining moose populations might be given fullest possible study the area formerly known as the Athabaska Forest Reserve was chosen for active field work since it possessed some of the best moose concentrations in the province. Though work was carried on in an area remote from the Biological Station itself the project was considered part of the Station programme.

I am also indebted to the National Research Council of Canada for making funds available, through a post-graduate bursary, to assist me in completing the final year of my studies.

A special vote of thanks is due Mr. Ward and Mr. Milne of the Soils Department, University of Alberta, for their efforts in analysing the soil samples from the salt licks; also Mr. J. E. Kelso, Provincial Analyst, who carried out determinations on the water samples.

I am grateful to Dr. Wilton and the staff of the Provincial Veterinary Laboratory for the instruction they gave me in performing postmortem examinations and also for the pathological studies they made on moose material I sent them during the summer.

Last but certainly not least, I wish to extend my sincerest thanks to Mr. Stan Clark of Entrance. His ungrudging assistance and companionship contributed largely to the success of my studies and did much to make my time in the field most memorable.

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APPENDIX

Table 1: Complete measurements of all moose skulls collected in 1952. All measurements are in millimeters and the tooth condition symbols are as follows:

L - lightly worn

M - moderately worn

W - wellworn

VW - very badly worn

Table 1: CRANIAL MEASUREMENTS OF MOOSE - 1952

Skull No.	1	2	3	4	5	6	7
Sex	F	F	F	M	M	M	M
Total length	593.1	544.8	-	609.6	584.2	-	627.4
Palatal length	368.3	320.0	-	365.8	344.2	-	365.8
Basal length	527.1	485.1	-	546.1	513.1	-	558.8
Rostrum	367.0	327.7	-	365.8	348.0	-	379.7
Antorbital breadth	151.1	148.6	154.9	162.6	154.9	146.1	167.6
Nasal aperture	269.2	236.2	-	281.9	261.6	-	284.5
Mastoid breadth	134.6	124.5	134.6	137.2	144.8	147.3	143.5
Height occiput	121.9	108.0	121.9	129.5	118.1	121.9	127.0
Upper toothrow	144.8	141.0	144.8	141.0	142.2	134.6	153.7
Lower toothrow	157.5	-	160.0	-	-	-	-
Least palate	65	55	59	68	60	58	62
Greatest palate	89.5	85	92	96	85	83	86.5
L. nasal width	51.5	59	57.5	60	60	56	57
G. nasal width	75.5	77.5	88	81	78	-	86
Zygomatic breadth	193.0	185.4	-	218.4	204.5	203.2	213.4
Vertical eye diam.	61.5	62	66	62	64	60	57
Brow width	149.9	143.5	144.8	162.6	157.5	142.2	167.6
Palatal foramen	119	96.5	-	121	111	-	118
Width of condyles	90	86	98	94	101.5	94	98
Beam of antler	-	-	-	-	-	47	56
Between burrs	-	-	-	-	-	188	175
Antler spread	-	-	-	-	-	-	965.2
Antler length	-	-	-	-	-	-	820.4
Width of palm	-	-	-	-	-	-	245.1
Tooth condition	LM	MW	VW	MW	MW	-	M

CRANIAL MEASUREMENTS - cont'd.

Skull No.	8	9	10	11	12	13	14
Sex	M	F	M	M	F	F	F
Total length	-	-	594.4	594.4	561.3	-	-
Palatal length	-	-	350.5	345.4	337.8	-	-
Basal length	-	-	525.8	523.2	509.3	-	-
Rostrum	-	-	363.2	355.6	350.5	-	-
Antorbital breadth	160.0	152.4	161.3	160.0	157.5	156.2	157.5
Nasal aperture	-	-	256.5	259.1	254.0	-	-
Mastoid breadth	137.2	137.2	144.8	152.4	-	134.6	134.6
Height occiput	151.1	124.5	124.5	125.7	-	116.8	119.4
Upper toothrow	139.7	149.9	148.6	148.6	139.7	142.2	127.3
Lower toothrow	-	-	-	167.6	-	-	-
Least palate	61	53	62	59.5	61	58.5	58
Greatest palate	89	86	88	94	91	89	86
L. nasal width	53	-	59	56	56	-	-
G. nasal width	76	-	81	77	86	-	-
Zygomatic breadth	207.0	195.6	208.3	201.9	209.6	203.2	200.7
Vertical eye diam.	53.5	65	59	58.5	62.5	58	61.5
Brow width	160.0	149.9	154.9	157.5	151.1	147.3	149.9
Palatal foramen	-	-	101	111	114	-	-
Width of condyles	94	94.5	98	99	92.5	91	104
Beam of Antler	52	-	52	36	-	-	-
Between burrs	180.3	-	160.0	-	-	-	-
Antler spread	1136.7	-	1257.3	-	-	-	-
Antler length	825.5	-	673.1	-	-	--	-
Width of palm	284.5	-	279.4	-	-	-	-
Tooth condition	L	M	M	W	VW	VW	M

CRANIAL MEASUREMENTS - 1952

Skull No.	15	16	17	18	19	20	21
Sex	F	M	M	F	M	M	M
Total length	561.3	-	579.1	-	586.7	594.4	-
Palatal length	327.7	-	353.1	-	342.9	342.9	-
Basal length	495.3	-	535.9	-	527.0	528.3	-
Rostrum	340.4	-	360.7	-	350.5	355.6	-
Antorbital breadth	152.4	147.3	157.5	158.8	154.9	157.5	154.9
Nasal aperture	241.3	-	274.3	-	264.2	264.2	-
Mastoid breadth	127.0	139.7	139.7	147.3	152.4	156.2	142.2
Height occiput	111.8	119.4	121.9	115.6	127.0	124.5	121.9
Upper toothrow	149.9	142.2	142.2	138.2	144.8	144.8	144.8
Lower toothrow	162.6	-	-	-	-	157.5	158.8
Least palate	59.5	58	54	62	60	61	54.5
Greatest palate	88	83.5	58	92	92	89	90.5
L. nasal width	53	53	55	-	63	53.5	555
G. nasal width	75	76	84.5	-	83	79	77
Zygomatic breadth	195.6	198.1	203.2	200.7	210.8	210.8	203.2
Vertical eye diam.	55	55	58.5	64	60	56	60
Brow width	149.9	152.4	152.4	154.9	162.6	154.9	162.6
Palatal foramen	107	-	116	-	99.5	104	-
Width of condyles	87.5	102	94	86.5	99	95	98
Beam of antler	-	41	-	-	-	--	50
Between burrs	-	172	-	-	-	-	180.3
Antler spread	-	762	-	-	-	-	876.3
Antler length	-	482.6	-	-	-	-	701.2
Width of palm	-	127	-	-	-	-	209.3
Tooth condition	LM	VL	W	VW	MW	M	LM

CRANIAL MEASUREMENTS - cont'd.

Skull No.	22	23	24	25	26	27	28
Sex	F	F	M	M	M	M	F
Total length	-	579.1	-	637.5	-	599.4	-
Palatal length	-	350.5	345.4	375.9	-	360.7	-
Basal length	-	523.2	-	561.3	-	-	-
Rostrum	-	358.1	358.1	388.6	-	358.1	-
Antorbital breadth	152.4	149.9	154.9	160.0	154.9	157.5	161.3
Nasal aperture	-	256.5	254.0	287.0	-	264.2	-
Mastoid breadth	127.0	129.5	-	142.2	135.9	142.2	129.5
Height occiput	116.8	116.8	-	129.5	121.9	124.5	116.8
Upper toothrow	152.4	141.0	144.8	151.1	144.8	144.8	143.5
Lower toothrow	-	154.9	-	-	158.8	-	152.4
Least palate	51	59	61	63	57	63.5	61
Greatest palate	81	82.5	84	88	87	89.5	89
L. nasal width	56.5	53	61.5	63	55	59	54
G. nasal width	69	80	88	82	84	84	-
Zygomatic breadth	198.1	190.5	-	207.0	198.1	210.8	198.1
Vertical eye diam.	62	58	-	61	60	55	57
Brow width	149.9	149.9	160.0	162.6	152.4	165.1	144.8
Palatal foramen	-	108.5	116	121	-	114	-
Width of condyles	90	94	-	98	94	98	95
Beam of Antler	-	-	-	50	-	50	-
Between burrs	-	-	-	198.1	-	172.7	-
Antler spread	-	-	-	876.3	-	1087.5	-
Antler length	-	-	-	838.2	-	831.9	-
Width of palm	-	-	-	276.9	-	259.1	-
Tooth condition	L	LM	M	LM	M	-	W

CRANIAL MEASUREMENTS - cont'd.

Skull No.	29	30	31	32	33	34	35
Sex	M	M	M	M	F	M	M
Total length	-	-	598.2	596.9	-	-	589.3
Palatal length	-	345.4	355.6	345.4	-	-	353.1
Basal length	-	-	533.4	528.3	-	-	523.2
Rostrum	-	348.0	365.8	355.6	-	-	358.1
Antorbital breadth	161.3	157.5	158.8	167.6	142.2	142.2	157.5
Nasal aperture	-	259.1	266.7	264.2	-	-	264.2
Mastoid breadth	143.5	-	135.9	148.6	123.2	-	139.7
Height occiput	116.8	-	118.1	129.5	109.2	-	119.4
Upper toothrow	147.3	148.6	146.1	154.9	139.7	149.9	142.2
Lower toothrow	-	-	-	-	-	-	160.0
Least palate	56	60	66	61	55	50	60
Greatest palate	89	94	83	92	80	82.5	85
L. nasal width	58	57.5	56	60	-	-	57
G. nasal width	-	87.5	78	80.5	-	-	92
Zygomatic breadth	210.8	-	204.5	208.3	193.0	177.8	215.9
Vertical eye diam.	63	-	57	59.5	56	63	60
Brow width	157.5	-	161.3	162.6	142.2	137.2	167.6
Palatal foramen	-	107.5	111	111	-	-	107
Width of condyles	95	-	92	104	85	-	96
Beam of antler	-	-	46.5	-	-	-	40
Between burrs	-	-	167.6	-	-	-	-
Antler spread	-	-	927.1	-	-	-	-
Antler length	-	-	311.1	-	-	-	-
Width of palm	-	-	259.1	-	-	-	-
Tooth condition	VW	W	M	W	L		VW

CRANIAL MEASUREMENTS - cont'd.

Skull No.	36	37	38	39	40	41	42
Sex	F	M	M	M	M	M	F
Total length	-	-	-	604.5	528.3	609.6	-
Palatal length	-	--	-	358.1	348.0	353.1	-
Basal length	-	-	-	538.5	525.8	537.2	-
Rostrum	-	-	-	370.8	355.6	368.3	-
Antorbital breadth	-	152.4	167.6	160.0	158.8	171.5	-
Nasal aperture	-	-	-	269.2	256.5	266.7	-
Mastoid breadth	-	132.1	146.1	149.9	146.1	149.9	-
Height occiput	-	116.8	124.5	125.7	123.2	129.5	--
Upper toothrow	144.8	143.5	147.3	144.8	143.5	152.4	144.8
Lower toothrow	-	-	160.0	158.8	-	-	-
Least palate	60	52	66	59	63	64	60
Greatest palate	91	84	92	93	91	94	87
L. nasal width	-	-	63.5	58	55	61	-
G. nasal width	-	-	93	80	70.5	85	-
Zygomatic breadth	-	200.7	215.9	214.6	213.4	213.4	-
Vertical eye diam.	-	55	59	58.5	59	62	-
Brow width	-	154.9	165.1	165.1	162.6	165.1	-
Palatal foramen	-	-	-	114	119	104	-
Width of condyles	-	93.5	100	99.5	94	105	-
Beam of antler	-	42.5	53.5	38	-	44	-
Between burrs	-	162.6	190.5	154.9	-	193	-
Antler spread	-	-	1087.5	-	-	-	-
Antler length	-	-	762	-	-	-	-
Width of palm	-	-	209.6	-	-	-	-
Tooth condition	-	M	-	W	MW	W	M

CRANIAL MEASUREMENTS - cont'd.

Skull No.	43	44	45	46	47	48	49
Sex	F	M	F	M	M	M	M
Total length	561.3	-	-	586.7	-	586.7	-
Palatal length	345.4	-	-	340.4	-	342.9	-
Basal length	513.1	-	-	516.9	-	513.1	-
Rostrum	358.1	-	-	349.3	-	332.7	-
Antorbital breadth	149.9	158.8	133.4	157.5	151.1	154.9	129.5
Nasal aperture	257.8	-	-	256.5	-	254.0	-
Mastoid breadth	127.0	142.2	116.8	139.7	137.2	154.9	-
Height occiput	114.3	121.9	106.7	119.4	121.9	129.5	110.5
Upper toothrow	139.7	144.8	134.6	148.6	144.8	142.2	119.4
Lower toothrow	154.0	-	-	-	-	154.9	-
Least palate	59	64.5	51	60	56	67.5	58
Greatest palate	83.5	91.5	77	92	86	90	70
L. nasal width	59	-	-	58	53	60	47
G. nasal width	86	-	-	84	75.5	79	65
Zygomatic breadth	193.0	212.1	-	205.7	208.3	213.4	-
Vertical eye diam.	59	-	-	62	53.5	60	-
Brow width	147.3	-	125.7	162.6	148.6	160.0	123.2
Palatal foramen	114.5	-	-	110	-	95	-
Width of condyles	89.5	104	90	98.5	93.5	98	93
Beam of antler	-	39	-	36.5	49	-	-
Between burrs	-	-	-	175.3	177.8	-	-
Antler spread	-	-	-	-	901.7	-	-
Antler length	-	-	-	-	539.8	-	-
Width of palm	-	-	-	-	184.2	-	-
Tooth condition	MW	W	L	W	LM	M	L

CRANIAL MEASUREMENTS - cont'd.

Skull No.	50	51	52	53	54	55
Sex	F	M	F	F	M	M
Total length	561.3	-	567.7	571.5	548.6	609.6
Palatal length	332.7	-	337.8	339.1	321.3	360.7
Basal length	497.8	-	502.9	508.0	-	-
Rostrum	342.9	-	345.4	345.4	331.4	370.8
Antorbital breadth	149.9	121.9	152.4	162.6	-	-
Nasal aperture	238.8	-	254.0	261.6	228.6	287.0
Mastoid breadth	137.2	110.5	124.5	129.5	130.8	144.8
Height occiput	118.1	101.6	120.7	119.4	127.0	124.5
Upper toothrow	149.9	118.1	147.3	141.0	148.6	151.1
Lower toothrow	163.8	-	-	152.4	160.0	165.1
Least palate	57	51	56	63	57.5	58
Greatest palate	87	65	87	95	80	92
L. nasal width	51	-	59	54	54.5	70
G. nasal width	80	-	83	77	89.5	95
Zygomatic breadth	198.1	160.0	210.8	196.9	203.2	233.7
Vertical eye diam.	56.5	50	61	66.5	-	-
Brow width	144.8	116.8	142.2	149.9	-	-
Palatal foramen	-	-	110	100	-	-
Width of condyles	94	90	88	93.5	-	94
Beam of antler	-	-	-	-	-	56
Between burrs	-	-	-	-	-	165.1
Antler spread	-	-	-	-	-	1087.5
Antler length	-	-	-	-	-	-
Width of palm	-	-	-	-	-	266.7
Tooth condition	L	L	M	MW	LM	W